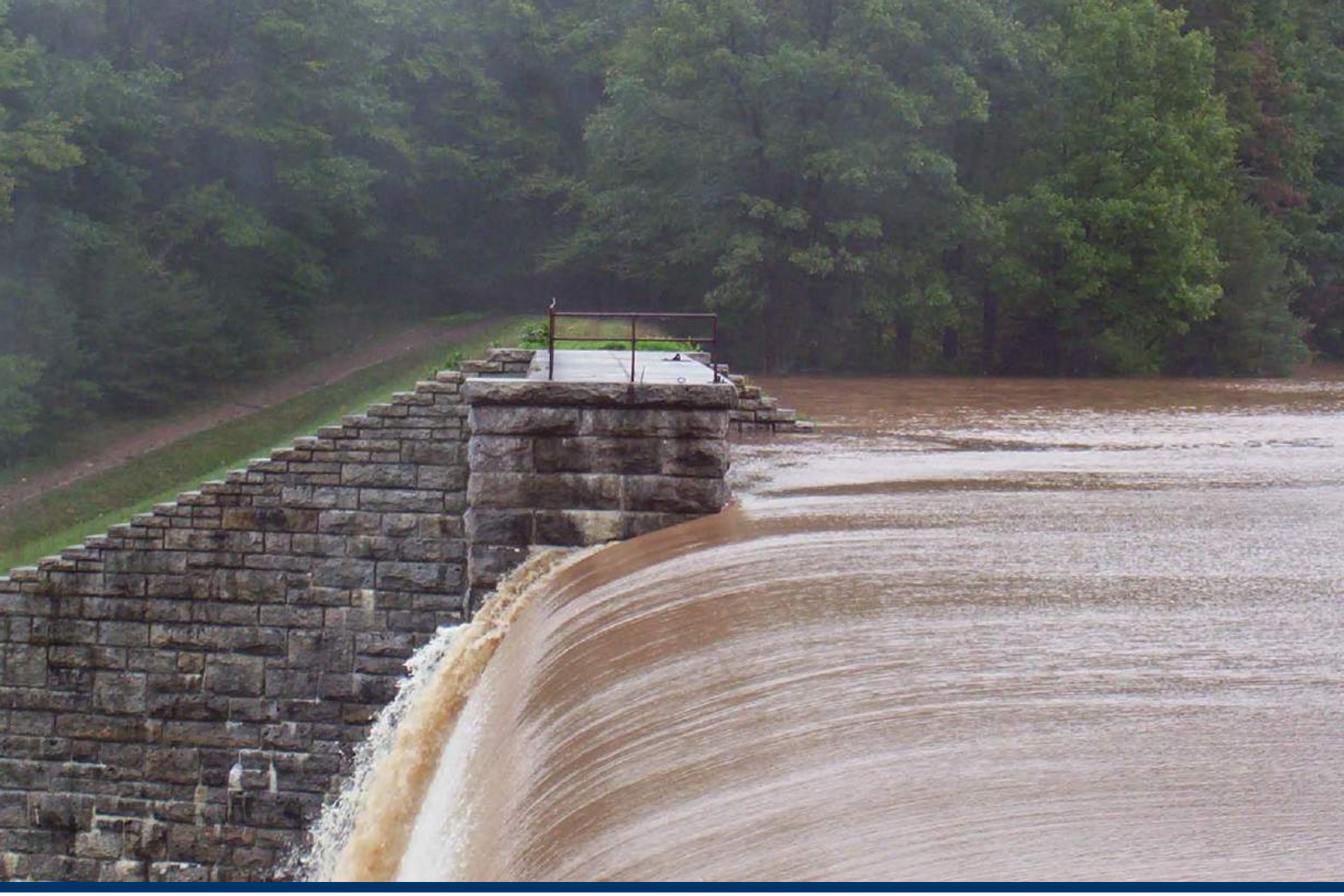


Summary of Existing Guidelines for Hydrologic Safety of Dams

FEMA P-919 / July 2012

FEMA

Preface

In September 2010, the Federal Emergency Management Agency's National Dam Safety Program sponsored development of this document under the supervision of James E. Demby, Jr., P.E. The primary authors of this document are Dr. Arthur Miller, P.E. (AECOM); and Paul Schweiger, P.E.; Amanda Hess, P.E.; Rod Holderbaum, P.E.; Bob Kline, P.E.; Don Roarabaugh, P.E.; and Gregory Richards, E.I.T. (Gannett Fleming).

The quality and scope of this report has been significantly improved by the efforts and knowledge of the Steering Committee and Research Work Group composed of the following dam safety experts:

Steering Committee:

James Gallagher, P.E.
Chief Engineer, Dam Bureau
New Hampshire Department of Environmental Services

Brian Long
Manager, Division of Water & Waste Management, Dam Safety Section
West Virginia Department of Environmental Protection

Dan Mahoney, P.E.
Director, Division of Dam Safety and Inspections
Federal Energy Regulatory Commission

John H. Moyle, P.E.
Manager, Bureau of Dam Safety and Flood Control
New Jersey Department of Environmental Protection

Laurence Siroky, P.E.
Bureau Chief, Water Operations
Montana Department of Natural Resources and Conservation

Research Work Group:

Brian Becker
Chief, Dam Safety Office, Bureau of Reclamation
U.S. Department of the Interior

Jason Boyle, P.E.
State Dam Safety Engineer
Minnesota Department of Natural Resources

Robert H. Dalton
Vasconcelles Engineering Corporation

James Demby
Assessment and Planning Section, Risk Analysis Branch, Mitigation Division
Department of Homeland Security/Federal Emergency Management Agency

Patrick Diederich
Chief of Dam Safety
Nebraska Department of Natural Resources

Greg Hanson
Research Leader, Hydraulic Engineering Research Unit, Agricultural Research Service
U.S. Department of Agriculture

Lisa Krosley
Denver Federal Center, Bureau of Reclamation
U.S. Department of the Interior

Dan Mahoney, P.E.
Director, Division of Dam Safety and Inspections
Federal Energy Regulatory Commission

John Ritchey
Bureau of Dam Safety of Flood Control
New Jersey Department of Environmental Protection

Michael K. Sharp
Engineer Research and Development Center
U.S. Army Corps of Engineers

Hal Van Aller
Dam Safety Division
Maryland Department of the Environment

Eugene P. Zeizel
Assessment and Planning Section, Risk Analysis Branch, Mitigation Division
Department of Homeland Security/Federal Emergency Management Agency

Summary of Existing Guidelines for Hydrologic Safety of Dams

The authors extend their appreciation to the following agencies and individuals for graciously providing information and permission to use their materials in this publication:

Association of State Dam Safety Officials, Sarah McCubbin-Cain
Canadian Dam Association
Queensland Department of Environment and Resource Management
United States Society on Dams, Larry Stephens
United States Army Corps of Engineers
United States Bureau of Reclamation

The authors caution readers of this document that sound engineering judgment should always be applied when using technical references. This publication is intended solely for use by professional personnel who are competent to evaluate the significance and limitations of the information provided herein, and who will accept total responsibility for the application of this information. Anyone making use of this information assumes all liability from such use.

Suggestions for changes, corrections, or updates to this document should be directed to:

Paul G. Schweiger, P.E.
Assistant Manager, Dams and Hydraulics Section
Gannett Fleming, Inc.
207 Senate Avenue
Camp Hill, PA 17011-2316
Fax: 717-763-1140
pschweiger@gfnet.com

Please reference specific pages, paragraphs, or figures within the document, together with proposed new material in any convenient format. Sources of proposed new material should be completely cited. Submission of material signifies permission for use in future revised editions of this document, but credit for such new material will be given where appropriate.

Federal Emergency Management Agency

Table of Contents

Executive Summary ES-1
1. Introduction 1-1
   1.1. Authorization 1-1
   1.2. Purpose 1-1
   1.3. Scope of Work 1-2
2. United States Dam Inventory Data 2-1
   2.1. Background 2-1
   2.2. Summary of Significant Statistics for Dams in the United States 2-2
3. Evolution of Design Flood Selection for Spillways 3-1
   3.1. Background 3-1
   3.2. Pre-United States Dam Building 3-1
   3.3. The Early Period (Before ~1900) 3-1
   3.4. Period of Empiricism or the Regional Discharge Period (1900-1930) 3-2
   3.5. Period of Rationalization or Period of Statistical Frequency Analysis and Storm Transposition (1930-1950) 3-3
   3.6. The Probable Maximum Precipitation Period Using Prescriptive Standards (1950-~2000) 3-5
   3.7. Risk-Informed Decision Making Period (2000-Present) 3-8
4. Origins of Dam Safety Design Guidelines 4-1
   4.1. Overview 4-1
   4.2. General Standard of Practice Prior to 1950 4-1
   4.3. ASCE Task Force on Spillway Design Floods (1955) 4-1
   4.4. AWWA Spillway Design Practice – Manual M13 (1964) 4-2
   4.5. USCOLD Workgroup on Criteria and Practices Utilized in Determining the Required Capacity of Spillways (1970) 4-3
   4.6. National Dam Inspection Act, PL 92-367 and USACE Guidelines for Existing Dams (1972) 4-4
   4.7. ASCE Task Committee on the Reevaluation of the Adequacy of Spillways of Existing Dams (1973) 4-6
   4.8. FEMA ad hoc ICODS – Federal Guidelines for Dam Safety (1979, Reprinted 2004) 4-7
   4.9. National Research Council Committee on Safety Criteria for Dams, Safety of Dams – Flood and Earthquake Criteria (1985) 4-8
   4.10. FEMA (ICODS) – Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams (1986) 4-9
   4.11. ASCE Task Committee on Spillway Design Flood Selection (1988) 4-11

4.12. FEMA Federal Guidelines for Dam Safety – Selecting and Accommodating Inflow Design Floods for Dams (1998 – Reprinted 2004) 4-12
4.13. FEMA Federal Guidelines for Dam Safety – Hazard Potential Classification System for Dams (1998 – Reprinted 2004) 4-14
4.14. FEMA Model State Dam Safety Program (2007) 4-15
5. Relevant International Guidelines 5-1
5.1. Introduction to Summaries of International Guidelines 5-1
5.2. ANCOLD Guidelines On Selection of Acceptable Flood Capacity for Dams 5-1
5.3. Canadian Dam Association Guidelines (2007) 5-3
6. Prior State and Federal Surveys Related to Design Flood Selection 6-1
6.1. Background 6-1
6.2. USCOLD – 1970 6-1
6.3. National Research Council – 1985 6-1
6.4. Dubler Thesis, Colorado State University – 1995 6-4
6.5. Paxson and Harrison – 2003 6-4
6.6. ASDSO Surveys 6-5
7. 2011 Hydrologic Safety of Dams Survey and Database 7-1
7.1. Questionnaire Distribution and Database Compilation 7-1
7.2. Response 7-1
8. Summary of Current Federal Hydrologic Design Guidelines 8-1
8.1. Background 8-1
8.2. Overview of Dam Classification and Spillway Design Criteria 8-1
8.2.1. Definition of Regulatory Dam 8-1
8.2.2. Dam Classifications and Selection of the Spillway Design Flood 8-1
8.2.3. Design Criteria 8-2
8.3. Summary of Guidelines from Select Federal Agencies 8-3
8.3.1. U.S. Bureau of Reclamation 8-3
8.3.2. U.S. Army Corps of Engineers 8-6
8.3.3. Natural Resources Conservation Service 8-9
8.3.4. Federal Energy Regulatory Commission 8-10
8.3.5. Mine Safety and Health Administration 8-10
8.3.6. Tennessee Valley Authority 8-10
8.3.7. Bureau of Indian Affairs 8-11
8.3.8. U.S. Forest Service 8-11
8.3.9. U.S. Fish and Wildlife Service 8-11
9. Summary of Current State Hydrologic Design Guidelines 9-1
9.1. Introduction to State Guidelines 9-1

9.2. Origins and Status of State Guidelines 9-1
9.3. Dam Classification 9-2
9.3.1. Regulatory Dam 9-2
9.3.2. Size Classification 9-3
9.3.3. Hazard Classification 9-4
9.3.4. Additional Class Distinctions 9-5
9.4. Determining the Spillway Design Flood 9-6
9.5. Storm Duration and Distribution 9-14
9.6. Antecedent Moisture Conditions and Initial Reservoir Pool Levels 9-15
9.7. Freeboard Requirements 9-15
9.8. Applicable Methodologies and Software 9-16
9.9. Provisions for Future Development 9-16
9.10. Early Warning Systems 9-17
9.11. Incremental Damage Analysis 9-18
9.12. Provisions for Developing Site Specific PMP 9-20
9.13. Risk-based Criteria 9-21
9.13.1. Current Use of Risk-based Criteria by the States 9-21
9.13.2. California 9-22
9.13.3. Washington 9-23
9.13.4. Montana 9-26
9.13.5. Inconsistencies with Current Risk-Based Criteria 9-26
9.14. Agency Review 9-28
10. Receptiveness of States to Changing Guidelines 10-1
10.1. The Need for Uniformity 10-1
10.2. Awareness of Existing Federal Guidelines 10-2
10.3. Perception of PMP and PMF Criteria 10-2
10.4. Concerns Regarding Consistency of Hydrologic Analyses 10-4
10.5. Perception and Concerns Regarding Risk-Based Criteria 10-4
10.6. Technical Ability and Availability of Staff to Implement and Enforce Guidelines 10-6
10.7. Overall Receptiveness and Obstacles to Changing Existing Guidelines 10-6
11. The Current State of the Practice 11-1
11.1. Summary 11-1

Appendices

Appendix A – Glossary and Acronyms

A.1. Glossary

A.2. Acronyms

Appendix B – Bibliography

Appendix C – Hydrologic Safety of Dams Surveys

C.1. Survey Content

C.2. Completed Federal Surveys

C.3. Completed State Surveys

Appendix D – Federal Guidelines

D.1. Bureau of Indian Affairs

D.2. Federal Emergency Management Agency

D.3. Mine Safety and Health Administration

D.4. National Park Service

D.5. Natural Resources Conservation Service

D.6. Nuclear Regulatory Commission

D.7. Tennessee Valley Authority

D.8. U.S. Army Corps of Engineers

D.9. U.S. Bureau of Reclamation

D.10. U.S. Fish and Wildlife Service

D.11. U.S. Forest Service

Appendix E – State Guidelines

E.1. Alabama

E.2. Alaska

E.3. Arizona

E.4. Arkansas

E.5. California

E.6. Colorado

E.7. Connecticut

E.8. Delaware

E.9. Georgia

E.10. Hawaii

E.11. Idaho

E.12. Illinois

E.13. Indiana

E.14. Iowa

E.15. Kansas

E.16. Kentucky

E.17. Louisiana

E.18. Maine

E.19. Maryland

E.20. Massachusetts

E.21. Michigan

E.22. Minnesota

E.23. Mississippi

E.24. Missouri

E.25. Montana

E.26. Nebraska

E.27. Nevada

E.28. New Hampshire

E.29. New Jersey

E.30. New Mexico

E.31. New York

E.32. North Carolina

E.33. North Dakota

E.34. Ohio

E.35. Oklahoma

E.36. Oregon

E.37. Pennsylvania

E.38. Puerto Rico

E.39. Rhode Island

E.40. South Carolina

E.41. South Dakota

E.42. Tennessee

E.43. Texas

E.44. Utah

E.45. Vermont

E.46. Virginia

E.47. Washington

E.48. West Virginia

E.49. Wisconsin

E.50. Wyoming

Appendix F – Association of State Dam Safety Officials (ASDSO) Summaries

F.1. Size Classification Schemes

F.2. Hazard Classification Schemes

Executive Summary

Background

There is a need for updated guidelines for evaluating the hydrologic safety of dams, and in particular, for determining the appropriate Inflow Design Flood (IDF) and freeboard requirements. The existing hydrologic guidelines of some states and federal agencies were written in the late 1970s. Since that time, significant technological and analytical advances have been made along with better watershed and rainfall information that improve the analysis of extreme floods and quantification of incremental dam failure consequences. Many existing dams that were constructed before dam safety rules existed still do not meet regulatory guidelines for safely passing the IDF. Existing guidelines often do not treat new and existing dams the same in recognition of the fact that upgrading older dams to pass the IDF can be difficult and expensive.

There continues to be much debate with the current criteria, both within the engineering profession and among dam owners and others involved with dam safety. Several states and federal agencies have recently updated their dam regulations, including the sections relating to hydrologic safety; however, there appears to be considerable inconsistencies and non-uniformity in the dam classification systems and spillway capacity criteria being specified.

The overriding purpose of this report is to document the available data and to present the state of the practice for evaluating the hydrologic safety of dams, including inventorying current practices used by state and federal agencies. This work included a review of hydrologic guidelines currently used in each state and federal agency that regulates dams, and was guided by an independent steering committee and reviewed by the Research Work Group. A subsequent publication will include new federal guidelines for the evaluation of the hydrologic safety of dams that could be applied nationwide.

United States Dam Inventory

The current National Inventory of Dams, developed and maintained by the U.S. Army Corps of Engineers (USACE), contains data on nearly 84,000 dams within the United States. Approximately 11,000 of these dams are considered High Hazard, another 11,000 dams are considered Significant Hazard, and the remaining are considered Low Hazard. Most of the dams (over 65,000) are regulated by the states and owned by a variety of private or municipal entities. Federal agencies own or regulate approximately 6 percent of dams [FEMA, 2010].

Evolution of Design Flood Selection for Spillways

An understanding of the timeframe of the development of the methodologies for selecting the Spillway Design Flood (SDF) in the United States is helpful to understanding the history of dam safety guidelines since each type of design flood selection methodology must first be introduced and evaluated by the dam safety community before it becomes accepted and included in the

guidelines. While laws related to the performance of dams have existed since before 1700 BC, dam designs during the early period of dam building in the United States were based solely on the judgment of the engineer. By about 1900, however, the field of surface water measurement had advanced enough to support the development of empirical equations to transpose maximum regional discharges to the drainage area of interest in order to predict peak flood discharges.

Systematic nationwide collection of surface water data began in earnest by the U.S. Geologic Survey in 1934 when the New Deal Federal Public Works Administration obtained funds to perform detailed studies of floods, rainfall, and runoff. The 1930s and 1940s saw many significant advances in hydrology including the innovation of the unit hydrograph which made it possible to estimate flood flows from storm rainfall.

The years following 1950 saw the development of elegant theoretical and mathematical approaches to solve hydrologic problems. This along with the advancement of computers to perform computationally demanding analyses led to greater use of watershed modeling using unit hydrographs and precipitation. During this period, engineers turned to meteorologists to establish limiting rates of precipitation for design purposes. Between 1963 and 1984, a series of Hydrometeorological Reports were subsequently developed to establish Probable Maximum Precipitation (PMP) estimates for the majority of the country.

While deterministic approaches to the hydrologic design of dams have been overwhelmingly supported over the past few decades, there has also been an increased interest in the application of risk analysis. The U.S. Bureau of Reclamation (Reclamation) appears to be the first agency to seriously apply risk-based decision making to dam safety. Beginning around 1995, Reclamation adopted the use of risk analysis as the primary support to their dam safety decision-making. In 1997, the USACE replaced the Probable Maximum Flood standard with an incremental procedure to provide a framework for evaluating the benefits of mitigating hazards presented by hydrologic deficiencies in high hazard situations.

Today, many professionals consider risk assessment to be a useful way to ensure dam safety as it requires dam owners to investigate failure modes in detail and understand where the greatest risks lie. However, the main drawback of this approach is that it is technically challenging, time consuming, and difficult to administer, and so the traditional standards based approach is generally still adopted by the states.

Origins of Dam Safety Design Guidelines

Thus far, the methodology used to determine spillway adequacy has been described without regard for the actual regulatory framework. Prior to 1950, regulatory guidelines and design standards for the hydrologic safety of dams were based mainly on judgment and experience. As of 1964, a fourth of the states exercised no supervision over dams at all, and a third exercised no responsibility over operation and maintenance of a dam once it was constructed. This same year, Franklin F. Snyder,

Hydraulic Engineer with the Office of the Chief of Engineers, published a dam classification and spillway design flood matrix that considered dam height, storage, and damage potential.

In the early 1970s a series of dam safety incidents occurred resulting in significant loss of life including the failure of Buffalo Creek Dam (West Virginia) in February 1972 and Canyon Lake Dam (South Dakota) in June 1972. Following these events, the Congress enacted the National Dam Inspection Act (PL 92-367) which became law on August 8, 1972. The Mine Safety and Health Administration (MSHA) also gained regulatory jurisdiction of coal refuse impoundments at this time. In the early 1970s, many states did not have laws regarding dam safety and often did not require a review of the dam design prior to construction or require construction inspection or post-construction inspection. It was also found that dam safety in most states was inadequate with a wide variation of practices, regulations and capabilities of all agencies supervising dam safety. There was also little or no overall coordination of dam safety efforts.

Dams subject to PL 92-367 were those having a height 25 feet or greater, or a maximum impounding capacity greater than 50-acre-feet. Dams less than six feet high or storing less than 15 acre-feet were excluded. Congress charged the USACE with implementing the provisions of the Act. In addition to carrying out a national program of inspection of dams for the purpose of protecting human life and property, the act also required: (1) an inventory of all dams located in the United States; (2) a review of each inspection made; and (3) recommendations for a comprehensive national program for the inspection and regulation of dams, and the respective responsibilities which should be assumed by Federal, State, and local governments and by public and private interests.

Because of the scale of the program, the USACE developed a classification system to screen the adequacy of spillway capacity. The selected classification system was quite similar to that proposed by Snyder in 1964 and closely resembles the current classification criteria used by many states.

In 1979, the Federal Emergency Management Agency (FEMA) and the *ad hoc* Interagency Committee on Dam Safety issued "Federal Guidelines for Dam Safety." This document provided the first guidelines for federal agency dam owners and dam owners regulated by federal agencies. For flood selection design or evaluation, the federal guidelines supported the use of risk analysis. The guidelines were clear, however, that the spillway design standard to be adopted for dams where loss of life or major property damage could be significant was the Probable Maximum Flood (PMF).

In 1986, FEMA published "Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams" as a supplement to the "Federal Guidelines for Dam Safety." The primary purpose of the document was to provide general guidelines on procedures for selecting and accommodating inflow design floods for use by federal agencies in developing agency criteria and to ensure more nationwide uniformity in application.

Several other guidance documents relating to the hydrologic safety of dams were published in the decades that followed by agencies such as FEMA, the American Society of Civil Engineers (ASCE), and the National Research Council. These documents included numerous recommendations supporting both deterministic and risk-based approaches to spillway design. The guidance documents also identified several inconsistencies in the state-of-the-practice.

Pertinent International Guidelines

While the scope of this study specifically addresses guidelines for hydrologic safety of dams within the United States, there are several developments in the international arena that are particularly relevant to the study. Recently updated guidelines in Australia and Canada were reviewed and are summarized to provide a glimpse of how other countries' guidelines are changing. The Australian National Committee on Large Dams (ANCOLD) led the way internationally in the development of acceptable risk criteria in dam safety and published *Guidelines on Risk Assessment* in 1994. This was followed with *ANCOLD Guidelines on Selection of Acceptable Flood Capacity for Dams* which was published in 2000 to provide more appropriate and consistent guidance within a risk process for dam safety evaluation under floods. These guidelines provided a basis for integrating risk assessment into dam safety. Guidelines published by the Canadian Dam Association (CDA) in 2007 include a dam classification system based on failure consequences and discuss both the traditional standards-based approach and the risk-based approach to dam safety decision making. Selecting the IDF using quantitative risk analyses is not discussed in CDA's guidelines and appears to be discouraged because of the inability to accurately assign a probability to extreme floods.

2011 Hydrologic Safety of Dams Survey and Summary of State and Federal Guidelines

In order to document the present state of the practice for evaluating the hydrologic safety of dams and inventory current practices used by state and federal agencies within the United States, a detailed questionnaire was prepared and distributed to all state dam safety agencies as well as any federal agencies which own, regulate, or assist in the design of dams. The questionnaire addressed many important issues related to the hydrologic safety of dams including dam classification criteria, determination of the spillway design flood, allowable methodologies and software, consideration of future development, incremental damage assessment, use of early warning systems, current practices related to risk analysis, and agencies' ability and receptiveness to perform risk analysis.

Surveys were completed by the appropriate dam safety agency from all 50 states as well as Puerto Rico with exception of Alabama and Florida. Of the federal agencies, respondents included the Bureau of Indian Affairs, Federal Energy Regulatory Commission (FERC), Mine Safety and Health Administration, Natural Resources Conservation Service, Tennessee Valley Authority (TVA), U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, U.S. Forest Service, and the U.S. Fish and Wildlife Service. A comparison of survey results with past documented surveys allows the identification of trends and changes related to the hydrologic safety of dams over the past 40 years.

The Current State of the Practice

The existing hydrologic guidelines of many states and federal agencies were written in the 1970s or 1980s. Since that time, significant technological and analytical advances have been made along with better watershed and rainfall information that have improved the analysis of extreme floods and quantification of incremental dam failure consequences. Review of the published policy and guidelines for each state as well as the responses to the detailed survey completed as part of this study have revealed several important findings that can be used to define the current state of the practice regarding the hydrologic safety of dams.

In general, the guidelines for the hydrologic safety of dams are not consistent and vary widely from state-to-state and between federal agencies in many respects. Although some states and agencies have recently updated their guidelines, many states and agencies have not significantly changed their guidelines since their development. Some of those who have changed their guidelines have incorporated some form of risk-based analyses, but the requirements and methodology differ widely.

Some of the most notable inconsistencies in the existing guidelines relate to classification systems. From the most basic criteria for what defines a regulatory or a jurisdictional dam to whether the dam is classified by size, hazard, or not at all, there is no overwhelming majority of configuration for these classification systems. While size classification is used by many states and hazard classification is used by all states, the number of classifications and the distinctions between the classes vary. There is also no consensus on distinctions between new dams and existing dams.

In determining the magnitude of the SDF, most states follow a prescriptive approach in which the design flood is specified based upon the dam's classification (size, hazard, or both). Both probabilistic and deterministic (based on PMP or PMF estimates) criteria are used for the prescriptive approach by the states and agencies. Many of the criteria in prescriptive approaches are arbitrary with no apparent scientific rationale, and the prescribed SDFs for identical dams in different states have varying magnitudes.

Historically, a few important federal agencies have led the way in the development of dam safety regulations and design standards, and the trend among these agencies is toward incorporating a risk-based approach rather than the prescriptive approach. The USACE is currently partnering with Reclamation, FERC, and TVA to achieve a common risk management framework and guidelines. This trend toward risk-based design is also apparent in the international practice.

The transition to risk-based analyses in some states has also begun. The methodologies developed by California, Washington, and Montana reflect an initial movement to make site-specific, cost-effective, and risk-based designs. They also demonstrate how the complexities of risk analysis can be applied in a simplified, standard-based system. Comparison of these three recently developed, risk-based approaches indicates a lack of consistency regarding the criteria used among the systems, the weights assigned to the criteria, and the resultant risk tolerances.

Although the trend appears to be the incorporation of risk-based approaches into guidelines for the hydrologic safety of dams, there are many obstacles to widespread acceptance by state regulatory agencies. The budgets, staff availability, and technical ability of many dam safety state agencies are very limited. Many respondents indicated that they have concerns regarding risk-based analyses to determine spillway capacity requirements due to review requirements and the lack of widely acceptable and defensible guidelines.

It should also be noted that the federal agencies who have led the way in developing risk analysis procedures and tolerances are owners of a significant number of dams. These agencies have been able to utilize the prioritization and ranking aspects of risk analysis to manage their respective portfolios in addition to using quantitative risk analysis in design. The administrative processes and reviews of regulatory agencies, such as FERC, MSHA, and most of the states, differ significantly from that of dam owners like USACE and Reclamation. The application of quantitative risk analysis for dam design in regulatory agencies may be burdensome or even unnecessary. The state dam regulatory agencies of California, Washington and Montana have recently developed risk-based indices to determine acceptable flood capacity; however, none of the states use quantitative risk assessment.

There are many differing opinions regarding the need for uniformity of design criteria between states and federal agencies. It is generally recognized that the implementation of strictly uniform criteria is not a possibility. Instead, a flexible framework of criteria may be required to provide for the specific requirements, budget, and technical ability of each state. While leading federal agencies and a few states have recently transitioned from strictly prescriptive to risk-based criteria, it is evident that a large portion of the dam safety community has significant reservations concerning the validity and practicality of risk analysis. Having one set of federal dam safety standards for risk determination may help to promote the use of risk-based analysis by states and potentially encourage increased uniformity of state guidelines.

The survey responses also indicate that a significant portion of the dam safety community is unaware of current and even long-standing landmark publications regarding guidelines for the hydrologic safety of dams. A quarter of respondents were unaware of FEMA's 2004 federal guidelines for "Selecting and Accommodating Inflow Design Floods for Dams," and approximately half were not familiar with the most recently published USACE, Reclamation, and ASCE inflow design and dam safety guidelines. It is therefore apparent that any attempt to encourage the adoption of more uniform guidelines and consideration of adopting risk-based criteria will require a more effective outreach and educational effort.

Although the literature search identified several studies that provided information on state practices related to selecting inflow design floods for dams, none of the studies provided a comprehensive compilation of this data. In addition to providing background information for developing new federal guidelines for the hydrologic safety of dams, this report and the associated database provide a comprehensive compilation of current federal and state guidelines that can be used by individual

states to evaluate and compare their current guidelines with those of other agencies. As individual states revise their guidelines, this information will provide them with important information that will help them to make informed decisions that should result in more uniformity.

1. Introduction

1.1. Authorization

There is a need for updated guidelines for evaluating the hydrologic safety of dams, and in particular, for determining the appropriate Inflow Design Flood (also referred to as Spillway Design Flood) and freeboard requirements. The existing hydrologic guidelines of many states and federal agencies were written in the late 1970s. Since that time, significant technological and analytical advances have been made along with better watershed and rainfall information that improve the analysis of extreme floods and quantification of incremental dam failure consequences. Many existing dams that were constructed before dam safety rules existed still do not meet regulatory guidelines for safely passing the Inflow Design Flood (IDF). Existing guidelines often do not treat new dams and existing dams the same in recognition of the fact that upgrading older dams to pass the IDF can be difficult and expensive.

There continues to be much debate with the current criteria, both within the engineering profession and among dam owners and others involved with dam safety. Several states and federal agencies have recently updated their dam regulations, including the sections relating to hydrologic safety, however, there appears to be considerable inconsistencies and non-uniformity in the dam classification systems and spillway capacity criteria being specified.

In September 2010, the Federal Emergency Management Agency (FEMA) authorized a new study titled: "*Development of Guidelines for the Evaluation of Risk-Based Hydrologic Safety of Dams.*" The objective of this study is to develop and publish a guidance document for the evaluation of the hydrologic safety of dams, including guidelines for determining the IDF for new and existing dams that could be applied nationwide. This project is being completed under the direction of Dr. Art Miller with management and execution of the project by the BakerAECOM Risk MAP Professional Technical Services (PTS) Team comprised of Gannett Fleming, AECOM, Michael Baker, Jr., Inc., and Taylor Engineering. The project team includes an Independent Steering Committee comprised of Dan Mahoney (FERC), John Moyle (NJ), Brian Long (WV), Jim Gallagher (NH), and Lawrence Siroky (MT).

1.2. Purpose

Prior to developing the guidance document for the risk-based evaluation of the hydrologic safety of dams, the study team was tasked with reviewing and documenting the hydrologic guidelines currently used by each state and federal agency that regulates dams. Previous publications and technical papers that contain hydrologic safety guidelines for dams were reviewed. Organizations dealing with dam safety were contacted to determine what guidelines and support materials exist, including the Australian National Committee on Large Dams (ANCOLD), the American Society of Civil Engineers (ASCE), the Association of State Dam Safety Officials (ASDSO), the Canadian

Dam Association (CDA), FEMA, the Interagency Committee on Dam Safety (ICODS), the National Research Council (NRC), U.S. Society on Dams (USSD), and others. This initial task also included conducting a survey to gather information from every state dam safety program and federal agency that owns or regulates dams.

The overriding purpose of this report is to document the available data and to present the state of the practice for evaluating the hydrologic safety of dams, including inventorying current practices used by state and federal agencies.

1.3. Scope of Work

The scope of work for developing the guidelines for the hydrologic safety of dams was divided into five tasks. Tasks 1 and 2 relate to the current document which summarizes the existing guidelines while Tasks 3 and 4 relate to preparing the new guidance document. Task 5 relates to monthly reporting. The scope of work for the first two tasks, covering the primary purpose and scope of this reports' effort, is as follows:

> *"Task 1: Data Search – The contractor will review and gather the hydrologic guidelines currently used in each state and federal agency that regulate dams. The contractor shall also review the ASCE publication titled, 'Evaluation Procedures for Hydrologic Safety of Dams,' as well as identifying and reviewing other publications that may contain hydrologic safety guidelines. The contractor shall also contact organizations dealing with dam safety to determine what existing guidelines may exist, such as ICODS, ASDSO and its 'Model State Dam Safety Program,' and FEMA's 'Selecting and Accommodating Inflow Design Floods for Dams.'*
>
> *"Task 2: Compile Data – Within 6 months of contract start-up, the contractor will compile available data and present a draft report which incorporates findings from Task 1. The draft report should include a state of the practice of evaluating the hydrologic safety of dams. The draft report will be submitted to the Research Work Group and an independent steering committee recommended by the contractor and approved by the Research Work Group for review. The Research Work Group and steering committee will provide comments on the draft report within 30 days of submission. The contractor will submit a revised Report incorporating the comments within 30 days of receipt of comments."*

2. United States Dam Inventory Data

2.1. Background

The purpose of this section is to provide a summary of basic information related to the inventory of dams within the United States. This data is helpful for establishing new guidelines for the hydrologic safety of existing and new dams as it provides general information on the location, age, ownership, hazard classification and size of dams in the United States. This summary of dams is based on information cataloged and reported by the Association of State Dam Safety Officials (ASDSO), the US Army Corps of Engineers (USACE), the American Society of Civil Engineers (ASCE) and the Federal Emergency Management Agency (FEMA) as described in the following paragraphs. Data from each of these entities does vary; therefore, there are inconsistencies in the data presented from various sources in this chapter.

National Inventory of Dams

The National Inventory of Dams (NID) is a database of dams in the United States which was developed and is maintained by the USACE. Congress authorized the USACE to inventory dams as part of the 1972 National Dam Inspection Act. Several subsequent acts have authorized maintenance of the NID and provided funding. The USACE collaborates with FEMA and state regulatory offices to collect data on dams. The goal of the NID is to include all dams in the United States which meet at least one of the following criteria:

1. High hazard classification - loss of at least one human life is likely if the dam fails
2. Significant hazard classification - possible loss of human life and likely significant property or environmental destruction
3. Equal or exceed 25 feet in height and exceed 15 acre-feet in storage
4. Equal or exceed 50 acre-feet storage and exceed 6 feet in height

Low hazard dams which do not meet the criteria specified in number 3 or 4 are not included in the NID even if they are regulated according to state criteria. In some states, the number of these dams is several times the number of dams included in the NID.

Association of State Dam Safety Officials

In addition to using information collected as part of the NID, ASDSO annually collects additional information on dams in the United States by survey for their State Dam Safety Program Performance Information Report. ASDSO data focuses on dams within the jurisdiction of each state regardless of whether or not they are included in the NID.

American Society of Civil Engineers

Since 1998, ASCE has issued four reports titled “Report Card for America’s Infrastructure.” These reports depict the condition and performance of the nation’s infrastructure, including dams, and

were prepared by an advisory panel of the nation's leading civil engineers. This panel analyzed hundreds of reports and studies in the process of assigning grades as well as surveying thousands of engineers.

Federal Emergency Management Agency

As part of the U.S. Department of Homeland Security, FEMA also has an interest in dam safety in the United States. In their 2010 biennial report to Congress, "Dam Safety in the United States, A Progress Report on the National Dam Safety Program," FEMA describes the achievements of the states, the federal agencies, and their partners in Fiscal Year (FY) 2008 and FY 2009 in meeting the vision, mission, and objectives of the National Dam Safety Program. This document contains many interesting statistics and graphics that are useful in summarizing the dam inventory of the United States.

2.2. Summary of Significant Statistics for Dams in the United States

Dam construction in the United States began in earnest in the second half of the 19th century and peaked with the surge in the American economy and population following World War II. The current NID contains data on nearly 84,000 dams. The average age of these dams is over 50 years. Figure 2.1 shows the relative construction date of dams based on data in the NID.

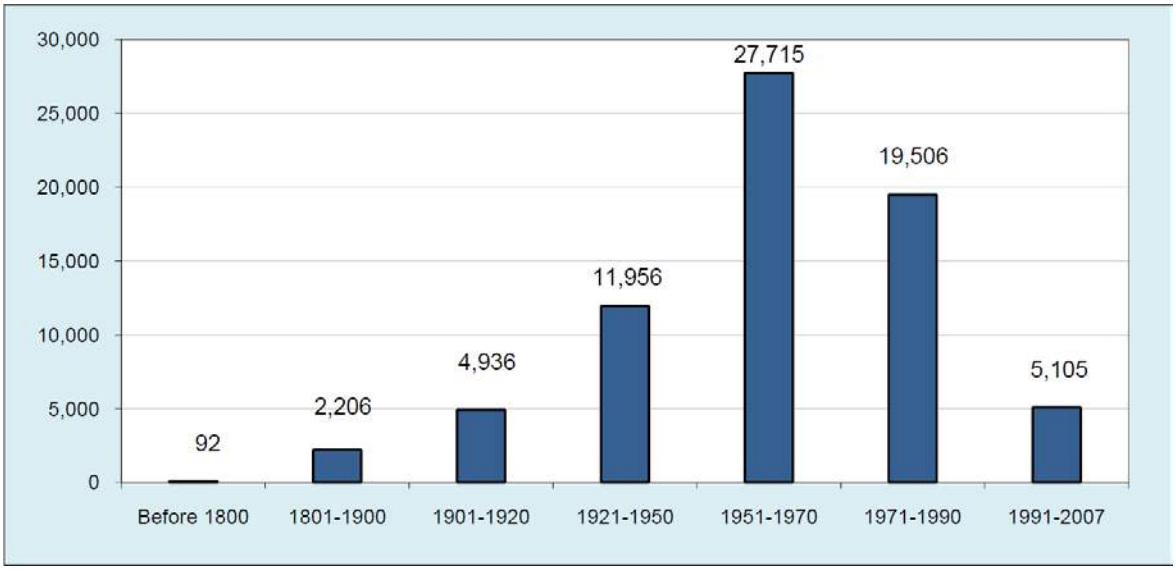


Figure 2.1 Year Dams Were Completed in the United States [USACE, 2009]

The 2009 Report Card for America's Infrastructure on Dams, prepared by ASCE, indicates that age has a two-fold effect on the determination of deficiency of a dam. First, the age of a dam contributes to deterioration. Second, design criteria and loadings which were considered

appropriate at the time of design, may now be considered insufficient, leading to dams being considered unsafe or deficient. The same publication reports that the number of dams determined to be unsafe or deficient is rising and now stands at more than 4,400 dams. ASCE's 2009 Report Card states, "Over the past six years, for every deficient, high hazard potential dam repaired, nearly two more were declared deficient."

Not only are dams in the United States aging and being declared deficient, but, at the same time, the number of high hazard potential dams is also increasing at a significant rate. According to statistics maintained by ASDSO, for the 10-year period from 2000 through 2009, the number of dams listed in the NID increased by about 9 percent. During this same period, the number of high-hazard, state-regulated dams increased by almost 14 percent. ASCE's 2009 Report Card on Dams states that the trend of increasing number of high hazard dams is a result of higher consequences of failure spurred by new downstream development. Development both upstream and downstream of dams is a widespread concern.

Within the United States, dams are owned and regulated by a variety of organizations. Most dams are privately or municipally-owned and are state-regulated. Figure 2.2 is a map of the United States showing the distribution of low, significant and high hazard potential dams. Figure 2.3 is a similar map showing only state-regulated high hazard potential dams.

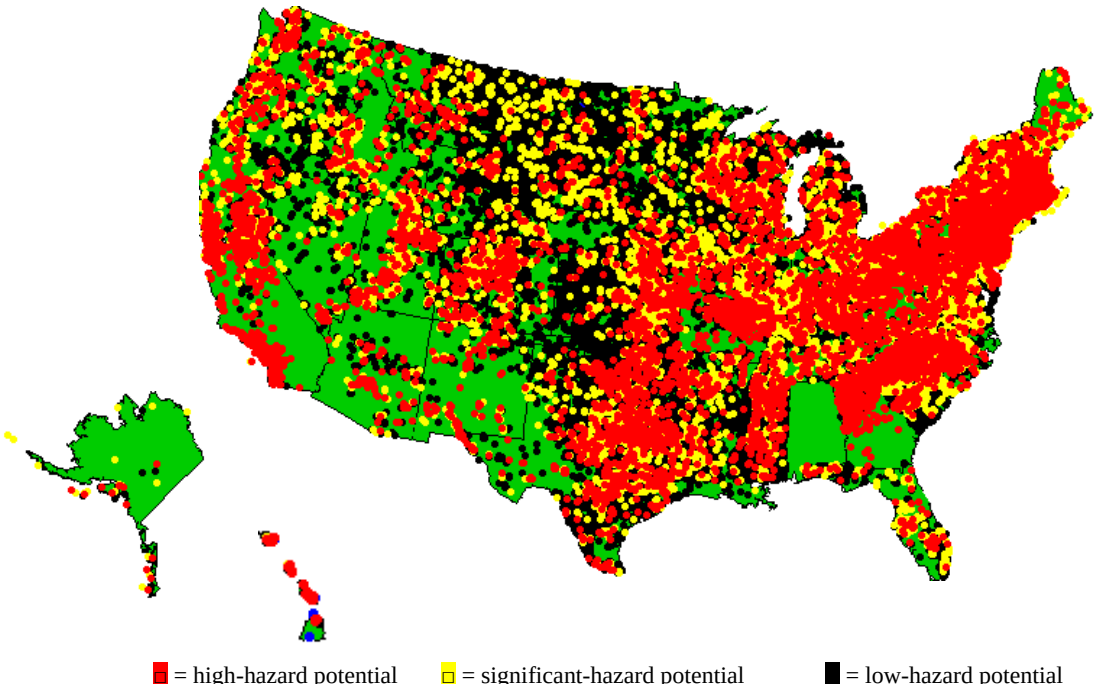


Figure 2.2 State-Regulated Dams in the United States According to Hazard Potential [FEMA, 2010]

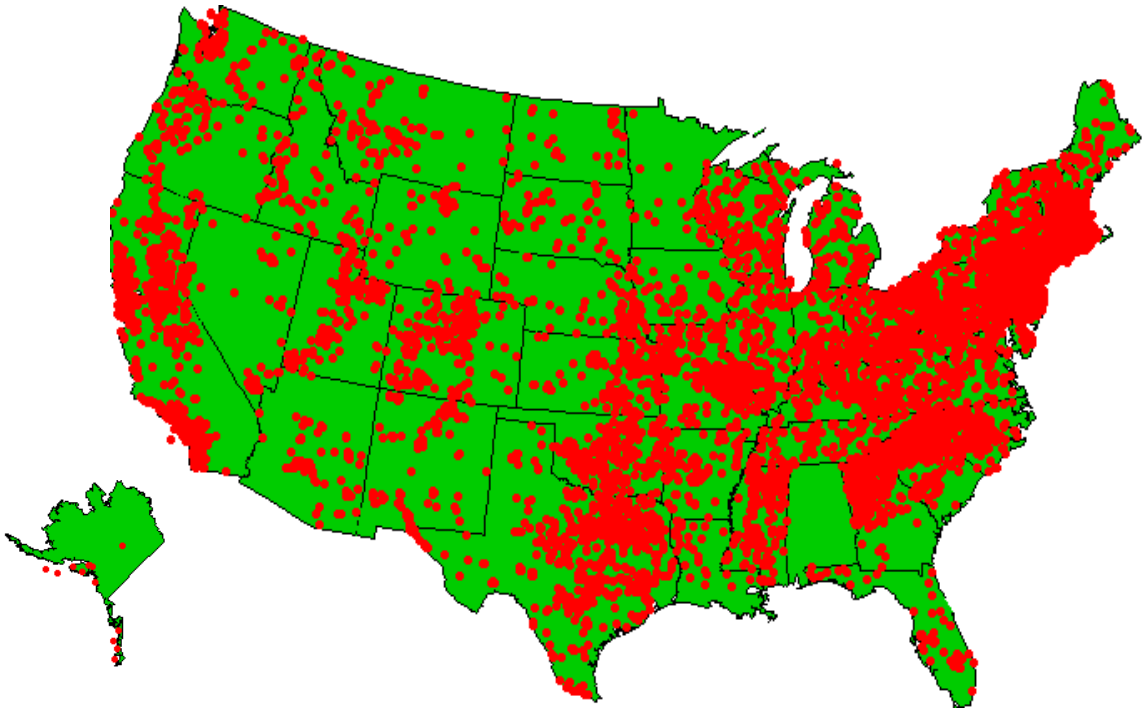


Figure 2.3 Map Showing Only State-Regulated High-Hazard Potential Dams [FEMA, 2010]

According to the FEMA biennial report to Congress, the federal government owns or regulates approximately 6 percent of the dams in the United States, and many of these dams are considerable in terms of size, function and hazard potential. The rest of the dams are within the jurisdiction of state dam safety programs. A summary of dams by state and hazard classification are summarized in Table 2-1 and Table 2-2. Figure 2.4 is a map showing the location of dams reported to the NID by the federal agencies. Table 2-3 is a summary of federal dam ownership by hazard classification.

Table 2-1 Dam Safety Statistics from the NID [USACE, 2009; ASDSO, 2008]

Hazard Potential	State Regulated Dams Listed in the NID	Total State Regulated Dams
High	10,856	10,993
Significant	11,163	10,931
Low	45,142	66,112
Total	67,161	88,036

Table 2-2 State Dam Safety Program Statistics [ASDSO, 2008]

State	State Regulated Dams				NID Dams			
	High Hazard	Significant Hazard	Low Hazard	Total	High Hazard	Significant Hazard	Low Hazard	Total
Alabama	0	0	0	0	0	0	0	0
Alaska	18	33	32	83	18	32	27	77
Arizona	100	36	116	252	93	39	120	252
Arkansas	103	95	208	406	102	92	209	403
California	688	274	285	1,247	334	708	211	1,253
Colorado	352	322	1,261	1,935	335	312	1,233	1,880
Connecticut	226	462	499	1,187	226	452	28	706
Delaware	58	5	0	63	9	27	1	37
Florida	72	330	472	874	72	321	412	805
Georgia	474	0	3,452	3,926	437	0	3,424	3,861
Hawaii	123	3	12	138	96	22	17	135
Idaho	107	149	313	569	94	129	140	363
Illinois	187	299	999	1,485	184	297	801	1,282
Indiana	240	249	599	1,088	241	250	500	991
Iowa	83	193	3,049	3,325	78	191	3,043	3,312
Kansas	202	238	5,618	6,058	183	247	5,474	5,904
Kentucky	178	217	671	1,066	161	193	600	954
Louisiana	31	69	443	543	28	65	440	533
Maine	28	67	573	668	25	80	545	650
Maryland	68	87	227	382	66	80	207	353
Massachusetts	308	746	536	1,590	324	741	554	1,619
Michigan	84	138	812	1,034	81	137	553	771
Minnesota	23	126	1,012	1,161	39	147	747	933
Mississippi	261	84	3,390	3,735	310	81	3,083	3,474
Missouri	469	137	68	674	455	132	66	653
Montana	105	152	2,636	2,893	102	131	2,377	2,610
Nebraska	124	212	1,972	2,308	129	212	1,886	2,227
Nevada	162	143	461	766	127	118	180	425
New Hampshire	122	174	2,779	3,075	89	193	344	626
New Jersey	215	338	1,168	1,721	202	366	226	794
New Mexico	181	88	129	398	170	92	96	358
New York	390	750	4,484	5,624	384	757	720	1,861
North Carolina	1,078	649	2,824	4,551	1,006	657	1,092	2,755
North Dakota	30	94	1,041	1,165	28	91	707	826
Ohio	375	543	679	1,597	411	559	558	1,528
Oklahoma	315	166	3,957	4,438	187	82	4,191	4,460
Oregon	126	197	995	1,318	122	181	530	833

Table 2-2 (continued) State Dam Safety Program Statistics [ASDSO, 2008]

State	State Regulated Dams				NID Dams			
	High Hazard	Significant Hazard	Low Hazard	Total	High Hazard	Significant Hazard	Low Hazard	Total
Pennsylvania	782	277	2,154	3,213	785	257	350	1,392
Puerto Rico	34	0	1	35	34	1	0	35
Rhode Island	97	83	470	650	17	41	136	194
South Carolina	153	481	1,683	2,317	153	481	1,683	2,317
South Dakota	47	144	2,158	2,349	47	144	2,158	2,349
Tennessee	150	210	302	662	266	330	465	1061
Texas	964	779	5,406	7,149	867	794	6,491	8,152
Utah	192	202	211	605	188	203	184	575
Vermont	57	136	379	572	57	133	161	351
Virginia	130	191	313	634	136	278	1,007	1,421
Washington	160	201	626	987	145	196	270	611
West Virginia	253	80	22	355	267	75	17	359
Wisconsin	189	170	3,294	3,653	196	138	604	938
Wyoming	79	112	1,321	1,512	79	116	1,153	1,348
Totals	**10,993**	**10,931**	**66,112**	**88,036**	**10,185**	**11,401**	**50,021**	**71,607**

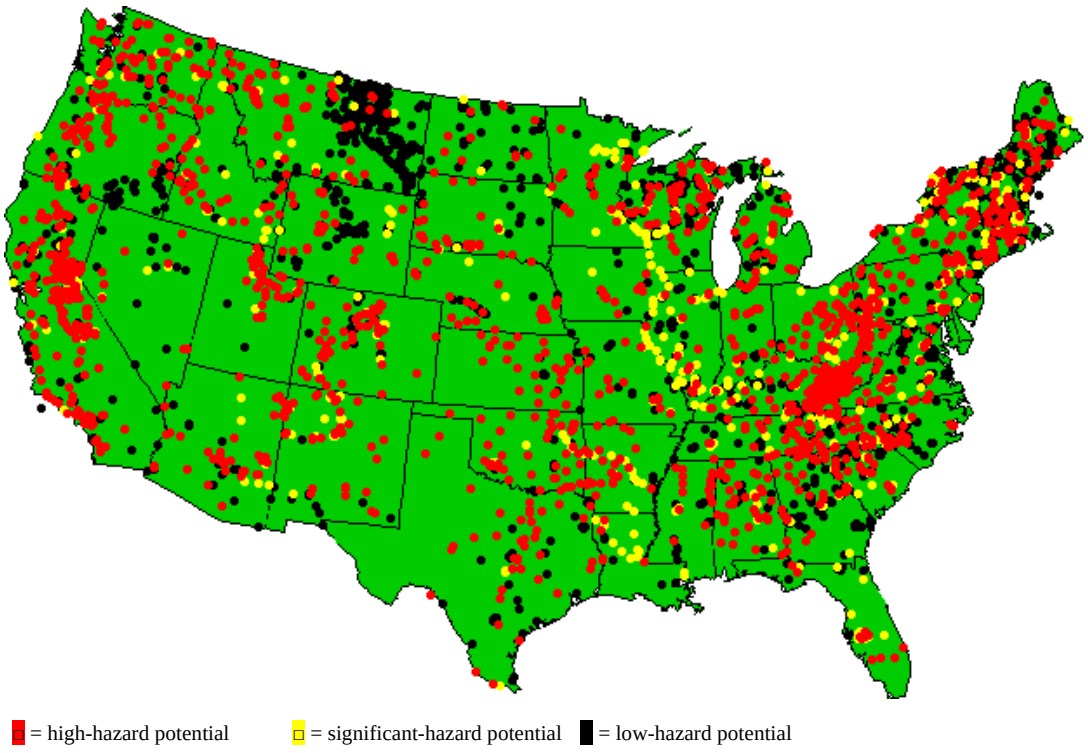


Figure 2.4 Dams Reported to the NID by the Federal Agencies [FEMA, 2010]

Table 2-3 Dams Owned and/or Regulated by Federal Agencies[1] [FEMA, 2010]

Agency	Total	High Hazard	Significant Hazard	Low Hazard
United States Department of Agriculture				
Agricultural Research Service	1	1		
USFS Owned	547	40	109	398
USFS Regulated	580	140	273	167
Natural Resources Conservation Service	27,254	2,233	2,299	22,722
Rural Housing Service[2]	25			
Rural Utilities Service[2]	25			
USDA Total:	**28,462**	**2,413**	**2,631**	**22,387**
Department of Defense				
United States Army Corps of Engineers	669[3]	500	133	31
Army	230	35	20	175
Navy	31[4]	5	3	20
Air Force	22	2	5	15
DOD Total:	**952**	**542**	**161**	**241**
Department of Education	**14**	**2**	**1**	**11**
Department of the Interior				
Bureau of Indian Affairs	895	102	29	764
Bureau of Land Management	609	8	1	600
Bureau of Reclamation	476	332	38	106
United States Fish and Wildlife Service	214	15	20	179
National Park Service	436	17	26	393
Office of Surface Mining	69	10	11	48
United States Geologic Survey	1	1		
DOI Total:	**2,700**	**485**	**125**	**2,090**
Federal Energy Regulatory Commission	**2,524**	**771**	**195**	**1,558**
International Boundary Water Commission	**7**	**3**	**1**	**3**
Mine Safety and Health Administration				
Coal	626	216	63	347
Metal and Nonmetal	1,903	144	175	1,584
MSHA Total:	**2,529**	**360**	**238**	**1,931**
Nuclear Regulatory Commission	**9**			**9**
Tennessee Valley Authority	**49[5]**	**36**	**10**	**3**

[1] Totals provided in Table 2-3 are reported exactly as listed in the source document.
[2] Breakdown of dams by hazard classification not available.
[3] Five USACE dams need to have a hazard classification determined.
[4] Three Navy dams need to have a hazard classification determined.
[5] Includes only main dam projects. Total, including associated saddle dams and dikes, is 84.

3. Evolution of Design Flood Selection for Spillways

3.1. Background

This Chapter focuses on the history and development of various methodologies for selecting the Spillway Design Flood (SDF) in the United States. The regulatory framework of dam safety guidelines and regulations is discussed in Chapter 4. An understanding of the timeframe of the development of the methodologies is helpful to understanding the history of dam safety guidelines since each type of design flood selection methodology must first be introduced and evaluated by the dam safety community before it becomes accepted and included in the guidelines.

3.2. Pre-United States Dam Building

Laws related to the performance of dams have existed since before 1700 BC. The Babylonian Code of Hammurabi is the earliest discovered example of a set of written laws, two of which (Law Nos. 53 and 54) specifically address the responsibility of dam owners to maintain their dams and provide restitution should their dam fail and flood downstream fields [King, 1910]. Engineers up until the 1800s appear to have had no known rationale for their spillway designs [Schnitter, 1994]. Many early Roman dams, mostly of modest height and of masonry with a stepped downstream face, appear to have been designed to be overtopped.

3.3. The Early Period (Before ~1900)

In the United States, few notable dams were constructed until the second half of the 19th century. In this early period, the design engineer had to rely on his own judgment as little or no streamflow or rainfall data were available. Usually the only available information was historical or anecdotal in terms of a past peak flood stage (high water mark) information. The corresponding flood discharge rates at a site were subsequently estimated from the high water mark or from past recorded flood levels transposed from adjacent streams. Early reports seem to provide a sense that the less cautious engineer had a confidence that the flood record was somewhat stable and that nature had shown what could be expected on a particular stream in terms of maximum flood potential in relatively few decades. Others believed the evaluation of major floods was impossible given the accepted techniques and resources available at that time [Myers, 1967].

During this early period, it should be recognized that the consequences of a dam failure were generally less severe than they are today. Early dams were typically constructed to limited heights. They were often constructed using rock-filled timber-cribs, stone masonry, or concrete and were resistant to erosion from overtopping. Many dams were constructed for the purpose of providing irrigation or power in remote areas where downstream development was insignificant. There may also have been an acceptance of the idea that some natural events are so extreme that man is not responsible for their consequences. The degree of conservatism of the design was generally

unknown. In 1889, 2,209 lives were lost when South Fork Dam, an earth embankment dam near Johnstown, Pennsylvania, overtopped and breached. The 72-foot-high structure was initially constructed between 1838 and 1853. This man-made catastrophe focused much needed attention on the importance of adequate spillway design capacity.

During the period between 1800 and 1900, several governmental agencies with an interest in hydrology were founded in the United States, including the Army Corps of Engineers (1802), the Fish and Wildlife Service (1871), the Geological Survey (1879), the Weather Bureau under the Department of Agriculture (1891), and the Mississippi River Commission (1893). These organizations helped to advance the field of surface water measurement and ushered in the beginning of stream gauging and precipitation gauging data collection [Chow, 1964]. Significant flow measurements were made in many rivers, and a comprehensive program to perform topographical and hydrographical surveys throughout the United States was initiated. The American Society of Civil Engineers and Architects (1852) was also founded during the Croton Aqueduct project for the City of New York, and soon emerged as a leading organization for organizing lectures and publishing technical papers on dam engineering.

3.4. Period of Empiricism or the Regional Discharge Period (1900-1930)

During the last part of the 19th century and the first 30 years of the 20th century, many formulas were developed to predict peak flood discharge based on the size and hydrologic characteristics of the drainage basin [Schnitter, 1994]. Ven Te Chow notes that although much work on the modernization of hydrology had been started, the development of quantitative hydrology was still immature. He refers to this period as the "Period of Empiricism." Hundreds of empirical formulas were proposed and the selection of their coefficients and parameters depended mainly on judgment and experience [Chow, 1964].

By analyzing the maximum discharges observed at hundreds of streams regionally rather than at a single stream, regional flood frequency formulas were developed. The concepts of *extrapolation*, *transposition* and *envelopment* were applied in the development of the formulas and recognized the random-chance nature of major storms occurring over a watershed. These concepts also recognized that hydrologic data observed at one location could serve as a basis for estimates at other locations. The most famous and widely used enveloping formula was the Myers' and Jarvis' ratings in which peak discharges are proportional to the square root of the drainage area and a coefficient that varies with region and geology. By transposing the largest observed values of peak discharge to drainage area within a particular geological and climatological area, it was assumed that these values approached the largest that could occur, or that they provided an adequate degree of safety [Myers, 1967].

One example of a dam designed during this period is the Gilboa Dam (Schoharie County, New York) which was designed and constructed during the period of 1917 to 1926 to impound a water

supply storage reservoir for New York City. With a height of 183.0 feet and a normal pool storage of approximately 60,000 acre-feet, the dam's construction was a noteworthy achievement in dam engineering during this period. For the hydrologic design of Gilboa Dam, regional floods were analyzed and the maximum event was transposed to the 314 square mile drainage area of the dam. This transposed flood event was then multiplied by a factor of three to provide a margin of safety per the engineer's judgment. The resulting flood flow of 168,000 cubic feet per second was referred to in 1917 design documents as the "probable maximum flood." This design flood compares favorably to current industry standards for calculating the probable maximum event [USACE, 1978].

Additional major governmental agencies were founded in the United States during this period that relied on hydrologic investigations to perform their functions including the Bureau of Reclamation (1902), the Forest Service (1906), the Miami Conservancy District (1914), and the U.S. Army Engineers Waterways Experiment Station (1928). The National Research Council of the National Academy of Sciences (1919), the Federal Power Commission (1920) the International Commission on Large Dams (1928), and USCOLD (1928), now the United States Society on Dams (2001), were also established during this period.

3.5. Period of Rationalization or Period of Statistical Frequency Analysis and Storm Transposition (1930-1950)

During this period, additional important government agencies were organized in the United States such as the Tennessee Valley Authority (1933), the Soil Conservation Service (1935), now known as the Natural Resources Conservation Service (1994), and the Weather Bureau (1940).

Systematic nationwide collection of surface water data began in earnest by the Geologic Survey in 1934 when the New Deal Federal Public Works Administration obtained funds to perform detailed studies of floods, rainfall, and runoff. The publication *Floods in the United States* provided information on floods, flood peaks, and river discharges for most of the major rivers in the country while the publication *Rainfall and Run-Off in the United States* provided minimum, maximum, and other precipitation statistics from precipitation stations throughout the country. Together, the two volumes covered the major areas of surface water hydrology as it was understood and significantly increased the data available to dam engineers [Reuss, 2002].

Several great hydrologists emerged during this period who used rational analysis instead of empiricism to solve hydrologic problems. In 1932, L. K. Sherman demonstrated the use of the unit hydrograph for translating rainfall excess into a runoff hydrograph. In 1933, R. E. Horton developed an approach to determine rainfall excess based on infiltration theory. In 1941, E. J. Gumbell proposed the use of the extreme-value distribution for frequency analysis of hydrologic data, and along with many others promoted the use of statistics in hydrology [Chow, 1964].

During a brief portion of this period, flood-frequency curves were extrapolated to estimate flood flows with return periods as large as 10,000 years. The flood selected for setting the spillway design capacity depended on the judgment of the engineer [ASCE, 1988]. Developing a SDF for a dam by straight frequency analysis of discharges from a long record initially showed great promise. After several major floods, however, the recorded peak discharges were found to exceed maximum recorded floods by several orders of magnitude and fall far outside of the defined flood frequency relationships. In 1942, the Boston Society of Civil Engineers examined the use of flood frequency relationships developed from flood records extending back 100 years, and concluded that it was difficult and uncertain to assign return periods to extreme observed floods. They also concluded that it would be even more difficult and uncertain to extrapolate to the long return period that would be required for a SDF [Myers, 1967].

Figure 3.1 provides an example of the difficulties in using statistics alone, and shows the maximum annual peak discharge for the Pecos River near Comstock, Texas for the 54-year period from 1900 to 1954. Based on the observed annual peak discharges at this gaging station no one could have predicted the observed peak discharge for the 1954 flood by extrapolating prior flood frequency data (statistics) alone.

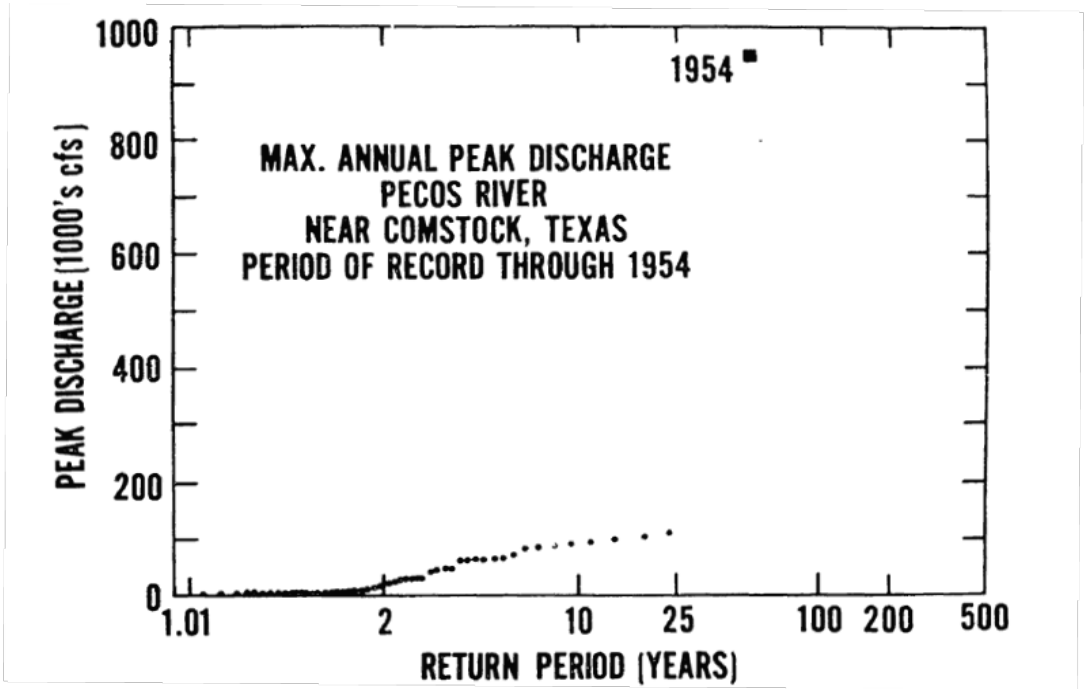


Figure 3.1 Maximum Annual Peak Discharge, Pecos River near Comstock [Myers, 1967]

With the innovation of the unit hydrograph, it became possible to estimate flood flows from storm rainfall. This led to storm transposition whereby precipitation recorded from major storms within a

region are transposed or centered over the basin under study. Runoff is then computed using unit hydrograph theory. This method was developed and advocated by members of the Corps of Engineers and Weather Bureau as a powerful tool for engineers in determining events which "could happen" over basins, but cautioned that this does not necessarily yield a "limiting storm." In the late 1930s, the Tennessee Valley Authority used the Myer's rating to establish the peak design discharge (plus generous freeboard) and storm transposition for flood volume [Myers, 1967].

3.6. The Probable Maximum Precipitation Period Using Prescriptive Standards (1950-~2000)

After 1950, the Agricultural Research Service (1953) was established, the Federal Power Commission was reorganized to form the Federal Energy Regulatory Commission (1978), and the federal government's disaster-recovery efforts were consolidated to form the Federal Emergency Management Agency (1979). Under FEMA's leadership, the Interagency Committee on Dam Safety (1980) was formed and the National Dam Safety Program was established (1980). In March 2003, FEMA joined 22 other federal agencies, programs, and offices in becoming the Department of Homeland Security (2003).

The Association of Dam Safety Officials (1983) was also formed during this period and initially had 34 member states. Today ASDSO is a leading non-profit organization with more than 3,000 members representing every state dam safety regulatory agency, federal and local governments, academia, dam owners, consultants, contractors, manufacturers and suppliers.

The development of elegant theoretical and mathematical approaches to solve hydrologic problems along with the advancement of computers to perform computationally demanding analyses led to greater use of watershed modeling using unit hydrographs and precipitation. This period also coincided with a rapid increase in population and the greatest period of dam building in the United States, where dam building passed from a project-by-project emphasis to a continuous program. During this period, engineers turned to meteorologists to establish limiting rates of precipitation for design purposes. By performing air mass analyses, limits on the amount of precipitation from a storm were estimated using humidity of the incoming air, wind velocity, and the percent of water vapor that could be precipitated. In 1959, the definition of the term Probable Maximum Precipitation appeared in the Glossary of Meteorology published by the American Meteorological Society as follows [Meyers, 1967]:

> *"The theoretical greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year"* [American Meteorological Society, 1959].

The resulting Probable Maximum Flood was defined as:

> *"The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the drainage basin under study"* [FEMA, 2004].

In the early years the terms “maximum possible precipitation (MPP)” and “maximum possible flood (MPF)” were sometimes used. In 1956 this terminology was changed to probable maximum precipitation (PMP) and probable maximum flood (PMF) to recognize the uncertainties in the precipitation and runoff estimates, and that the worst combination of events was not assumed when translating rainfall into runoff [ASCE, 1988; Tomlinson & Kappel, 2009]. PMP was viewed as an estimate as there remain unknowns and unmeasured atmospheric parameters that are important to extreme rain storms [NRC, 1985]. Similarly, the PMF is less than the maximum possible flood to the extent that the combinations of natural factors assumed in the determination are less than a theoretical maximum, and the reduction tends to vary depending on the person performing the analysis and/or agency or company policy [ASCE, 1988].

Between 1963 and 1984, a series of Hydrometeorological Reports (HMR) were subsequently developed for the Continental United States by the U.S. Weather Bureau, now the National Weather Service (NWS). The oldest of these reports is HMR 39 prepared for Hawaii in 1963. The most recent is HMR 59 for California which was updated in 1999. Figure 3.2 illustrates the coverage of the HMR studies.

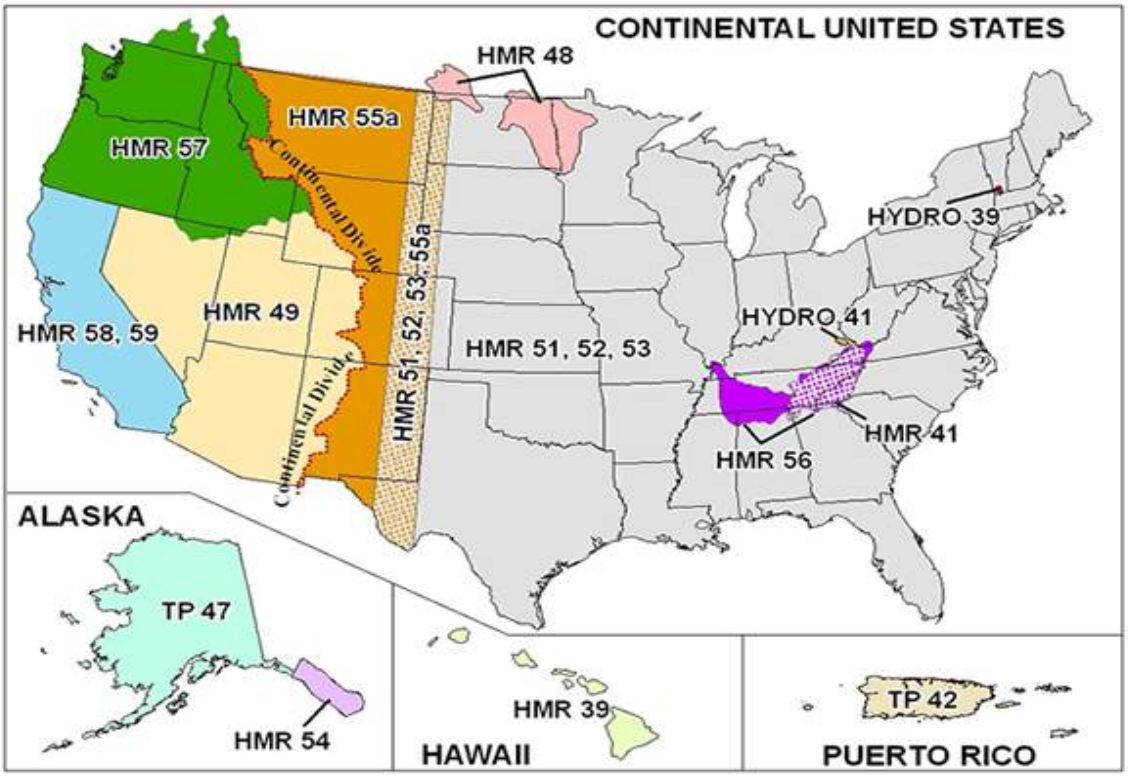


Figure 3.2 Hydrometeorological Reports prepared by the NWS for the Continental United States [NOAA, 2011]

Most of the HMRs use analyses of individual storm depth-area-duration rainfall patterns to evaluate spatial and temporal rainfall distributions and include a multiplication factor to address orographic effects. HMR 51, which covers the eastern two-thirds of the U.S., does not include any orographic adjustments but identifies two "stippled regions" in which the authors of the HMRs acknowledged that terrain effects were not evaluated and suggest that future NWS studies examine these regions more closely.

PMP estimates developed using HMRs and site specific studies in conjunction with watershed models to compute flood runoff, have been widely accepted as the basis for design of spillways for dams where failure of the structure by overtopping cannot be tolerated, and has resulted in progressively more conservative design requirements for spillways. The adoption of this standard has raised difficult questions as to what should be done with existing dams constructed before this standard where the spillways do not satisfy this criterion.

Site specific PMP studies have also been performed by private contractors recognizing the fact that the published HMRs provide generalized rainfall values that are not basin-specific and tend to represent the largest PMP values across broad regions. Many recent site-specific studies have produced PMP values significantly different from the HMR values. Reasons for the differences (mostly reductions) are attributed to using basin characteristics that are specific to the topography and local climate of the watershed being studied, new storm data like NWS NEXRAD, improved analysis procedures, and technology advances such as new computer models, weather radar, and geographic information system (GIS) software to analyze depth-area-duration tables. Site specific PMP study values are generally 5 to 15 percent lower than values from the published HMRs, although some studies have shown minimal reductions. The largest PMP reductions from site specific studies have been for long duration storms for large drainage areas, and have been greater than 50 percent lower [Tomlinson & Kappel, 2009; Applied Weather Associates, 2008].

Statewide studies of extreme storm events have also been performed in an effort to support risk-based design criteria for spillways. The states of Washington, Montana, California and Wisconsin have authorized statewide studies. For example, beginning in 1981, the state of Washington began collecting and analyzing data to define the characteristics of extreme storms for use in developing risk-based criteria for spillway design. This work was led by Dr. Mel Shaefer and resulted in the publication of "*Technical Note 3*" in 1993 which provided engineering guidance for developing design storms for use in computing IDFs using rainfall-runoff computer models. This document was updated in 2009 using more than 700 precipitation gages and high resolution mapping techniques within a GIS framework, and includes probabilistic based procedures for generating precipitation magnitude-frequency relationships for any location within the state [MGS Engineering Consultants, 2009].

In a letter dated June 1, 1984 to the NRC Committee on Safety Criteria for Dams, the NWS provided some additional information regarding the extensive material on PMP estimates and

techniques that they developed to provide the basis for the most conservative criteria for spillway design. The following is extracted from their letter to the NRC Committee:

> *"Theoretically the PMP has zero probability of actual occurrence. A report (Riedel, J. T., and Shreiner, L. C. 1980) compares the greatest known storm rainfall depths with generalized PMP estimates for the United States east of the 105th meridian and west of the Continental Divide. This was done for rainfall depths averaged over six area sizes (10, 200, 1,000, 5,000, 10,000, and 20,000 mi^2) each for durations (6, 12, 24, 48 and 72 hours) covering the eastern United States. A similar comparison was made for the western United States, but with fewer combinations. A summary of the results is presented in [Table 3-1]."*

Another comparison shows that for the eastern and western United States there were 170 and 66 separate storms that occurred from 1819 to 1979 which had depths exceeding 50% of PMP for at least one area size and duration, respectively. Riedel and Schreiner also pointed out that the greatest rainfall amount in a storm may not have been observed and documented, especially in the west. In a few recorded storms, total rainfall amounts have exceeded 100% of the PMP. These include the Smethport, PA storm of July 17-18, 1942 in which 30.8 inches of rain fell in 4.5 hours, and the Cherry Creek, CO storm of May 30-31, 1935 where 24 inches of rain was observed in a period of less than 6 hours [Huffman, 1999].

Table 3-1 Comparison of Greatest Known Storm Rainfall Depths with Generalized PMP Estimates within the United States [Riedel & Shreiner, 1980]

Location	Number of Storms Exceeding Various Percentages of PMP		
	70%	80%	90%
East of the 105th Meridian	160	49	4
West of the Continental Divide	16	5	0

3.7. Risk-Informed Decision Making Period (2000-Present)

Although the period of time beginning in 2000 can be considered the period of risk-informed decision making, several advances and publications prior to 2000 paved the way for the introduction of risk into SDF selection. The earliest reference to using risk-based analyses to determine the SDF appears to be in a 1964 manual prepared by the American Water Works Association (AWWA) titled: *Manual M13 – Spillway Design Practice*. The AWWA guidelines presented in this manual stress that for water supply dams, "the selection of a spillway capacity less than the maximum probable flood is a very serious decision for the designer and for management," and recommends the use of a "thorough cost study to evaluate the variable costs of (1) repairs to the dam and spillway, (2) lost water during periods of repairs, (3) damages caused by insufficient

spillway, and (4) construction of spillways of specific capacity" [AWWA, 1964]. Although the concepts of risk, flood probability, and consequences are discussed in the manual, procedures for performing a formal risk analysis and establishing decision criteria are not addressed in Manual M13. The AWWA guidelines indicate that this type of cost analysis is largely subjective and almost entirely a matter of judgment.

In 1973, an ASCE Task Committee on the Reevaluation of the Adequacy of Spillways of Existing Dams published a report in the Journal of the Hydraulics Division [ASCE, 1973]. In the report, the Task Committee advocated "risk taking" in spillway capacity design and recommended that spillway capacities for new and existing dams of all sizes be based on a thorough economic analysis of the "social cost of risks and the cost of modification" computed on an average annual basis. An evaluated level of risk at which the total of all social costs will be at a minimum was proposed. The Task Committee recommended use of a monetary value for human life and injury in the analysis based on practices of courts in awarding damages in cases involving accidental deaths and injury. The ASCE Task Committee's report generated much controversy and their recommended approach was viewed as a "radical departure" from accepted standards [Williams, 1973]. The recommendation to place a monetary value on human life and suffering in the economic analysis was ultimately not accepted by the engineering profession or by regulatory agencies. Other factors contributing to the lack of interest for the recommended approach included the need to select an interest rate for the analysis of equivalent present-day costs, and the problem of assigning probabilities for extreme flood events.

From the time the ASCE Task Committee on the Reevaluation of the Adequacy of Spillways of Existing Dams published their report in 1973 through the present, there has been much discussion, debate and controversy on the use of risk-based analyses for dams. Between 1979 and 2000, several studies and guidelines on selecting acceptable flood capacity for dams were published by various individuals and agencies including the following:

1979 – *Federal Guidelines for Dam Safety*, FEMA ad hoc ICODS (Reprinted 2004)
1985 – *Flood and Earthquake Criteria,* NRC Committee on Safety Criteria for Dams
1986 – *Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams,* FEMA (ICODS)
1988 – *Evaluation Procedures for Hydrologic Safety of Dams,* ASCE Task Committee on Spillway Design Flood Selection
1996 – *Dam Safety Policy for Spillway Design Floods,* Dubler, James & Neil S. Grigg
1998 – *Selecting and Accommodating Inflow Design Floods for Dams,* FEMA Federal Guidelines for Dam Safety (Reprinted 2004)

Summaries of each of these documents as well as the aforementioned AWWA manual and the ASCE Task Committee report as they relate to spillway flood design criteria are presented in Chapter 4. Each of the documents listed above make reference to the use of risk-based analyses for selection of SDFs for dams. Most of these documents provide general guidelines and discussions

on the issues involved in the decision analysis procedures. None of the documents provide risk tolerance criteria for making a final safety design decision.

The U.S. Bureau of Reclamation (Reclamation) appears to be the first agency to seriously apply risk-based decision making to dam safety and have emerged as world leaders in this approach. Beginning around 1995, Reclamation adopted the use of risk analysis as the primary support for their dam safety decision-making and have developed several important publications related to risk analysis including the following:

1998 – *Implementation of Risk Analysis Principles into the Bureau of Reclamation's Dam Safety Program Actions*
1999 – *A Framework for Characterizing Extreme Floods for Dam Safety Risk Assessment*
2000 – *Risk Based Profiling System*
2003 – *Guidelines for Achieving Public Protection in Dam Safety Decision-making*
2006 – *Guidelines for Evaluating Hydrologic Hazards*
2010 – *Dam Safety Risk Analysis Best Practices Training Manual*

Reclamation has devoted significant resources to the development of risk-based hydrologic hazard methods and guidelines related to extreme rainfall probabilities. A framework for the characterization of extreme flood events has also been developed which considers various types of flood estimation procedures ranging from paleoflood hydrology to regional precipitation frequency with L-Moments. The resultant reports and guidelines created by Reclamation facilitate the incorporation of hydrologic data in risk analysis.

In 2003, because of the growing interest in the use of risk assessment methods for dam safety, the USSD published a white paper titled *"Dam Safety Risk Assessment: What Is It?, Who Is Using It and Why?, Where Should We Be Going With It?"* [USSD, 2003]. The paper represented a consensus position of a diverse group of USSD members and other dam safety professionals at that time. The overall purpose of the paper was to assess the state-of-the-practice in dam safety risk assessment, and to provide commentary on appropriate types of applications and ways to facilitate and strengthen its use [USSD, 2003].

The USSD paper identified and described four risk assessment application categories: (1) Failure Modes Identification; (2) Index Prioritization; (3) Portfolio Risk Assessment; and (4) Quantitative Risk Assessment. Of the four risk assessment application categories, only the Quantitative Risk Assessment approach has been used as an analytical method to help select acceptable spillway design capacity for dams. The other three methods have been used primarily as a means of identifying dam deficiencies and prioritizing their repair or resolution. The USSD white paper emphasizes that limitations must be fully considered and that risk assessment approaches should be used only as a supplement and not as a replacement for the traditional approach. The USSD white paper concluded that this "risk-enhanced" approach provides a way for the benefits of improved

understanding and management of dam safety risks to be realized, while maintaining a reference to established practice [Bowles et al, 2003].

Another leader in the forefront of risk-based methods is the U.S. Army Corps of Engineers (USACE). In the 1990s, USACE held workshops and invested research to evaluate risk analysis frameworks and began publishing regulations and documents supporting the use of risk analysis including the following:

1996 – *Risk Analysis for Dam Safety Evaluation: Hydrologic Risk*
1996 – *Risk-Based Analysis for Flood Damage Reduction Studies, EM 1110-2-1619*
1997 – *Dam Safety Assurance Program, Regulation No. 1110-2-1155*
2001 – *Hydrologic Research Needs for Dam Safety*
2003 – *Application of Paleohydrology to Corps Flood Frequency Analysis*
2007 – *Updated Principles for Risk Analysis*
2007 – *Draft Inflow Hydrographs Toolbox*
2007 – *Interim Risk Reduction Measures for Dam Safety*
2009 – *Interim Tolerable Risk Guidelines for US Army Corps of Engineers Dams*
2010 – *Safety of Dams – Policy and Procedures, ER 1110-2-1156 (DRAFT)*

In 1997, USACE replaced the PMF standard with an incremental procedure to provide a framework for evaluating the benefits of mitigating hazards presented by hydrologic deficiencies in high hazard situations, as described in their *Dam Safety Assurance Program, Regulation No. 1110-2-1155* [USACE, 1997]. The PMF standard was replaced because it did not provide analysis of the benefits versus costs of design as compared to a lesser flood and recognition of the fact that the PMF design does not result in zero risk [Eiker et al, 1998]. The new USACE policy was a compromise between the desire to provide a risk-based analysis of the benefits gained from mitigating the hazard and the traditional approach of requiring a design that is capable of safely passing the PMF.

The incremental procedure required by the 1997 USACE policy included two phases. Phase I was used to determine the Base Safety Conditions (BSC) as follows:

> *"…. A comparative hazard analysis in which the threshold flood (TF) and the BSC are established. The TF is the flood that fully utilizes the existing dam, i.e., the flood that just exceeds the design maximum water surface elevation at the dam (top of dam minus freeboard). The BSC is determined by comparing the loss of life for various floods, expressed as percentages of the PMF, with and without dam failure. PMF is determined in accordance with standard Hydrometeorological procedures. The flood, expressed as a percentage of PMF for which loss of life is not different for with and without dam failure conditions, is the BSC, but should never be more than 100% of the PMF"* [USACE, 1997].

Phase II was the risk-cost analysis required if modifications for a flood greater than the BSC were recommended. An important aspect of the new USACE policy was the focus on loss of life as the

criteria for determining the BSC in the incremental analysis. Economic damage was not considered.

Although the USACE's incremental analysis represented a significant advance in developing an IDF for dam design, it was recognized by the USACE that it did not provide a means for comparing the benefits and costs to mitigate spillway capacity deficiencies within their portfolio of dams. Given the limitations on annual funding available for mitigating dam deficiencies, the USACE subsequently adopted the use of Risk Assessment to provide decision variables that relate the hazard and remediate measures for a particular dam deficiency to other dams. This approach was pursued as it allowed decision makers to develop a ranking system for prioritizing the implementation of the remediation measures. The remediation of the hazard would then depend on the ranking and funding available for implementing the remediation measure [Eiker et al, 1998].

The USACE later began working closely with Reclamation, the Federal Energy Regulatory Commission (FERC), and the Tennessee Valley Authority (TVA) to develop a common dam safety risk management framework and policies for its portfolio of dams that includes tolerable risk guidelines. In 2010, the USACE published a draft form of *ER 1110-2-1156; Safety of Dams – Policy and Procedures.* This document prescribes the guiding principles, policy, organization, responsibilities, and procedures for implementation of risk-informed dam safety program activities and a dam safety portfolio risk management process within the USACE and represents a significant paradigm shift. As explained in the *Guidelines on Risk Assessment* prepared by the Australian National Committee on Large Dams (ANCOLD) in 2003,

> "*The USACE is moving from a solely standards-based approach for its dam safety program to a dam safety portfolio risk management approach. The standards-based or essential guidelines approach is included in the risk-informed approach to the dam safety program and dam safety program decisions will now be risk-informed. One of the bases for a risk-informed decision, and prioritization of the work, is a consideration of the achievement of tolerable risk guidelines following implementation of risk reduction measures. In addition, it should be recognized that other non-quantitative factors will influence practical decision making for the dam safety program.*
>
> *"There was previously a view in some quarters that risk assessment was a means to justify less costly safety upgrades of dams than those required by the traditional approach. It is now recognized that such a view seriously misunderstands the true aim of risk assessment, which is more informed decision-making than would be possible from reliance on the traditional approach alone. It may be that the additional understanding that comes from the risk assessment process, will reveal that a less costly solution to a dam safety problem could be justified, though a decision that way should be made with great care and having regard to all of the community risk and business risk considerations. But it could as easily be the case that risk assessment shows that a more stringent safety level, and thus a more costly solution, ought to be implemented."*

The USACE's tolerable risk guidelines are based on an adaptation of the 2003 Reclamation guidelines, the risk evaluation guidelines published by the Australian National Committee on Large Dams [ANCOLD, 2003], and adaptations of the ANCOLD guidance implemented by the New South Wales Government Dam Safety Committee (NSW DSC) Risk Management Policy Framework for Dam Safety [NSW DSC, 2006]. According to the Tolerable Risk Guidelines, a dam is considered to be "Adequately Safe" (DSAC Class V) when residual risk is considered tolerable and meets all essential USACE guidelines with no dam safety issues. A summary of these guidelines is included in Chapter 8.

For determining the probability associated with the PMF and lesser events, the current interim USACE procedure is to perform statistical smoothing as described in EM 1110-2-1415 Hydrologic Frequency Analysis and the Draft Inflow Hydrographs Toolbox [USACE, 2007]. The PMF is assigned a probability of 1 in 10,000 (0.0001) per year.

Today, many professionals consider risk assessment to be a useful way to provide dam safety as it requires dam owners to investigate failure modes in detail and understand where the greatest risks lie. However, the main drawback of this approach is that it is technically challenging, time-consuming, and difficult to administer. Because of this, the traditional standards based approach is generally still adopted by the states. Note that the federal agencies who have led the way in developing risk analysis procedures and tolerances are owners of a significant number of dams. The administrative processes and reviews of regulatory agencies, such as FERC and most of the states, differ significant from that of dam owners like USACE and Reclamation. The application of quantitative risk analysis for dam design by regulatory agencies may be burdensome or even unnecessary. The state dam regulatory agencies of California, Washington and Montana have recently developed risk-based indices to determine acceptable flood capacity; however, none of the states use quantitative risk assessment.

4. Origins of Dam Safety Design Guidelines

4.1. Overview

Chapter 3 presented a history of SDF selection for dams in the United States without regard for the actual regulatory framework. That chapter described the state of the practice as far as methodology used to evaluate SDFs. Chapter 4 focuses on the application of the methodology in formal guidelines within the United States.

4.2. General Standard of Practice Prior to 1950

Prior to approximately 1950, hydrologic design standards for dams were based mainly on judgment and experience. In general, the probable maximum flood, as best determined at that time, was generally accepted as the standard for dams where the consequences of failure required the greatest conservatism. Pennsylvania enacted the first known dam safety legislation in the United States in 1913, and California's Division of Safety of Dams was created in 1929. Both states were prompted to action by catastrophic dam failures that occurred in their respective states. A U.S. Committee on Large Dams (USCOLD) survey on practices and regulations within the United States found that as of 1964, a fourth of the states exercised no supervision over dams at all, and a third exercised no responsibility over operation and maintenance of a dam once it was constructed. USCOLD then organized a committee to draft a model law to be considered by states for enactment. In 1968, the committee completed a proposed law that was modeled after the 1929 California law [Golze, 1973].

4.3. ASCE Task Force on Spillway Design Floods (1955)

The first organized effort to document SDF policy and criteria in the United States appears to have occurred in June 1955 when the first ASCE Task Force on Spillway Design Floods was organized. This committee attempted to formulate a questionnaire for submission to government agencies, utilities, private engineering firms, and technical groups with an interest in dam design in order to review and summarize existing spillway design policy and criteria. The task force was unsuccessful in developing a questionnaire and collecting the data; however, they developed the following three classifications of spillway requirements for dams [ASCE, 1988]:

Class 1: Dams where failure cannot be tolerated
Class 2: Dams where failure would result in serious economic loss
Class 3: Dams where structural failure would result in minor damage

The task force's final report was presented in four papers in a symposium on the Hydrology of Spillway Design on May 16, 1962 as part of the first ASCE Water Resources Engineering Conference. The papers were published in the Journal of the Hydraulics Division in May 1964 and summarized the existing practice for designing new dams. With respect to Class 1 dams, Mr. Franklin Snyder, a member of the task force, made the following statement:

> *"For large major structures that would be subject to possible failure if the selected capacity were exceeded, there would be few instances, if any, where anything less than the provision for the probable maximum flood can be justified"* [Snyder, 1964].

Snyder also published a dam classification and suggested the matrix as presented in Table 4-1 be used to select the minimum SDF. It is interesting to note that Snyder's suggested classification matrix closely resembles the current classification criteria used by many states (See Chapter 9).

Table 4-1 Snyder's Classification of Dams [Snyder, 1964]

Failure Category	Danger Potential		Damage Potential		SDF
	Storage (Acre-Feet)	Height (Feet)	Loss of Life	Damage	
Minor	<1,000	<50	None	Cost of Dam	50-100 Year
Intermediate	1,000 – 50,000	40 to 100	Possible/small	Within Capacity of Owner	SPF(1)
Intolerable	>50,000	>60	Considerable	Excessive	PMF

(1) The SPF is the Standard Project Flood which is the most severe storm "reasonably characteristic" of the region.

4.4. AWWA Spillway Design Practice – Manual M13 (1964)

In 1964, the AWWA published *Manual M13 – Spillway Design Practice*. The manual was intended to be a general reference for engineers in the water utility practice, and provides procedures for selecting SDFs for dams constructed on drainage areas less than 1,000 square miles. The guidelines stress that for water supply dams, "the selection of a spillway capacity less than the maximum probable flood is a very serious decision for the designer and for management" and recommends the use of a "thorough cost study to evaluate the variable costs of (1) repairs to the dam and spillway, (2) lost water during periods of repairs, (3) damages caused by insufficient spillway, and (4) construction of spillways of specific capacity" [AWWA, 1964]. The manual goes on to state that this type of cost analysis is largely subjective and almost entirely a matter of judgment.

As shown in Table 4-2, the AWWA manual presents three classifications of dams based on possible damages from overtopping to select the SDF. It is interesting to note that the AWWA criteria include an assessment of the anticipated damage to the dam following overtopping. The guidelines note that for smaller watersheds, the peak discharge computed from PMP may be ten or more times the maximum observed peak streamflow. In addition to the SDF requirements shown in Table 4-2, the AWWA indicated that "even under the most advantageous circumstances, the total freeboard above the maximum water level in the reservoir should not be less than 3-5 feet" [AWWA, 1964].

Table 4-2 Summary of 1964 AWWA Spillway Design Flood Guidelines [AWWA, 1964]

Possible Damages from Overtopping	Spillway Design Flood
Destruction of dam and catastrophic losses at downstream urban areas	Probable maximum precipitation (PMP) on very wet ground
Moderate damage to dam and little loss at downstream urban areas	Greatest known storm on another watershed that can be transposed to the study watershed
Minor damage to dam or other structures and no losses possible downstream	Storm obtained by applying a reduction factor to the probable maximum precipitation, or frequency studies to past floods

4.5. USCOLD Workgroup on Criteria and Practices Utilized in Determining the Required Capacity of Spillways (1970)

In 1967, a USCOLD workgroup was formed to compile information and to prepare a report regarding criteria and practices used in the United States for determining the required capacity of spillways. The national survey titled "*Criteria and Practices Utilized in Determining the Required Capacity of Spillways"* was published in 1970. The workgroup surveyed the USACE, Reclamation, TVA, Soil Conservation Service, state agencies, investor-owned utility companies and private engineering firms using a questionnaire. Only two state agencies (Pennsylvania and California) were surveyed. The final report summarized spillway requirements or "standards" for new dams for four hazard categories.

The workgroup indicated that all respondents stated that their current policies were consistent with the following statements:

> *"… The policy of deliberately accepting a recognizable major risk in the design of a high dam simply to reduce the cost of the structure has been generally discredited from the ethical and public welfare standpoint, if the results of a failure would imperil the lives and lifesavings of the populace of the downstream floodplain. Legal and financial capability to compensate for economic losses associated with major dam failures are generally considered as inadequate justifications for accepting such risks, particularly when severe hazards to life are involved. Accordingly, it is the policy of this agency that high dams impounding large volumes of water be designed to conform with Security Standard 1"* (design the dam and spillway large enough to assure that the dam will not be overtopped by floods up to the probable maximum) [USCOLD, 1970].

The workgroup also compared current (1970) criteria with past criteria and policies and concluded:

> *"The policies which are now generally accepted are not radically different from those followed 20 or more years ago by the responding organizations, even though procedures and techniques have been changed and improved and have been adopted rather uniformly as they have been developed. Accordingly, differences that do exist result largely from variations in interpretation of the policies, some differences in analytical technique, and designer's judgment"* [USCOLD, 1970].

The USCOLD report also provided a general summary of freeboard criteria and starting reservoir levels assumed in the SDF analyses, and identified erosion of spillway channels that could lead to breaching the spillway or eroding the toe of embankment dams as a common design concern.

4.6. National Dam Inspection Act, PL 92-367 and USACE Guidelines for Existing Dams (1972)

In the early 1970s a series of dam safety incidents occurred resulting in significant loss of life including the failure of Buffalo Creek Dam (West Virginia) in February 1972 and Canyon Lake Dam (South Dakota) in June 1972. In June of 1972, severe flooding caused by Hurricane Agnes endangered many dams. Large areas in Pennsylvania and New York experienced rainfall rates that were within 90 percent of PMP values [Riedel, 1973]. The Black Hills, South Dakota storm of June 1972 resulted in rainfalls that were 75 percent of the PMP [Riedel, 1973]. Following these events, the Congress enacted the National Dam Inspection Act (PL 92-367) and it became law on August 8, 1972. At that time many states did not have laws regarding dam safety and often did not require a review of the dam design prior to construction or require construction inspection or post-construction inspection. It was also found that dam safety in most states was inadequate with a wide variation of practices, regulations and capabilities of all agencies supervising dam safety. There was also little or no overall coordination of dam safety efforts.

Dams subject to PL 92-367 were those having a height 25 feet or greater, or a maximum impounding capacity greater than 50-acre-feet. Dams less than six feet high or storing less than 15 acre-feet were excluded. Congress charged the USACE with implementing the provisions of the Act. In addition to carrying out a national program of inspection of dams for the purpose of protecting human life and property, the act also required: (1) an inventory of all dams located in the United States; (2) a review of each inspection made; and (3) recommendations for a comprehensive national program for the inspection and regulation of dams, and the respective responsibilities which should be assumed by Federal, State, and local governments and by public and private interests.

Because of the scale of the program, the USACE developed a classification system to screen the adequacy of spillway capacity. The selected classification system used the dam size based on dam height and impoundment volume as shown in Table 4-3, and the hazard potential based on loss of life and economic loss as presented in Table 4-4. Table 4-5 presents the USACE's recommended SDF based on the Hazard and Size classification. A comparison of the criteria in the Tables 4-3 through 4-5 with that proposed by Snyder in 1964 in Table 4-1 shows remarkable similarities.

Where a range of SDF is indicated, the USACE guidelines specify that the magnitude that most closely relates to the involved risk should be selected. The use of partial PMF values are not discussed. For "Significant Hazard" dams, no more than six single-family type inhabitable structures were permitted in the downstream and upstream inundation zones, and consideration was

to be given to probable future development in order to select a conservative but realistic category [Hagen, 1973]. The original USACE guidelines also contained freeboard criteria, but these were deleted from the final guidance documents. The decision on freeboard allowance for each project was left to the inspection team [Hagen, 1973]. The USACE guidelines were reported to be based on a professional consensus [Dubler, 1995].

Table 4-3 USACE Dam Classification [USACE, 1979]

Category	Impoundment	
	Storage (Acre-Feet)	Height (Feet)
Small	<1,000 and 50	<40 and 25
Intermediate	1,000 and < 50,000	40 and <100
Large	50,000	100

Table 4-4 USACE Hazard Potential [USACE, 1979]

Category	Loss of Life (Extent of Development)	Economic Loss (Extent of Development)
Low	None expected	Minimal
Significant	Few	Appreciable
High	More than a few	Excessive

Table 4-5 USACE Hydrologic Evaluation Guidelines Recommended Spillway Design Floods [USACE, 1979]

Hazard Potential	Size	Spillway Design Flood (SDF)
Low	Small Intermediate Large	50 to 100-Year Flood 100-Year to ½ PMF PMF
Significant	Small Intermediate Large	100-year to PMF ½ PMF to PMF PMF
High	Small Intermediate Large	½ PMF to PMF PMF PMF

In developing the spillway capacity guidelines, the USACE made a distinction between new and existing dams and emphasized that the proposed guidelines were intended for existing dams. As stated in a discussion paper presented by the USACE, the "analysis of hydrologic and hydraulic

competency of existing structures should not be as rigorous as the design requirements for new dams. Costs associated with extra conservatism in a new project are almost always a small fraction of the cost required to modify an existing structure" [Hagen, 1973].

4.7. ASCE Task Committee on the Reevaluation of the Adequacy of Spillways of Existing Dams (1973)

In 1973, following four years of study, the ASCE Task Committee on the Reevaluation of the Adequacy of Spillways of Existing Dams published their report in the Journal of the Hydraulics Division [ASCE, 1973]. In the report, the Task Committee advocated "risk taking" in spillway capacity design and recommended that spillway capacities for new and existing dams of all sizes be based on a thorough economic analysis of the "social cost of risks and the cost of modification" computed on an average annual basis. An evaluated level of risk at which the total of all social costs will be at a minimum was proposed. The Task Committee recommended use of a monetary value for human life and injury in the analysis. Mr. Bob Buehler, Chief of the Flood Control Branch of the TVA and member of the committee, subsequently published a paper on "The Monetary Value of Life and Health" [Buehler, 1973]. Values assigned by Mr. Buehler in an example economic analysis presented in a paper titled *Reevaluation Spillway Adequacy of Existing Dams* showed values of $150,000, $200,000, and $10,000 for deaths, disabling injuries, and non-disabling injuries, respectively [Buehler, 1973].

Assigning a probability to extreme floods was a concern expressed by engineers reviewing the report. For expediency, the ASCE Task Committee's solution to the problem of assigning probability to extreme events was to arbitrarily assign an average return interval of 10,000 years to the PMF. This was considered by the committee to be a conservatively low return period, yet high enough to accomplish the purposes of the analysis process. Assigning a 10,000-year probability to the PMF at that time was suggested and supported by others as well [Beard, 1973]. With the upper extreme fixed arbitrarily at 10,000 years and the lower extreme defined by observed data, a curve on probability paper provided probabilities for all in-between floods.

An interesting and intriguing argument presented by the committee, and demonstrated with analysis examples, was that risk costs can increase as additional dam safety is provided, since improved safety is often provided by raising the dam and/or increasing spillway capacity with a resulting increase in downstream flood flow. The economic analysis approach was recommended to avoid mistakes where circumstances exist in which modification to reduce failure probability would increase rather than decrease potential average annual losses, and that "modification with good intent to increase safety would be an incorrect move" [Buehler, 1973].

The ASCE Task Committee's report generated much controversy and 13 published discussions which was said to be a record number. The discussions were equally divided in favor and against the proposed approach [Buehler, 1973]. The recommendation to place a monetary value on human life and suffering in the economic analysis was ultimately not accepted by the engineering

profession or by regulatory agencies. The approach was viewed as a "radical departure" from accepted standards [Williams, 1973]. For dams where loss of life was not expected, the risk-based economic analysis proposed by the ASCE Task Committee was supported by the Bureau of Reclamation with the provision that the public be kept aware of the possibility of failure, that a land use plan be enforced that ensured the minimum hazard to life, and that a periodic re-examination must be scheduled and made to verify that the downstream hazard and damage assumptions continue to be valid [Bertle, 1973]. The economic analysis proposed by the ASCE Task Committee was also viewed as impractical for smaller dam projects as the cost to perform the analysis could approach the cost of the structural modifications [Williams, 1973].

4.8. FEMA ad hoc ICODS – Federal Guidelines for Dam Safety (1979, Reprinted 2004)

In 1979, the *ad hoc* Interagency Committee on Dam Safety (ICODS) issued "Federal Guidelines for Dam Safety." This document provided the first guidelines for federal agency dam owners and dam owners regulated by federal agencies. As stated in the preface:

> *"These guidelines apply to Federal practices for dams with a direct Federal interest and are not intended to supplant or otherwise conflict with State or local government responsibilities for safety of dams under their jurisdiction."*

For flood selection for design or evaluation, the federal guidelines supported the use of risk analysis, and stated:

> *"The selection of the design flood should be based on an evaluation of the relative risks and consequences of flooding, under both present and future conditions. Higher risks may have to be accepted for some existing structures because of irreconcilable conditions"* [FEMA, 1979].

The guidelines were clear, however, that the spillway design standard to be adopted for dams where loss of life or major property damage could be significant was the PMF. The following statement concerning selection of the flood for design for spillways is in the 1979 guidelines:

> *"When flooding could cause significant hazards to life or major property damage, the flood selected for design should have virtually no chance of being exceeded. If lesser hazards are involved, a smaller flood may be selected for design. However, all dams should be designed to withstand a relatively large flood without failure even when there is apparently no downstream hazard involved under present conditions of development"* [FEMA, 1979].

For existing dams, "risk-based analyses should be considered in establishing priorities for examining and rehabilitating the dams, or for improving their safety" [FEMA, 1979]. The guidelines did not provide a specific framework for classifying dams or for assigning SDFs using risk-based analyses.

4.9. National Research Council Committee on Safety Criteria for Dams, Safety of Dams – Flood and Earthquake Criteria (1985)

In response to a request by the Assistant Secretary of the Interior for Water and Science and the Assistant Secretary of the Army for Civil Works, the National Research Council (NRC) established an *ad hoc* Committee on Safety Criteria for Dams to prepare an inventory of currently used criteria for dams relating to safety from hazards of extreme floods and earthquakes, and to identify and evaluate alternative criteria for safety of federal dams. The committee was made up of experts in risk assessment, regulation of dams, law, science, and engineering. A comprehensive survey of design criteria in use for dams relative to hazards of extreme floods was performed for 35 states, 10 federal agencies, four technical societies (ASCE, ICOLD, and USCOLD), nine firms, and one foreign country (England).

The following key findings were made by the Committee as they relate to selecting spillway inflows for dams:

- Current dam practices reflect a great variety of standards used to classify dams relative to hazards and in the criteria for evaluation of safety from extreme floods.
- While simple hazard rating categories based on downstream development may be useful for identifying dams for high-priority safety evaluation and study, they do not reflect the potential for incremental loss of life and damage caused by failure of a dam due to an inadequate spillway when a river is already in flood.
- More uniformity is needed among the several federal and state agencies establishing size and hazard definitions and correlative design standards.
- New concepts and improved methods for estimating floods have resulted in generally larger flood estimates and future estimates of magnitude for extreme floods can be expected to increase. However, unless the runoff characteristics of the watershed were to change, increments in future flood estimates should be less than those noted in the past. There have been instances where more intensive hydrometeorological studies have resulted in reductions in estimates of PMP by earlier investigations.
- A dam designed for the PMF using the PMP does not provide absolute assurance that the dam is safe for every possible flood.
- The federal government has become increasingly involved in risk management issues and a number of federal agencies have developed various risk management standards, but these are not applicable to risk management for dams. Adaptation of these concepts to dam safety requires research.
- Court decisions relating to dam failures in general have held the owner liable for the damages resulting from a failure.

The Committee made the following recommendations:

- To the extent practicable, reservoir safety evaluations should strike a balance among project benefits, construction costs, social costs, and public safety. Currently available technology does not permit this balancing with full confidence in the results.
- Safety evaluation standards for existing dams and new dams do not need to be the same.
- The use of PMFs based on estimated PMP as the general design standard for new high-hazard dams should be continued. Instances may be encountered where a lower standard may be justified if failure of a dam during floods of PMF magnitude would cause no significant increase in potential loss of life or property damage.
- For existing high-hazard dams, the adopted SDF should take into account estimated flood probabilities, expected project performance, and incremental damages that would result from dam failure for a range of floods up to and including the PMF.
- In the design of new dams and spillways when design alternatives of approximately equal cost are available, a selection among these alternatives should give consideration to potential future needs for increased safety against floods.
- Periodic reviews of hazard determinations and safety decisions for all dams should be required, especially when safety evaluations are based on criteria less conservative than the PMF.
- As advances occur in hydrology, meteorology, and the relevant databases, and as changes are noted in public attitudes toward risk, federal agencies should periodically undertake a review of dam safety practices and standards by an independent body representing the professions involved in engineering for dams and experts from other relevant disciplines.

For new high-hazard dams, the Committee recommended the PMF be adopted for the SDF unless risk analyses that examine the incremental impact of overtopping and dam failure during an extraordinary flood demonstrate that little or nothing is gained by such a high standard. The SDF would be the smallest value that ensures that a dam breach results in no significant increase in potential for loss of life or major property damage.

For existing high-hazard dams, the Committee concluded that there was no universally satisfactory approach to establishing spillway capacity criteria. The Committee therefore recommended that risk-based analysis be considered for existing high-hazard dams "for which the PMF is not required." A section describing risk-based analyses was included in the report.

No specific recommendations were made by the Committee for spillway design requirements for intermediate hazard and low hazard dams.

4.10. FEMA (ICODS) – Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams (1986)

This publication was prepared by an ICODS working group on inflow design floods to supplement the *FEMA Federal Guidelines for Dam Safety* which was published in 1979. The primary purpose

of the document was to provide general guidelines on procedures for selecting and accommodating inflow design floods for use by federal agencies in developing agency criteria and to ensure more nationwide uniformity in application. The guidelines apply to both proposed and existing dams.

For existing and proposed dams where failure is expected to result in loss of life or extensive property damage, the guidelines specified using the PMF as the IDF. The evaluation dam failure impacts are based on both existing and future conditions. Key statements made in the guidelines with respect to evaluating dam failure impacts and selection of the IDF follow:

> *"The PMF should be adopted as the IDF in those situations where consequences attributable to dam failure from overtopping are unacceptable. The determination of unacceptability exists when the area affected is evaluated and factors indicate loss of human life, extensive property and environmental damage, or serious social impact may be expected as a result of dam failure"* [FEMA, 1986].
>
> "*Dams and their appurtenant structures should be designed to give satisfactory performance and to practically eliminate the probability of failure"* [FEMA 1986].
>
> *"The presence of public facilities within the potential area inundated by dam failure that would attract people on a temporary basis (e.g., campgrounds, State or National parks, etc.) requires special consideration"* [FEMA, 1986].
>
> *"The presence of an emergency action plan and/or a warning system should not be substituted for safe design practice or for use in reducing the potential for loss of life in the analysis for selecting the IDF"* [FEMA, 1986].
>
> *"Re-evaluation of an existing dam with respect to selecting and accommodating the IDF should normally be based on the same basic guidelines as for proposed dams"* [FEMA, 1986].

The guidelines make a specific distinction between service, auxiliary, and emergency spillways. For the design of auxiliary and emergency spillways, infrequent limited damage during passage of the IDF is acceptable provided the damage does not endanger the dam or usefulness of the service spillway and the control section of the spillway is not degraded to the extent it results in an unacceptable loss of storage or uncontrolled discharges which exceed the peak inflow. According to the guidelines, emergency spillways may be permitted to sustain significant damage when used and may be designed to a lower structural standard than auxiliary spillways.

Consideration for floods less than the PMF were permitted only when there were no existing permanent human habitations, commercial or industrial development, or such developments that were projected to occur within the foreseeable future, and transient population was not expected to be affected within the hazard area. An exception was made for a few permanent human habitations located within the flood hazard area provided there was no significant increase in the hazard resulting from the occurrence of floods larger than the proposed IDF up to the PMF (for example, where failure would not add appreciable volume to the outflow hydrograph and the downstream

inundation would be essentially the same with or without failure). For selection of the IDF less than the PMF, "the spillway capacity should be not less than some minimum standard to reduce the risk of loss of benefits during the life of the project; to hold O&M costs to a reasonable level; to maintain public confidence in agencies responsible for dam design, construction, and operation; and to be in compliance with local, State, or other regulations applicable to the facility" [FEMA, 1986].

The guidelines also made provisions for Federal agencies to develop agency-specific criteria and allowed the use of risk analyses as an approach to evaluating spillway inflow requirements less than the PMF on a case-by-case basis for existing dams.

> "*It is recognized that for some existing dams which do not meet current hydrologic design criteria but have been soundly designed and well constructed, it may be prudent to select an IDF smaller than the PMF. … However, any relaxation of design criteria should be undertaken on a case-by-case basis after the consequences of dam failure have been thoroughly evaluated and quantified. … Local interests should be made aware of the possibility of larger floods occurring when a flood smaller than the PMF is selected as the IDF*" [FEMA, 1986].

A section describing risk-based analyses was included in the guidelines.

4.11. ASCE Task Committee on Spillway Design Flood Selection (1988)

This ASCE Task Committee was formed in 1984 in response to the growing national concern for dam safety and the lack of uniformity in the hydrologic procedures used in dam safety evaluation. The charge of the Task Committee was to develop standards for selecting SDFs which could be readily implemented and applied nationwide. Their objective was to identify an acceptable procedure for selecting the SDF which, in addition to the traditional economic analysis, would permit the inclusion of loss of life, owner liability, social disruption, and the magnitude of destruction. The committee consisted of 14 persons. The final report was submitted to nearly 60 outside peer reviewers and was revised six times.

The ASCE Committee developed a quantitative risk assessment approach for selecting the SDF that applies to both new and existing dams. The Committee's design selection process was based on dividing dams into three categories depending on their failure consequences as summarized in Table 4-6.

The quantitative risk assessment proposed by the Committee for Category 2 dams does not provide specific risk guidelines or thresholds for the potential for loss of life and economic damage but assumes them to be "a matter of judgment." The Committee provides a tabulation of population at risk (PAR) from dam failure versus warning time for use in the initial screening of Category 1 dams. The values range from a PAR of 50 for a flood wave arrival time less than 2 hours to a PAR of 1,000 or more for a time of flood wave arrival of less than 12 hours.

Table 4-6 Summary of ASCE Committee's Spillway Design Flood Selection Process [ASCE, 1988]

Category	Description	Spillway Design Flood
1	Dams where failure consequences include loss of life or other social and economic losses that warrant the use of the PMF as the spillway design flood.	PMF
2	Dams where the social and economic consequences of failure are not large enough to require use of the PMF as the spillway design flood.	PMF unless quantitative risk assessment shows smaller flood is justified
3	Small dams where the cost of construction is small and the failure damage is low and confined to the owner.	10- to 100-year flood[1]

1 *The committee suggests that the owner may benefit from a quantitative risk assessment to determine the spillway design flood. However, it may not warrant the cost of the analysis. Guidelines adapted from the SCS were offered with the provision that the owner should consider the chances the investment will be lost during the planned project life.*

It is unclear how loss of life is to be addressed for a Category 2 dam since there is no explicit accounting for loss of life in the proposed quantitative risk assessment or in the examples provided; only economic losses that can be quantified in dollars are explicitly considered, although loss of life estimates are shown in the summary of consequences. The committee does state that "the relative weighing of nonmonetary consequences and their comparison to dollar savings is a matter of judgment which will vary among decision makers for each site examined."

A requirement attached to adopting a SDF less than the PMF for Category 2 dams is that the dam owner must consider the cost of indemnifying possible victims of dam failure against financial losses. The cost of indemnification, rather than the flood damage, is taken as the proper measure of damage sustained by parties other than the dam owner. In addition to the loss of project benefits and physical damages created by the dam failure, the indemnification costs include income losses, emergency response, flood fighting, disaster assistance, reoccupation, cleanup, personal trauma, and post-disaster studies. The ASCE Committee concluded that the procedure requires a regulatory mechanism to make sure that the dam owner maintains the capability throughout the project life to fully compensate all victims should the dam fail.

A criticism of the ASCE Task Committee's proposed procedure is that the relative weighing of non-monetary consequences and their comparison to dollar savings were assumed to be a matter of judgment, and no criteria were provided for making a final design decision [Graham, 2000].

4.12. FEMA Federal Guidelines for Dam Safety – Selecting and Accommodating Inflow Design Floods for Dams (1998 – Reprinted 2004)

In 1994, an ICODS subcommittee was formed to review and update the existing Federal Guidelines for Dam Safety to meet current dam safety challenges and to ensure consistency across agencies and users. With the passage of the National Dam Safety Program Act in 1996 (Public Law 104-303), ICODS and its Subcommittees were reorganized to reflect the objectives and requirements of

Public Law 104-303. In 1998, the newly convened ICODS Subcommittees completed work on the update of the *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams*. The ICODS Subcommittees were also made responsible for maintaining the guidelines to help achieve the objectives of the National Dam Safety Program.

The current (1998 – reprinted 2004) *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams* places an emphasis on basing the selection of the SDF on an accurate hazard potential determination that evaluates the consequences of dam failure based on the dam being in place, and comparing the impacts of with-failure and without-failure conditions on existing development and prospective future development. The guidelines stipulate that the flood wave created by a dam failure should be routed downstream to the point where the incremental effect of a failure no longer results in unacceptable consequences. The IDF is then selected based on the results of the incremental hazard evaluation. This evaluation involves simulating a flood event during existing and dam failure conditions. The additional downstream consequences due to the incremental increase in flood flows downstream are assessed for each dam failure scenario. The above procedure is to be repeated until the flood inflow condition is identified such that a failure at that flow or larger flows (up to the PMF) will no longer result in unacceptable additional consequences. The resultant flow is the IDF for the dam. The maximum IDF is always the PMF. The guidelines provide specific guidance and procedures, including a comprehensive flowchart, for conducting an incremental hazard evaluation to select the appropriate IDF.

The guidelines stipulate that the PMF should be adopted as the IDF in those situations where consequences of a dam failure for floods less than the PMF are unacceptable. A flood less than the PMF may be adopted as the IDF in situations where the consequences of dam failure at flood flows larger than the selected IDF are acceptable as determined by the incremental hazard evaluation. When an IDF less than the PMF is selected, the consequences of a dam failure resulting from floods in excess of the IDF must be limited to the dam owner's facilities. The guidelines stipulate that acceptable consequences exist when evaluation of the area affected indicates either of the following two conditions:

1. There are no permanent human habitations, known national security installations, or commercial or individual developments, nor are such habitations or commercial or industrial developments projected to occur within the potential hazard area in the foreseeable future.
2. There are permanent human habitations within the potential hazard area that would be affected by failure of the dam, but there would be no significant incremental increase in the threat to life or property resulting from the occurrence of a failure during floods larger than the proposed IDF.

The guidelines indicate that when a dam break analysis shows downstream incremental effects of approximately two feet or more, engineering judgment and further analysis are necessary to finally evaluate the need for modification of the dam. In general, the consequences of failure are considered acceptable when the incremental effects (depth) of failure on downstream structures are

less than two feet. The consequence analysis should also include consideration of impacts to vital community services such a municipal water or energy supply and may require increasing the spillway capacity to ensure those services are continued during and following extreme flood conditions. The guidelines suggest that it would not be appropriate to set the IDF for a spillway with an exceedance flood frequency less than the 100-year flood, including low-hazard dams.

The guidelines note that "there are times when selection (of the IDF) becomes difficult and it may be necessary to conduct further analyses with a risk-based approach," but follows by stating that "incremental hazard evaluation is, in essence, a risk-based approach." No guidelines were provided for performing an alternate type of risk-based analysis.

The guidelines indicate that it may be appropriate to perform site-specific PMP studies or regional PMP studies to better define existing NWS HMR estimates, provided the additional analysis costs are warranted.

The guidelines address minimum freeboard requirements (the difference between the top of dam and the maximum pool elevation during the IDF) and note that it is generally not necessary to prevent splashing or occasional overtopping of a dam by waves under extreme conditions, however, the number and duration of such occurrences should not threaten the structural integrity of the dam. The guidelines for minimum freeboard allowance do, however, recommend consideration of combinations of components that have a reasonable probability of simultaneous occurrence including: wind-generated wave run-up, effects of possible malfunction of the spillway and outlet works, settlement of the embankment, and landslide-generated waves.

4.13. FEMA Federal Guidelines for Dam Safety – Hazard Potential Classification System for Dams (1998 – Reprinted 2004)

The ICODS Subcommittee on Federal/Non-Federal Dam Safety Coordination was also tasked to develop a new guideline, *Hazard Potential Classification System for Dams*, which was subsequently published in 1998 and reprinted in 2004. Three classification levels were adopted: Low, Significant, and High. The hazard potential classification system categorizes dams based on the probable loss of human life and the impacts on economic, environmental, and lifeline interests and is summarized in Table 4-7. The assigned classification of a dam is based on failure consequences that will result in the assignment of the highest hazard potential classification of all probable failure and misoperation scenarios. The guidelines state that the probable scenarios considered are to be reasonable, justifiable, and consistent with the FEMA *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams*.

Table 4-7 Summary of Proposed ICODS Hazard Potential Classification System for Dams [FEMA, 1998]

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low	None expected	Low and generally limited to owner
Significant	None expected	Yes
High	Probable. One or more expected.	Yes (but not necessary for this classification)

The ICODS Subcommittee recommended that the proposed Hazard Potential Classification System be adopted in lieu of existing numerical and alphabetical systems to eliminate confusion in the dam safety community and to educate the public on the importance of dam safety. The guidelines do not establish how the system should be used, such as prescribing specific spillway design criteria.

4.14. FEMA Model State Dam Safety Program (2007)

This document was prepared by ASDSO to outline key components of an effective dam safety program. The first edition of this document was published in 1987 with amendments in 1998 to reflect the experience of state programs. Spillway design criteria for dams are not provided in this document.

5. Relevant International Guidelines

5.1. Introduction to Summaries of International Guidelines

While the scope of this study specifically addresses guidelines for hydrologic safety of dams within the United States, there are several developments in the international arena that are particularly relevant to the study. Recently updated guidelines in Australia and Canada were reviewed and are summarized in the following sections to provide a glimpse of how other countries' guidelines are changing. This literature review is by no means intended to be a comprehensive overview of international guidelines.

5.2. ANCOLD Guidelines on Selection of Acceptable Flood Capacity for Dams

In Australia, there is no federal legislation on dam safety. Therefore, Australian jurisdictions that have dam safety regulations in place including Victoria, New South Wales, Queensland, and the Australian Capital Territory (ACT) are responsible for developing their own dam safety guidelines. In order to provide a basis for consistency throughout Australia in the assessment of hydrologic safety of dams, the Australian National Committee on Large Dams (ANCOLD) established a Working Party in 1994 to revise the existing standards based guidelines in light of moves to integrate risk assessment into dam safety procedures.

The prior *1986 ANCOLD Guidelines on Design Floods for Dams* introduced the concept of incremental flood hazard categories for ranking the recommended design flood against consequences of a dam failure. At that time risk analysis was being considered; however, the methodology was not well developed. As a result, the 1986 guidelines did not propose the use of risk analyses for dams where lives were at risk. In 1987, the guidelines were revised to include *Australian Rainfall and Runoff*, which included a chapter on estimation of extreme floods.

ANCOLD then led the way internationally in the development of acceptable risk criteria in dam safety and published *Guidelines on Risk Assessment* in 1994. These guidelines provided a basis for integrating risk assessment into dam safety. At that time it became apparent that procedures for risk-based dam safety evaluation were still in the development phase worldwide, and the 1994 risk guidelines needed review. In addition flood estimation procedures for risk-based dam safety evaluation were required to provide flood probabilities for application in risk assessment.

In 2000, *ANCOLD Guidelines on Selection of Acceptable Flood Capacity for Dams* was published to provide more appropriate and consistent guidance within a risk process for dam safety evaluation under floods. The 2000 guidelines superseded the 1986 guidelines in accordance with the ANCOLD aim for integration of risk assessment into the guidelines. The estimation of extreme floods and associated assigned probabilities are based on the procedures developed for Australia in 1999. A point reiterated in the 2000 ANCOLD guidelines is that spillway capacity should be

assessed within the total load context and not as a separate case so that all safety issues can be identified and an optimum solution can be developed.

The guidelines include a deterministic "fall-back option" that the owner can adopt instead of the quantitative risk assessment approach. The fall-back option is intended to be more conservative and result in a higher design requirement and cost to bring the dam up to the required standard than the alternative risk assessment procedure. The fall-back option involves first determining the Hazard Category based on consequences and then assigning the acceptable flood capacity based on the assigned return period for the selected Hazard Category rating. The hazard category rating system adopted by Queensland in 2007 based on the ANCOLD Guidelines as well as the corresponding range of acceptable flood capacities for the different hazard categories are presented in Table 5-1. The guidelines also specify flood surcharge "wet" and "dry" freeboard requirements.

Table 5-1 Queensland Hazard Category Rating System [State of Queensland, 2007]

Incremental Population at Risk (PAR)	Severity of Damage and Loss			
	Negligible	Minor	Medium	Major
$2 \le PAR \le 10$	Low: 5.0×10^{-4} / 5.0×10^{-4}	Significant: 5.0×10^{-4} / 1.0×10^{-4}	Significant: 1.0×10^{-4} / 1.0×10^{-4}	High C: 1.0×10^{-5} / C
$10 < PAR \le 100$	5.0×10^{-4} / 1.0×10^{-4}	Significant: 1.0×10^{-4} / 1.0×10^{-4}	High C: C / C	High B: B / B
$100 < PAR \le 1000$	A / A	High A: A / A	High A: A / A	A / A
$PAR > 1000$	If in this region, go to the next highest severity of Damage and Loss category for the same PAR		PMF / PMF	Extreme: PMF / PMF

Where

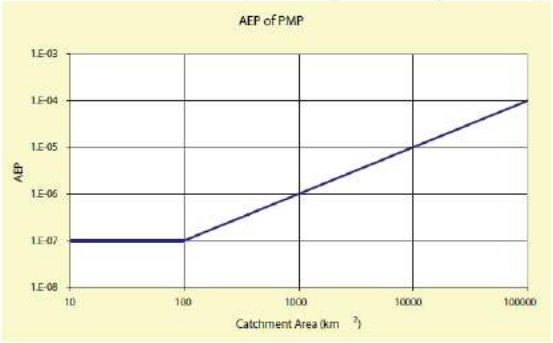
A = PMP Design Flood

B = PMP Design Flood or 10^{-6}, whichever is the smaller flood event

C = PMP Design Flood or 10^{-5} whichever is the smaller flood event

Note that the probability of the PMP Design Flood is a function of the catchment area.

Table 2: Required range of A cceptable Flood Capacities for different hazard categories



Supplied courtesy of the Department of Environment and Resource Management, Queensland, Australia.
© State of Queensland (Department of Environment and Resource Management) 2011

The ANCOLD *Guidelines on Risk Assessment* was revised in 2003. Victoria, New South Wales, Queensland subsequently adopted the ANCOLD guidelines with minor differences in the limits for tolerability of risk and other provisions. The Victorian regulations require risk assessments for high hazard dams. Risk assessments are optional for the Queensland and New South Wales regulations [Sih et al, 2010]. Reclamation and USACE have recently revised and adopted elements of the ANCOLD guidelines in the formulation of their new risk-based guidelines.

5.3. Canadian Dam Association Guidelines (2007)

Regulation of dams in Canada is primarily a provincial responsibility. Federal agencies have limited jurisdiction related to international boundary waters with the United States and some responsibility for security of critical infrastructure. In 1995, after three years of effort by working groups, the Canadian Dam Safety Association (CDA) published *Dam Safety Guidelines*. In 1999, the CDA issued a revision, and in 2007, the CDA published its most recent guidelines that include a companion series of technical bulletins on dam safety. The technical bulletins suggest methodologies and procedures for use by qualified professionals as they perform dam analyses and safety assessments.

The CDA guidelines include a dam classification system based on failure consequences and discuss both the traditional standards-based approach and the risk-based approach to dam safety decision making. However, IDF requirements are only specified using a deterministic assessment. *Technical Bulletin 6 – Hydrotechnical Considerations for Dam Safety* presents details of the CDA guidelines for selecting the inflow design flood (IDF) and freeboard. The suggested CDA IDF for use in deterministic assessments is presented in Table 5-2. The suggested CDA dam classification scheme is shown in Table 5-3. The IDFs presented in Table 5-2 make reference to the 1 in 1,000-year flood, and ratios of 1/3 and 2/3 between the 1 in 1,000-year flood and the PMF. The CDA guidelines indicate that beyond the 1 in 1,000-year flood, floods cannot be obtained by flood statistics methods. The proposed method consists of interpolating the flood hydrographs rather than the flood peaks or volumes since experience has shown unacceptable distortions using these parameters.

Selecting the IDF using quantitative risk analyses is not discussed and appears to be discouraged because of the inability to accurately assign a probability to extreme floods. As noted in Table 5-2, “extrapolation of flood statistics beyond the 1 in 1,000 year flood is discouraged.”

Provinces, like British Columbia, have adopted the CDA guidelines with only minor modifications. Table 5-4 shows the downstream consequence classification system presented in the 2009 *British Columbia Dam Safety Guidelines*. Minimum design standards for determining the IDF for dams constructed after 2008 are identical to those shown in Table 5-2. The British Columbia guidelines note that the 1999 CDA dam safety guidelines were updated in 2007 and that this update resulted in, among other things, a more stringent suggested annual exceedance probability (AEP) for determining the IDF. For dams constructed prior to 2008, the British Columbia Dam Safety

Program allows dam design engineers to use the 1999 CDA Dam Safety Guidelines. Since the 2007 CDA guidelines use a different dam classification table than the British Columbia Dam Safety Regulations, design engineers are instructed to contact their Dam Safety Officer for the policy on how to use the two classification tables together.

Table 5-2 Suggested CDA Inflow Design Flood for Use in Deterministic Assessments [CDA, 2007]

Consequence Class	IDF
Low	1/100-year
Significant	Between 1/100 and 1/1000-year (Note 1)
High	1/3 between 1/1000-year and PMF (Note 2)
Very High	2/3 between 1/1000-year and PMF Note 2)
Extreme	PMF

Note 1. Selected on basis of incremental flood analysis, exposure and consequence of failure.
Note 2. Extrapolation of flood statistics beyond 1/1000-year flood (10^{-3} AEP) is generally discouraged. The PMF has no asssociated AEP. The flood defined as "1/3 between 1/1000-year and PMF" or "2/3 between 1/1000 year and PMF" has no defined AEP.

Table 5-3 Suggested CDA Dam Classification System [CDA, 2007]

Dam class	Population at risk [note 1]	Incremental losses		
		Loss of life [note 2]	Environmental and cultural values	Infrastructure and economics
Low	None	0	Minimal short-term loss No long-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	Significant loss or deterioration of *important* fish or wildlife habitat Restoration or compensation in kind highly possible	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very high	Permanent	100 or fewer	Significant loss or deterioration of *critical* fish or wildlife habitat Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Major loss of *critical* fish or wildlife habitat Restoration or compensation in kind impossible	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

Note 1. Definitions for population at risk:

None—There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary—People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent—The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

Note 2. Implications for loss of life:

Unspecified—The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

Table 5-4 British Columbia Dam Safety Dam Classification System [British Columbia, 2009]

Rating	Loss of Life	Economic and Social Loss	Environmental and Cultural Losses
VERY HIGH	Large potential for multiple loss of life involving residents and working, travelling and/or recreating public. Development within inundation area (the area that could be flooded if the dam fails) typically includes communities, extensive commercial and work areas, main highways, railways, and locations of concentrated recreational activity. Estimated fatalities could exceed 100.	Very high economic losses affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to large residential areas, concentrated commercial land uses, highways, railways, power lines, pipelines and other utilities. Estimated direct and indirect (interruption of service) costs could exceed $100 million.	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and/or practicality of restoration and/or compensation is low.
HIGH	Some potential for multiple loss of life involving residents, and working, travelling and or recreating public. Development within inundation area typically includes highways and railways, commercial and work areas, locations of concentrated recreational activity and scattered residences. Estimated fatalities less than 100.	Substantial economic losses affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to concentrated commercial land uses (highways, railways, power lines, pipelines and other utilities). Scattered residences may be destroyed or severely damaged. Estimated direct and indirect (interruption of service) costs could exceed $1 million.	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and practicality of restoration and/or compensation is high.
LOW	Low potential for multiple loss of life. Inundation area is typically undeveloped except for minor roads, temporarily inhabited or non- residential farms and rural activities. There must be a reliable element of natural warning if larger development exists.	Low economic losses to limited infrastructure, public and commercial activities. Estimated direct and indirect (interruption of service) costs could exceed $100,000.	Loss or significant deterioration of regional important fisheries habitat (including water quality), wildlife habitat, rare and endangered species, unique landscapes or sites of cultural significance. Feasibility and practicality of restoration and/or compensation is high. Includes situations where recovery would occur with time without restoration.
VERY LOW	Minimal potential for any loss of life. The inundation area is typically undeveloped	Minimal economic losses typically limited to owners property and do not exceed $100,000. Virtually no potential for future development of other land uses within the foreseeable future.	No significant loss or deterioration of fisheries habitat, wildlife habitat, rare or endangered species, unique landscapes or sites of cultural significance.

6. Prior State and Federal Surveys Related to Design Flood Selection

6.1. Background

As design practices and regulatory guidelines relating to the selection of a design flood have developed over the past several decades, multiple organizations and individuals have striven to understand what the industry standard was at a particular point in time. The use of surveys has been a common tool in identifying current dam safety practices. Several past surveys regarding design flood selection are summarized in this chapter. Each survey provides a snapshot in time of dam safety practices and regulations as well as common opinions and ideologies of the dam safety community. A careful review of each of the surveys is helpful in identifying the trends and changes regarding the hydrologic safety of dams over the past 40 years.

6.2. USCOLD – 1970

In the late 1960s, the U.S. Committee on Large Dams performed a survey of dam design practices for sizing spillways in the United States. Surveys were solicited from both federal and state dam safety agencies, and results were published in a 1970 report "Criteria and Practices Utilized in Determining the Required Capacity of Spillways."

It was reported that all respondents to the survey followed policies discouraging the use of risk analysis when designing high hazard dams. Without exception, respondents agreed that the prevention of overtopping during extreme flood events is of such importance that the required cost is justified. It was also noted that the policies generally accepted at the time were not radically different from those from 20 or more years previous to the study, although procedures and techniques had improved.

6.3. National Research Council – 1985

As part of a study entitled "Safety of Dams: Flood and Earthquake Criteria" performed by the Committee on Safety Criteria for Dams of the Water Science and Technology Board of the NRC's Commission on Engineering and Technical Systems, inquiries regarding current dam safety provisions were made to federal agencies most concerned with dams, state dam safety units, several prominent dam engineering firms, and other organizations with interests in dam safety. The data from 10 federal agencies, 35 state and local agencies, 9 private firms, and 4 professional engineering societies were used to determine the state of the practice in 1985.

The survey found a broad range of classification criteria being used at the time. Most dam classification systems were based on dam height, volume of water impounded, the extent of

development in the downstream dam failure hazard area, or a combination of the preceding characteristics. The summary notes that:

> *"While it appears that many of the differences in dam classification systems are the result of arbitrary choices of regulatory authorities, it also appears that most of the classification systems have been structured to meet the perceived needs of the issuing agency or state government"* [NRC, 1985].

In regards to spillway capacity, the survey found that the majority of design criteria were based on deterministic estimates of the PMP or PMF, some percentage of the PMP or PMF, and probabilistic flood events with a return period of 100 years or less frequent. The Soil Conservation District and the state of West Virginia reported using mixed criteria based upon both probabilistic and deterministic estimates. The only reports of probabilistic floods less frequent than the 100-year event occurred in California (1,000 year flood event) and Michigan (200-year flood event). A summary of spillway capacity criteria used by various U.S. states and agencies in 1985 is included in Table 6-1.

Table 6-1 Spillway Capacity Criteria Reported to Be in Use by Various U.S. Agencies in 1985 [NRC, 1985]

Deterministic Criteria	Mixed Criteria	Probabilistic Criteria
Criteria specifying rainfalls		
PMP	P100 + 0.40 (PMP – P100)	2.25 P100
0.90 PMP	P100 + 0.26 (PMP – P100)	1.50 P100
0.80 PMP	P100 + 0.12 (PMP – P100)	P100
0.75 PMP	P100 + 0.06 (PMP – P100)	P50
0.50 PMP		P10
0.45 PMP		
0.40 PMP		
0.33 PMP		
0.30 PMP		
0.25 PMP		
0.225 PMP		
0.20 PMP		
0.10 PMP		
Criteria specifying floods		
PMF		1,000-year flood
0.75 PMF		200-year flood
0.50 PMF		100-year flood
0.40 PMF		50-year flood
0.30 PMF		
0.25 PMF		
0.20 PMF		

Criteria specific to each agency included in this study are published within the report. The following key points regarding spillway capacity design were noted:

- There was a fair consensus on the spillway requirements for large, high-hazard dams. The use of PMP or PMF estimates for such dams predominated, although many state regulatory agencies indicated that their standards did not require the full PMP or PMF.
- There was a much greater diversity of hydrologic criteria for the safety of classes of dams other than large, high hazard dams.
- While simple hazard rating categories based on downstream development may be useful for identifying dams for high-priority safety evaluation and study, they do not reflect the potential for incremental loss of life and damage caused by failure of a dam due to an inadequate spillway when a river is already in flood.
- Though not included in most published criteria, the use of incremental damage assessments was growing in acceptance and used to establish the required spillway capacity.
- New concepts and improved methods for estimating floods have resulted in generally larger flood estimates and future estimates of magnitude for extreme floods can be expected to increase. However, unless the runoff characteristics of the watershed were to change, increments in future flood estimates should be less than those noted in the past. There have been instances where more intensive hydrometeorological studies have resulted in reductions in estimates of PMP by earlier investigations.
- A dam designed for the PMF using the PMP does not provide absolute assurance that the dam is safe for every possible flood.
- The study noted that the use of arbitrary criteria such as a percentage of the 100-year storm, fraction of the PMF, or combinations of the PMF and probability based floods was common, even though there is no documented scientific rationale for such approaches.

For new high-hazard dams, the Committee recommended the PMF be adopted for the SDF unless risk analyses that examine the incremental impact of overtopping and dam failure during an extraordinary flood demonstrate that little or nothing is gained by such a high standard. The SDF would be the smallest value that ensures that a dam breach results in no significant increase in potential for loss of life or major property damage.

For existing high-hazard dams, the Committee concluded that there was no universally satisfactory approach to establishing spillway capacity criteria. The Committee therefore recommended that risk-based analysis be considered for existing high-hazard dams “for which the PMF is not required.” A section describing risk-based analyses was included in the report.

No specific recommendations were made by the Committee for spillway design requirements for intermediate hazard and low hazard dams.

Additional recommendations made by the Committee are summarized in Section 4.9.

6.4. Dubler Thesis, Colorado State University – 1995

James R. Dubler published the thesis "Dam Safety Policy for Spillway Design Floods" as part of his Master of Science degree at Colorado State University in 1995. Representatives of 46 state dam safety agencies provided responses to a survey included in the thesis.

The study found that disagreement concerning the selection of the SDF among professionals still existed. At the time of the survey, risk analysis was not popular in the professional community, and most states' guidelines for the selection of the SDF were based on a prescriptive approach. The survey also explored a variety of topics related to the SDF and risk analysis including incremental damage analysis, early warning systems, the development of probable maximum flood estimates, downstream development controls, advantages and disadvantages concerning risk analysis, and opinions regarding the level of conservatism required for spillway design.

Dubler made the following conclusions in his thesis:

- The use of prescriptive standards for important structures usually implies adoption of the "no-risk" stance. This is inappropriate. That is not to say use of the PMP/PMF as a design criterion is necessarily inappropriate, but it is inappropriate to make that selection on the basis of "no-risk."
- It is not reasonable to have different probabilities of failure for different aspects of dam design.
- It is not reasonable to have different degrees of conservatism for different sorts of risks facing society.
- The risk analysis approach is not popular in the professional community. Perhaps this is partly because "risk" is a bad word. Perhaps we need a more appealing label, such as "balanced design."
- There are those who believe it is wrong for public policy to explicitly acknowledge that for some stated endeavor a certain degree of risk exists. The unfortunate fact is that risks do exist and accidental deaths do occur. We as a society must decide what portion of our resources we are willing to allocate to reduce such deaths. Clearly, certain expenditures involving construction or retrofitting of spillways are not justifiable. It is the moral duty of the engineer, and in fact of everyone, to make optimum use of resources.

6.5. Paxson and Harrison – 2003

In 2003, Greg Paxson and John Harrison of Schnabel Engineering, Inc. performed an independent survey of state dam safety officials as part of a technical paper entitled "Hydrology and Hydraulics for Dams: State of the Practice or Practice of States?" All 50 states were included in the study which placed an emphasis on the hydrologic and hydraulic methods and models used.

The survey revealed that a total of 76 percent of the states would allow the development of site specific PMP studies. Eighty-eight percent of the states would allow the use of incremental damage

assessment to establish the SDF. Only 43 percent would allow the use of rigorous risk-based analysis. It was noted that the allowance of these practices did not necessarily equate to their common use.

The authors of the technical paper commented that standardization of certain practices not dependent upon regional conditions would likely be beneficial to the dam safety community. Standard criteria could include approved hydrologic models, freeboard requirements, reservoir inflow and initial water surface elevation criteria for dam failure inundation analyses, and criteria for incremental damage analysis.

6.6. ASDSO Surveys

The Association of State Dam Safety Officials has performed numerous surveys of the state dam safety agencies over the past decade. Recent material includes the "State Dam Safety Dam Size Classification Schemes" and "State Dam Safety Hazard Potential Classification" which were both published in 2010 and are included in Appendix F. On an annual basis, ASDSO collects information on states' public awareness, education, staffing, training, budgets, legislation/regulations, program improvements, litigation, dam failures/incidents, dam removals, research, and other activities.

7. 2011 Hydrologic Safety of Dams Survey and Database

7.1. Questionnaire Distribution and Database Compilation

The purpose of this report is to document the present state of the practice for evaluating the hydrologic safety of dams, including inventorying current practices used by state and federal agencies. As a significant portion of this effort, a detailed questionnaire was prepared and distributed to all state dam safety agencies as well as any federal agencies which own, regulate, or assist in the design of dams. Members of the research team initially reviewed each agency's published policies and guidelines and completed applicable portions of the questionnaire. Respondents were requested to complete the survey and verify any responses initially completed by the research team. Electronic copies of the questionnaire were distributed to potential respondents in February 2011. Questionnaires were completed by respondents and returned to the research team by May 2011.

As questionnaires were returned, a member of the research team reviewed each response to ensure its accuracy and completeness. If needed, the respondent was contacted to clarify their responses. In a few cases, questionnaires were edited to create consistency between responses, thereby enabling comparison and analysis of the results. For example, when asked if the agency had hazard classification criteria, the survey allowed several responses including "Yes (High, Significant, and Low)." Several agencies responded "Yes (Other)" and commented that they utilized classification system consisting of high, moderate, and low hazards. In these cases, the terms "moderate" and "significant" were judged to be equivalent and interchangeable and the response was edited by the research team accordingly. All responses were incorporated into an electronic database which facilitated analysis of the survey results.

The questionnaire addressed many important issues related to the hydrologic safety of dams including dam classification criteria, determination of the SDF, allowable methodologies and software, consideration of future development, incremental damage assessment, use of early warning systems, current practices related to risk analysis, and agencies' ability and receptiveness to perform risk analysis. Thirteen questions were included in an "off-the-record" or anonymous portion of the survey due to their potentially sensitive nature. A copy of the survey questionnaire and corresponding answer choices is included in Appendix C.

7.2. Response

Of the 63 surveys distributed, a total of 58 were completed. Surveys were completed by the appropriate dam safety agency from all 50 states, as well as Puerto Rico, with exception of Alabama and Florida. The State of Alabama does not currently have a dam safety program and therefore did not provide a response. Florida's Dam Safety Program elected to not complete the

questionnaire due to the fact that dams within the state are regulated separately by each water management district. Each of the five districts within the state has different spillway design standards.

Of the federal agencies, respondents included:

- Bureau of Indian Affairs
- Federal Energy Regulatory Commission
- Mine Safety and Health Administration
- Natural Resources Conservation Service
- Tennessee Valley Authority
- U.S. Army Corps of Engineers
- U.S. Bureau of Reclamation
- U.S. Forest Service
- U.S. Fish and Wildlife Service

The National Park Service declined to participate. The Bureau of Land Management and U.S. Nuclear Regulatory Commission did not respond to the survey request.

Chapters 8 and 9 of this report present the key findings of this survey effort in relation to current hydrologic design practices of both the federal and the state agencies, respectively. "On-the-record" portions of questionnaires completed by respondents and finalized by the Research Team are included in Appendix C.

8. Summary of Current Federal Hydrologic Design Guidelines

8.1. Background

Historically, a few key federal agencies have led the way in developing dam safety regulations and design standards. Agencies that have typically been at the forefront of dam safety include the Federal Emergency Management Agency, Bureau of Reclamation, Army Corps of Engineers, and the Natural Resources Conservation Service. Summaries of the hydrologic design practices of these agencies are provided in this chapter. A compilation of pertinent federal publications and guidance documents are included in Appendix D. Policies of other federal agencies who responded to the Hydrologic Safety of Dams Survey are also reviewed.

8.2. Overview of Dam Classification and Spillway Design Criteria

8.2.1. Definition of Regulatory Dam

In identifying non-jurisdictional or non-inventory dams, all federal agencies other than FERC and the Mine Safety and Health Administration (MSHA) follow the definition outlined in FEMA's Federal Guidelines for Dam Safety. FEMA's guidelines specify that a dam is:

> *"…any artificial barrier, including appurtenant works, which impounds or diverts water and which (1) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or water course, to the maximum water storage elevation or (2) has an impounding capacity at a maximum water storage elevation of fifty acre-feet or more. These guidelines do not apply to any such barrier which is not in excess of six feet in height regardless of storage capacity, or which has a storage capacity at maximum water storage elevation not in excess of fifteen acre-feet regardless of height. This lower size limitation should be waived if there is a potentially significant downstream hazard"* [FEMA, 2004].

The MSHA's non-coal program area also follows these guidelines; however, for the coal program, any impoundment less than 5 feet high or less than 20 feet high with a storage volume of less than 20 acre-feet is considered non-jurisdictional. FERC considers any dam included in a FERC license to be a jurisdictional dam.

8.2.2. Dam Classifications and Selection of the Spillway Design Flood

All of the federal agencies responding to the survey indicated the use of hazard classification criteria. All of these agencies use a three-class system consisting of high, significant, and low hazard. Most of the agencies defined "Significant Hazard" as having *no potential for loss of life,*

though extensive economic losses would be expected. Under these agencies, any dam creating a hazard to human life would be classified as "High Hazard." The Bureau of Indian Affairs (BIA) definition of a significant hazard dam states that between 1 and 6 lives would be at risk or significant property damage could occur if the dam failed. USACE indicated that loss of life is "not probable" during the failure of a significant hazard dam.

The only federal agencies indicating the use of size classification criteria were the U.S. Fish and Wildlife Service (USFWS) and MSHA. Both of these agencies use a combination of hazard and size classification to determine the SDF. Most of the other federal agencies prescriptively assign the SDF based on hazard classification only. The only exceptions to this are USACE and Reclamation who are leading the way in developing spillway design criteria using risk analysis. Additionally, the BIA indicated that the use of risk analysis in connection with its prescriptive hazard classification system was acceptable.

With the exception of the Bureau of Reclamation, all federal agencies use the same criteria for both the design of new dams and the evaluation and rehabilitation of existing dams. Reclamation indicated that the application of updated design guidelines to an existing dam would vary by project after considering the amount of risk reduction, feasibility of the modification, and cost/benefit analysis results.

8.2.3. Design Criteria

By way of the 2011 Hydrologic Safety of Dams survey, several key points were identified concerning the practices of federal agencies. These are as follows:

- For PMP/PMF designs, most federal agencies determine the necessity for freeboard on a case-by-case basis. The Natural Resources Conservation Service (NRCS), TVA, and U.S. Forest Service (USFS) do not require freeboard for such designs.
- Most federal agencies either allow or encourage the use of early warning systems on Significant and High Hazard structures; however, they will not consider an early warning system as an alternative to designing a dam for the regulatory SDF. MSHA will allow storm runoff flood control dams to be designed to low hazard criteria if an early warning system is provided to prompt the evacuation of downstream personnel.
- All federal agencies permit the use of site specific PMP studies.
- The only federal agency that does not allow the use of an incremental damage assessment to establish the SDF is the TVA.
- While not all federal agencies have reviewed a risk-based design, there are no federal guidelines or regulations that forbid such designs. Federal agencies that have reviewed risk-based designs include the BIA, NRCS, USACE, Reclamation, and USFWS.

8.3. Summary of Guidelines from Select Federal Agencies

8.3.1. U.S. Bureau of Reclamation

As noted in Section 3.7, Reclamation appears to be the first federal agency worldwide to seriously apply risk-based decision making to dam safety. The Bureau began applying principles of risk analysis to dam safety as early as the 1980s. In 1985, the NRC Committee on Safety Criteria for Dams reported that while many Reclamation dams were held to the industry standard PMF, the concepts of incremental damage analysis and even the beginnings of full-fledged risk analysis (including consideration of social, environmental, and political effects of dam failure in additional to incremental damage and loss of life) were incorporated in Reclamation design criteria.

Since that time, Reclamation has moved away from deterministic design flood standards and has emerged as a major promoter of risk analysis. In utilizing risk analysis, each dam site and structure is considered individually with the SDF being determined on a case-by-case basis. Under current Reclamation practice, any modifications to spillway design capacity would follow a risk-based approach using Reclamation's Risk Analysis Best Practices Manual and would vary by project. Modifications to existing structures must consider the amount of risk reduction, feasibility of modification, and cost/benefit analysis when selecting the design criteria. Reclamation's recommended guidelines for evaluating the need and urgency to implement risk reduction activities based on the estimated risk are shown in Table 8-1 and Figure 8.1. Incremental damage analysis is used when appropriate but not required.

In 2006, Robert E. Swain, John F. England, Jr., and Kenneth L. Bullard of Reclamation published Guidelines for Evaluating Hydrologic Hazards as a guidance document for generating hydrologic hazard information to be used in evaluating the hydrologic risk at dams. This document outlines a procedure for developing hydrologic hazard curves using a combination of seven hydrologic methods. These methods include the use of flood frequency analysis with historical and paleoflood data as well as the development of a PMF using published HMR and Reclamation guidelines. Other significant contributions and guidelines that Reclamation has published over the past two decades to facilitate application of risk analysis to dam safety are noted in Section 3.7.

Table 8-1 Bureau of Reclamation Risk Reduction Guidance [Adapted from Reclamation, 2003]

Guidance for Estimated Risk	
Estimated risk is portrayed to be greater than 0.01 lives per year	Reclamation considers that there is justification for taking expedited action to reduce risk. While there is a full range of possible risk reduction actions that can be taken, Reclamation should focus on those that can quickly reduce risk or improve understanding of the uncertainties associated with the risk. As confidence increases that the risk is in this range, actions considered should concentrate more on reducing the risk than reducing the uncertainties. Any reassessment of the risk should be done prior to increased storage if at all possible, and every effort should be made to complete the reassessment within 90 days of determining the need for expedited risk reduction action.
Estimated risk is portrayed between 0.01 and .001 lives per year	Reclamation considers that there is justification for taking action to reduce risk. When the range of risk estimates falls in this range, there are a wide variety of possible actions which may be appropriate. However, the actions can be scheduled into the dam safety program and coordinated with other needs at the facility or at other facilities. Actions to reduce risks should be implemented on a schedule that is consistent with budgeting and appropriations processes. Typically, risk reduction should be accomplished within 7 years of a decision that risks need to be reduced. When there is an indicated need for risk reduction, the time spent on additional loading definition, data collection, and risk assessment should be completed in a reasonable timeframe. While it is desirable for this timeframe to be within a year, other times may be considered reasonable by decision makers based on the severity of the identified risks. Decisions on adequate time frames should be documented in appropriate decision documents.
Estimated risk is portrayed to be less than 0.001 lives per year	The justification to implement risk reduction actions or conduct additional studies diminishes as estimated risks become smaller than .001. Risk reduction action costs, uncertainties in the risk estimates, scope of consequences, operational and other water resources management issues play an increased role in decision making. Actions considered reasonable and prudent should be considered for implementation when the risk is in this range.

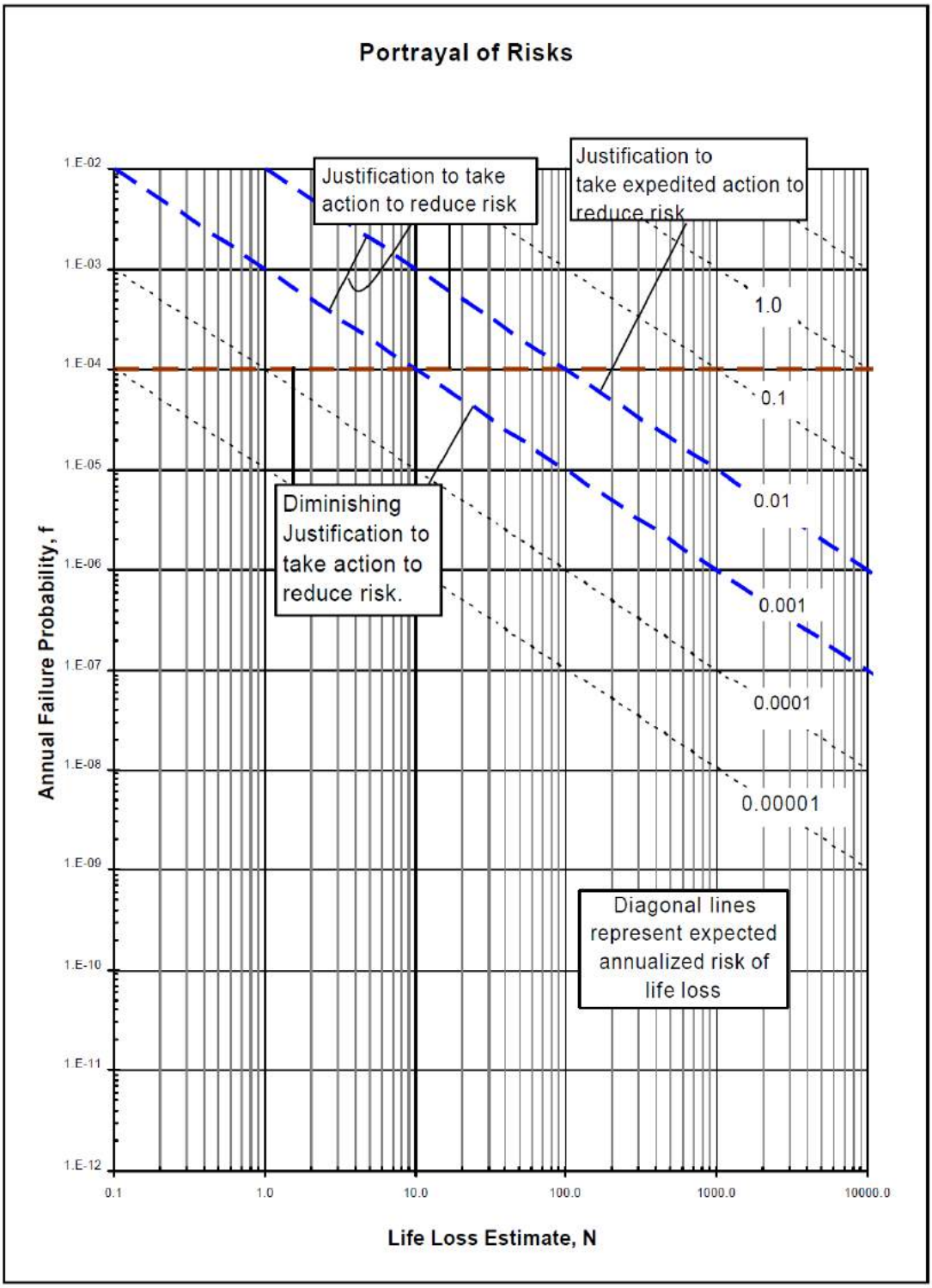


Figure 8.1 Reclamation f-N Chart for Displaying Probability of Failure, Life Loss, and Risk Estimates [Reclamation, 2003]

8.3.2. U.S. Army Corps of Engineers

The other major contributor to the development of risk-based dam safety standards in the United States has been the U.S. Army Corps of Engineers. USACE has published numerous guidance documents outlining policy and procedures related to dam safety. Under current guidelines, High hazard dams with potential life loss must pass 100% of the PMF per Standard 1 of ER 1110-8-2. Significant hazard dams with no probable life loss must pass major floods typical of the region without excessive damage or loss of operability per Standard 2 of ER 1110-8-2. Significant hazard dams with no incremental life loss due to dam failure must pass a minimum of 1/2 PMF per Standard 3 of ER 1110-8-2. Low hazard dams typically fall under Standard 4 of ER 1110-8-2 which requires rainfall-runoff probability analyses with no specific minimum requirement. These design standards are consistent with those that were utilized at the time of the 1985 NRC report.

One of the most recent USACE publications is ER 1110-2-1156 which is in draft form and is dated September 30, 2010. This publication provides an overview of the Dam Safety Program, provides guidelines and procedures for decisions, and discusses periodic assessments, inspections, and other items.

Some of the most relevant and state-of-the-art portions in ER 1110-2-1156 are the guidelines for assessing tolerable risk. The overall goal is to lower the residual risk to a tolerable level while also meeting project-specific requirements for what is practicable. The project-specific limits defined for what is practicable are termed “ALARP” which stands for “As Low As Reasonably Practicable.”

ER 1110-2-1156 presents the state-of-the-art guidelines for assessing tolerable risk including the application of the following concepts: “Tolerable Risk,” “Broadly Acceptable Risk,” “Tolerable Risk Range,” and “As-Low-As-Reasonably-Practicable” in a generalized and project specific tolerability of risk framework. A schematic illustrating these concepts is shown in Figure 8.2. Determining ALARP is ultimately a matter of judgment. General guidance is provided in ER 1110-2-1156 on how to satisfy the ALARP requirement.

The following four risk measures are evaluated under the USACE tolerable risk guidelines:

1. Annual Probability of Failure (APF)
2. Life Safety Risk
3. Economic Risk
4. Environmental and Other Non-Monetary Risk

Incremental consequences (consequences resulting from dam failure vs. consequences resulting without dam failure) are to be considered when performing quantitative risk analysis.

The USACE’s policy for the estimated annual probability of failure (APF) is that it is unacceptable to be greater than 1 in 10,000 (0.0001). An APF will be considered tolerable when it is less than 1 in 10,000 (0.0001) per year provided the other tolerable risk guidelines are met.

The USACE has identified three types of risk safety guidelines; (1) individual incremental life safety risk using probability of life loss, (2) societal incremental life safety risk expressed as a probability distribution of potential life loss (F-N chart), and (3) societal incremental life safety risk expressed as an Annualized Life Loss (ALL). For existing and new dams, the individual incremental life safety risk probability of life loss should be less than 1 in 10,000 and 1 in 100,000 per year, respectively. For existing dams the societal risk should be less than the tolerable risk limit line shown on Figure 8.3 and satisfy the ALARP requirements. Dams with failure risks that plot above a tolerable risk limit shown on Figure 8.3 are considered to have an unacceptable level of risk, except in exceptional circumstances. Annualized incremental societal life loss is evaluated based on the guidelines presented in Figure 8.4.

Risk informed hydrologic designs are permitted for flood damage reduction studies (e.g. levees, channel improvements, etc) per ER 1105-2-101. However, despite the significant efforts given to developing risk analysis for dam safety, risk-informed hydrologic designs are not permitted for dams under current USACE guidelines. Risk-informed hydrologic analyses for dams are used to prioritize risk reduction actions for dams in the USACE inventory and to inform decisions on incremental risk reduction actions for specific projects.

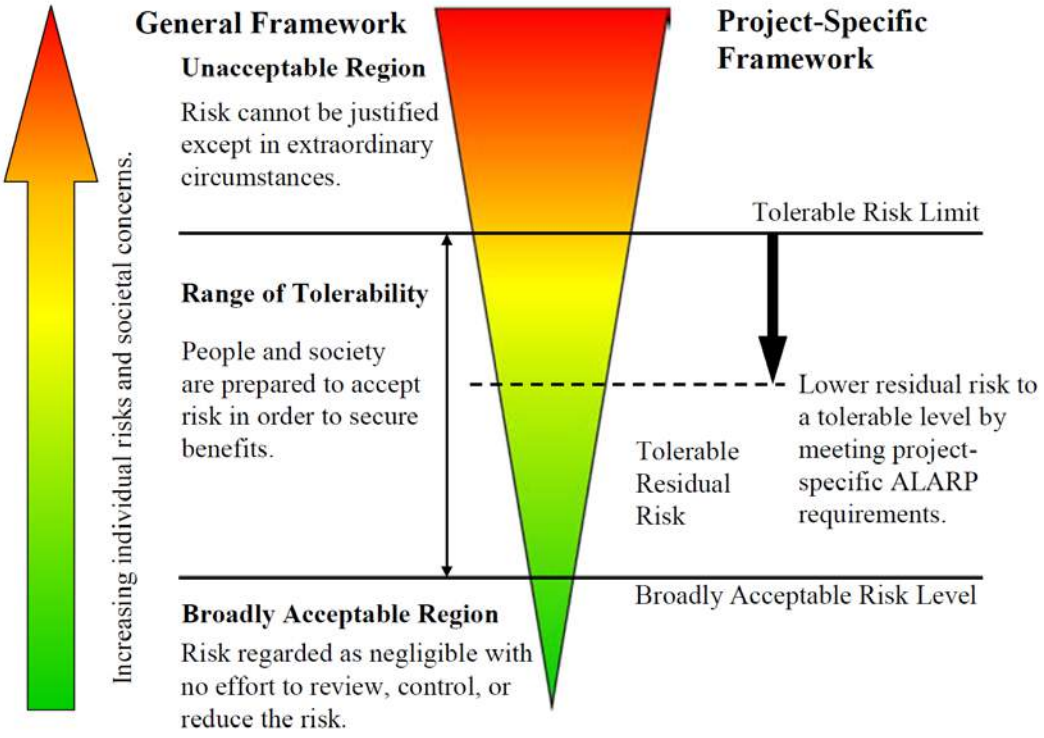


Figure 8.2 Generalized and Project Specific Tolerability of Risk Framework [USACE, 2010]

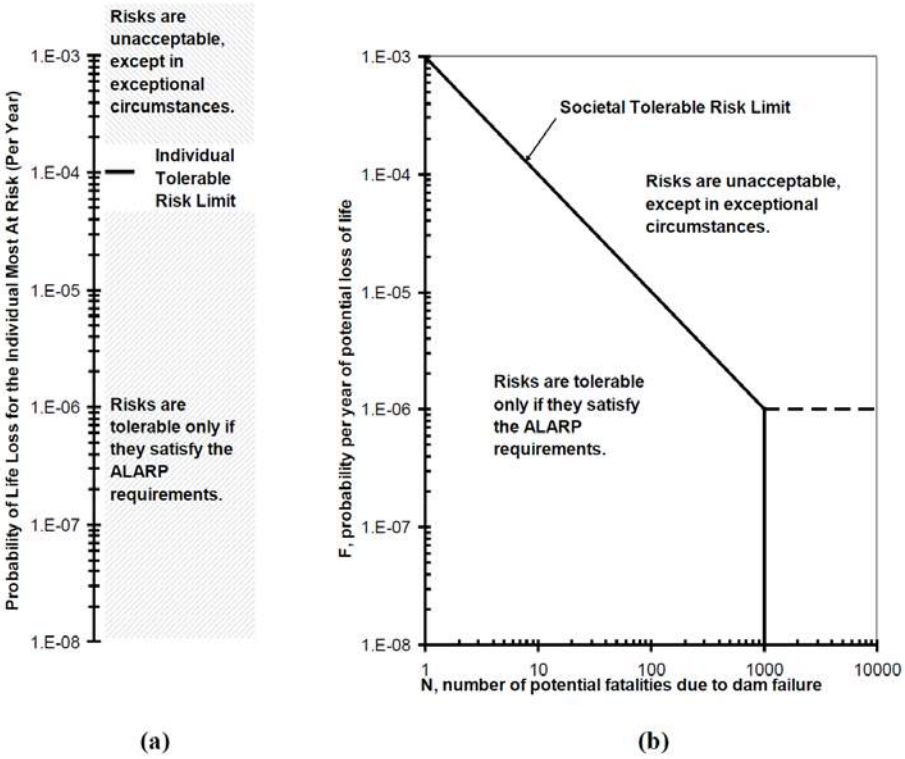


Figure 8.3 Individual Risk Guidelines (a) and Societal Risk Guidelines (b) for Existing Dams [USACE, 2010]

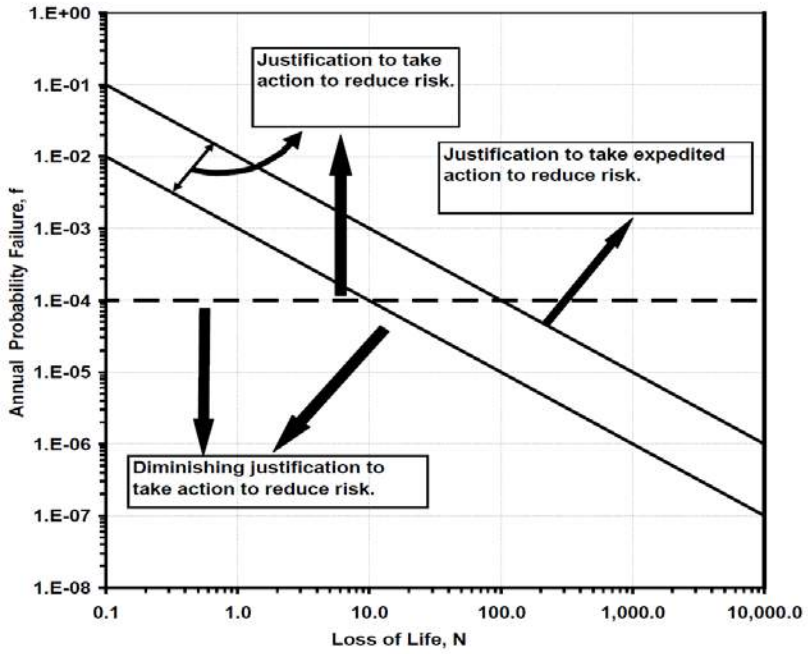


Figure 8.4 F-N Chart for Displaying Annual Probability of Failure and Annualized Life Loss [USACE, 2010]

8.3.3. Natural Resources Conservation Service

NRCS (previously known as the Soil Conservation Service or SCS) is not a regulatory agency, but rather an agency that provides financial and technical assistance to landowners and project sponsors in the evaluation, design, and installation of dams. SCS/NRCS guidelines were first developed in the 1930s. Since then the guidelines have evolved and are reviewed and updated on a continual basis. The NRCS has adopted a nationwide standard and allows state NRCS offices to revise the standards to make them more restrictive, but not less restrictive. Additionally, NRCS dams must meet all state and local regulations.

The NRCS has published numerous guidelines regarding the design and safety of dams. Technical Release 60 (TR-60) contains design requirements for earth dams and their associated spillways; National Engineering Handbook Part 630, Chapter 21 contains procedures for developing inflow hydrographs; and the National Conservation Practice Standard No. 378 contains design requirements for ponds and their associated spillways. NRCS design flood criteria from the TR-60 publication are listed in Table 8-2. These criteria are identical to those used by the NRCS in 1985 [NRC, 1985]. About 60 percent of NRCS dams are small, low hazard structures that provide water for livestock, fish and wildlife, recreation, fire control, or other related uses. Design criteria for these structures are listed in Table 8-3 as described in the National Conservation Practice Standard No. 378 for ponds.

NRCS encourages the use of a site-specific PMP where information is available. Where limiting physical site constraints exist, the NRCS does allow the use of incremental damage assessment in the rehabilitation of existing dams provided downstream land use controls are put in place to prevent voiding incremental risk assumptions [Hoeft et al, 2010]. NRCS will consider risk-based designs, but they are not a part of design guidelines.

Table 8-2 Minimum Auxiliary Spillway Capacity Criteria for Dams of the Natural Resources Conservation Service [NRCS, 2005]

Class of Dam	Product of storage X effective height	Existing or planned upstream dams	Precipitation data for [1]	
			Auxiliary spillway hydrograph	Freeboard hydrograph
Low [2]	less than 30,000	none	P_{100}	$P_{100} + 0.12(PMP - P_{100})$
	greater than 30,000		$P_{100} + 0.06(PMP - P_{100})$	$P_{100} + 0.26(PMP - P_{100})$
	all	any [3]	$P_{100} + 0.12(PMP - P_{100})$	$P_{100} + 0.40(PMP - P_{100})$
Significant	all	none or any	$P_{100} + 0.12(PMP - P_{100})$	$P_{100} + 0.40(PMP - P_{100})$
High	all	none or any	$P_{100} + 0.26(PMP - P_{100})$	PMP

[1] P_{100} = Precipitation for 100-year return period. PMP = Probable maximum precipitation
[2] Dams involving industrial or municipal water are to use minimum criteria equivalent to that of Significant Hazard Class.
[3] Applies when the upstream dam is located so that its failure could endanger the lower dam

Table 8-3 Minimum Auxiliary Spillway Capacity Criteria for Ponds of the Natural Resources Conservation Service [NRCS, 2002]

Drainage area (Ac.)	Effective height of dam[1] (Ft.)	Storage (Ac-Ft)	Minimum design storm[2] Frequency (Years)	Minimum design storm[2] Minimum duration (Hours)
20 or less	20 or less	< than 50	10	24
20 or less	> than 20	< than 50	25	24
> than 20		< than 50	25	24
All others			50	24

1. As defined under "Conditions where Practice Applies".
2. Select rain distribution based on climatological region.

8.3.4. Federal Energy Regulatory Commission

FERC guidelines for the hydrologic safety of dams are consistent with FEMA's "Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams." These guidelines emphasize hazard evaluation as the primary means of determining the SDF. This emphasis includes the use of incremental damage analysis. FERC has also used information obtained from risk-based hydrologic analysis to aid in reviewing spillway designs. Although FERC has not utilized or developed risk analysis as fully as USACE or Reclamation, they have transitioned from a very deterministic and prescriptive approach to placing increasing emphasis on risk-related practices such as incremental damage analysis. A complete summary of FERC/FEMA's guidelines is included in Section 4.12.

8.3.5. Mine Safety and Health Administration

MSHA guidelines for the hydrologic safety of dams are based upon FEMA's "Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams." As noted previously, MSHA also utilizes a size classification system in conjunction with hazard classification to determine the appropriate SDF.

8.3.6. Tennessee Valley Authority

TVA guidelines are based upon FEMA's Federal Guidelines for Dam Safety as well as self-imposed criteria that TVA has developed over time. At present, TVA regulates 49 dams. They are in the process of creating a Dam Safety Governance organization which will implement guidelines for any impoundment within the TVA system which meets the definition of a dam within FEMA's Federal Guidelines for Dam Safety.

TVA typically selects the PMF as the appropriate SDF for dams with a high hazard classification. Significant and low hazard dams must pass the "TVA precipitation" as defined by a hydrometeorological design basis report developed for TVA by the National Weather Service. This precipitation is significantly less than the PMP. These SDF criteria are very similar to those used by the Authority in 1985 [NRC, 1985].

8.3.7. Bureau of Indian Affairs

BIA has custom developed dam safety guidelines based upon those published by Reclamation. In following with Reclamation guidelines, BIA determines the SDF using a combination of risk analysis and hazard classification. Under these guidelines, the SDF is typically defined as the largest flood which will cause incremental dam failure flooding. However, BIA reserves the right to select something smaller based on downstream conditions. Normally, the IDF will not be greater than a 10,000-year storm.

8.3.8. U.S. Forest Service

Both FEMA and USACE guidelines were consulted in the development of revised USFS dam safety guidelines. It is anticipated that the new guidelines will be completed in summer 2011. With the adoption of new guidelines, the Forest Service will discontinue the use of design flood criteria based upon a combination of size and hazard classification. SDF standards will be based entirely upon hazard classification. High Hazard dams will be required to pass the PMF, significant hazard dams will be required to pass 50% of the PMF, and low hazard dams will be required to pass the 100-year flood. Incremental damage analysis may allow spillway capacity to be reduced, but not any lower than the minimum thresholds which are as follows: 50% PMF (High Hazard), 100-year event (Significant Hazard), 50-year event (Low Hazard). Other than its use of incremental damage analysis, the revised USFS guidelines do not address risk analysis.

8.3.9. U.S. Fish and Wildlife Service

USFWS owns and self-regulates over 250 dams. SDF standards for these dams are based upon a combination of size and hazard classification. SDF criteria for varying size and hazard classes are as follows: all sizes of High Hazard dams (100% PMF); large, Significant Hazard dams (50-100% PMF); small or intermediate, Significant Hazard dams (50% PMF); large, Low Hazard dams (100-year to 500-year event); and small or intermediate, Low Hazard dams (100-year event). Incremental damage analysis may allow spillway capacity to be reduced, but not any lower than the 100-year flood. The Service indicated that risk-based hydrologic designs are permitted and have been used in the past.

9. Summary of Current State Hydrologic Design Guidelines

9.1. Introduction to State Guidelines

This chapter provides a summary of current state hydrologic design guidelines based on survey results, an examination of the actual guidelines, and review of prior state and federal surveys related to design flood selection. The information available from these sources was abundant, and only the most important and relevant findings are reviewed within this Chapter. Appendix C contains the completed surveys. A compilation of pertinent state regulations and guidance documents are included in Appendix E.

9.2. Origins and Status of State Guidelines

Most state dam safety officials who responded to the questionnaire indicated that their agency utilizes some sort of hydrologic design guidelines. Such guidelines are often published in the form of state administrative code, agency regulations and guidance documents, or a combination of both. Guidelines often hold the force of law. While guidelines are typically custom suited to each state and geographic region, the majority of state guidance documents draw heavily from federal dam safety regulations and design practices. The federal guidelines most commonly utilized by the states include those of FEMA, Reclamation, USACE, NRCS, and MSHA. A summary of when states adopted SDF criteria throughout the last century is shown in Figure 9.1 and shows that most states established SDF criteria prior to 1990.

In many states, dam safety guidelines are updated or revised on either a continual or recurring basis. However, of the 49 responding states, 31 indicated that they do not have any plans to update or revise their guidelines in the near future. At least 12 of the states had not updated spillway design guidelines in more than 15 years. It is noted that some states may consider altering requirements to be unfavorable due to potential cost consequences for dam owners in compliance with previous standards, potential for weakening of the overall standards due to lobbying, or the possible perception by the public that lives downstream are not worth the cost of protection.

In following with federal programs of the 1970s and 1980s, most states use a prescriptive approach to spillway design capacity. However, in the past few decades, a few states have adopted a more detailed, risk-based approach.

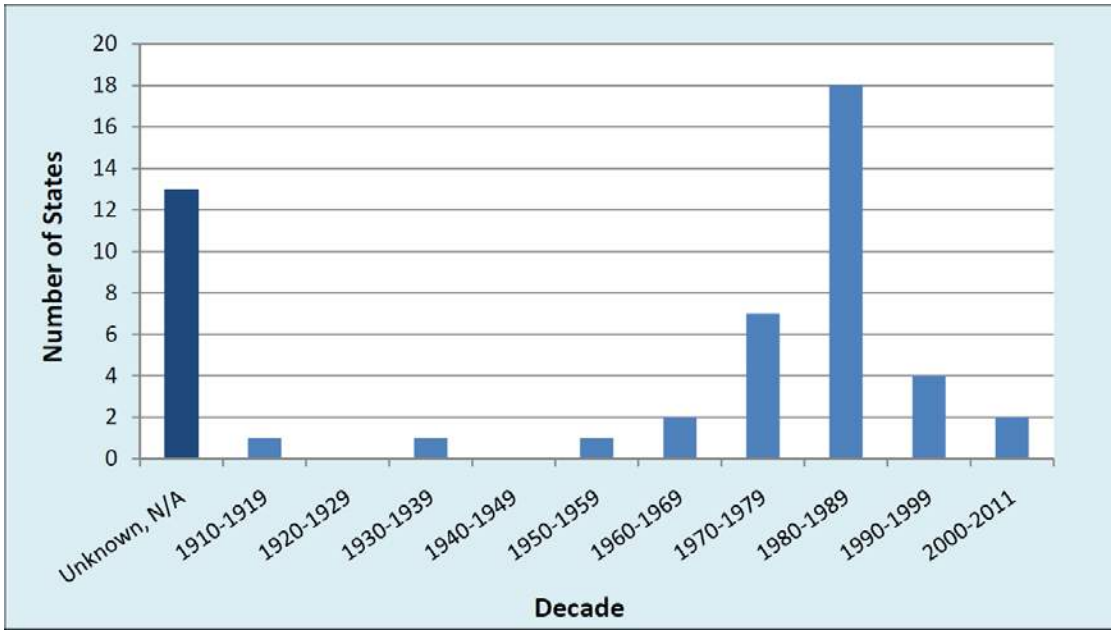


Figure 9.1 State Adoption of Spillway Design Flood Criteria by Decade

9.3. Dam Classification

States use many methods to identify and regulate dams within their jurisdiction. It appears that methods of dam classification have changed very little since the NRC's evaluation of flood design criteria in 1985. As noted in that report:

> *"There is considerable variety in the classification systems that have been adopted, and this variety often makes difficult any precise comparisons between criteria used by different agencies. Most systems for classifying dams specifically utilize dam height, volume of water impounded, and character of the development in the relevant downstream area as parameters in regard to probable effects of dam failure…*
>
> *"While it appears that many of the differences in dam classification systems are the result of arbitrary choices of regulatory authorities, it also appears that most of the classification systems have been structured to meet the perceived needs of the issuing agency or state government"* [NRC, 1985].

This broad variance of size, hazard, and other classification criteria is described in Sections 9.3.1 thru 9.3.4. Since these criteria are often used in prescribing the SDF, classification criteria is a very important aspect of the hydrologic safety of dams.

9.3.1. Regulatory Dam

The definition of a regulatory or jurisdictional dam varies greatly from one state to another. Most states determine the status of an impoundment based either loosely or entirely upon the similar

definitions outlined in both the NID and FEMA's Federal Guidelines for Dam Safety (See Section 8.2.1). A total of 92% of the states define a jurisdictional dam by considering the storage volume of the impoundment. For 88% of the states, the height of the dam is also considered. Only 27% of the states mentioned the consideration of downstream hazard potential when determining if a dam is jurisdictional. Eight percent of states regulations included the drainage area in determining the regulatory status of an impoundment.

A few exceptions were also cited in determining the status of a dam. Under these exceptions, some states have defined farm ponds, road fills that do not normally impound water, dams associated with cranberry operations, dams used for manure storage, and dams not on watercourses as non-jurisdictional structures.

In the questionnaire, respondents were asked how their agency defines a "non-inventory or non-jurisdictional" dam. It is noted that in some states these two terms are distinctly defined. These states typically maintain an inventory of many small, limited hazard dams that do not necessarily fall under their regulatory jurisdiction.

9.3.2. Size Classification

In order to prescribe design standards or other regulations related to dams, several states utilize size classification criteria. Of the 49 surveys received, 29 states indicated that they utilize some sort of size classification system (See Figure 9.2). The names, number of size categories, and range limits vary extensively throughout the country. For example, depending on the state, a small-sized dam may be identified as a Class III, Class A, Class C, or small dam.

With respect to the number of size categories, the majority of size classification systems utilized by the states have only 3 classes (typically small, medium or intermediate, and large). Six states (Georgia, Kansas, Maryland, North Carolina, Ohio, and South Carolina) use size classification systems with 4 categories (either very large or very small in addition to the typical 3-class system). Four state/territories (Montana, New York, Puerto Rico, and Wisconsin) use size classification systems with only 2 categories (typically large and small). North Dakota is the only state that indicated a size classification system with 5 categories.

Size classification of a dam is typically based upon the height of the dam, the volume of storage, or some combination or product of the two values. The height and volume ranges vary dramatically. For example, the upper limit defining a small dam range anywhere from 10 feet high to 50 feet high and 12.5 acre-feet to 10,000 acre-feet. The most common definition of a small dam is less than 40 feet high storing less than 1,000 acre-feet. The lower limit defining a large dam is also extremely varied with the height ranging between 25 to 100 feet and the storage volume ranging between 50 acre-feet and 50,000 acre-feet. The most commonly used definition of a large dam is one having a height greater than 100 feet and storage greater than 50,000 acre-feet.

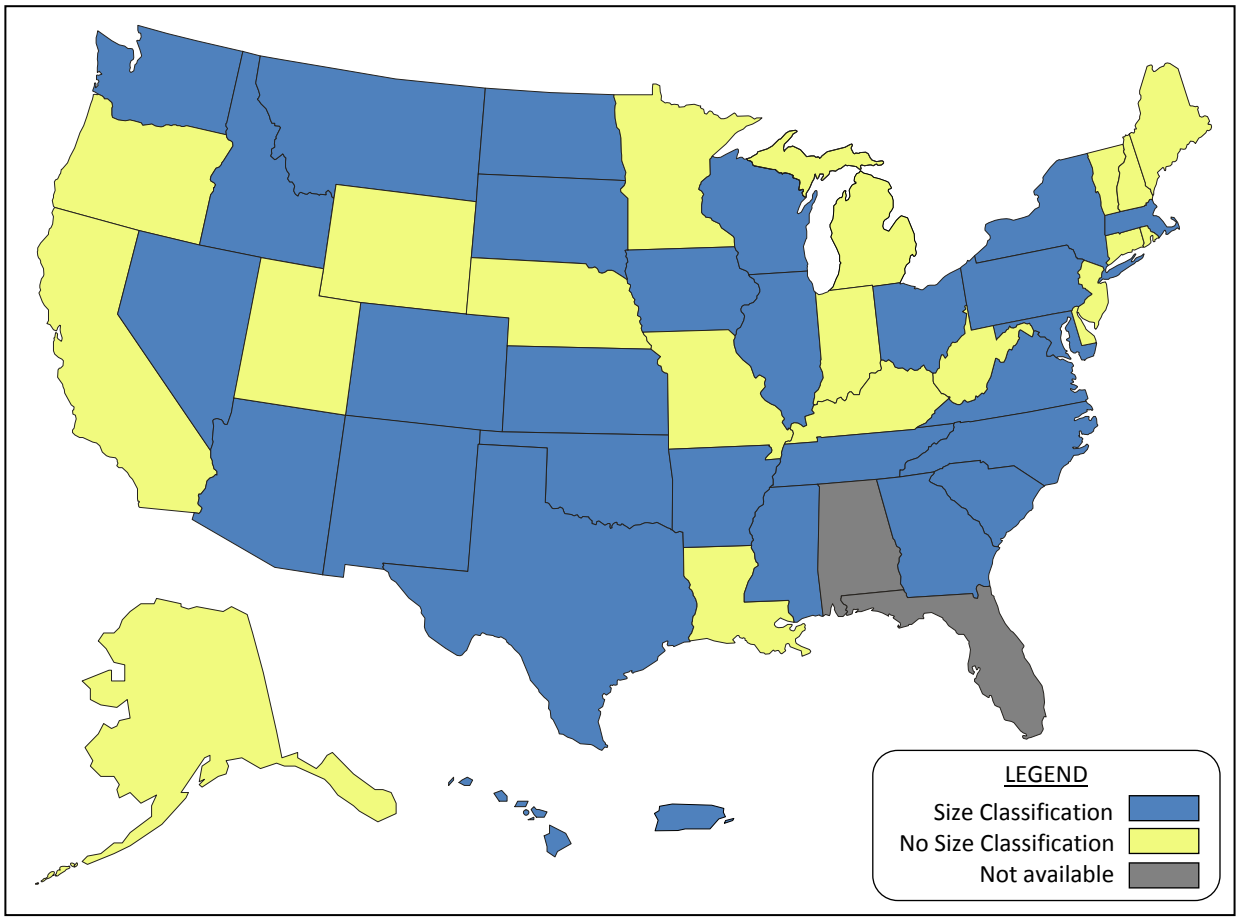


Figure 9.2 Size Classification Criteria within the United States and Puerto Rico

9.3.3. Hazard Classification

All of the states responding to the survey indicated the use of hazard classification criteria by their agency. A majority of 73% of respondents (36 states) use a three-class system consisting of high, significant, and low hazards. An additional 20% (10 states) have implemented a four-class system which typically includes a "Limited Hazard" classification below the "Low Hazard" class. Among the states using a three- or four-class system, there is a significant amount of disagreement concerning the definition of significant and high hazard dams. The key point of divergence is whether the probable loss of human life constitutes a high hazard rating. Sixty-five percent of the states have defined "Significant Hazard" as having *no potential* for loss of life, though extensive economic losses are expected. In these states, any dam creating a hazard to human life would be classified as "High Hazard." For the remaining 35% of the states, there are several ways that potential for loss of human life has been included in the definition of significant hazard. Some states define the loss of life potential as "few" or even designate a population at risk threshold for a significant hazard dam (such as 1 to 6 people or 1 or 2 habitable structures). Other states designate

that the failure or misoperation of a significant hazard dam will cause "possible loss of human life" (as opposed to "probable loss of human life" for a high hazard dam). Others state that the failure of a significant hazard dam has a "low probability" of causing loss of human life.

Georgia and Montana utilize a similar hazard classification system that is entirely based upon the likelihood of loss of human life. Dams are divided into two categories: those that will cause probable loss of life and those that will not. Connecticut is the only state to use a 5-class hazard classification system (Negligible, Low, Moderate, Significant, and High). Figure 9.3 illustrates the number of hazard classes used by each state.

9.3.4. Additional Class Distinctions

Since new spillway requirements are often more conservative, upgrading an existing dam to meet current requirements each time the criteria are changed can be costly. For this reason, many states allow a reduction of SDF or even exemption from the updated criteria for dams existing prior to adoption of the criteria. Fifty-one percent of the responding states indicated that their guidelines for new and existing dams differ. The other 49% of the states hold all dams to the same standard, regardless of when they were constructed.

In addition to distinction between new and existing dams, several states require that mine tailings and coal ash dams be held to a different design standard. Fourteen percent of the respondents stated that their guidelines include additional design criteria for such dams.

In Alaska, the protection of anadromous fish habitat has been included in the hazard potential classification system. Missouri specifies varying hazard criteria based on dam type (conventional or industrial), stage of construction, and environmental class.

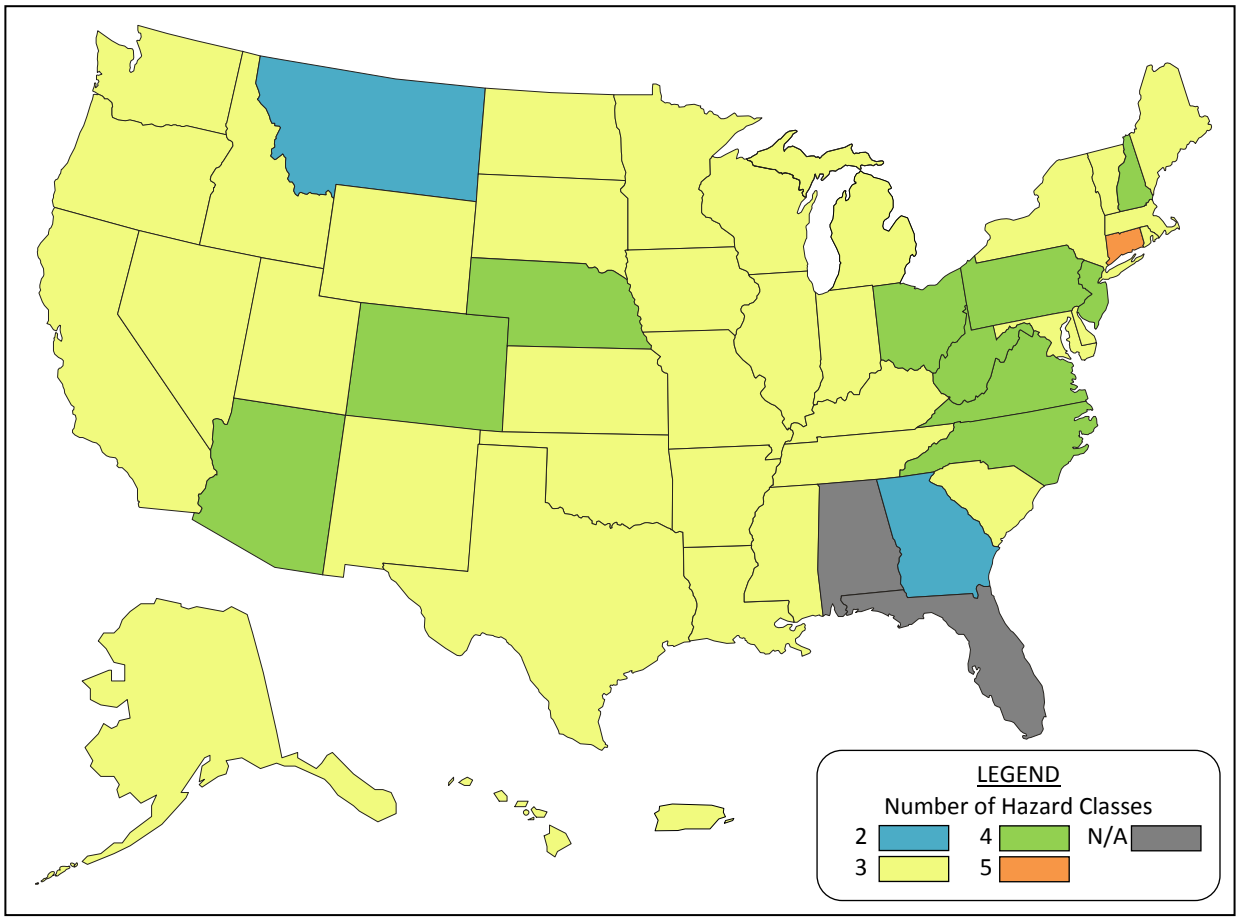


Figure 9.3 Hazard Classification Criteria within the United States and Puerto Rico

9.4. Determining the Spillway Design Flood

In determining the magnitude of the SDF, most states follow a prescriptive approach. Under a prescriptive approach, a design flood would be specified based upon the dam's classification (size, hazard, or both). Of the states using a prescriptive approach for SDF selection, most criteria are based upon either the hazard classification or a combination of size and hazard classifications. Georgia is the only state where the SDF is determined using only size classification criteria. Figure 9.4 shows a summary of each state's current approach to determining the SDF.

In the past few decades, a few states (including California, Washington, and Montana) have developed risked-based spillway design criteria. These methods are typically simpler than a rigorous risk analysis yet more complex than the typical hazard classification system. These criteria often determine the SDF using probabilistic loss of life estimates or consequence rating evaluation. The design flood in a risk-based system is often determined using a sliding scale between some lower threshold flood event and the maximum theoretical event. A few examples of such criteria are discussed in greater depth in Section 9.13 of this chapter.

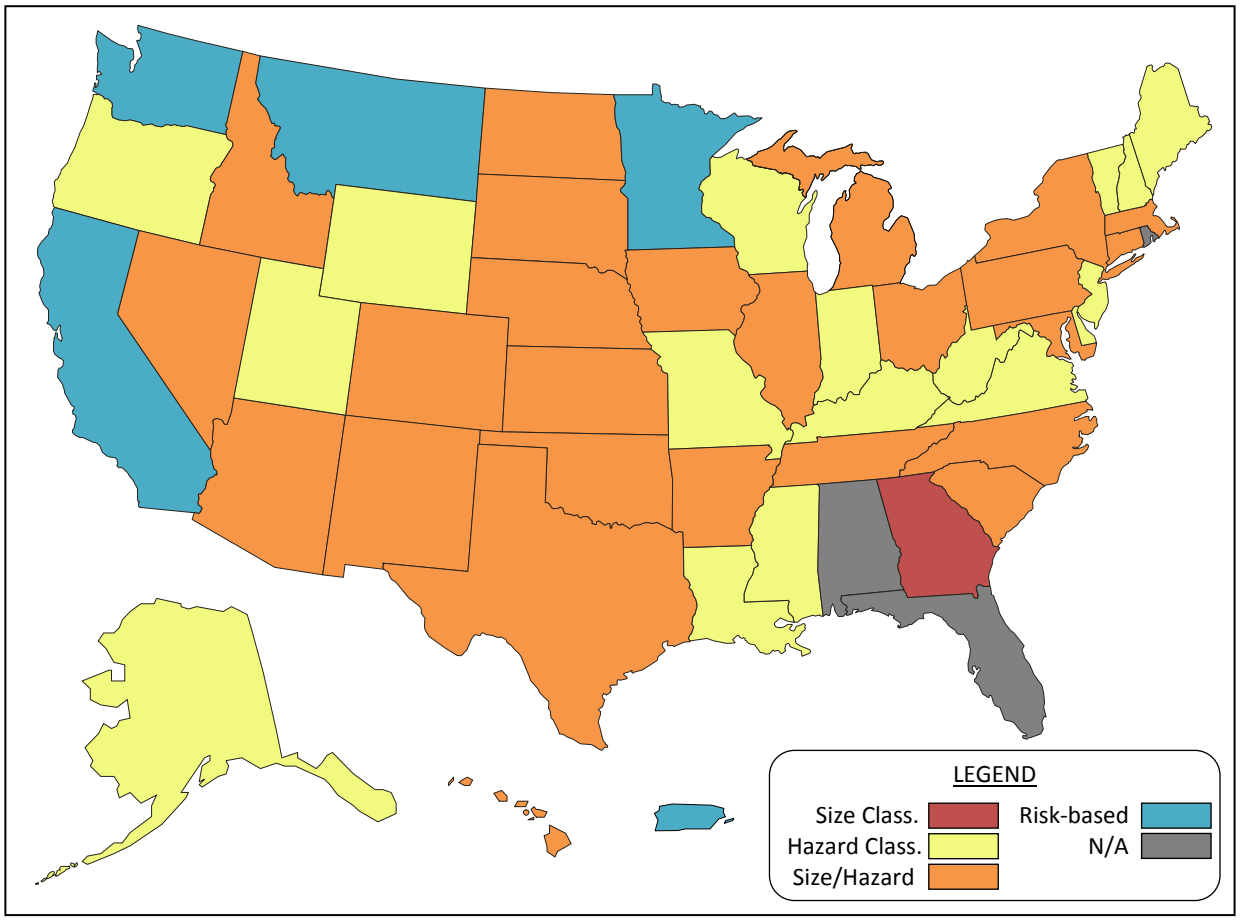


Figure 9.4 Approach to Selecting the SDF within the United States and Puerto Rico

Criteria for determining the SDF can be classified further as either probabilistic or deterministic. Probabilistic criteria are based on either floods or rainfall events which have specified probabilities or return periods. Deterministic criteria are based on PMP estimates or PMF estimates which are a derivative of the PMP. Of the states that utilize a deterministic approach, 33% define criteria with relation to the PMP while 67% are defined with relation to the PMF.

The variance in SDF criteria for new dams is significant as illustrated in Figures 9.5, 9.6, and 9.7. These figures represent the ranges of events specified by each state for low, significant, and high hazard dams. As described previously, there are many differences in the dam classification systems used by various states. In states where a High, Significant, and Low hazard rating system does not apply, classification systems were generalized to allow the comparison of SDF criteria. Also note that although probability events are shown on the figures, their plotted locations are not representative of their magnitude with relation to the probable maximum event. Tables 9-1 thru 9-3 provide additional analysis of spillway design criteria for both new and existing dams.

For new High Hazard dams, nearly half of the responding states indicated that the SDF should be no less than the probable maximum event. Eighty-two percent of the states use criteria extending up to the probable maximum event, usually dependent on size or hazard. A few states require only a fraction of the probable maximum event including Missouri (50 to 75% PMP depending on stage of construction), Colorado (45 to 90% PMP), Kansas (40% PMP), and Michigan (200-year event to 50% PMF). Wisconsin specifies that the SDF for a High Hazard dam is the 1000-year event. Idaho and Alaska specify that a SDF of 100-year magnitude is sufficient in some instances.

For new Significant Hazard dams, the range of SDF criteria is increasingly varied with acceptable design ranges stretching from the full probable maximum event down to the 100-year event. Thirteen states specify 50% of the probable maximum event as the SDF for a significant hazard dam. Several other states use the 50% mark as either an upper or lower limit.

For new Low Hazard dams, 15 states specify the 100-year event for spillway design. Eight additional states specify the 100-year event as a lower design limit. Low hazard spillway design in 11 states extends down to the 50-year flood. North Dakota is the only state allowing the 25-year event as a low hazard design event. For some large, low hazard dams, South Carolina and Tennessee require that the spillway pass the full probable maximum event. California's minimum design event is the 1000-year flood.

In Colorado, the spillway design ranges shown in Figures 9.5 thru 9.7 relate to a standard design using percentage of the PMP as developed using the appropriate HMR. Colorado has also specified SDF criteria for special cases such as high elevation dams and site specific PMP studies. For dams at elevations higher than 5,000 feet above MSL, PMP estimates can be decreased by an additional 5% or more depending on elevation [Colorado DNR, 2007].

In Virginia, the past few years have seen significant changes with regard to the hydrologic safety of dams. In response to revised regulations containing stricter hazard classification criteria, a dam owner recently led an effort to pass legislation that would provide relief to existing dam owners [Zamensky, 2010]. Multiple bills were subsequently passed. Under the new laws, the maximum design storm event to be required of existing dams is 90% of the PMP (formerly 100% of the PMP). Further reduction to 60% of the PMP was also permitted if certain conditions were met. These conditions include performing daily inspections, having an approved Emergency Action Plan, and obtaining insurance in an amount that would cover all losses due to dam failure. With regards to incremental damage analysis, the new laws also reduced the allowable lower limit of the SDF from 50% of the PMF to the 100-year flood [Commonwealth of Virginia, 2010].

Overall, it appears that current state SDF criteria for all dam hazard classes are similar to those reported in 1985 by the NRC. The following observations made in 1985 are equally applicable today:

- "Use of PMP estimates for evaluating spillway capacity requirements for large, high-hazard dams predominates, although a number of state agencies have indicated that their standards do not require that such dams pass the full estimated PMF based on the PMP.

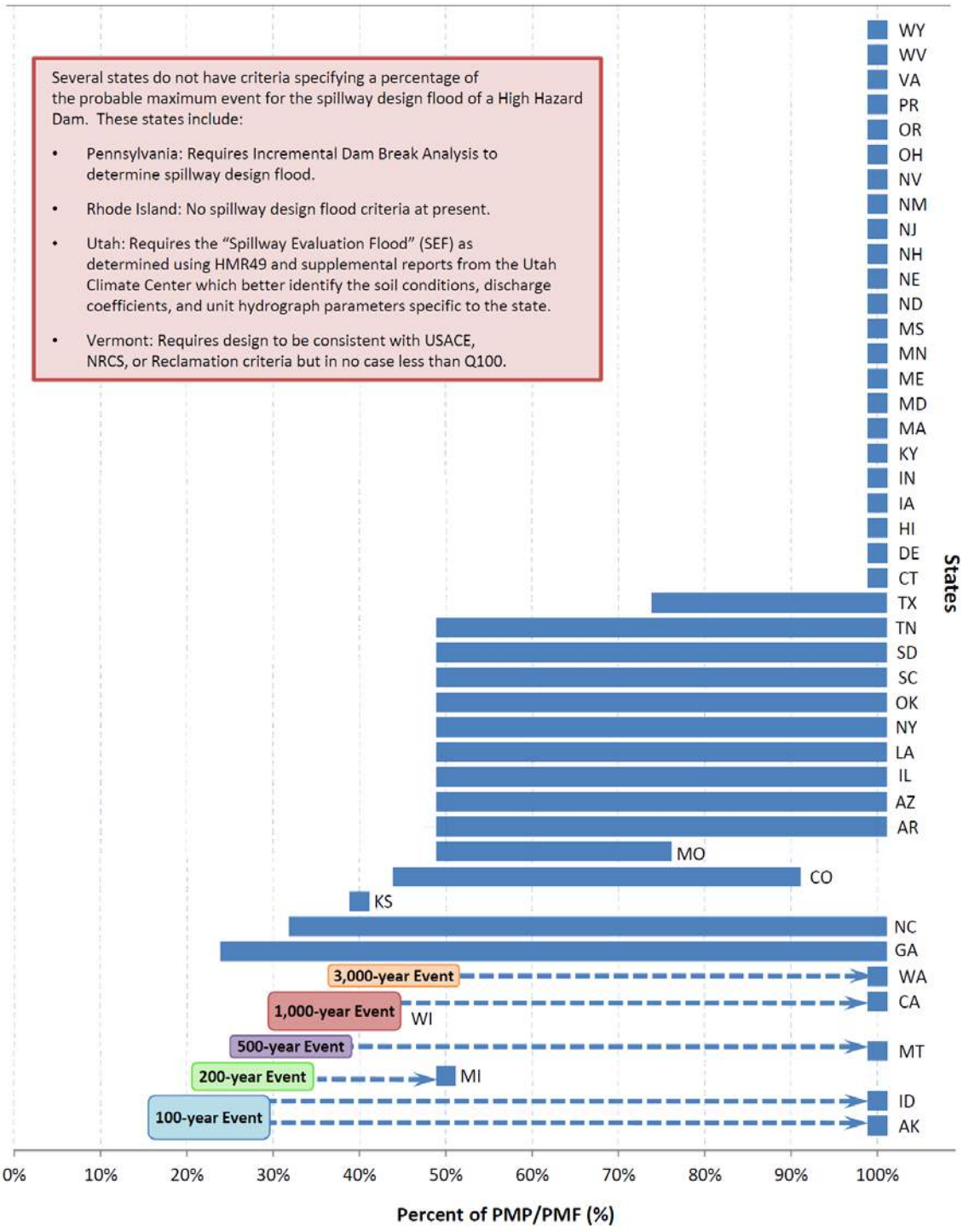
- "The influence of the practices of the principal federal dam-building agencies is evident in the majority of the standards for large, high-hazard dams, but the practices of those agencies have had less effect on current state standards for small dams in less hazardous situations.
- "Apparently as a result of the National Dam Inspection Program for nonfederal dams carried out by the Corps of Engineers in the 1977-1981 period, several state dam safety agencies have adopted the spillway capacity criteria used in those inspections.
- "Several states have adapted the standards used by the Soil Conservation Service (now NRCS) for the design of the tens of thousands of smaller dams constructed under that agency's programs.
- "Current practices include use of arbitrary criteria (such as 150 percent of the 100-year flood, fractions of the PMF, and combinations of the PMF with probability based floods) for which there is no apparent scientific rationale."

Note that the NRC's Committee on Safety Criteria for Dams questioned the use of composite criteria (combining flow frequency concepts with PMF concepts) as well as specifying percentages of the PMP, PMF, or various frequency events. "The problem with such a criterion, based on an arbitrary percentage of a derived flood or an arbitrary combination of floods developed from differing concepts, is that it permits no direct evaluation of the relative degree of safety provided." [NRC, 1985] The issue was further expounded upon in 1988 by the ASCE Task Committee on Spillway Design Flood Selection who stated:

> *"Studies by the National Weather Service indicate that the occurrence of a storm producing PMP is not equally probable nationwide. Thus, using a fraction of the PMF results in selecting a safety design flood which varies widely in exceedance probability… As long as the PMF is used to define a probable upper limit to flooding for use in a safety design, this is not a major concern. The exceedance probability of the PMF, assuming it is correctly defined, is essentially zero. When selecting a safety design flood less than the PMF, use of a fraction of the PMF produces a variation in exceedance probability that results in an inconsistent national safety standard"* [ASCE, 1988].

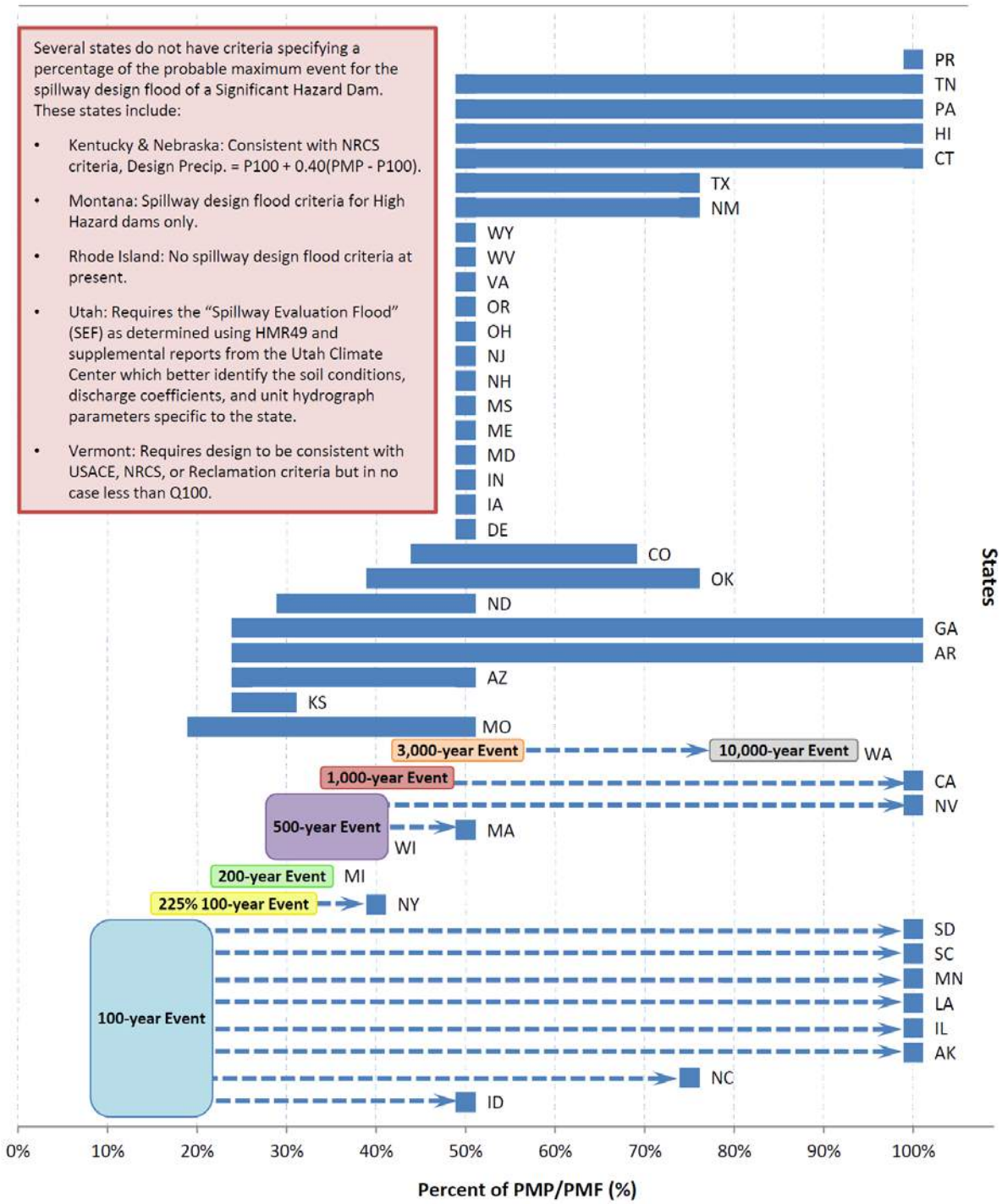
In light of technological advances which aid in calculating and assessing failure consequences, the ASCE Committee continued on to also question the practice of grouping dams based on size except for "projects too small and damages too low to warrant the expense of a specific failure analysis" [ASCE, 1988].

Although these concepts were disputed by experts in the mid- to late-1980s, the majority of state dam safety agencies continue to utilize such criteria multiple decades later. The NRC Committee did recognize that regional differences in climate, geography, and urbanization could justify differences in spillway design criteria. However, they also noted that not all criteria "could be efficient in limiting risks of dam failures to acceptable limits or in protecting the public interest" and recommended that more uniform approaches to specifying spillway capacity be considered.



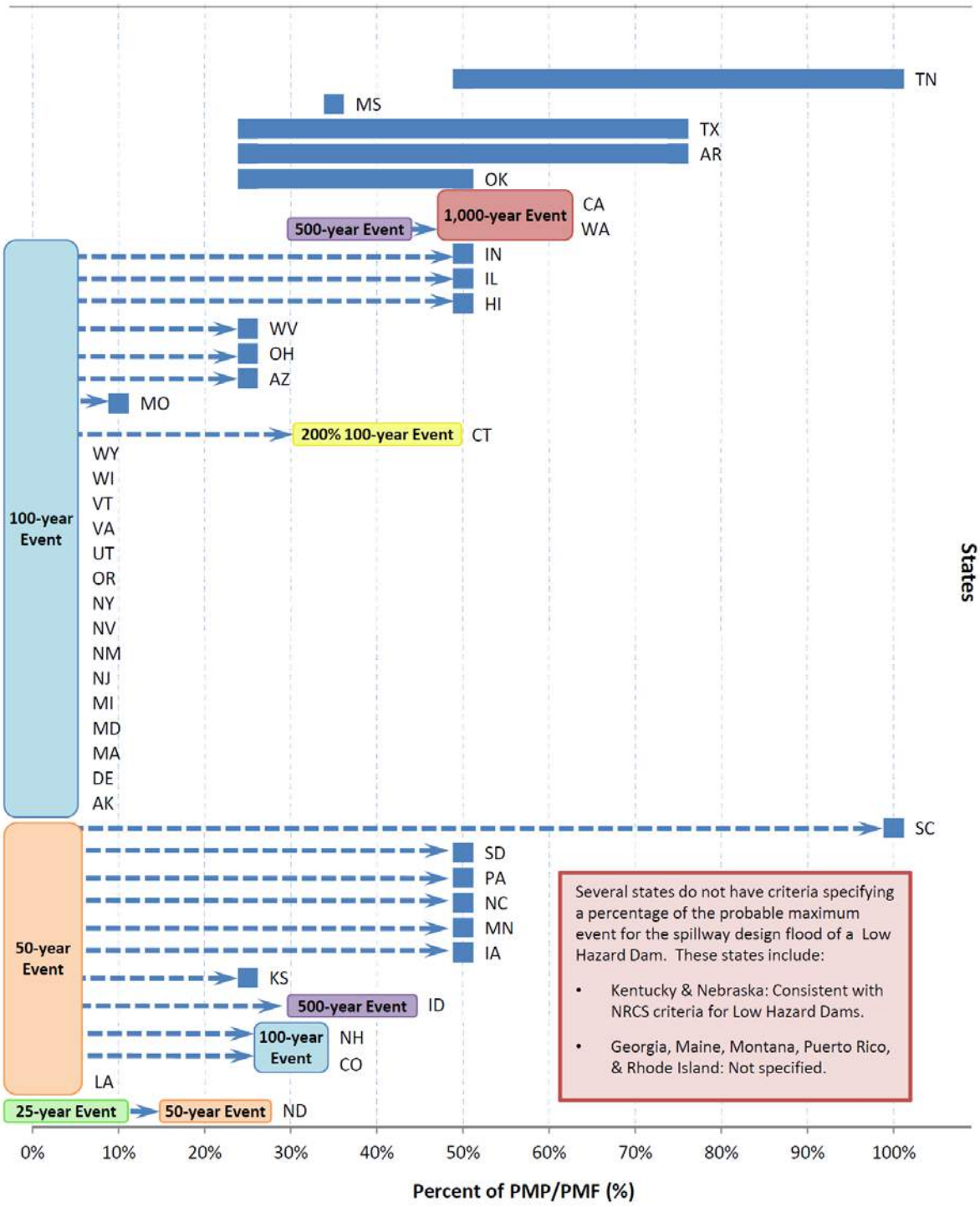
Note: For probability events (such as the 100-year flood), the corresponding percentage of the probable maximum event varies significantly in different areas of the country. The plotted location of probability events do not, therefore, represent the corresponding PMP/PMF percentage.

Figure 9.5 Range of Spillway Design Flood Criteria for New High Hazard Dams



Note: For probability events (such as the 100-year flood), the corresponding percentage of the probable maximum event varies significantly in different areas of the country. The plotted location of probability events do not, therefore, represent the corresponding PMP/PMF percentage.

Figure 9.6 Range of Spillway Design Flood Criteria for New Significant Hazard Dams



Note: For probability events (such as the 100-year flood), the corresponding percentage of the probable maximum event varies significantly in different areas of the country. The plotted location of probability events do not, therefore, represent the corresponding PMP/PMF percentage.

Figure 9.7 Range of Spillway Design Flood Criteria for New Low Hazard Dams

Table 9-1 Spillway Design Flood Criteria for New and Existing High Hazard Dams

Spillway Design Criteria	Number of States Specifying Criteria for New Dams	Number of States Specifying Criteria for Existing Dams
Requiring a Max Less Than 100% PMF	4	9
Requiring up to 100% PMF	17	15
Requiring Exactly 100% PMF	23	19
Requiring Incremental Damage Analysis	1	1
No Answer/Other*	4	5

**Includes 1,000-year event as well as recommendations to use various federal criteria.*

Table 9-2 Spillway Design Flood Criteria for New and Existing Significant Hazard Dams

Spillway Design Criteria	Number of States Specifying Criteria for New Dams	Number of States Specifying Criteria for Existing Dams
Requiring a Max up to 50% PMF	7	7
Requiring Exactly 50% PMF	13	13
Requiring Maximum between 50% PMF and 100% PMF	19	17
No Answer/Other*	10	12

**Includes 200-year event, 500-year event, 150% 100-year event, 25% PMP, 30% PMP, 40% PMP, and recommendations to use specific federal criteria.*

Table 9-3 Spillway Design Flood Criteria for New Low Hazard Dams

Spillway Design Criteria	Number of States Specifying Criteria for New Dams
Requiring Exactly 100-year Event	15
Requiring up to 100-year Event	2
Requiring up to 25% PMF	4
Requiring up to 50% PMF	9
Requiring up to 75% PMF	2
Requiring up to 100% PMF	2
Other*	9
Not Specified	6

**Includes 25-year event, 50-year event, 200% 100-year Event, 500-year event, 1000-year event, 10% PMP, 35% PMP, and NRCS criteria for low hazard dams.*

9.5. Storm Duration and Distribution

Thirty-seven percent of the states do not specify design storm duration within their hydrologic design guidelines. Of the 63% that do provide specific guidance regarding storm duration, it is typical to base the duration on the watershed's time of concentration or consider durations ranging from 6 hours to 72 hours. It should be noted that time of concentration is not the only determining factor in selecting the appropriate storm duration. For example, a reservoir with a large amount of available storage may not be significantly impacted by a short duration storm. A longer duration event yielding a larger volume of runoff could, therefore, govern the hydrologic design. Caution should be used when applying limiting or specific design criteria. Such criteria should allow for deference to a competent design engineer. The respondent in Alaska noted that hydrologic design criteria have specifically been excluded from their regulations to allow engineers to develop reasonable designs.

For the temporal distribution of the design storm, 57% of the states do not provide guidance. Of the 43% that do define the temporal distribution, about half indicate that the HMRs published by the National Weather Service should be used. Other commonly used temporal distributions include those developed by the NRCS as well as regional or custom distributions developed by the states.

One respondent noted that the duration and temporal distribution of a rainfall design event can have considerable impact on the required hydrologic design of a dam. Prior to 2005, the NRCS 6-hour design storm distribution was the basis for design of NRCS dams. The 6-hour rainfall amount and storm distribution has been used by the NRCS for over 50 years to set the top of dam and spillway requirements and is well established. Longer storm durations were considered only if the time of concentration exceeded six hours or the contributing drainage area exceeded 100 square miles. For dams with contributing drainage areas exceeding 100 square miles, the NRCS recommended that individual watershed PMP studies be performed by the NWS to take into account orographic features that are smoothed in the generalized precipitation studies.

In 2005, the NRCS revised TR-60 to require the analysis of both the 6-hour and 24-hour duration with the most critical results used for checking the discharge capacity and the integrity of the auxiliary spillway. It should be noted that although the 6- and 24-hour PMP rainfall amounts are obtained from NWS Hydrometeorological Reports, the rainfall distributions presented in TR-60 are used by the NRCS rather than the rainfall distributions presented in the hydrometeorological reports. For example, in the eastern United States, the rainfall distribution for the 24-hour duration PMP storm is not the same "critically stacked" rainfall distribution obtained using HMR-52, as it does not include critically stacking shorter duration rainfalls within the peak 6-hour rainfall. The NRCS approach to constructing the 24-hour storm is to critically stack incremental rainfall amounts of successive 6-, 12- and 24-hour durations, but distributing each 6-hour PMP depth uniformly over each six-hour period. This distribution is referred to by the NRCS as the 5-point storm distribution. The aforementioned 24-hour rainfall distribution was adopted primarily for checking the integrity

of the auxiliary spillway since it produces a greater runoff volume and longer spillway flows as compared to the 6-hour PMP storm.

A comprehensive discussion of temporal rainfall distributions for near PMP storm events for design of NRCS dams is presented in a paper by James N. Moore et al. (2001). Based on an evaluation 72 NRCS dams, use of the 24-hour 5-point rainfall distribution would require 54 percent of the dam heights to increase with 61 percent within plus or minus one foot of the 6-hour design criteria. The HMR-52 rainfall distribution would require 97 percent of the dam heights to increase with 47 percent within plus or minus one foot of the 6-hour design criteria.

Montana and Washington have developed regional precipitation-frequency analyses to determine the return period of extreme events [Fischer & Lemieux, 2010; MGS Engineering Consultants, Inc., 2009]. Nebraska has had a site-specific PMP study performed for the entire state which resulted in PMP reductions ranging from 3 to 56 percent [Applied Weather Associates, 2008].

The majority of states do not provide guidance regarding the spatial distribution of a storm. The few states that do include it in their guidelines indicate that spatial distribution should only be used in cases where the drainage area is greater than 10 square miles.

9.6. Antecedent Moisture Conditions and Initial Reservoir Pool Levels

In developing the SDF and designing the dam, initial assumptions such as antecedent moisture conditions (AMC) and the initial reservoir pool level can have a significant impact on the results. Twenty-nine of the forty-nine states (59%) surveyed do not specify or provide direction regarding either of these variables in their guidelines. Of the states that do specify antecedent moisture conditions, most use either SCS AMC-II or AMC-III criteria. Several states also have specific directives regarding the consideration of snowmelt and frozen ground conditions.

For initial reservoir pool level criteria, most states specify that normal water surface elevation be used as an initial routing condition. Others specify similar criteria such as the “lowest uncontrolled spillway inlet” or “at the crest of the spillway for permanent water storage.”

9.7. Freeboard Requirements

For a PMP/PMF design, 37% of the surveyed states do not require freeboard above the peak PMP/PMF reservoir level. The remaining states use many varying criteria based on dam type, wave run-up calculations, dam size or hazard classification, and case-by-case evaluations. The following comments from survey respondents illustrate several of these varying criteria:

- Oklahoma – “Minimum freeboard varies from 1 to 3 feet based on both hazard and size classification.”

- Illinois – Freeboard is determined on a "case-by-case basis considering many factors including duration of high water levels during the design flood, the effective wind fetch and reservoir depth available to support wave generation, the probability of high wind speed occurring from a critical direction, the potential wave run up based on roughness and slope, and the ability of the dam to resist erosion from overtopping waves."
- Iowa – "For dams with emergency spillways, the top of dam elevation after settlement shall not be less than the highest peak pool elevation reached during the freeboard design flood. For dams without an emergency spillway, the top of dam elevation shall be 2 feet higher than the peak flood elevation expected to occur during passage of the freeboard design flood, unless it is specifically designed to withstand the overflow."
- Nevada – "'Rule of thumb' is 3 feet. Wave run up calculations are preferred and required if the owner is requesting a smaller freeboard. Exceptions are tailings facilities for deposition (beach) side embankments and Storm Water detention facilities."
- Colorado – "The minimum freeboard requirements for new or enlarged dams shall be based upon the dam height required to prevent overtopping by wave action, or the sum of the IDF maximum water surface level plus 1 foot of residual freeboard, but not less than 5 feet unless the State Engineer approves a lesser amount. Except for concrete dams where the design engineer has demonstrated that overtopping of the dam will not be detrimental to the safety of the dam, the IDF can be accommodated with zero residual freeboard or the overtopping depth at which the dam still meets the stability and stress requirements of Rule 5.9.5."
- Georgia – Based on wave run up computations with a "3-foot maximum."
- New York – "One foot minimum for small dam, 2 foot minimum for large dam."

This sampling of criteria as well as the large percentage of states that do not require freeboard demonstrates the variation that exists in current freeboard criteria. It is also apparent that there is a significant variation in the level of detail required for freeboard analysis among the states.

9.8. Applicable Methodologies and Software

The majority of state agencies will allow the use of any analysis methodologies, procedures, or computer software as long as results are verifiable and applied using good engineering practice. There are, however, several states which stipulate a specific methodology (i.e. using HMRs to develop the PMP) or approved computer software (i.e. HEC applications, NWS DAMBRK, SITES, etc.). The states of Mississippi, New York, and Pennsylvania specifically do not allow the use of the rational method in any case.

9.9. Provisions for Future Development

One common issue faced by regulatory agencies is development both upstream and downstream of existing dams. Development within a watershed can cause increased runoff and peak inflows higher than those used to design a dam. In some cases, development extends into the flood pool of a structure which poses a risk to those developments.

The development of an area downstream of a dam often causes a condition called "hazard creep." Low or significant hazard dams which are oftentimes built in rural areas are reclassified as high hazard dams due to development that occurs after construction of the dam. These reclassified dams are then subject to increasingly conservative design standards and usually need to be upgraded to pass flood events of a greater magnitude.

Figure 9.8 illustrates the percentage of states that specifically require consideration of future development when determining the SDF. Note that 22 states (45%) do not require the designer to consider upstream or downstream development when designing a dam, and only 6 states (12%) require the consideration of development upstream of the dam. Sixty-nine percent of states surveyed felt that hazard creep due to development was a problem, though only twelve percent considered it a major problem.

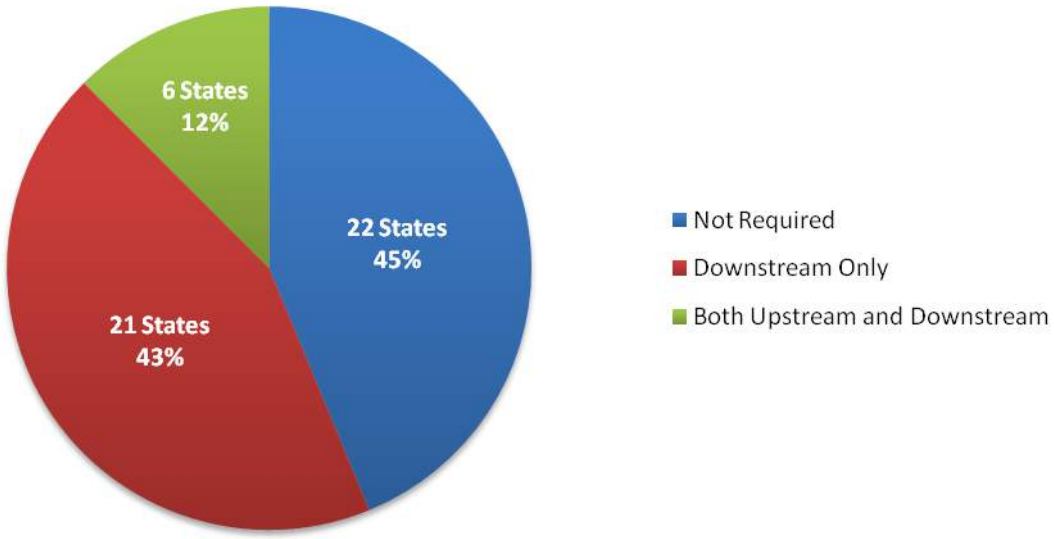


Figure 9.8 Consideration of Future Development for Spillway Design Flood Criteria

In Illinois, Delaware, and New Jersey, all Low and Significant Hazard dams must incorporate alternatives in the proposed design for increasing the total spillway capacity if the downstream hazard potential increases. Future downstream land use, land use controls, and growth projections are considered in the review of the spillway capacity design.

9.10. Early Warning Systems

When asked if an early warning system would be considered as an alternative to designing a high hazard dam for the regulatory SDF, the majority of states indicated that such an alternative would not be acceptable. Many noted that a safe design should be passive and not require significant maintenance or operation. Of the 10 states that would consider this as a viable alternative, most

required significant justification and additional protective measures to be included with the early warning system. Most of these agencies would only consider this as an alternative for existing dams or as a temporary solution until structural modifications are made.

In 1995, Dubler asked state dam safety officials a similar question and found that about 15 states would allow the use of an early warning system on a case-by-case basis. This indicates a slight trend away from the use of these systems over the past 15 years.

9.11. Incremental Damage Analysis

As described in Chapter 3, incremental damage analysis is a comparative hazard approach that creates a compromise between the desire to provide a risk-based analysis of the benefits gained from mitigating the hazard and the traditional approach of requiring a design capable of safely passing the PMF. Of the responding states, 67% indicated that they allow the use of incremental damage analysis to establish the SDF (See Figure 9.9). A few allowed this type of analysis only in evaluating existing dams. Of those who allow incremental damage analysis, less than half require that future downstream conditions within the dam failure inundation zone be considered in the incremental damage analysis.

It is interesting to note that in the survey performed in 2003 by Paxson and Harrison, 88% of survey participants responded that their state would allow incremental damage analysis as opposed to 65% in 2011. The reason for this discrepancy is unknown; however, the 2011 response seems to correspond more closely to Dubler's 1995 survey in which 59% of respondents indicated that incremental damage analysis was utilized. In any case, it appears that the use of incremental damage analyses has become more common in the past decade.

Since incremental damage analysis is typically used to decrease the SDF, some states place a minimum limit on the SDF regardless of downstream consequences. Eighteen states indicated that they have restrictions or guidelines on the use of incremental damage assessments or risk analyses. Table 9-4 summarizes most of these criteria.

While most states perform incremental damage analysis in the downstream dam failure inundation zone to establish the magnitude of the SDF, some have also applied the concept to the mitigation of flooding due to spillway discharge. This would apply in situations where gate operators or fuse plugs provide the dam owner some control over spillway discharge. In Arizona, spillways are required to be constructed in a manner that avoids flooding in excess of that which would have occurred under the same conditions before construction. Other states have expressed similar interest in regulating flooding due to spillway discharge.

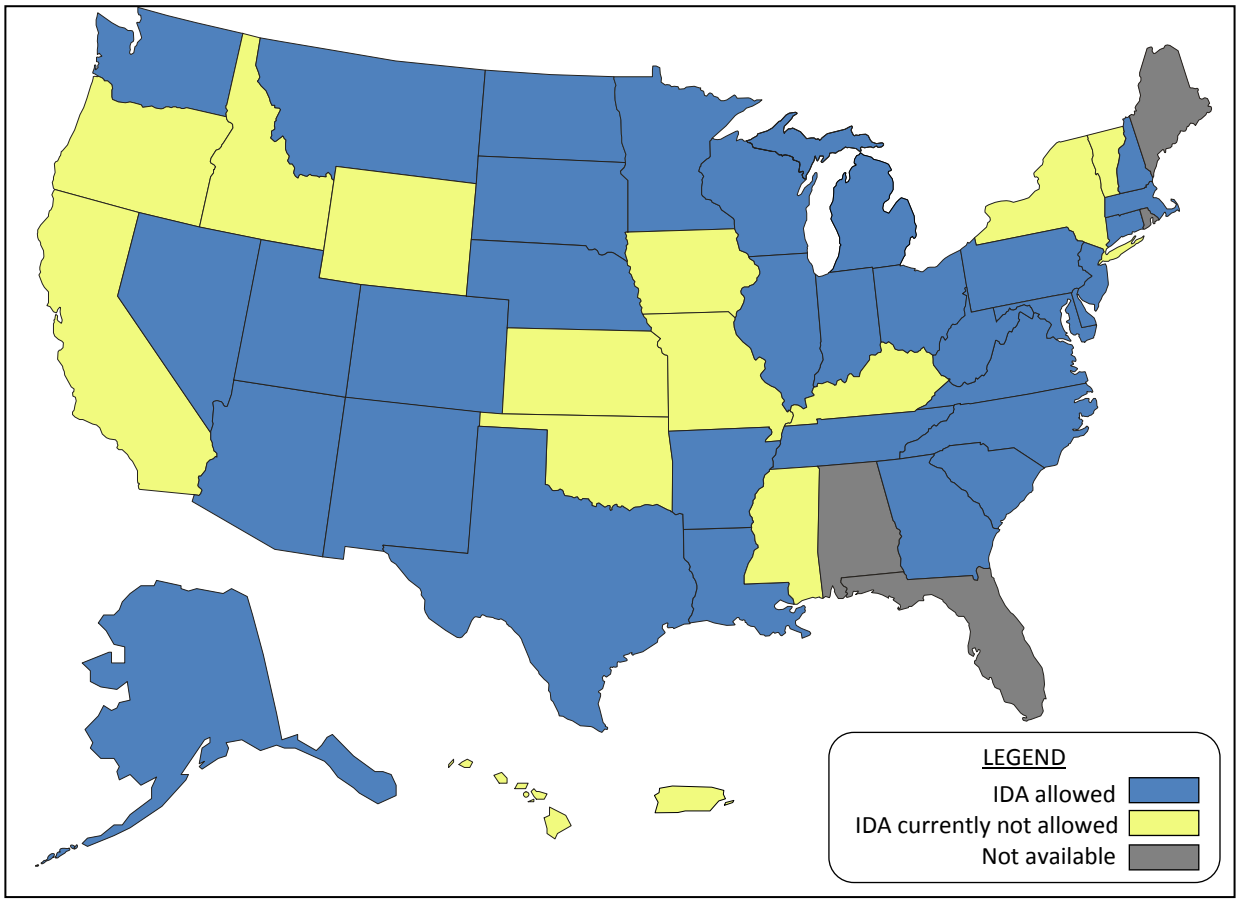


Figure 9.9 Use of Incremental Damage Analysis in the United States and Puerto Rico

Table 9-4 Minimum Design Event when Incremental Damage Analysis is Applied

Criteria	States Using this Criteria
Minimum SDF: 100-year flood (High and Significant Hazards); 50-year Flood (Low Hazard)	VA
Minimum SDF: 100-year frequency flood or storm event	AK, CO, DE, IL, NC, NJ, NM, NV, PA, SD, UT
Minimum SDF: 200-year flood or flood of record, whichever is greater	MI
Minimum SDF: 40% PMF (High Hazard); 20% PMF (Significant Hazard); 100-year flood (Low Hazard)	OH
Minimum SDF: 50% PMP (High Hazard); 100-year flood (Low Hazard)	IN
Minimum SDF: 70% PMP (High Hazard); 25% PMP (Significant Hazard); P100 (Low Hazard)	WV
SDF can only be reduced by up to 10%	GA

9.12. Provisions for Developing Site Specific PMP

The practice of developing a site specific PMP for a dam design is allowed in 32 states (65%). It is restricted in 6 states (12%). Permission to perform a site specific study in the remaining 11 states (22%) has never been requested (See Figure 9.10). It is important to note that of the 32 states allowing site specific PMP studies, more than half (17 states) have no guidelines, requirements, or restrictions regarding this practice.

Those that do have guidelines, requirements, or restrictions utilize a variety of criteria. Several states require a site specific design to pass through special levels of review or even be overseen by a board of consultants. Mississippi will only consider a site specific study if the drainage area is greater than 10 square miles. New Jersey only allows the use of site specific PMP's for existing structures. Colorado has a completely separate requirements matrix for site specific analyses. Using this guideline, a dam is required to pass a higher percentage of the site specific PMP/PMF than is required if the SDF has been developed following the HMR approach.

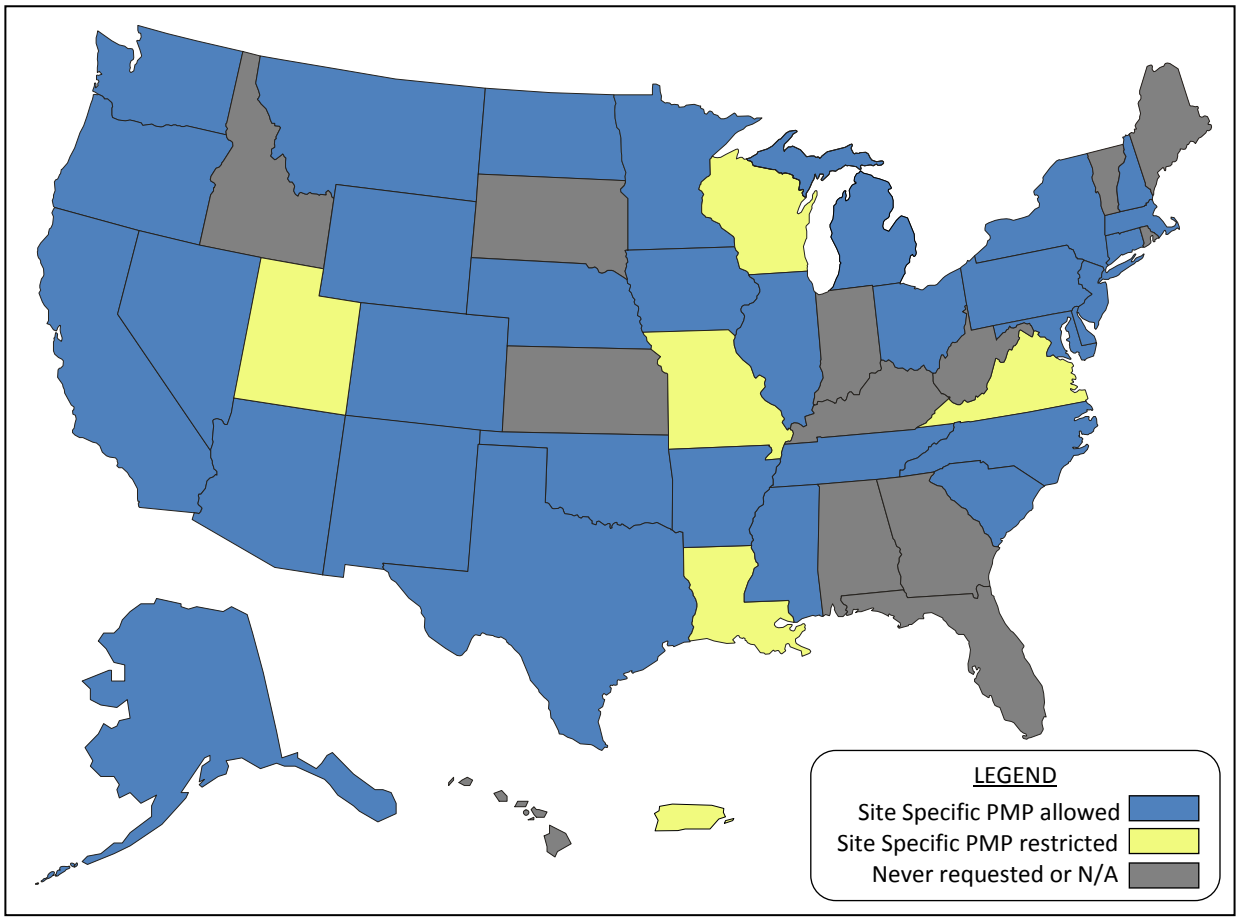


Figure 9.10 Use of Site Specific PMP Studies in the United States and Puerto Rico

9.13. Risk-based Criteria

Within the 1988 report published by ASCE, the Task Committee on Spillway Design Flood Selection concluded that the only standard which "could be applied consistently both today and in the future would be a selection based upon a site-specific evaluation of the likelihood of failure and the social, economic, and environmental consequences of failure – a quantitative risk assessment. A quantitative risk assessment provides the decision maker at each level of the decision making process – the engineer, the dam owner, and the regulator – with the information needed to select a safety design flood" [ASCE, 1988]. States tend to look toward the federal agencies to initiate changes in regulations, and the majority of federal agencies have made policy shifts toward the use of risk analysis (See Chapter 8). The level of acceptance continues to be greatly varied. It appears that the Bureau of Reclamation has fully embraced the use of quantitative risk analysis for the hydrologic design of dams. Several other state and federal agencies are taking a more gradual approach to adopting risk-based designs. In these agencies, the use of incremental damage analysis is a common way to introduce components of risk analysis into design criteria. It should be noted that the establishment of any guidelines introduces some sort of risk assessment. States that currently base dam design standards on size or hazard classification systems are effectively performing very generalized and informal risk analysis.

9.13.1. Current Use of Risk-based Criteria by the States

Of the 49 states surveyed, 15 (31%) indicated that they permit or review risk-based designs. Seven states (14%) indicated that risk-based designs are either forbidden by regulation or will not be considered due to administrative decision. The remaining 27 states (55%) indicated that their regulations do not specifically address the topic of risk analysis and it has never come up for consideration.

The same question regarding risk-based hydrologic designs was asked in Dubler's survey. In 1995, 43% indicated that they either permitted or reviewed risk-based designs on a case-by-case basis. The 2003 survey by Paxson and Harrison also indicated that 43% of states would allow the use of risk-based analysis. This decrease indicates that over the past decade, a number of states have stopped allowing the use of risk analysis. Chapter 10 provides a discussion of several trends which may have caused this reduction in the allowance of risk analysis.

In contrast to the current trend, a few states have dedicated significant resources over the past 30 years to develop risk-based design criteria for dams. Generally speaking, these risk-based guidelines do not comprise rigorous or quantitative risk analysis. Rather, they incorporate both principles of risk with some sort of hazard classification or consequence rating system. The design flood in a risk-based system is often determined using a sliding scale between a lower threshold flood event and the maximum theoretical event. California, Washington, and Montana each have unique risk-based criteria for the hydrologic design of dams.

9.13.2. California

In 1981, the State of California became the first state to adopt a risk-based methodology that could be applied to any spillway in the state [Calzascia & Fitzpatrick, 1987]. One challenge of devising such a method is that it must be able to be applied both rationally and consistently across a broad range of dam types and sizes. Under this methodology, a dam's hazard classification is determined by considering reservoir capacity, dam height, estimated number of people evacuated in anticipation of failure, and potential downstream damage.

> *"Each factor is categorized as low, moderate, high or extreme. The method produces a composite numerical rating termed the Total Class Weight (TCW)… With this system, small remote dams generally have a TCW of 2, while large urban dams might have a TCW of 36. The capacity of the reservoir and height of the dam are clearly defined. Estimated evacuation and potential downstream damage are uncertain and require an investigation of the potentially flooded area. This investigation includes estimating the population at risk, the possible loss of life, the physical property damage, the social consequences and the environmental impact. Through application to the many dams under its jurisdiction, [California's Division of Safety of Dams] has developed a coherent and uniform approach to conducting the damage investigations so that consistent total class weights are found"* [Calzascia & Fitzpatrick, 1987].

Figure 9.11 illustrates the weighting system used in California to determine the TCW. California considers the TCW criteria as an adequate assessment of risk; therefore, they do not allow the use of quantitative risk analysis. Once the TCW has been determined, the appropriate design storm is selected.

> *"The minimum allowable design event required is a 1000 year storm which corresponds with a TCW of 4. The maximum event is a storm derived from the Probable Maximum Precipitation and is equated with a TCW of 30. The design event is interpolated between these limits at the computed TCW"* [Calzascia & Fitzpatrick, 1987].

By applying these risk-based criteria, less than 8% of California's dams are required to pass the full PMF [Calzascia & Fitzpatrick, 1987].

DAMAGE POTENTIAL CLASSIFICATION FOR

FLOOD ESTIMATE AND SPILLWAY ANALYSIS

Name of Dam _____ Type of Dam _____Dam No. _____

County _____ Located on _____

	Damage Potential Rating			
	Extreme	High	Moderate	Low
Capacity _____ AF	100,000 & Over	1,000-99,999	100-999	15-99
(circle weight)	6	4	2	0
Height _____ Ft.	150 & Over	100-149	50-99	6-49
(circle weight)	6	4	2	0
Estimated Evacuation _____	1,000 & Over	100-999	1-99	None
(circle weight)	12	8	4	0
Potential D/S Damage	High	Moderate	Low	None
(circle weight)	12	8	4	0

Total Class Weight _____

Figure 9.11 Total Class Weight and Hazard Potential Classification in California [Calzascia & Fitzpatrick, 1987]

9.13.3. Washington

In 1990, Washington State adopted an approach to dam safety that "can be characterized as employing risk concepts in a standards-based framework" [Johnson, 2000]. The state's approach utilizes what it calls the "Design Step Format." Under this format, a range of failure consequences are divided into 8 steps. For Design Step 1, the annual exceedance probability of the design event is 1 in 500. This step would apply "when the downstream consequences of a dam failure would be minimal and there would be no potential for loss of life" [Washington State Department of Ecology, 1993]. In situations where the consequences of failure would be "catastrophic," the theoretical maximum design event (PMP/PMF) is applied under Design Step 8. This maximum theoretical event is assumed to have an annual exceedance probability of 10^{-6}. In order to utilize probability-based hydrologic events, Washington has performed regional precipitation-frequency analyses to determine the return period of extreme events.

Table 9-5 outlines the range of consequence rating points assigned to several hazard indicating parameters. Using a cumulative total of consequence rating points, the designer can determine both the design step and the required annual exceedance probability for design as shown in Figure 9.12. This annual exceedance probability will apply to all aspects of the dam design (hydrologic, seismic, etc.) in an effort to provide "balanced protection." Table 9-6 relates the Washington State's design step criteria to typical downstream hazard classifications.

By adopting this approach to dam safety, the state has been able to apply risk concepts in a format that is fairly simple and easy to use. A similar ranking system has been applied to evaluate existing dams, thus allowing a prioritization of compliance efforts. "Of the 46 dams inspected under the National Dam Inspection Program still listed as unsafe in 1990, 40 had been repaired by 1999 [under this standard]. In addition, 78 of the 101 additional dams identified by the state dam safety program since 1985 have been repaired" [Johnson, 2000].

Table 9-5 Numerical Rating Format for Additive Weighting Scheme for Assessing Consequences of Dam Failure [Adapted from Washington Department of Ecology, 1993]

Consequence Categories	Consequence Rating Points	Indicator Parameter	Considerations
CAPITAL VALUE OF PROJECT	0 – 150	DAM HEIGHT	Capital Value of Dam
	0 – 75	PROJECT BENEFITS	Revenue Generation or Value of Reservoir Contents
POTENTIAL FOR LOSS OF LIFE	0 – 75	CATASTROPHIC INDEX	Ratio of Dam Breach Peak Discharge to 100-Year Flood
	0 – 300	POPULATION AT RISK	Population at Risk Potential for Future Development
	0 – 100	ADEQUACY OF WARNING	Likely Adequacy of Warning in Event of Dam Failure
POTENTIAL FOR PROPERTY DAMAGE	0 – 250	ITEMS DAMAGED	Residential and Commercial Property
		OR	Roads, Bridges, Transportation Facilities
		SERVICES	Lifeline Facilities Community Services
		DISRUPTED	Environmental Degradation from Reservoir Contents (Tailings/Wastes/etc.)

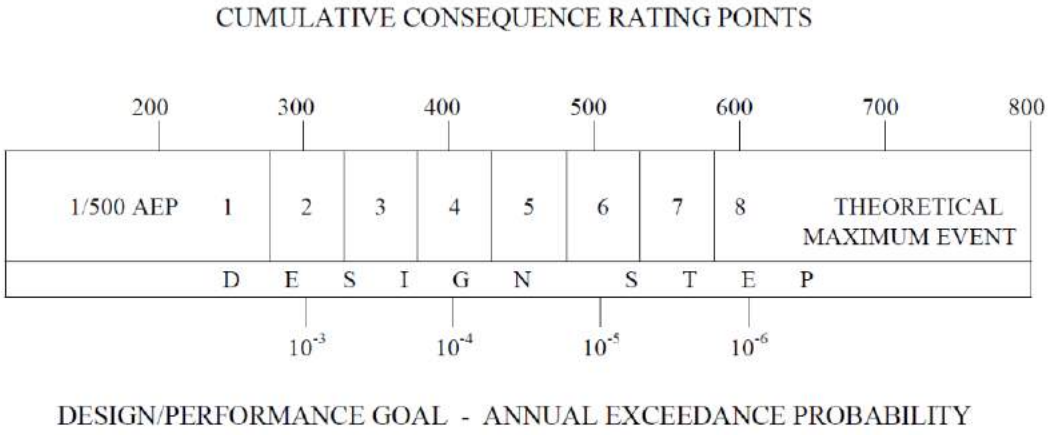


Figure 9.12 Design Step Format and Consequence Rating Points [Washington Department of Ecology, 1993]

Table 9-6 Relationship of Design Step to Downstream Hazard Classification [Adapted from Washington Department of Ecology, 1993]

Downstream Hazard Potential	Downstream Hazard Classification	Population at Risk	Economic Loss	Environmental Damages	Typical Design Step
LOW	3	0	Minimal: No inhabited structures; Limited agriculture development.	No deleterious materials in reservoir	1 – 2
SIGNIFICANT	2	1 to 6	Appreciable: 1 or 2 inhabited structures; Notable agriculture or work sites; Secondary highway and/or rail lines.	Limited water quality: Degradation from reservoir contents and only short term consequences	3 – 4
HIGH	1C	7 to 30	Major: 3 to 10 inhabited structures; Low density suburban area with some industry and work sites; Primary highways and rail lines.	Severe water quality: Degradation potential from reservoir contents and long term effects on aquatic and human life	3 – 6
HIGH	1B	31 to 300	Extreme: 11 to 100 inhabited structures; Medium density suburban or urban area with associated industry; property and transportation features.		4 – 8
HIGH	1A	More than 300	Extreme: More than 100 inhabited structures; Highly developed, densely populated suburban or urban area with associated industry, property, transportation, and community life line features.		8

9.13.4. Montana

Prior to 1999, Montana's Dam Safety Rules established spillway design criteria based on dam height and storage. After recognizing that the required spillway capacity was disproportionate to the level of downstream development, the state developed new hydrologic design criteria based upon estimated loss of life (LOL). Similar to Washington State, Montana has performed regional precipitation-frequency analyses to determine the return period of precipitation events having recurrence intervals up to 5,000 years [Fischer & Lemieux, 2010].

LOL estimates are obtained by considering three factors: 1) PAR or population occupying the area inundated by a dam failure flood, 2) the warning time given to PAR exposed to the resultant flood wave, and 3) the severity of the flood. In general, LOL is significantly less than PAR. The Montana DCNR publication titled "Technical Note 2, Loss of Life Determination for Spillway Capacity Analysis" describes in detail how to calculate LOL.

> *"If the estimated LOL is equal to or less than 0.5, the minimum IDF is the 500-year recurrence interval… If the LOL is greater than 0.5 and less than or equal to 5, the minimum IDF recurrence interval is determined by multiplying the LOL by 1,000* (i.e. a dam with estimated LOL of 2 would be required to pass the 2,000-year flood event)… *If the LOL is greater than 5 and less than 1,000, the precipitation depth for determining the IDF is calculated with equations that effectively interpolate between depths for the 5,000-year storm and the PMP... The IDF for an LOL greater than or equal to 1,000 is the probable maximum flood, or PMF. The PMF is runoff produced by the PMP"* [Hydrometrics, Inc., 2008].

Montana's SDF determination process is illustrated by a flowchart in Figure 9.13.

9.13.5. Inconsistencies with Current Risk-Based Criteria

Within the past few decades, the use of risk analysis and risk-based design criteria has increased. The methodologies developed by California, Washington, and Montana reflect a growing desire for site-specific, cost-effective, and risk-based designs. They also demonstrate how the complexities of risk analysis can be applied in a simplified, standard-based system. Due to a lack of resources and staff in many state dam safety offices, such simplification would likely be necessary if broad application were to be successful. There is also a general lack of region-specific precipitation-frequency analyses, thus making it difficult for states desiring to adopt risk-based criteria to assign annual exceedance probabilities to extreme events.

Perhaps the most apparent observation regarding these recently developed, risk-based approaches is the lack of both consistency between the states as well as defensible risk tolerance criteria. California's weighting criteria are based entirely on the storage volume and height of the dam, the estimated evacuation, and potential downstream damage. Washington's consequence rating points are determined based on similar criteria (capital value of project, potential for loss of life, potential for property damage); however, in Washington's system, loss of life accounts for 50% of the entire

design weight while it accounts for only 33% of the total weight in California. Montana alternatively bases the design entirely (100%) on potential loss of life and completely disregards the value or size of the project as well as potential property damage due to dam failure.

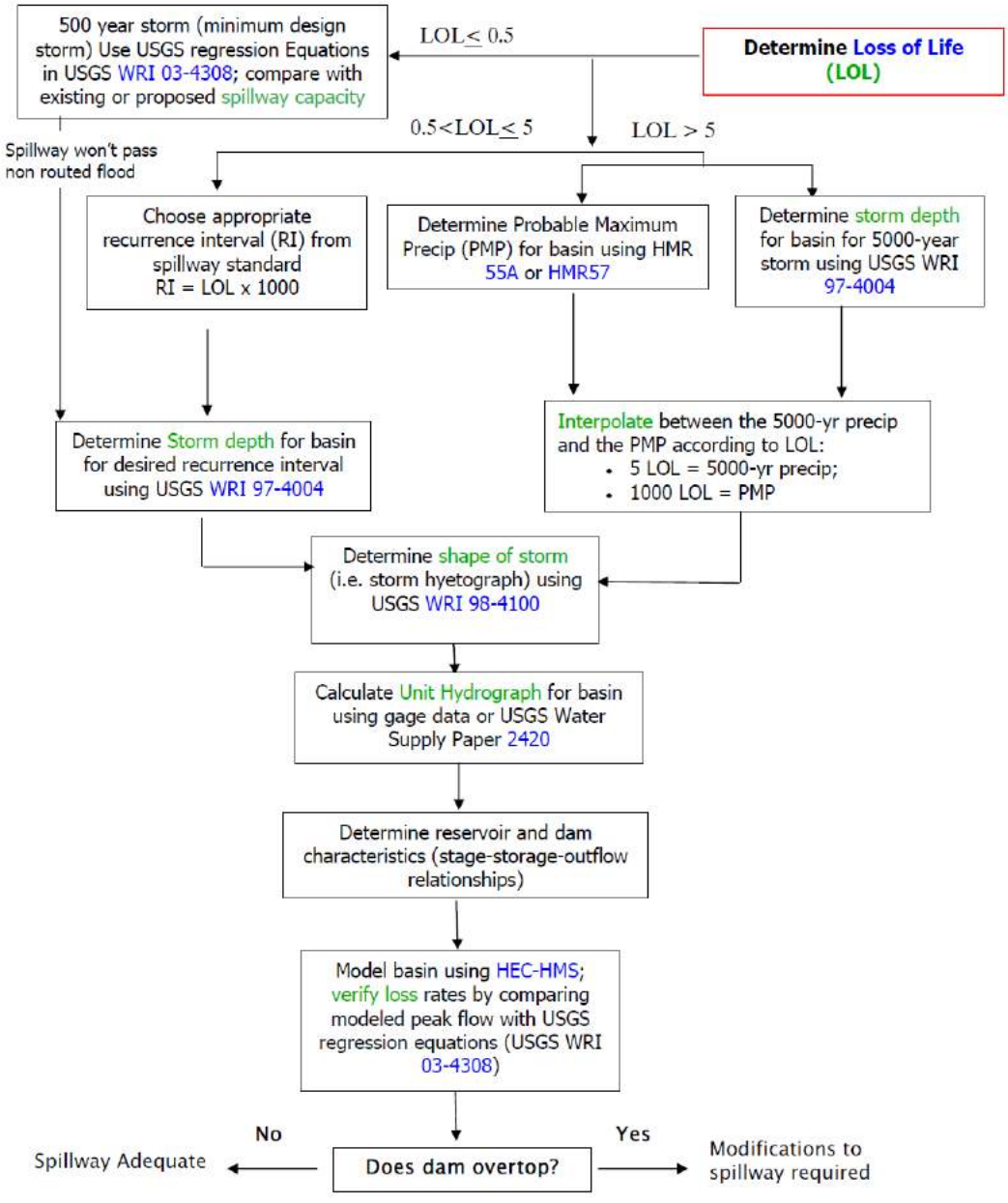


Figure 9.13 Procedure for Determining Spillway Adequacy [Montana DNRC, 2008]

Also inconsistent in the states' approaches are the probabilities of spillway design events required. In California, the minimum SDF is the 1,000-year event while Washington and Montana both allow a minimum of the 500-year event. Even though all three indicate that the PMP/PMF is the maximum event, the different weighting systems, loss of life determination, and other varying criteria could introduce significant deviation in spillway capacity requirements from one state to another.

It may be that risk-based criteria have been structured to meet the perceived needs or societal demands of the issuing agency or state. However, it is also possible that these differences are the result of somewhat subjective choices made by regulatory authorities. In either case, the considerable variety in risk-based criteria will complicate any precise comparisons between criteria used by different agencies. It will also result in a variation or imbalance of risk tolerances with regards to dam safety throughout the country.

9.14. Agency Review

The role of state dam safety agencies in determining the SDF varies from state to state. Only 8 of the 49 state agencies perform an independent verification of all submitted designs. An additional 15 agencies perform both limited detail reviews and in depth verifications as they deem fit (case-by-case basis). Most other agencies perform reviews of the hydrologic design, but do not verify the design independently. A few agencies also act as the designer/engineer for work done on state-owned dams.

10. Receptiveness of States to Changing Guidelines

10.1. The Need for Uniformity

There are many differing opinions regarding the need for uniformity of design criteria between states and federal agencies. It is generally recognized that the implementation of strictly uniform criteria is not a possibility. A flexible framework of criteria would be required to provide for the specific requirements, budget, and technical ability of each state. The NRC Committee's critique of the state-of-the-practice summarizes this issue in the following:

> *"The goal of dam safety is to limit the risks from dam failures to acceptable levels. Probability of failure is controlled partly by design standards and partly by quality of design, construction, inspection, operation, and maintenance. Ideally, hazard failure probability, and acceptable damage would be quantified for the site-specific conditions of each individual existing or proposed dam in order to establish site-specific standards for achieving this goal. With few exceptions, current practices do not involve quantification of these three critical elements for each dam.*
>
> *"Instead, the most widespread current practice is to classify dams in three broad, not well-defined, qualitative damage potential categories (i.e. high, intermediate, and low hazard) and to somewhat arbitrarily assign one of three or four grades or ranges of design standards to each dam depending on its height, storage capacity, and qualitative hazard rating. Current practice treats all of the elements needed for selecting design standards in a generalized way; thus, the appropriateness of the design standards as applied to individual dams is generally unknown.*
>
> *"In defense of this current general practice, it must be recognized that most of the scores of federal and state regulatory agencies each have hundreds to thousands of dams under their jurisdictions. Given their limited resources, as a practical matter, they must use a generalized system of assigning design standards according to generalized hazard and size classifications, at least as an interim step until more detailed site-specific studies can be made. However, the wide range of hazard versus size versus design standards among various agencies reflects a lack of uniformity even within the generalized current practice.*
>
> *"This lack of uniformity in dam classification and safety design standards appears to result from three main factors: (1) lack of interagency and intergovernmental communication, (2) variations in engineering judgment in selecting the generalized standards, and (3) variations in public policy attitudes at the times the standards were selected. In any case, a critique of present practices must point out that, though a generalized approach to selecting design standards is justified as a practical interim step, there is a need for more uniformity among the various federal and state agencies in establishing size and hazard definitions and correlative design standards"* [NRC, 1985].

10.2. Awareness of Existing Federal Guidelines

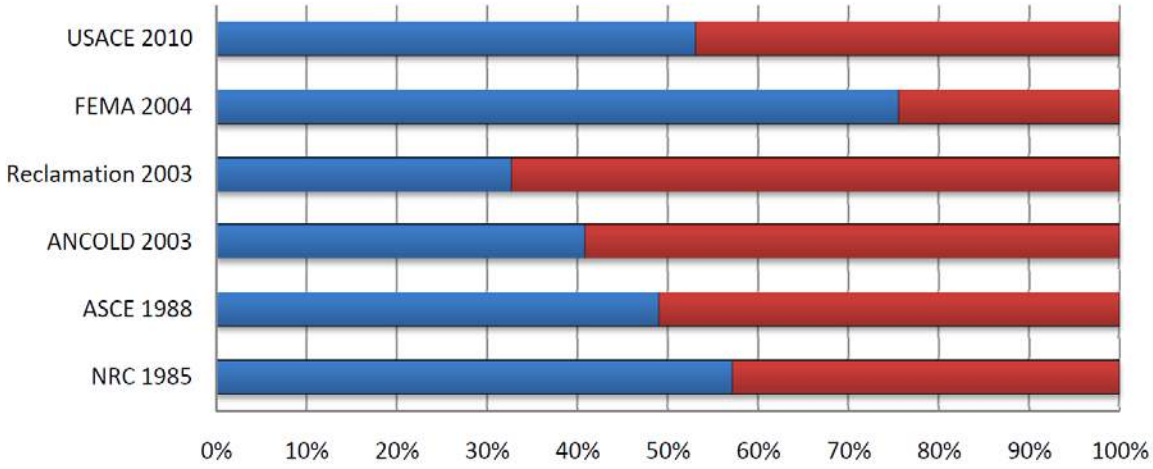
As noted in Section 9.1, the majority of states adopted guidelines or regulations regarding the SDF in the 1970s and 1980s. Since then, each state dam safety agency has had varying degrees of success in updating these guidelines. Some states have recently revised their guidelines or maintain a continuous process of revision and are very aware of current research and recommendations regarding dam safety. Other agencies which are under-staffed or under-funded have limited time to give to such activities. As part of the survey, all agency representatives were asked if they were aware of several documents published on the federal and international levels regarding spillway design criteria. These documents are as follows:

1. Safety of Dams: Policy and Procedures (ER 1110-2-1156), *Draft Version* – U.S. Army Corps of Engineers [USACE, 2010]
2. Federal Guidelines for Dam Safety – Selecting and Accommodating Inflow Design Floods for Dams – Federal Emergency Management Agency [FEMA, 2004]
3. Guidelines for Achieving Public Protection in Dam Safety Decision-making - U.S. Bureau of Reclamation [Reclamation, 2003]
4. Guidelines on Selection of Acceptable Flood Capacity for Dam & Guidelines on Risk Assessment – Australian National Committee on Large Dams [ANCOLD, 2000 & 2003]
5. Evaluation Procedures of Hydrologic Safety of Dams – Prepared by the Task Committee on Spillway Design Flood Selection of the Committee on Surface Water Hydrology of the Hydraulics Division of the American Society of Civil Engineers [ASCE, 1988]
6. Safety of Dams: Flood and Earthquake Criteria – Prepared by the Committee on Safety Criteria for Dams, National Research Council [NRC, 1985]

The results are shown in Figure 10.1 and indicate that a significant portion of the dam safety community is unaware of current and even long-standing publications regarding the hydrologic safety of dams. A quarter of respondents were unaware of FEMA's federal guidelines for inflow design. It is apparent that any attempt to encourage the adoption of more uniform guidelines would require a significant outreach and educational effort on the part of FEMA.

10.3. Perception of PMP and PMF Criteria

When asked if they thought that designing for the PMP/PMF is unreasonably conservative, 31% of the respondents agreed. Fifty-one percent indicated that the PMP/PMF is a reasonable design criterion. The remaining 18% were either neutral or undecided (See Figure 10.2). This is interesting when considering that about half of the states require a full PMP/PMF design for high hazard structures, and in over 80% of the states, the SDF range extends up to the full PMP/PMF. It is also interesting to note that in Dubler's 1995 survey, only 17% of the states agreed that the PMP/PMF was unreasonably conservative, and none of those respondents strongly agreed. Conversely, 76% of states indicated in the 1995 survey that the PMP/PMF was a reasonable design criterion (59% indicated strongly disagreeing that the PMP/PMF was unreasonable).



	NRC 1985	ASCE 1988	ANCOLD 2003	Reclamation 2003	FEMA 2004	USACE 2010
Aware	57%	49%	41%	33%	76%	53%
Unaware	43%	51%	59%	67%	24%	47%

Figure 10.1 Awareness of Previously Published Spillway Design Guidelines

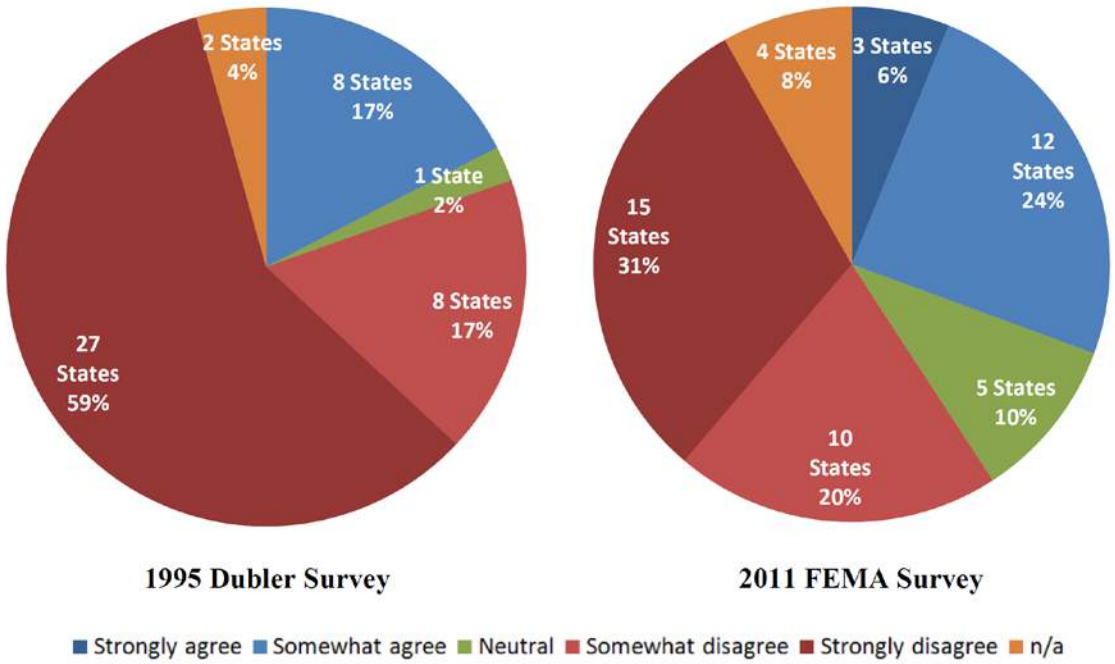


Figure 10.2 Do you agree that designing for the PMF is unreasonably conservative?

While these opinions indicate that a slight majority of the professional community supports design for the PMP/PMF, it also indicates that existing guidelines and spillway design criteria do not align with the current views of all dam safety professionals. Over the past 15 years, support for the PMP/PMF design in general appears to have diminished.

10.4. Concerns Regarding Consistency of Hydrologic Analyses

Many different design methods and models are currently used by dam designers. Twenty-six of the states indicated that they have concerns regarding the consistency of hydrologic and hydraulic analyses. Many of these concerns seem to stem from a general lack of training and experience of consultants as well as varying levels of detail given to the analyses. The variability of inputs into models, the various models used, and the inherent uncertainty in the computational methods and data are common sources of variability in analysis results.

10.5. Perception and Concerns Regarding Risk-Based Criteria

While leading federal agencies and a few states have transitioned from strictly prescriptive to risk-based criteria, it is evident that a large portion of the dam safety community doubts the validity and practicality of risk analysis. Fifty-one percent of respondents indicated that they have concerns regarding either the use of risk analyses or incremental damage analysis to determine spillway capacity requirements. Respondents indicated a number of concerns with these approaches to spillway design including the following:

- The complexity of risk analysis makes it expensive and time consuming to either perform or review.
- There is a general lack of minimum design criteria available. Current methodologies are still under development and are neither mature nor proven.
- Risk-based analyses lack consistency.
- Any argument can be justified using risk analysis if data are selectively analyzed and evaluated.
- There are currently no clear or acceptable guidelines for evaluating incremental damage.
- Many dam safety personnel lack training necessary to perform or review such designs.
- Risk analysis is too subjective and could be problematic over time with new development downstream of a dam.
- Risk analysis does not adequately address the worth of human life. "The potential adverse effects of a dam failure make 'allowing' a risk threshold somewhat unsettling both morally and politically."
- Results of such a design may not be defensible during a lawsuit.

Figure 10.3 illustrates the current opinions of state dam safety officials regarding risk analysis, its usefulness, and constraints. This figure also shows the responses to the same survey questions as

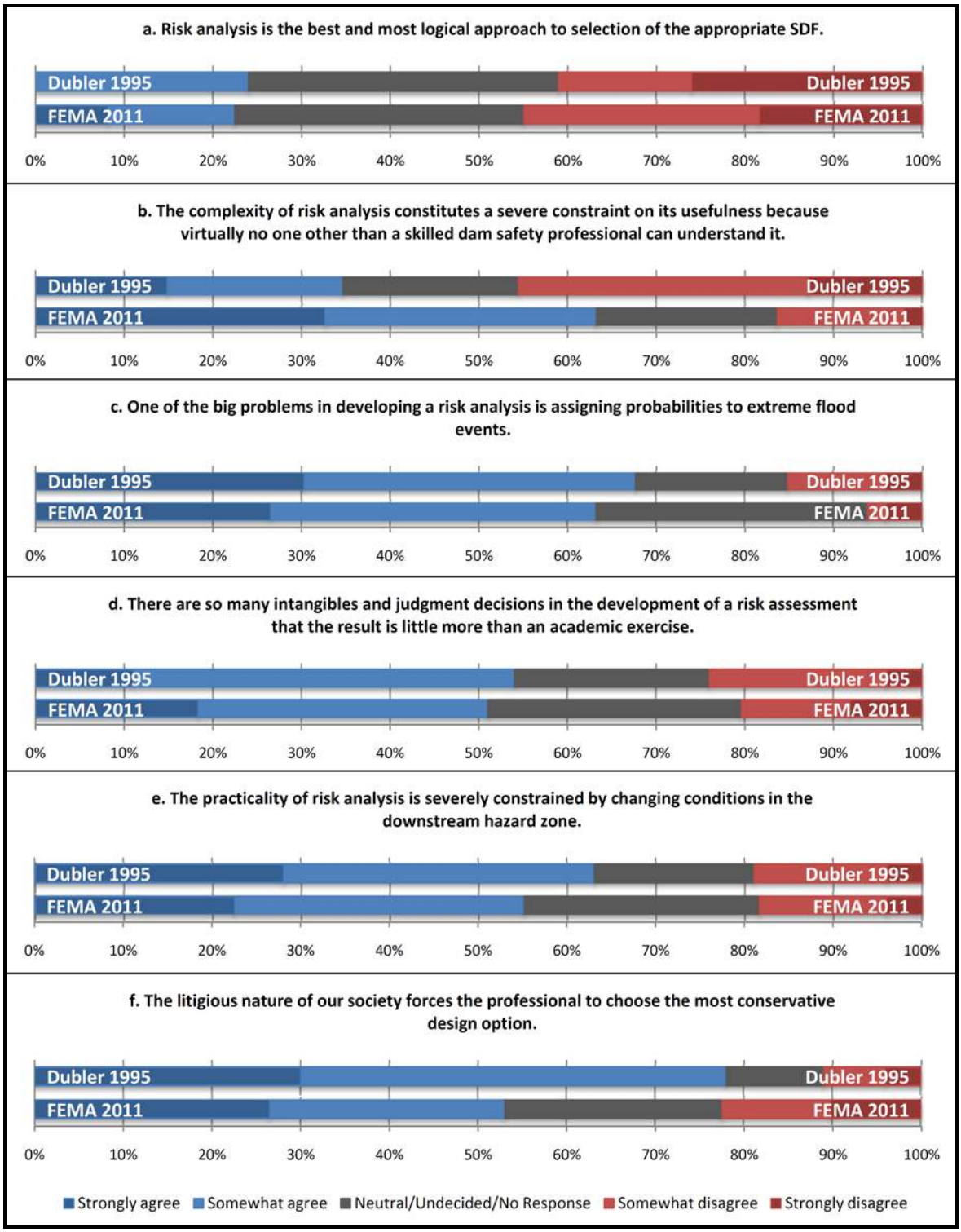


Figure 10.3 Opinions regarding risk analysis: 1995 vs. 2011

collected by Dubler in 1995. While there are significant differences of opinions regarding the complexity of risk analysis as well as the litigious nature of society and its implications for dam design, the overall views of state dam safety officials appear to be very similar to those found in the 1995 survey. The past 15 years have seen little change in opinion regarding risk-based analysis for the hydrologic safety of dams.

10.6. Technical Ability and Availability of Staff to Implement and Enforce Guidelines

The training and resources available to state dam safety agencies oftentimes determines the level of enforcement of dam safety guidelines. This also impacts an agency's ability to implement state-of-the-art practices in their state. Survey respondents were asked if they felt their agency and personnel had the resources (availability and budget) and technical ability to review several more recent advances that relate to the hydrologic safety of dams (See Table 10-1). The majority of agencies felt that they lacked both the technical ability and resources to review rigorous risk analyses. With regard to site specific PMP studies, a majority believed they had the technical ability required but lacked the necessary resources. The majority of states have the necessary resources and training to review incremental damage analyses. There are significant percentages of state regulatory agencies which feel they lack both the training and the resources required to review these state-of-the-art practices.

Table 10-1 Resources and Technical Ability of State Dam Safety Agencies

		Site Specific PMP	Incremental Damage Analysis	Rigorous Risk Analysis
Technical Ability	*Yes*	59%	78%	31%
	No	41%	22%	69%
Availability and Budget	*Yes*	41%	57%	22%
	No	59%	43%	78%

10.7. Overall Receptiveness and Obstacles to Changing Existing Guidelines

Fifty-seven percent of the surveyed states believe that increased uniformity in state dam safety guidelines across the country would be beneficial; thirty-nine percent believed that increased

uniformity would not be beneficial; and four percent did not respond to this question. Many indicated that it would be difficult to implement uniformity of the guidelines without eliminating many necessary regional distinctions that are currently in place. A solution would be to provide a uniform framework of guidelines that also provides for the specific requirements, budget, and technical ability of each state.

In general, dam safety officials were more receptive to adopting new recommended guidelines if they resulted in lower SDF criteria as opposed to higher SDF criteria. When asked how difficult it would be to change current regulations, the majority of states responded that it would be difficult. All others indicated a moderate level of difficulty. For many, such changes are expensive and time consuming, often extending over a period of years. Several respondents indicated that the current partisan political climate would also cause difficulty in changing regulations.

Many state representatives indicated that before the states attempt to standardize their guidelines, the major federal agencies who have traditionally led the effort to develop acceptable dam safety standards need to come to agreement. If these federal players could agree on basic items such as condition assessment, spillway standards, and risk determination, then the states would certainly be more receptive to adopting similar criteria.

11. The Current State of the Practice

11.1. Summary

This document, the "Summary of Existing Guidelines for the Hydrologic Safety of Dams," is the first of two documents commissioned by FEMA related to the Hydrologic Safety of Dams. The purpose of this document is to compile available data and to summarize the state of the practice of evaluating the hydrologic safety of dams. The second document will be in the form of guidelines which will assist dam safety programs in evaluating the adequacy of their current hydrologic guidelines.

At the root of this study is the acknowledgement of the basic need for adequate guidelines for evaluating the hydrologic safety of dams. The inventory of United States dams is large, aging and increasing in hazard as the United States becomes more and more developed. This Summary of Existing Guidelines has traced the evolution and history of design flood practice for dams as well as the application of the methodology in formal dam safety guidelines. The existing hydrologic guidelines of many states and federal agencies were written in the 1970s or 1980s. Since that time, significant technological and analytical advances have been made along with better watershed and rainfall information that have improved the analysis of extreme floods and quantification of incremental dam failure consequences. Review of the published policy and guidelines for each state as well as the responses to the detailed survey completed as part of this study have revealed several important findings that can be used to define the current state of the practice regarding the hydrologic safety of dams.

In general, the guidelines for the hydrologic safety of dams are not consistent and vary widely from state-to-state and between federal agencies in many respects. Although some states and agencies have recently updated their guidelines, many states and agencies have not significantly changed their guidelines since their development. Some of those who have changed their guidelines have incorporated some form of risk-based analyses, but the requirements and methodology differ widely.

Some of the most notable inconsistencies in the existing guidelines relate to classification systems. From the most basic criteria for what defines a regulatory or a jurisdictional dam to whether the dam is classified by size, hazard, or not at all, there is no overwhelming majority of configurations for these classification systems. While size classification is used by many states and hazard classification is used by all states, the number of classifications and the distinctions between the classes vary. There is also no consensus on distinctions between new dams and existing dams.

In determining the magnitude of the SDF, most states follow a prescriptive approach in which the design flood is specified based upon the dam's classification (size, hazard, or both). Both probabilistic and deterministic (based on PMP or PMF estimates) criteria are used for the prescriptive approach by the states and agencies. Many of the criteria in prescriptive approaches

are arbitrary with no apparent scientific rationale [NRC, 1985], and the prescribed SDFs for identical dams in different states would have drastically varying magnitudes.

Historically, a few important federal agencies have led the way in the development of dam safety regulations and design standards, and the trend among these agencies is toward incorporating a risk-based approach rather than the prescriptive approach. In fact, USACE is currently partnering with Reclamation, FERC, and TVA to achieve a common risk management framework and guidelines. Internationally, the trend is also toward integrating risk assessment into dam safety procedures. Recent changes to guidelines in Australia and Canada have addressed risk-based approaches.

The transition to risk-based analyses in some states has also begun. The methodologies developed by California, Washington, and Montana reflect an initial movement to make site-specific, cost-effective, and risk-based designs. They also demonstrate how the complexities of risk analysis can be applied in a simplified, standard-based system. Comparison of these three recently developed, risk-based approaches indicates a lack of consistency regarding the criteria used among the systems, the weights assigned to the criteria, and the resultant risk tolerances.

Although the trend appears to be the incorporation of risk-based approaches into guidelines for the hydrologic safety of dams, there are many obstacles to widespread acceptance by state regulatory agencies. The budgets, staff availability, and technical ability of many state dam safety agencies are very limited. Many respondents indicated that they have concerns regarding risk-based analyses to determine spillway capacity requirements due to review requirements and the lack of widely acceptable and defensible guidelines.

It should also be noted that the federal agencies who have led the way in developing risk analysis procedures and tolerances are owners of a significant number of dams. These agencies have been able to utilize the prioritization and ranking aspects of risk analysis to manage their respective portfolios in addition to using quantitative risk analysis in design. The administrative processes and reviews of regulatory agencies, such as FERC, MSHA, and most of the states, differ significantly from that of dam owners like USACE and Reclamation. The application of quantitative risk analysis for dam design in regulatory agencies may be burdensome or even unnecessary. The state dam regulatory agencies of California, Washington and Montana have recently developed risk-based indices to determine acceptable flood capacity; however, none of the states use quantitative risk assessment.

There are many differing opinions regarding the need for uniformity of design criteria between states and federal agencies. It is generally recognized that the implementation of strictly uniform criteria is not a possibility. Instead, a flexible framework of criteria may be required to provide for the specific requirements, budget, and technical ability of each state. While leading federal agencies and a few states have recently transitioned from strictly prescriptive to risk-based criteria, it is evident that a large portion of the dam safety community has significant reservations concerning the validity and practicality of risk analysis. Having one set of federal dam safety

standards for risk determination may help to promote the use of risk-based analysis by states and potentially encourage increased uniformity of state guidelines.

The survey responses also indicate that a significant portion of the dam safety community is unaware of current and even long-standing landmark publications regarding guidelines for the hydrologic safety of dams. A quarter of respondents were unaware of FEMA's 2004 federal guidelines for "Selecting and Accommodating Inflow Design Floods for Dams," and approximately half were not familiar with the most recently published USACE, Reclamation, and ASCE inflow design and dam safety guidelines. It is therefore apparent that any attempt to encourage the adoption of more uniform guidelines and consideration of adopting risk-based criteria will require a more effective outreach and educational effort.

Although the literature search identified several studies that provided information on state practices related to selecting inflow design floods for dams, none of the studies provided a comprehensive compilation of this data. In addition to providing background information for developing new federal guidelines for the hydrologic safety of dams, this report and the associated database provide a comprehensive compilation of current federal and state guidelines that can be used by individual states to evaluate and compare their current guidelines with those of other agencies. As individual states revise their guidelines, this information will provide them with important information that will help them to make informed decisions that should result in more uniformity.

Appendix A. Glossary and Acronyms

A.1 Glossary
A.2 Acronyms



FEMA

A.1. Glossary

Below is a listing of terms used within this report. Many of these definitions were taken from FEMA's Federal Guidelines for Dam Safety, Glossary of Terms, April 2004.

Appurtenant structure. Ancillary features of a dam such as outlets, spillways, power plants, tunnels, etc.

Breach. An opening through a dam that allows the uncontrolled draining of a reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional opening caused by discharge from the reservoir. A breach is generally associated with the partial or total failure of the dam.

Consequences. Potential loss of life or property damage downstream of a dam caused by floodwaters released at the dam or by waters released by partial or complete failure of dam. Also effects of landslides upstream of the dam on property located around the reservoir.

Dam. An artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water.

Dam failure. Catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water or the likelihood of such an uncontrolled release It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters that adversely affect a dam's primary function of impounding water is properly considered a failure. These lesser degrees of failure can progressively lead to or heighten the risk of a catastrophic failure. They are, however, normally amenable to corrective action.

Dam safety. Dam safety is the art and science of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment. It requires the collective application of engineering principles and experience, and a philosophy of risk management that recognizes that a dam is a structure whose safe function is not explicitly determined by its original design and construction. It also includes all actions taken to identify or predict deficiencies and consequences related to failure, and to document, publicize, and reduce, eliminate, or remediate to the extent reasonably possible, any unacceptable risks.

Deterministic methodology. A method in which the chance of occurrence of the variable involved is ignored and the method or model used is considered to follow a definite law of certainty, and not probability.

Emergency Action Plan (EAP) Exercise. An activity designed to promote emergency preparedness; test or evaluate EAPs, procedures, or facilities; train personnel in emergency management duties; and demonstrate operational capability. Exercises consist of the performance of duties, tasks, or operations very similar to the way they would be performed in a real emergency. However, the exercise performance is in response to a simulated event.

Exceedance Probability. The likelihood that a random event will exceed a specified magnitude in a given time period, usually 1 year unless otherwise indicated.

Failure mode. A potential failure mode is a physically plausible process for dam failure resulting from an existing inadequacy or defect related to a natural foundation condition, the dam or appurtenant structures design, the construction, the materials incorporated, the operations and maintenance, or aging process, which can lead to an uncontrolled release of the reservoir.

Flood. A temporary rise in water surface elevation resulting in inundation of areas not normally covered by water. Hypothetical floods may be expressed in terms of average probability of exceedance per year such as one-percent-chance-flood, or expressed as a fraction of the probable maximum flood or other reference flood.

> **Flood, Inflow Design (IDF).** The flood flow above which the incremental increase in downstream water surface elevation due to failure of a dam or other water impounding structure is no longer considered to present an unacceptable threat to downstream life or property. The flood hydrograph used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works and for determining maximum storage, height of dam, and freeboard requirements.
>
> **Flood, Probable Maximum (PMF).** The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the drainage basin under study.

Flood plain. An area adjoining a body of water or natural stream that may be covered by floodwater. Also, the downstream area that would be inundated or otherwise affected by the failure of a dam or by large flood flows. The area of the flood plain is generally delineated by a frequency (or size) of flood.

Hazard. A situation that creates the potential for adverse consequences such as loss of life, property damage, or other adverse impacts.

> **Hazard potential.** The possible adverse incremental consequences that result from the release of water or stored contents due to failure of the dam or misoperation of the dam or appurtenances. Impacts may be for a defined area downstream of a dam from flood waters released through spillways and outlet works of the dam or waters released by partial or complete failure of the dam. There may also be impacts for an area upstream of the dam from effects of backwater flooding or landslides around the reservoir perimeter.
>
> **Hazard potential classification.** A system that categorizes dams according to the degree of adverse incremental consequences of a failure or misoperation of a dam. The hazard
>
> potential classification does not reflect in any way on the current condition of the dam (i.e., safety, structural integrity, flood routing capacity).

Hydrograph, breach or dam failure. A flood hydrograph resulting from a dam breach.

Hydrograph, flood. A graph showing, for a given point on a stream, the discharge, height, or other characteristic of a flood with respect to time.

Hydrograph, unit. A hydrograph with a volume of one inch of runoff resulting from a storm of a specified duration and areal distribution. Hydrographs from other storms of the same duration and distribution are assumed to have the same time base but with ordinates of flow in proportion to the runoff volumes.

Hydrology. One of the earth sciences that encompasses the natural occurrence, distribution, movement, and properties of the waters of the earth and their environmental relationships.

Indemnification Cost. The present cost to provide sufficient security against all claims of loss or damage in the event of a future dam failure.

Population at Risk. All those persons who could be in the flooded area below a dam attributable to the failure of the dam at the time of failure.

Probable Maximum Flood (PMF). See Flood. **Probable Maximum Precipitation (PMP).** Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location during a certain time of the year.

Reservoir. A body of water impounded by a dam and in which water can be stored.

Risk. A measure of the likelihood and severity of adverse consequences (National Research Council 1983). Risk is estimated by the mathematical expectation of the consequences of an adverse event occurring, i.e., the product of the probability of occurrence and the consequence, or alternatively, by the triplet of scenario, probability of occurrence, and the consequence.

Risk analysis. A procedure to identify and quantify risks by establishing potential failure modes, providing numerical estimates of the likelihood of an event in a specified time period, and estimating the magnitude of the consequences. The risk analysis should include all potential events that would cause unintentional release of stored water from the reservoir.

Risk assessment. The process of deciding whether existing risks are tolerable and present risk control measures are adequate and, if not, whether alternative risk control measures are justified. Risk assessment incorporates the risk analysis and risk evaluation phases.

Spillway. A structure over or through which flow is discharged from a reservoir. If the rate of flow is controlled by mechanical means, such as gates, it is considered a controlled spillway. If the geometry of the spillway is the only control, it is considered an uncontrolled spillway.

Spillway, auxiliary. Any secondary spillway that is designed to be operated infrequently, possibly in anticipation of some degree of structural damage or erosion to the spillway that would occur during operation.

Spillway, emergency. See Spillway, auxiliary.

Spillway, service. A spillway that is designed to provide continuous or frequent regulated or unregulated releases from a reservoir, without significant damage to either the dam or its appurtenant structures. This is also referred to as principal spillway.

Spillway capacity. The maximum spillway outflow that a dam can safely pass with the reservoir at its maximum level.

Spillway channel. An open channel or closed conduit conveying water from the spillway inlet downstream.

Spillway chute. A steeply sloping spillway channel that conveys discharges at super-critical velocities.

Spillway crest. The lowest level at which water can flow over or through the spillway.

Spillway Design Flood (SDF). The flood flow above which the incremental increase in downstream water surface elevation due to failure of a dam or other water impounding structure is no longer considered to present an unacceptable threat to downstream life or property. The flood hydrograph used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works and for determining maximum storage, height of dam, and freeboard requirements.

Storage. The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel.

Surcharge. The volume or space in a reservoir between the controlled retention water level and the maximum water level. Flood surcharge cannot be retained in the reservoir but will flow out of the reservoir until the controlled retention water level is reached.

Watershed. The area drained by a river or river system or portion thereof. The watershed for a dam is the drainage area upstream of the dam.

A.2. Acronyms

ACT. Australian Capital Territory

AEP. Annual Exceedance Probability

ALARP. As Low As Reasonably Practicable

ALL. Annualized Life Loss

AMC. Antecedent Moisture Condition

ANCOLD. Australian National Committee on Large Dams

APF. Annual Probability of Failure

ASCE. American Society of Civil Engineers

ASDSO. Association of State Dam Safety Officials

AWWA. American Waterworks Association

BC. British Columbia

BSC. Base Safety Conditions

CDA. Canadian Dam Safety Association

DOD. Department of Defense

DOI. Department of Interior

FEMA. Federal Emergency Management Agency

FERC. Federal Energy Regulatory Commission

FPC. Federal Power Commission

GIS. Geographic Information Systems

HMR. Hydrometeorological Report

ICODS. Interagency Committee on Dam Safety

ICOLD. International Commission on Large Dams

IDF. Inflow Design Flood

LOL. Loss of Life

MPF. Maximum Possible Flood.

MPP. Maximum Possible Precipitation

MRC. Mississippi River Commission

MCD. Miami Conservancy District

MSHA. Mine Safety and Health Administration

NOAA. National Oceanic and Atmospheric Administration

NWS. National Weather Service, formerly USWB

NID. National Inventory of Dams

NRC. National Research Council of the National Academy of Sciences

NRCS. Natural Resources Conservation Service, formerly SCS

NSW DSC. New South Wales Government Dam Safety Committee

O&M. Operation and Maintenance

PAR. Population at Risk

PMF. Probable Maximum Flood

PMP. Probable Maximum Precipitation

SCS. Soil Conservation Service, currently known as the NRCS

SDF. Spillway Design Flood

TCW. Total Class Weight

TF. Threshold Flood

TVA. Tennessee Valley Authority

USCOLD. United States Committee on Large Dams, currently known as USSD

USBR. United States Bureau of Reclamation

USFS. United States Forest Service

USFWS. United States Fish and Wildlife Service

USGS. United States Geological Survey

USSD. United States Society on Dams, formerly USCOLD

USACE. United States Army Corps of Engineers

USDA. United States Department of Agriculture

USWB. United States Weather Bureau, currently the National Weather Service

WES. U.S. Army Corps of Engineers Waterways Experiment Station

Appendix B. Bibliography

B.1 Bibliography



B.1. Bibliography

American Meteorological Society. (1959). *Glossary of Meteorology.* Boston, MA: ed. by Ralph E. Huschke.

ANCOLD. (2003). *Guidelines on Risk Assessment.* Australian National Committee on Large Dams.

ANCOLD. (2000). *Guidelines on Selection of Acceptable Flood Capacity for Dams.* Australian National Committee on Large Dams.

Applied Weather Associates. (2008). *Site-Specific Probable Maximum Precipitation (PMP) Study for Nebraska.* Lower Platte North NRD.

ASCE. (1973). *Inspection, Maintenance, and Rehabilitation of Old Dams.* Pacific Grove, CA: American Society of Civil Engineers.

ASCE. (1974). *Safety of Small Dams.* Henniker, New Hampshire: American Society of Civil Engineers.

ASCE. (1988). *Evaluation Procedures for Hydrologic Safety of Dams.* New York: Hydraulics Division, Committee on Surface Water Hydrology, Task Committee on Spillway Design Flood Selection, American Society of Civil Engineers.

ASCE. (2009). *Policy Statement 280 - Responsibility for Dam Safety.* American Society of Civil Engineers.

ASCE. (2009). *Report Card for America's Infrastructure.* American Society of Civil Engineers.

ASDSO. (2010). *State Dam Safety Hazard Potential Classification.* Association of State Dam Safety Officials.

ASDSO. (2010). *State Dam Safety Size Classification Schemes.* Association of State Dam Safety Officials.

ASDSO. (2008). *Statistics for State Dam Safety Program Information Report.* Assocation of State Dam Safety Officials.

AWWA. (1964). *Manual M13 – Spillway Design Practice.* American Water Works Association.

Beard, L. R. (1973). Probabilities of Rare Floods. *Engineering Foundation Conference Proceedings: Inspection, Maintenance, and Rehabilitation of Old Dams.* New York, NY: American Society of Civil Engineers.

Bertle, F. (1973). Selection of Spillway Floods for Existing Structures. *Engineering Foundation Conference Proceedings: Inspection, Maintenance, and Rehabilitation of Old Dams.* New York, NY: American Society of Civil Engineers.

Bowles, D. S., Anderson, L. R., & Glover, T. F. (1998). The practice of dam safety risk assessment and management: its roots, its branches, and its fruit. *18th USCOLD Annual Meeting and Lecture.* Buffalo, NY: US Committee on Large Dams.

Bowles, D. S., Anderson, L. R., Glover, T. F., & Chauhan, S. S. (2003). Dam Safety Decision-making: Combining Engineering Assessments with Risk Information. *2003 USSD Annual Lecture.* Charleston, SC: U.S. Society on Dams.

British Columbia. (2009). *BC Dam Safety Guidelines: Plan Submission Requirements for the Construction and Rehabilitation of Dams, Version 8.1.* Victoria, BC: British Columbia Ministry of Environment.

Buehler, B. J. (1973). Re-evaluating Spillway Capacity of Existing Dams. *Engineering Foundation Conference Proceedings: Inspection, Maintenance, and Rehabilitation of Old Dams.* New York, NY: American Society of Civil Engineers.

Calzascia, E. R., & Fitzpatrick, J. A. (1987). *Hydrologic Analysis within California's Dam Safety Program.* California Department of Water Resources.

CDA. (2007). *Dam Safety Guidelines.* Canadian Dam Association.

Chow, V. T. (1964). *Handbook of Applied Hydrology.* New York: McGraw-Hill.

Clark, C. (2010). Rain, floods, and dam safety. Charldon Hill Research Station, UK, International Water Power and Dam Construction.

Cluckie, I. D., & Pessoa, M. L. (1990, 35:5). Dam Safety: an evaluation of some procedures for design flood estimation. *Hydrological Sciences Journal* , 547-568.

Colorado DNR. (2007). *Rules and Regulations for Dam Safety and Dam Construction, 2 CCR 402-1.* Denver, CO: State of Colorado Department of Natural Resources.

Commonwealth of Virginia. (2010). *Chapter 249 of the Code of Virginia as amended by Senate Bill 276.*

Commonwealth of Virginia. (2010). *Chapter 270 of the Code of Virginia as amended by House Bill 438.*

Dubler, J. R. (1995). *Dam Safety Policy for Spillway Design Floods.* Colorado State University.

Dubler, J. R., & Grigg, N. S. (1996). Dam Safety Policy for Spillway Design Floods. *Journal of Professional issues in Engineering Education and Practice* , 163-169.

Eiker, E. A., Goldman, D. M., & Davis, D. W. (1998). A Hybrid Deterministic-Risk-Based Approach to Hydrologic Dam Safety Analysis. *USCOLD Annual Lecture Series.*

England, J. F. (2006). *Frequency Analysis and Two-Dimensional Simulations of Extreme Floods on a Large Watershed.* Colorado State University.

England, J. F., & Swain, R. E. (2008). Extreme Flood Probability Estimation Methods for Dam Safety Risk Analysis. *USSD Annual Conference* .

Estergaard, A., & Bell, P. W. (2000). Inflow Design Flood Selection: Current Guidelines and Future Approaches. *Canadian Dam Assocation 3rd Annual Conference.* Regina, Saskatchewan.

FEMA (ICODS). (2004). *Federal Guidelines for Dam Safety - Selecting and Accomodating Inflow Design Floods for Dams.* Federal Emergency Management Agency.

FEMA (ICODS). (2004). *Federal Guidelines for Dam Safety (FEMA 93).* Federal Emergency Management Agency.

FEMA. (2010). *Dam Safety in the United States: A Progress Report on the National Dam Safety Program.* Federal Emergency Management Agency.

FEMA. (1979). *Federal Guidelines for Dam Safety.* Federal Emergency Management Agency.

FEMA. (1986). *Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams.* Federal Emergency Management Agency.

FEMA. (2007). *Model State Dam Safety Program.* Federal Emergency Management Agency.

FEMA. (2001). The National Dam Safety Program Research Needs Workshop: Risk Assessment for Dams. Federal Emergency Management Agency.

Fischer, G., & Lemieux, M. (2010). Technically Speaking…Montana's Technical Notes for Risk-Based Dam Safety Analyses. *ASDSO Annual Conference.* Seattle: Association of State Dam Safety Officials.

Golze, A. R. (1973). The Reaction to USCOLD's Proposed Law for Dam Safety. *Engineering Foundation Conference Proceedings: Inspection, Maintenance, and Rehabilitation of Old Dams.* New York, NY: American Society of Civil Engineers.

Graham, W. J. (2000). Should Dams be Modified for the Probable Maximum Flood? *Journal of the American Water Resources Association* .

Hagen, V. K. (1973). Safety Investigation of Dams, Hydrologic and Hydraulic Aspects. *Engineering Foundation Conference Proceedings: Inspection, Maintenance, and Rehabilitation of Old Dams.* New York, NY: American Society of Civil Engineers.

Hoeft, C. C., & Locke, M. (2010). Application of the Inflow Design Flood Analysis Alternative to NRCS TR-60 Design Storm Criteria for High Hazard Dams. *2nd Joint Federal Interagency Conference.* Las Vegas, NV.

Hoyt, W. G. (1936). Studies of relations of rainfall and run-off in the United States. *Water Supply Paper, 772* . U.S. Govt. Print. Off.

Huffman, R. G. (1999). The Inflow Design Flood for High Hazard Dams. *ASDSO Annual Conference.* Association of State Dam Safety Officials.

Hydrometrics, Inc. (2008). *Technical Note 1: Analysis of Spillway Capacity in Montana.* Helena, MT: Montana Department of Natural Resources and Conservation.

ICOLD Bulletin, Dams and Floods Committee. (2010). *Integrated Flood Risk Managment.* International Commission on Large Dams.

Institution of Civil Engineers. (1978). *Floods and Reservoir Safety.* London.

Institution of Civil Engineers. (2005). *Reservoir Flood Standards.* London.

Jarvis, C. (1936). Floods in the United States, magnitude and frequency. *Water Supply Paper #771*. VA: U.S. Geological Survey.

Johnson, D. L. (1995). Determining Design/Performance Goals for Spillway Adequacy: The Washington State Approach. *ASDSO West Regional Conference.* Red Lodge, Montana: Association of State Dam Safety Officials.

Johnson, D. L. (2000). Risk is not a Four Letter Work: Ten Years of Success Using a Risk-Based Dam Safety Approach in Washington. *17th Annual Conference of ASDSO.* Providence, Rhode Island: Association of State Dam Safety Officials.

King, L. W. (1910). *The Code of Hammurabi (Translated by L. W. King).*

Lott, G. A. (1954). The World-Record 42-minute Holt, Missouri, Rainstorm. *Monthly Weather Review* , 50-59.

Marsden, J., McDonald, L., Bowles, D., Davidson, R., & Nathan, R. (2007). Dam safety, economic regulation and society's need to prioritise health and safety expenditures. *IPENZ Proceedings of Technical Groups 33/2 (LD)* , 1-12.

MGS Engineering Consultants, Inc. (2009). *Dam Safety Guidelines, Technical Note 3: Design Storm Construction (prepared by Mel Schaefer).* Washington State Department of Ecology.

Munger, D., Bowles, D., Boyer, D., Davis, D., Margo, D., Moser, D., et al. (2009). Interim Tolerable Risk Guidelines for US Army Corps of Engineers Dams. *Annual USSD Conference.* US Society on Dams.

Myers, V. A. (1967). *The estimation of extreme precipitation as the basis for design floods - Resume of practice in the United States.* Office of Hydrology, Weather Bureau (ESSA).

Newton, D. W. (1987). Design Floods Evaluation Procedures for Hydrologic Safety of Dams. *ASDSO Annual Conference.* Association of State Dam Safety Officials.

NOAA. (2011). *Current NWS Probable Maximum Precipitation (PMP) Documents and Related Studies*. Retrieved May 5, 2011, from NOAA Hydrometeorological Design Studies Center: http://www.weather.gov/oh/hdsc/studies/pmp.html

NRC. (1985). *Safety of Dams: Flood and Earthquake Criteria.* Committee on Safety Criteria for Dams, National Research Council.

NRC. (1983). *Safety of Existing Dams: Evaluation and Improvement.* Committee on the Safety of Existing Dams, Water Science and Technology Board, Commission on Engineering and Technical Systems, National Research Council.

NRCS. (2005). *TR-60, Earth Dams and Reservoirs.* Natural Resources Conservation Service, U.S. Department of Agriculture.

NRCS. (2002). *National Handbook of Conservation Practices – Standard No. 378 – Pond.* Natural Resources Conservation Service, U.S. Department of Agriculture.

NSW DSC. (2010). *Acceptable Flood Capacity for Dams.* Australia: New South Wales Dam Safety Committee.

NSW DSC. (2006). *Risk Management Policy Framework For Dam Safety.* New South Wales Dam Safety Committee.

Paxson, G., & Harrison, J. (2003). Hydrology and Hydraulics for Dams: State of Practice or Practice of States? *ASDSO Annual Conference.* Association of State Dam Safety Officials.

Pisaniello, J. (2010). The need for 'adequate' farm dam safety management accountability to avoid dam failure. *The Australian Journal of Emergency Management* , 31-38.

Pisaniello, J., & McKay, J. (1998). The need for private dam safety assurance policy - a demonstrative case study. *The Australian Journal of Emergency Management* .

Pisaniello, J., & McKay, J. (2005). The need for private dam safety assurance policy-demonstrative case study 10 years later. *The Australian Journal of Emergency Management* , 15-21.

Pisaniello, J., Zhifang, W., & Mckay, J. (2006). Small dam safety issues-engineering/policy models and community responses from Australia. *Water Policy* , 81-95.

Reclamation. (2010). *Dam Safety Risk Analysis Best Practices Training Manual.* Bureau of Reclamation, U.S. Department of the Interior.

Reclamation. (2003). *Guidelines for Achieving Public Protection in Dam Safety Decisionmaking.* Bureau of Reclamation, U.S. Department of the Interior.

Reclamation. (1998). *Implementation of Risk Analysis Principles into the Bureau of Reclamation's Dam Safety Program Actions* . Bureau of Reclamation, U.S. Department of the Interior.

Reclamation. (2000). *Risk Based Profiling System.* Bureau of Reclamation, U.S. Department of the Interior.

Reuss, M. A. (2002). Probability analysis and the search for hydrologic order in the United States, 1885-1945. *Water Resources impact (AWRA), Volume 4, Number 3* , 7-15.

Riedel, & Schreiner. (1980). Comparison of Generalized Estimates of Probable Maximum Precipitation with Greatest Observed Rainfalls. *NOAA Technical Report NWS 25* .

Riedel, J. T. (1973). Survey of Procedues for Estimating Design Precipitation Values. *Engineering Foundation Conference Proceedings: Inspection, Maintenance, and Rehabilitation of Old Dams.* New York, NY: American Society of Civil Engineers.

Schnitter, N. J. (1994). *A History of Dams: The Useful Pyramids.* Ashgate Publishing.

Sih, K., Hill, P., Ryan, S., & Pierera, S. (2010). Regulating Dam Safety: How do we compare? *ANCOLD 2010 Conference* , 1-10.

Snorteland, N. (2010). *USACE Transition to a Risk-informed Dam Safety Process.* U.S. Army Corps of Engineers.

Snyder, F. F. (1964). Hydrology of Spillway Design. *Journal of the Proceedings of the ASCE, Hydraulics Division.* American Society of Civil Engineers.

State of Queensland. (2005). *Draft Guidelines on Acceptable Flood Capacity for Dams.* Queensland Department of Environment and Resource Management.

State of Queensland. (2007). *Guidelines on Acceptable Flood Capacity for Dams.* Queensland Department of Environment and Resource Management.

Stedinger, J. R., Heath, D. C., & Thompson, K. (1996). *Risk Analysis for Dam Safety Evaluation: Hydrologic Risk, IWR Report 96-R-13.* Institute for Water Resources, U.S. Army Corps of Engineers.

Swain, R. E., Bowles, D., & Ostenaa, D. (1998). A Framework for Characterization of Extreme Floods for Dam Safety Risk Assessments. *USCOLD Annual Lecture.* Buffalo, NY.

Swain, R. E., England, J., & Raff, D. (2006). Guidelines for Evaluating Hydrologic Hazards. Bureau of Reclamation, U.S. Department of the Interior.

Tomlinson, E., & Kappel, W. (2009). Dam Safety: Revisiting PMPs. *HydroWorld* .

USACE. (2003). *Application of Paleohydrology to Crops Flood Frequency Analysis.* U.S. Army Corps of Engineers.

USACE. (1997). *Dam Safety Assurance Program, Regulation No. 1110-2-1155.* U.S. Army Corps of Engineers.

USACE. (2010). *Draft Engineering and Design: Safety of Dams - Policy and Procedures (ER 1110-2-1156).* U.S. Army Corps of Engineers.

USACE. (2007). *Draft Inflow Hydrographs Toolbox.* U.S. Army Corps of Engineers.

USACE. (1997). *Engineering and Design: Hydrologic Engineering Requirements for Reservoirs, Chapter 14 (Spillways and Outlet Works).* U.S. Army Corps of Engineers.

USACE. (1991). *Engineering and Design: Inflow Design Floods for Dams and Reservoirs – ER 1110-8-2(FR).* U.S. Army Corps of Engineers.

USACE. (2001). *Hydrologic Research Needs for Dam Safety (Various Authors).* U.S. Army Corps of Engineers.

USACE. (2007). *Interim Risk Reduction Measures for Dam Safety.* U.S. Army Corps of Engineers.

USACE. (2009). *Interim Tolerable Risk Guidelines for US Army Corps of Engineers Dams.* U.S. Army Corps of Engineers.

USACE. (2009). *National Inventory of Dams*. Retrieved from U.S. Army Corps of Engineers: http://nid.usace.army.mil

USACE. (1979). *Recommended Guidelines for Safety Inspection of Dams - ER 1110-2-106.* U.S. Army Corps of Engineers.

USACE. (1979). *Recommended Guidelines for Safety Inspection of Dams.* U.S. Army Corps of Engineers.

USACE. (1996). *Risk Analysis for Dam Safety Evaluation: Hydrologic Risk.* U.S. Army Corps of Engineers.

USACE. (1996). *Risk-Based Analysis for Flood Damage Reduction Studies, EM 1110-2-1619.* U.S. Army Corps of Engineers.

USACE. (2007). *Updated Principles for Risk Analysis.* U.S. Army Corps of Engineers.

USACE. (1978). *Phase 1 Inspection Report National Dam Safety Program – Mohawk River Basin, Gilboa Dam, Schoharie County, New York, Inventory Number NY178.* New York District, U.S. Army Corps of Engineers.

USCOLD. (1970). *Criteria and Practices Utilized in Determining the Required Capacity of Spillways.* U.S. Committee on Large Dams.

USSD. (2003). *Dam Safety Risk Assessment: What Is It?, Who Is Using It and Why?, Where Should We Be Going With It?* Working Group on Risk Assessment, Committee on Dam Safety, U.S. Society on Dams.

Utah State University & Reclamation. (1999). *A Framework for Characterizing Extreme Floods for Dam Safety Risk Assessment*. Bureau of Reclamation, U.S. Department of the Interior.

Washington State Department of Ecology. (1989). *Characteristics of Extreme Precipitation Events in Washington State.* State of Washington.

Washington State Department of Ecology. (1993). *Dam Safety Guidelines, Part IV: Dam Design and Construction.* State of Washington.

Webb, J. W. (2006). *USACE Hydrologic Safety Assessment.* U.S. Army Corps of Engineers.

Williams, G. (1973). Re-evaluating Spillway Capacity of Existing Dams. *Engineering Foundation Conference Proceedings: Inspection, Maintenance, and Rehabilitation of Old Dams.* New York, NY: American Society of Civil Engineers.

Zamensky, G. (2010). Navigating Dam Safety Rules in Virginia. *ASDSO Annual Conference.* Association of State Dam Safety Officials.

Zhou, R. D., Donnelly, C. R., & Judge, D. G. (2008). On the relationship between the 10,000 year flood and probable maximum flood. *Hydrovision 2008* .

Appendix C. Hydrologic Safety of Dams Surveys

C.1 Survey Content
C.2 Completed Federal Surveys
C.3 Completed State Surveys



FEMA

C.1. Survey Content



FEMA

HYDROLOGIC SAFETY OF DAMS

QUESTIONNAIRE

On the Record

1. Respondent information:
   - State/Federal Dam Safety Organization _____
   - Name of Representative _____
   - Title of Representative _____
   - Phone number(s) _____
   - Email address _____

2. Number of dams under Organization's jurisdiction by type:
   - Total Dams _____
   - Total Regulated Dams _____
   - High Hazard Dams _____
   - Significant Hazard Dams _____
   - Low Hazard Dams _____
   - Unregulated Dams _____
   - Other _____

3. What year did your Agency adopt minimum Inflow Design Flood criteria? _____

4. How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:
   - ☐ Less than 25 feet high (from streambed) and 15 acre-feet of storage (top of dam)
   - ☐ Less than 6 feet high (from streambed) and 50 acre-feet of storage (top of dam)
   - ☐ Both of the above
   - ☐ Less than 50 acre-feet of storage (top of dam)
   - ☐ Other (Please specify) _____

5. Are there types/categories of dams (other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)
   - ☐ Yes (Please explain)
   - ☐ No

6. Does the Organization have published size classification criteria?
   - ☐ Yes
   - ☐ No

   If "Yes", check and complete as appropriate:
   - Class A (Small) =<_____ feet high and stores =< _____ acre-feet
   - Class B (Medium)
   - Class C (Large) =>_____ feet high and stores => _____ acre-feet
   - Other (Specify) _____

7. Does the Organization have published hazard classification criteria?
   - ☐ Yes (High, Significant, and Low)
   - ☐ Yes (High, Significant, Low, Limited Hazard)
   - ☐ Yes (Other)
   - ☐ No

   If "Yes" and Significant Hazard is defined, how is Significant Hazard defined?
   - ☐ Loss of life potential is "few" with "appreciable" economic loss
   - ☐ No potential for loss of life with significant but not excessive economic loss
   - ☐ Other (Please specify) _____

8. Does the Organization have guidelines for determining the spillway design flood?
   - ☐ Yes
   - ☐ No

   If "Yes", what is the status of the guidelines; do they have the force of law?
   - ☐ Published within State Laws
   - ☐ Published guidelines/regulations that are required
   - ☐ Published guidelines/regulations for consideration by the engineer/designer
   - ☐ Unpublished guidelines that are required
   - ☐ Unpublished guidelines for consideration by the engineer/designer
   - ☐ Other (Please specify) _____

9. What is the origin of the guidelines?
   - ☐ Custom developed by Organization
   - ☐ USBR guidelines
   - ☐ NRCS guidelines
   - ☐ FEMA/FERC federal guidelines
   - ☐ USACE guidelines (including Phase I Study guidelines)
   - ☐ Combination of the above (Please specify) _____
   - ☐ Other (Please specify) _____
   - ☐ Unknown

10. When were the guidelines last revised (MM/DD/YYYY)? _____

11. Are there any plans to update or revise the guidelines in the near future?
   - ☐ Yes (Please specify) _____
   - ☐ No

12. Are the guidelines different for new and existing dams?
   - ☐ Yes (Please elaborate) _____
   - ☐ No

13. Which of the following best describes your agency's role in determining the spillway design flood:
   - ☐ Agency does not review any technical information, but ensures that design is performed by qualified professionals
   - ☐ Agency reviews submitted designs
   - ☐ Agency performs independent verification of submitted designs
   - ☐ Agency acts as designer/engineer
   - ☐ Agency utilizes a combination of the above approaches, possibly on a case-by-case basis
   - ☐ Other (Please explain) _____

14. How are the guidelines applied?
   - ☐ Based on both size and hazard classification
   - ☐ Based on size classification only
   - ☐ Based on hazard classification
   - ☐ Based on risk analysis
   - ☐ Based on a combination of risk analysis and hazard/size classification
   - ☐ Based on other criteria (Please specify) _____

15. For PMP/PMF designs, is freeboard required?
   - ☐ No
   - ☐ Based on wave run up computations
   - ☐ 1.0'
   - ☐ 1.5'
   - ☐ 2.0'
   - ☐ 3.0' or more
   - ☐ Other (Please specify) _____

16. Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that must be used?
    - ☐ Yes
    - ☐ No

    If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?
    - ☐ Must use HMRs for developing PMP
    - ☐ Must use SCS unit hydrograph
    - ☐ Must use HEC-1
    - ☐ Must use HEC-HMS
    - ☐ Must use SITES
    - ☐ Other (Please specify) _____

17. Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?
    - ☐ Yes (Please specify) _____
    - ☐ No

18. Do the guidelines specify any criteria for storm duration?
    - ☐ Yes (6-hour)
    - ☐ Yes (24-hour)
    - ☐ Yes (48-hour)
    - ☐ Yes (72-hour)
    - ☐ Yes (Based on Tc)
    - ☐ No
    - ☐ Other (Please specify) _____

19. Do the guidelines specify any criteria for temporal storm distribution?
    - ☐ Yes (HMR)
    - ☐ Yes (NRCS Standard)
    - ☐ Yes (Regional)
    - ☐ Yes (Other, Please specify) _____
    - ☐ No

20. Do the guidelines specify any criteria for spatial storm distribution?
    - ☐ Yes (Please specify) _____ _____
    - ☐ No

21. Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?
    - ☐ Yes (Please specify) _____
    - ☐ No

22. Does the organization allow development of a site specific PMP?
    - ☐ Yes
    - ☐ No
    - ☐ Unknown (never requested)

    If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?
    - ☐ Yes (Please specify) _____
    - ☐ No

23. Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?
    - ☐ Yes, a major problem
    - ☐ Yes, a moderate problem
    - ☐ Yes, a minor problem
    - ☐ No
    - ☐ Unsure

24. Do guidelines require consideration or analysis of future development?
    - ☐ Yes (Impacts of development on watershed hydrology)
    - ☐ Yes (Impacts of development on hazard classification or failure consequences)
    - ☐ Yes (Both of the above)
    - ☐ Yes (Other; please specify) _____
    - ☐ No

25. Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?
    - ☐ Yes (Please specify) _____
    - ☐ No

26. Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?
    - ☐ Yes
    - ☐ No

    If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?
    - ☐ Yes
    - ☐ No

27. Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?
    - ☐ Yes (Please specify) _____
    - ☐ No

28. Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF? If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined. _____

New High Hazard Dams must pass	_____ % of PMP, or	_____ % of PMF
Existing High Hazard Dams must pass	_____ % of PMP, or	_____ % of PMF
New Significant Hazard Dams	_____ % of PMP, or	_____ % of PMF
Existing Significant Hazard Dams	_____ % of PMP, or	_____ % of PMF

29. For low hazard dams, the spillway design requirement is:
    - ☐ 25-year flood
    - ☐ 50-year flood
    - ☐ 100-year flood
    - ☐ 500-year flood
    - ☐ Not specified
    - ☐ Other (Please specify) _____

30. Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?
    - ☐ Yes
    - ☐ No

31. Does your organization permit risk based hydrologic designs?
    - ☐ Yes; our regulations permit them
    - ☐ Yes; although our regulations do not specifically address this topic, we review risk-based designs on a case-by-case basis
    - ☐ No; our regulations forbid them
    - ☐ No; our regulations address this topic and we have made an administrative decision not to consider risk-based designs
    - ☐ Our regulations do not specifically address this topic and it has never come up for consideration
    - ☐ Other (Please explain) _____

32. Has your agency ever reviewed a risk-based hydrologic analysis?
    - ☐ Yes (Reviewed and approved)
    - ☐ Yes (Reviewed and rejected)
    - ☐ Yes (Both approved and rejected)
    - ☐ No
    - ☐ Unsure
    - ☐ Other (Please explain)

33. How difficult would it be to change your regulations? Please explain. _____
    - ☐ Difficult
    - ☐ Moderate
    - ☐ Easy

34. Are they any unique provisions in your regulations?
    - ☐ Yes (Please explain) _____
    - ☐ No

Off the Record

35. Do you agree that designing for the PMF is unreasonably conservative?
    - ☐ Strongly agree
    - ☐ Somewhat agree
    - ☐ Neutral
    - ☐ Somewhat disagree
    - ☐ Strongly disagree
    - ☐ Undecided

36. In your opinion, does the general public believe that the PMF is unreasonably conservative?
    - ☐ Yes, the general public strongly opposes the PMF design
    - ☐ Yes, the general public somewhat opposes the PMF design
    - ☐ No, the general public strongly favors the PMF design
    - ☐ No, the general public somewhat favors the PMF design
    - ☐ Undecided
    - ☐ No opinion
    - ☐ Other (Please explain) _____

37. Do you have any concerns regarding the consistency of hydrologic and hydraulic analyses?
    - ☐ Yes (Please specify) _____
    - ☐ No

38. Are you aware of the guidelines in the following documents?
    a. Safety of Dams: Flood and Earthquake Criteria – Prepared by the Committee on Safety Criteria for Dams, National Research Council (1985) ☐ Yes ☐ No
    b. Evaluation Procedures of Hydrologic Safety of Dams – Prepared by the Task Committee on Spillway Design Flood Selection of the Committee on Surface Water Hydrology of the Hydraulics Division of the American Society of Civil Engineers (1988) ☐ Yes ☐ No
    c. Guidelines on Selection of Acceptable Flood Capacity for Dams, and Guidelines on Risk Assessment – ANCOLD (2000, 2003) ☐ Yes ☐ No
    d. Guidelines for Achieving Public Protection in Dam Safety Decisionmaking - US Bureau of Reclamation (2003) ☐ Yes ☐ No
    e. Federal Guidelines for Dam Safety – Selecting and Accommodating Inflow Design Floods for Dams – FEMA (2004) ☐ Yes ☐ No
    f. Safety of Dams: Policy and Procedures (ER 1110-2-1156) – US Army Corps of Engineers (2010) ☐ Yes ☐ No

39. Do you have any concerns regarding the use of risk analyses or incremental damage assessments to determine spillway capacity requirements?
    - ☐ Yes (Please specify) _____
    - ☐ No

40. Do you agree or disagree with the following statements:

a.	Risk analysis is the best and most logical approach to selection of the appropriate SDF.	☐ Strongly agree ☐ Neutral ☐ Undecided	☐ Somewhat agree ☐ Somewhat disagree ☐ Strongly disagree
b.	The complexity of risk analysis constitutes a severe constraint on its usefulness because virtually no one other than a skilled dam safety professional can understand it.	☐ Strongly agree ☐ Neutral ☐ Undecided	☐ Somewhat agree ☐ Somewhat disagree ☐ Strongly disagree
c.	One of the big problems in developing a risk analysis is assigning probabilities to extreme flood events.	☐ Strongly agree ☐ Neutral ☐ Undecided	☐ Somewhat agree ☐ Somewhat disagree ☐ Strongly disagree
d.	There are so many intangibles and judgment decisions in the development of a risk assessment that the result is little more than an academic exercise.	☐ Strongly agree ☐ Neutral ☐ Undecided	☐ Somewhat agree ☐ Somewhat disagree ☐ Strongly disagree
e.	The practicality of risk analysis is severely constrained by changing conditions in the downstream hazard zone.	☐ Strongly agree ☐ Neutral ☐ Undecided	☐ Somewhat agree ☐ Somewhat disagree ☐ Strongly disagree
f.	The litigious nature of our society forces the professional to choose the most conservative design option.	☐ Strongly agree ☐ Neutral ☐ Undecided	☐ Somewhat agree ☐ Somewhat disagree ☐ Strongly disagree

41. Do you believe your agency has the technical ability to review the following:

Site Specific PMP Studies	☐ Yes	☐ No
Incremental Damage Assessments	☐ Yes	☐ No
Rigorous Risk Analyses	☐ Yes	☐ No

42. Do you believe your agency has the resources (availability and budget) to review the following:

Site Specific PMP Studies	☐ Yes	☐ No
Incremental Damage Assessments	☐ Yes	☐ No
Rigorous Risk Analyses	☐ Yes	☐ No

43. Would you like to see any changes in your current guidelines?
    - ☐ Yes (Please specify) _____
    - ☐ No

44. Do you believe that increased uniformity in state dam safety guidelines across the country would be beneficial?
    - ☐ Yes
    - ☐ No

45. Would you be receptive to adopting new recommended guidelines if they resulted in lower spillway design flood criteria for existing and new dams?
    - ☐ Yes
    - ☐ No

46. Would you be receptive to adopting new recommended guidelines if they resulted in higher spillway design flood criteria for existing and new dams?
    - ☐ Yes
    - ☐ No

47. Do you have any other comments? _____

C.2. Completed Federal Surveys



FEMA

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Bureau of Indian Affairs
Name of Representative	John Anevski
Title of Representative	Chief, Division of Water and Power
Phone number(s)	(202) 208-5480
Email address	john.anevski@bia.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	900
Total Regulated Dams	900
High Hazard Dams	91
Significant Hazard Dams	45
Low Hazard Dams	764
Unregulated Dams	0
Other	0

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 2006

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Based on Indian Dam Safety Act of 1994 (P.L. 103-302)--Between 1 and 6 lives would be at risk or significant property damage could occur if the dam failed.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

Comments: The current BIA Handbook calls for the Base Safety Condition to be determined and this is the largest flood which will cause incremental dam failure flooding. However, BIA reserves the right to select something smaller based on downstream conditions. Normally, the IDF will not be greater than a 10,000 year storm.

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Custom based on Bureau and USBR Guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 07/08/2007

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Plan to include revised current guidelines in BIA Safety of Dams Handbook in FY 2012

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on a combination of risk analysis and hazard/size classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: The current BIA Handbook calls for the Base Safety Condition to be determined and this is the largest flood which will cause incremental dam failure flooding. However, BIA

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: EWS instrumentation will be installed, operated, and maintained at High or Significant Hazard dams and in the upstream basin when early detection of hydrologic events would provide additional time needed for emergency management activities.

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Easy

Comments: Most of our criteria for IDF development is in the form of guidelines/standards and is not found in regulations. However, we would normally consult with Tribal organizations if and when revisions occur.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Federal Energy Regulatory Commission
Name of Representative	Daniel J. Mahoney
Title of Representative	Director, Dam Safety and Inspection
Phone number(s)	(202) 502-6743
Email address	daniel.mahoney@ferc.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	2530
Total Regulated Dams	2530
High Hazard Dams	780
Significant Hazard Dams	192
Low Hazard Dams	1558
Unregulated Dams	0
Other	0

3 When did your Organization adopt minimum Inflow Design Flood criteria? 1981

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Every dam included in a FERC license

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: They have the force of law.

9 What is the origin of the guidelines?

FEMA/FERC federal guidelines

10 When were the guidelines last revised (MM/DD/YYYY)?

Comments: FERC Engineering Guidelines are constantly updated and revised

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Continually revised as necessary.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

Comments: We review all of them, but when necessary we perform an independent verification

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: On a case by case basis, anticipated wave run-up and engineering judgement

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Outlet works and service spillways should be designed for frequent use and should by highly reliable. Auxiliary spillways are usually designed for infrequent use and it is acceptable to sustain limited damage during passage of the IDF. Emergency spillway may be used to obtain a high degree of hydrologic safety with minimal additional cost. Because of their infrequent use, it is acceptable for them to sustain significant damage when use and they may be designed with lower structural standards than those used for auxiliary spillways.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: A BOC is normally required to oversee the development of the PMP/PMF

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments:

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: In general, if there is no allocated or planned flood control storage (i.e., run-of-river), the flood routing usually begins with the reservoir at the normal maximum pool elevation. If regulation studies show that pool levels would be lower than the normal maximum pool elevation during the critical inflow design flood (IDF) season, then the results of those specific regulation studies should be analyzed to determine the appropriate initial pool level for routing the IDF.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: Follow FEMA's "Federal Guidelines for Dam Safety: Selecting and Accomodating Inflow Design Floods for Dams" (April 2004)

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Other (Please explain)

Comments: We have considered risk based hydrologic analysis as another bit of information when reviewing IDFs

33 How difficult would it be to change your regulations? Please explain.

Moderate

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	DOL - Mine Safety and Health Administration
Name of Representative	Stanley Michalek
Title of Representative	Acting Dam Safety Officer
Phone number(s)	412-386-6974 (202-693-9476 until 4/4/11)
Email address	michalek.stanley@dol.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	2089
Total Regulated Dams	2089
High Hazard Dams	429
Significant Hazard Dams	266
Low Hazard Dams	1394
Unregulated Dams	unknown
Other	n/a

3 What year did your Agency adopt minimum Inflow Design Flood criteria? approx. 1975

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: < 5 feet high; or < 20 feet high and < 20 ac-ft. This is criteria used by Agency's coal program area. For the non-coal program area, the size criteria specified by NID is used.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: In some cases, flood control dams that would be classified as high hazard potential are allowed to be designed to low hazard storm event with warning system.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	<40	feet high and stores =<	<1000	acre-feet
Class B (Medium)					
Class C (Large)	=>	40	feet high and stores =>	1,000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Facilties where failure would likely not result in loss of human life, but can cause economic loss, environmental damage, or disruption of lifeline facilities.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: MSHA guidelines use the inflow design flood in the design (freeboard design flood).

9 What is the origin of the guidelines?

FEMA/FERC federal guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 10/01/2007

Comments: "Coal Mine Impoundment Inspection and Plan Review Handbook"

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

MSHA uses inflow design flood.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

3.0' or more

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: Designer must consider most severe storm duration up to 72 hours.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

Comments: Storm must be temporally and spatially distributed to produce the most severe conditions with respect to freeboard and spillway discharge.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: Storm must be temporally and spatially distributed to produce the most severe conditions with respect to freeboard and spillway discharge.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: While we allow it, we've never seen it done.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

Comments: Question poorly worded. We do not require consideration of future development in the design plan, but do require consideration/analysis after the development takes place.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC III for PMF; pool at elevation of lowest ungated outlet.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: inflow design flood or freeboard design flood.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Once hazard potential rating would be determined using incremental damage assessment, design storm is defined by guidelines.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50-100	% of the	PMF
Existing Significant Hazard Dam must pass	50-100	% of the	PMF

Comments: For significant hazard potential, storm depends on size classification of dam.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: For small reservoir - 100 year, 24 hour
For large reservoir - 1/2 PMF

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: Dams constructed to control floods due to storm runoff may be designed to low hazard storm criteria and use an early warning system to evacuate downstream personnel.

31 Does your organization permit risk-based hydrologic designs?

Other (Please explain)

Comments: We do not forbid risk-based designs. We have not seen one submitted. There is some question whether our regulations would allow them.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Not with regard to hydrologic issues. We do allow low hazard impoundments to be "abandoned" as live dams if specific criteria are met.

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	USDA - Natural Resources Conservation Service
Name of Representative	Noller P. Herbert
Title of Representative	Director, Conservation Engineering Division
Phone number(s)	(202) 720-2520
Email address	noller.herbert@wdc.usda.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	27254
High Hazard Dams	2233
Significant Hazard Dams	2299
Low Hazard Dams	22722
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1930's

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: Defined in "USDA - NRCS National Engineering Manual (NEM) Part 520, Subpart C Section F." http://directives.sc.egov.usda.gov/viewDirective.aspx?hid=27493

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: Regardless of structure purpose or type of dam, it is subject to either TR-60 or Conservation Practice Standard 378 design standards.

6 Does the Organization have published size classification criteria?

No

Comments: Design standards are based on hazard classification criteria, not size classification.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Significant Hazard - Dams in predeominately rural or agriclutural areas where failure may damage isolated homes, main highways, or minor railroads, or interrupt service of relatively important utilities.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: TR-60 contains policy on storm size; National Engineering Handbook Part 630, Chapter 21 contains procedure for developing inflow hydrograph.

9 What is the origin of the guidelines?

NRCS guidelines

Comments: SCS/NRCS guidelines were first developed in the 1930s when the first floodwater retarding dams were installed under the pilot watershed program. Since then the guidelines have evolved and are reviewed and updated on a continual basis.

10 When were the guidelines last revised (MM/DD/YYYY)? 07/01/2005

Comments: They are continually under revision and we are trying to get to the point again that they are reviewed every 5 years.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: We are currently in the process of updating a number of standards and guidelines used in dam design and dam safety activities

12 Are the guidelines different for new and existing dams?

No

Comments: The guidelines are the same for new and existing dams except in the case of rehabilitation of structures where site constraints prohibit the use of the existing guidelines. For those situations, FEMA 94 guidelines on Inflow Design Flood is allowed.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

Approach dependent upon time and resources available as determined by NRCS State Conservationists.

14 How are the guidelines applied?

Based on hazard classification only

Comments: Based upon size, various types of materials may be allowed for certain appurtenances (for example principal spillway pipes may be either corrugated metal, pvc, steel or concrete depending upon structure size).

15 For PMP/PMF designs, is freeboard required?

No

Comments: PMP/PMF is used to set the top of dam elevation. NRCS does not include additional freeboard.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use SITES

Comments: SITES must be used for TR-60 structures. Conservation Practice Standards 378 designs may use other analyses/methodologies/procedures/computer software dependent upon NRCS state conservation engineer guidance.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: This is based on the professional judgment of the designer, reviewer and approver.

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: Both a short duration (6 hour or longer) and a long duration (24 hour or longer) storm shall be analyzed and the most critical results used to check the capacity and the integrity of the auxiliary spillway.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: Principal spillway design hydrographs use NRCS standard distributions. Spillway design hydrographs (used for auxiliary spillway design) use type B or standard distributions. PMP/PMF uses PMP distribution as defined in HMR 52 or 5-point distribution (developed based on HMR 52 methodologies).

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: Uniform rainfall depth assumed over the entire watershed. Rainfall depth may be adjusted based on watershed drainage area.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Spillway frequency of use criteria are provided. Also, earth and vegetated auxiliary spillways are designed on the basis that some erosion or scour will occur during passage of infrequent storms, but the spillway will not breach during passage of the freeboard storm.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: NRCS encourages the use of a site-specific PMP where information is available. Site specific PMP studies must be performed by a qualified professional.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

Comments: NRCS does not regulate any of the dams for which it provides technical or financial assistance. Changing dam classifications is a problem for our customers and sponsors.

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

Comments: TR-60 requires that consideration must be given to the damage that might occur to existing and future developments.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Use average antecedent runoff conditions (ARC II) or greater unless a special study shows that a different condition is justified. The initial reservoir stage for principal spillway hydrograph routing shall be at the crest of the lowest ungated inlet or (if not subtracted from the stage-storage curve) the anticipated elevation of the sediment storage, whichever is higher, except as provided below. For dams with significant base flow, principal spillway hydrograph routings must start not lower than the elevation of the water surface associated with the base flow. Significant base flow is average annual or seasonal flow that would produce at least 0.5 feet of head over the lowest principal spillway inlet immediately prior to a flood or occupy more than 10 percent of the floodwater storage capacity. For dams with joint use storage capacity, when one of the uses is floodwater detention, routing of the principal spillway hydrograph may begin at the lowest anticipated elevation of the joint use pool in accordance with the operation plan. Single purpose, low hazard class irrigation dams with gated outlets and earth or vegetated auxiliary spillways, which are located on ephemeral streams in areas where the average annual precipitation is less than 25 inches, may be considered to have discharged up to 70 percent of the storage, exclusive of sediment storage in determining the elevation to start routing. For auxiliary spillway and freeboard hydrographs, routings start at the 10-day draw-down elevation or the principal spillway hydrograph.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

Comments: Methods in the Federal Guidelines for Dam Safety - Inflow Design Floods, FEMA 94, may alternately be used to proportion the embankment and auxiliary spillway, provided downstream land use controls exist to prevent voiding incremental risk assumptions after the dam is completed. Only for rehabiliation projects. Not allowable for new projects.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Only allowed for rehabilitation projects - not allowed for new projects. For high hazard dams, when using an IDF (FEMA 94) analysis, the minimum storm that can be used can be no less than the freeboard design storm for a significant hazard dam. (P100+0.4(PMP-P100))

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass		% of the	
Existing Significant Hazard Dam must pass		% of the	

Comments: Significant Freeboard Design Hydrograph: P100 + 0.40(PMP - P100)

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: If product of storage and effective height is less than 30,000 and there are no upstream dams: P100 + 0.12(PMP - P100); if product of storage and effective height is greater than 30,000 and there are no upstream dams: P100 + 0.26(PMP - P100); if there is an existing or planned upstream dam: P100 + 0.40(PMP - P100)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: NRCS might consider an early warning system as alternative, but it is not a part of design guidelines.

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

Comments: NRCS will consider risk based designs, but they are not a part of design guidelines.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Both approved and rejected)

Comments: NRCS has both approved and rejected designs based on FEMA 94 guidelines.

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: It takes time for review and coordination but we do not have to get any legislative approval for a change

34 Are there any unique provisions in your regulations?

No

Comments: NRCS tries to apply standards nationwide. States are allowed to revise the standards to make them more restrictive, but not less restrictive. Additionally, NRCS must meet all state and local regulations.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Tennessee Valley Authority
Name of Representative	Michael T. Scott
Title of Representative	Dam Safety Officer
Phone number(s)	423.751.6995
Email address	mtscott2@tva.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	49
High Hazard Dams	36
Significant Hazard Dams	10
Low Hazard Dams	3
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? circa 1978

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: This survey has been completed for TVA's 49 regulated dams. TVA is currently creating a Dam Safety Governance organization which will implement guidelines for any impoundment within the TVA system which meets the definition of dam given in FEMA 93.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: TVA is currently creating a Dam Safety Governance organization which will implement dam safety guidelines for any impoundment (tailings, coal combustion products, etc.) which meet the definition of a dam as given in FEMA 93.

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: TVA follows FEMA 333 for assigning hazard classifications.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: Our historic practice has been to select the PMF as the appropriate spillway design flood for TVA dams with a high hazard classification.

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: FEMA (Federal Guidelines) and self imposed criteria that TVA has historically adopted

10 When were the guidelines last revised (MM/DD/YYYY)? 1/1/2008

Comments: Note that the date is approximate. TVA's self imposed criteria changed based on new information including: operating guides, orifice flow coefficients, etc.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: TVA Dam Safety Governance organization will issue guidelines and each business unit will create implementing procedures.

12 Are the guidelines different for new and existing dams?

No

Comments: It is not expected that the hydrologic safety of dams guidelines will be different for new and existing dams.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency acts as designer/engineer

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

Comments: TVA has followed specific methodologies which were not stipulated. TVA uses rainfall design basis developed by NWS under contract with TVA, estimated watershed response (inflows) using TVA developed tools used to schedule the reservoir system, and routed those inflows through the system using hydrologic models developed by TVA.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: TVA uses a 9-day sequence specified by a hydrometeorological design basis report developed by NWS (contracted work).

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: TVA uses a distribution specified by a hydrometeorological design basis report developed by NWS (contracted work).

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: TVA uses a distribution specified by a hydrometeorological design basis report developed by NWS (contracted work).

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: TVA uses the hydrometeorological design basis report developed by NWS (contracted work).

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: Historically, this has not been a problem for TVA.

24 Do guidelines require consideration or analysis of future development?

No

Comments: Most communities downstream of TVA dams participate in the FEMA flood insurance program, and so they are somewhat self-regulating.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Historic practice includes median moisture conditions and conservatively high initial reservoir pool levels.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: 100-year frequency event minimum

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass		% of the	
Existing High Hazard Dam must pass		% of the	
New Significant Hazard Dam must pass		% of the	
Existing Significant Hazard Dam must pass		% of the	

Comments: Our historic practice has been to select the PMF as the appropriate spillway design flood for TVA dams with a high hazard classification. Significant hazard dams must pass the "TVA precipitation" as defined by the NWS study. This precipitation is significantly less than the PMP.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: TVA practice is that Low hazard dams must pass the "TVA precipitation" as defined by the NWS study. This precipitation is significantly less than the PMP.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: This practice has been adopted by TVA in the past, but was not used as the permanent solution (used as an interim measure).

31 Does your organization permit risk-based hydrologic designs?

Other (Please explain)

Comments: TVA has not practiced risk-basd hydrologic designs. However, the topic has been considered with no firm conclusions.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Changes to Dam Safety Guidelines would have to be approved by the Dam Safety Officer, Chief Operating Officer, and possibly the TVA Board of Directors/Chief Executive Officer.

34 Are there any unique provisions in your regulations?

No

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Army Corps of Engineers
Name of Representative	Eric C. Halpin
Title of Representative	Special Assistant for Dam and Levee Safety
Phone number(s)	202-761-7662
Email address	Eric.C.Halpin@usace.army.mil

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	697
High Hazard Dams	525
Significant Hazard Dams	138
Low Hazard Dams	34
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? Procedures Pertaining to Deter

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: Criteria is per the National Dam Safety Program Act.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

Comments: ER 1110-2-106, "Recommended Guidelines for Safety Inspection of Dams", 26 September 1979. This regulation is no longer valid. Current USACE guidance classifies dams by hazard potential and not size.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Loss of life not probable.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: ER 1110-8-2(FR), "Inflow Design Floods for Dams and Reservoirs", 1 March 1991.

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

10 When were the guidelines last revised (MM/DD/YYYY)? 03/01/1991

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: USACE has a program for updating guidance but there are no specific dates established for this regulation.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency acts as designer/engineer

14 How are the guidelines applied?

Based on other criteria (Please specify)

Comments: Standard 1: Risk to life and property; Standard 2: Run of river projects; Standard 3: Base safety condition, negligible incremental impacts due to failure; Standard 4: Small Dams

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Three feet minimum for concrete dams. Three feet minimum for embankment dams unless pool is within three feet of the maximum pool for more than 36 hours in which case the minimum is five feet. Required freeboard may be greater than the minimum based on wind setup, wave action, uncertainty in analysis procedures, or uncertainty in project function.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

Comments: Development of site specific PMPs is allowed. EM 1110-2-1417, "Flood Runoff Analysis", 31 August 1994.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: USACE maintains software lists that classify software as follows: Required, Recommended, Ok to use, Retired, Not Allowed for Use.

18 Do the guidelines specify any criteria for storm duration?

Yes (Based on Tc)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: HMR spatial distribution with orientation adjusted to maximize peak discharge.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Site specific PMPs require approval by HQUSACE.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: Although downstream development can change hazard potential classification and inflow design flood requirements, this has not been an issue for USACE dams. A more common issue relates to changes in routine operation due to downstream development. Hazard potential classification affects frequency of dam safety exercises.

24 Do guidelines require consideration or analysis of future development?

Yes (Other; please specify)

Comments: Analysis of new projects requires consideration of most likely future conditions. Existing projects based on existing conditions. Design of spillways requires consideration of potential for hazardous flow regardless of current or future development (ER 1110-2-1451).

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: ER 1110-8-2(FR) provides requirements for antecedent reservoir pool conditions. EM 1110-2-1417 provides guidelines for antecedent moisture conditions. Criteria can be modified at the regional (MSC) level based on regional conditions.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: Applies to Standard 3 dams per ER 1110-8-2(FR).

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Minimum 1/2 PMF for Standard 3 dams per ER 1110-8-2(FR).

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass		% of the	
Existing Significant Hazard Dam must pass		% of the	

Comments: High hazard dams with potential life loss must pass 100% of the PMF per Standard 1 of ER 1110-8-2(FR). Significant hazard dams with no probable life loss must pass major floods typical of the region without excessive damage or loss of operability per Standard 2 of ER 1110-8-2(FR). Significant hazard dams with no incremental life loss due to dam failure must pass a minimum of 1/2 PMF per Standard 3 of ER 1110-8-2(FR).

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Low hazard dams typically fall under Standard 4 of ER 1110-8-2(FR) which requires rainfall-runoff probability analyses with no specific minimum requirement.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Early warning can be considered as a risk reduction measure but would not be accepted in lieu of meeting minimum essential guidelines for the inflow design flood.

31 Does your organization permit risk-based hydrologic designs?

Other (Please explain)

Comments: Risk informed hydrologic designs are permitted for flood damage reduction studies (e.g. levees, channel improvements, etc) per ER 1105-2-101. Risk informed hydrologic designs are not permitted for dams. Risk informed hydrologic analyses for dams are used to prioritize risk reduction actions for dams in the USACE inventory and to inform decisions on incremental risk reduction actions for specific projects.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Both approved and rejected)

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: A significant challenge would be establishing appropriate new/revised essential guidelines. Updating USACE regulations is a well defined process but usually takes 2-5 years to complete.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: There are numerous guidelines that address/allow consideration of site-specific circumstances, regional considerations, and portfolio prioritization.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	US Bureau of Reclamation
Name of Representative	Brian Becker
Title of Representative	Chief, Dam Safety Office
Phone number(s)	303-445-2776
Email address	bbecker@usbr.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	587
Total Regulated Dams	468
High Hazard Dams	332
Significant Hazard Dams	38
Low Hazard Dams	98
Unregulated Dams	
Other	119

3 What year did your Agency adopt minimum Inflow Design Flood criteria? Around 1951.

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Reclamation follows definition in the Federal Guidelines for Dam Safety (FGDS). (Your pull downs use the word "and" between the 2 dimensions, when the FGDS uses "or" and your pull-downs incorrectly mixing the 2 dimensions. The way the FGDS reads is 25ft and 50 ac-ft for one jurisdiction test and 6' and 15ac-ft for the other test.)\

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Prior to adopting FEMA 333, Reclamation Dam Safety Program used the following definition for Significant: "Few Loss of Life is defined as 1 to 6 lives in jeopardy. Appreciable economics is defined as rural area with notable agriculture, industry, or worksites, or outstanding natural resources." While we now follow FEMA 333 definitions, dams that were assigned a hazard class of significant by following our 1988 guidelines and have potential life loss, these facilities have not been changed to high-hazard. It is the Reclamation's Dam Safety view that since these significant-hazard dams are treated as high-hazard.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

Comments: Reclamation uses the Reclamation Flood Hydrology Manual and the Reclamation Public Protection Guidelines (PPG) and uses a risk based approach.

9 What is the origin of the guidelines?

USBR guidelines

Comments: The risk assessment methodology of 1999 is superceded by the current Best Practices and used in coordination with the PPG. Reclamation has moved away from deterministic design flood standards and now uses risk-based approach. (Reclamation prefers the acronym of "Reclamation" instead of USBR or BOR.)

10 When were the guidelines last revised (MM/DD/YYYY)? 04/04/2011

Comments: Dam Safety Risk Analysis Best Practices Manual is updated as needed; approximately once or twice a year. PPG was last updated in 2010.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Dam Safety Risk Analysis Best Practices Manual is updated as needed; approximately once or twice a year. PPG was last updated in 2010.

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: The application of updated design guidelines, or state-of-the-art, will vary by project. Modifications to existing structures must consider the amount of risk reduction, feasibility of the modification, and the cost/benefit when trying to apply state-of-the art.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency acts as designer/engineer

In determining the spillway design flood, we set spillway design as case by case. It's very structure/site specific.

14 How are the guidelines applied?

Based on risk analysis

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Following the Federal Guidelines for Dam Safety, freeboard conditions include consideration factors that can reasonably occur at the given project site but include, wave height based on fetch and wind velocity assumptions, settlement, allowance for improper gate operation, landslide-generated wave potential, and perphaps an arbitrary allowance for contingencies to provide an increased factor of safety.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

Comments: The Dam Safety Risk Analysis Best Practice was written to guide the engineer but also allows for deviation if justifiable.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: Duration of flood overtopping is a critical element in determining the failure probability; however, it is difficult to accurately estimate.

18 Do the guidelines specify any criteria for storm duration?

No

Comments: Basis for storm duration is the PMP hydromet reports and is dependant upon site conditions. Type of spillway is a critical factor as well size of reservoir.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: The Reclamation Flood Hydrology Manual specifies a 2/3 PMP distribution. We vary this based on site conditions and individual extreme storms according to Reclamations's

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: The Flood Hydrology Manual specifies a successive subtraction for PMP over watershed subbasins. We vary this based on site conditions and individual extreme storms according to Reclamations's guidelines for estimating hydrologic hazard curves.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Reclamation uses risk analysis but most likely freeboard would be integrated with other analysis, such as gate operations.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: PMPs are obtained for moderate level of effort studies such as Issue Evaluations, Corrective Action Studies, and Final Design. Reclamation uses generalized PMPs from the HMRs and according to Reclamation Flood Hydrology Manual and the Hydrologic Hazard Guidelines. Instead of site specific PMPs, Reclamation uses risk analysis.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: It is not a regulatory problem since changes in downstream development are reviewed during facility exams.

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: The risk analysis decision tree evaluates loads at various reservoir elevations. Antecedent moisture conditions are a parameter in modeling and are considered during the risk analysis process.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: The Guidelines do not require an incremental damage assessment but are used if appropriate.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: Any modifications to spillway design capacity would follow a risk-based approach using Reclamation's Risk Analysis Best Practices Manual.

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: For new design of high hazard dam, an EWS would probably not be allowed as an alternative for the regulatory spillway design flood. In cases of risk reduction, the cost to modify up to state-of-the-art may require the use of an EWS.

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

Comments: A better answer is Yes, our guidelines permit them.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Both approved and rejected)

33 How difficult would it be to change your regulations? Please explain.

Moderate

34 Are there any unique provisions in your regulations?

No

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

FEMA

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	US Fish and Wildlife Service
Name of Representative	Brad Iarossi
Title of Representative	Chief, Dam Bridge and Seismic Safety Branch
Phone number(s)	703-358-2211
Email address	Brad_Iarossi@fws.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	259
High Hazard Dams	17
Significant Hazard Dams	18
Low Hazard Dams	224
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1991

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: The U.S. Fish and Wildlife Service uses the definition of a dam found in the National Dam Safety Program Act to define a dam as "inventory dam". Impundment structures that do not meet these size/hazard criteria are considered "non-inventory" and are not subject to dam safety inspections etc.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

Comments: Intermediate (Medium) 40-100 feet high; 1000 - 50,000 acre feet

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: The U.S. Fish and Wildlife Service self regulates our dams, therefore the design guidelines are followed, but are not in statute as we are not a regulator.

9 What is the origin of the guidelines?

Unknown

10 When were the guidelines last revised (MM/DD/YYYY)? 09/12/2008

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: The guidelines will likely be revised to incorporate risk assessments and updates to the EAP format.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Incremental damage assessments are often used to establish inflow design floods.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Evaluated on a case by case basis

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

Comments: It is not a regulatory problem as we are not a regulator, however, as a responsible dam owner, we modify our dams appropriately based on hazard classification.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: If data is available

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Minimum inflow design is the 100-year flood.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50-100	% of the	PMF
Existing Significant Hazard Dam must pass	50-100	% of the	PMF

Comments: Significant: Small (50% PMF), Intermediate (50% PMF), Large (50-100% PMF)

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Small (100-year), Intermediate (100-year), Large (100-year to 500-year)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Absolutely NOT!

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Easy

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Forest Service
Name of Representative	Clifford Denning
Title of Representative	Program Manager, Geotech and Dams
Phone number(s)	414-297-3305
Email address	cdenning@fs.fed.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	437
High Hazard Dams	31
Significant Hazard Dams	83
Low Hazard Dams	323
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? s dated 1993 and minimum inf

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: Non-inventory dams are dams with a low or undertermined hazard potential classification that do not meet: a) Equal or exceed 25 feet in height and exceed 15 acre-feet in storage or b) Exceed 6 feet in height and equal or exceed 50 acre-feet in storage.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

Comments: New Forest Service Manual does not have published size classification criteria.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Would result in no probable loss of human life but could cause economic loss, disruption of lifeline facilities, or other significant impacts and would result in non-recoverable environmental damage.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: The level of design detail increases from preliminary to final design and with increasing size, value, and hazard potential classification of the structure. The level of detail of the geological and geotechnical investigation, design, design reports, and drawings must be adequate to construct the dam within acceptable safety parameters for its size and hazard potential classification. Utilize current U. S. Army Corps of Engineers or Bureau of Reclamation standards and procedures for dams in planning, investigating, and designing dams on National Forest System lands.

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: FEMA and USACE guidelines were consulted in the revision of our direction.

10 When were the guidelines last revised (MM/DD/YYYY)? 05/01/2011

Comments: The Forest Service guidelines are currently being revised and the above date is an estimated date of completion.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: They are currently being revised

12 Are the guidelines different for new and existing dams?

No

Comments: Existing dams which can accommodate at least 75 percent of the inflow design flood do not need to be modified to increase spillway capacity to the minimum requirements , until the dams undergo major reconstruction.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

Comments: At a minimum, utilize standards and procedures established by the Bureau or Reclamation, U. S. Army Corps of Engineers, or Natural Resources Conservation Service for determining the design storm event and sizing the spillway. Any appropriate Federal and State standards may be used case by case. Conduct site-specific evaluations to develop the inflow design hydrographs.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: At a minimum, utilize standards and procedures established by the Bureau or Reclamation, U. S. Army Corps of Engineers, or Natural Resources Conservation Service for determining the design storm event and sizing the spillway. Any appropriate Federal and State standards may be used case by case. Conduct site-specific evaluations to develop the inflow design hydrographs.

18 Do the guidelines specify any criteria for storm duration?

No

Comments: At a minimum, utilize standards and procedures established by the Bureau or Reclamation, U. S. Army Corps of Engineers, or Natural Resources Conservation Service for determining the design storm event and sizing the spillway. Any appropriate Federal and State standards may be used case by case. Conduct site-specific evaluations to develop the inflow design hydrographs.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: At a minimum, utilize standards and procedures established by the Bureau or Reclamation, U. S. Army Corps of Engineers, or Natural Resources Conservation Service for determining the design storm event and sizing the spillway. Any appropriate Federal and State standards may be used case by case. Conduct site-specific evaluations to develop the inflow design hydrographs.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: At a minimum, utilize standards and procedures established by the Bureau or Reclamation, U. S. Army Corps of Engineers, or Natural Resources Conservation Service for determining the design storm event and sizing the spillway. Any appropriate Federal and State standards may be used case by case. Conduct site-specific evaluations to develop the inflow design hydrographs.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: Conduct site-specific evaluations to develop the inflow design hydrographs.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: We have had several dams change classifications because of downstream development due to lack of zoning requirements.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: Consider and document reasonably foreseeable downstream development as well as existing development in the assessment.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Under no circumstances should the spillway capacity be reduced below the applicable minimum threshold (High=0.5PMF, Significant=100-year RP, Low=50-year RP).

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

Comments: Incremental Damage Analysis may allow spillway capacity to be reduced, but not any lower than the minimum threshold stated in question 27.

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: While we would not accept as an alternative the new direction states "To afford the maximum opportunity to alleviate problems that could threaten the integrity or operation of a dam remote sensing is required on all Forest Service operated dams with a high hazard potential classification."

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Unsure

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: While not impossible, changes require review and edits at different levels.

34 Are there any unique provisions in your regulations?

No

C.3. Completed State Surveys



ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Alaska
Name of Representative	Charles Cobb
Title of Representative	State Dam Safety Engineer
Phone number(s)	(907) 269-8636
Email address	charles.cobb@alaska.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	171
Total Regulated Dams	79
High Hazard Dams	19
Significant Hazard Dams	30
Low Hazard Dams	30
Unregulated Dams	57
Other	35

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 2004

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 10 feet in height and poses no threat to lives and property; less than 20 feet in height, impounding less than 50 acre-feet and poses no threat to lives and property.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Certain tailings dams must meet highest design standard

6 Does the Organization have published size classification criteria?

No

If "Yes", check and complete as appropriate:

Class A (Small) =< _____ feet high and stores =< _____ acre-feet

Class B (Medium)

Class C (Large) => _____ feet high and stores => _____ acre-feet

Other (Specify) _____

Comments:

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Other (Please specify)

Comments: failure or improper operation of the barrier will result in: Significant danger to public health; Probable loss of or probable signifcant damage to homes, occupied structures, commercial property, high-value property, major highways, primary roads, railroads or public utilities, except those which belong to the barrier owner; other probable significant property losses or damage; probable loss of or significant damage to waters identified as important for the spawning, rearing or migration of anadromous fish.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Other (Please specify)

Comments: State published guidelines which do not have the force of law, and reference to FEMA 94 (1998) in published regulations (Alaska Administrative Code) which does have the force of law.

9 What is the origin of the guidelines?

Custom developed by Organization

Comments: Alaska Dam Safety Program

10 When were the guidelines last revised (MM/DD/YYYY)? 06/01/2005

Comments:

11 Are there any plans to update or revise the guidelines in the near future?

No

Comments:

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Depends

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

The department will at a minimum review submitted designs, and depending on the hazard potential of the structure will on a case-by-case basis perform an independent verification. In some unusual circumstances the department may perscribe the IDF if the owner of an existing dam lacks the resources to define it themselves.

14 How are the guidelines applied?

Based on hazard classification only

Comments:

15 For PMP/PMF designs, is freeboard required?

No

Comments:

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Comments:

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments:

18 Do the guidelines specify any criteria for storm duration?

No

Comments:

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments:

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments:

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

Comments: 100 year flood minimum IDF for all dams

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments:

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

Comments:

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments:

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

Comments:

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments:

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: 100 year flood is minimum IDF for all dams

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass		% of the	
Existing High Hazard Dam must pass		% of the	
New Significant Hazard Dam must pass		% of the	
Existing Significant Hazard Dam must pass		% of the	

Comments: Minimum Standard for any dam: 100 year flood
Maximum Standard for any dam: PMF

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments:

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: Yes for existing dam, No for new construction

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

Comments:

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

Comments:

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Requires public comment and review

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Protection of anadromous fish habitat included in hazard potential classification
Design criteria specifically excluded to allow engineers to develop reasonable designs

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Arizona
Name of Representative	Nicole Spence-Gibson
Title of Representative	Engineering Section
Phone number(s)	602-771-8658
Email address	nsgibson@azwater.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	252
High Hazard Dams	100
Significant Hazard Dams	36
Low Hazard Dams	116
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1978

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: (a) any barrier that is or will be less than six feet in height, regardless of storage capacity
(b) any barrier between 6 and 25 ft in height with a storage capacity of less than 50 AF
(c) any barrier that has or will have a storage capacity of fifteen acre-feet or less, regardless of height
(d) any barrier for the purpose of controlling liquid-borne material
(e) any barrier that is a release-contained barrier (f) any barrier that is owned, controlled, operated, maintained or managed by the United States Government or its agencies or instrumentalities if a safety program that is as least as stringent as the state safety program applies and is enforced against the agent or instrumentality.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Significant hazard potential is defined as failure or improper operation of a dam would be unlikely to result in loss of human life but may cause significant or high economic loss, intangible damage requiring major mitigation, and disruption or impact on lifeline facilities. Property losses would occur in a predominantly rural or agricultural area with a transient population but significant infrastructure.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

9 What is the origin of the guidelines?

Custom developed by Organization

10 When were the guidelines last revised (MM/DD/YYYY)? 03/01/2004

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Our rules related to the magnitude of idf do differ for new and existing dams.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Largest of the following: i.) The sum of the inflow design flood maximum water depth above the spillway crest plus wave run up. ii.) The sum of the inflow design flood

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: Our rules do not specifiy criteria for storm duration; however, we developed general guidelines to assist with for the evaluation of spillway adequacy. For the evaluation, we require PMF studies include the 6-hour local and 72-hour. Site-specific PMP depths and distributions are accepted if independently reviewed by a qualified third-party meteorologist.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: Time-distribution for the 6-hour local PMP follows the HMR 49 procedure. The 72-hour general storm PMP uses: A. 1st Day - Second Largest Day uniformly distributed. B. 2nd Day - Largest Day sequenced as follows: 1. 3rd largest 6-hr period uniformly distributed 2. 2nd largest 6hr period uniformly distributed 3. Largest 6-hour period uniformly distributed and 4. 4th largest 6-hr period uniformly distributed. c. 3rd Day - Smallest day uniformly distributed. Site-specific PMP depths and distributions may be accepted if independently reviewed by a qualified third party meteorologist.

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: See Comment 19.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: The evaluation shall include land use zoning and development projected for the affected area over the 10 year period following classification of the dam.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	50-100	% of the	PMF
New Significant Hazard Dam must pass	25-50	% of the	PMF
Existing Significant Hazard Dam must pass	25-50	% of the	PMF

Comments: For significant hazard, design is determined by size classification. For high hazard, design is determined based on the number of persons at risk and the potential for downstream damage.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 25% of the PMF, Very low hazard potential dams it is the 100-year.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Our regulations do not specifically address this topic and it has never come up for consideration.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Any changes to our regulations would require stakeholder meetings and would go through the Governoring Regulatory Review Council.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

1. Emergency Spillway Requirements. An applicant shall: a. Construct each spillway in a manner that avoids flooding in excess of the flooding that would have occurred in the same location under the same conditions before construction. The owner of a dam shall demonstrate that a spillway discharge would not result in incremental adverse consequences. In determining whether a spillway discharge of a dam would result in incremental adverse consequences, the Director shall evaluate whether the owner has taken any or all of the following actions: issuing public notice to downstream property owners, complying with flood insurance requirements, adopting emergency action plans, conducting mock flood drills, acquiring flow easements or other acquisitions of real property, or other actions appropriate to safeguard the dam site and flood channel. b. Include a control structure to avoid head cutting and lowering of the spillway crest for spillways excavated in soils or soft rock. In the alternative, the design may provide evidence acceptable to the Director that erosion during the inflow design flood will not result in a sudden release of the reservoir. c. Provide each spillway and channel with a minimum width of 10 feet and suitable armor to prevent erosion during the discharge resulting from the inflow design flood. d. Ensure that downstream spillway channel flows do not encroach on the dam unless suitable erosion protection is constructed.
e. Ensure that each spillway, in combination with outlets, is able to safely pass the peak discharge flow rate, as calculated on the basis of the inflow design flood. f. Not construct bridges or fences across a spillway unless the construction is approved in writing by the Director. The Director's approval may include conditions regarding the design and operation of the spillway and fencing, based on safety concerns. g. Not use a pipe or culvert as an emergency spillway unless the Director approves the use following review of the dam design and site characteristics.

Comments:

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

FEMA

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Arkansas
Name of Representative	Alvin Simmons, Jr., P.E.
Title of Representative	Engineer Supervisor
Phone number(s)	501-682-3981
Email address	alvin.simmons@arkansas.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	406
High Hazard Dams	103
Significant Hazard Dams	95
Low Hazard Dams	208
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria?

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 25 feet dam height or less than 50 acre-feet of storage (top of dam)

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Appreciable (Significant structures, industrial, or commercial development, or cropland); $100,000 to $500,000.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

9 What is the origin of the guidelines?

Combination of the above (Please specify)

10 When were the guidelines last revised (MM/DD/YYYY)? 10/01/1993

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Within the next 2 years

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Existing dams will be evaluated periodically to determine if development of downstream areas warrants change in hazard classification and review of spillway design flood (SDF). Overtopping during the SDF may be allowed if properly prepared analyses demonstrate that: (1) overtopping will have a return interval greater than 25 years; and (2) the dam will withstand the projected overtopping without failure.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

Comments: NRCS dams

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	50-100	% of the	PMF
New Significant Hazard Dam must pass	25-100	% of the	PMF
Existing Significant Hazard Dam must pass	25-100	% of the	PMF

Comments: Percentage ranges are given and are based upon effective height of dam or maximum storage, whichever computed SDF is greated.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 0.25PMF to 0.75PMF depending on size of dam (small, intermediate, or large).

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	California
Name of Representative	David A. Gutierrez
Title of Representative	Chief, Division of Safety of Dams
Phone number(s)	916-227-9800
Email address	daveg@water.ca.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1247
High Hazard Dams	688
Significant Hazard Dams	274
Low Hazard Dams	285
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1930

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: We also have other execptions to jurisdiction.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: However, dams of different consequence class have varying design standards/requirements. For instance, a PMF is applied to very high hazard dams while a 1000 year level storm is for very low potential consequence. Same with earthquakes. Flood Control dams also have different requirements.

6 Does the Organization have published size classification criteria?

No

Comments: Damage potential classification based on capacity, height, estimated evacuation, and potential d/s damage

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Other (Please specify)

Comments: Damage potential classification based on capacity, height, estimated evacuation, and potential d/s damage

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

Comments: The force of law is not specifically outlined but California gives dam safety program broad authority to enforce these requirements. These are not "guidelines" as defined by the State of California, but Technical Reference how it is done at DSOD.

9 What is the origin of the guidelines?

Custom developed by Organization

10 When were the guidelines last revised (MM/DD/YYYY)? 03/01/1981

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: There is no specific date yet determined

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: The technical reference does not outline variations, but DSOD has different policy for new and existing dams.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on a combination of risk analysis and hazard/size classification

15 For PMP/PMF designs, is freeboard required?

1.5'

Comments: Additional freeboard is required for severe wave conditions from wind effects. In addtion 1.5 feet is required on new dams while existing dams may not be required to have more than zero residual freeboard depending on wave runup.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

Comments: Our inhouse evaluations use HEC. Statiscial requirements for dams is dependent on potential consequence.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (72-hour)

Comments: In general, the total precipitation duration is taken to be 72 hours. If routing will not significantly affect the peak outflow, a shorter storm (e.g., 24 hours) can be considered since the peak inflow will be about the same in either case.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: The guidelines do not specify to this detail, but DSOD practice considers spatial storm distribution.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

Comments: Spillway design criteria is based on frequency of flooding up to the PMP

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

Comments: On occasion downstream development changes the hazard classification, but in most cases in California, most of the dams are already at the highest level.

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: For non flood control dams, reservoir is taken at spillway level. Antecendent moisture conditions are considered in evaluating the runoff coefficient.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

Comments: Guidelines don't specify, but DSOD has considered incremental damage in past and plans to develop guidelines for use.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: It is prudent to a allow a continuous range of design floods corresponding to the developed Total Class Weights. The minimum allowable design event required is a 1000 year storm which corresponds with a TCW of 4. The maximum event is a storm derived from the Probable Maximum Precipitation and is equated with a TCW of 30. The design event is interpolated between these limits at the computed TCW. Typically, probable maximum precipitation storms are required only for dams that impound 1000 acre-feet or more, are at least 50 feet high, would require an estimated evacuation of at least 1000 people, and have a damage potential of $25,000,000 or greater. However, most dams require a design storm falling between the 1000 year event and the probable maximum event. Figure 2 presents a histogram of TCW (as determined by DSOD) for all jurisdictional dams within California. As can be seen, less than 8 percent of all dams require a PMF.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 1000-year

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: We have allowed the use of early warning systems as part of interim measures until dam is repaired.

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

Comments: The definition of risk based hydrologic design is not defined in this question and means different things to different people. However based on the risk, DSOD applies statistical storms starting with a 1000 year level up to a PMP

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: We usually apply policy and give direction based on that policy. Regulations are too stiff and do not seem the appropriate way to deal with technical issues. Statutes are even worse and should never be used to dictate technical issues.

34 Are there any unique provisions in your regulations?

No

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

FEMA

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Colorado
Name of Representative	Mark R. Haynes
Title of Representative	Chief Dam Safety Engineer
Phone number(s)	303-866-3581
Email address	mark.haynes@state.co.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	3000
Total Regulated Dams	1935
High Hazard Dams	352
Significant Hazard Dams	322
Low Hazard Dams	1261
Unregulated Dams	1065
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1967

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 100 acre-feet or creates a reservoir with a surface area less than 20 acres at the high-water line, or is less than 10 feet in height.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	20	feet high and stores =<	100	acre-feet
Class B (Medium)					
Class C (Large)	=>	50	feet high and stores =>	4,000	acre-feet
Other (Specify)					

Comments: The three classes in increasing size are: Minor Dam, Small Dam, Large Dam.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: The classfications are as follows: High, Significant, Low, and No Public Hazard (NPH).

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

USBR guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/2007

11 Are there any plans to update or revise the guidelines in the near future?

No

Comments: Next update in 10 years

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Grandfather clause for dams built prior to 1988. Minimum IDF criteria of the 100-year storm.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Have final approval of IDF

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

Comments: The minimum freeboard requirements for new or enlarged dams shall be based upon the dam height required to prevent overtopping by wave action, or the sum of the inflow design flood maximum water surface level plus one foot of residual freeboard, but not less than five feet unless the State Engineer approves a lesser amount. Except for concrete dams where the design engineer has demonstrated that overtopping of the dam will not be detrimental to the safety of the dam, the inflow design flood can be accommodated with zero residual freeboard or the overtopping depth at which the dam still meets the stability and stress requirements of Rule 5.9.5.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

Comments: For high frequency storms.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: Depends on procedures in HMRs and Hydrologic Software

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Site Specific Hydrometeorologic Analysis (SSHMA) may be used to determine the appropriate site specific extreme storm precipitation (SSESP) for the determination of the IDF. Site-specific evaluations are subject to approval by the State Engineer. Any procedures developed and approved by the State Engineer shall be used to determine the applicable Extreme Precipitation Event. Snowmelt conditions shall be considered as base flow when appropriate. The percentage reduction of the PMP as shown in Rule 5.9.1.5 are not applicable or allowed in the determination of site specific extreme storm precipitation or PMP values determined by the procedures and analysis provided for in this Rule for all High Hazard dams and Large Significant Hazard dams. Specific percentages of the Site-specific PMP are required based on size and hazard classification.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: Constant

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: No for antecedent moisture conditions and yes for initial reservoir pool levels.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Minimum IDF is the 100-year event

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	0.45-0.90	% of the	PMP
Existing High Hazard Dam must pass		% of the	
New Significant Hazard Dam must pass	0.45-0.68	% of the	PMP
Existing Significant Hazard Dam must pass		% of the	

Comments: Based on size classification as well. There are also percentages of the PMP for special cases involving reductions due to elevation and site specific PMPs.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 50 to 100 year depending on size classification.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Could require Statutory changes and would require public review and hearings.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Connecticut
Name of Representative	Arthur P. Christian II, P.E.
Title of Representative	Supervising Civil Engineer
Phone number(s)	860-424-3880
Email address	art.christian@act.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	3024
High Hazard Dams	242
Significant Hazard Dams	267
Low Hazard Dams	2515
Unregulated Dams	1455
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria?

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: Or all other dams with an impoundment capacity of three (3) acre-feet or less.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (Other)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Negligible (Class AA), Low (Class A), Moderate (Class BB), Significant (Class B), and High (Class C)

8 Does the Organization have guidelines for determining the spillway design flood?

No

If "Yes", what is the status of the guidelines; do they have the force of law?

Unpublished guidelines for consideration by the engineer/designer

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Written by Philip Moreschi

10 When were the guidelines last revised (MM/DD/YYYY)? n/a

Comments: Continuous revision

11 Are there any plans to update or revise the guidelines in the near future?

Comments: Continuous revision

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

Comments: No specific requirements although wave runup may be considered by the design engineer based on the specific dam.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Comments: The agency requires standard public domain software applications such as Hec-HMS or NRCS type modeling.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: The agency requires that the engineer demonstrates that the methodolgy/analysis is both appropriate and an accepted engineering standard.

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

Comments: Hazard classifications get changed routinely however most changes occur within the category of low hazard dams. Therefore spillway design requirements do not need to be modified.

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: Only if future development is known to be planned.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	50-100	% of the	PMF
New Significant Hazard Dam must pass	50-100	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

Comments: The above criteria assume that the impoundment sizes are large and intermediate as defined by the ACOE spillway design criteria.

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: With one foot of freeboard or passing two times the 100 year without overtopping.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

Comments: The agency has not considered risk-based hydrologic designs at this time.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

Comments: The agency has not considered risk-based hydrologic designs at this time.

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: It is a lengthy formal process that can take up to two years. It is time intensive and sensitive to deadlines and subject to the will of a legislative committee.

34 Are there any unique provisions in your regulations?

No

Comments: The agency's regulations only pertain to the periodic inspection of dams.

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Delaware
Name of Representative	David R. Twing
Title of Representative	State Dam Safety Engineer
Phone number(s)	302-834-5557
Email address	david.twing@state.de.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	49
Total Regulated Dams	49
High Hazard Dams	44
Significant Hazard Dams	5
Low Hazard Dams	0
Unregulated Dams	0
Other	0

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 2009

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: any one of the following: privately owned; low hazard; less than 6 feet high; less than 15 acre-feet of storage

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: High Hazard includes any dam whose failure or misoperation will cause probable loss of human life. Significant Hazard includes any dam whose failure or misoperation will cause possible loss of human life, economic loss, environmental damage, and disruption of lifeline facilities. Low Hazard is unlikely to cause loss of human life but may cause minor economic and/or environmental losses.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Custom developed by Organization

10 When were the guidelines last revised (MM/DD/YYYY)? 12/11/2009

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Incremental damage assessment may be used to reduce the spillway design flood of existing dams.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Performance criteria specified for pipe conduit spillways, vegetated auxiliary spillways, etc. Activation criteria are also specified.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: Not a problem for us yet because we just started our dam safety program; the hazard classifications for all dams in the state were determined in 2008

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: All Class II and III dams shall, where practicable, incorporate in the proposed design the ability to make modifications necessary to increase the spillway capacity of the facility or other alternative measures if the downstream hazard potential increases.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: For existing dams only.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Minimum design storm for the dam shall be the 100-year storm.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Changes in the regulations that don't involve changing the enabling legislation still require public notice, so I would use "moderate" to describe that process.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Georgia
Name of Representative	Tom Woosley
Title of Representative	Program Manager
Phone number(s)	404-362-2678
Email address	tom_woosley@dnr.state.ga.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	3926
High Hazard Dams	474
Significant Hazard Dams	0
Low Hazard Dams	3452
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1978

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 25 feet or stores less than 100 acre-feet. Also those less than 6 feet in height regardless of storage capacity or which have storage capacity of less than 15 acre-feet regardless of height.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	25	feet high and stores =<	500	acre-feet
Class B (Medium)					
Class C (Large)	=>	35	feet high and stores =>	1000	acre-feet
Other (Specify)	Very Large Dams: > 100 feet and > 50,000 acre-feet				

7 Does the Organization have published hazard classification criteria?

Yes (Other)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Other (Please specify)

Comments: Only two categories: Category I means the classification where improper operation or dam failure would result in probable loss of human life. Category II means the classification where improper operation or dam failure would not be expected to result in probable loss of human life.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: The law states the requirement, the guidelines detail out how we would determine the PMP

9 What is the origin of the guidelines?

Custom developed by Organization

Comments: Developed with help of consultants in 1998

10 When were the guidelines last revised (MM/DD/YYYY)? 06/01/2007

Comments: Version 3.1

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Talking about it, but not in the works right now.

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Based on visual inspection and detailed hydrologic and hydraulic evaluation, including documentation of completed design and construction procedures, up to 10 percent lower requirement (22.5, 30, 45, 90) may be accepted on existing PL566 (including RC&D structures) and PL 534 Project Dams at the discretion of the Director, provided the project is in an acceptable state of maintenance. The design storm may be reduced on existing dams if the applicant's engineer can successfully demonstrate to the Director, by engineering analysis, that the dam is sufficient to protect against probable loss of human life downstream at a lesser design storm. Earth emergency spillways shall not function until the 50 year storm.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on size classification only

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

Comments: 3-foot maximum

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HEC-1

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: Models other than HEC-1 must be approved prior to design.

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Earth emergency spillways shall not function until the 50 year storm. SITES integrity analysis is required for earthen spillway.

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC-III is to be used on the 6-hr storm

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: For existing dams only.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Requirement can be reduced by up to 10%.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

Comments: Very large dam (100% of PMP), Large dam (50% of PMP), Medium dam (33.3% of PMP), and Small dam (25% of PMP)

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

No; our regulations forbid them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Extremely, especially in the current political climate

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Hawaii
Name of Representative	Edwin Matsuda
Title of Representative	Civil Engineer
Phone number(s)	808-587-0268
Email address	edwin.y.matsuda@hawaii.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	138
High Hazard Dams	123
Significant Hazard Dams	3
Low Hazard Dams	12
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1992

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: < 25ft height & < 50acft volume at max water surface elevation; or < 6 ft height; or < 15 acft volume at max water surface elevation

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: "Significant hazard" means a dam's or reservoir's failure will result in no probable loss of human life but can cause major economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams or reservoirs are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Unpublished guidelines that are required

Comments: Design flows are specified in the draft administrative rules and pending approval will have the same authority as the law.

9 What is the origin of the guidelines?

Other (Please specify)

Comments: Originally specified in our guidelines and probably based on FEMA guidance material in the early 1990s. Current draft reflects previous guidelines with some minor

10 When were the guidelines last revised (MM/DD/YYYY)? 12/01/1992

Comments: Guidelines are currently being updated. Administrative rules have been drafted, passed through public hearings and is pending final approval.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Currently contracted out to consultant

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

Comments: Freeboard requirement determined on case by case requirement. Proposed Rules will specify "the greater of the following: (1) Two feet above the water level during the peak spillway flow associated with the inflow design flood; (2) Sum of the wave run-up and reservoir setup resulting from a 100 mph wind speed during the peak spillway flow associated with the inflow design flood."

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: Existing guidelines specify SCS type I distribution however not defined in current draft HAR. May be addressed in guidelines update.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50-100	% of the	PMF
Existing Significant Hazard Dam must pass	50-100	% of the	PMF

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 100 year for small and intermediate low hazard dams and 0.5PMF for large low hazard dams.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: There are provisions within our draft administrative rules for our approving board to grant variances to the requirements. Sufficient justification and assurances would likely be required for these to be approved.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Changes to our regulations can either be done through statute via our state legislature or through rules which require proceeding through the rule making process. Either change or revision will likely face a large amount of questions and possible resistance and require a lot of time and resources to address.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Our revisions do allow for our approving board to grant variances to the requirements stated. This was believed to be the best method of covering many of the specific issues in the regulations that we may not have addressed adequately. Also allows for owners of existing dams some other means of mitigating deficiencies which the dam may not have been required to meet when it was designed.

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Idaho
Name of Representative	John Falk
Title of Representative	
Phone number(s)	208-287-4927 / 208-287-4800
Email address	John.Falk@idwr.idaho.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	569
High Hazard Dams	107
Significant Hazard Dams	149
Low Hazard Dams	313
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? Last revised 2006

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Statute definition is for Regulated Dams; i.e. 10 feet or more in height or with an impounding capacity of 50 acre-feet or more. Conversely, non-regulated dams are those less than 10' high AND less than 50 ac-ft.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Mine tailings impoundment structures which are, or will be, more than 30 feet high are regulated by the state dam safety program.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	20	feet high and stores =<	100	acre-feet
Class B (Medium)					
Class C (Large)	=>	40	feet high and stores =>	4,000	acre-feet
Other (Specify)					

Comments: Contained within Administrative Rules only

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Other (Please specify)

Comments: In the Administrative Rules, the term "Risk" is substituted for "Hazard" inappropriately. In Rule, "Significant Risk" is based on flood depth, velocity, and consequence of significant damage to intrastructure; loss of life is not mentioned.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

Comments: Contained within Administrative Rules

9 What is the origin of the guidelines?

Unknown

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/2006

Comments: Administative Rules last revised in 2006

11 Are there any plans to update or revise the guidelines in the near future?

No

Comments: Lack of staff resources to pursue revisions

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Exemptions if approved by Director, exemptions based on existence prior to the state's dam safety laws.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

…with reference to existing Administrative Rule.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: Problem will intensify because cost for rehabilitation is increasingly costly, permitting may be Catch-22, and lack of dam safety resources likely will not allow periodic review and/or enforcement.

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	Q100-100	% of the	PMF
Existing High Hazard Dam must pass	Q100-100	% of the	PMF
New Significant Hazard Dam must pass	Q100-50	% of the	PMF
Existing Significant Hazard Dam must pass	Q100-50	% of the	PMF

Comments: High hazard dam: Q100-PMF, depending on size of dam; Significant hazard dam: Q100-0.5PMF, depending on size of dam.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Q50-Q500 depending on size of dam; these lower and upper boundaries are prescriptive and extreme, and badly in need of revision.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Comments: Cannot speculate as existing Statute and Rule do not address applicability. Organization would consider revising Rules to offer the opportunity, with conditions.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

Comments: The only review has been cursory for federal dams or federal regulated hydroelectric dams in which the State is a marginal participant.

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: The procedure appears to be moderately involved (formation of committee, legislative committee recognition, hearings/testimony prior to acceptace by legislature). However, dam safety staff has been significantly reduced making any proposed revisions unlikely without neglecting primary safety mission of routine inspection and design review.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Illinois
Name of Representative	Jason Campbell
Title of Representative	Senior Permit Engineer
Phone number(s)	217-558-4532
Email address	jason.campbell@illinois.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1485
High Hazard Dams	187
Significant Hazard Dams	299
Low Hazard Dams	999
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1980

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: Also, if the drainage area of the dam is 6400 acres or less in a rural area, or 640 acres in an urban area

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Technical publications other than the Corps Guidelines may be used to assure the use of current and applicable data for the hydrologic and hydraulic review of dam design.

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/2003

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Reduced spillway design requirements for dams built before September 2, 1980. Any submittal for variation from the reduced spillway design flood must include a detailed hydraulic risk assessment that shows that additional spillway capacity will not provide a decrease in potential loss of life or property damage or a detailed economic risk assessment that shows that the chosen spillway design alternative provides the minimum rehabilitation costs plus damage losses; a detailed early warning and emergency evacuation plan coordinated with the local ESDA; and a list (with mailing addresses) of all persons living within the dam breach wave inundation area.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Case-by-case basis considering many factors including duration of high water levels during the design flood, the effective wind fetch and reservoir depth available to support wave generation, the probability of high wind speed occurring from a critical direction, the potential wave runup on the dam based on roughness and slope, and the ability of the dam to resist erosion from overtopping waves.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

Comments: Procedures developed by US Army Corps of Engineers, US Dept of the Interior (Bureau of Reclamation), US Dept of Agriculture (Natural Resources Conservation Service), and the National Weather Service are recommended as acceptable. The programs typically used by OWR for review include: HEC-1, HEC-HMS, HEC-2, HEC-RAS and FLDWAV.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: At least a 24-hour duration.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Regulations distinguish between principal spillway design flood and total spillway design flood.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: Never been done at this point.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: Changing the classification / spillway design requirements is not difficult, occasionally there is some resistance to implementation of the new classification.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: For all proposed Class II or III dams, a determination of alternatives for increasing the total spillway capacity to accommodate the PMF shall also be submitted to OWR. The initial dam design shall provide for the capability of increasing the spillway capacity. future downstream land use, land use controls, and growth projections will be considered in the review of the spillway capacity design.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: No less than 100-year flood unless it is a small size, Class III structure with dam height multiplied by impounding capacity less than or equal to 300.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	30-60	% of the	PMF
New Significant Hazard Dam must pass	100yr-100	% of the	PMF
Existing Significant Hazard Dam must pass	100yr-60	% of the	PMF

Comments: Class I: 0.5PMF-1.0PMF; Class II: 100-yr-PMF; Class III: 100-yr-0.5PMF; Ranges depend on the size of dam.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Ranges from 100-yr for a small dam to 0.5PMF for a large dam.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: Any submittal for variation from the above-listed spillway design flood must include a detailed hydraulic risk assessment that shows that additional spillway capacity will not

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Unsure

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Theoretically, it should not be very difficult. However given the current state of State politics it would in all likelyhood be very difficult.

34 Are there any unique provisions in your regulations?

No

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Indiana
Name of Representative	Kenneth E. Smith, P.E.
Title of Representative	Assistant Director
Phone number(s)	317-232-4224
Email address	kesmith@dnr.IN.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1088
High Hazard Dams	240
Significant Hazard Dams	249
Low Hazard Dams	599
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? not formally adopted

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: The drainage area above the dam site is less than one square mile; the height of the dam above the natural stream bed or the lowest point on the valley floor is less than 20 feet; the volume of water impounded by the dam to the emergency spillway level is less than 100 acre-feet; or the rights of other property owners are affected.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: coal mine related dams held to MSHA standards, by the Division of Reclamation

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Also includes a "Multiple Dams" classification. Where failure of a dam could contribute to failure of a downstream dam or dams, the minimum hazard class of the dam shall not be less than that of any such downstream structure.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: attempted to use typical national best management practices

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/2001

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: will revise if a new unified national practice is published

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: The design storm for existing dams can be reduced using Incremental Damage Evaluation

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (Based on Tc)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (NRCS Standard)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: administrative legal processes, public notice and hearings required

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC II

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: For existing dams only. The owner and engineer should recognize that dam construction typically results in higher risks. If an Incremental Hazard Evaluation procedure is utilized,

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: 50% PMP minimum for High Hazard dams, 100-Year minimum for Low Hazard dams

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass	50	% of the	PMP
Existing Significant Hazard Dam must pass	50	% of the	PMP

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Ranges from 100-year to 50% PMP.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Iowa
Name of Representative	Mr. Jonathan Garton
Title of Representative	Senior Dam Safety Engineer
Phone number(s)	515-281-6940
Email address	jonathan.garton@dnr.iowa.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	3568
Total Regulated Dams	3568
High Hazard Dams	99
Significant Hazard Dams	222
Low Hazard Dams	3247
Unregulated Dams	341
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? Pre 1990

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Iowa Jurisdictional thresholds: a. Any dam designed to provide a sum of permanent and temporary storage exceeding 50 acre-feet at the top of dam elevation, or 25 acre-feet if the dam does not have an emergency spillway, and which has a height of 5 feet or more.
b. Any dam designed to provide permanent storage in excess of 18 acre-feet and which has a height of 5 feet or more.
c. Any dam across a stream draining more than 10 square miles.
d. Any dam located within 1 mile of an incorporated municipality, if the dam has a height of 10 feet or more, stores 10 acre-feet or more at the top of dam elevation, and is situated such that the discharge from the dam will flow through the incorporated area.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Major Dams have special requirements and are defined as: 1. Any high hazard dam.
2. Any moderate hazard dam with a permanent storage exceeding one hundred (100) acre-feet or a total of permanent and temporary storage exceeding two hundred fifty (250) acre-feet at the top of the dam elevation. 3. Any dam, including low hazard dams, where the height of the emergency spillway crest measured above the elevation of the channel bottom at the centerline of the dam (in feet) multiplied by the total storage volume (in acre-feet) to the emergency spillway crest elevation exceeds 30,000. For dams without emergency spillways, these measurements shall be taken to the top of dam elevation.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<		feet high and stores =<		acre-feet
Class B (Medium)					
Class C (Large)	=>		feet high and stores =>		acre-feet
Other (Specify)					

Comments: See comment above concerning major dam criteria.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Structures located in areas where failure may damage isolated homes or cabins, industrial or commercial buildings, moderately traveled roads or railroads, interrupt major utility services, but without substantial risk of loss of human life.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

NRCS guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 12/01/1990

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Yes, we are beginning the process this year of updating our entire dam safety program rules.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: For dams with emergency spillways, the top of dam elevation after settlement shall not be less than the highest peak pool elevation reached during the freeboard design flood. For dams without an emergency spillway, the top of dam elevation shall be two feet higher than the peak flood elevation expected to occur during passage of the freeboard design flood, unless it is specifically designed to withstand the overflow.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: 6 hour, 24 hour, and 10-day storm durations are specified and recommendations are made for each.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: Some acceptable methods of distributing the rainfall in Iowa are found in the U.S.D.A. Soil Conservation Service publication, TR-60, Earth Dams and Reservoirs; and the Illinois State Water Survey publication, Time Distribution of Rainfall In Heavy Storms by F. A. Huff.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Performance and activation criteria are given for both principal and emergency spillways.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Follow guidelines in HMR 51 and 52.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: Dam owners are required to upgrade the dam if hazard classification changes.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Conservative loss rates (interception, infiltration, etc.) and antecedent moisture conditions should be used in computing rainfall excess. Also, when applicable, snowmelt runoff rates should be estimated. The Soil Conservation Service (SCS) weighted curve number method is acceptable for determining rainfall losses and is explained in National Engineering Handbook Section 4 Hydrology, SCS, 1972.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Low hazard classified as major structures must also pass 50% of the PMF. Otherwise, a. Where the height of the emergency spillway crest* measured above the elevation of the channel bottom at the centerline of the dam (in feet) multiplied by the total storage volume (in acre-feet) to the emergency spillway crest elevation* is between 3,000 and 30,000, the flood shall correspond to the rainfall calculated from the following formula developed by the USDA Soil Conservation Service. Rainfall = P100 + 0.12 (PMP – P100) b. Where the height of the emergency spillway crest* measured above the elevation of the channel bottom at the centerline of the dam (in feet) multiplied by the total storage volume (in acre-feet) to the emergency spillway crest elevation* is less than 3,000, the flood shall be that resulting from the 50- year, 24-hour precipitation.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: There is a formal rule making process for the DNR that involves public input. It is a lengthy process but can be initiated at any time.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Kansas
Name of Representative	Kimberly A. Feldkamp, P.E.
Title of Representative	Dam Safety Team Leader
Phone number(s)	785-296-4625
Email address	kimberly.feldkamp@kda.ks.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	6058
High Hazard Dams	202
Significant Hazard Dams	238
Low Hazard Dams	5618
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1984

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: A jurisdictional “dam” means any artificial barrier including appurtenant works with the ability to impound water, waste water or other liquids that has a height of 25 feet or more; or has a height of six feet or greater and also has the capacity to impound 50 or more acre feet. Anything that does not meet this definition is non-jurisdictional.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<		feet high and stores =<	3000	acre-feet
Class B (Medium)					
Class C (Large)	=>		feet high and stores =>	30000	acre-feet
Other (Specify)	Class 1 is less than 25 feet high and an effective storage of less				

Comments: Each dam with an effective height of less than 25 feet and an effective storage of less than 50 acre-feet shall be considered to be a class size 1 dam. The class size of all other dams shall be determined from the following table:

Class size	Size factor
2	less than 3,000
3	3,000 through 30,000
4	more than 30,000

"Effective height" means the difference in elevation between the crest of an auxiliary spillway or service spillway and the lowest point of the downstream toe of a dam. If the dam does not have an auxiliary or service spillway, the effective height means the difference in elevation between the top of the dam and the lowest point of the downstream toe of the dam.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

NRCS guidelines

Comments: The NRCS guidelines was used as guidance to develop our own criteria

10 When were the guidelines last revised (MM/DD/YYYY)? 05/18/2007

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: There could be different guidelines on existing dams depending upon when they were permitted or constructed.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: It varies do to size class and hazard classification.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use SCS unit hydrograph

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Auxiliary spillway failure criteria are provided. The auxiliary spillway shall not fail by breaching during the spillway stability design event indicated in the following: Hazard Class A, Size 1, 2, or 3: 0.3PMP; Hazard Class A, Size 4: 0.4 PMP; Hazard Class B, All Sizes: 0.5 PMP; Hazard Class C, All Sizes: PMP.

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC II or III depending on location. The routing shall begin by assuming that the water surface elevation is at the elevation of the lowest uncontrolled spillway inlet, not including any low-flow augmentation works.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	40	% of the	PMP
Existing High Hazard Dam must pass	40	% of the	PMP
New Significant Hazard Dam must pass	25-30	% of the	PMP
Existing Significant Hazard Dam must pass	25-30	% of the	PMP

Comments: New and existing high hazard dams must pass 40% of PMP plus have 3 feet of freeboard. Significant hazard new and existing dam size class 1 and 2 must pass 25% of PMP plus have 2 feet of freeboard and significant hazard new and existing dams class 3 and 4 must pass 30% of PMP plus have 3 feet of freeboard.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Size class 1 50-year with 1 foot freeboard. Size class 2 100-yr plus 2 feet freeboard. Size Class 3 100-yr 3 feet of freeboard. Size class 4 25%PMP with 3 feet of freeboard.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: The proposed regulations would have to be approved by the following Department of Agriculture Legal, Department of Administration, Attorney General's Office, and the Administrative Rules and Regulations Joint Committee

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Kentucky
Name of Representative	Ms. Marilyn Thomas
Title of Representative	Environmental Engineer Consultant
Phone number(s)	502-564-3410
Email address	marilync.thomas@ky.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1066
High Hazard Dams	178
Significant Hazard Dams	217
Low Hazard Dams	671
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? pre-1978

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 25 feet in height and an impounding capacity of less than 50 acre-feet or no downstream hazard to human life.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Class A (High), Class B (Moderate), and Class C (High)

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

NRCS guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 06/01/1999

11 Are there any plans to update or revise the guidelines in the near future?

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: SITES, HMS, NWS DAMBRK, HEC-RAS are acceptable

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Criteria are given for activation, performance, and capacity of earth emergency spillways.

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMCII or greater

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass		% of the	
Existing Significant Hazard Dam must pass		% of the	

Comments: P Design (Class B, Significant) = P100 + 0.40*(PMP-P100)

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: P Design (Class A) =P100 + 0.12*(PMP-P100)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Dam owners may not properly maintain or operate warning systems, rendering them ineffective.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Reg changes must be approved by the legislature. If the legislature perceives the change as more demanding or expensive to dam owners that change likely won't be approved. We've worked for 10 years to get approval for Emergency Action Plans with no success.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Louisiana
Name of Representative	Zahir "Bo" Bolourchi, P.E.
Title of Representative	Director, P.W. & Water Resources Programs
Phone number(s)	225-274-4170
Email address	Bo.Bolourchi@la.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	599
Total Regulated Dams	555
High Hazard Dams	33
Significant Hazard Dams	72
Low Hazard Dams	450
Unregulated Dams	49
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1981

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: LA R.S. 38:22

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Appreciable damage to property or possible loss of life.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Other (Please specify)

10 When were the guidelines last revised (MM/DD/YYYY)? 03/01/1997

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Design storm is determined by down stream conditions

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

3.0' or more

Comments: Title 44, CRF 65.10 (B-1 Freeboard)

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: For the purpose of the Dam Safety Program, the Emergency Spillway shall be defined as being overtopped by the 100-year storm or greater and the Principal Spillway shall be defined as being overtopped by a storm less than the 100-year storm. Also, some damage to the emergency spillway is tolerable since they are activated only during major storm events.

22 Does the organization allow development of a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: Change in classification is based on down stream conditions

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	50-100	% of the	PMF
New Significant Hazard Dam must pass	100-yr-100	% of the	PMF
Existing Significant Hazard Dam must pass	100-yr-100	% of the	PMF

Comments: These are minimum IDFs. Regulations stipulate that an incremental assessment be performed for all High Hazard and some Significant Hazard dams. The full PMF is the maximum IDF for both of these hazard classes.

29 For low hazard dams, the spillway design requirement is:

50-year flood

Comments: Minimum IDF (no incremental assessment required)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

No; our regulations forbid them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Change in regulations could be challenging at this time.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Maine
Name of Representative	Tony Fletcher, P.E.
Title of Representative	State Dam Inspector
Phone number(s)	207-624-4465
Email address	Tony.Fletcher@maine.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	860
High Hazard Dams	29
Significant Hazard Dams	71
Low Hazard Dams	536
Unregulated Dams	191
Other	33

3 What year did your Agency adopt minimum Inflow Design Flood criteria? n/a

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: No probable loss of life but major economic loss, environmental damage or disruption of lifeline facilities.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Other (Please specify)

Comments: The USACE are recommended when questions arise.

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

10 When were the guidelines last revised (MM/DD/YYYY)? n/a

Comments: Never revised

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Makes recommedations

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

24 Do guidelines require consideration or analysis of future development?

No

Comments: A hazard inspection is required every 6 years when the hazard of a dam is reviewed.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Comments:

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Maryland
Name of Representative	Harald W. Van Aller
Title of Representative	Geotechnical Engineer
Phone number(s)	410-901-4042
Email address	hvanaller@mde.state.md.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	406
Total Regulated Dams	382
High Hazard Dams	68
Significant Hazard Dams	87
Low Hazard Dams	227
Unregulated Dams	Unknown
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? About 1976

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: All dams in MD are juridictional regardless of size, although some low hazard dams less than 20 ft high can be approved by local soil conservation district in lieu of a state waterway construction permit.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	25	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	50	feet high and stores =>	20,000	acre-feet
Other (Specify)	Class IV, see comments.				

Comments: Category IV is reserved for small dams which have a drainage area of less than 1 square mile (640 acres), and a normal depth of water less than 15 feet above the original stream bed, a normal pool storage of less than 100 acre-feet, and a normal surface area less than 12 acres.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: "small possibility" of loss of life. Located in predominately rural or agricultural areas where failure may cause damage to isolated residences or cause interruption of use or service of public utilities or roads. Damage is within the financial capability of owner to repair

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

USBR guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 07/01/1979

Comments: Some minor changes have been made since 1979, but no substantial changes have been made to hazard classification and design storm requirements

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Current regs address only new dams. MD has been working on new regulations for about 15 years which would also include pre-existing dams.

12 Are the guidelines different for new and existing dams?

No

Comments: The new regulations would have different guidelines for pre-existing dams.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: No specific freeboard is required. The design shall allow for certain freeboard as a minimum, not to be reduced under any circumstances during the operation of the dam and reservoir. The design freeboard is for that reservoir stage which will exist when the pool has reached maximum level during the inflow design flood with the outlet works and overflow spillway operating as planned. The freeboard is to be calculated to prevent overtopping and protect the dam against the destructive forces of waves, frost, settlement, and surface erosion.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: For drainage areas less than or equal to 10 square miles, TR-20 or HEC-1 must be used. For drainage areas larger than 10 square miles, HMR-52 and HEC-1 is recommended.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: software must be in the public domain (not proprietary) so the results can be duplicated by agency staff

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

Comments: For drainage areas less than or equal to 10 square miles, use a 24-hour duration for the 100-year and brim-up storm events, and a 6-hour duration for the 50%PMF and PMF.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: 100-year unless it is a small dam

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: This has only been evaluated at one dam that I am aware of. use of FERC guidelines is suggested to other dam owners who ask about this issue.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: Current regulations are based on ultimate development of land based on current zoning.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

Comments: Although current regulations do not allow for incremental analysis, MD has been allowing this on a case by case basis

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

Comments: Class II (Significant): Regulations state: The design storm shall be the "standard project flood" or the largest flood of record, whichever is greater.

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: Plus 2 feet of freeboard, unless the design includes an open channel emergency spillway, in which case freeboard can be reduced to 1 foot.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: At one time we allowed that, but not currently.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

Comments: However, the Corps of Engineers has recently cited a risk-based analyses for rejecting the need to upgrade a large dam designed in the 1960's and constructed in MD in 1980 to safely pass the full PMF

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: We have been working on revised regulations for more than 15 years.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Massachusetts
Name of Representative	Michael D. Misslin
Title of Representative	Deputy Chief Engineer
Phone number(s)	617-626-4927
Email address	Mike.Misslin@state.ma.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1545
High Hazard Dams	304
Significant Hazard Dams	727
Low Hazard Dams	514
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria?

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: All dams are inventoried. The following are non-jurisdictional:1) any barrier which is not in excess of six feet in height, regardless of storage capacity, or which has a storage capacity at max water storage elevation not in excess of 15 acre feet, regardless of height. 2) any barrier with low hazard potential classification in the use of agriculture.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: FERC regulated dams are exempt from regulation

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	15	feet high and stores =<	50	acre-feet
Class B (Medium)					
Class C (Large)	=>	40	feet high and stores =>	1,000	acre-feet
Other (Specify)					

Comments: non-jurisdictional: not in excess of 15 ac ft regardless of ht & not in excess of 6 ft regardless of storage capacity; small: >= 15 ac ft and <50 ac ft storage & >= 6 ft and < 15

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Sig Haz Pot definition: Dams located where failure may cause loss of life and damge home(s), industrial or commercial facilities, secondary highway(s) or railroad(s) or cause interruption of use or service of relatively important facilities.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Other (Please specify)

Comments: Regulatory requirements for new and existing dams.

9 What is the origin of the guidelines?

Other (Please specify)

Comments: federal guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 11/04/2005

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Existing dams are required to pass a smaller spillway design flood.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: case by case

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: regulations reference US Army Corps, US Bureau of Reclamation and USDA NRCS.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Emergency spillway frequency and performance guidelines are provided.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Unsure

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	500-yr to 50	% of the	PMF
New Significant Hazard Dam must pass	500-yr to 50	% of the	PMF
Existing Significant Hazard Dam must pass	0-yr to 500	% of the	PMF

Comments: Varies depending on hazard classification, size, and whether it's a new or existing dam. Variations range from 100 year to full PMF.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Ranges from 50-year to 100-year for existing dams; 100-year for new dams. Change in requirement depends on the size of dam.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Both approved and rejected)

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Michigan
Name of Representative	Byron Lane
Title of Representative	Chief, Hydrologic Studies and Dam Safety Unit
Phone number(s)	517-241-9862
Email address	LANEB@michigan.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1034
High Hazard Dams	84
Significant Hazard Dams	138
Low Hazard Dams	812
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1990

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 6 feet in height or has an impounding capacity of 5 surface acres or less.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Inventory dams which have court ordered lake levels. There are 235 of them.

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

9 What is the origin of the guidelines?

Unknown

10 When were the guidelines last revised (MM/DD/YYYY)? 05/24/1995

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency acts as designer/engineer

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Michigan does not require PMP/PMF designs.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Agency must approve the design flood.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: No less than the 200-year flood or the flood of record, whichever is greater.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	200 yr-50	% of the	PMF
Existing High Hazard Dam must pass	200 yr-50	% of the	PMF
New Significant Hazard Dam must pass	200-yr	% of the	
Existing Significant Hazard Dam must pass	200-yr	% of the	

Comments: High hazard dams < 40 feet shall pass the 200-year flood or the flood of record whichever is greater. High hazard dams > 40 feet shall pass 0.5PMF. Significant hazard dams shall pass the 200-year flood or the flood of record whichever is greater.

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: Or the flood of record, whichever is greater.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Minnesota
Name of Representative	Jason Boyle, P.E.
Title of Representative	State Dam Safety Engineer
Phone number(s)	651-259-5715
Email address	Jason.Boyle@state.mn.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1161
High Hazard Dams	24
Significant Hazard Dams	126
Low Hazard Dams	1012
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? not formally adopted yet

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 6 feet high; or less than 15 acre-feet of storage; or less than 25 feet high and less than 50 acre-feet of storage with no potential for loss of life; or Federal dam

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Yes, tailings and coal ash dams are held to a different standard.

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Unpublished guidelines for consideration by the engineer/designer

Comments: Regulatory has final say.

9 What is the origin of the guidelines?

Other (Please specify)

Comments: Based on California or ICODS guidelines?

10 When were the guidelines last revised (MM/DD/YYYY)?

Comments: They have not been revised.

11 Are there any plans to update or revise the guidelines in the near future?

No

Comments: It would be a good idea to update these.

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: There is some leeway for existing dams, depending on the situation.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on a combination of risk analysis and hazard/size classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

Comments: We try to ensure the most critical storm duration is used. Based on dam type and time of concentration.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Spillway design floods based on frequency of flooding.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Consistency with other methods.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: It has not been a problem to date.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

Comments: We do check these assumptions.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	100-yr-100	% of the	PMF
Existing Significant Hazard Dam must pass	100-yr-100	% of the	PMF

Comments: Class II (Significant): 100 year to PMF.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 50-yr to 50% PMF

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: May consider it for existing dams.

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Changing regulations would be difficult, changing our internal guidelines would be fairly easy.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Mississippi
Name of Representative	James MacLellan
Title of Representative	Director of Dam Safety Division
Phone number(s)	601-961-5061
Email address	James_MacLellan@deq.state.ms.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	3755
Total Regulated Dams	3755
High Hazard Dams	257
Significant Hazard Dams	76
Low Hazard Dams	3422
Unregulated Dams	0
Other	0

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1982

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 8 feet in height, or impounds less than 25 acre-feet, or doesn't impound a stream and doesn't present a downstream threat

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	25	feet high and stores =<	150	acre-feet
Class B (Medium)					
Class C (Large)	=>	50	feet high and stores =>	1000	acre-feet
Other (Specify)					

Comments: The size criteria is in the guidance for the design of dams - general guidance

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Significant Hazard is a class of dam in which failure poses no threat to life but may cause significant damage to public infrastructure - roads, railroads, utilities

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: The portion of the regulations that determine the spillway design flood come from NWS HMR and NRCS design hydrograph as well as the hazard classification

10 When were the guidelines last revised (MM/DD/YYYY)? 08/25/2005

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: High hazard dams that were constructed prior to 1982 are allowed to remain in operation if they pass 50% of PMP and are structurally sound.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

Agency reviews submitted designs and performs independent verification if needed. Agency does independent analysis for state lakes.

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: Must use HMR and SCS unit hydrograph

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: Rational equation is not accepted in any case.

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (NRCS Standard)

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: Only if drainage area is greater than 10 square miles.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Principal spillway must pass 100 year 24 hour design storm without activating emergency spillway for High hazard dams.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Will only consider a site specific PMP if drainage area is greater than 10 square miles.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass	50	% of the	PMP
Existing Significant Hazard Dam must pass	50	% of the	PMP

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 35% of the PMP.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: It involves a lot of work on mine and our legal department's part. The difficulty to accepting the change would depend on public opposition and justifying to our Commission.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Missouri
Name of Representative	Paul Simon
Title of Representative	Civil Engineer - Dam Safety
Phone number(s)	573-368-2179
Email address	paul.simon@dnr.mo.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	5240
Total Regulated Dams	677
High Hazard Dams	457
Significant Hazard Dams	147
Low Hazard Dams	73
Unregulated Dams	4563
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1981

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Any artificial or man-made barrier which does or may impound water and is less than 35 feet in height.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: Design requirements are based on downstream hazard classification for all regulated dams.

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: They are: class I, which contains ten (10) or more permanent dwellings or any public building; class II, which contains one to nine (1–9) permanent dwellings, or one (1) or more campgrounds with permanent water, sewer and electrical services or one (1) or more industrial buildings; and class III, which is everything else.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: class 1 = 75% pmp, class 2 = 50% pmp, class 3 = 100 year event

9 What is the origin of the guidelines?

Custom developed by Organization

Comments: NWS HMR 51 is used to define the pmp.

10 When were the guidelines last revised (MM/DD/YYYY)? 06/09/1994

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on hazard classification only

Comments: Also determined by dam type (conventional or industrial), stage of construction, and environmental class

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: The critical duration is used, normally 6, 12, or 24hr storm.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: Bulletin 71, Rainfall Frequency Atlas of the Midwest is recommended in the Engineering Analysis of Dams manual for Missouri, dated August 1989. Huff distribution is used.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: hmr 51 is recommended in the Engineering Analysis of Dams manual for Missouri, dated August 1989.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

Comments: 50-100 yr event is the minimum recommended to activate grass lined emergency spillway in the Engineering Analysis of Dams manual for Missouri, dated August 1989.

22 Does the organization allow development of a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: All cost is on the dam owner.

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

Comments: AMC 2 is recommended in the Engineering Analysis of Dams manual for missouri, dated August 1989.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	75-50	% of the	PMP
Existing High Hazard Dam must pass	75-50	% of the	PMP
New Significant Hazard Dam must pass	50-20	% of the	PMP
Existing Significant Hazard Dam must pass	50-20	% of the	PMP

Comments: Ranges depending on the stage of construction

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Ranges from 0.10PMP to 100 year depending on the stage of construction

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: We would have to go through a public hearing process.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Montana
Name of Representative	Laurence Siroky
Title of Representative	Chief, Water Operations
Phone number(s)	(406) 444-6816
Email address	lsiroky@mt.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	2893
High Hazard Dams	105
Significant Hazard Dams	152
Low Hazard Dams	2636
Unregulated Dams	
Other	

3 When did your Organization adopt minimum Inflow Design Flood criteria? 1999

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Less than 50 acre-feet of storage (top of dam)

Comments: All dams regardless of size are jurisdictional dams. Only High Hazard dams and 50 acre-feet or larger are required to be permitted.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: State minimum design standards apply only to HH dams.

6 Does the Organization have published size classification criteria?

Yes

Comments: We have regulations that specify the criteria for a HH dam and applies to dams 50 acre-feet or larger.

7 Does the Organization have published hazard classification criteria?

Yes (Other)

Comments: High Hazard if loss of human life is likely to occur within the breach flooded area as a result of failure of the dam. All other dams are classified separately. Significant and Low Hazard dams are not regulated or inspected by the state.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

Comments: We have agency regulations as well as guidelines.

9 What is the origin of the guidelines?

Custom developed by Organization

Comments: Washington State's approach was consulted in the development of these guidelines.

10 When were the guidelines last revised (MM/DD/YYYY)? 10/01/2008

11 Are there any plans to update or revise the guidelines in the near future?

No

Comments: We are in the process of adding siesmic standards.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on a combination of risk analysis and hazard/size classification

Comments: IDF is determined based on estimated loss of life downstream from the dam caused by spillway failure.

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Comments: Tech notes(guidelines are being developed)

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Regional)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: HMR

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: Minimum inflow design flood for estimated loss of life of 0.5 or less shall be the 500-year recurrence interval flood. Minimum inflow design flood for estimated loss of life greater

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Moderate

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Design standards apply to HH dams only.

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Nebraska
Name of Representative	Mr. Patrick Diederich
Title of Representative	Chief of Dam Safety
Phone number(s)	402-471-1222
Email address	

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	2386
High Hazard Dams	134
Significant Hazard Dams	192
Low Hazard Dams	2061
Unregulated Dams	0
Other	0

3 What year did your Agency adopt minimum Inflow Design Flood criteria? unknown

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Unpublished guidelines that are required

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

10 When were the guidelines last revised (MM/DD/YYYY)?

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Currently underway

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Reduced spillway design flood for existing dams as outlined in Question 28

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use SITES

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (Based on Tc)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Regional)

Comments: Site-Specific PMP Study for Nebraska by Applied Weather Associates, LLC (Ed Tomlinson)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Follow industry standards

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Use normal pool with a TR-60 10-day drawdown requirement; AMC II

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	50	% of the	PMP
New Significant Hazard Dam must pass		% of the	
Existing Significant Hazard Dam must pass		% of the	

Comments: NRCS guidelines on SH dams

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: NRCS TR-60

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Nevada
Name of Representative	Robert K. Martinez, P.E.
Title of Representative	Chief, Engineering & Dam Safety
Phone number(s)	775-684-2844
Email address	robertm@water.nv.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	962
Total Regulated Dams	792
High Hazard Dams	171
Significant Hazard Dams	145
Low Hazard Dams	476
Unregulated Dams	0
Other	170

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1951 separate statutes; 2003 codified regulations

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: All dams are "jurisdictional" so non-inventory are: Less than 20 feet in height or less than 20 feet in height and impounds less than 20 acre-feet of water. Dams permitted under an older standard (10' high and 10AF of water) are also still inventoried.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Most effluent, process fluid, and tailing impoundments are exempt from having a spillway, but must be "ring dikes" or divert run-on water. Storm Water Detention dams may have reduced freeboard requirement for PMF.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	20	feet high and stores =<	100	acre-feet
Class B (Medium)					
Class C (Large)	=>	50	feet high and stores =>	10000	acre-feet
Other (Specify)					

Comments: "Class C" (Large) is "=>50 feet in height OR >= 10,000 acre feet of storage.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Reasonably low probability of loss of human life or high probability of extensive economic loss or disruption of a lifeline.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Office policy was incorporated into the regulations in 2003. Guidelines are expanded upon Chapter 535 of the Nevada Revised Statutes (NRS) and Chapter 535 of the Nevada Administrative Code (NAC). Policy was developed in association with COE, USBR, FERC, FEMA, and public input.

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/2011

Comments: Minor revisions to reflect inventory numbers and changes to forms.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: We anticipate an update commencing in SFY2012.

12 Are the guidelines different for new and existing dams?

No

Comments: However; owners of existing dams are not expected to "instantly" cure any deficiencies due to regulatory thresholds, but be working towards a solution.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Models are not re-run but the asumptions/parameters and model type/suitability are reviewed.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: "Rule of thumb" is 3'. Wave runup calculations are preferred and required if the owner is requesting a smaller freeboard. Exceptions are tailings facilities for deposition (beach) side embankments and Storm Water detention facilities, as requested and supported by calculations then approval by this office.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: However we are discouraging use of TR-55 under most conditions.

18 Do the guidelines specify any criteria for storm duration?

NO

Comments: Loosely based on Tc. The consultant is expected to use reasonable and prudent criteria which are reviewed. The storm duration is more closely tied to the storage regime. 6hr and 24hr local storms are most common but regional storm may control in some circumstances.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: NRCS type II and type III most commonly used but HMR approach also utilized.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: Areal reduction for large watersheds is allowed/expected. Generally under HMR 49 guidelines.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

Comments: Individual operating criteria are developed by the owner and local jurisdictions regarding allowed flow rates/spillway activation and reviewed for adequacy. Operating criteria drives storm selection for design aspects of an individual structure. In all regards the facility must "accomodate" the IDF and the means by which that is accomplished is largely up to the owner and designer.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

Comments: As urbanization occurs, previously compliant or what may be called "safe" structures become noncompliant or "unsafe" due to hydrologic or other inadequacy.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: Likely downstream land use is considered in determining hazard classification and IDF selection.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

Comments: Again, individual operating regime drives antecedent conditions. Response to a specific recurrence interval storm and antecedent moisture are handled on a case-by-case basis. For the intermountain west, the most common antecedent moisture condition is "dry" for convection-type storms but "rain on snow" events often are most severe.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: However, if in the review it is determined that the downstream area is likely to see development in the near future (10-20 years) potential impacts are expected to be discussed. It is largely a local government land-use planning issue. Again, it is on a case-by-case basis. Future anticipated conditions often are the driving force in new dam design.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Never less than a 1% chance of exceedence storm.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	500yr-100	% of the	PMF
Existing Significant Hazard Dam must pass	500yr-100	% of the	PMF

Comments: Significant Hazard: 100% PMF if no provision for a spillway is incorporated into the design or it is classified as a "large" dam. The greater of 0.5PMF or a 500 year flood for "medium" and "small" dams.

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: But we may allow one to help mitigate for certain unsafe conditions (such as an increased hazard situation at an existing dam) depending on the specific need and situation if it is proposed and is reasonable.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Although exempt from the "normal" statutory process to adopt or modify regulations, we do follow them. That requires workshops and public comment. Not impossible but time consuming and somewhat costly.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Nevada specifically prohibits use of CMP within a dam embankment unless it is the interior "form" for a CIP concrete pipe. Dam owners are prohibited from abandoning a dam. All dams are jurisdictional and notice of construction must be made for "below permitting threshold" dams. Owners of a dam are defined as any person who has a water right impounded by the dam, owns land on which the dam lies or owns land on which the reservoir lies.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	New Hampshire Dam Bureau
Name of Representative	Jim Gallagher
Title of Representative	Chief Engineer
Phone number(s)	(603) 271-1961
Email address	James.Gallagher@des.nh.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	2615
High Hazard Dams	134
Significant Hazard Dams	164
Low Hazard Dams	554
Unregulated Dams	
Other	1773

3 When did your Organization adopt minimum Inflow Design Flood criteria? 1981

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 6 feet high.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: FEMA guidelines customized by program

10 When were the guidelines last revised (MM/DD/YYYY)? 08/20/2005

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Reviewed and updated or readopted every 5 to 7 years. Currently in the review process.

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Dams constructed prior to 2/19/1981 are required to pass the following flows with 1 foot of freeboard and without manual operations: Class A (50-year flood or site specific), Class B (100-year flood or site specific), Class C (250% of 100-year flood or site specific)

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

Comments: A combination of the 2nd, 3rd, and 4th options. Our agency also designs and performs the repair and reconstruction of 274 state-owned dams

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

Comments: For existing dams and new Low Hazard and Non-Menace dams, owners have option of one foot of freeboard rather than maximum wave run up.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (Based on Tc)

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: Hazard Creep has caused an increase in hazard classification for some dams in the state requiring an increase in spillway discharge capacity,

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: 50-year and 100-year storms shall incorporate antecedent moisture condition 2 as defined in the USDA NRCS NEH, 210-VI-NEH-630.10, August 1, 1969

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

Comments: Not currently, but we are currently evaluating whether or not tot require minimum spillway discharge standards regardless of downstream consequences.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass		% of the	
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass		% of the	

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: 100-year for Low Hazard, 50-year for Non-Menace

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Regulations are reviewed and updated if necessary every 5 to 7 years. Rulemaking process includes assembling an Advisory Committee of dam owners, consultants, and other interested parties; review and approval by the Agency Legal Unit; and review and approval by Legislative Committee on Administrative Rules.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: waiver provisions

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	New Jersey Office of Engineering and Construction
Name of Representative	John Moyle
Title of Representative	Manager, Dam Safety and Flood Control
Phone number(s)	609-984-0859
Email address	john.moyle@dep.state.nj.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1721
High Hazard Dams	215
Significant Hazard Dams	338
Low Hazard Dams	1168
Unregulated Dams	
Other	

3 When did your Organization adopt minimum Inflow Design Flood criteria? 1981

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Any dam which raises the waters of a stream five feet or more above its usual, mean, low water height

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

10 When were the guidelines last revised (MM/DD/YYYY)? 06/16/2008

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Every 5 years the state must readopt the standards.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

1.0'

Comments: Greater than 1' is required if special conditions of severe frost damage, ice damage or wave action may occur

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

Comments: For Classes III and IV only

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (NRCS Standard)

Comments: Type III storm or later

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Pipe conduits used as principal spillways must meet different criteria than auxiliary spillways. For example, all pipe conduits shall convey water at the maximum design velocity without damage to the interior surface. On the other hand, vegetated or unlined auxiliary spillways must be able to pass the design storm without jeopardizing the safety of the structure. Frequency of use criteria are also specified for auxiliary spillways.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Only for existing dams

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: All Class II and III dams shall, where practicable incorporate in the proposed design, the ability to make modifications necessary to increase the spillway capacity of the facility or other alternative measures if the downstream hazard potential increases.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: Not specified - used for existing dams only.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Minimum design storm shall be the 100 year storm.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass	50	% of the	PMP
Existing Significant Hazard Dam must pass	50	% of the	PMP

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: 24-hour, Type III storm

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: There is a public notification process that takes approximately a year to change a rule.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	New Mexico
Name of Representative	Elaine C. Pacheco, P.E.
Title of Representative	Dam Safety Bureau Chief
Phone number(s)	505-827-6111
Email address	elaine.pacheco@state.nm.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	297
High Hazard Dams	149
Significant Hazard Dams	62
Low Hazard Dams	86
Unregulated Dams	101
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1985

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: NM Law was changed in 2009 to mirror the National Inventory Criteria for the size of a jurisdictional dam.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: With the change in NM Law the exemptions for Stock and erosion control dams were no longer needed.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

Comments: NM Classes are small, intermediate and large.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: No probable loss of life but can cause economic loss, environmental damage, disruption of lifeline facilities.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Other (Please specify)

Comments: Combination of federal and other western states.

10 When were the guidelines last revised (MM/DD/YYYY)? 12/31/2010

Comments: Changes to the Incremental Damage Assessment language to try and clarify the process.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Hope to develop guidelines for evaluating incremental damage. It would be great if FEMA's proposed guidelines provided details rather than a general approach.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Agency will perform independent verification on a case by case basis.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

Comments: Anticipated wave runup resulting from a 100 mph wind with reservoir level at the spillway crest will not overtop the dam; Anticipated wave runup resulting from a 50 mph wind with maximum reservoir level from routed SDF will not overtop the dam; Clay core cover and capillary rise requirements are satisfied; A minimum of 3 feet of freeboard remains after seismic deformation; In any case, at least 4 feet of freeboard shall be provided.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: AHYMO a black box program customized from HYMO for hydrology in the Albuquerque area. Program is a black box hard wired and is no longer allowed because intermediate results could not be verified.

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: NM requires that both the Local Storm (6 hours) and General Storm (72 hours) be considered and the more critical storm (results in highest routed water level in the reservoir) be used.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

Comments: Local Storm: HMR 55A and HMR 49 recommend the distribution in HMR5 or USACE EM 1110-2-1411. The more critical distribution is selected. General Storm: The HMRs do not specify a distribution. Center peaking or USBR 2/3 peak is acceptable.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: No damage to the spillway during normal operation. Damage to the spillway during the SDF is acceptable as long as the damage does not result in an uncontrolled release of the reservoir.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: However, analysis will be evaulated for appropriateness. NM is also developing a tool for site specific Extreme Precipitation for areas west of the continental divide to the eastern plains.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

Comments: Hazard creep is a major problem for dams designed and constructed by the NRCS and for other entities

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Initial reservoir pool must be at normal operation or at the crest of the spillway for permanent water storage reservoirs.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Lower limit is the 100-year event.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass	50-75	% of the	PMP
Existing Significant Hazard Dam must pass	50-75	% of the	PMP

Comments: Significant varies with size classification

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Our regulations state no, but waivers could be requested and we might consider the request if adequate justification is provided and the owner has a history of reliability

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

Comments: We would be open to consider this option.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Process is defined in statute. Funds would need to be identified and the change presented to stakeholders to get support (or at least no opposition) during the hearing process.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	New York
Name of Representative	Alon Dominitz
Title of Representative	
Phone number(s)	518-402-8130
Email address	axdomini@gw.dec.state.ny.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	5624
High Hazard Dams	390
Significant Hazard Dams	750
Low Hazard Dams	4484
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1970's or earlier

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: A construction permit is required unless the dam is 6 ft high or may impound less than 1 million gallons, or is less than 15 ft high AND may impound less than 3 million gallons.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: Inventory contains structures not considered dams - dams that were never built, failed, or removed.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	40	feet high and stores =>	1,000	acre-feet
Other (Specify)					

Comments: No Medium Size Classification. Storage refers to normal storage

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: A dam failure may result in damage to isolated homes, main highways, and minor railroads; may result in the interruption of important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; and/or is otherwise likely to pose the threat of personal injury and/or substantial economic loss or substantial environmental damage. Loss of human life is not expected.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Appear to be mostly NRCS criteria, plus for gravity dams USBR Design of Small Dams and USACE

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/1989

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: In early stages of internal development now

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Low (100-year), Significant (150% of 100-year), High (50% PMF)

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

May do independent verification for certain projects

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: 1 ft minimum for small dam, 2 ft minimum for large dam

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: Do not allow Rational Method

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Service Spillway Design Flood vs. Spillway Design Flood

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Have allowed a couple, combined with Incremental Hazard Assessment.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: 2009 revised regulations give hazard class much more importance, so change hazard classes is a growing problem.

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

Comments: New guidance on Engineering Assesment Reports mentions this - DOW TOGS 3.1.4

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

Comments: Typically assume normal initial pool

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

Comments: When site-specific PMP is combined with 1/2 PMF Existing Dam spillway capacity standard, we have asked for an incremental damage assessment. In other cases, dam owners have conducted incremental damage assessment on own initiatiative, to reduce spillway design flood or hazard classification

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

Comments: Nothing in guidelines but have never accepted less than 100-year storm

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	50	% of the	PMF
New Significant Hazard Dam must pass	225% of 100yr-40	% of the	PMF
Existing Significant Hazard Dam must pass	150% of 100yr	% of the	

Comments: Depending on size and hazard classification

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Not for new dam. Maybe for existing, if all other options were exhausted. Have never approved this.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Authority for state to regulate any dam whose failure could cause significant damage, regardless of size

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	North Carolina
Name of Representative	Steve McEvoy
Title of Representative	State Dam Safety Engineer
Phone number(s)	919-733-4574
Email address	Steve.McEvoy@ncdenr.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	4640
High Hazard Dams	1125
Significant Hazard Dams	655
Low Hazard Dams	2860
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1980

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 15 feet in structural height or less than 10 acre-feet of storage at top of dam elevation unless high hazard. All high hazard dams are jurisdictional.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Dams designed in accordance with NRCS Engineering Standard 378 are allowed to deviate from frequency of use criteria for unlined emergency spillways

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	35	feet high and stores =<	750	acre-feet
Class B (Medium)					
Class C (Large)	=>	50	feet high and stores =>	7500	acre-feet
Other (Specify)	Very Large: > 100 feet high and stores > 50000 acre-feet				

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Includes interruption to public utilities and minor damage to isolated homes or commercial and industrial buildings

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Custom developed by Organization

Comments: Developed by state dam safety staff and codified through appropriate legal procedure

10 When were the guidelines last revised (MM/DD/YYYY)? 12/01/1994

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: The guidelines specify activation and performance criteria for vegetated earth or unlined emergency spillways.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Utilize Hyrdometeorological Report (HMR) Numbers 51, 52, 56

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

Comments: The spillway should be sized so that the increased downstream damage resulting from overtopping failure of the dam would not be significant as compared with the damage caused by the flood in the absence of dam overtopping failure. SDF for high hazard dams cannot be more frequent than the 100-year return frequency.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: A design storm more frequent than once in 100 years will not be acceptable for any Class C dam.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	33-100	% of the	PMP
Existing High Hazard Dam must pass	33-100	% of the	PMP
New Significant Hazard Dam must pass	100yr - 75	% of the	PMP
Existing Significant Hazard Dam must pass	100yr - 75	% of the	PMP

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Ranges from 50 year to 1/2PMP, depending on size of dam.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: Dams will be subject to reclassification if the Director determines that the hazard potential has changed. Non-structural provisions of adequately demonstrated effectiveness and reliability such as flood plain zoning, and early warning systems may be considered by the Director in making this determination.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

Comments: Our agency will review incremental damage analysis for SDF selection which could be considered as somewhat related to risk analysis

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

Comments: Nothing other than incremental damage analysis

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments:

Change requires public comment process and legislative scrutiny. Process takes approximately two years.

34 Are there any unique provisions in your regulations?

No

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	North Dakota
Name of Representative	Mr. Jonathan Kelsch
Title of Representative	Engineer / Manager
Phone number(s)	701-328-4948
Email address	jkelsch@nd.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1165
High Hazard Dams	30
Significant Hazard Dams	94
Low Hazard Dams	1041
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? unknown

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: under 12.5 acre-feet of storage

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Existing dams that are functioning correctly and built to a different standard.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	10	feet high and stores =<	12.5	acre-feet
Class B (Medium)					
Class C (Large)	=>		feet high and stores =>		acre-feet
Other (Specify)	Five categories: Less than 10 ft, 10-24 ft, 25-39 ft, 40-55 ft, and Over 55 ft				

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

9 What is the origin of the guidelines?

Custom developed by Organization

10 When were the guidelines last revised (MM/DD/YYYY)? 06/01/1985

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

Comments: Exceptions can be made for existing dams to be repaired.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (Based on Tc)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Activation and damage criteria for principal vs. emergency spillways.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Recommended guidelines have been published (not required)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC II or III

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: Probably location dependent, not usually required for rural areas

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass		% of the	PMP
Existing High Hazard Dam must pass		% of the	PMP
New Significant Hazard Dam must pass		% of the	PMP
Existing Significant Hazard Dam must pass		% of the	PMP

Comments: Dam Design Classification I: 25-yr, II: 50-yr, III: 30% PMP, IV: 50% PMP, V: 100% PMP

29 For low hazard dams, the spillway design requirement is:

Not specified

Comments: See above criteria for five classifications.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Both approved and rejected)

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Ohio
Name of Representative	Dena Barnhouse
Title of Representative	Project Manager
Phone number(s)	614-265-6723
Email address	Dena.Barnhouse@dnr.state.oh.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	3572
Total Regulated Dams	1564
High Hazard Dams	368
Significant Hazard Dams	554
Low Hazard Dams	642
Unregulated Dams	991
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1967

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Dam less than 6 feet in height OR less than 15 acre-feet in storage OR greater than 6 feet and less than 10 feet in height and less than 50 acre-feet in storage are exempt from Ohio's dam safety laws.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Ohio has jurisdiction over dams less than 25 feet in height and less than 50 acre-feet in storage with downstream hazard limited to the dam itself and agricultural land (Class IV). There is no minimum inflow design flood for Class IV dams specified in Ohio's dam safety laws.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	500	acre-feet
Class B (Medium)					
Class C (Large)	=>	60	feet high and stores =>	5000	acre-feet
Other (Specify)	Small > 25 feet high and stores > 50 acre-feet				

Comments: The "other" category above is a Class IV dam as described in question 5 above.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Class I (High), Class II (Significant), Class III (Low), and Class IV (limited).

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

9 What is the origin of the guidelines?

Combination of the above (Please specify)

10 When were the guidelines last revised (MM/DD/YYYY)?

Comments: Critical flood guidelines added in the 1990's.

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

For existing dams, this agency performs rough calculations to determine whether the dam owner must hire an engineer to do further calculations. For dams being permitted, the dam owner's engineer submits an analysis which we review and sometimes perform our own calculations to verify the results.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: All methodologies must follow current publications from ODNR, USCOE, USGS, NOAA, or others acceptable to ODNR.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: All methodologies must follow current publications from ODNR, USCOE, USGS, NOAA, or others acceptable to ODNR.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: All methodologies must follow current publications from ODNR, USCOE, USGS, NOAA, or others acceptable to ODNR.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Emergency spillway channels must flow less than once in 50 years for Class I dams, once in 25 years for Class II dams, and less than once in 10 years for Class III dams.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: ODNR has currently hired a consultant to provide site specific PMP study for 2 department-owned dams. The results will be used to provide revised PMP values for roughly 2/3 of the state. The study will be indepdently reviewed before adopted.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Class I (40% PMF minimum), Class II (20% PMF minimum), Class III (100-year minimum)

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

Comments: Can be reduced to the critical flood through an incremental damage assessment.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 25% PMF down to no less than 100 year based on incremental damage assessment.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

No; our regulations forbid them

Comments: This type of analysis is not addressed in regulations. By omission, the regulations forbid them.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

34 Are there any unique provisions in your regulations?

No

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Oklahoma
Name of Representative	Robert S. Fabian
Title of Representative	Technical Section Program Manager
Phone number(s)	405-530-8800
Email address	rsfabian@owrb.ok.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	4672
Total Regulated Dams	4543
High Hazard Dams	320
Significant Hazard Dams	202
Low Hazard Dams	4021
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 26828

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: 15 af or less of impounding capacity irregardless of height of dam and 6 feet to 25 feet in height and with an impounding capacity of less than 50 acre-feet.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	50	feet high and stores =<	10,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: A written guidance document is under development describing criteria to be used for determination of a dam's hazard potential.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Unknown

10 When were the guidelines last revised (MM/DD/YYYY)? 07/01/1995

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Any dam constructed prior to June 13, 1973 and which is classified as intermediate size and high hazard potential according to 785:25-3-3 shall be required to pass a minimum design of 50% of the PMF. Any dam constructed prior to June 13, 1973 and which is classified as large size and high hazard potential according to 785:25-3-3 shall be required to pass a minimum design flood of 75% of the PMF.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Minimum freeboard varies from 1 to 3 feet based on both hazard and size classification

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

Comments: This is in a guidance document being develop and is not part of dam safety rules and regulations at this time.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: If watershed above dam is greater than 10 sq. mi. then use concentric elipse pattern. This is in a guidance document being develop and is not part of dam safety rules and regulations at this time.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Dam safety rules specify a PMF and freeboard requirement based on size and hazard classification of the dam.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: This is in a guidance document being develop and is not part of dam safety rules and regulations at this time.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Specify saturated antecedent moisture condition and initial reservoir pool at normal levels.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	50-75	% of the	PMF
New Significant Hazard Dam must pass	40-75	% of the	PMF
Existing Significant Hazard Dam must pass		% of the	

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 25-50% of PMF depending on size classification

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: A non-structural alternative will only be considered as a temporay solution until such time as structural changes could be made.

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

Comments: We rarely have a request for a risk-based hydrologic analysis.

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: This is a time consuming process that includes an analysis of impacts, including financial impacts, on the regulated community.

34 Are there any unique provisions in your regulations?

No

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Oregon
Name of Representative	Keith Mills
Title of Representative	Dam Safety Engineer
Phone number(s)	503-986-0840
Email address	millska@wrd.state.or.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1318
High Hazard Dams	126
Significant Hazard Dams	197
Low Hazard Dams	995
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? N/A

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 10 feet in height or that impounds less than 9.2 acre-feet.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

If "Yes", check and complete as appropriate:

Class A (Small)	=<		feet high and stores =<	acre-feet
Class B (Medium)				
Class C (Large)	=>		feet high and stores =>	acre-feet
Other (Specify)	Oregon classifies dams into two categories: large and small.			

Comments: Small dams are those less than 9.2 acre-feet and 10 feet in height. They are not subject to state dam safety oversight. All large dams must be designed by an engineer licensed in Oregon.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Unpublished guidelines for consideration by the engineer/designer

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Some custom as well

10 When were the guidelines last revised (MM/DD/YYYY)? N/A

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

We ask for PMF - High Hazard; 1/2 PMF Significant Hazard; 100 year flood with 2 feet of spillway freeboard for low hazard. All are minimum design criteria.

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

2.0'

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: We need compelling evidence the analysis is appropriate.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

Comments: Likely to become more of a problem with new development.

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass		% of the	
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass		% of the	

Comments: We ask owners to upgrade spillway capacity when the hazard rating is upgraded. If it is necessary, would use a legal process to compel an owner to upgrade.

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: 100 year with 2 feet of freeboard in the emergency spillway.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Pennsylvania
Name of Representative	Roger P. Adams, P.E.
Title of Representative	Chief, Division of Dam Safety
Phone number(s)	717-772-5951
Email address	roadams@state.pa.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	Unknown
Total Regulated Dams	3213
High Hazard Dams	782
Significant Hazard Dams	277
Low Hazard Dams	2154
Unregulated Dams	Unknown
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1913

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than or equal to 15 feet and the impounding capacity at maximum storage elevation is less than or equal to 50 acre-feet and the drainage area is less than or equal to 100

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Under PA mining laws, coal waste slurry dams have added regulations on time to dewater.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

Comments: Note: In PA, Class A is large and Class C is small.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Category 1 = substantial population at risk (PAR) and/or excessive economic loss (EL); Category 2 = few PAR and/or appreciable EL; Category 3 = no PAR and or significant EL; and Category 4 = no PAR and minimal EL.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: By regulation

9 What is the origin of the guidelines?

Custom developed by Organization

10 When were the guidelines last revised (MM/DD/YYYY)? 01/08/2011

Comments: Regulations revised.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Developing a process to conduct an incremental dam break analysis.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: Rational Method

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

Comments: By regulations.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: For projects increasing spillway capacity, we may require no increase in outflows up to the 100-year frequency flood.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Must be approved by NOAA.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: By Regulation

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

Comments: Incremental dam break analysis is required for high hazard dams. SDF is based on no additional impact to homes.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: 100-year frequency flood is considered a minimum SDF for high hazard dam.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	IDBA	% of the	PMF
Existing High Hazard Dam must pass	IDBA	% of the	PMF
New Significant Hazard Dam must pass	50-100	% of the	PMF
Existing Significant Hazard Dam must pass	50-100	% of the	PMF

Comments: New regulations require Incremental Dam Break Analysis (IDBA) to determine spillway design flood.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Medium (100-year to 1/2 PMF); Small (50-year to 100-year)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Other (Please explain)

Comments: Regulations do not address this issue; however, our procedures do not allow for this type of analysis

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: We just went through a change so we are familiar with the procedure.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Requiring an incremental dam break analysis for the spillway design flood for high hazard dams.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Puerto Rico
Name of Representative	Luis A. Suarez Sanchez
Title of Representative	Administrator, Dams & Reservoirs Safety Program
Phone number(s)	787-521-3256
Email address	l-suarez@prepa.com

2 Number of dams under Organization's jurisdiction by type:

Total Dams	36
Total Regulated Dams	36
High Hazard Dams	35
Significant Hazard Dams	0
Low Hazard Dams	1
Unregulated Dams	0
Other	0

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1979

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Is 25 feet or less in height or has an impounding capacity at the maximum water storage elevation of 50 acre-feet or less.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	25	feet high and stores =<	50	acre-feet
Class B (Medium)					
Class C (Large)	=>	25	feet high and stores =>	50	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

FEMA/FERC federal guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/1998

Comments: In 1998 the Guidelines Development Subcommittee update the FEMA Guidelines.

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on a combination of risk analysis and hazard/size classification

15 For PMP/PMF designs, is freeboard required?

1.0'

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: Can use the computer software of the Corp of Engineer and analysis methodologies developed by USBR to Puerto Rico.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

Comments: We use 24-hr too.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Antecedent moisture condition III and normal pool level.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass		% of the	
New Significant Hazard Dam must pass	100	% of the	PMF
Existing Significant Hazard Dam must pass		% of the	

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Rhode Island
Name of Representative	Paul Guglielmino
Title of Representative	Senior Sanitary Engineer
Phone number(s)	401-222-1360 xt. 7122
Email address	paul.guglielmino@dem.ri.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	671
Total Regulated Dams	538
High Hazard Dams	97
Significant Hazard Dams	83
Low Hazard Dams	492
Unregulated Dams	94
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? N/A

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: RI defines a 'regulated' dam as a low hazard dam that is six (6) feet or more in height or has fifteen (15) acre-feet or more of storage capacity; or a high hazard dam; or a significant hazard dam. 'Not regulated' doesn't meet the criteria. 'Non-jurisdictional' dams are FERC (for example), not RI, regulated. 'Non-inventory' are dams that we don't have in our database (typically small dams that wouldn't be regulated.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: RI doesn't have specific design standards.

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: A dam where failure or misoperation results in no probable loss of human life but can cause major economic loss, disruption of lifeline facilities or impact other concerns detrimental to the public's health, safety or welfare.

8 Does the Organization have guidelines for determining the spillway design flood?

No

9 What is the origin of the guidelines?

Unknown

10 When were the guidelines last revised (MM/DD/YYYY)? n/a

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: No to changing the hazard classification. N/a to design requirements.

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: None.

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: It would be more difficult if the regulation change required a change in the law.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Although dam safety law has been in place since 1800's, our first set of regulations were promulgated in 2007. We're just entering puberty.

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	South Carolina
Name of Representative	Steven M. Bradley, P.E.
Title of Representative	Dam Safety Hydrologist
Phone number(s)	803-898-4027
Email address	

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	2317
High Hazard Dams	153
Significant Hazard Dams	481
Low Hazard Dams	1683
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1980

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 25 feet in height or shall have an impounding capacity at maximum water storage elevation of less than 50 acre-feet.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)	Very Small < 25 feet high and stores < 50 acre-feet				

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Published guidelines, but still subject to a lot of engineering judgment.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

FEMA/FERC federal guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? n/a

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: New dams are conservatively classified.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

Comments: For 50 mph wind. For small dams, we usually use 1 ft.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

Comments: Usually check it using HEC-1 (transitioning to HEC-HMS)

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: Has to pass review

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

Comments: Great majority of drainage areas are very small (<10 square miles). For these we use 24-hour duration.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: Use of SCS Type II is common.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Activation criteria for earth spillways: Low hazard (1 year), Significant Hazard (10 year), High (25 year)

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Depends on credentials on person performing analysis

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC-II, Normal pool

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	500yr-100	% of the	PMF
New Significant Hazard Dam must pass	100yr-50	% of the	PMF
Existing Significant Hazard Dam must pass	100yr-50	% of the	PMF

Comments: High Hazard: Very Small (100yr to 1/2PMF), Small (1/2PMF to PMF, Intermediate and Large (PMF). Significant Hazard: Small (100yr to 1/2PMF), Intermediate (1/2PMF to PMF), Large (PMF).

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Small (50-yr to 100-yr), Intermediate (100-yr to 1/2 PMF), Large (1/2 PMF to PMF)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Current political climate makes it very difficult

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: We supply forms for EAPs to dam owners. All high hazard dams are being updated to meet FEMA rules

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	South Dakota
Name of Representative	Timothy G. Schaal
Title of Representative	Natural Resources Engineer
Phone number(s)	605-773-3352
Email address	tim.schaal@state.sd.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	2349
High Hazard Dams	47
Significant Hazard Dams	144
Low Hazard Dams	2158
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1986

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: A barrier is not considered a dam if height does not exceed 6 feet regardless of storage capacity of if storage capacity does not exceed 15 acre-feet.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Design requirements for category 1 tailings dams. Dams constructed to store, without discharge, tailings as defined by 45-6B-3 (14) shall be sized to retain the PMF plus at least a 100-year flood

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

Comments: SDCL 46-2-5 & 46-7-3

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

Comments: Corps of Engineers Phase I Inspections Recommemded Guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 4/23/1989

11 Are there any plans to update or revise the guidelines in the near future?

No

Comments: not in the "Near Future"

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Category 3 dams constructed before October 27, 1986 are exempt from minimum spillway requirements unless the dam fails and is rebuilt.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

Comments: we are open to other suggestions/methods

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

Comments: For 25-year, 50-year, and 100-year frequency floods.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: 74:02:08:02 states that if the classification of a dam changes, the dam must comply with spillway requirements of the higher catergory

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: SDCL 46-7-5.3

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: SDCL -46-7-5.3

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	50-100	% of the	PMF
New Significant Hazard Dam must pass	100yr-100	% of the	PMF
Existing Significant Hazard Dam must pass	100yr-100	% of the	PMF

Comments: High Hazard: Small (0.5PMF), Intermediate (0.5PMF), Large (PMF). Significant Hazard: Small (100-year), Intermediate (0.5PMF), Large (PMF).

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Small (50-year), Intermediate (100-year), Large (0.5 PMF)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Comments: That would be a Water Management Board decision

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

Comments: SDCL 46-7-5.3

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Legislative Research Council review and approval, public notice and Water Management Board approval, Legislative Oversite Committee review and approval

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Tennessee
Name of Representative	Lyle Bentley
Title of Representative	Chief, Dam Safety Program
Phone number(s)	615-532-0154
Email address	Lyle.Bentley@tn.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	1227
Total Regulated Dams	662
High Hazard Dams	150
Significant Hazard Dams	210
Low Hazard Dams	302
Unregulated Dams	565
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1987

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Dam means any artificial barrier, together with appurtenant works, which does or may impound or divert water, and which either (1) is or will be twenty (20) feet or more in height from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the Commissioner, or (2) has or will have an impounding capacity at maximum water storage elevation of thirty (30) acre-feet or more. Provided, however, that any such barrier which is or will be less than six (6) feet in height, regardless of storage capacity, or which has or will have a maximum storage capacity not in excess of fifteen (15) acre-feet, regardless of height, shall not be considered a dam, nor shall any barrier, regardless of size, be considered a dam, if, in the judgment of the Commissioner, such barrier creates an impoundment used only as a farm pond.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Dams designed and mostly paid for by the federal government, such as watershed district dams, cannot be required to have changes made in the design.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	49	feet high and stores =<	999	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Category 1 (High), Category 2 (Significant), and Category 3 (Low).

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

Comments: The Corps standards used in the Phase 1 investigations I the late 1970's and early 1980's.

10 When were the guidelines last revised (MM/DD/YYYY)? 02/19/2001

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Different Freeboard Design Storms for new and existing dams.

13 Which of the following best describes your agency's role in determining the spillway design flood:

It's specified in the regualtions.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Sufficient freeboard shall be provided to prevent overtopping with the passage of the freeboard hydrograph plus the additional freeboard required by the site for wave action.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Activation and performance guidelines are provided for vegetated earth or unlined emergency spillways

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: No, although it has been a source on contention at times.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: This only applies if development is actually planned - not if development could occur "one day."

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMP
Existing High Hazard Dam must pass	50-100	% of the	PMP
New Significant Hazard Dam must pass	50-100	% of the	PMP
Existing Significant Hazard Dam must pass	33-100	% of the	PMP

Comments: Existing, High Hazard: Large and Intermediate (PMP), Small (1/2 PMP). Significant Hazard: Large (PMP), Intermediate (1/2 PMP), Small (1/3 PMP). New (regardless of hazard class): Large and Intermediate (PMP), Small (1/2 PMP)

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Existing: Large (1/2 PMP), Intermediate (1/3PMP), Small (100-year).
New (regardless of hazard class): Large and Intermediate (PMP), Small (1/2 PMP)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

No; our regulations address this topic and we have made an administrative decision not to conside

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: It can be done through our rulemaking process.

34 Are there any unique provisions in your regulations?

No

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Texas
Name of Representative	Warren D. Samuelson, P.E.
Title of Representative	Dam Safety Program Coordinator
Phone number(s)	512-239-5195
Email address	warren.samuelson@tceq.texas.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	7212
High Hazard Dams	1002
Significant Hazard Dams	735
Low Hazard Dams	5485
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1986

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)	Intermediate = Equal to or Greater than 1,000 AF & Less than 50,000 AF or Equal to or Greater than 40 ft & Less than 100 ft				

Comments: Small = Equal to or Greater than 15 AF & Less than 1,000 AF; Equal to or Greater than 50 AF & Less than 1,000 AF; Equal to or Greater than 25 ft & Less than 40 ft; or Greater than 6 ft & Less than 40 ft

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Loss of one to six lives or one or two habitable structures in the breach inundation area downstream of the dam

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

Comments: Guidelines entitled "Hydrologic and Hydraulic Guidelines for Dams in Texas"

9 What is the origin of the guidelines?

Custom developed by Organization

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/2007

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: An owner of a large- or high-hazard existing dam that was required to meet 100% of the probable maximum flood (PMF) before the effective date of these rules and that is shown by an evaluation by a professional engineer to meet 75% or more of the PMF will not be required to upgrade the dam to meet minimum hydrologic criteria in paragraph (1)(A) of this subsection.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: HEC-HMS, HEC-1, SITES, WIN TR20, WIN TR55, HEC-RAS, and NWS Dynamic Wave Models. Other models may be acceptable upon written approval.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: Minimum storm duration is specified based on drainage area. All durations from the minimum up to the 72-hour duration shall be used to determine the most critical duration or the duration that produces the maximum reservoir level.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: PMP distributions are provided for 1-hr to 72-hr duration events. More conservative distributions (such as the HMR-51 or NRCS distributions) can be used.

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: Based upon drainage area

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: It is often accepted that erosion damage will occur should the emergency spillway operate, but that the effective cost of the very infrequent repairs is much lower than the upfront capital costs of the means to prevent the erosion. Most emergency spillways are built to prevent passage of flows for less than about the 50- or 100-year flood.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: We get comments from Legislative staff due to changing hazard classification. Owners also have a problem understanding floods that have "never occurred".

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Superimpose the PMP upon watershed soils assumed to be saturated. This will equate to losses at the beginning of the design storm equal to zero or Natural Resources Conservation Service Antecedent Runoff Conditions III (ARC III), or some other equivalent and approved assumptions. In Texas, there is no need to analyze snowmelt contributions to runoff or frozen ground conditions for infiltration for design-flood calculations.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	75-100	% of the	PMF
Existing High Hazard Dam must pass	75-100	% of the	PMF
New Significant Hazard Dam must pass	50-75	% of the	PMF
Existing Significant Hazard Dam must pass	50-75	% of the	PMF

Comments: Significant: Small (50% PMF), Intermediate (50-75% PMF), Large (75% PMF)
High: Small (75% PMF), Intermediate (75-100% PMF), Large (100% PMF)

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Small (25% PMF), Intermediate (25-50% PMF), Large (50-75% PMF)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: It happened one time a number of years ago. The owners would have to provide much more justification for it to be approved today.

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: The last change to the rules took four years and four different stakeholder meetings. The process is done internal to the agency, but takes a long time. Today, there would be considerable input from the Legislature. It would be difficult to get some of the changes we got in 2009 today.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Utah
Name of Representative	Everett Taylor
Title of Representative	Dam Safety
Phone number(s)	801-538-7372
Email address	everetttaylor@utah.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	5031
Total Regulated Dams	5031
High Hazard Dams	196
Significant Hazard Dams	301
Low Hazard Dams	4534
Unregulated Dams	0
Other	0

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1990

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Owned by Bureau of Reclamation

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Low Hazard, Flood control, less than 20 ac-ft & not high hazard

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (Other)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Other (Please specify)

Comments: Those dams which, if they fail, have a low probablility of causing loss of human life, but would cause appreciable property damage, including damage to public utilities.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

Comments: Found within State Administrative Rules

9 What is the origin of the guidelines?

Other (Please specify)

Comments: HMR 49 with state approved adjustments based on commissioned studies.

10 When were the guidelines last revised (MM/DD/YYYY)? 12/31/2003

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

Comments: The 72 hour SEF using HMR49/ USUL as well as the 6 hour SEF using HMR49/ USUS.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: Reserve the right to question methodologies

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: Route the 72 hour SEF using HMR49/ USUL as well as the 6 hour SEF using HMR49/ USUS to determine the more extreme event.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: In designing the spillway for a dam to pass the IDF, the State Engineer will consider the use of a principal spillway in conjunction with emergency spillways. The principal spillway must be designed so that no structural damage will occur during passage of the IDF. Emergency spillways, including Fuse Plug Spillways, may be designed so that some damage may be expected during use provided the anticipated damage does not represent a threat to the dam. Sunny day failure modeling of Fuse Plug Spillways may be required to determine if they are creating an additional unacceptable risk. Overtopping of the dam will not be considered as an emergency spillway on earthfill dams, unless it can be demonstrated that the dam is protected from erosion, and the duration of overtopping will not saturate the dam and reduce its stability.

22 Does the organization allow development of a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Reservoir pool at spillway crest (except flood control) AMC III for 100 year flood criteria

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: 100-year flood

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: The IDF for all High and Moderate Hazard Dams will be the SEF. It will be necessary to calculate both the 72 hour SEF using HMR49/ USUL as well as the 6 hour SEF using HMR49/ USUS. Both of these hydrographs must be routed through the reservoir to determine which one represents the most extreme event. Once the critical SEF has been determined, it must be compared to a flood generated by the 100 year, 6 hour (for local storms), or 100 yr, 24 hour (for general storms) precipitation applied on a saturated watershed. If the routed 100 year event, including appropriate allowances for freeboard, is more critical than the SEF it must be used as the minimum IDF.

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: Possibly on upgrading existing structure to meet minimum standards. Not for new construction.

31 Does your organization permit risk-based hydrologic designs?

No; our regulations forbid them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Changed through administrative rule process

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Vermont
Name of Representative	Stephen Bushman
Title of Representative	Environmental Engineer IV
Phone number(s)	802-241-3450
Email address	steve.bushman@state.vt.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	572
High Hazard Dams	55
Significant Hazard Dams	136
Low Hazard Dams	379
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria?

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Non jurisdictional: Capable of impounding 500,000 cubic feet or less of water. No non-inventory dam in VT, all dams we know of are included in inventory.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Primarily USACE and NRCS.

10 When were the guidelines last revised (MM/DD/YYYY)?

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: New dams must meet appropriate SDF. We have allowed reconstruction of existing dams to meet less than SDF required for a new dam, but at least Q100, and usually improvement over existing.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Freeboard, as appropriate, but not less than 1.5 feet with a routed Q100 inflows, and not less than 3.0 feet from principal spillway crest.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

Comments: No, but typically 24-hr is used.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: No, but typically HMR is used.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: As appropriate (USCOE, NRCS)

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

Comments: Typically use normal pool level

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: SDF and outlet works capacities should be consistent with guidelines or service criteria established by Federal agencies such as the Corps of Engineers, Soil Conservation Service and the Bureau of Reclamation for a given size and hazard classification, with the following additional requirements: 1) SDF, as appropriate, but in no case less than a routed Q100 (one hundred-year frequency) inflow (Ref: FERC Engineering Guidelines . . . , October 1993, Paragraph 2-3.3.). 2) Freeboard, as appropriate, but not less than 1.5 feet with a routed Q100 inflows, and not less than 3.0 feet from principal spillway crest (usually NWL). Applies to all embankment dams and other dams where appropriate.

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: SDF

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Unsure

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Statute change required. Would require amendment to individual sections of the law or addition of new sections. Difficulty increases with complexity of change.

34 Are there any unique provisions in your regulations?

No

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Virginia
Name of Representative	Robert T. Bennett, P.E., R.A., C.F.M.
Title of Representative	Director, Div. of Dam Safety & Floodplain Man.
Phone number(s)	804-786-3914
Email address	Robert.Bennett@dcr.virginia.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	11,568
Total Regulated Dams	1,568
High Hazard Dams	162
Significant Hazard Dams	382
Low Hazard Dams	1024
Unregulated Dams	10,000 +/-
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1982

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Owned or regulated by the Federal Government, or Permitted Mining Dam, or size exempt. Size exempt: <6', or <50 ac-ft for dams 6' - 25', or <15 ac-ft for dams >25'

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Pemitted Dams by VA Dept. Mines, Minerals, & Energy, and Agricultural Use Dams that are <25' high and Agricultural Use Dams < 100ac-ft.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

Comments: Medium is between Large and Small. Small is further defined as >=6'

7 Does the Organization have published hazard classification criteria?

Yes (Other)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: From 4VAC50-20-40: Significant Hazard Potential is defined where an impounding structure failure may cause the loss of life or appreciable economic damage. "May cause loss of life" means that impacts will occur that could cause a loss of human life, including but not limited to impacts to facilities that are frequently utilized by humans other than residences, businesses, or other occupied structures, or to secondary roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, secondary roadways, railroads, personal property, and agricultural interests. "Secondary roadways" include, but are not limited to, secondary highways, low-volume urban streets, service roads, or other low-volume roadways.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

10 When were the guidelines last revised (MM/DD/YYYY)? 12/22/2010

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Will be forming a Technical Advisory Committee (TAC) to revise regulations in 2011, may or may not change guidelines on determining SDF.

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Existing high hazard dams maximum SDF required = Flood resulting from the 90%PMP, new high hazard dams maximum required SDF = PMF.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Agency advises dam owners through the required certificate to operate renewal process that upgrades are needed if applicable.

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Yes, in conformance with Fed. Guidelines (See USBR Design of Small Dams) Freeboard determination and justification must be addressed by the owner's engr.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: Federal guidelines unless alternate method pre-approved by Dam Safety.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: Any software not approved by Fed. or non Fed. Approved and not pre-approved by Dam Safety

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: PMF hydrographs for 6-, 12-, and 24-hr. The hydrograph that creates the largest peak outflow used to determine capacity for nonfailure and failure analysis.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: Must comply with federal standard being used for calculations.

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: Must comply with federal standard being used for calculations.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Freeboard Design Flood may be used for NRCS Flood Control Struct. Only. All others must use spillway design flood and applicable Fed. Guidelines.

22 Does the organization allow development of a site specific PMP?

No

Comments: Not yet.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

Comments: Both is for impacts on watershed hydrology and impacts on downstream hazards.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Regs. 4VAC50-20-50 …."C. PMF: Probable Maximum Flood is the flood that might be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region."

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Minimum threshold for IDA: High (100-yr), Significant (100-yr), Low (50-yr)

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	90	% of the	PMP
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

Comments: The above numbers are without guidelines for incremental damage analysis reduction of spillway capacity requirements.

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Other (Please explain)

Comments: No

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Other (Please explain)

Comments: Proposed by dam owner, but concept rejected without consideration.

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: See: http://www.dcr.virginia.gov/dam_safety_and_floodplains/documents/dsregs.pdf

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Washington State
Name of Representative	Jerald LaVassar, P.E.
Title of Representative	Unit Lead, Dam Safety Office
Phone number(s)	360-407-6625
Email address	jlsd461@ecy.wa.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	1381
Total Regulated Dams	1217
High Hazard Dams	137
Significant Hazard Dams	224
Low Hazard Dams	856
Unregulated Dams	164
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1989

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Non-jurisdictional - Less than 10 acre-feet of storage (top of dam); USACE or USBR ownership; or FERC regulation. Of the unregulated dams, 106 are high hazard USACE, USBR or FERC dams.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	15	feet high and stores =<		acre-feet
Class B (Medium)					
Class C (Large)	=>	50	feet high and stores =>		acre-feet

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Population at Risk = 1 to 6 people. 1 or 2 inhabited structures. Other criteria include notable agriculture or work sites, secondary highway and/or rail lines, limited water quality degradation and only short term environmental impacts.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: Guidelines establish design minimums as a function of the downstream hazard setting.

9 What is the origin of the guidelines?

Custom developed by Organization

Comments: Dam Safety Guidelines, Technical Note 3: Design Storm Construction. Washington State Department of Ecology Publication No. 99-55G.

10 When were the guidelines last revised (MM/DD/YYYY)? 10/30/2009

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: New dams typically have the rainfall depth increased by 15%.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on a combination of risk analysis and hazard/size classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Usually based on wave run up computations; if computed freeboard is too low, may be superseded by minimum requirements; minimums depend on size of dam, range from 0.5 feet to 1.0 feet. Ref: Dam Safety Guidelines, Part IV: Dam Design and Construction. Washington State Department of Ecology Publication No. 99-55D. See Section 4.6, Reservoir Freeboard.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: WSDSO's basic requirement is to use good engineering practice. Usually means using HEC-HMS with our Tech Note 3 dam safety storms. On occasion, we have accepted HSPF with our Tech Note 3 dam safety storms inserted into the rainfall record. We have also accepted NRCS storms that captured the same (or greater) total rainfall volume and peak rainfall intensity as our Tech Note 3 dam safety storms. As noted in item 13, we often do our own calculations to verify the designer's calculations.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: Three storm scenarios must be considered: a short 4- to 6-hour storm, an intermediate 18-hour storm, and a long 72-hour storm. The IDF is the scenario that yields the highest peak water level in the reservoir.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Regional)

Comments: Design storm hyetographs are provided in Technical Note 3, at 5-minute intervals for the short storms and at 15-minute intervals for the intermediate and long storms.

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: Again, WSDSO's basic requirement is to use good engineering practice. One method is to use Areal Adjustments to Account for Storm Spatial Distributions as a Percent of At-Site Precipitation Amount - see Dam Safety Gudelines Tech Note 3: Design Storm Construction, Section 1.2.3

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Because of infrequent operation, economy in design and construction can sometimes be accomplished for small and intermediate size dams by utilizing the concept of survivability. That is, erosional damage can often be tolerated provided the damage does not jeopardize the structural integrity of the impounding barrier or allow an uncontrolled release of the reservoir waters.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Must be more conservative than Washington State DSO Design Storm Criteria as described in Tech Note 3. The 2009 update to Tech Note 3 is more recent than HMR-57 (NWS, Oct. 1994),and is based on a larger database of storms.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: There are several dimensions to this issue: (a) Downstream development may require simply a reclassification based on the existing flood analysis and inundation mapping, or may require us to do a new dam breach flood study. (b) The new hazard rating will require us to do a new hydrology study to determine the spillway dimensions required to pass the new (larger) inflow design flood. (c) The dam owner must modify or reconstruct the spillway(s) to the new dimensions. The inundation and IDF studies (a, b) may be a problem for us (Dam Safety Office) depending on our other inspection and plan review workload. The physical work on the spillway (c) may be a problem for the dam owner, depending on their ability to fund the reconstruction. If we (Dam Safety) perform the engineering analyses, we have found that this fosters something of a partnership attitude with the dam owner so that they may be more willing to devote their funds to the physical construction (a more tangible product). A few dam owners may require specific enforcement action to nudge them into making the spillway modifications, which creates additional workload for the Dam Safety Office.

24 Do guidelines require consideration or analysis of future development?

No

Comments: Our Design Step Worksheet asks the engineer of record to consider the potential for future development and his/her assessment then is reflected in the minimum design level. If the engineer's assessment is grossly at odds with what we judge the potential for future development to be, we will raise the concern with the owner. Our position is that the owner is then making an informed judgment of whether to pay some more now or much more later if they ignore growth potential.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Should be representative of typical conditions during the season when the storm might occur. This usually means normal pool elevation, typical snowpack, and AMC-II soil moisture conditions.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Must select a Inflow Design Flood with reservoir routing through the embankment's spillways, determine the flood levels and areal extent of dam failure inundation vs stream flood inundation, proceed to the next design step if it exceeds 2 ft and assess against the US Bureau of Reclamation Hazard Assessment Curves (Ref: Dam Safety Guidelines, Part IV, Section 2.4). If any population at risk, minimum Design Step is Step 3, recurrence interval 1 in 3,000 years. (Ref: Dam Safety Guidelines Technical Note 2, Selection of Design/Performance Goals for Critical Project Elements. Washington State Department of Ecology Publication No. 99-55F. See Section 5.1.5 on page 22.)

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: Consquence rating points determine the design flood based on a sliding scale. The scale ranges from the 500-year flood to the PMF or theoretical maximum event.

29 For low hazard dams, the spillway design requirement is:

500-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Generally, safety design must be passive.

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Administrative procedures are quite detailed and time-consuming, with considerable public involvement, at a time when we have no extra staff to devote to that effort.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Risk-based design storm levels; design storm hyetographs based on Washington State historical storms; numerical rating scheme for design/performance goals. Also, the level of detail in our guidance documents is more detailed typically than other states.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	West Virginia Dam Safety Section
Name of Representative	Brian Long
Title of Representative	Section Manager
Phone number(s)	(304) 926-0499 ext1005
Email address	brian.r.long@wv.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	524
Total Regulated Dams	355
High Hazard Dams	253
Significant Hazard Dams	80
Low Hazard Dams	22
Unregulated Dams	44
Other	125

3 When did your Organization adopt minimum Inflow Design Flood criteria? 1982

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: Exemptions for federal owned dam, farm pond dams, and road fills that do not normally impound water

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Coal refuse dams vary in freeboard requirements

6 Does the Organization have published size classification criteria?

No

Comments: An impoundment exceeding forty (40) feet in height or four hundred (400) acre-feet storage volume shall not be classified as a Class 3 (low hazard) dam.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: Rule guidelines are passed by Legislature, signed by Gov with force of law

9 What is the origin of the guidelines?

Other (Please specify)

Comments: NRCS & MSHA

10 When were the guidelines last revised (MM/DD/YYYY)? 06/01/2009

Comments: Revision to create a revolving loan fund

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on hazard classification only

Comments: Risk assessment is allowed with justification

15 For PMP/PMF designs, is freeboard required?

No

Comments: Coal refuse dams are required to include additional freeboard.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

Comments: Applicant may use any procedure. WVDEP advises procedures used to review applications.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: Applicant may use any software. WVDEP advises software used to review applications.

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: Type II storm distribution used in review

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: Point rainfall reduction assumed in review for watersheds exceeding 10 square miles

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC II unless a different condition is required by the Secretary

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

Comments: Future downstream conditions are required as part of the dam break analysis

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Class I - no less than 70% of the PMP; Class II - no less than 25% of the PMP; Class III - no less than P100

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass	50	% of the	PMP
Existing Significant Hazard Dam must pass	50	% of the	PMP

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 25% of the PMP; Class IV required to pass P100

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

Comments: Rule permits reduction of hazard potential or design storm (see #27) based upon risk assessment analysis subject to agency approval

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Both approved and rejected)

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Statute require additional "Criteria" to govern design, construction, repair, inspection & maintenance of proposed dams with annual review to consider improved technology.

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Wisconsin
Name of Representative	Meg Galloway
Title of Representative	State Dam Safety Engineer
Phone number(s)	608-266-7014
Email address	Meg.galloway@dnr.state.wi.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	3653
High Hazard Dams	189
Significant Hazard Dams	170
Low Hazard Dams	3294
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1985

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: The state definition of Large Dam matches the NID criteria.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: We do not have jurisdictional authority under our dam statutes over dams associated with cranberry operations, manure storage facilities, tailings facilities and dams not on watercourses.

6 Does the Organization have published size classification criteria?

Yes

Comments: Large: >6 feet and =>50 acre feet or =>25 feet and >15 acre-feet.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: We may also call a dam signifcant if failure would cause significant environmental harm.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

Comments: Rules are in Administrative Code NR 333

9 What is the origin of the guidelines?

Unknown

10 When were the guidelines last revised (MM/DD/YYYY)? 7/1/2001

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

In most cases we do a review of submitted design. In some cases we may do independent analysis. Agency engineers may do analysis on department-owned dams; however, the analysis will receive an independent review by another agency engineer.

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Do not use PMP/PMF. We do not have written freeboard criteria but we will push for freeboard to be included in design on a case-by-case basis

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: Must use methods identified as acceptable in our Floodplain regulations (NR 116)

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: If it is not acceptable by the floodplain regulations the decision would be made on a case-by-case basis

18 Do the guidelines specify any criteria for storm duration?

No

Comments: We have occasionally commented on and requested a change in storm duration during the review process

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

No

Comments: Do not use PMP criteria

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

Comments: It should never be a problem as the design criteria are tied into existing land use and future land use controls. It is occasionally an issue for an existing dam if land use controls do not get put in place in a timely manner to prevent hazard creep.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: NR 333 and NR 116 tie dam safety and floodplain regulations together to try and minimize development potential in the hazard area downstream of dams.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: Any owner may provide documentation to justify a different spillway capacity from that specified in Table I. The department shall review such documentation and may approve the spillway capacity proposed by the owner if it determines that such capacity will not result in an additional hazard to life, health or property when compared to the capacity specified in Table I.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: High (Q1000), Significant (Q500)

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Unless done for emergency purposes the rule making process typically takes at least 18 months.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Linking the hazard potential to both existing land use and land use controls downstream of the dam.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Wyoming
Name of Representative	Mr. Larry L. Stockdale
Title of Representative	Safety of Dams Engineer
Phone number(s)	307-777-3500
Email address	lstock@seo.wy.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1512
High Hazard Dams	79
Significant Hazard Dams	112
Low Hazard Dams	1321
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? n/a

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Anything less than 15 acre-feet regardless of height, less than or equal to 6 feet in height regarless of capacity, or less than 20 feet in height and less than 50 acre-feet.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

Comments: Regulations in draft form.

9 What is the origin of the guidelines?

Combination of the above (Please specify)

10 When were the guidelines last revised (MM/DD/YYYY)? n/a

Comments: Still in draft form.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Will be revised when review comments are received

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: High and Significant hazard are a performance design. Frequency is based on the 100-year.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Moderately difficult due to public comment, etc.

34 Are there any unique provisions in your regulations?

No

Appendix D. Federal Guidelines

D.1 Bureau of Indian Affairs
D.2 Federal Emergency Management Agency
D.3 Mine Safety and Health Administration
D.4 National Park Service
D.5 Natural Resources Conservation Service
D.6 Nuclear Regulatory Commission
D.7 Tennessee Valley Authority
D.8 U.S. Army Corps of Engineers
D.9 U.S. Bureau of Reclamation
D.10 U.S. Fish and Wildlife Service
D.11 U.S. Forest Service



FEMA

D.1. Bureau of Indian Affairs



1.1 Purpose. This Chapter establishes the basic policy, authorities, and responsibilities for the Bureau of Indian Affairs (BIA) Safety of Dams (SOD) Program.

1.2 Policy. It is the BIA SOD Program policy to:

A. Reduce the potential loss of human life and property damage due to a catastrophic dam failure by making BIA dams as safe as practically possible; and

B. Encourage flood plain management below dams and on reservoir shorelines.

1.3 Authorities.

A. Presidential Memorandum issued April 23, 1977, to the Heads of Federal Agencies that have dam safety responsibilities, requiring each agency to conduct a thorough review of practices affecting the safety and integrity of dams;

B. Executive Memorandum dated October 9, 1979, implementing Federal Guidelines for Dam Safety for each agency;

C. 25 U.S.C. § 3801, Public Law 103-302**,** Indian Dams Safety Act of 1994. This law directs the Secretary to establish a dam safety maintenance and repair program within the BIA to monitor the condition of all dams on Indian lands and maintain them in a satisfactory condition on a long-term basis;

D. 33 U.S.C. § 467, Public Law 92-367**,** National Dam Inspection Act of 1972; and

E. 33 U.S.C. § 2201 et seq., Public Law 99-662, Water Resources Development Act of 1986.

1.4 Guidance. Government-wide, Department of the Interior, and BIA guidance documents are available from the BIA SOD Officer, MS 4515-MIB, 1849 C Street NW, Washington, DC 20240.

A. Government-Wide. Federal Guidelines for Dam Safety, June 25, 1979.

B. Department of the Interior.

(1) Departmental Manual Part 753, Dam Safety Program;

(2) Secretarial Order No. 3048, February 28, 1980;

(3) Interagency Agreement between the BIA and the Bureau of Reclamation, dated May 16, 1996;

(4) Value Engineering Guidance Handbook, No. VE-1; and

(5) Departmental Manual Part 369, Value Engineering.

C. Bureau of Indian Affairs. Bureau of Indian Affairs Safety of Dams Handbook (BIA SOD Handbook).

D. Other Federal Agencies. Bureau of Reclamation and Federal Emergency Management Administration technical guidance documents referenced in the BIA SOD Handbook are available from the Bureau of Reclamation, Technical Service Center, Client Liaison, BIA and Tribal Projects, P.O. Box 25007, D-8010, Denver, CO 80225-0007.

1.5 Responsibilities.

A. Director, Office of Trust Responsibilities, designates the BIA SOD Officer.

B. BIA SOD Officer.

(1) Plans, manages, directs, and provides program oversight and guidance to Regional SOD Officers;

(2) Provides staff assistance and advice to the Commissioner/Deputy Commissioner of Indian Affairs;

(3) Develops and manages programs relating to the BIA responsibilities to Indian tribes as they relate to the SOD Program;

(4) Monitors compliance and makes recommendations for changes to Federal, Departmental, and BIA SOD guidelines;

(5) Drafts legislation and regulations as required, and reviews proposed legislation and regulations initiated elsewhere that may affect the SOD Program;

(6) Formulates policy recommendations and provides direction and guidance on implementation to Regional Directors or their designated representatives;

(7) Serves as liaison and promotes working agreements with tribes, states, and other Federal agencies concerning SOD Program activities;

(8) Represents the BIA on the Department of the Interior Dam Safety Working Group;

(9) Coordinates with other program offices of the BIA and other agencies on SOD issues, including emergency preparedness; and

(10) Reviews and provides updates on BIA data for the National Inventory of Dams.

C. Regional Directors.

(1) Provide program oversight for the operation of the SOD Program within their jurisdiction in accordance with established policy, procedures, directives, and this manual part;

(2) Submit an Annual Status Report to the BIA SOD Officer by December 31 of each year for all SOD Program dams under the jurisdiction of the Regional Office; and

(3) Designate a Regional SOD Officer.

D. Regional SOD Officers.

(1) Plan, manage, and direct Regional SOD Program activities;

(2) Prepare the Regional Director's Annual Status Report on each SOD Program dam as described in the BIA SOD Program Handbook;

(3) Maintain the Regional Office record-keeping and reporting system for the SOD Program, including the National Inventory of Dams;

(4) Provide technical assistance to other Regional staff and tribes;

(5) Coordinate SOD activities with the BIA SOD Officer and provide liaison with other organizations and government agencies;

(6) Serve as the Contracting Officer's Representative (COR) or Contracting Officer's Technical Representative (COTR) on Regional SOD Program contracts when designated by the Regional Contracting Officer;

(7) Coordinate all SOD Program activities with Agency Superintendents and Agency and tribal SOD personnel, and expedite all matters relating to dam safety for any new dam project, on or off a reservation, which could affect trust lands, including those planned, designed, and/or constructed by others;

(8) Review all roadway embankments which cross waterways with the potential to affect BIA dams or trust lands to determine possible hazards from impoundment of water and to ensure adequate design of such embankments;

(9) Immediately report to the Regional Director any dam failure, incident, or any abnormal operations which adversely affect public safety or dam operations;

(10) Maintain a set of the documents referenced in the Record Keeping section of the BIA SOD Handbook;

(11) Develop and implement emergency management procedures as described in Chapter 2, Section 2.5 of this Part for each SOD Program dam;

(12) Provide oversight for, and conduct a final inspection of, all completed modifications to existing dams or new dam construction, prepare a Final Project Report for each project, and determine the need for any post construction activities; and

(13) Arrange and facilitate training for Regional and tribal SOD Program personnel.

E. Agency Superintendents.

.

(1) Coordinate SOD Program activities with the Regional SOD Officer, including training for Agency personnel involved in the SOD Program; and

(2) Ensure that Agency responsibilities in Emergency Action Plans for dams under their jurisdiction are implemented.

2.1 Scope. BIA SOD Program dams include all dams that meet the criteria in the National Dam Inspection Act. This includes all dams which impound or divert water and are 25 feet or more in height from the natural bed of the watercourse, measured from the downstream toe (or lowest elevation) of the dam to the top (crest) of the dam, or which have an impounding capacity at maximum water storage elevation of 50 acre-feet or more. This does not include dams which are less than six feet in height, regardless of storage capacity, nor dams having a storage capacity at maximum water elevation of less than 15 acre-feet, unless downstream hazards to life or property exist.

2.2 Downstream Hazard Classification. A Downstream Hazard Classification (High, Significant, or Low) will be determined for each BIA SOD Program dam in accordance with the Bureau of Reclamation's Assistant Commissioner-Engineering Research Technical Memorandum No. 11, Downstream Hazard Classification Guidelines.

2.3 Applicability.

A. SOD Program requirements in this Chapter apply to all BIA dams with a High or Significant Downstream Hazard Classification.

B. BIA SOD Program funding is available only for dams with a High or Significant Downstream Hazard Classification.

C. For BIA dams with a Low Downstream Hazard Classification, further application of any SOD Program technical requirements in this Chapter and the SOD Program Handbook to activities conducted with non-SOD Program funding is at the discretion of the Regional SOD Officer based on the specific conditions at each Low Hazard dam.

2.4 Operation and Maintenance for Existing Dams includes the operation and maintenance activities for the dams and appurtenant structures and the emergency management activities undertaken to safely operate and maintain dams.

A. Standing Operating Procedures. Standing Operating Procedures must be established for each High or Significant Hazard dam. The procedures permit responsible persons, knowledgeable in reservoir operations, but who are unfamiliar with the conditions at a particular dam, to operate the dam and reservoir during emergency situations and at times when the regular operator is not available to perform normal duties. Additional details on Standing Operating Procedures are contained in the BIA SOD Handbook. Copies of the Standing Operating Procedures are maintained at the Agency Office and the dam site, if an on-site facility exists.

B. Documentation. A documented history of the field exploration programs, design, construction, operation, maintenance, instrumentation data monitoring, periodic examinations, corrective actions, repairs, and remedial work will be established and maintained by the Regional SOD Officers so that data relating to the dam are preserved and readily available for reference. This documentation will commence with the initial site investigation for the dam and continue through the life of the structure.

C. Training. Personnel involved in the operation and maintenance of BIA dams will be

trained to detect, evaluate, and appropriately respond to emergency and non-emergency situations. Regional SOD Officers and Agency Superintendents are to identify training needs for the personnel under their supervision and request such training from appropriate sources.

2.5 Emergency Management.

A. Emergency Action Plan. This plan will be developed for all High or Significant Hazard dams as required by 753DM1.5. An Emergency Action Plan (EAP) is prepared to aid the facility manager and operations and maintenance personnel during an emergency situation or unusual occurrence. It provides information on detection of problems, immediate steps to take, whom to notify, what decisions to make, steps to take in the event of loss of communications, and other appropriate measures.

B. Inundation Maps. Inundation maps will be developed for each High or Significant Hazard dam. The inundation maps include, as a minimum, delineation of flooded areas to the point where the subject flood no longer poses a risk. The inundation maps will be included in the EAP.

C. Warning and Evacuation Plans. The Regional SOD Officer is responsible for identifying all entities, including local, state, tribal, and federal, who would be impacted during a dam failure or large operational releases. These entities should be encouraged to develop their own Warning and Evacuation Plans for each dam. The EAP must be coordinated with these Warning and Evacuation Plans.

D. Incident Response. Following an incident or emergency event, an incident report will be prepared by the Regional SOD Officer and submitted to the Regional Director and the BIA SOD Officer.

E. Early Warning Systems (EWS). EWS instrumentation will be installed, operated, and maintained at High or Significant Hazard dams and in the upstream basin when early detection of hydrologic events would provide additional time needed for emergency management activities.

2.6 Monitoring of Non-Bureau of Indian Affairs Dams. The Regional SOD Officer will be aware of the safety status of dams which are not under the jurisdiction of the BIA, but pose a potential hazard to persons or property on trust lands. The Regional SOD Officer will ensure that the EAP for these dams provides adequate notification to the BIA in the event of a dam failure or other emergency event.

2.7 Evaluation of Existing Dams.

A. Safety Evaluation of Existing Dams (SEED) Examination Program. The BIA SEED Examination Program is an onsite examination to document the structural integrity of High or Significant Hazard dams and appurtenant structures. SEED examinations will be conducted according to the BIA SOD Handbook.

B. Deficiency Verification Analysis (DVA) Report. A Deficiency Verification Analysis will

be performed on each High or Significant Hazard dam to determine if the dam has deficiencies which could lead to the failure of the dam. The results of this analysis will be included in the DVA Report and will serve as the technical documentation of any deficiencies that must be resolved or mitigated.

2.8 Short-term Remediation Actions. Examination and evaluation activities could reveal deficiencies or potential deficiencies which, if uncorrected, could eventually lead to failure or misoperation of a dam. The following actions may be taken under the direction of the Regional SOD Officer when conditions warrant. Some actions may involve NEPA compliance.

A. Emergency Corrective Action. Emergency corrective action is required for deficiencies which could result in failure of the dam within a short period of time. The BIA SOD Officer and Regional Director will be notified immediately by the Regional SOD Officer of any dams that are in this condition, and informed as to what action is being taken to remove the threat;

B. Interim Actions. Measures considered necessary to protect the public during the time between a safety examination and the safety modifications will be implemented at the earliest possible time after completion of the onsite examination. Interim actions could include implementing reservoir level restrictions, temporary breach, operational changes, installation of early warning systems, or specific monitoring of instrumentation at the dam site; or

C. Non-emergency Corrective Action. Non-emergency corrective action is taken when there is no immediate threat to the safety or operation of the dam, or any threat to life or property downstream. The corrective action should be scheduled in advance of the fiscal year in which the work is to be done to allow time for planning, funding through the normal budgeting process, and arrangements for special reservoir operations when required.

2.9 Design Process for New Dams and for Modifications to Existing Dams. The design of new dams and modifications to existing dams contain the same elements, which include:

A. Conceptual Designs. The initial phase of the design process, which leads to the selection of a preferred design alternative, must include the following:

(1) National Environmental Policy Act compliance will be initiated and substantially completed during this phase of the design process in accordance with 40 CFR 1500-1508;

(2) National Historic Preservation Act compliance will be conducted in accordance with 36 CFR 60 and 36 CFR 80;

(3) Native American Graves Protection and Repatriation Act and Archaeological Resources Protection Act compliance will be conducted as required;

(4) A Conceptual Design Report will be prepared to document all viable alternatives for a new dam or for resolving or mitigating verified deficiencies at an existing dam; and

(5) A Value Engineering study, if required, will be completed during this phase of the design process in accordance with the Department of the Interior Value Engineering Guidance

Handbook, No. VE-1.

B. Final Design. Final design, including assumptions, calculations, drawings and specifications will be completed for the selected alternative.

(1) Appropriate and practical state-of-the-art design methods and procedures will be incorporated into the final design;

(2) A Design Summary Report will be prepared which includes complete written documentation of all data, computations, and the decision making process, including the rationale supporting the design decisions;

(3) Construction specifications, including all bidding, award, and contract documents, will be in accordance with current Federal Acquisition Regulations and other applicable laws and regulations; and

(4) An environmental compliance review will be conducted by Regional environmental and archeological personnel.

C. Independent Technical Review. An independent technical review is required for every modification or construction project. The review will be:

(1) Arranged by the Regional SOD Officer;

(2) Performed early in the final design process, preferably not later than at the 30 percent completion milestone of the final design; and

(3) Conducted by qualified engineers and other experts not otherwise involved in the project, including Regional environmental and archeological personnel.

2.10 Construction of New Dams and Modifications to Existing Dams. BIA personnel play a key role in several elements of the construction process, including:

A. Construction Management. During the construction phase, close coordination between the BIA, design personnel, construction personnel, and Regional safety and environmental officers is required to assure that the project design intent is carried out, that new field information is incorporated into the construction, and that the cost and time schedules are being met. This includes site inspections.

B. Documentation, Records, and Drawings. Complete written and photographic documentation of the construction will be developed and maintained by the project construction engineer and the Regional SOD Officer. This includes, but is not limited to, records of the foundation excavation and treatment, revised drawings to show "as built" conditions, and complete records of all construction inspections.

C. First and Subsequent Fillings. All aspects of the dam and reservoir performance must

be monitored and evaluated by the project construction engineer and the Regional SOD Officer from visual observation and instrumentation data during first filling. First filling must be conducted according to the first fill plan developed during the design phase.

D. Completion Report and Project Acceptance.

(1) Upon completion of construction, the project construction engineer will prepare a completion report in consultation with design and environmental personnel that documents compliance with specifications and drawings;

(2) A detailed inspection of the constructed project will be conducted or arranged by the Regional SOD Officer, and upon approval and acceptance of the project, the facility will be transferred from a construction to an operation and maintenance status; and

E. Final Project Report.

(1) After construction and the first and subsequent successful fillings and monitoring, all identified deficiencies in the DVA Report from pre-construction will be examined to determine if the deficiencies are corrected. A Final Project Report will be prepared by the Regional SOD Officer that documents the status of these deficiencies; and

(2) After the Final Project Report is submitted, the dam will transfer to an operation and maintenance status. The periodic SEED examination and analysis process will resume once the dam is in this status.

F. Post-Construction Activities. The Regional SOD Officer will critique and evaluate design, construction, and administrative activities to assist in improving future designs and construction methods for dams. The Regional SOD Officer will determine which post-construction activities are appropriate for each project and whether a written report is warranted.

D.2. Federal Emergency Management Agency





Federal Guidelines for Dam Safety

April 2004

FEMA

FEDERAL GUIDELINES FOR DAM SAFETY

prepared by the
INTERAGENCY COMMITTEE ON DAM SAFETY

U. S. DEPARTMENT OF HOMELAND SECURITY
FEDERAL EMERGENCY MANAGEMENT AGENCY
JUNE 1979

Reprinted April 2004

PREFACE

These guidelines represent the culmination of efforts, initiated by President Carter in April 1977, to review procedures and criteria used by Federal Agencies involved in the design, construction, operation, and regulation of dams and to prepare guidelines for management procedures to ensure dam safety. The guidelines are based on an intensive review of Agency practices conducted by the Departments and Agencies themselves, by an *ad hoc* interagency committee of the Federal Coordinating Council for Science, Engineering and Technology (FCCSET), and by an Independent Review Panel of recognized experts from the academic and private sectors. These reviews are summarized in two earlier reports: *Improving Federal Dam Safety,* a report of the FCCSET, November 1977, and *Federal Dam Safety Report of the OSTP Independent Review Panel,* December 1978.

Publication of the guidelines marks the final step in the review process. However, the Departments and Agencies recognize that there must be a continuing Federal effort to improve dam safety. Federal dam safety remains a fundamental responsibility of each Federal employee in every Department and Agency involved and it is on their technical expertise and dedication that the safety of Federal dams rests. These guidelines recognize that underlying fact and support management efforts to discharge that responsibility effectively and efficiently.

These guidelines apply to Federal practices for dams with a direct Federal interest and are not intended to supplant or otherwise conflict with State or local government responsibilities for safety of dams under their jurisdiction. Current Federal initiatives to assist States and others with non-Federal dam safety programs are being pursued under other authorities. The objective of both programs, however, is the same: to allow the people of this country to enjoy the benefits of water resource development with the best assurance of dam safety possible.

The members of the FCCSET *Ad Hoc* Committee are to be commended for their diligent and highly professional efforts. Gratitude and appreciation are also due the several Departments and Agencies involved for their whole-hearted interest and support.

Frank Press, Chairman
Federal Coordinating Council
for Science, Engineering and
Technology

TABLE OF CONTENTS

		Page
I.	**INTRODUCTION**	**1**
	A. BACKGROUND	**1**
	B. AUTHORITY AND IMPLEMENTATION	**2**
	C. DEFINITIONS	**4**
II.	**OBJECTIVES AND SCOPE**	**7**
III.	**GUIDELINES**	**9**
	A. ORGANIZATION MANAGEMENT	**9**
	1. General	9
	a. Administration	9
	b. Design Responsibility	10
	c. Construction Responsibility	10
	d. Operation Responsibility	10
	e. Technical Coordination	10
	f. Emergency Planning	11
	g. Risk-Based Analysis	11
	2. Staffing	11
	a. Technical Support	11
	b. Competence	12
	c. Continuity	12
	d. Professional Advancement	12
	3. Training	12
	a. Internal	12
	b. Academic	14
	c. Professional	14
	d. New Technology	14
	4. Communication	14
	a. Interdisciplinary	14
	b. Interagency	15
	5. Documentation	15
	a. Design Record	16
	b. Construction Record	16
	c. Initial Reservoir Filling and Surveillance Record	16
	d. Operation and Maintenance Record	17
	e. Permanent Files	17
	6. Reviews	17
	a. Extent	17
	b. Internal	17
	c. External	18
	7. Research and Development	19
	a. Methods and Materials	20
	b. Risk-Based Analysis	20

TABLE OF CONTENTS (Cont.)

	Page
c. Interagency Coordination	20
8. Contracts	20
a. Documents	20
b. Modifications	20
9. Constraints	20
a. Funding for Organizational Management	21
b. Public Concerns	21
B. MANAGEMENT OF TECHNICAL ACTIVITIES-SITE INVESTIGATION AND DESIGN (SID)	**21**
1. Hydrology	21
a. Hazard Evaluation	21
b. Flood Development	22
c. Flood Selection for Design (or Evaluation)	22
d. Hydrologic Design of Reservoir	22
e. Downstream Effects	22
f. Warning Systems	23
2. Earthquake Investigation and Design	23
a. Investigation Factors	23
b. Selection of Design Earthquakes	23
c. Engineering Seismology	23
d. Need for Earthquake Analysis	23
e. Seismic and Geologic Studies	23
f. Design for Earthquake Forces	24
3. Geotechnics	24
a. General	24
b. Exploration and Identification of Geotechnical Problems	25
c. Geotechnical Design	26
d. Foundation Treatment	26
e. Instrumentation	27
f. Inspection and Continuing Evaluation during Construction	27
g. Reevaluation at Existing Structures	28
4. Hydraulic Appurtenances	28
a. General	28
b. Design Flood Releases	28
c. Other Water Releases	29
d. Reservoir Evacuation	29
e. Control of Flows during Construction	29
f. Design Criteria and Guidance	29
g. Reanalysis Because of Changes	29
h. Hydraulic Design Involvement during Life of Structure	29
5. Concrete Dams and Concrete Elements of Embankment Dam	30
a. Site Specific Design	30
b. Materials	30

TABLE OF CONTENTS (Cont.)

Page

c. Design of Structures 30
d. Definition of Loads 30
e. Design Methods 31
f. Design Evaluation 31
g. Instrumentation 31
h. Construction and Operational Follow-up 31
6. Embankment Dams 31
a. Site Specific Design 31
b. Materials 32
c. Design Constructability 32
d. Embankment Design 32
e. Instrumentation 33
f. Construction and Operational Follow-up 33

C. MANAGEMENT OF TECHNICAL ACTIVITIES- CONSTRUCTION (CON) 34

1. Introduction 34
a. Construction Contracts 34
b. Construction/Design Interface 34
2. Evaluation during Construction 35
3. Orientation of Construction Engineers and Field Inspectors 35
a. Design Related 35
b. Foundation 36
c. Materials 36
d. Construction General 36
4. Construction Assurance 37
a. Construction Procedures 37
b. Construction Materials Testing 37
c. Quality Assurance 37

D. MANAGEMENT OF TECHNICAL ACTIVITIES- OPERATION AND MAINTENANCE (O&M) 38

1. Operation and Maintenance 38
a. General 38
b. Operating Procedures 38
c. Maintenance Procedure 39
2. Periodic Inspection Program 39
a. General 39
b. Types and Frequencies of Inspections 40
c. Instrumentation 42
d. Correction of Deficiencies 43
e. Documentation 44
3. Emergency Action Planning 45
a. General 45
b. Evaluation of Emergency Potential 45

TABLE OF CONTENTS (Cont.)

	Page
c. Actions to Prevent Failure or Minimize Effects of Failure	46
d. Actions Upon Discovery of a Potentially Unsafe Condition	49

IV. APPENDICES

A. FCCSET *AD HOC* INTERAGENCY COMMITTEE MEMBERS	A-1
B. INTERAGENCY GUIDELINES SUBCOMMITTEE MEMBERS	B-1
C. OCTP INDEPENDENT REVIEW PANEL MEMBERS	C-1
D. ACKNOWLEDGEMENTS	D-1
E. BIBLIOGRAPHY	E-1

I. INTRODUCTION

These guidelines apply to management practices for dam safety of all Federal agencies responsible for the planning, design, construction, operation, or regulation of dams. They are not intended as guidelines or standards for the technology of dams. The basic principles of the guidelines apply to all dams. However, reasonable judgments need to be made in their application commensurate with each dam's size, complexity, and hazard.

The Federal agencies have a good record and generally sound practices on dam safety. These guidelines are intended to promote management control of dam safety and a common approach to dam safety practices by all the agencies. Although the guidelines are intended for and applicable to all agencies, it is recognized that the methods of the degree of application will vary depending on the agency mission and functions.

A. BACKGROUND

Throughout history, in all parts of the world, dams built to store water have occasionally failed and discharged the stored waters to inflict sometimes incalculable damage in the loss of lives and great damage to property. Failures have involved dams built without application of engineering principles, but have also involved dams built to, at the time, accepted engineering standards of design and construction. The technology of dams has improved with the increased knowledge of design principles and of the characteristics of foundation and dam materials, and it is generally agreed that safe dams can be built and existing dams can be safely maintained with proper application of current technology. It is the intent of these guidelines to outline management practices that will help to ensure the use of the best current technology in the design, construction, and operation of new dams and in the safety evaluation of existing dams.

As early as 1929, following the failure of the St. Francis Dam, the State of California enacted a dam safety program. Subsequently, other dam failures causing loss of life and property have prompted additional legislation on state and national levels.

The Congress in 1972 enacted Public Law 92-367, known as the "National Dam Inspection Act." The Secretary of the Army was authorized to inspect non-Federal dams in the nation meeting the size and storage limitations of the Act to evaluate their safety; report inspection results to the States and advise the States on actions needed to ensure dam safety; report to the Congress the information given to the States; prepare a national inventory of dams; and make recommendations to the Congress "for a comprehensive national program for the inspection and regulation for safety purposes of dams of the nation." Responsibilities under the law were delegated to the Corps of Engineers. The activities performed under the program consisted of an inventory of dams; a survey of each State and Federal agency's capabilities, practices, and regulations regarding the design, construction, operation, and maintenance of dams; development of guidelines for inspection and evaluation of dam safety; and formulation of recommendations for a comprehensive national program. A report on these activities and proposed legislation to implement a Federal dam safety program were transmitted to Congress in November 1976, but lack of funding prevented the execution of the detailed dam inspections.

The failure during initial filling in 1976 of the Teton Dam in Idaho, a Federal earth embankment dam over 300 feet high, reactivated intense public and governmental concern for dam safety. Congressional and Federal agency investigations were made into this disaster and the entire question of dam safety, and new Federal legislation for dam safety was initiated in the Congress.

An April 23, 1977, Presidential memorandum (reproduced in Section I.B) directed federal agencies to review their dam safety practices, addressing many elements of dam safety. Major elements included internal and external review, qualifications of personnel, integration of new technology, emergency preparedness plans, and review of existing dams. The agencies' reviews and the assessment of the reviews by a Federal *ad hoc* interagency committee and by an Independent Review Panel showed that sound practices are generally being used, but concluded that improvement is needed in some management practices for dam safety.

B. AUTHORITY AND IMPLEMENTATION

The authority for preparation of these guidelines is contained in a memorandum from President Carter dated April 23, 1977, which read as follows:

"MEMORANDUM FOR:

The Secretary of the Interior
The Secretary of Agriculture
The Secretary of the Army
The Director, Office of Management and Budget
The President's Adviser on Science and Technology
The Chairman, Federal Power Commission
The Chairman, Tennessee Valley Authority
The Commissioner, U.S. Section, International Boundary and Water Commission

The safety of dams has been a principal concern of Federal agencies that are involved with the various aspects of their planning, construction, operation and ultimate disposal. Events of the past several years have highlighted the need to review procedures and criteria that are being employed by these agencies with the objective of ensuring that the most effective mechanisms are established to give the best assurance of dam safety possible within the limitations of the current state of knowledge available to the scientific and engineering communities. The safety of such projects should continue to be accorded highest consideration, and it is the responsibility of the head of each agency concerned to ensure the adequacy of his agency's dam safety program.

I. Agency Dam Safety Reviews

The head of each Federal agency responsible for, or involved with site selection, design, construction, certification or regulation, inspection, maintenance and operation, repair and ultimate disposition of dams shall immediately undertake a thorough review of practices which could affect the safety and integrity of these structures. This review will encompass all activities which can be controlled or regulated by the agency.

Several aspects of the problem require special attention. In particular, the following items should be investigated: the means of inclusion of new technological methods into existing structures and

procedures; the degree to which probabilistic or risk-based analysis is incorporated into the process of site selection, design, construction, and operation; the degree of reliance on in-house, interagency, and outside expert interpretation of geologic data in site selection and design development; the effect on dam safety of earthquake or other earth movement hazards; the effects of cost-saving incentives on decisions both prior to and during construction; the procedures by which dam safety problems are identified, analyzed, and solved; the involvement of local communities in identifying, analyzing, and solving dam safety questions; and the major outstanding dam safety problems of the agency.

II. Interagency Report and Proposed Guidelines

The Chairman of the Federal Coordinating Council for Science, Engineering and Technology (FCCSET) shall convene an *ad hoc* interagency committee to coordinate dam safety programs, seeking consistency and commonality as appropriate, and providing recommendations as to the means of improving the effectiveness of the Government-wide dam safety effort. The agency reviews described above should be provided to the FCCSET as a basis for the interagency analysis on a timetable established by the FCCSET group as reasonable and consistent with the October 1, 1977 deadline for a final report. Representation on the FCCSET for this activity should be expanded to include other appropriate Federal agencies or departments including, but not limited to, the Tennessee Valley Authority, the United States Section-International Boundary and Water Commission and the Federal Power Commission. The FCCSET effort will include preparation of proposed Federal dam safety guidelines for management procedures to ensure dam safety. FCCSET should report on all these items.

III. Independent Review Panel

In addition, the Director of the Office of Science and Technology Policy will arrange for review of agency regulations, procedures and practices, and of the proposed federal dam safety guidelines, by a panel of recognized experts to be established immediately. The panel will obtain the views and advice of established organizations, professional societies, and others concerned with the safety of dams which are in any way affected by a Federal role.

The review report thereon should be completed no later than October 1, 1978."

(signed) Jimmy Carter

The *ad hoc* interagency committee called for in paragraph II of the memorandum was established by FCCSET, under the direction of the Office of Science and Technology Policy. The committee was represented by:

Office of Science and Technology Policy (Chairman)
Department of the Army
Department of Agriculture
Department of the Interior
Nuclear Regulatory Commission (NRC)
U.S. Section, International Boundary and Water Commission (IBWC)
Federal Energy Regulatory Commission (FERC) (Formerly Federal Power Commission)
Tennessee Valley Authority (TVA)

The Nuclear Regulatory Commission was added to the dam agencies addressed in the memorandum. Members of the *ad hoc* committee are listed in Appendix A.

Also established were subcommittees for the preparation of the proposed Federal dam safety guidelines called for in paragraph II of the memorandum. These subcommittees and their task groups had representatives from all the agencies with responsibilities for dams. Appendix B lists the members of the subcommittees and task groups and their agencies.

In accordance with the Presidential memorandum, the participating agencies submitted their reports on review of agency management practices involving dam safety; the subcommittees submitted the proposed Federal dam safety guidelines; and the *ad hoc* committee prepared the FCCSET report, *Improving Federal Dam Safety*, dated November 15, 1977. The report contains summaries of the agency reports, and the subcommittee proposed guidelines and summary thereof; assesses the agency reports; and makes recommendations for improvement of management practices for dam safety.

Pursuant to paragraph III of the President's memorandum, the Independent Review Panel was formed with specialists from the academic and private sectors concerned with dams. Members of the panel are listed in Appendix C. The panel reviewed the FCCSET and associated reports and proposed guidelines, and submitted a report, *Federal Dam Safety, Report of the OSTP Independent Review Panel,* December 6, 1978.

These guidelines were developed from the FCCSET report and its proposed guidelines, from Independent Review Panel recommendations, and with the cooperation of the panel.

C. DEFINITIONS

The following definitions apply in these guidelines.

Dam or Project. Any artificial barrier, including appurtenant works, which impounds or diverts water, and which (1) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum water storage elevation or (2) has an impounding capacity at maximum water storage elevation of fifty acre-feet or more. These guidelines do not apply to any such barrier which is not in excess of six feet in height regardless of storage capacity, or which has a storage capacity at maximum water storage elevation not in excess of fifteen acre-feet regardless of height. This lower size limitation should be waived if there is a potentially significant downstream hazard.

The guidelines apply with equal force whether the dam has a permanent reservoir or is a detention dam for temporary storage of floodwaters. The impounding capacity at maximum water storage elevation includes storage of floodwaters above the normal full storage elevation.

In addition to conventional structures, this definition of "dam" specifically includes "tailings dams," embankments built by waste products disposal and retaining a disposal pond.

Dam Failure. Catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water. It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters which adversely affect a dam's primary function of impounding water is properly considered a failure. Such lesser degrees of failure can progressively lead to or heighten the risk of a catastrophic failure. They are, however, normally amenable to corrective action.

Contract. Contracts relating to project design, construction equipment, operation, or regulation, as applicable to the project and the agency function. Where work is described using the terms contract or contractor, it is meant to include also similar work by the agency's own personnel

Maintenance. Maintaining structures and equipment in intended operating condition; equipment repair and minor structure repair.

Rehabilitation or Improvement. Repair of structure deterioration to restore original condition; alteration of structures to improve dam stability, enlarge reservoir capacity, or increase spillway and outlet works capacity; replacement of equipment.

Hazard. Potential loss of life or property damage downstream of a dam from floodwaters released at the dam or waters released by partial or complete failure of the dam, and upstream of the dam from effects of rim slides. A hazard is considered significant if there is a potential to cause loss of life or major damage to permanent structures, utilities, or transportation facilities.

Emergency Preparedness Plan. Formal plan of procedures to alleviate hazards during construction of or after completion of a dam or to reduce damages if conditions develop in which dam failure is likely or unpreventable. These emergency plans related to dam safety do not include flood plain management for the controlled release of floodwater for which the project is designed.

II. OBJECTIVES AND SCOPE

The overall purpose of these guidelines is to enhance national dam safety. The immediate objective is to encourage high safety standards in the practices and procedures Federal agencies use or require of those they regulate for dam site investigation, design, construction, operation and maintenance, and emergency preparedness. As these guidelines are directly applied to make Federal dams as safe as practical, it is hoped that they will also influence state dam safety agencies and public and private dam owners to be more safety conscious where programs are now weak.

The guidelines are intended to outline Federal agency management procedures that will continually stimulate technical methods in dam planning, design, construction, and operation for minimizing risk of failure. The objective of dam safety would be achieved as management and technical decisions during all project stages give proper recognition to safety considerations, and the strategy of these guidelines toward that end is to describe definite management practices to reinforce decision-maker awareness of safety needs. Those charged with administering these guidelines must recognize that the achievement of dam safety is through a continuous, dynamic process in which guidelines, practices, and procedures are examined periodically and updated. Technical procedures need to change with technological advancement, and management should ensure that observed deficient practices are corrected and that successful practices are duplicated.

The goal of making dams as safe as practical implies a limit to maximum reasonable effort. Those charged with implementing these guidelines need to recognize that no dam can ever be completely "fail-safe" because of incomplete understanding of or uncertainties associated with natural (earthquakes and floods) and manmade (sabotage) destructive forces; with materials behavior and response to these forces; and in control of the construction process. Management must ensure that uncertainties are properly balanced with competent technical judgment.

Although dams have been built for thousands of years, dam engineering is not an exact science and is more accurately described as an "art." It is true that this branch of engineering, like any other, draws heavily upon mathematical principles and physical laws, but every stage of the planning and execution of a dam project also requires the exercise of experienced judgment. This is true in designing and constructing new dams, and especially true in evaluating and/or improving existing dams. For many of these "older dams," there is little information available to document original site exploration, design, construction, and past operation. These dams must be carefully inspected and observed for indicators of distress.

To illustrate a principle from just one aspect of dam design, there are practical limitations on the amount of physical data that can be obtained during planning and design. Judgment and extrapolation are necessary to assess foundation conditions and to design an appropriate structure. Experience is essential in applying these judgments.

Construction is a critical phase in achieving a safe dam. Any project must be continuously evaluated, and "re-engineered" as required, during construction to assure that the final design is compatible with conditions encountered during construction. Quality of construction is also critical to safety. Deficiencies in materials or construction practices can occur during all stages of

the construction, and constant vigilance is necessary to prevent them. Sampling and testing at a completed project cannot be relied on as an effective substitute for inspection and quality control during construction.

Monitoring existing dams and reacting quickly to inadequate performance or to danger signals is a continuing critical aspect for dam safety. Careful monitoring and quick response can prevent failures, including those caused by poor construction.

The guidelines are intended to make as small as possible the failure risk inherent in constructing new dams, and to prioritize needs to improve existing dams according to hazard potential as estimated by technical analysis and as constrained by financial and personnel resources.

In the development of these guidelines, consideration was given to the broad diversity of agency missions. The guidelines were designed to be free of specific agency policies and unnecessary details. The resultant level of detail in the guidelines represents an attempt to achieve a balance between general management goals for assuring dam safety and meaningful principles which can survive technological changes and be useful to the non-Federal community.

A special situation exists regarding the application of these guidelines to dams of international nature. Several dams of concern to the United States are located partially in the United States and partially in Mexico or Canada. Those dams located at the U.S.-Mexican border are only partly subject to the jurisdiction of a U.S. Federal agency, the U.S. Section of the International Boundary and Water Commission. In this case, the U.S. should seek agreement with the Mexican Section of the Commission for adoption of applicable sections of these guidelines for ensuring dam safety. For dams located on the U.S.-Canadian border, the guidelines should be referred to the U.S. Section of the International Joint Commission (IJC) to seek agreement with the Canadian Section of the Commission on means by which the guidelines could be implemented through the entities that are responsible for construction, operation, and maintenance of the projects.

Section III.A., *Organization Management,* outlines the elements of agency management responsibilities for dam safety. Sections III.B, III.C, and III.D, *Management of Technical Activities,* contain additional guidance on technical activities for *Site Investigation and Design, Construction, and Operation and Maintenance* (includes Periodic Inspection Program and Emergency Action Planning). *Appendix E* is a bibliography of references to related guidelines and practices developed by Federal dam building agencies and other scientific and technical organizations. The body of knowledge represented by the bibliography is intended to be representative of dam technology, but not inclusive of all available literature that may be helpful.

III. GUIDELINES

A. ORGANIZATION MANAGEMENT

1. General

Heads of Federal agencies are responsible for the development and implementation of policy, resources and procedures for safe design, construction, operation, and inspection of each dam under their jurisdiction, as applicable to the agency mission. The agency management structure assists the head of the agency in discharging this responsibility and shares in it. The management structure is ultimately responsible for obtaining compliance with the intent of these management and technical activities guidelines, and for assuring that procedures are evaluated and updated periodically.

a. Administration

The head of each Federal agency having responsibility for design, construction, operation, or regulation of dams should establish a dam safety office (officer) which reports directly to the head of the agency or his designated representative. The office should be responsible for ensuring that the agency, as a matter of policy and in actual practice, makes every reasonable and prudent effort to enhance the safety of the dams under its jurisdiction. Duties of the office should include surveillance and evaluation of the agency's administrative and technical or regulatory practices related to dam safety concerning design and construction of new dams, and operation, maintenance and rehabilitation of existing dams; recommending improvements in the practices when evaluation reveals safety-related deficiencies; and maintaining an inventory of agency dams.

The functions of the office should be advisory to the agency head, and through the agency head to the agency administrative and technical units. The staffing and detailed duties of the office should be commensurate with the agency mission.

If a Federal dam safety office is established within the recently proposed Federal Emergency Management Agency (FEMA), the heads of the dam safety offices in the respective agencies should be advisory in FEMA's interagency coordinating functions.

The agency organization for the design, construction, operation, or regulation of a dam project should be structured so that a single identifiable, technically qualified administrative head has the responsibility for assuring that all management and technical safety aspects of dam engineering are adequately considered throughout the development and operation of the project. The position must have continuity of guidance and direction, and the authority and resources to ensure these responsibilities can be carried out.

Management should ensure that organization staffing is sufficient and qualified for the projected workload, and that all programs necessary for the safety of dams are established, continued, and realistically funded. Allocation of manpower and funds should give high priority to safety-related functions. Safety-related functions and features must not be sacrificed to reduce costs, improve project justification, or expedite time schedules.

b. Design Responsibility

The design function can never be considered finished as long as the dam remains in place; design involvement should continue throughout construction and operation of the project. The design office should establish specific programs for onsite construction and operational inspection for review by appropriate design personnel and technical specialists. The programs should include frequent and mandatory inspections during construction to confirm that site conditions conform to those assumed for design or to determine if design changes may be required to suit the actual conditions. A major requirement is inspection and approval of the dam foundation and foundation treatment before placing of dam materials. Final design inspection of the construction should include complete project surveillance and testing of operating equipment. Operational design inspections should continue throughout the life of the project, in accordance with a formal inspection program covering all project features. Management must program adequate funds to assure dam safety is not compromised by failure to conduct regular and thorough inspections and reviews.

The design function includes responsibility for planning any dam instrumentation to be installed during construction and/or operation to monitor conditions that could potentially threaten dam safety. The design should identify the purpose of the instrumentation, and include the plans for timely reading, collecting, reducing, and interpreting the data. It should include an advance determination of critical instrument observations or rates of data change, and a plan of action if observations indicate a critical condition may occur.

c. Construction Responsibility

The responsibility for administering construction and supply contracts, for understanding the design and contract intent, for maintaining technical coordination between design and construction engineers, and for managing the construction staff to assure compliance with specifications should be vested in an identified engineer at the construction project. He should have the administrative and technical control of all resources necessary to accomplish safe construction of the dam. Construction personnel should understand the conditions upon which the design is based and the relationship between these conditions and the design features. When unanticipated conditions are encountered, design personnel should be involved in determining their effect.

d. Operation Responsibility

The responsibility for project operation should be assigned to a single staff member of the operating organization. He should also handle the operating organization requirements for coordination with the design organization, including reporting changed conditions discovered by operators and participation of the operating organization personnel with design personnel in the periodic inspection program.

e. Technical Coordination

All technical specialties required to plan, design, construct, and operate dams to achieve dam safety should be staffed and their efforts coordinated to ensure technical adequacy. A project design engineer should be assigned technical coordination responsibility for each dam. He should handle necessary technical coordination within the agency and with private and public organizations.

Continuing liaison should be maintained among the personnel concerned with the various stages of project development and operation so that each concerned discipline and organizational unit knows and understands the relevant activities of the others. This coordination must be given constant attention to be sure proper action is taken.

f. Emergency Planning

An emergency plan should be formulated for each dam. The plan should be in the detail warranted by the size and location of the dam and reservoir. It should evaluate downstream inundation hazards resulting from floods or dam failure, and upstream conditions that might result from major land displacements or increased flood flows, including the effects from failure of upstream dams.

Where applicable, the plan should include inundation maps for the flows resulting from design floods and from possible failure of the dam. The complete emergency plan should be transmitted to appropriate local, state, and Federal governmental bodies. The plan should be periodically reviewed and kept up to date, and periodically publicized to maintain awareness of its existence.

In addition to the emergency plan for the completed dam, a similar plan should be prepared for the construction period, including area facilities that may remain during the period and floods that may be anticipated.

g. Risk-Based Analysis

Risk-based analytical techniques and methodologies are a relatively recent addition to the tools available for assessing dam safety. With further refinement and improvement, risk-based analyses will probably gain wider acceptance in the engineering profession and realize potential as a major aid to decision-making in the interest of public safety. However, even when fully developed, risk analyses cannot be used as a substitute for sound professional judgment of engineers, contractors, or review boards. In view of the dual problems of uncertainty in analysis and possibility of misinterpretation by the public, but in recognition of the high potential these techniques have, agencies should be encouraged to conduct research to refine and improve the techniques and to develop the methodologies and base of expertise necessary to apply them to dam safety evaluations. Specifically, agencies should strive to perfect techniques for evaluating the probability of possible deficiencies causing dam failure and estimating the potential losses due to such a failure. Meanwhile, the agencies should evaluate the potential consequences of failure of the dams under their jurisdiction. Although the value of potential property losses can be estimated, it is recognized that potential loss of lives can only be quantified, but not evaluated. On new dams, potential losses can be used in study of project alternatives and in assessment of additional safety incorporated into the dam facilities. On existing dams, a risk-based analysis should be considered in establishing priorities for examining and rehabilitating the dams, or for improving their safety.

2. Staffing

a. Technical Support

Management should assure adequate and competent technical staffing to perform the essential functions in planning design, construction, and operation and maintenance of dams. Technical

staff should be well supported by administrative, clerical, and other elements to ensure that the technical staff is not diverted from technical work. In the planning and design function, particular emphasis should be given to adequate staffing in hydrology, hydraulics, geology, engineering seismology, field investigation, and geotechnical and structural design. Sufficient expertise should be available on the construction staff and on the operation staff to maintain an understanding of design decisions related to the various design specialties.

Construction inspection staffing should assure quality as well as quantity inspection coverage. Staffing should be reviewed by higher authority than the local construction office. Field personnel should be well trained and experienced if the design is to be implemented and a safe structure is to be constructed. They must not only recognize the need for adherence to the design, but must be able to recognize when the design is at odds with conditions being encountered. The responsibility and importance of the construction staff to dam safety must be given appropriate consideration in organizational and position classification decisions.

The operating personnel must be qualified to perform the many functions required in the operation, including the recognition of conditions possibly detrimental to dam safety. Operation and maintenance staffing requires careful attention to personnel responsible for operating inspections, and to personnel who participate in the periodic inspection program. It is essential that support personnel and equipment are provided to accomplish needed maintenance activities.

b. Competence

Job-related experience, professional aptitudes, and educational background should be major factors in evaluating the competence of individuals for the requirements of each responsible position concerned with the safe design, construction, and operation of dams. All positions should be staffed by competent engineers or specialists in the related disciplines.

c. Continuity

Staffing policies should recognize that continuity of technical positions is essential to maintain consistent high standards of practice. This applies in all elements of project development from design to operation, and is especially critical in those positions having supervisory responsibility related to dam safety.

d. Professional Advancement

The agencies should maintain a positive program for advancement of technical personnel in recognition of acquired experience, training and education, and increased competence. It is essential that agencies maintain the technical as well as the managerial expertise required for safe, effective dam design, construction, and operating programs. Organizational structure, position classification, and career incentives must recognize both technical and managerial responsibility and compensate both equitably.

3. Training

a. Internal

To supplement technical staffing, agency management should provide internal personnel training. A rotational training program should be established to familiarize new personnel with

all major aspects of the agency functions and the interrelationships of its organizational units. Provisions should be made for technical personnel to observe and participate in decision-making meetings and to make site visits with more experienced staff. Staff members should be allowed to attend consultant meetings in order to gain valuable experience.

Technical personnel concerned with all phases of project development should be given broad exposure to a variety of field conditions. For example, geologists and geotechnical personnel should gain experience with soil and rock drill crews and in the laboratory testing facilities; design personnel should be familiar with concrete and soil placing and testing techniques; operating personnel should be familiar with equipment installation and testing procedures.

A rotational training program should be considered that would place construction engineers in the design organization during design and design engineers in the field during construction on temporary assignments. Preconstruction training should be provided for inspection personnel, covering the design engineering considerations and the requirements and importance of thorough field inspection. The training should be given by embankment or structural engineers and geologists assigned from design or by the construction engineer who had received preconstruction orientation by the designers, geologists, and embankment and structural engineers (section III.A.4.a). This training should make sure that all inspectors know the expected requirements in detail. Onsite instruction sessions for inspection of new features of construction should be developed and given by supervisors or lead inspectors before initiation of the work.

Operation and maintenance personnel should be trained by personnel experienced in operation of similar projects, covering all features of facilities operation and inspection. Thorough training should be provided for the personnel who will take observations on and monitor any installed dam instrumentation. The training should be conducted by experienced observers and by the engineers responsible for analyzing the structure effects revealed by the instrumentation data.

Technically qualified operating personnel should be trained in problem detection and evaluation, and application of appropriate remedial (emergency and non-emergency) measures. This is essential for proper evaluation of developing situations at all levels of responsibility which, initially, must be based on observations made by trained operating personnel at the project. The training should cover the problems that experience has shown are most likely to occur with the type of dam and facilities, and include the kinds of monitoring best suited to early detection of those problems. Such training will permit prompt action when time is a critical factor. A sufficient number of personnel should be trained to ensure adequate coverage of all tasks at all times. If a dam is operated by remote control, training must include procedures for dispatching trained personnel to the site at any reported indication of distress.

Personnel involved in inspections should be trained for the requirements of these duties. The training should cover the types of information needed to prepare for the inspections, critical features that should be observed, inspection techniques, and preparation of inspection reports.

b. Academic
Agency management should establish and maintain a program for continuing formal education and training aimed at increasing and broadening the agency's base of professional expertise in areas related to safe design and construction of dams. Such training should provide for part and/or full time attendance at universities and at special courses prepared by technical and professional organizations. Programs should be designed to further the development of younger personnel and to provide refresher training or sabbaticals for senior personnel.

Supervisory construction, inspection, and operation and maintenance staff should keep current on modern methods and techniques by attending technical courses. Pertinent courses are available from private sources and educational institutions. Also, agencies that develop internal educational programs for this purpose should make them available to other agencies, permitting the agencies to gain mutual benefit in the exchange of information on new methods and practices.

c. Professional
Professional growth of personnel should be encouraged by policies which ensure adequate training, support participation in technical and professional societies, and establish attractive career and promotional ladders for technical specialists. Professional registration and active membership in professional and technical societies should be given due consideration in assessing qualifications for higher technical positions.

d. New Technology
Provision should be made for the establishment of procedures to screen and disseminate information on technical advances relating to dam design, construction, and operation. Programs for continuing professional training should be oriented toward keeping the technical staff abreast of improved technology. Interagency coordination on training in new technology should be established in areas of mutual interest.

4. Communication
Effective methods of communication, coordination, and review should be established and functioning properly at all times, and be periodically reviewed and updated. Procedures for communications among Federal, State, and local agencies on safety-related matters should be established. Specific areas of suggested communication are discussed below.

a. Interdisciplinary
Direct and easily accessible means of communication should be established between personnel in planning, design, construction, and operations. Coordination is necessary for preparation of the site investigation plan and for a common understanding of information needed for design. Prior to the site investigation the design staff should arrange for meetings between geologists, geotechnical engineers, and designers to review known site conditions, project functional requirements, and preliminary design concepts. A visit to the site should be included in the review of existing information.

A document, referred to by some agencies as "Design Considerations," should be prepared by the design staff to transmit site-specific design considerations to the construction staff. This

document should cover, but not be limited to, hydrologic and hydraulic considerations, geologic and geotechnical data, foundation conditions, foundation treatment details, and anticipated foundation problems. It should specify points at which inspection and approval are required by the design staff. Copies of the document should be furnished to those responsible for dam operation and inspection.

Additionally, the design staff should arrange preconstruction orientation for the construction engineers by the designers, geologists, and embankment and structural engineers so that the construction engineer and his staff fully understand the design concepts and the significance of the results of the exploratory work. The construction engineers need to provide the designers, prior to advertising the construction contract, comments on the constructability and the ease of contract administration for the plans and specifications.

During construction, the construction engineers should be alert for conditions that need to be reported to the design engineers. Field personnel should notify design personnel of any critical construction sequence or of a suspected change in conditions that could affect the design of the structure. Design engineers with relevant expertise must be available to make regular visits to the construction site, and additional visits as needed when varying conditions arc encountered. Changes in construction or materials should be made only after plans for changes are approved by design personnel.

The design staff should furnish to the operation staff documents, referred to by some agencies as "Operation and Maintenance Manuals," containing pertinent design and construction information on structures and equipment required for effective and safe operation of the dam. A conference of design and operating personnel should be held to ensure that the operators understand the operating and inspection procedures required for safe and reliable operation. Both the operators and the designers should have copies of equipment operating and testing manuals and procedures. The operators should notify the designers of any safety-related operating malfunctions and the actions taken to correct them. There should be continuing communication between operating and design staffs regarding plans and schedules for periodic safety inspections of the dam. Copies of operation and maintenance manuals should be furnished to the dam inspection staff.

b. Interagency

Interagency communications should be maintained on safety matters related to design, construction, and operation of dams, and related research. This should include exchange of materials such as design standards, construction specifications, significant research reports, and final design and construction reports on major structures. The agencies should establish communications to periodically review investigation methods, construction materials testing standards, analytical methods, design philosophies, and management procedures.

5. Documentation

Throughout project development (planning, site investigation, design, construction, initial reservoir filling, and operation), all data, computations, and engineering and management decisions should be documented. Documentation should cover investigation and design, construction plans and construction history, operation and maintenance instructions and history,

damage and repairs and improvements, and periodic inspections during construction and operation. It should include, but not be limited to, memoranda, engineering reports, criteria, computations, drawings, and records of all major decisions pertaining to the safety of the dam.

a. Design Record

Written documentation should be maintained in standardized format on all design-related information for the project. Planning design documentation should cover the project objectives and the studies made to locate, size, classify as to potential hazard, and select the type of dam and auxiliary facilities. Site investigation documentation should cover geologic mapping and studies made of the geologic and geotechnical explorations and conditions for the various dam sites considered and the detailed investigations for the chosen site. Geological, seismological, and geotechnical features and considerations, whether specifically identified during the investigation, interpretations from the data and experience at other sites, or suspected by experienced personnel, should be fully documented. Design documentation should include all design criteria, data and qualitative information, assumptions, analyses and computations, studies on discarded alternatives, and derived judgments and decisions.

As-built drawings should be prepared as facilities are completed, and should be made available to operation and maintenance personnel and to the dam inspection staff.

b. Construction Record

All phases of the construction should be documented, including reporting of routine and special activities. Changes in construction plans and departures from expected site conditions should be documented, with any consequent design changes. The record should include information on materials and construction processes, field exploration and test results, geologic mapping of foundations and excavations, inspection records, as-built drawings, and decisions to adapt the design to actual field conditions.

A formal plan for a construction inspection system should be developed, including inspection procedures and types and forms of reports. The system should identify and record the status of inspection of approved and rejected materials. Survey notes, sketches, and records of all materials tests made for the control of construction quality should be maintained for the life of the project. A job diary should be maintained for each construction contract to provide a complete history of the work, listing in chronological order the events having a bearing on performance of the work, and analysis of cause and effects of special events. Photographic documentation of significant events, findings, and safety problems should be provided. The inspection program and record should give special attention to factors that may have a future influence on dam safety.

Documentation must also be provided, as required, by applicable procurement, safety and health personnel, and financial regulations.

c. Initial Reservoir Filling and Surveillance Record

An initial reservoir filling and surveillance plan should be prepared by the design staff. Initial filling should be well documented, including a record of reservoir elevations and controlled water releases during the filling. The record should include complete written justification and

design approval of any deviations from the planned filling. The surveillance record should include all information obtained from inspection of the dam, appurtenant structures, abutments, and reservoir rim during the initial filling.

d. Operation and Maintenance Record
Operation and maintenance should be fully documented, including the routine activities and systematic inspection processes, and complete information on project maintenance, rehabilitation, and improvements. In addition to records on the actual operations, the operating record should include data on reservoir levels, inflow and outflow, drainage system discharge and structural behavior.

If there are maintenance problems that require continuing remedial work, a thorough record of the work should be maintained, and a final report made after complete remedy of the problem.

e. Permanent Files
One copy of all documents concerning the project should be assembled in a single project file. The file should be kept up to date and should be maintained as a permanent archival reference. A second file of the materials should always be easily accessible to responsible personnel for reference in future reviews and inspections, and in dealing with problems, repairs, etc. Both files should be continuously updated with records on problems, repairs, operation, instrumentation, and inspection for the life of the project. Information such as foundation reports and as-built drawings and maps should be permanently retained at the project and also at the agency's engineering design office.

6. Reviews

a. Extent
All factors affecting the safety of a dam during design, construction, and operation should be reviewed on a systematic basis at appropriate levels of authority. Reviews include those internal to the agency, and those external to the agency, by individuals or boards (consultants) with recognized expertise in dam planning, design, and construction.

b. Internal
Provision should be made for automatic internal review of all design decisions, methods, and procedures related to dam safety. Review should be at levels of authority above the design section or designer-supervisor relation. Uniformity of criteria and design technique should be maintained, as well as methods to ensure that specific experience is exchanged and used to advance the agency's ability to design, construct, and operate safe dams.

Management technical personnel should review the construction periodically. Reviewing personnel should include geologists, geotechnical engineers, and embankment and/or structural engineers who have had experience in responsible positions relating to similar structures. When appropriate, the reviews should include mechanical and/or electrical equipment engineers. Preconstruction inspection should be made after geologic mapping is done and prior to ground surface disturbance. On large projects, construction reviews would normally be at critical construction periods such as start and completion of foundation preparation and grouting, dam

construction at several stages, and completion of the dam. Visits by appropriate personnel are recommended every six months, and to accompany the consultants during scheduled reviews. The final construction inspection should cover inspection of completed structures and equipment, the adjacent valley floor and abutments, and the reservoir rim.

On smaller projects, the frequency of construction review and the disciplines represented in the review would vary with the size and complexity of the project. However, management should make certain that construction reviews arc sufficient to cover the requirements for dam safety.

Reviews should be made of the agency's procedures for post-construction operation and periodic inspections. These would include the responsibilities for collection and evaluation of data from any dam instrumentation.

Reviews should be made to ensure that the project emergency preparedness plan is periodically updated.

Formal documentation should be made of all significant findings from reviews and inspections.

c. External

The need for review of a dam by independent experts (consultant board or firm) from outside the agency should be determined on a case-by-case basis, depending on the degree of hazard, size of the dam, complexity of the site geology and geotechnology, complexity of the design, or a specific need perceived by the public. Consultant reviews should provide appropriate overview evaluations of site investigation, design, and construction.

Consultant reviews of operation and maintenance practices, and of alterations and improvements, should be conducted when the agency considers such reviews advisable.

The following text deals first with design and construction reviews. Applicable portions apply also to post-construction reviews; specifics for post-construction reviews are in the last paragraph of the section.

The agency should be represented at each consultant meeting by appropriate design and construction staff. When appropriate, meetings should include a site visit. At each meeting the agency should formally document all aspects of the continued development of the project for presentation in a meeting-opening briefing to the consultants. The consultants should formally document findings and recommendations and present them at a closing conference with the agency staff.

The consultant board members should be chosen to assure coverage of all areas of expertise needed to assess the dam design, construction, and safety. The board should contain at least three, but normally not more than five, permanent members. The board should always contain a general civil engineer, a geologist and/or geotechnical engineer, as appropriate, a concrete and/or embankment dam engineer, and usually a member for the electrical and mechanical features, especially necessary if a power plant is part of the project. Additional specialists covering specific aspects such as structural integrity, earthquake response, or three-dimensional analysis

should be assigned for short intervals as recommended by the board. The board should be formed during the design stage and consulted (if possible) on site selection, on type of structure, and for input to the feasibility study. The board should be kept active throughout design and construction, in order to keep the board completely familiar with all aspects of the project so they are in a position to respond rapidly if problems arise.

During design and construction of large projects, the board should meet every 6 to 12 months, depending upon activities and duration of the work. Meetings should be scheduled to review at specific phases of construction. These phases might include, but not be limited to, review during the early stages of foundation cleanup and treatment, on completion of foundation cleanup, and during the early stages of embankment and/or concrete placement. All board members should attend every meeting even though some meetings may not apply to all members. This would ensure that the entire board is fully aware of the complete work status before being asked for their input on specific points.

The briefing to the board by agency personnel at the start of a meeting should include exploration data, structural adequacy and seepage characteristics of the foundation, proposed foundation treatment, grouting programs, quarry test data, test fill data, embankment requirements for zones and material for those zones, sources of materials, compaction requirements, inspection requirements, instrumentation program, type of spillway (gated or ungated), proposed water release control systems, diversion requirements and care and diversion of water, power generation anticipated, and surge tank design. For concrete dams, the review would include concrete design and placement requirements in lieu of the embankment information.

On a smaller project, the use of consultants should be commensurate with the dam size and complexity, and with the degree of associated hazard. If there is significant hazard, the agency should obtain consultant reviews adequate to assure independent assessment of the dam safety.

Consultants should be engaged during agency evaluations of existing dams if considered necessary to provide independent support for agency assessment of dam safety. This might be in connection with studies for alterations or improvements for potential criticality of dam stability resulting from structure deterioration, or from increased reservoir levels due to possible flood inflows larger than design floods and consequent inadequate spillway capacity. It might involve consultation on seismic design; and in the case of old dams, especially embankment dams with inadequate records of materials properties, it might include consultation on the advisability and procedures for new materials investigations. Consultants on features of existing dams may be individuals rather than formal boards.

7. Research and Development

A strong research and development effort is a necessary element in reducing the uncertainties still present in dam design, hydrology and hydraulics, materials behavior, and construction techniques, equipment and practices. As part of their dam safety programs, agency management should identify opportunities and needs for research and programs to meet those needs both internally and through other agencies such as the National Science Foundation and the U.S. Geological Survey.

a. Methods and Materials
Management should ensure that a continuing review is made of state-of-the-art methods, experience, research, etc., and that improvements are incorporated into agency criteria and methods of analysis, exploration, construction, testing, and instrumentation. The process should build from experience on past projects relating to constructability, observed behavior, problems encountered, and problem solutions tried and their results. Experience histories should be reviewed, summarized, and disseminated to evaluate current practice in order to advance agency practices. Research and development needed on materials and their use as revealed by dam observation and monitoring and new developments should be conducted on a continuing basis. Establishing a schedule of research priorities is necessary for overall research and development goals and for orderly and consistent progress in advancing dam technology.

b. Risk-Based Analysis
The agencies should individually and cooperatively support research and development of risk-based analysis and methodologies as related to the safety of dams. This research should be directed especially to the fields of hydrology, earthquake hazard, and potential for dam failure. Existing agency work in these fields should be continued and expanded more specifically into developing risk concepts useful in evaluating safety issues. Existing work is exemplified by (1) the interagency research conference cited in paragraph c below, (2) its adjunct meetings on hydraulics and earthquakes, and (3) the NRC methods of risk evaluation for nuclear plants as applicable to radiological safety-related dams.

c. Interagency Coordination
Existing interagency research coordination activities should be continued, with attention to minimizing unnecessary duplication. The biennial research coordination conference on water resources among the Corps of Engineers, Bureau of Reclamation, Tennessee Valley Authority, and Bonneville Power Administration is an example of beneficial exchange needed on issues relating to dam safety.

8. Contracts

a. Documents
Agency procedures should ensure that all contracts for dam design, construction, and operation are written to accomplish the design intent and to require that contractors provide complete documentation of their work.

b. Modifications
During the construction period, any modifications in the design or construction which result from significant departures from expected field conditions, design reviews, or other studies should be promptly included in revisions to appropriate contracts. Such modifications, and any discovered later, that affect operation should be included in operation contracts (and in agency operation, monitoring, and maintenance policy). The basis and justification for any change should be documented.

9. Constraints
Many constraints which are outside agency authority can directly or indirectly affect dam safety. Managers at all levels must be continually aware of their fundamental responsibilities for dam

safety and exercise vigilance in identifying constraints on fulfilling those responsibilities. Every manager has a duty to seek resolution or mitigation of such constraints through his own agency channels or through interagency or intergovernmental channels as appropriate and available to him.

a. Funding for Organizational Management

Continuity and adequacy of funding are essential to carry out the various programs which ensure safe dams. The Zero Based Budget system offers an opportunity to managers to identify for high funding priority those activities, programs, staff levels, and other operating requirements of a sound dam safety program. Managers should avail themselves of this opportunity. Agencies should cooperatively develop common budgetary terms and consistent processes to provide the necessary visibility of dam safety funding essentials at all levels and within all branches of the government. Long-term programming objectives should be established and adhered to, to meet the requirements of organization management, personnel staffing and training, research and development, quality construction and operation, a complete program of inspection and evaluation of the safety of existing dams, and a planned program for the rehabilitation and/or improvement of existing dams.

b. Public Concerns

Public individuals and groups should have the opportunity to voice their concerns in the development of public works projects and during their operation. These concerns often represent constraints in the form of local or regional political interests, legislation, perceptions of risk and hazard, environmental factors, social conflicts, etc., which can influence technical decisions. Agencies should develop and organize their procedures for early assimilation of those public views which affect possible design, construction, or operating parameters and, in turn, influence dam safety. Resolution of public issues conflicts and problems, including use of executive and legislative government decisions, should be made prior to the start of construction so that dam safety is not compromised.

B. MANAGEMENT OF TECHNICAL ACTIVITIES — SITE INVESTIGATION AND DESIGN (SID)

This section of the guidelines outlines the site investigation and design technical activities that agency management should ensure are undertaken to obtain safe design of dams. It is recognized that the extent of application of these guidelines will vary depending on the size and function of the dam.

1. Hydrology

a. Hazard Evaluation

Areas impacted by dam construction and existing dams should be examined for potential hazards to present and future developments in the event of major flooding by controlled flood discharges or flooding induced by dam failure or misoperation. This hazard evaluation is the basis for selection of the performance standards to be used in dam design or in evaluation of existing dams.

b. Flood Development

Hypothetical floods, generally of severe magnitude, should be developed for use in design or evaluation of major dam and reservoir features, including development of appropriate floods for the construction period.

c. Flood Selection for Design (or Evaluation)

The selection of the design flood should be based on an evaluation of the relative risks and consequences of flooding, under both present and future conditions. Higher risks may have to be accepted for some existing structures because of irreconcilable conditions.

When flooding could cause significant hazards to life or major property damage, the flood selected for design should have virtually no chance of being exceeded. If lesser hazards are involved, a smaller flood may be selected for design. However, all dams should be designed to withstand a relatively large flood without failure even when there is apparently no downstream hazard involved under present conditions of development.

d. Hydrologic Design of Reservoir

In addition to selection of a design flood, the hydrologic design of a new reservoir or the evaluation of an existing project involves consideration of discharge and storage capacities, reservoir regulation plans including constraints, land requirements, and wind/wave effects. The evaluation of existing projects also should include observed performance capabilities and whether improvements are necessary to ensure safety.

Reservoir regulation plans should be developed in the planning of projects so that realistic release rates will be used in routing the design flood. Regulation plans should include the construction period. When gate operations are involved, a water control management plan should be established to direct reservoir regulation in an effective and efficient manner. An emergency regulation plan is also required for use by the dam tender in the event of loss of communication with the water control management staff during a flood. A data information system should be designed to collect and process pertinent hydro meteorological data in a timely and reliable manner.

The reservoir regulation plans, water control management plan, and data information systems should be periodically reviewed for safely deficiencies and potential for misoperation during both severe flood events and normal conditions. Necessary corrections should be made as soon as practicable.

e. Downstream Effects

Safety design includes studies to ascertain areas that would be flooded during occurrence of the design flood and in the event of dam failure. The areas downstream from the project should be evaluated to determine the need for land acquisition, flood plain management, or other methods to prevent major damage. Information should be developed and documented suitable for releasing to downstream interests regarding remaining risks of flooding.

f. Warning Systems

Safety design should include an emergency flood warning system and action plan that would effectively notify all concerned in ample time for appropriate action.

2. Earthquake Investigation and Design

a. Investigation Factors

The following factors should be considered in selection of design earthquakes.

(1) Geologic and tectonic setting of the site area by analysis of the lithology, stratigraphy, structural geology, and tectonic history.

(2) Historical earthquake record to include the size, location, and other seismological characteristics as available, and the relationship, if possible, with the tectonic siting of the area in which the earthquakes have occurred.

(3) Influence of the properties of the surficial materials on the determination of the size of historical earthquakes.

(4) Influence of faulting or other tectonic features on the estimate of the occurrence, size, and location of possible future earthquakes.

b. Selection of Design Earthquakes

From the above factors, earthquakes should be selected that have sufficient potential of occurring to require consideration in the dam design. Earthquake description should include estimates to the extent practical of the size, location, depth, focal mechanism, and frequency of occurrence.

c. Engineering Seismology

Determination should be made of the characteristics of ground motion that would be expected from the design earthquakes, to the extent possible, to include amplitude (displacement, velocity and acceleration), frequency content, and duration.

d. Need for Earthquake Analysis

The probable effects of earthquakes on the dam and its appurtenant structures should be evaluated to determine the need for inclusion of earthquake forces in the structures analyses. Evaluation includes consideration of factors such as the project stage, hazard and risk factors, the size of the dam and reservoir, the potential ground motion at the site, site geology, and type of structure. Where determination is made that no earthquake forces are required in analysis, the determination should be justified.

e. Seismic and Geologic Studies

(1) Earthquake Sources. The essential first step is determination of the design seismic events (usually the maximum credible earthquakes) and an estimate of the ground motion at the site due

to these events. From a study of the regional tectonics and seismicity, and both regional and local geology, potential sources for seismic events are identified, and the maximum credible earthquake magnitudes postulated.

(2) Design Events. A maximum credible earthquake (MCE) is defined herein as the hypothetical earthquake from a given source that could produce the severest vibratory ground motion at the dam. Time histories of the estimated rock motion (accelerograms) at the dam for the various seismic events are selected to characterize the severity of the strong motions by their peak accelerations, frequency content, and duration.

f. Design for Earthquake Forces

(1) Safety Concerns. All earthquake-related safety concerns should be identified. Potential safety concerns include but should not be limited to dam foundation integrity, stability, unacceptable stress levels, fault displacements; abutments stability; effects of dam overtopping; dam stability; susceptibility of embankment dams to embankment or foundation liquefaction, cracking or excessive deformation.

A survey of component and accessory structures and equipment should be made to identify those which have functions that are essential for earthquake-related safety.

(2) Analysis Method. Determination of appropriate earthquake analysis methods for evaluation of safety concerns may be, as appropriate, by qualitative evaluations, pseudostatic analysis, and dynamic analysis. The methods selected should be appropriate to the identified safety concerns, in accordance with good engineering practice and with currently available technology.

(3) Structural Adequacy. Structural adequacy assessments should be made of all safety-related components and concerns identified. These assessments should incorporate all applicable data and analysis.

3. Geotechnics

a. General

(1) Site Specifics. After a site is selected, a program for the geotechnical exploration, design, and analysis of that specific site is required. No checklist can be made which would cover all eventualities at all sites, or at any one site, and attempts to formulate such a list would be counterproductive to the intent to ensure dam safety. The best insurance for adequate geotechnical work is a well-trained and experienced staff actively involved in field inspections throughout all phases of the development of the site.

(2) Documentation. Because many evaluations are possible for a given set of geotechnical conditions, it is important that full documentation be made of the reasoning process involved in geotechnical decisions. General guidelines for documentation are given in section III.A.5.

(3) Management of Diverse Technical Expertise. Geotechnical work encompasses the expertise of geologists, geophysicists, and engineers—all with diverse experience, training, interest, and technical terminology. The administrative and technical supervision of these experts should be structured to optimize coordination and cooperation. Management should encourage intellectual curiosity and an inquisitive approach to all geotechnical work. Since the field of geotechniques is rapidly expanding, management should assure that those associated with site exploration and development maintain currency with the state of the art.

b. Exploration and Identification of Geotechnical Problems

The exploration program needs to be site specific, flexible, and executed so as to obtain the maximum data from each part of the program. Agency management should ensure sufficient funding for an orderly development of the exploration program in order to reduce uncertainties and to make adequate provisions for required corrective measures.

The initial onsite exploration should be preceded by a review of all available information pertinent to the development of the site (literature, maps, photographs, well and spring information, seismic data, area construction records, etc.). This should lead to the preparation of a detailed geological map of the site using all available data. Geotechnical explorations generally proceed from wide-spaced borings and geophysical surveys to determine the general geological conditions, to additional explorations assigned in an ongoing sequence to develop the geologic correlations and to determine the type of dams suitable for the site. The extent, depth, and type of exploration depend on the complexity of the geology and size and type of dam.

Generally, explorations are not complete at the end of the planning phase but continue during the preparation of plans and specifications and into the construction phase. Conditions encountered during construction often require additional explorations to evaluate the need for changes in the design.

All potential geological problems, inferred from onsite data and from experience at similar sites, should be fully explored and described. This information should cover the types of adverse features and geologic processes generally associated with a geological environment similar to that at the site. It should also cover the expected short- and long-term behavior of foundation and reservoir rim materials at the site when subjected to the changed geological environment associated with the construction and operation of the dam and to geologic processes operating during the life of the project.

During the course of the design and continued exploration of the project, all potential problems should be investigated and corrected with appropriate treatment, or where uncertainty remains, design defenses should be provided to control or monitor the problems. Types of problems which might require consideration include reservoir-induced seismicity, solubility, pipability and liquefaction potential of materials, foundation heave or deterioration during excavation, reservoir rim leakage and stability, past and future mining, and differential consolidation associated with petroleum or water extraction.

c. Geotechnical Design

Geotechnical design considerations for the dam foundation and reservoir area are essentially defined after the geologic conditions of the site, the type of dam, and the magnitude of the stresses imposed on the foundation by the dam and reservoir have been determined.

Foundation design typically consists of four distinct elements. These are (1) definition of the geometry of the foundations and areas of potential instability in the foundations, abutments, and slopes; (2) determination of the properties of foundation materials using judgment, past experience, laboratory testing, and in situ testing; (3) an analytical procedure that predicts the behavior of the foundation in terms of stability, permeability, and deformation; and (4) a reevaluation of parts (1) through (3) as construction progresses so that a comparison can be made of preconstruction assumptions and conditions with the actual conditions revealed by the foundation excavation and treatment. Additional exploratory work may be required.

d. Foundation Treatment

(1) General. The preparation of the foundation, including the abutments, is one of the most important phases of construction. The primary purposes of foundation treatment are to provide stability, obtain positive control of seepage, and minimum adverse deformation. The geology, foundation conditions, foundation treatment, and proposed structure should be considered together.

(2) Stability. Surfaces should be prepared to provide a satisfactory contact between the foundation and the overlying structure by removal of unsuitable materials. Deficiencies in the foundation which are not removed should either be treated by modification of the structure or by appropriate foundation treatment tailored to handle the conditions encountered.

(3) Positive Control of Seepage. Highly permeable foundations should be treated by such measures as cutting off the pervious material, grouting, increasing the seepage path by upstream blankets, or controlling the seepage with drainage systems. Where appropriate, surficial cavities should be traced, cleaned out, and backfilled with material satisfying the design requirements. When cavities exist at depth, measures should be taken to ensure against the migration of cavity filling material.

(4) Control of Piping. Silts and fine sands in the foundation, which are susceptible to piping, should be removed if practical, cut off near the downstream limits of the dam, covered with impervious material, or provided with filtered drainage systems. If pipable material is used in the dam, the foundation surface treatment should prevent migration of dam material into the foundation.

(5) Deformation. Foundations subject to differential settlement or foundations having highly compressible anomalies can cause stress concentrations or cracking in dams. The foundation excavation should be shaped to remove abrupt changes in elevation to preclude excessive differential settlement or stress concentrations. Low shear strength material in a foundation can

cause shear failure. Excavation and replacement of low strength material is a positive method for treating a foundation that has either or both of these unfavorable conditions.

e. Instrumentation

Although a well conceived foundation instrumentation program serves to monitor the foundation and gives an indication of distress, it cannot of itself certify the safety of the foundation. The expertise of the engineer/geologist to analyze and design and prepare a foundation that will safely carry the loads and water pressure imposed by the dam and the reservoir is fundamental to the design adequacy of the foundation. The purposes of foundation instrumentation are fourfold: to (1) provide data to validate design assumptions; (2) provide information on the continuing behavior of the foundation; (3) observe the performance of critical known features; and (4) advance the state of the art of foundation engineering.

The general requirements for foundation instrumentation should be determined early in the design of the project, and the rationale for the instrumentation should be thoroughly documented. Factors that will influence the need for and the type of instrumentation include the geology of the foundation, size and type of the dam and reservoir, and the location of the project. Flexibility must be provided in the program to allow for changes from anticipated foundation conditions that are encountered during construction and/or operations.

Intrinsic to an instrumentation program is the schedule for reading the instruments before and during construction, during initial reservoir filling, and through the service life of the project. No less important is the need for clear instructions for the prompt evaluation of data and prompt notification to responsible personnel when observations are atypical or diverge markedly from the design assumptions.

f. Inspection and Continuing Evaluation during Construction

Those responsible for the investigation and design of the foundation should make onsite evaluations to confirm that actual conditions conform to those assumed in the design and to review documentation of site conditions.

A qualified project geologist should examine and map geologic details of the foundation as it is being exposed during construction. Investigation and testing at this point provide details useful in controlling grouting and other improvements and in confirming the competency of the foundation. Even though extensive exploration and testing may have been conducted prior to construction, most foundations can be expected to reveal unanticipated conditions which may require redesign or changes in the type or extent of foundation treatment.

Approval should be obtained from the geotechnical and design staffs before placement of dam materials on the foundation. This approval should be documented and should indicate that all unanticipated conditions encountered were dealt with and that the foundation and its treatment meet the design requirements.

g. Reevaluation at Existing Structures

Older Federal dams may not have been designed to standards equal to current criteria. Also, a substantial portion of safety-related dam incidents are associated with foundation problems which develop in a time-dependent fashion after construction. For these reasons, systematic reevaluation of existing Federal dams should be made.

These reevaluation should go beyond analysis of problems which are observed visually or from instrumentation data. A review should be made of all existing exploratory information, design information, construction records, and operation records, to determine the adequacy of the foundation with respect to the present site of the dam. Where available information is insufficient or where deficiencies are found or suspected, modern criteria for analysis, instrumentation, exploration, and testing should be used as appropriate to gather the necessary data to show that no problem exists or to furnish information to modify the structure or foundation.

4. Hydraulic Appurtenances

a. General

(1) Protective Measures**.** All hydraulic appurtenances used for releasing water should be designed to preclude jeopardy to the damming provisions.

(2) Blockage. Allowances for or preclusion of blockage of hydraulic facilities should be incorporated in the design.

(3) Reliability. When operational failure of a gated passage would jeopardize the damming provisions, alternate capacity should be provided. When operation of a gated passage is essential to safety, reliable manpower, communications and accessibility should be assured.

(4) Hydraulics and Hydrology. Hydraulic and hydrologic design considerations should be correlated with section III.B.1.

b. Design Flood Releases

(1) Spillway and Outlets. Gated spillways are the usual hydraulic appurtenances for control of all or the major portion of the design flood and major emergency releases. Outlets (sluiceways, conduits and tunnels) may be used alone or in conjunction with spillways to control flood discharges.

(a) Selection of type. Spillways and outlets should be selected to meet the site specific purposes of the project. For a drainage area with short concentration time combined with reservoir storage capacity that is small relative to the flood volume, especially for embankment dams, (1) the spillway should usually be uncontrolled, and (2) outlets should not normally be used for sole or part control of the design flood except in special cases where the outlets can be uncontrolled.

(b) Capacity. Spillway and outlet capacity should be sufficient to satisfy the discharge

requirements of the reservoir regulation plan and other design considerations.

(2) Power Facilities. A portion of installed turbine flow capacity may be considered to assist in control of the design flood if it is demonstrated that possible power load interruptions during the design flood would not preclude operation of the power facilities.

c. Other Water Releases

Other water release hydraulic appurtenances such as navigation facilities, locks, fish facilities, ice sluices**,** trash sluices, and water quality facilities should conform to the requirements of section 4.a.

d. Reservoir Evacuation

Where practicable, reservoir release facilities should be provided to lower the pool to a safe level adequate to correct conditions that might threaten the integrity of the dam.

e. Control of Flows during Construction

The provisions of section 4.a also apply generally to the design of hydraulic appurtenances used during construction. The capacity of these appurtenances should be sufficient to satisfy the discharge requirements of the regulation plan for control of water during construction.

f. Design Criteria and Guidance

(1) General. If existing design criteria and guidance from past projects and experience are used for design of the hydraulic appurtenances, their sufficiency should be documented.

(2) Hydraulic Model Tests. When sufficient criteria and guidance are not available for analytical design of the hydraulic appurtenances, physical hydraulic model studies should be performed.

(3) Prototype Testing. Features of safety-related hydraulic appurtenances that are beyond the state of the art, or for which model to prototype relationships have not been verified, should be tested in the prototype.

g. Reanalysis Because of Changes

Changes in project purpose, new purposes, operational requirements, limitations of constraints, design criteria, or legal requirements may require that a reanalysis be made of the hydraulic appurtenances.

h. Hydraulic Design Involvement during Life of Structure

Hydraulic design engineers should participate in the project periodic inspection program to evaluate the operational adequacy of all hydraulic appurtenances essential to dam safety throughout the life of the structure including final disposition.

5. Concrete Dams and Concrete Elements of Embankment Dams

a. Site Specific Design

Because all dam sites are unique, the type of dam and its appurtenances should be specifically matched to site conditions and project requirements. It is essential when reviewing the safety of existing dams to consider conditions which may have changed physically and new concepts resulting from new technology, or because of additional project information since construction, such as foundation deterioration, increased flood hydrographs, or larger design earthquakes.

b. Materials

Concrete for the structures requires competent investigation of materials sources and adequacy of supply testing of materials properties in accordance with accepted standards, and proper proportioning of concrete mixes (including additives) for strength, durability, control of thermal properties, and economy.

c. Design of Structures

There are three components of a dam which must be considered for safety: the foundation, the dam, and its appurtenant structures.

(1) Foundation. Proper design of a concrete dam requires information on the foundation geological conditions and materials properties to assure its capability to support the loads of the dam and reservoir, in its natural state or as improved by foundation treatment.

(2) Dam. Concrete dams should be designed to be safe against overturning and sliding without exceeding allowable stresses of the foundation and the concrete for all loading conditions imposed on the dam. The shape and/or curvature of a dam and its contact with the foundation are extremely important in providing stability and favorable stress conditions. Proper consideration should be given to ensure the dam's safety in the event of overtopping.

Joints in the dam should be properly designed to control cracking due to thermal, shrinkage, and structural effects. Temperature control measures such as proper concrete mix design, pre-cooling of the concrete mix, and post-cooling of the concrete blocks can also be used to control cracking. Openings in the dam such as waterways, galleries, chambers, and shafts should be designed with consideration for their effects on the behavior of the structure.

(3) Appurtenances. Safety-related appurtenances, such as outlet works structures, spillways, and navigation locks, should be designed with the same degree of safety as the main dam. If the project has a powerhouse as an integral part of the dam, it should be designed for the same safety requirements as the dam.

d. Definition of Loads

The dam and appurtenances should be designed for all static and dynamic loads to which they will be subjected. Dynamic loadings to be considered should include inertial, hydrodynamic, and earth pressures from earthquake ground motions and structural response; and dynamic loads resulting from flowing water.

e. Design Methods
The methods required for design of the several types of concrete dams and their appurtenances vary from simple to complex, depending on the type and size of the structure, the hazard potential of the site, the kinds of loading, and foundation conditions. The design process involves judgment and analytical expertise to select appropriate methods to analyze a structure whether it requires a simple or complex analysis, and to determine design input data that is representative of the range and variation of foundation and structural material properties. The selection of input parameters is just as important as the mechanics of the analysis used.

f. Design Evaluation
Technically qualified supervisory personnel should assure that structures are designed to meet the requirements for safety. This includes confirmation of design input parameters, design methods, and utilization of allowable factors of safety against overturning, sliding, and stressing appropriate to the probability of the loading conditions.

g. Instrumentation
Knowledge of the behavior of structures and their foundations may be gained by studying the service action of the structures using observations on embedded and other internal instrumentation and external measurements. Information from which a continuing assurance of the structural safety of the dam can be assessed is of primary importance, but information on structure behavior and the properties of dam and foundation materials serve to verify the design and to provide information for improvement of design. Observations may be made in the dam and foundation in terms of strain, deflection, pressure, temperature, stress, deformation, and drainage flows. External measurements for deflection and settlements may be made by precise surveys on targets set on the dam, in galleries, in vertical wells in the dam, in tunnels, and on the foundation. Status reports on the condition of structures should be issued regularly. Examinations of existing structures should include assessments of whether additional instrumentation is required.

h. Construction and Operational Follow-up
It is necessary that the designers should be involved in the construction and operation processes to confirm that the design intent is carried out, and to allow changes and modifications resulting from redesign necessitated by differences between design assumptions and actual field or operating conditions.

6. Embankment Dams
Section 5 contains general dam considerations; the following additional considerations are applicable to embankment dams.

a. Site Specific Design
Embankment design should be developed for specific site conditions and based on adequate exploration and testing to determine all pertinent geologic and material factors with particular emphasis on shear strength and stability, permeability and control of seepage, and consolidation and settlement.

Embankment dams are particularly vulnerable to damage and possible failure from internal erosion when founded on rock having large cavities, open joints, discontinuities, or other geologic defects. The sites should be carefully explored and special attention given to design of cutoffs, foundation treatment, and other defensive measures. Special problems related to embankment integrity may include soft rock such as clay shales, areal subsidence, old mining activity, solution-susceptible rock, and collapsing soils.

b. Materials

Embankments can generally be designed to utilize locally available construction material; investigation of materials characteristics is required and problem materials should be either discarded or protected by defensive design. There is often a need for importing special materials for slope protection, filters, and drainage systems**.** Any embankment zoning should consider the properties and quantities of available materials and the effect of their characteristics on the construction process.

c. Design Constructability

Embankment designs should be constructible with regard to such items as location of borrow areas with respect to flooding, in-situ moisture conditions, climatic effects on construction schedules, width of zoning, and needs for special material processing. Design should include protection of critical features from overtopping by floods during construction.

d. Embankment Design

The safety of an embankment is dependent on its continued stability without excessive deformation under all conditions of environment and operation, and on control of seepage to preclude adverse effects on stability and prevent migration of soil materials. Design considerations given below are specific to embankment dams.

(1) Seismic. Where earthquake design is necessary, consideration should be given to earthquake-related concerns of soil liquefaction and cracking potential, stability and excessive deformation, abutment stability, overtopping effects, and required defensive measures.

(2) Stability. Embankment stability should be analyzed for all pertinent static and dynamic loading conditions without exceeding allowable shearing stresses in the embankment or foundation. Factors of safety should be appropriate to the probability of the loading conditions, and should consider the effects of loading and time on shear strength, particularly if limited placement volume can result in rapid construction. In most cases**,** embankments should be designed for unrestricted rates of reservoir filling and drawdown.

(3) Settlement and Cracking. The potential for transverse cracking of the embankment caused by differential settlement, tension zones, and possible hydraulic fracturing should be minimized by careful consideration of abutments, foundation and cutoff trenches, and their geometry and treatment. Filter zones of adequate size should be positioned upstream and downstream of the impervious zone at all locations where there is a possibility of transverse cracking regardless of cause. Potential problems of differential settlement should be considered in establishing the construction sequence.

(4) Seepage. The design should attempt to prevent or minimize seepage through the embankment and its foundation and abutments; however, the designer should recognize that seepage usually occurs and that protective control measures must be provided. Filtering transition zones and foundation and abutment treatment to seal openings should be provided wherever necessary to preclude migration of soil materials into or out of all embankment element contacts both upstream and downstream. Filters, drainage blankets, and transitions should be of a quality and size to conservatively control and safely discharge seepage for all conditions for the life of the project. Particular attention should be given to contacts with foundation, abutments, embedded structures, and the end slope of closure sections to ensure adequate compaction and bonding to control seepage.

(5) Zoning. Embankment zoning when used should ensure adequate stability for all pertinent conditions, and should control seepage through the embankment and provide filter action to prevent migration of material.

(6) Erosion. Upstream and downstream slopes and foundation and abutment contacts should be protected against erosion from surface runoff, wave action, and impinging currents. Spillways and outlet works should be located and designed so that discharges do not erode the embankment or its foundation.

e. Instrumentation

Embankment design and prediction of embankment performance are based on an imprecise combination of theory and empirical procedure; consequently, performance during construction and operation should be monitored by a designed system of external measurements and/or installed instrumentation. A well planned system of instruments, when appropriate, should be installed to provide data on internal and external movements and on water pressures at critical locations in the embankment and foundation during both construction and operation.

f. Construction and Operational Follow-up

In addition to the need for designers to be involved in construction and operation of dams in general to confirm the design intent and assess the need for possible design changes, certain other requirements should be observed at embankment dams. Stability should be evaluated during and after construction using strength parameters from as-placed materials and observations of pore pressure and seepage if and when conditions warrant. Designers should inspect and review performance of embankments during and after reservoir impoundment to detect and provide prompt remedial treatment for problems. While major emphasis is placed on initial impoundment, the surveillance should continue for the life of the project. As the state of the art advances in analysis, material behavior, and methods of observation, deficiencies in embankments may be suspected or become obvious and should be investigated and corrected. Collected experience information should be summarized and used to further advance the state of the art.

C. MANAGEMENT OF TECHNICAL ACTIVITIES — CONSTRUCTION (CON)

1. Introduction

This section of the guidelines outlines the construction technical activities that agency management should ensure are undertaken to obtain safe construction of dams. The principles and guidelines arc prepared in a broad sense to ensure that construction of a safe structure is the prime requisite.

a. Construction Contracts

Construction contracts should be based on site conditions as interpreted at the time of contract award. All anticipated work on foundation cleanup, preparation, and treatment should be included as specified items of the work. Contract provisions should require the contractor to submit to the construction engineer advance notice of significant shift change, to enable adequate inspection coverage of multishift operations.

b. Construction/Design Interface

Many aspects of construction directly overlap in design considerations. Reference is made below to numbered paragraphs in Section III.B. Management of Technical Activities-Site Investigation and Design, which concern such common interests:

3. Geotechnics
a. General
(1) Site Specifics
b. Exploration and Identification of Geotechnical Problems
c. Geotechnical Design
d. Foundation Treatment
e. Instrumentation
f. Inspection and Continuing Evaluation during Construction

4. Hydraulic Appurtenances
e. Control of Flows during Construction

5. Concrete Dams and Concrete Elements of Embankment Dams
a. Site Specific Design
b. Materials
c. Design of Structures
(1) Foundation
g. instrumentation
h. Construction and Operational Follow-up

6. Embankment Dams
a. Site Specific Design
b. Materials
c. Design Constructability
d. Embankment Design
(3) Settlement and Cracking
(4) Seepage

e. Instrumentation
f. Construction and Operational Follow-up

2. Evaluation during Construction
Field personnel must be highly trained and experienced if the design principles and site conditions are to be understood and a safe structure is to be constructed.

When differing site conditions (different from those anticipated) are encountered, construction supervisory forces must have authority to suspend any or all portions of the work affected until the design engineers, with assistance as needed, can evaluate the condition and determine if design modification is required.

Construction milestones should be identified when the design engineers will inspect the work and concur with the progress of construction.

3. Orientation of Construction Engineers and Field Inspectors
Construction engineers need to be aware of design philosophies and assumptions as to site conditions and function of project structures, and must understand the designers' intent concerning special technical provisions in the specifications. Identified preconstruction activities should include the orientation of construction engineers to the site specificity of the design and to the close communication requirements with all concerned engineering disciplines during the construction process. For major projects, there should be periodic meetings between design and construction engineers to discuss upcoming construction activities. Also, during the initial stages of important construction activities, the construction engineers should request site inspection by the design engineers to assure construction procedures are in accordance with design requirements.

Construction specifications, supplemental reports, and conferences to orient field personnel to the particular site, the features of the dam, and the designers' intent for construction should, as applicable, include the following:

a. Design Related
(1) Design concepts. Explanation of philosophies and assumptions and the reasons for special requirements in the specifications to assure accomplishment of design intent.

(2) Construction sequence. Identification and explanation of the dates to which construction progress must conform to satisfy project requirements, and the special sequences for construction activities that are required by design.

(3) Instrumentation systems. Description of the instrument types, their purpose, the procedures for installation of each instrument type, the method and time interval for reading each instrument, and the importance of prompt data transmission for analysis and feedback.

(4) Care and diversion of water. Description of the design features included to prevent and/or control flooding and turbidity and accomplish diversion and closure of the dam. This should also contain the design requirements for controlling normal flows through the work area to assure that construction is always accomplished under dry conditions. Critical aspects of the construction schedule related to flood problems should be emphasized.

b. Foundation

(1) Description. Discussion of the type of foundation conditions expected to exist, i.e., over-burden, general rock description, formation weaknesses such as joints, shears and faults, and acceptable foundation conditions.

(2) Excavation. Discussion of the depth and nature of materials expected to be encountered, the controls for dewatering and blasting, identification of critical areas, quantity estimates, and an acceptable foundation.

(3) Preparation. Review of the methods of rock foundation preparations such as: cleaning; the use of wire mesh, mortar, shotcrete, or rock bolts; grouting, and treatment of faults, shears and joints; as well as subsequent exploration to assure desired results. Review of methods of earth foundation preparation.

c. Materials

(1) Materials from required excavation. Definition of acceptable and unacceptable properties of materials, the usage and the processing requirements if used, and identification of waste area locations.

(2) Other excavated materials. Identification of the location and amount of usable material, "based on current test data," available from all designated areas, including borrow pits. Review of the blasting methods that are expected to produce the desired rock quality and sizes. Discussion of the expected amounts of waste and the areas where borderline material may be used in lieu of wasting, such as in berms or certain zones of the downstream shell of an earthfill dam.

(3) Embankment. Description of both acceptable and unacceptable material properties, place-ment, and compaction procedures for each zone. Review of required procedures for areas adjacent to abutments, around instruments, and at interfaces between zones and/or structures.

(4) Concrete and concrete materials. Identification of acceptable aggregate sources and review of mix designs, joint and surface treatment, finish requirements, form tolerances, and placement procedures. Cooling as well as hot and cold weather protection requirements should be defined.

d. Construction General

(1) Field control. Discussion of the quality assurance procedures required to control all phases of construction. Acceptable placement standards should be established for concrete, earth and rock materials, and embankments.

(2) Structural. Discussion of structural steel installation, reinforcing steel placement, and anticipated problem areas and specified treatment for such areas.

(3) Mechanical-electrical. Description of equipment installation requirements, special procedures, performance tests, protective coatings, and protection devices such as ground fault indicators.

(4) Environmental-Identification of those construction controls required to minimize environmental damage, comply with environmental regulations, and assure public involvement.

4. Construction Assurance

a. Construction Procedures
Agency criteria must assure that acceptable methods and procedures are specified and utilized to accomplish design requirements. At the same time, the design and construction organizations must maintain the flexibility necessary to modify design, material requirements, and construction specifications as conditions dictate without altering the basic design intent.

b. Construction Materials Testing
A materials laboratory must be established at the field construction office that is adequately staffed and equipped to accomplish the on-site testing requirements set forth in the engineering considerations and instructions to field inspection personnel. Provisions should be made for a thorough and periodic review "above project level" of the construction materials testing procedures to assure their continued suitability. Periodic companion test samples of embankment material should be checked by higher echelon for uniform test assurance.

c. Quality Assurance
It is mandatory that adequate construction quality assurance systems and procedures be established to assure safe dam construction. The quality assurance system must guarantee, by direct inspection and testing, that construction is accomplished in compliance with the contract plans and specifications. The quality assurance system must identify when site conditions require modification of the design to ensure construction of a safe dam and must document the construction activities and test results. Daily inspector’s reports, laboratory test data records, and photographs are the minimum mandatory methods of documentation. General guidelines for documentation are given in section III.A.5.

As a part of the quality assurance program the contractor should normally be required to submit various plans for approval not limited to, but including, the following:

Construction Schedule Safety Program
Care and Diversion of Water (including pollution control)
Fire Protection
Plant Layout (including haulroads)
Environmental Measures
Equipment Inventory
Dewatering Foundations and Borrow Areas

Excavation Sequence of Foundations and Borrow Areas
Drilling and Blasting Procedures
Concrete Placement
Restoration of Construction Area

D. MANAGEMENT OF TECHNICAL ACTIVITIES-OPERATION AND MAINTENANCE (O&M)

This section of the guidelines outlines the technical activities for operation and maintenance, periodic inspection program, and emergency action planning that agency management should ensure are undertaken to obtain safe operation of dams.

1. Operation and Maintenance

a. General

The intent is to define practices which will ensure safe operation of dams and reservoirs and to require a maintenance program that will provide timely repair of facilities. It is assumed that each Federal agency is responsible for proper operation and maintenance of dams that are owned by the agency or that are under its jurisdiction.

Operation and maintenance personnel should be selected on the basis of their capability to acquire the knowledge needed to perform the many functions of operation and maintenance, and should be trained for the associated duties at each specific project.

All operation and maintenance manuals should be kept current, and records should be maintained of instructions, inspections and equipment testing, with copies to those responsible for design and dam safety inspections. General guidelines for documentation are given in section III.A.5.

In the following sections, outlets or outlet gates refer to gates or valves on any outlets such as sluices, conduits or tunnels, pumps, generating units, and infrequently operated plant intake and discharge gates. If the project has a navigation lock, emergency closure and other infrequently operated equipment are also included.

b. Operating Procedures

Written operating instructions should be prepared for the dam and its associated structures and equipment. The instructions should cover the functions of the dam and reservoir and describe procedures to follow during flood conditions to ensure dam safety.

Reservoir operating rule curves should be available for each normal mode of operation and for emergency conditions.

An auxiliary power system, such as a gasoline or diesel-operated generator, is essential if the outlet and spillway gates and other dam facilities are electrically operated.

All spillway and outlet gates should be tested on a regular schedule. The tests should include use of both the primary and the auxiliary power systems.

Project security is a matter of concern at all major dams. This includes preventing structural damage by vandals or saboteurs and unauthorized operation of outlet or spillway gates. In most cases, restricting public access is essential, and in some instances armed guards may be necessary.

Public safety is of paramount importance at all dams and reservoirs. Specifically, public safety on the reservoir, in areas adjacent to the reservoir, and below the dam should be considered, particularly in recreational areas. Safety measures should include identification of high watermarks to indicate past or probable reservoir levels and streamflows, posting of safety instructions at highly visible and key locations, and providing audible safety warnings upstream of and below outlets as appropriate.

Communication should be maintained among affected governmental bodies and with the public to enhance the safety aspects of the operation of the dam. Communication alternatives include written communications, radio, telephone, television, and newspapers.

c. Maintenance Procedures

Written instructions should provide information needed for proper maintenance of all water control facilities.

Specialists should prepare maintenance checklists indicating the maintenance procedures and protective measures for each structure and for each piece of operating, communications, and power equipment, including existing monitoring systems. Special attention should be given to known problem areas.

Special instructions should be provided for checking operating facilities following floods, earthquakes, tornados, and other natural phenomena.

Maintenance procedures include preventive measures such as painting and lubrication as well as repairs to keep equipment in intended operating condition, and minor structural repairs such as maintaining drainage systems and correcting minor deterioration of concrete and embankment surfaces. The design staff should be apprised of any significant maintenance work.

2. Periodic Inspection Program

a. General

The purpose of a periodic inspection program is to verify throughout the operating life of the project the structural integrity of the dam and appurtenant structures, assuring protection of human life and property. Periodic inspections disclose conditions which might disrupt operation or threaten dam safety, in time for them to be corrected. When such conditions are encountered, it is necessary to determine the adequacy of structures and facilities to continue

serving the purposes for which they were designed, and to identify the extent of deterioration as a basis for planning maintenance, repair or rehabilitation.

The following general principles and guidelines for a periodic inspection program should be used by Federal agencies responsible for operation or regulation of dams.

All existing dams with a significant hazard potential should have a safety evaluation based on current technical guidelines and criteria. New dams added to the inspection program should be planned, designed, and constructed in accordance with current technical criteria. Improvements in dam technology require that dams and appurtenant structures be reassessed to assure dam safety for more stringent design and materials criteria.

Periodic inspection of dams, reservoirs, and appurtenant structures involves important aspects other than dam safety; however, these guidelines encompass only dam safety issues. Each agency is responsible for assuring that the existing dams for which it is responsible are periodically inspected, and that new dams are re-inspected initially upon completion of construction and periodically thereafter.

b. Types and Frequencies of Inspections

The inspection types and intervals herein recommended are for general guidance in developing inspection programs for all Federal dams. These guidelines do not preclude other inspections or more frequent inspections if deemed necessary depending on project history and importance of the facility. For some projects less frequent inspections may be permissible where hazard potential and structural integrity warrant such relaxation.

To maintain control of the inspection program, a formal inspection schedule should be maintained which lists each feature to be inspected, frequency of inspection, date last inspected, date of last inspection report, maintenance record, description of repairs made, and date of next inspection. The schedule should also have a note on major alterations that are made.

Inspection personnel should be selected carefully, have qualifications commensurate with their assigned levels of responsibility, and receive training in the inspection procedures. Qualifications and training required for inspection personnel may vary with the complexity of the facility and with the level of inspection.

(1) Informal Inspections. The purpose of informal inspections is to have as far as practicable a continuous surveillance of the dam. Employees at the project are to make frequent observations of the dam and appurtenances and of operation and maintenance. They are to identify and report abnormal conditions in accordance with adequate instructions and guidance. A detailed checklist of items to be inspected may be provided. The instructions or checklists should be prepared specifically for the project by engineering and operating specialists. The personnel performing these inspections should be properly trained and made aware of the heavy reliance placed upon them, and the great importance and absolute necessity of their careful inspection and reporting. Any unusual conditions that seem critical or dangerous should be reported

immediately to the agency's inspection organization or to those assigned inspection responsibility.

Particular attention should be given to detecting evidence of (or changes in) leakage, erosion, sinkholes, boils, seepage, slope instability, undue settlement, displacement, tilting, cracking, deterioration, and improper functioning of drains and relief wells.

(a) Frequency of informal inspections. Informal inspections should be scheduled by experienced, trained engineers as needed according to the dam's size, importance, and potential for loss of life and damage to property. The schedule for inspection should be changed by the engineers as required to be responsive to observed changing conditions.

Operating personnel should make an inspection immediately after any unusual event such as large floods, earthquakes, suspected sabotage, or vandalism.

(b) Qualifications of personnel for informal inspections. Informal inspections in most instances can be performed satisfactorily by dam tenders or operation and maintenance personnel not formally educated in the field of engineering or geology. Persons selected to make informal inspections, however, must have sufficient training and experience to allow them to recognize abnormal conditions, must have demonstrated their ability to perform operation and maintenance functions, and must have an appreciation for the importance of their responsibilities. They must be provided adequate written instructions on performance of responsibilities and must be evaluated periodically to assure that they understand the requirements and are capable of performing them. In addition, procedures for monitoring structural performance, observing the structure, its foundation, abutments, and appurtenances, and reporting abnormal conditions must be clearly defined and understood by these personnel.

(2) Intermediate Inspections. Intermediate inspections should include a thorough field inspection of the dam and appurtenant structures, and a review of the records of inspections made at and following the last formal inspection. If unusual conditions are observed that are outside the expertise of these inspectors, arrangements should be made for inspections to be conducted by specialists.

(a) Frequency of intermediate inspections. Intermediate inspections should be performed preferably on an annual basis, but at least biennially, where there is a high probability that dam failure could result in loss of life. For other dams, intermediate inspections should be scheduled by responsible engineers on the basis of the dam's size, importance, and potential for damage to property.

(b) Qualifications of personnel for intermediate inspections. Intermediate inspections should be performed by technically qualified engineers, experienced in the operation and maintenance of dams and trained to recognize abnormal conditions. The inspectors should have access to and be familiar with all permanent documentation, especially the operation and maintenance histories for the dam and should be directly responsible for and intimately familiar with the operating characteristics of the dam. The dam tender or operator should be a participant in these inspections.

(3) Formal and Special Inspections. A formal inspection is required periodically to verify the safety and integrity of the dam and appurtenant structures. Formal inspections should include a review to determine if the structures meet current accepted design criteria and practices. The inspection should include a review of all pertinent documents including instrumentation, operation, and maintenance and, to the degree necessary, documentation on investigation, design, and construction. In making the detailed inspection of the dam appurtenant structures and equipment, diving inspections of underwater structures affecting the integrity of the dam should be included. All formal inspections should be conducted by a team of highly trained specialists. To assure that a dam and its appurtenant facilities are thoroughly inspected, checklists should be prepared to cover the condition of structural, electrical, and mechanical features. This inspection should also verify that operating instructions are available and understood, instrumentation is adequate and data is assessed to assure structures are performing as designed, and there are emergency provisions for access to and communication with all project operating facilities.

(a) Frequency of formal inspections. Formal inspections should be made periodically at intervals not to exceed 5 years. Depending on past experience or the project history, some dams may require more frequent formal inspections.

(b) Frequency of special inspections. Special inspections should be performed immediately after the dam has passed unusually large floods and after the occurrence of significant earthquakes, sabotage, or other unusual events reported by operating personnel.

(c) Qualifications of personnel for formal and special inspections. Formal and special inspections should be conducted under the direction of licensed professional engineers experienced in the investigation, design, construction, and operation of dams. The inspection team should be chosen on a site-specific basis considering the nature and type of the dam. The inspection team should comprise individuals having appropriate specialized knowledge in structural, mechanical, electrical, hydraulic, and embankment design; geology; concrete materials; and construction procedures. They must be capable of interpreting structural performance and relating conditions found to current criteria and safety aspects. It is imperative that the inspection team adequately prepare for the inspections by reviewing and discussing all documents relative to the safety of the dam.

c. Instrumentation

Instrumentation or performance observation devices are used to supplement visual inspections in evaluating the performance and safety of dams. Careful examination of instrumentation data on a continuing basis may reveal a possible critical condition. Conversely, instrumentation may be a means of assuring that an observed condition is not serious and does not require immediate remedial measures.

(1) Adequacy of Instrumentation. Instrumentation to monitor structural and functional performance should be installed in dams where complex or unusual site conditions have been encountered or where there is a high probability that failure could result in loss of life or extensive property damage. Instruments should be examined periodically for proper functioning. The adequacy of the installed instrumentation should be assessed from time to

time by specialists to determine if it is sufficient to help evaluate the performance of the dam. When required, additional instrumentation should be installed to confirm suspicious trends or to explore an indicated potential adverse trend.

(2) Observation of Monitoring Devices. The instrumentation data should be collected by personnel trained specifically for the purpose, including training to recognize and immediately report to those responsible for inspections any anomalies in the readings or measurements. Performance observation data should be properly tabulated for record purposes.

(a) Frequency of observations. The frequency of instrument readings should be established at the time the instrumentation system is designed in order to give a timely warning of possible adverse conditions. Whenever necessary, more frequent readings, sometimes as often as hourly, should be taken to monitor a suspected rapidly changing adverse condition. The frequency or number of readings may be reduced after the project has been in operation for an extended time and performance observation data indicates that readings have stabilized.

(3) Data Analysis. It is essential that instrumentation data be processed, reviewed and assessed in a timely manner by specialists familiar with the design, construction, and operation of the project. Operation manuals and design information should be referred to in the evaluation of possible adverse trends. The performance observation data should be periodically analyzed to determine whether project structures are reacting as assumed in the design, and to detect behavior conditions that may indicate the need for corrective action.

d. Correction of Deficiencies

The inspection program could reveal those deficiencies or potential deficiencies which, if uncorrected, could eventually lead to failure of the dam. Deficiencies may vary from emergency type items where immediate action is required, to non-emergency type items which must be corrected in a timely manner but do not present an immediate danger to the safety of the structure. In all cases corrective action should be made under the supervision of qualified personnel. Emergency action plans to be implemented when failure has already occurred or is imminent are discussed in Section III.D.3, Emergency Action Planning.

(1) High Priority Corrective Action. High priority corrective action is required for deficiencies which could result in failure of the dam within a short period of time. Heads of agencies should have authorities, procedures and levels of delegation for transfer of funds and other emergency funding provisions to ensure they are adequate for accomplishing corrective actions in cases where time constraints will not permit allocation through the normal budget process. Procedures for seeking transfer authority beyond that delegated to the agency and/or requests for supplemental appropriations should also be reviewed to ensure such requests can be forwarded quickly and with all necessary supporting documentation to enable expeditious action by the President and/or the Congress.

(2) Non-emergency Corrective Action. Non-emergency corrective action is action taken when there is no immediate threat to the safety or operation of the dam, nor any threat to life or property downstream. The corrective action should be scheduled in advance of the fiscal year in which the work is to be done to allow time for planning, funding through the normal

budgeting process, and arranging for special reservoir operations when required. Some of these deficiencies may be corrected through the regular operation and maintenance program discussed in Section III.D.1, Operation and Maintenance.

(3) Follow-up Action. Periodic inspection reports should continue to list previously identified deficiencies along with any newly discovered deficiencies and show the status of corrective action. Appropriate inspection personnel should make frequent field examinations as long as the problem exists to see all corrective measures are being completed. When deficiencies are not corrected in a reasonable length of time, an investigation should be made to determine the reason for delay and appropriate management personnel should be notified of the findings.

e. Documentation

Proper documentation of the dam's current condition and past performance is necessary to assess the adequacy of operation, maintenance, surveillance, and proposed corrective actions. A complete record or history of the investigation, design, construction, operation, maintenance, surveillance, periodic inspections, modifications, repair, and remedial work should be established and maintained so that relevant data relating to the dam is preserved and readily available for reference. This documentation should commence with the initial site investigation for the dam and continue through the life of the structure.

(1) Instrumentation. All instrumentation observation data and evaluations thereof should be properly tabulated and documented for record purposes. Maintenance of instrumentation systems requires that details of the installation be available for a clear understanding of its functioning. A complete history of past repairs, testing, readings, and analyses should be available as pertinent reference data in the evaluation of current instrumentation data.

(2) Inspections. All inspection observations, especially as related to the safety of the dam, should be documented. The extent and nature of inspection reports required for the informal, intermediate formal, and special inspections will vary in proportion to the intensity of the inspection and the nature of the findings. Informal inspection reports may range from memoranda to supervisors which describe conditions and corrective actions, to detailed accounts of an event or occurrence. Intermediate inspection reports may vary from similar memoranda or trip reports to more formal reports containing substantial records, detail, and recommendations. Formal and special inspections require complete formal technical reports of all findings, corrective actions and recommendations, for permanent record and reference purposes in order to form a basis for major remedial work when required.

All reports should be in a self-explanatory form that permits their retention as permanent records and should carefully document times of inspections, inspection personnel, and findings of the inspection.

(3) Correction of Deficiencies. All deficiencies corrected as a result of the recommendations contained in periodic inspection reports should be fully documented in report form and made a part of the permanent project record. Alterations made to the facility as a result of changes in criteria to meet current practices or changes in dam technology should be fully documented, including as-constructed drawings.

3. Emergency Action Planning

a. General

It is intended that the guidelines for the design, construction, operation and maintenance, and inspection of dams will minimize the risk of future dam failures. Nevertheless, it is recognized that despite the adequacy of those guidelines and their implementation, the possibility of dam failures still exists**.** Even though the probability of such failures is small, preplanning is required to identify conditions which could lead to failure, in order to initiate emergency measures to prevent such failures as a first priority, and, if this is not possible, to minimize the extent and effects of such failure. These guidelines provide operating and mobilization procedures to be followed upon indication of an impending or possible dam failure or a major flood.

Each Federal agency which owns or is responsible for dams and each public or private owner of a Federally regulated dam (hereinafter, dam agency or owner) should evaluate the possible modes of failure of each dam, indicators or precursors of failure for each mode, possible emergency actions appropriate for each mode, and the effects on downstream areas of failure by each mode. In every case the evaluation should recognize the possibility of sudden failure, and should provide a basis for such "worst case" emergency planning actions in terms of notification and evacuation procedures where failure would pose a significant danger to human life and property. Plans should then be prepared in a degree of detail commensurate with the hazard, and instructions provided to operators and attendants regarding the actions to be taken in an emergency. Planning should be coordinated with local officials, as necessary, to enable those officials to draw up a workable plan for notifying and evacuating local communities when conditions affecting dam safety arise.

b. Evaluation of Emergency Potential

Prior to development of an emergency action plan, consideration must be given to the extent of land areas, and types of development with the areas, that would be inundated as a result of dam failure or flood, and the time available for emergency response.

(1) Determination of Mode of Dam Failure. There are many potential causes and modes of dam failure, depending upon the type of structure and its foundation characteristics. Similarly, there are degrees of "failure" and, often progressive stages of failure. Many dam failures can be prevented from reaching a final catastrophic stage by recognition of early indicators or precursor conditions, and by prompt, effective emergency actions. While emergency planning should emphasize preventive actions, recognition must be given to the catastrophic condition and hazard potential. Analysis should be made to determine the most likely mode of dam failure under the most adverse condition and the resulting peak water outflow following the failure. Where there is a series of dams on the stream, analyses should include consideration of

the potential for progressive "domino" failure of the dams.

(2) Inundation Maps. To evaluate the effects of dam failure, maps should be prepared delineating the area which would be inundated in the event of failure. Land uses and significant development or improvements within the area of inundation should be indicated. The maps should be equivalent to or more detailed than the United States Geological Survey (USGS) quadrangle maps, 7-1/2 minute series, or of sufficient scale and detail to identify clearly the area that should be evacuated if there is evident danger of failure of the dam. Copies of the maps should be distributed to local government officials for use in the development of an evacuation plan.

(3) Classification of Inundation Areas. To assist in the evaluation of hazard potential, areas delineated on inundation maps should be classified in accordance with the degree of occupancy and hazard potential. The potential for loss of life is affected by many factors, including but not limited to the capacity and number of exit roads to higher ground and available transportation. Hazard potential is greatest in urban areas. Since the extent of inundation is usually difficult to delineate precisely because of topographic map limitations, the evaluation of hazard potential should be conservative.

The hazard potential for affected recreation areas varies greatly, depending on the type of recreation offered, intensity of use, communication facilities, and available transportation. The potential for loss of life may be increased where recreationists are widely scattered over the area of potential inundation since they would be difficult to locate on short notice.

Many industries and utilities requiring substantial quantities of water for one or more stages in the manufacture of products or generation of power are located on or near rivers or streams. Flooding of these areas and industries can, in addition to causing the potential for loss of life, damage to machinery, manufactured products, raw materials and materials in process of manufacture, interrupt essential community services.

Rural areas usually have the least hazard potential. However, the potential for loss of life exists, and damage to large areas of intensely cultivated agricultural land can cause high economic loss.

(4) Time Available for Response. Analyses should be made to evaluate the structural, foundation, and other characteristics of the dam and determine those conditions which could be expected to result in slow, rapid or practically instantaneous dam failure.

c. Actions to Prevent Failure or Minimize Effects of Failure

(1) Development of Emergency Action Plan. An emergency action plan should be developed for each dam that constitutes a hazard to life and property, incorporating preplanned emergency measures to be taken prior to and following assumed dam failure. The plan should be coordinated with local governmental and other authorities involved in public safety and be approved by appropriate top level agency or owner management. To the extent possible, the emergency action plan should define emergency situations that require immediate notification of local officials. The emergency action plan should include notification plans, which are

discussed in section (2) below.

Emergency scenarios should be prepared for possible modes of failure for each dam. Periodically these scenarios should be used to test the readiness capabilities of project staff and logistics.

A procedure should be established for review and revision, as necessary, of the emergency action plan, including notification plans and evacuation plans, at least once every 2 years. Such reviews should be coordinated among all organizations responsible for preparation and execution of the plans.

(2) Notification Plans. Plans for notification of key personnel and the public are an integral part of the emergency action plan and should be prepared for slowly developing, rapidly developing, and instantaneous dam failure conditions. Notification plans should include a list of names and position titles, addresses, office and home telephone numbers, and radio communication frequencies and call signals, if available, for agency or owner personnel, public officials, and other personnel and alternates who should be notified as soon as emergency situations develop. A procedure should be developed to keep the list current.

Each type of notification plan should contain the order in which key agency or owner supervisory personnel or alternates should be notified. At least one key supervisory level or job position should be designated to be manned or the responsible person should be immediately available by telephone or radio 24 hours a day. A copy of each notification plan must be posted in a prominent place at the project site near a telephone and/or radio transmitter. All project personnel should be familiar with the plans and the procedures each is to follow in the event of an emergency. Copies of the notification plans should be readily available at the home and the office of each person involved.

Where dams located upstream from the dam for which the plan is being prepared could be operated to reduce inflow or where the operation of downstream dams would be affected by failure of the dam, operators of those dams should be kept informed of the current and expected conditions of the dam as the information becomes available.

Civil defense officials having jurisdiction over all or part of the area subject to inundation should receive early notification. Local law enforcement officials and, when possible, local government officials and public safety officials should receive early notification.

The capabilities of the Defense Civil Preparedness Agency's National Warning System (NAWAS) should be determined for the project and utilized as appropriate. Information can be obtained from State or local civil defense organizations.

Potentially affected industries downstream should be kept informed so that actions to reduce risk of life and economic loss can be taken. Coordination with local government and civil defense officials would determine responsibility for the notification. Normally, this would be a local government responsibility.

When it is determined that a dam may be in danger of failing, the public officials responsible for the decision to implement the evacuation plan should be kept informed of the developing emergency conditions.

The news media, including radio, television, and newspapers, should be utilized to the extent available and appropriate. Notification plans should define emergency situations for which each medium will be utilized and should include an example of a news release that would be the most effective for each possible emergency. Use of news media should be preplanned insofar as is possible by agency and owner personnel and the State and/or local government. Information should be written in clear, concise language. Releases to news media should not be relied upon as the primary means of notification.

Notification of recreation users is frequently difficult because the individuals are often alone and away from any means of ready communication. Consideration should be given to the use of standard emergency warning devices such as sirens at the dam site. Consideration should be given to the use of helicopters with bullhorns for areas further downstream. Vehicles equipped with public address systems and helicopters with bullhorns are capable of covering large areas effectively.

Telephonic communication should not be solely relied on in critical situations. A backup radio communication system should be provided and tested at least once every 3 months. Consideration should be given to the establishment of a radio communication system prior to the beginning of construction and to the maintenance of the system throughout the life of the project.

(3) Evacuation Plans. Evacuation plans should be prepared and implemented by the local jurisdiction controlling inundation areas. This would normally not be the dam agency or owner. Evacuation plans should conform to local needs and vary in complexity in accordance with the type and degree of occupancy of the potentially affected area. The plans may include delineation of area to be evacuated; routes to be used; traffic control measures; shelter, methods of providing emergency transportation; special procedures for the evacuation and care of people from institutions such as hospitals, nursing homes, and prisons; procedures for securing the perimeter and for interior security of the area; procedures for the lifting of the evacuation order and reentry to the area; and details indicating which organizations are responsible for specific functions and for furnishing the materials, equipment, and personnel resources required.

The assistance of local civil defense personnel, if available, should be requested in preparation of the evacuation plan. State and local law enforcement agencies usually will be responsible for the execution of much of the plan and should be represented in the planning effort. State and local laws and ordinances may require that other State, county, and local government agencies have a role in the preparation, review, approval, or execution of the plan. Before finalization, a copy of the plan should be furnished to the dam agency or owner for information and comment.

(4) Stockpiling Repair Materials. Suitable construction materials should be stockpiled for

emergency use. The amounts and types of construction materials needed for emergency repairs should be determined based on the structural, foundation, and other characteristics of the dam; design and construction history; and history of prior problems.

(5) Locating Local Repair Forces. Arrangements should be made with, and a current list maintained of, local entities, including contractors, and Federal, State and local construction departments, for possible emergency use of equipment and labor.

(6) Training Operating Personnel. Technically qualified project personnel should be trained in problem detection, evaluation, and appropriate remedial (emergency and non-emergency) measures. This is essential for proper evaluation of developing situations at all levels of responsibility which, initially, must be based on at-site observations. A sufficient number of personnel should be trained to assure adequate coverage at all times. If a dam is operated by remote control, arrangements must be made for dispatching trained personnel to the project at any indication of distress.

(7) Increasing Inspection Frequency. Frequency of appropriate surveillance activities should be increased when the reservoir level exceeds a predetermined elevation. Piezometers, water level gauges, and other instruments should be read frequently and on schedule. The project structures should be inspected as often as necessary to monitor conditions related to known problems and to detect indications of change or new problems that could arise. Hourly or continuous surveillance may be mandated in some instances. Any change in conditions should be reported promptly to the supervisor for further evaluation.

The supervisor should issue additional instructions, as necessary, and alert repair crews and contractors for necessary repair work if developing conditions indicate that emergency repairs or other remedial measures may be required.

d. Actions Upon Discovery of a Potentially Unsafe Condition

Action to be taken will depend on the nature of the problem and the time estimated to be available for remedial or mitigation measures. As time permits, one or more of the following actions will be required.

(1) Notification of Supervisory Personnel. This is essential, if time permits, since development of failure could vary in some or many respects from previous forecasts or assumptions, and advice may be needed.

(2) Initiation of Predetermined Remedial Action. It is imperative that at least one technically qualified individual, previously trained in problem detection, evaluation, and remedial action, be at the project or on call at all times. Depending on the nature and seriousness of the problem and the time available, emergency actions can be initiated, such as lowering the reservoir and holding water in upstream reservoirs. Other actions to be taken include notifying appropriate highway and traffic control officials promptly of any rim slides or other reservoir embankment failures which may endanger public highways.

(3) Determination of Need for Public Notification. To the extent possible, emergency situations

that will require immediate notification of public officials in time to allow evacuation of the potentially affected area should be predefined for the use of management and project personnel. If sufficient time is available, the decision to notify public officials that the dam can be expected to fail will be made at a predetermined supervisory level within the agency or owner organization. If failure is imminent or has already occurred, project personnel at the dam site would be responsible for direct notification of the public official. The urgency of the situation should be made clear so that public officials will take positive action immediately.

APPENDIX A
FCCSET *AD HOC* INTERAGENCY COMMITTEE MEMBERS

Members

Phillip M. Smith (Chairman)
Assistant Director for Natural Resources and Commercial Services
Office of Science and Technology Policy
Washington, D.C.

William S. Bivins
Hydrology and Meteorology Branch
Director of Site Safety and Environmental Analysis
Nuclear Regulatory Commission
Washington, D.C.

Neil F. Bogner
Director, Engineering Division
Soil Conservation Service
Department of Agriculture
Washington, D.C.

George L. Buchanan
Chief, Civil Engineering and Design Branch
Division of Engineering Design
Office of Engineering Design and Construction
Tennessee Valley Authority
Knoxville, Tennessee

Donald Dillon
Deputy for Policy Planning and Legislative Analysis
Department of the Army
Washington, D.C.

Joseph Friedkin
Commissioner, U.S. Section
International Boundary and Water Commission
Washington, D.C.

Gary Wicks
Deputy Assistant Secretary for Land and Water Resources
Department of the Interior
Washington, D.C.

Gerald R. Wilson, Jr.
Chief, Project Analysis Branch
Licensed Projects Division
Federal Energy Regulatory Commission
Washington, D.C.

Consultant to OSTP

Bruce A. Tschantz
Department of Civil Engineering
University of Tennessee
Knoxville, Tennessee

APPENDIX B
INTERAGENCY GUIDELINES SUBCOMMITTEE MEMBERS

Members

Site Investigation and Design (SID) Subcommittee Members

George L. Buchanan, TVA, Chairman
David C. Ralston, SCS
Ernest L. Dodson, Army-Corps
Robert A. Wilson, BLM
William D. Woodbury, BOM
E.T. Scherich, BoR
Walter L. West, FWS
Robert Fujimoto, MESA
Henry W. Coulter, USGS
Gerald R. Wilson, Jr., FERC
William S. Bivins, NRC

SID Task Group Members

Hydrology
Vernon Hagan, Army-Corps, Chairman
Norman Miller, SCS
Fred A. Bartle, BoR
Dennis Tarmay, FERC
Ed Hawkins, NRC
Donald W. Newton, TVA

Seismology
Jim Divine, USGS, Chairman
Al Geiger, SCS
Ellis Krimitzsky, Army-Corps
Andy Vikone, BoR
John Kellerher, NRC
Donald J. Reinhold, TVA

Seismic Engineering
Richard W. Kramer, BoR, Chairman
A.G. Franklin, Army-Corps
Jim Talbot, SCS
Richard McMullen, NRC
Thomas J. Abraham, TVA

Geotechnical
James H. Coulson, TVA, Chairman
Jake Redlinger, Army-Corps
James Legas, BoR
Robert Peterson, MESA
Henry W. Coulter, USGS
Harry Thomas, FERC

Hydraulics
Svein Vigander, TVA, Chairman
Sam Powell, Army-Corps
Edwin C. Rossilon, BoR
Robert F. McVain, FWS
Gus Center, MESA

Concrete Dams
Glenn Tarbox, BoR, Chairman
Keith O'Donnell, Army-Corps
Billy F. Horton, FWS
Kuo-Hua Yang, FERC
Earl L. Spearman, TVA

Embankment Dams
Robert L. James, Army-Corps, Chairman
David C. Ralston, SCS
Edwin W. Gray, BoR
Dan Kealy, BOM
Constantine Tjoumas, FERC
Samuel D. Stone, TVA

Construction (CON) Subcommittee Members

Donald A. Giampaoli, BoR, Chairman
Neil F. Bogner, SCS
Joseph M. Nelson, Army-Corps
William R. Groseclose, BoR
Walter L. West, FWS
Herman E. Smalling, TVA

CON Task Group Members

Inspection
Joseph M. Nelson, Army-Corps, Chairman
William R. Groseclose, BoR
Herman E. Smalling, TVA

Contractor Quality Control
Neil F. Bogner, SCS, Chairman
Joseph M. Nelson, Army-Corps
Walter L. West, FWS

Staffing
Walter L. West, FWS, Chairman
Joseph M. Nelson, Army-Corps
Herman E. Smalling, TVA

Standardization of Materials Testing
William R. Groseclose, BoR, Chairman
Neil F. Bogner, SCS
Dess L. Chapelear, BoR

Identification of Acceptable Construction Methods
Herman E. Smalling, TVA, Chairman
Joseph M. Nelson, Army-Corps
Dess L. Chapelear, BoR

Construction Documentation
Neil F. Bogner, SCS, Chairman
Dess L. Chapelear, BoR
Herman E. Smalling, TVA

Operation and Maintenance (O&M) Subcommittee Members

Gerald R. Wilson, Jr., FERC, Chairman
James A. Wolfe, FS
William F. Britnell, Army-Corps
Philip Corke, BIA
Roy H. Boyd, BoR
S. Anthony Stanin, MESA
Sears Y. Coker, FERC
Desloge Brown, Initial Chairman (ret'd)
T.R. Martin, IBWC
Harold C. Buttrey, TVA

O&M Task Group Members

O&M Procedures
Roy H. Boyd, BoR, Chairman
Paul E. Nylander, SCS
William F. Britnell, Army-Corps
Philip Corke, BIA
S. Anthony Stanin, MESA
Ronald A. Lesniak, FERC
T.R. Martin, IBWC
Meigs Brewer, Jr., TVA

Periodic Inspection Program
Harold C. Buttrey, TVA, Chairman
James A. Wolfe, FS
Ralph H. Fike, Army-Corps
S.J. Occhipiati, FERC
B.A. Pritchard, BoR

Emergency Action Planning
Sears Y. Coker, FERC, Chairman
James E. Shanks, Army-Corps
Edgar C. Roper, BoR
Robert A. Shelton, TVA

Legend
Army-Department of the Army
BIA-Bureau of Indian Affairs
BLM-Bureau of Land Management
BOM-Bureau of Mines
BoR-Bureau of Reclamation
Corps-Corps of Engineers
DOI-Department of the Interior
FERC-Federal Energy Regulatory Commission
FS-Forest Service
FWS-Fish and Wildlife Service
IBWC-International Boundary and Water Commission
MESA-Mining Enforcement and Safety Administration
NRC-Nuclear Regulatory Commission
SCS-Soil Conservation Service
TVA-Tennessee Valley Authority
USDA-Department of Agriculture
USGS-United States Geological Survey

APPENDIX C
OSTP INDEPENDENT REVIEW PANEL MEMBERS

Members

Professor Frank E. Perkins, Chairman
Department of Civil Engineering
Massachusetts Institute of Technology
Cambridge, Massachusetts

Professor Clarence R. Allen
Department of Geology
California Institute of Technology
Pasadena, California

Dr. Elio D'Appalonia
D'Appalonia Consulting Engineers, Inc.
Pittsburgh, Pennsylvania

Mr. Gerald W. Farquhar, Attorney
Ford, Farquhar, Kornblat & O'Neill
Washington, D.C.

Mr. H. Keith Honeker
Kentucky Department of Natural
Resources and Environmental Protection
Frankfort, Kentucky

Professor L. Douglas James, Director
Utah Water Research Laboratory
Utah State University
Logan, Utah

Mr. Eric B. Kollguard
International Engineering Company
San Francisco, California

Mr. Ray E. Lineley
Hydrocomp, Inc.
Palo Alto, California

Mr. Gordon W. Prescott
Department of Geosciences
Purdue University
W. Lafayette, Indiana

Professor H. Bolton Seed
Department of Civil Engineering
University of California, Berkeley
Berkeley, California

Professor Erik H. Vanmarcke
Department of Civil Engineering
Massachusetts Institute of Technology
Cambridge, Massachusetts

Consultant to OSTP

Professor Bruce A. Tschantz
Department of Civil Engineering
University of Tennessee
Knoxville, Tennessee

APPENDIX D
ACKNOWLEDGMENTS

The authority for preparation of the guidelines is given in section I.B. They were prepared by an interagency guidelines task group composed of the Chairmen of the subcommittees identified in Appendix B. Specific sections preparation assignments were:

Section I. SID Chairman, George L. Buchanan, TVA

Section II, CON Chairman, Donald A. Giampaoli, BoR, and O&M Chairman, Gerald R. Wilson, FERC, with the cooperation of L. Douglas James, representative of the Independent Review Panel (Appendix C) to the guidelines task group, and Bruce A. Tschantz, consultant to OSTP and advisor to the task group.

Section III A. and III.B. SID Chairman

Section III.C. CON Chairman

Section III.D. O&M Chairman

The Chairmen were assisted by their subcommittee and task groups members (listed in Appendix B).

Reviews were made by subcommittee members and by representatives of the agencies other than the preparing agency and by L. Douglas James of the Independent Review Panel. Major contributory reviews were made by representatives of the major dam building agencies, BoR, Corps, SCS, and TVA, and the Independent Review Panel member.

Editing and assembly of the final working draft for submittal to FCCSET were handled by the SID Chairman (TVA). Oliver H. Raine of the SID Chairman's engineering staff assisted in the preparation and review of various portions of the guidelines and in the editing and assembly of the working draft.

APPENDIX E
BIBLIOGRAPHY

The listed references are selected as representative of Federal agency and other publications related to dam safety, and are not intended to be inclusive of dam technology.

GENERAL

Engineering Foundation Conference Proceedings, Published by the American Society of Civil Engineers:

Inspection, Maintenance and Rehabilitation of Old Dams, Pacific Grove, CA, 1973

Safety of Small Dams, Henniker, NH, 1974

Responsibility and Liability of Private and Public Interests on Dams, Pacific Grove, CA, 1975

The Evaluation of Dam Safety, Pacific Grove, CA, 1976

Lessons from Dam Incidents, International Commission on Large Dams, 1973

Lessons from Dam Incidents, USA, United States Committee on Large Dams/American Society of Civil Engineers, 1975

Earth and Earth-Rock Dams, Sherard, Woodward, Gizienski and Clavenger, 1963 (Wiley)

Foundations of Earthquake Engineering, Newmark and Rosenblueth, 1971 (Prentice-Hall)

Public Law 92-347, National Program of Inspection of Dams, U.S. 92nd Congress, 1972

BUREAU OF MINES

IC 8755, Design Guide for Metal and Nonmetal Tailings Disposal, 1977

BUREAU OF RECLAMATION

Concrete Manual, 8th Edition, 1975

Earth Manual, 2nd Edition, 1974

Ground Water Manual, 1st Edition, 1977

Design of Gravity Dams, 1st Edition, 1976

Design of Arch Dams, 1st Edition, 1977

Design of Small Dams, 2nd Edition, 1973; Rev. Reprint 1977

Manual for Safety Evaluation of Existing Dams, 1st Edition, 1977

CORPS OF ENGINEERS

Engineering Manuals (EM):

EM-1110-2-1602, Hydraulic Design of Reservoir Outlet Structures

EM-1110-2-1603, Hydraulic Design of Spillways

EM-1110-2-1902, Stability of Earth and Rockfill Dams

EM-1110-2-1908, Instrumentation of Earth and Rockfill Dams

EM-1110-2-1911, Construction Control for Earth and Rockfill Dams

EM-1110-2-2200, Gravity Dam Design

EM-1110-2-2300, Earth and Rockfill Dams General Design and Construction Considerations

EM-1110-2-4300, Instrumentation for Measurement of Structural Behavior of Concrete Gravity Structures

Engineering Reports (ER):

- EM-1110-2-50, Low Level Discharge for Drawdown of Impoundments
- EM-1110-2-1450, Hydrologic Frequency Estimates
- EM-1110-2-1806, Earthquake Design and Analysis for Corps of Engineers Dams

National Program of Inspection of Dams, Volume I, Appendix D, Recommended Guidelines for Safety Inspection of Dams, 1975

MINING ENFORCEMENT AND SAFETY ADMINISTRATION

Engineering and Design Manual, Coal Refuse Disposal Facilities, 1975

Design Guidelines for Coal Refuse Piles and Water, Sediment, or Slurry Impoundments and Impoundment Structures, 1976

Coal Refuse Inspection Manual, 1976

NUCLEAR REGULATORY COMMISSION

Regulatory Guides Related to Radiological Safety and Construction for Nuclear Power Plants:

- 1.33, Quality Assurance Program Requirements (Operation), 1977
- 1.60, Design Response Spectra for Seismic Design of Nuclear Power Plants, 1973
- 1.64, Quality Assurance Requirements for the Design of Nuclear Power Plants, 1976
- 1.127, Inspection of Water-Control Structures Associated with Nuclear Power Plants, 1977

NUREG-75/087, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, Office of Nuclear Reactor Regulation, 1975

SOIL CONSERVATION SERVICE

National Engineering Handbook:

- Section 4, Hydrology
- Section 8, Engineering Geology
- Section 19, Construction Inspections
- Section 20, Specifications for Construction Contracts

Technical Releases:

- TR52, A Guide for the Design and Layout of Earth Emergency Spillways
- TR60, Earth Dams and Reservoirs

Soil Mechanics Notes:

1. Tentative Guides for Determining Gradation of Filter Materials
2. Soil Mechanics Considerations for Embankment Dams
3. Flow Net Construction and Use

TENNESSEE VALLEY AUTHORITY

General Construction Specifications:

- No. G-2 for Plain and Reinforced Concrete
- No. G-9 for Rolled Earthfill for Dams and Power Plants
- No. G-26 for Pressure Grouting of Rock Foundation with Portland Cement

Engineering Procedures (EP):

- EP 1.04, Inspection and Maintenance of Nonpower Water Control Projects
- EP 1.07, Inspection and Maintenance of Hydroelectric Projects
- EP 1.08, Navigation Lock Inspections



Federal Guidelines for Dam Safety

Selecting and Accomodating Inflow Design Floods for Dams

April 2004

FEMA

FEDERAL GUIDELINES FOR DAM SAFETY: SELECTING AND ACCOMMODATING INFLOW DESIGN FLOODS FOR DAMS

prepared by the
INTERAGENCY COMMITTEE ON DAM SAFETY

U.S. DEPARTMENT OF HOMELAND SECURITY
FEDERAL EMERGENCY MANAGEMENT AGENCY
OCTOBER 1998

Reprinted April 2004

PREFACE

In April 1977, President Carter issued a memorandum directing the review of federal dam safety activities by an *ad hoc* panel of recognized experts. In June 1979, the *ad hoc* interagency committee on dam safety (ICODS) issued its report, which contained the first guidelines for federal agency dam owners. The Federal Guidelines for Dam Safety (Guidelines) encourage strict safety standards in the practices and procedures employed by federal agencies or required of dam owners regulated by the federal agencies. The Guidelines address management practices and procedures but do not attempt to establish technical standards. They provide the most complete and authoritative statement available of the desired management practices for promoting dam safety and the welfare of the public.

To supplement the Guidelines, ICODS prepared and approved federal guidelines in the areas of emergency action planning; earthquake analysis and design of dams; and selecting and accommodating inflow design floods for dams. These publications, based on the most current knowledge and experience available, provided authoritative statements on the state of the art for three important technical areas involving dam safety. In 1994, the ICODS Subcommittee to Review/Update the Federal Guidelines began an update to these guidelines to meet new dam safety challenges and to ensure consistency across agencies and users. In addition, the ICODS Subcommittee on Federal/Non-Federal Dam Safety Coordination developed a new guideline, Hazard Potential Classification System for Dams.

With the passage of the National Dam Safety Program Act of 1996, Public Law 104-303, ICODS and its Subcommittees were reorganized to reflect the objectives and requirements of Public Law 104-303. In 1998, the newly convened Guidelines Development Subcommittee completed work on the update of all of the following guidelines:

- Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners
- Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams
- Federal Guidelines for Dam Safety: Earthquake Analyses and Design of Dams
- Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams
- Federal Guidelines for Dam Safety: Glossary of Terms

The publication of these guidelines marks the final step in the review and update process. In recognition of the continuing need to enhance dam safety through coordination and information exchange among federal and state agencies, the Guidelines Development Subcommittee will be responsible for maintaining these documents and establishing additional guidelines that will help achieve the objectives of the National Dam Safety Program.

The members of all of the Task Groups responsible for the update of the guidelines are to be commended for their diligent and highly professional efforts:

Harold W. Andress, Jr.
Chairman, Interagency Committee on Dam Safety

SELECTING AND ACCOMMODATING INFLOW DESIGN FLOODS FOR DAMS TASK GROUP

David Achterberg**
DOI, Bureau of Reclamation

Jerrold W. Gotzmer*
Federal Energy Regulatory Commission

Ronald Spath*
Federal Energy Regulatory Commission

Ming Tseng*
U.S. Army Corps of Engineers

Donald E. Woodward*
USDA, Natural Resources Conservation Service

Norman Miller
USDA, Natural Resources Conservation Service

Sam A. Shipman
Tennessee Valley Authority

*Chair of Task Group that completed final document
**Member of Task Group that completed final document

TABLE OF CONTENTS

I. INTRODUCTION 1
A. Purpose 1
B. Background 1
1. Early Periods 1
2. Transition 2
3. Current Practices 2
C. Scope 3
1. General 3
2. Philosophy and Principles 3
3. Content 4

II. DEFINITIONS OF TERMS 5

III. SELECTING INFLOW DESIGN FLOODS 11
A. Introduction 11
B. Hazard Potential Evaluation 11
1. General 12
2. Hydrologic Modes of Failure 12
a. Overtopping 12
b. Erosion in Earth Spillways 12
c. Overstressing of Structural Components 13
3. Defining the Hazard Potential 13
4. Evaluating the Consequences of Dam Failure 14
5. Studies to Define the Consequences of Dam Failure 15
6. Incremental Hazard Evaluation for Inflow Design Flood Determination 17
7. Criteria for Selecting the Inflow Design Flood 19
C. PMFs for Dam Safety 21
1. General 21
2. PMP 21
D. Floods To Protect Against Loss of Benefits During the Life of the Project-
Applicable Only to Low-Hazard Dams 22

IV. ACCOMMODATING INFLOW DESIGN FLOODS 23
A. Introduction 23
1. General 23
2. Guidelines for Initial Elevations 23
3. Reservoir Constraints 23
4. Reservoir Regulation Requirements 23
5. Evaluation of Domino-like Failure 24

TABLE OF CONTENTS (Continued)

B. Spillway and Flood Outlet Selection and Design 25
1. General 25
2. Gated or Ungated Spillways 25
3. Design Considerations 26
C. Freeboard Allowances 27
1. General 27
2. Freeboard Guidelines 28

Appendix A - References by Top A-1

Appendix B – Inflow Design Flood Selection Procedures
Figure 1. Illustration of Incremental Increase Due to Dam Failure
Figure 2. Illustration of Incremental Area Flooded by Dam Failure
Figure 3. Regions Covered by PMP Studies

I. INTRODUCTION

A. Purpose

The purpose of these Guidelines is to provide thorough and consistent procedures for selecting and accommodating Inflow Design Floods (IDFs). The IDF is the flood flow above which the incremental increase in water surface elevation downstream due to failure of a dam or other water retaining structure is no longer considered to present an unacceptable additional downstream threat.

B. Background

Current practice in the design of dams is to use the IDF that is deemed appropriate for the hazard potential of the dam and reservoir, and to design spillways and outlet works that are capable of safely accommodating the floodflow without risking the loss of the dam or endangering areas downstream from the dam to flows greater than the inflow. However, there are many dams whose discharge capabilities were designed using methods that are now considered unconservative and potentially unsafe.

Inflow design flood selection began primarily as a practical concern for protection of a dam and the benefits it provides. The early 1900's saw an increase in the Nation's social awareness that was demonstrated by various legislative acts designed to protect the public from certain high risk activities. The same era witnessed an increase in the number and size of dams built. When the "big dam" era began in the 1930's, safety clearly became a more dominant factor. It was recognized that dams needed to be designed to accommodate water flows that might be greater than the anticipated "normal" flow.

1. Early Periods. Before 1900, designers of dams had relatively little hydrologic data or tools to indicate flood potential at a proposed dam site. Estimates of flood potential were selected by empirical techniques and engineering judgment based on high water marks or floods of record on streams being studied.

Later, engineers began examining all past flood peaks in a region to obtain what was hoped to be a more reliable estimate of maximum flood-producing potentials than a limited record on a single stream. Designers would base their spillway design on these estimates, sometimes providing additional capacity as a safety factor. Some spillways were designed for a multiple of the maximum known flood, for example, twice the maximum known flood. The multiples and safety factors were based on engineering judgment; the degree of conservatism in the design was unknown.

By the 1930's, it became apparent that this approach was inadequate. As longer hydrologic records were obtained, new floods exceeded previously recorded maximum floods. With the introduction of the unit hydrograph concept by Sherman in 1933, it became possible to estimate floodflows from storm rainfall. The design of dams began to be based upon the transposition of major storms that had occurred within a region, *i.e.*,

transfer and centering of relevant storm rainfall patterns over the basin above the dam site being evaluated. It was recognized that flood peaks are dependent on topography, size of individual watersheds, and chance placement of the storm's center over the watershed. In addition, within meteorologically similar areas, observed maximum rainfall values could provide a better indication of maximum flood potentials than data on flood discharges from individual watersheds. If, in the judgment of the designer, the storm was not representative of what might occur, rainfall amounts were increased to represent a more severe event, and the dam was designed accordingly.

2. Transition. Engineers next turned to hydrometeorologists to determine if upper limits for rates of precipitation could be established on a rational basis. Careful consideration was given to the meteorology of storms that produced major floods in various parts of the country. The large scale features of the storm and measures of atmospheric moisture, such as dewpoint temperatures, were considered as well as the rainfall depth-area-duration values produced by these storms. It was then possible to increase the storm dewpoint temperature and other factors affecting rainfall to the maximum appropriate values. This increase resulted in estimates of probable maximum precipitation (PMP), and thus introduced the concept of a physical upper limit to precipitation. When translated to runoff, the estimated floodflow is known as the probable maximum flood (PMF).

At first, the terms maximum possible precipitation and maximum possible flood were used. However, the terminology was changed to probable maximum to recognize the uncertainties in the estimates of the amount of precipitation, and the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region. Today, the PMF is generally accepted as the standard for the safety design of dams where the incremental consequences of failure have been determined to be unacceptable.

In the late 1940's, the ability to estimate the consequences of dam failure, including the loss of life, was still quite limited. The height of the downstream flood wave and the extent of wave propagation were known to be a function of dam height and reservoir volume. Thus, early standards for dam design were based upon the size of the dam in terms of its height, the reservoir storage volume, and the downstream development.

The practice of setting inflow design flood standards based upon the size of a dam, its reservoir volume, and current downstream development resulted in an inconsistent level of design throughout the country. The determination of the consequences of a dam failure is more complex than can be evaluated by these simple relationships.

3. Current Practices. In 1985, the National Academy of Sciences (NAS) published a study of flood and earthquake criteria which contained an inventory of current practices in providing dam safety during extreme floods. The inventory showed considerable diversity in approach by various federal, state, and local government agencies,

professional societies, and private firms. While the inventory shows a fair consensus on spillway requirements for dams having a high-hazard potential, there is a wide range of criteria being applied to dams with lower hazard classifications.

Several observations about the evaluation of hydrologic conditions were made in the NAS study. Use of PMP for evaluating spillway capacity requirements for large, high-hazard dams predominates, although some state agencies have standards that do not require such dams to pass the full estimated PMF based on the PMP. The influence of the principal federal dam-building and dam safety agencies is evident in the majority of the standards for large, high-hazard dams, but the practices of those agencies have had less effect on current state standards for small dams in less hazardous situations.

As a result of inspections authorized by Public Law 92-367, the National Dam Inspection Act, and carried out by the U.S. Army Corps of Engineers from 1977 to 1981, several states have adopted the spillway capacity criteria used in those inspections. Several other states have adopted the standards used by the Natural Resources Conservation Service (formerly the Soil Conservation Service) for the design of smaller dams constructed under that agency's programs.

Most agencies draw a distinction between design criteria that are applied to existing dams and those that are applied to new dams. However, because dam failures present the same consequences to life and property, it is desirable that existing dams meet the criteria established for new dams.

Today, hydrologically safe designs should be based on current state-of-the-art criteria. Now that engineers can estimate downstream flood levels resulting from dam failure, safety design standards can be tied specifically to a detailed evaluation of the impacts of a flood if a dam were to fail. Although debate continues over the proper criteria and degree of conservatism warranted when evaluating and designing modifications to existing dams, and when designing new dams, criteria used by dam designers, regulators, and owners now focus on ensuring public safety.

C. Scope

1. General. These Guidelines are not intended to provide a complete manual of all procedures used for estimating inflow design floods; the selection of procedures is dependent upon available hydrologic data and individual watershed characteristics. All studies should be performed by an engineer experienced in hydrology and hydraulics, directed and reviewed by engineers experienced in dam safety, and should contain a summary of the design.

2. Philosophy and Principles. The basic philosophy and principles are described in sufficient detail to achieve a reasonable degree of uniformity in application, and to achieve a consistent and uniform nationwide treatment among federal agencies in the design of dams from the standpoint of hydrologic safety.

3. Content. The following topics are discussed in these Guidelines:

- Selecting the IDF - The selection of the appropriate IDF for a dam is related to the hazard potential classification and is the result of the incremental hazard evaluation.

- Accommodating the IDF - Site-specific considerations are necessary to establish hydrologic flood routing criteria for each dam and reservoir. The criteria for routing the IDF or any other flood should be consistent with the reservoir regulation procedure that is to be followed in actual operation.

II. DEFINITION OF TERMS

This chapter contains definitions of technical terms used in these Guidelines.

Breach: An opening through a dam which drains the reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional discharge from the reservoir.

Concurrent Inflows: Flows expected on tributaries to the river system downstream of the dam at the same time a flood inflow occurs.

Concurrent Floods: Flows expected on the river to which the river system with a dam is a tributary at the same time a flood inflow occurs at the reservoir.

Dam Failure: The catastrophic breakdown of a dam, characterized by the uncontrolled release of impounded water. There are varying degrees of failure.

Deterministic Methodology: A method in which the chance of occurrence of the variable involved is ignored and the method or model used is considered to follow a definite law of certainty, and not probability.

Dewpoint Temperature: The temperature at which dew begins to form or vapor begins to condense into a liquid.

Dynamic Routing: Hydraulic flow routing based on the solution of the St.-Venant Equation(s) to compute the changes of discharge and stage with respect to time at various locations along a stream.

Embankment Dam: Any dam constructed of excavated natural materials (includes both earthfill and rockfill dams).

Erosion: The wearing away of a surface (bank, streambed, embankment) by floods, waves, wind, or any other natural process.

Flashboards: Structural members of timber, concrete, or steel placed in channels or on the crest of a spillway to raise the reservoir water level but are intended to be quickly removed, tripped or fail, in the event of a flood.

Flood: A temporary rise in water surface elevation resulting in inundation of areas not normally covered by water. Hypothetical floods may be expressed in terms of average probability of exceedance per year such as one-percent-chance flood, or expressed as a fraction of the probable maximum flood or other reference flood.

Flood Plain: The downstream area that would be inundated or otherwise affected by the failure of a dam or by large flood flows.

Flood Routing: A process of determining progressively the amplitude of a flood wave as it moves past a dam and continues downstream.

Flood Storage: The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel.

Freeboard: Vertical distance between a specified stillwater reservoir surface elevation and the top of the dam, without camber.

Foundation: The portion of the valley floor that underlies and supports the dam structure.

Gate: A movable water barrier for the control of water.

Hazard: A situation which creates the potential for adverse consequences such as loss of life, property damage, or other adverse impacts. Impacts in the area downstream of a dam are defined by the flood waters released through spillways and outlet works of the dam or waters released by partial or complete failure of the dam. There may also be impacts upstream of the dam due to backwater flooding or landslides around the reservoir perimeter.

Hazard Potential Classification: A system that categorizes dams according to the degree of adverse incremental consequences of a failure or misoperation of a dam. The Hazard Potential Classification does not reflect in any way on the current condition of the dam (*i.e.*, safety, structural integrity, flood routing capacity).

Hydrograph, Flood: A graphical representation of the flood discharge with respect to time for a particular point on a stream or river.

Hydrology: One of the earth sciences that encompasses the natural occurrence, distribution, movement, and properties of the waters of the earth and their environmental relationships.

Hydrometeorology: The study of the atmospheric and land-surface phases of the hydrologic cycle with emphasis on the interrelationships involved.

Inflow Design Flood (IDF): The flood flow above which the incremental increase in downstream water surface elevation due to failure of a dam or other water impounding structure is no longer considered to present an unacceptable additional downstream threat. The IDF of a dam or other water impounding structures is the flood hydrograph

used in the design or evaluation of a dam, its appurtenant works, particularly for sizing the spillway and outlet works, for determining maximum height of a dam, freeboard, and flood storage requirements. The upper limit of the IDF is the probable maximum flood.

Intake: Placed at the beginning of an outlet-works waterway (power conduit, water supply conduit), the intake establishes the ultimate drawdown level of the reservoir by the position and size of its opening(s) to the outlet works. The intake may be vertical or inclined towers, drop inlets, or submerged, box-shaped structures. Intake elevations are determined by the head needed for discharge capacity, storage reservation to allow for siltation, the required amount and rate of withdrawal, and the desired extreme drawdown level.

Inundate: To overflow, to flood.

Inundation Map: A map showing areas that would be affected by flooding from an uncontrolled release of a dam's reservoir.

Landslide: The unplanned descent (movement) of a mass of earth or rock down a slope.

Maximum Wind: The most severe wind for generating waves that is reasonably possible at a particular reservoir. The determination will generally include results of meteorologic studies which combine wind velocity, duration, direction, fetch, and seasonal distribution characteristics in a realistic manner.

Meteorological Homogeneity: Climates and orographic influences that are alike or similar.

Meteorology: The science that deals with the atmosphere and atmospheric phenomena, the study of weather, particularly storms and the rainfall they produce.

One-Percent-Chance Flood: A flood that has 1 chance in 100 of being equaled or exceeded during any year.

Orographic: Physical geography that pertains to mountains and to features directly connected with mountains and their general effect on storm path and generation of rainfall.

Outlet Works: A dam appurtenance that provides release of water (generally controlled) from a reservoir.

Probable Maximum Flood (PMF): The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the drainage basin under study.

Probable Maximum Precipitation (PMP): Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location during a certain time of the year. Reservoir Regulation Procedure (Rule Curve): Refers to a compilation of operating criteria, guidelines, and specifications that govern the storage and release function of a reservoir. It may also be referred to as operating rules, flood control diagram, or water control schedule. These are usually expressed in the form of graphs and tabulations, supplemented by concise specifications and are often incorporated in computer programs. In general, they indicate limiting rates of reservoir releases required or allowed during various seasons of the year to meet all functional objectives of the project.

Reservoir Rim: The boundary of the reservoir including all areas along the valley sides above and below the water surface elevation associated with the routing of the IDF.

Risk: The relationship between the consequences resulting from an adverse event and its probability of occurrence.

Risk-based Analysis: A procedure in which the consequences and risks of adverse events and alternatives for mitigation are evaluated and arranged in a manner that facilitates a decision on the action to be taken. A risk-based analysis may be the basis for the selection of the IDF for a particular dam.

Seiche: An oscillating wave in a reservoir caused by a landslide into the reservoir or earthquake-induced ground accelerations or fault offset.

Sensitivity Analysis: An analysis in which the relative importance of one or more of the variables thought to have an influence on the phenomenon under consideration is determined.

Settlement: The vertical downward movement of a structure or its foundation.

Significant Wave Height: Average height of the one-third highest individual waves. May be estimated from wind speed, fetch length, and wind duration.

Spillway: A structure over or through which flow is discharged from a reservoir. If the rate of flow can be controlled by mechanical means, such as gates, it is considered a controlled spillway. If the geometry of the spillway is the only control, it is considered an uncontrolled spillway. Definitions of specific types of spillways follow:

> **Service Spillway:** A spillway that is designed to provide continuous or frequent regulated or unregulated releases from a reservoir without significant damage to either the dam or its appurtenant structures. This is also referred to as principal spillway.

Auxiliary Spillway: Any secondary spillway which is designed to be operated infrequently, possibly in anticipation of some degree of structural damage or erosion to the spillway that would occur during operation.

Emergency Spillway: A spillway that is designed to provide additional protection against overtopping of dams, and is intended for use under extreme flood conditions or misoperation or malfunction of the service spillway and/or the auxiliary spillway.

Spillway Capacity: The maximum spillway outflow which a dam can safely pass with the reservoir at its maximum level.

Stillwater Level: The elevation that a water surface would assume if all wave actions were absent.

Storm: The depth, area, and duration distributions of precipitation.

Storm Center: Location of the storm pattern such that the precipitation falls on a specific drainage basin to create the runoff at the site under consideration.

Storm Transposition: The application of a storm from its actual location of occurrence to some other area within the same region of meteorological homogeneity. Storm transposition requires the determination of whether the particular storm could occur over the area to which it is to be transposed.

Surcharge: The volume or space in a reservoir between the controlled retention water level and the maximum water level. Flood surcharge cannot be retained in the reservoir but will flow out of the reservoir until the controlled retention water level is reached.

Toe of the Dam: The junction of the downstream slope or face of a dam with the ground surface; also referred to as the **downstream toe**. The junction of the upstream slope with the ground surface is called the heel or the **upstream toe**.

Topographic Map: A detailed graphic delineation (representation) of natural and man-made features of a region with particular emphasis on relative position and elevation.

Tributary: A stream that flows into a larger stream or body of water.

Unit Hydrograph: A hydrograph with a volume of one inch of direct runoff resulting from a storm of a specified duration and areal distribution. Hydrographs from **other storms** of the same duration and distribution are assumed to have the same time base but with ordinates of flow in proportion to the runoff volumes.

Watershed: The area drained by a river or river system.

Wave Runup: Vertical height above the stillwater level to which water from a specific wave will run up the face of a structure or embankment.

Wind Setup: The vertical rise of the stillwater level at the face of a structure or embankment caused by wind stresses on the surface of the water.

III. SELECTING INFLOW DESIGN FLOODS

A. Introduction

Many thousands of dams have been constructed in the United States, and new dams continue to add to this total. The proper operation of dams to withstand natural forces, including extreme hydrologic events, is an important matter of public safety and concern.

In today's technical world, extreme hydrologic events resulting in dam failures are classified as "low-probability, high-consequence" events. In addition, the potential for losses due to increased downstream development may increase the consequences of a dam failure.

There has been a growing concern and increased attention to dam safety over the past two decades, primarily as a result of a number of catastrophic dam failures. As a result, the inspection of non-federal dams authorized by Public Law 92-367, the National Dam Inspection Act, identified some 2,900 unsafe dams of which 2,350 had inadequate spillway capacities. Since there are approximately 23,772 high and significant-hazard dams in the present National Inventory of Dams, the number of dams which have inadequate spillways could be significantly higher.

The adequacy of a spillway must be evaluated by considering the hazard potential, which would result from failure of the project works during flood flows. (See Chapter II for a definition of hazard potential.) If failure of the project works would present an unacceptable downstream threat, the project works must be designed to either withstand overtopping for the loading condition that would occur during a flood up to the probable maximum flood, or to the point where a failure would no longer cause an unacceptable additional downstream threat.

The procedures used to determine whether or not the failure of a project would cause an unacceptable downstream threat vary with the physical characteristics and location of the project, including the degree and extent of development downstream.

Analyses of dam failures are complex, with many historical dam failures not completely understood. The principal uncertainties in determining the outflow from a dam failure involve the mode and degree of failure. These uncertainties can be circumvented in situations where it can be shown that the complete and sudden removal of the dam would not result in unacceptable consequences. Otherwise, reasonable failure postulations and sensitivity analyses should be used. Suggested references regarding dam failure studies are listed in Appendix A. If it is judged that a more extensive mode of failure than that normally recommended for the type of structure under investigation is possible, then analyses should be done to determine whether remedial action is required. Sensitivity studies on the specific mode of failure should be performed when failure is due to overtopping.

B. Hazard Potential Evaluation

A properly designed, constructed, and operated dam can be expected to improve the safety of downstream developments during floods. However, the impoundment of water by a dam can

create a potential hazard to downstream developments greater than that which would exist without the dam because of the potential for dam failure. There are several potential causes of dam failure, including hydrologic, geologic, seismic, and structural.

These Guidelines are limited to the selection of the inflow design flood (IDF) for the hydrologic design of a dam.

1. General. Once a dam is constructed, the downstream hydrologic regime may change, particularly during floods. The change in hydrologic regime could alter land use patterns to encroach on a flood plain that would otherwise not be developed without the dam. **Consequently, evaluation of the consequences of dam failure must be based on the dam being in place, and must compare the impacts of with-failure and without-failure conditions on existing development and known and prospective future development when evaluating the downstream hazard potential.**

2. Hydrologic Modes of Failure. Many dam failures have resulted because of an inability to safely pass flood flows. Failures caused by hydrologic conditions can range from sudden, with complete breaching or collapse, to gradual, with progressive erosion and partial breaching.

The most common modes of failure associated with hydrologic conditions include overtop-ping, erosion of earth spillways, and overstressing the dam or its structural components. The following paragraphs describe briefly each of the modes of failure caused by hydrologic conditions.

a. Overtopping. Overtopping of a dam occurs when the water level in the reservoir exceeds the height of the dam and flows over the crest. Overtopping will not necessarily result in a failure. Failure depends on the type, composition, and condition of the dam and the depth and duration of flow over the dam.

Embankment dams are very susceptible to failure when overtopped because of potential erosion. If the erosion is severe, it can lead to a breach and failure of the dam. During overtopping, the foundation and abutments of concrete dams also can be eroded, leading to a loss of support and failure from sliding or overturning. In addition, when a concrete dam is subjected to overtopping, the loads can be substantially higher than those for which the dam was designed. If the increased loading on the dam itself due to overtopping is too great, a concrete dam can fail by overturning or sliding.

b. Erosion in Earth Spillways. High or large flows through earthen spillways adjacent to dams can result in erosion that progresses to the dam and threatens it. Erosion can also cause headcutting that progresses toward the spillway crest and eventually leads to a breach. Discontinuities in slope, nonuniform vegetation or bed materials, and concentrated flow areas can start headcuts and accelerate the erosion process. Flood depths that exceed the safe design parameters can produce erosive forces that may cause serious erosion in the spillway.

Erosion that occurs due to flow concentrations can start where roads or trails are devoid of vegetation or have ruts that run parallel to the spillway flow. A varied mix of earth materials, unlevel cross sections, uneven stands of vegetation, and obstructions such as trash accumulations can cause turbulent, concentrated flow conditions that start gullies that can widen and migrate upstream to breach the spillway crest.

Runoff brought into a spillway channel by a side inlet may also disrupt the desirable uniform flow pattern and increase the erosion in the channel.

The probability of failure of an earthen auxiliary spillway due to erosion is increased when the capacity of the service spillway inlets (outlet works) or gates are reduced due to trash accumulations. These accumulations reduce the available capacity through these appurtenances and increase the volume, depth, frequency, and duration of flow in the auxiliary spillway.

c. Overstressing of Structural Components. As flood flows enter the reservoir, the reservoir will normally rise to a higher elevation. Even though a dam (both concrete and earth embankment dams) may not be overtopped, the reservoir surcharge will result in a higher loading condition. If the dam is not properly designed for this flood surcharge condition, either the entire dam or the structural components may become overstressed, resulting in an overturning failure, a sliding failure, or a failure of specific structural components (such as the upstream face of a slab and buttress dam). Embankment dams may be at risk if increased water surfaces result in increased pore pressures and seepage rates, which exceed the seepage control measures for the dam.

3. Defining the Hazard Potential. The hazard potential is the possible adverse incremental consequences that result from the release of water or stored contents due to failure of the dam or misoperation of the dam or appurtenances. Hazard potential does not indicate the structural integrity of the dam itself, but rather the effects if a failure should occur. The hazard potential assigned to a dam is based on consideration of the effects of a failure during both normal and flood flow conditions.

Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environ-mental losses. Losses are principally limited to the owner's property.

Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

The hazard potential classification assigned to a dam should be based on the worst-case failure condition, *i.e.*, the classification is based on failure consequences resulting from the failure condition that will result in the greatest potential for loss of life and property damage. For example, a failure during normal operating conditions may result in the released water being confined to the river channel, indicating a low-hazard potential. However, if the dam were to fail during a floodflow condition, and the resultant incremental flood flow would be a potential loss of life or serious damage to property, the dam would have high-hazard potential classification.

In many cases, the hazard potential classification can be determined by field investigations and a review of available data, including topographic maps. However, when the hazard potential classification is not apparent from field reconnaissance, detailed studies, including dambreak analyses, are required. These detailed studies are required to identify the floodflow condition above which the additional incremental increase in elevation, due to failure of a dam, is no longer considered to present an unacceptable threat to downstream life and property.

The hazard potential classification of a project determines the level of engineering review and the criteria that are applicable. Therefore, it is critical to determine the appropriate hazard potential of a dam because it sets the stage for the analyses that must be completed to properly evaluate the integrity of any dam.

4. Evaluating the Consequences of Dam Failure.
There have been about 200 notable dam failures resulting in more than 8,000 deaths in the Twentieth Century. Dam failure is not a problem confined to developing countries or to a compilation of past mistakes that are unlikely to occur again.

Many dam owners have a difficult time believing that their dams could experience a rainfall many times greater than any they have witnessed over their lifetimes. Unfortunately, this attitude leads to a false sense of security because floods much greater than those experienced during any one person's lifetime can and do occur.

Estimates of the potential for loss of human life and the economic impacts of damage resulting from dam failure are the usual bases for defining hazard potential. Social and environmental impacts, damage to national security installations, and political and legal ramifications are not easily evaluated, and are more susceptible to subjective or qualitative evaluation. Because their actual impacts cannot be clearly defined, particularly in economic terms, their consideration as factors for determining the hazard potential must be on a case-by-case basis.

In most situations, the investigation of the impacts of failure on downstream life and property is sufficient to determine the appropriate hazard potential rating and to select the appropriate IDF for a project. However, in determining the appropriate IDF for a project, there could be

circumstances beyond loss of life and property damage, particularly when a failure would have minimal or no impact on downstream life and property, which would dictate using a more conservative hazard potential and IDF. For example, the reservoir of a dam that would normally be considered to have a low-hazard potential classification based on insignificant incremental increases (in elevation) due to a failure may be known to contain extensive toxic sediments. If released, those toxic sediments would be detrimental to the ecosystem. Therefore, a low-hazard potential classification would not be appropriate. Instead, a higher standard should be used for classifying the hazard potential and selecting the IDF.

5. Studies To Define the Consequences of Dam Failure.
The degree of study required to sufficiently define the impacts of dam failure for selecting an appropriate IDF will vary with the extent of existing and potential downstream development, the size of the reservoir (depth and storage volume), and type of dam. Evaluation of the river reach and areas impacted by a dam failure should proceed only until sufficient information is generated to reach a sound decision, or until there is a good understanding of the consequences of failure. In some cases, it may be apparent from a field inspection or a review of aerial photographs, Flood Insurance Rate Maps, and recent topographic maps, that consequences attrib-utable to dam failure would occur and be unacceptable. In other cases, detailed studies, including dambreak analyses, will be required. It may also be necessary to perform field surveys to determine the basement and first floor elevations of potentially affected habitable structures (such as residential and commercial).

When conducting dambreak studies, the consequences of the incremental increase due to failure under both normal (full reservoir with normal streamflow conditions prevailing) and floodflow conditions up to the point where a dam failure would no longer significantly increase the threat to life or property should be considered. For each flood condition, water surface elevations with and without dam failure, flood wave travel times, and rates of rise should be determined. This evaluation is known as an incremental hazard evaluation (See Appendix B, Flowchart 2). Since dambreak analyses and flood routing studies do not provide precise results, evaluation of the consequences of failure should be conservative.

The type of dam and the mechanism that could cause failure require careful consideration if a realistic breach is to be assumed. Special consideration should be given to the following factors:

- Size and shape of the breach
- Time of breach formation
- Hydraulic head
- Storage in the reservoir
- Reservoir inflow

In addition, special cases where a dam failure could cause *domino-like* failure of downstream dams resulting in a cumulative flood wave large enough to cause a threat should be considered.

The area affected by dam failure during a given flow condition on a river is the additional area inundated by the incremental increase in flood elevation due to failure over that which would occur normally by flooding without dam failure. The area affected by a flood wave resulting from a theoretical dam breach is a function of the height of the flood wave and the downstream distance and width of the river at a particular location. An associated and important factor is the flood wave travel time. These elements are primarily a function of the rate and extent of dam failure, but also are functions of channel and floodplain geometry and roughness and channel slope.

The flood wave should be routed downstream to the point where the incremental effect of a failure will no longer result in unacceptable additional consequences. When routing a dambreak flood through the downstream reaches, appropriate concurrent inflows should be considered in the computations. Downstream concurrent inflows can be determined using one of the following approaches:

- Concurrent inflows can be based on historical records if these records indicate that the tributaries contributing to the flood volume are characteristically in a flood stage at the same time that flood inflows to the reservoir occur. Concurrent inflows based on historical records should be adjusted so they are compatible with the magnitude of the flood inflow computed for the dam under study.

- Concurrent inflows can be developed from flood studies for downstream reaches when they are available. However, if these concurrent floods represent inflows to a downstream reservoir, suitable adjustments must be made to properly distribute flows among the tributaries.

- Concurrent inflows may be assumed equal to the mean annual flood (approximately bankfull capacity) for the channel and tributaries downstream from the dam. The mean annual flood can be determined from flood flow frequency studies. As the distance downstream from the dam increases, engineering judgment may be required to adjust the concurrent inflows selected.

In general, the study should be terminated when the potential for loss of life and property damage caused by routing floodflows appears limited. This point could occur when the following takes place:

- There are no habitable structures, and anticipated future development in the floodplain is limited.

- Floodflows are contained within a large downstream reservoir.

- Floodflows are confined within the downstream channel.

- Floodflows enter a bay or ocean.

The failure of a dam during a particular flood may increase the area flooded and also alter the flow velocity and depth of flow as well as the rate of rise of flood flows. These changes in flood flows could also affect the amount of damage. To fully evaluate the hazard created by a dam, a range of flood magnitudes needs to be examined. Water surface profiles, flood wave travel times, and rates of rise should be determined for each condition.

The results of the downstream routing should be clearly shown on inundation maps with the breach-wave travel time, maximum depth of flow, and maximum velocity, indicated at critical downstream locations. The inundation maps should be developed at a scale sufficient to identify downstream habitable structures within the impacted area. **The current recommended method for dambreak analysis is the unsteady flow and dynamic routing method used in the National Weather Service (NWS) model.**

Most of the methods used for estimating dambreak hydrographs, including the widely used NWS model, required selecting the size, shape, and time of formation of the dam breach as input parameters for the computations. Therefore, **sensitivity analyses are considered necessary.** Sensitivity analyses, based on varying flood inflow conditions and breach parameters, should be performed only to the extent necessary to make a decision.

Dambreak studies should be performed in accordance with accepted Guidelines. Refer to Appendix A for a list of sources of information related to dambreak studies.

6. Incremental Hazard Evaluation for Inflow Design Flood Determination. The appropriate IDF for a project is selected based on the results of the incremental hazard evaluation. This evaluation involves simulating a dam failure during normal and floodflow conditions and routing the water downstream. The additional down-stream threat due to the incremental increase in water surface elevation from dam failure is assessed for each failure scenario.

To evaluate the incremental increase in consequences due to dam failure, begin with the normal inflow condition and the reservoir at normal full reservoir level with normal streamflow conditions prevailing. That condition should be routed through the dam and downstream areas, with the assumption that the dam remains in place. The same flow should then be routed through the dam with the assumption that the dam fails.

The incremental increase in downstream water surface elevation between the with-failure and without-failure conditions should then be determined, *i.e.*, how much higher would the water downstream be if the dam failed than if the dam did not fail? The consequences that could result should then be identified. If the incremental rise in flood water downstream results in unacceptable additional consequences, assess the need for remedial action.

If the study under normal flow conditions indicates no adverse consequences, the same analyses should be done for several larger flood levels to determine the greatest unacceptable consequences. Under each incrementally larger inflow condition, identify the consequences of failure. For each larger assumed flood inflow condition (which can be percentages of the probable maximum flood (PMF)):

- assume the dam remains in place during the nonfailure conditions; and
- assume the dam fails when the *peak* reservoir elevation is attained for the assumed inflow condition.

It is not appropriate to assume that a dam fails on the rising limb of the inflow hydrograph. For example, current methods cannot accurately determine the extent of overtopping that an earth dam can withstand or how rapidly the dam will erode and ultimately breach from overtopping. Therefore, until such methodologies are available and proven, a conservative approach should be followed which assumes that failure occurs at the peak of the flood hydrograph. The assumption should also be made that the dam has been theoretically modified to contain or safely pass all lower inflow floods. This is an appropriate assumption because this procedure requires that the dambreak analyses start at the normal operating condition, with incremental increases in the flood inflow condition for each subsequent failure scenario up to the point where a failure no longer constitutes unacceptable additional consequences. In summary, before selecting larger floods for analysis, determine what failure at a lower flood constituted a threat to downstream life and property.

The above procedure should be repeated until the flood inflow condition is identified such that a failure at that flow or larger flows (up to the PMF) will no longer result in unacceptable additional consequences. The resultant flood flow is the IDF for the project. The maximum IDF is always the PMF, but in many cases the IDF will be substantially less than the PMF.

A PMF should be determined if it is needed for use in the evaluation. If a PMF value is already available, it should be reviewed to determine if it is still appropriate. The probable maximum precipitation (PMP) for the area should be determined either through the use of the Hydrometeorological Reports (HMR's) developed by the NWS or through the services of a qualified hydrometeorologist. In addition, the hydrologic characteristics of the drainage basin that would affect the runoff from the PMP into the reservoir should be determined. After this information is evaluated, the PMF can be determined.

Once the appropriate IDF for the dam has been selected (whether it is the PMF or something less), it should then be determined whether the dam can safely withstand or pass all floodflows up through the IDF. If it can, then no further evaluation or action is required. If it cannot, then measures must be taken to enable the project to safely accommodate all floods up through the IDF to alleviate the incremental increase in unacceptable additional consequences a failure may have on areas downstream.

It is important to investigate the full range of flood flow conditions to verify that a failure under flood flows larger than the selected IDF up through the PMF will not result in any additional hazard. In addition, once the design for remedial repairs is selected, the IDF should be verified for that design.

Appendix B provides specific guidance and procedures, including a comprehensive flowchart, for conducting an incremental hazard evaluation to select the appropriate IDF for a dam and determine the need for remedial measures.

7. Criteria for Selecting the Inflow Design Flood. Ideally, dams should be able to safely accommodate floodflows in a manner that will not increase the danger to life and property downstream. However, this situation is not always the case, and may not always be achievable.

There are various methods or reasons for selecting the inflow design flood and determining whether the dam can safely accommodate the flood. The method chosen may be determined by the amount of time and/or funds available to conduct an evaluation. For example, if time and funds are scarce, a conservative inflow design flood (*e.g.*, the PMF) can be selected.

Sometimes, inflow design flood selection is straightforward, *i.e.*, given certain criteria, a specific inflow design flood must be used, due to political decisions and policies established by government agencies. For example, statutes may require that a flood such as the PMF, a specific fraction of the PMF, or a flood of specific frequency be selected for a dam with a certain hazard classification. Fortunately, the most widely accepted approach involves incremental hazard evaluations to identify the appropriate IDF for a dam.

There is not a separate IDF for each section of a dam. A dam is assigned only **one** IDF, and it is determined based on the consequences of failure of the section of the dam that creates the greatest hazard potential downstream. This should not, however, be confused with the design criteria for different sections of a dam which may be based on the effect of their failure on downstream areas.

The PMF should be adopted as the IDF in those situations where consequences attributable to dam failure for flood conditions less than the PMF are unacceptable.

A flood less than the PMF may be adopted as the IDF in those situations where the consequences of dam failure at flood flows larger than the selected IDF are acceptable. In other words, where detailed studies conclude that the risk is only to the dam owners' facilities and no increased damage to downstream areas is created by failure, a risk-based approach is acceptable. Generally, acceptable consequences exist when evaluation of the area affected indicates the following:

- There are no permanent human habitations, known national security installations, or commercial or industrial developments, nor are such habitations or commercial or industrial developments projected to occur within the potential hazard area in the foreseeable future.

- There are permanent human habitations within the potential hazard area that would be affected by failure of the dam, but **there would be no significant incremental increase in the threat to life or property resulting from the occurrence of a failure during floods larger than the proposed IDF.** For example, if an impoundment has a small storage volume and failure would not add appreciably to the volume of the outflow flood hydrograph, it is likely that downstream inundation would be essentially the same with or without failure of the dam.

The consequences of dam failure may not be acceptable if the hazard potential to these habitations is increased appreciably by the failure flood wave or level of inundation. **When a dambreak analysis shows downstream incremental effects of approximately two feet or more, engineering judgment and further analysis will be necessary to finally evaluate the need for modification to the dam. In general, the consequences of failure are considered acceptable when the incremental effects (depth) of failure on downstream structures are approximately two feet or less. However, the two-foot increment is not an absolute decision-making point. Sensitivity analyses and engineering judgment are the tools used in making final decisions.** For example, if it is determined that a mobile home sitting on blocks can be moved and displaced by as little as six inches of water, then the acceptable incremental impact would be much less than two feet. As a second example, if a sensitivity analysis demonstrates that the largest breach width recommended is the only condition that results in an incremental rise of two feet, then engineering judgment becomes necessary to determine whether a smaller breach having acceptable consequences of failure is more realistic for the given conditions, *e.g.*, flow conditions, characteristics of the dam, velocity in vicinity of structures, location, and type of structures.

In addition, selection of the appropriate magnitude of the IDF may include consideration of whether a dam provides vital community services such as municipal water supply or energy. Therefore, a higher degree of protection may be required against failure to ensure those services are continued during and following extreme flood conditions when alternate services are unavailable. If losing such services is economically acceptable, the IDF can be less conservative. However, loss of water supply for domestic purposes may not be an acceptable public health risk.

Flood frequency and risk-based analyses may be used to hold operation and maintenance costs to a reasonable level, to maintain public confidence in owners and agencies responsible for dam safety, and to be in compliance with local, state, or other regulations

applicable to the facility. Generally, it would not be an appropriate risk to design a dam having a potential for failure at a flood frequency of less than once in 100 years.

When determining the effect flood inflows will have on dam safety, a hydrologic approach may be used. Simply stated, when determining the effect flood inflows will have on dam safety, the following approach establishes the IDF for the project, and either:

- determines whether an existing project can safely accommodate the IDF; or
- determines how a new project will be designed to safely accommodate the IDF.

Because the entire spectrum of floods up to the PMF level generally needs to be considered in selecting the IDF, it is usually necessary to determine the PMP magnitudes and to develop the PMF based on that information.

The effort involved in conducting PMP and PMF analyses is quite detailed. Depending on the significance of the study being pursued, these analyses should be directed by an engineer trained and experienced in this specialized field.

The incremental hazard evaluation procedure presented in the previous section is the most direct method for selecting an inflow design flood. However, there are times when selection becomes difficult and it may be necessary to conduct further analyses with a risk-based approach. The incremental hazard evaluation is, in essence, a risk-based approach.

C. PMFs for Dam Safety. The PMF is the upper limit of floods to be considered when selecting the appropriate IDF for a dam.

1. General. A deterministic methodology should be used to determine the PMF. In the deterministic methodology, a flood hydrograph is generated by modeling the physical atmospheric and drainage basin hydrologic and hydraulic processes. This approach attempts to represent the most severe combination of meteorologic and hydrologic conditions considered reasonably possible for a given drainage basin. The PMF represents an estimate of the upper limit of run-off that is capable of being produced on the watershed. Refer to Appendix A for a list of sources of information related to flood studies.

2. PMP. The concept that the PMP represents an upper limit to the level of precipitation the atmosphere can produce has been stated in many hydrometeorological documents. The commonly used approach in deterministic PMP development for non-orographic regions is to determine the limiting dew point temperature at the surface (used to obtain the moisture maximization factor) and to collect a "sufficient" sample of extreme storms. These extreme storms are moved to other parts of the study area. The latter are done through a method known as storm transposition, *i.e.,* the adjustment of moisture observed in a storm at its actual site of occurrence to the corresponding moisture level at the site from which the PMP is to be determined. Storm transposition is based on the concept that all storms within a meteorologically

homogeneous region could occur at any other location within that region with appropriate adjustments for effects of elevation and moisture supply. The maximized transposed storm values are then enveloped both depth-durationally and depth-areally to obtain PMP estimates for a specific basin. Several durations of PMP should be considered to ensure the most appropriate duration is selected.

In orographic regions, where local influences affect the delineation of meteorological homogeneity, transposition is generally not permitted. Alternative procedures are offered for these regions that are less reliant on the adequacy of the storm sample. Most of these procedures involve development of both nonorographic and orographic components (sometimes an orographic intensification factor is used) of the PMP. Orographic and nonorographic PMPs are then combined to obtain total PMP estimates for an orographic basin. Currently, generalized PMP estimates are available for the United States (see Figure 3).

As our understanding and the availability of data increases, the "particular" PMP estimates that appear in NWS HMRs may require adjustment to better define the conceptual PMP for a specific site. Therefore, **it may be appropriate to refine PMP estimates with site-specific or regional studies.** The results of available research, such as that developed by the Electric Power Research Institute, should be considered in performing site-specific studies. Because these studies can become very time consuming and costly, the benefit of a site-specific study must be considered carefully. Currently, generalized NWS PMP estimates are available for the entire conterminous United States, as well as Alaska, Hawaii, and Puerto Rico.

D. Floods To Protect Against Loss of Benefits During the Life of the Project - Applicable Only to Low-Hazard Dams

Dams identified as having a low-hazard potential should be designed to at least meet a minimum standard to protect against the risk of loss of benefits during the life of the project, hold operation and maintenance costs to a reasonable level, maintain public confidence in owners and agencies responsible for dam safety, and be in compliance with local, state, or other regulators applicable to the facility. Floods having a particular frequency may be used for this analysis. In general, it would not be appropriate to design a dam having a low-hazard potential for a flood having an average return frequency of less than once in 100 years.

IV. ACCOMMODATING INFLOW DESIGN FLOODS

A. Flood Routing Guidelines

1. General. Site-specific considerations should be used to establish flood routing criteria for each dam and reservoir. The criteria for routing any flood should be consistent with the reservoir regulation procedure that is to be followed in actual operation. The general guidelines to be used in establishing criteria are presented below and should be used if applicable.

2. Guidelines for Initial Elevations. In general, if there is no allocated or planned flood control storage (*i.e.*, run-of-river), the flood routing usually begins with the reservoir at the normal maximum pool elevation. If regulation studies show that pool levels would be lower than the normal maximum pool elevation during the critical inflow design flood (IDF) season, then the results of those specific regulation studies should be analyzed to determine the appropriate initial pool level for routing the IDF.

3. Reservoir Constraints. Flood routing criteria should recognize constraints that may exist on the maximum desirable water surface elevation. A limit or maximum water surface reached during a routing of the IDF can be achieved by providing spillways and outlet works with adequate discharge capacity. Backwater effects of floodflow into the reservoir must specifically be considered when constraints on water surface elevation are evaluated. Reservoir constraints may include the following:

- Topographic limitations on the reservoir stage which exceed the economic limits of dike construction; public works around the reservoir rim, which are not to be relocated, such as water supply facilities and sewage treatment plants; dwellings, factories, and other developments around the reservoir rim, which are not to be relocated. If there is a loss of storage capacity caused by sediment accumulation in portions of the reservoir, then this factor should be accounted for in routing the IDF. Sediment deposits in reservoir headwater areas may build up a delta, which can increase flooding in that area, as well as reduce flood storage capacity, thereby having an effect on routings.

- Geologic features that may become unstable when inundated and result in landslides, which would threaten the safety of the dam, domestic and/or other developments, or displace needed storage capacity.

- Flood plain management plans and objectives established under federal or state regulations and/or authorities.

4. Reservoir Regulation Requirements. Considerations to be evaluated when establishing flood routing criteria for a project include the following:

- Regulation requirements to meet project purposes, the need to impose a maximum regulated release rate to prevent flooding or erosion of downstream areas and control rate of drawdown, the need to provide a minimum regulated release capacity to recover flood control storage for use in regulating subsequent floods, the practicability of evacuating the reservoir for emergencies and for performing inspection, maintenance, and repair. Spillways, outlet works, penstocks, and navigation locks for powerplants are sized to satisfy project requirements and must be operated in accordance with specific instructions if these project works are relied upon to make flood releases, subject to the following limitations:

    - Only those release facilities which can be expected to operate reliably under the assumed flood condition should be assumed to be operational for flood routing. Reliability depends upon structural competence and availability for use. Availability and reliability of generating units for flood release during major floods should be justified. Availability of a source of auxiliary power, for gate operation, effects of reservoir debris on operability and discharge capacity of gates and other facilities, accessibility of controls, design limits on operating head, reliability of access roads, and availability of operating personnel at the site during floods are other factors to be considered in determining whether to assume release facilities are operational. A positive way of making releases to the natural watercourse by use of a bypass or wasteway must be available if canal outlets are to be considered available for making flood releases. Bypass outlets for generating units may be used if they are or can be isolated from the turbines by gates or valves.

    - In flood routing, assumed releases are generally limited to maximum values determined from project uses, by availability of outlet works, tailwater conditions including effects of downstream tributary inflows and wind tides, and downstream nondamaging discharge capacities until allocated storage elevations are exceeded. When a reservoir's capacity in regulating flows is exceeded, then other factors, particularly dam safety, will govern releases. During normal flood routing, the rate of outflow from the reservoir should not exceed the rate of inflow until the outflow begins to exceed the maximum project flood discharge capacity at normal pool elevation, nor should the maximum rate of increase of outflow exceed the maximum rate of increase of inflow. This is to prevent outflow conditions from being more severe than pre-dam conditions. An exception to the above would be where streamflow forecasts are available and pre-flood releases could reduce reservoir levels to provide storage for flood flows.

5. Evaluation of Domino-like Failure. If one or more dams are located downstream of the site under review, the failure wave should be routed downstream to determine if any of the

downstream dams would breach in a domino-like action. The flood routing of flows entering the most upstream of a series of such dams may be either dynamic or level pool. The routing through all subsequent downstream reservoirs should be a dynamic routing. Tailwater elevations should consider the effect of backwater from downstream constrictions.

B. Spillway and Flood Outlet Selection and Design

1. General. Spillways and flood outlets should be designed to safely convey major floods to the watercourse downstream from the dam. They are selected for a specific dam and reservoir on the basis of release requirements, topography, geology, dam safety, and project economics.

2. Gated or Ungated Spillways. An ungated spillway releases water when-ever the reservoir elevation exceeds the spillway crest level. A gated spillway can regulate releases over a broad range of water levels.

Ungated spillways are more reliable than gated spillways. Gated spillways provide greater operational flexibility. Operation of gated spillways and/or their regulating procedures should generally ensure that the peak flood outflow does not exceed the natural downstream flow that would occur without the dam.

The selection of a gated or ungated type of spillway for a specific dam depends upon site conditions, project purposes, economic factors, costs of operation and maintenance, the IDF itself, and other considerations.

The following paragraphs focus on considerations that influence the choice between gated and ungated spillways:

- Discharge capacity - For a given spillway crest length and maximum allowable water surface elevation, a gated spillway can be designed to release higher discharges than an ungated spillway because the crest elevation may be lower than the normal reservoir storage level. This is a consideration when there are limitations on spillway crest length or maximum water surface elevation.

- Project objectives and flexibility - Gated spillways permit a wide range of releases and have capability for pre-flood drawdown.

- Operation and maintenance - Gated spillways may experience more operational problems and are more expensive to construct and maintain than ungated spillways. Constant attendance or several inspections per day, by an operator during high water levels, is highly desirable for reservoirs with gated spillways, even when automatic or remote controls are provided. During periods of major flood inflows, the spillway should be closely monitored. Gated spillways are more subject to clogging from debris and jamming from ice, whereas properly designed ungated spillways are basically free from these problems. Gated spillways require regular maintenance and periodic testing of gate operations. However, ungated spillways can have flashboards, trip gates, and stop log

sections, which can have operational problems during floods and may require constant attendance or several inspections per day during high water levels.

- Reliability - The nature of ungated spillways reduces dam failure potential associated with improper operation and maintenance. Where forecasting capability is unreliable, or where time from the beginning of runoff to peak inflow is only a few hours, ungated spillways are more reliable, particularly for high-hazard structures. Consequences of failure of operation equipment or errors in operation can be severe for gated spillways.

- Data and control requirements - Operational decisions for gated spillways should have real time hydrologic and meteorologic data to make proper regulation possible.

- Emergency evacuation - Unless ungated spillways have removable sections, such as flashboards, trip gates, or stop log sections, they cannot be used to evacuate a reservoir during emergencies. The capability of gated spillways to draw down pools from the top of the gates to the spillway crest can be an advantage when emergency evacuation to reduce head on the dam is a concern.

- Economics and selection - Designs to be evaluated should be technically adequate alternatives. Economic considerations often indicate whether gated or ungated spillways are selected. The possibility of selecting a combination of more than one type of spillway is also a consideration. Final selection of the type of crest control should be based on a comprehensive analysis of all pertinent factors, including advantages, disadvantages, limitations, and feasibility of options.

3. Design Considerations. Dams and their appurtenant structures should be designed to give satisfactory performance. These Guidelines identify three specific classifications of spillways (service, auxiliary, and emergency) and outlet works that are used to pass floodwaters, each serving a particular function. The following paragraphs discuss functional requirements.

Service spillways should be designed for frequent use and should safely convey releases from a reservoir to the natural watercourse downstream from the dam. -Considerations must be given to waterway free-board, length of stilling basins, if needed, and amount of turbulence and other performance characteristics. It is acceptable for the crest structure, discharge channel (*e.g.*, chute, conduit, tunnel), and energy dissipator to exhibit marginally safe performance characteristics for the IDF. However, they should exhibit excellent performance characteristics for frequent and sustained flows, such as up to the 1-percent chance flood event. Other physical limitations may also exist that have an effect on spillway sizing.

Auxiliary spillways are usually designed for infrequent use and it is acceptable to sustain limited damage during passage of the IDF. The design of auxiliary spillways should be based on economic considerations and should be subject to the following requirements:

- The auxiliary spillway should discharge into a watercourse sufficiently separated from the abutment to preclude abutment damage and should discharge into the main stream a sufficient distance downstream from the toe of the dam so that flows will not endanger the dam's structural integrity or usefulness of the service spillway. The auxiliary spillway channel should either be founded in competent rock or an adequate length of protective surfacing should be provided to prevent the spillway crest control from degrading to the extent that it results in an unacceptable loss of conservation storage or a large uncontrolled discharge which exceeds peak inflow.

Emergency spillways may be used to obtain a high degree of hydrologic safety with minimal additional cost. Because of their infrequent use, it is acceptable for them to sustain significant damage when used and they may be designed with lower structural standards than those used for auxiliary spillways.

An emergency spillway may be advisable to accommodate flows resulting from misoperation or malfunction of other spillways and outlet works. Generally, they are sized to accommodate a flood smaller than the IDF. The crest of an emergency spillway should be set above the normal maximum water surface (attained when accommodating the IDF) so it will not overflow as a result of reservoir setup and wave action. The design of an emergency spillway should be subject to the following limitations:

- The structural integrity of the dam should not be jeopardized by spillway operation. Large conservation storage volumes should not be lost as a result of degradation of the crest during operation. The effects of a downstream flood resulting from uncontrolled release of reservoir storage should not be greater than the flood caused by the IDF without the dam.

Outlet works used in passing floods and evacuating reservoir storage space should be designed for frequent use and should be highly reliable. Reliability is dependent on foundation conditions, which influence settlement and displacement of waterways, on structural competence, on susceptibility of the intake and conduit to plugging, on hydraulic effects of spill-way discharge, and on operating reliability.

C. Freeboard Allowances

1. General. Freeboard provides a margin of safety against overtopping failure of dams. It is generally not necessary to prevent splashing or occasional overtopping of a dam by waves under extreme conditions. However, the number and duration of such occurrences should not threaten the structural integrity of the dam, interfere with project operation, or create hazards to personnel. Freeboard provided for concrete dams can be less conservative than for embankment

dams because of their resistance to wave damage or erosion. If studies demonstrate that concrete dams can withstand the IDF while overtopped without significant erosion of foundation or abutment material, then no freeboard should be required for the IDF condition. Special consideration may be required in cases where a powerplant is located near the toe of the dam. The U.S. Bureau of Reclamation has developed guidelines (See Appendix A) that provide criteria for freeboard computations.

Normal freeboard is defined as the difference in elevation between the top of the dam and the normal maximum pool elevation. Minimum freeboard is defined as the difference in pool elevation between the top of the dam and the maximum reservoir water surface that would result from routing the IDF through the reservoir. Intermediate freeboard is defined as the difference between intermediate storage level and the top of the dam. Intermediate freeboard may be applicable when there is exclusive flood control storage.

2. Freeboard Guidelines. Following are guidelines for determining appropriate freeboard allowances:

- Freeboard allowances should be based on site-specific conditions and the type of dam (concrete or embankment). Both normal and minimum freeboard requirements should be evaluated in determining the elevation of the top of the dam. The resulting higher top of dam elevation should be adopted for design. Freeboard allowances for wind-wave action should be based upon the most reliable wind data available that are applicable to the site. The significant wave should be the minimum used in determining wave runup, and the sum of wind setup and wave runup should be used for determining requirements for this component of freeboard.

- Computations of wind-generated wave height, setup, and runup should incorporate selection of a reasonable combined occurrence of pool level, wind velocity, wind direction, and wind durations based on site-specific studies. It is highly unlikely that maximum winds will occur when the reservoir water surface is at its maximum elevation resulting from routing the IDF, unless the reservoir capacity is small compared to flood volume because the maximum level generally persists only for a relatively short period of time (a few hours). Consequently, winds selected for computing wave heights should be appropriate for the short period the pool would reside at or near maximum levels. Normal pool levels persist for long periods of time. Consequently, maximum winds should be used to compute wave heights.

- Freeboard allowance for settlement should be applied to account for consolidation of foundation and embankment materials when uncertainties exist in computational methods or data used yield unreliable values for camber design. Freeboard allowance for settlement should not be applied where an accurate determination of settlement can be made and is included in the camber. Freeboard allowance for embankment dams for estimated earthquake-generated movement, resulting seiches, and permanent embankment displacements or deformations should be considered if a dam is located in

an area with potential for intense seismic activity. Reduction of freeboard allowances on embankment dams may be appropriate for small fetches, obstructions that impede wave generation, special slope and crest protection, and other factors.

- Freeboard allowance for wave and volume displacement due to potential landslides, which cannot be economically removed or stabilized, should be considered if a reservoir is located in a topographic setting where the wave or higher water resulting from displacement may be destructive to the dam or may cause serious downstream damage.

- Total freeboard allowances should include only those components of freeboard which can reasonably occur simultaneously for a particular water surface elevation. Components of freeboard and combinations of those components, which have a reasonable probability of simultaneous occurrence, are listed in the following paragraphs for estimating minimum, normal, and intermediate freeboards. The top of the dam should be established to accommodate the most critical combination of water surface and freeboard components from the following combinations.

For **minimum** freeboard combinations, the following components, when they can reasonably occur simultaneously, should be added to determine the total minimum freeboard requirement:

- Wind-generated wave runup and setup for a wind appropriate for the maximum reservoir stage for the IDF.

- Effects of possible malfunction of the spillway and/or outlet works during routing of the IDF.

- Settlement of embankment and foundation not included in crest camber.

- Landslide-generated waves and/or displacement of reservoir volume (only cases where landslides are triggered by the occurrence of higher water elevations and intense precipitation associated with the occurrence of the IDF).

For **normal** freeboard combinations, the most critical of the following two combinations of components should be used for determining normal freeboard requirements:

Combination 1 -

- Wind-generated wave runup and setup for maximum wind, and settlement of embankment and foundation not included in camber.

Combination 2 -

- Landslide-generated waves and/or displacement of reservoir volume, settlement of embankment and foundation not included in camber, and settlement of embankment and foundation or seiches as a result of the occurrence of the maximum credible earthquake.

For **intermediate** freeboard combinations, in special cases, a combination of inter-mediate winds and water surface between normal and maximum levels should be evaluated to determine whether this condition is critical. This may apply where there are exclusive flood control storage allocations.

Appendix A - References By Topic

Flood Studies

A. American Nuclear Society, "Determining Design Basis Flooding at Power Reactor Sites," ANSI/ANS-2.8-, 1981.

B. Cudworth, Arthur G., Jr., Flood Hydrology Manual, U.S. Department of the Interior, Bureau of Reclamation, Denver Office, 1989.

C. Federal Energy Regulatory Commission, Chapter 8, "Determination of the Probable Maximum Flood," 1993.

D. Federal Energy Regulatory Commission, Engineering Guidelines for the Evaluation of Hydropower Projects, Chapter 2, "Selecting and Accommodating Inflow Design Floods for Dams," October 1993.

E. Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations, September 1990.

F. Hydrologic Engineering Center, Flood Emergency Plans, Guidelines for Corps Dams, June 1980.

G. Hydrology Subcommittee, Estimating Peak Flow Frequencies for Natural Ungaged Watersheds, a Proposed Nationwide Test, U.S. Water Resources Council, 346 pp, 1981.

H. Hydrology Subcommittee, Guidelines for Determining Flood Flow Frequency, Hydrology Subcommittee Bulletin 17B, with editorial corrections, Interagency Advisory Committee on Water Data, U.S. Geological Survey, 28 pp., 1982.

I. Interagency Committee on Water Data, Feasibility of Assigning a Probability to the Probable Maximum Flood, Prepared by Working Group of Hydrology Committee, 1985 Draft.

J. International Symposium on Flood Frequency and Risk Analyses at Louisiana State University, Baton Rouge, LA, May 14-17, 1986.

K. Lane, W. L., Rare Flood Frequency Estimation, a Case Study of the Pecos River, (Abstract), EOS Transactions of AGU, 66(18), 267, 1985.

L. Myers, V.A., "The Estimation of Extreme Precipitation as the Basis for Design Floods - Resume of Practice in the United States," Proceedings of the Leningrad Symposium on Floods and Their Computation, August 1967, Vol. 1, International Association of Scientific Hydrology, Gentbrugge, Belgium, 84-101, 1969.

M. Naef, F., Can We Model the Rainfall-Runoff Process Today?, Hydrological Sciences Bulletin, 26, 1981.

N. Powledge, G. R. and D. L. Sveum, Overtopping Embankment Dams--An Alternative in Accommodating Rare Floods?, Paper presented at the ICOLD meeting, San Francisco, 1988.

O. Reidel, J. T. and L. C. Shreiner, "Comparison Of Generalized Estimates Of Probable Maximum Precipitation With Greatest Observed Rainfall," NOAA Technical Report NWS 25, National Weather Service/National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland, 1980.

P. U.S. Army Corps of Engineers, "Inflow Design Floods for Dams and Reservoirs," Engineer Regulation No. 1110-8-2 (FR), 1991.

Q. U.S. Army Corps of Engineers, "Water Levels and Wave Heights for Coastal Engineering Design," Engineer Manual No, 1110-2-1414, 1989.

R. U.S. Bureau of Reclamation, Training Aids for Dam Safety, Module: Evaluation of Hydrologic Adequacy, Technical Service Center, Denver, CO, 1990.

S. U.S. Department of Commerce, "Meteorological Estimation of Extreme Precipitation for Spillway Design Floods," Myers, V. A., Weather Bureau Technical Memorandum WBTM HYDRO-5, Environmental Science Services Administration, Office of Hydrology, Washington, D.C., 1967.

Selecting and Accommodating Inflow Design Floods Studies

A. American Society of Civil Engineers, "Evaluation Procedures for Hydrologic Safety of Dams," Report by the Task Committee on Spillway Design Flood Selection, Committee on Surface Water Hydrology, Hydraulics Division, New York, New York, 1988.

B. Chow, V. T., Open Channel Hydraulics, McGraw-Hill Book Company, Inc., New York, Chapter 20, 1959.

C. Committee on Safety Criteria for Dams, Safety of Dams - Flood and Earthquake Criteria, Prepared under the Auspices of Water Science and Technology Board, Commission on Engineering and Technical Systems, National Research Council, Washington, D.C., National Academy Press, 374 pp., 1985.

D. Federal Energy Regulatory Commission, Engineering Guidelines for the Evaluation of Hydropower Projects, Chapter 2, "Selecting and Accommodating Inflow Design Floods for Dams," October 1993.

E. Henderson, F. M., Open Channel Flow, McMillan Company, New York, Chapters 8 and 9, 1966.

F. Hydrologic Engineering Center, UNET, One-Dimensional Unsteady Flow Through a Full Network of Open Channels, September 1992.

G. National Research Council, Safety of Existing Dams: Evaluation and Improvement, Committee on the Safety of Existing Dams, Water Science and Technology Board, Commission on Engineering and Technical Systems, National Academy Press, Washington, D.C., 1983.

H. Powledge, G. R. and D. L. Sveum, Overtopping Embankment Dams--An Alternative In Accommodating Rare Floods?, Paper presented at the ICOLD meeting, San Francisco, 1988.

Dam Failure/Dambreak Studies

A. Cecilio, C. B. and A. G. Strassburger, Downstream Hydrograph from Dam Failure, Engineering Foundation Conference on Evaluation of Dam Safety, 1976.

B. Federal Energy Regulatory Commission, Engineering Guidelines for the Evaluation of Hydropower Projects, Chapter 2, "Selecting and Accommodating Inflow Design Floods for Dams," October 1993.

C. Fread, D. L., DAMBRK - The NWS Dam-Break Flood Forecasting Model, National Weather Service, Silver Spring, Maryland, 1988 Version.

D. Fread, D. L., "NWS FLDWAV Model: The Replacement of DAMBRK for Dam-Break Flood Prediction," Proceedings, Association of State Dam Safety Officials, 10th Annual Conference, Kansas City, Missouri, September 26-29, 1993.

E. Fread, D. L., "The Development and Testing of a Dam-Break Flood Forecasting Model," Proceedings, Dam-Break Flood Modeling Workshop, U.S. Water Resources Council, Washington, D.C., pp. 164-197, 1977.

F. Gandlach, D. L. and W. A. Thomas, "Guidelines for Calculating and Routing a Dam-Break Flood," Research Note No. 5, U.S. Army Corps of Engineers, Hydrologic Engineering Center, 1977.

G. Soil Conservation Service, Simplified Dam-Breach Routing Procedure, (To be used only for flood routing technique, not dambreak discharge), March 1979.

H. U.S. Bureau of Reclamation, "Freeboard Criteria and Guidelines for Computing Freeboard Allowances for Storage Dams," ACER Technical Memorandum No. 2., 1981.

I. U.S. Bureau of Reclamation, Training Aids for Dam Safety, Module: Evaluation of Hydrologic Adequacy, Technical Service Center, Denver, CO, 1990.

J. Westmore, Jonathan N. and Danny L. Fread, The NWS Simplified Dam-Break Flood Forecasting Model, National Weather Service, Silver Spring, Maryland, 1981.

Appendix B – Inflow Design Flood Selection Procedures

IDF SELECTION PROCEDURES: OVERVIEW

HOW IS THE IDF SELECTED?

The purpose of this Appendix is to describe the procedures used to select the appropriate inflow design flood (IDF) for a dam, and to determine the need for remedial action. These procedures are presented in two flowcharts. The first flowchart describes the steps needed to determine:

- **If the probable maximum flood (PMF) was used in the original design of the dam.**
- **If the PMF or some lesser flood is the appropriate IDF.**
- **Whether remedial action at the dam is needed to enable it to safely accommodate the appropriate IDF.**

To determine whether the PMD or some lesser flood is the appropriate IDF, it may be necessary to conduct an incremental hazard evaluation. This process is presented in the second flowchart.

Following each flowchart is a breakdown of the procedures. Each block is presented individually, and includes an explanation of the steps taken.

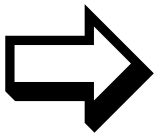
IDF SELECTION PROCEDURES: SELECTING THE APPROPRIATE IDF

INTRODUCTION

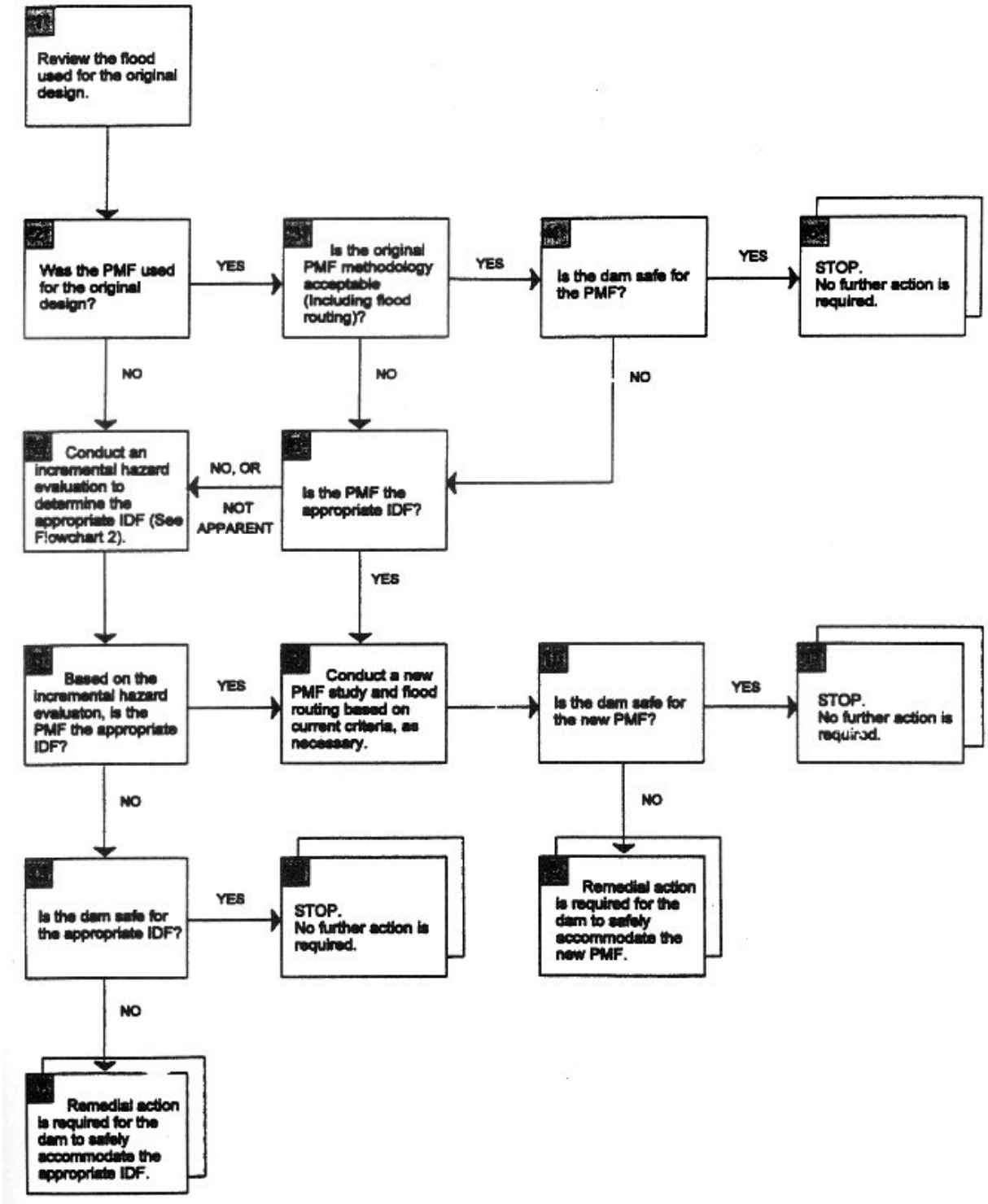
PROCEDURES FOR DETERMINING THE APPROPRIATE IDF AND THE NEED FOR REMEDIAL ACTION

Flowchart 1 presents a logical, step-by-step approach for evaluating the hydrologic design of an existing dam, and determining the appropriate IDF for the dam and whether remedial action is needed in order for the dam to safely accommodate the IDF.

Flowchart 1 is on the next page.



FLOWCHART 1 – PROCEDURES FOR DETERMINING THE APPROPRIATE INFLOW DESIGN FLOOD (IDF) AND THE NEED FOR REMEDIAL ACTION



IDF SELECTION PROCEDURES: DETERMINING THE APPROPRIATE IDF

EXPLANATION OF FLOWCHART 1 **– An explanation of the IDF flowchart is presented below.**

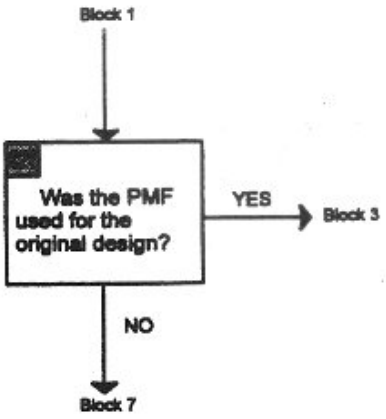
Block 1



The initial step in selecting the appropriate IDF and determining the need for dam safety modification is to review the basis for the original hydrologic design of an existing dam. This information will provide valuable insight regarding whether the flood originally used for design purposes satisfies current criteria or whether detailed investigations and analyses will be required to determine the appropriate IDF for the dam.

In those situations where the original design information has been lost, detailed investigations and analyses will normally be required.

Block 2

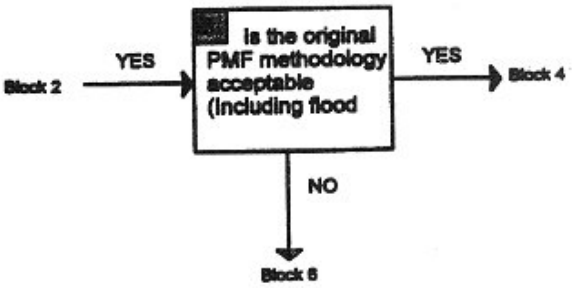


Once you have identified the basis for the original hydrologic design, the next step is to determine if the flood used for the original design is the probable maximum flood (PMF). This question is important, since the upper limit of the IDF is the PMF.

If your answer is YES, continue to Block 3.

If your answer is NO, go to Block 7. In Block 7 you will perform an incremental hazard evaluation to determine the appropriate IDF.

Block 3



To ensure the reliability of the original PMF study or the assumptions made on the various parameters affecting the study, it is necessary to determine if the PMF methodology originally used is still acceptable under current criteria.

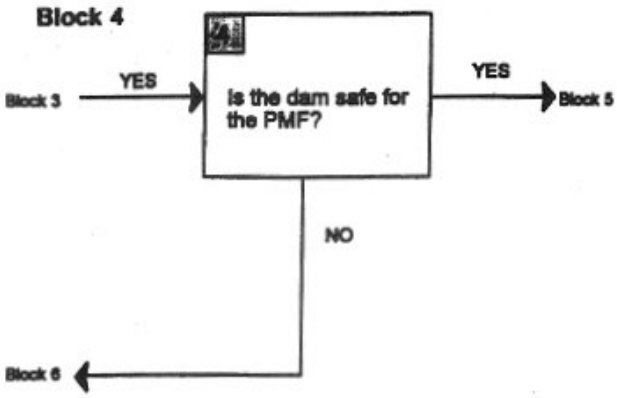
If your answer is YES, continue to Block 4.

If your answer is NO, go to Block 6. In Block 6, you will answer the question: Is the PMF the appropriate IDF?

Continued…

IDF SELECTION PROCEDURES: DETERMINING THE APPROPRIATE IDF

EXPLANATION OF FLOWCHART 1 (Continued)

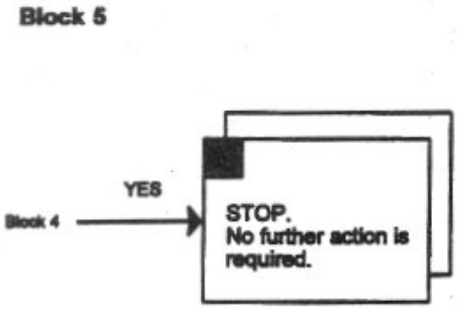


Determine if the dam is safe for the PMF. Your answer to this question will indicate whether remedial action will be required.

If your answer is YES, continue to Block 5.

If your answer is NO, go to Block 6. In Block 6, you will answer the question:

Is the PMF the appropriate IDF?



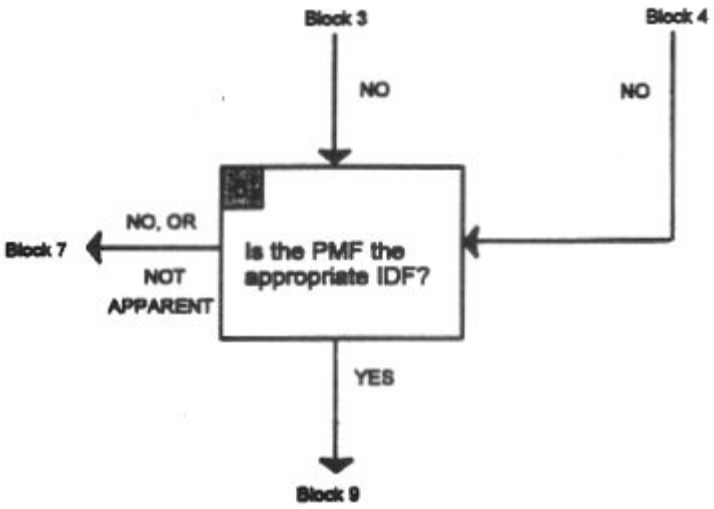
If the PMF is considered to be the appropriate IDF for the dam, no further investigations or remedial work for hydrologic conditions will be required.

Continued…

IDF SELECTION PROCEDURES: DETERMINING THE APPROPRIATE IDF

EXPLANATION OF FLOWCHART 1 (Continued)

Block 6



IF…

In Block 3 you determined that the original PMF methodology is NOT acceptable,

OR…

In Block 4 you determined that the dam is NOT safe for the PMF,

THEN…

You need to determine if the PMF is the appropriate IDF.

In some cases, such as when the dam is totally submerged during the PMF, it may be obvious that the appropriate IDF is something less than the PMF. In other cases, it will not be apparent whether the IDF should be the PMF or something less. In these two cases, it will be necessary to perform an incremental hazard evaluation to determine the appropriate IDF for the dam. Continue to Block 7.

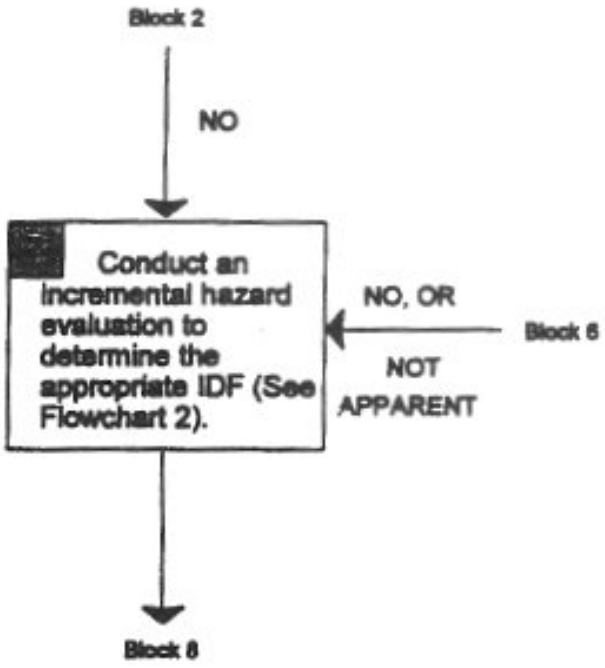
Sometimes, based on the size and volume of the dam and reservoir, the proximity of the dam to downstream communities, or even because of political decisions, it will be obvious that the IDF should be the PMF. If this is the case, a new PMF study will be required. Go to Block 9.

Continued…

IDF SELECTION PROCEDURES: DETERMINING THE APPROPRIATE IDF

EXPLANATION OF FLOWCHART 1 (Continued)

Block 7



IF…

In Block 2 you determined that the flood used in the original design is NOT the PMF,

OR…

In Block 6, you determined that it is obvious that the IDF should be less than the PMF or it is not apparent if the IDF should be the PMF or something less,

THEN…

You need to perform an incremental hazard evaluation to determine the appropriate IDF. Performing the incremental hazard evaluation involves:

Conducting dambreak sensitivity studies, reviewing incremental rises between with-failure and without-failure conditions for a range of flood inflows (see Flowchart 2), and

Selecting the appropriate IDF on the basis of the dambreak studies and incremental impacts on downstream areas.

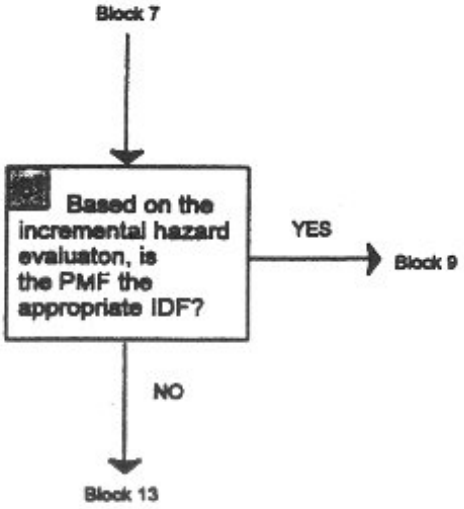
A procedural flowchart for performing a hazard evaluation appears in Flowchart 2, followed by an explanation of the procedure.

Continued…

IDF SELECTION PROCEDURES: DETERMINING THE APPROPRIATE IDF

EXPLANATION OF FLOWCHART 1 (Continued)

Block 8



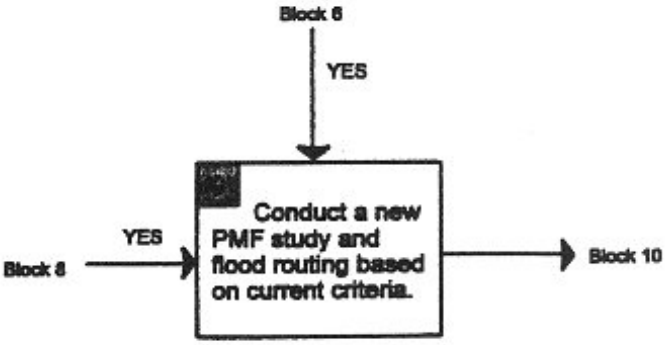
You should use the results of the incremental hazard evaluation and dambreak studies conducted in Block 7 to determine if the PMF is the appropriate IDF.

The IDF should be the PMF when the incremental consequences of failure are unacceptable, regardless of how large the assumed flood inflow becomes.

If your answer is YES, continue to Block 9.

If your answer is NO, go to Block 13. In Block 13 you will answer the question: Is the dam safe for the appropriate IDF?

Block 9



IF…

In Block 6 you determined that the PMF is obviously the appropriate IDF,

OR…

If, based on the incremental hazard evaluation conducted in Block 8, the PMF is the appropriate IDF,

THEN…

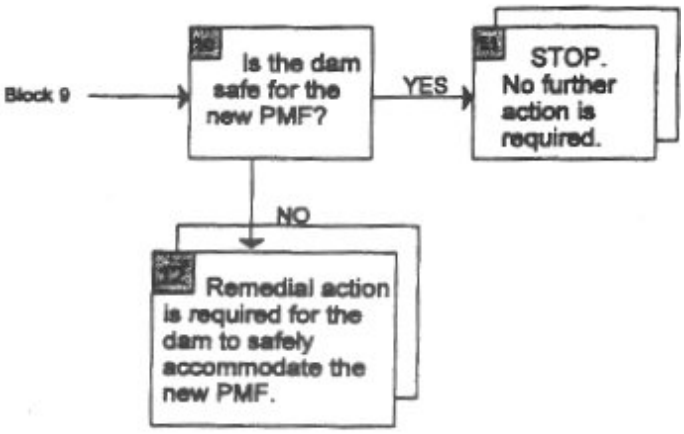
You should conduct a new PMF study and flood routing based on current criteria, unless it was determined in Block 3 that the original PMF is acceptable under current criteria.

Continued…

IDF SELECTION PROCEDURES: DETERMINING THE APPROPRIATE IDF

EXPLANATION OF FLOWCHART 1 (Continued)

Blocks 10, 11, And 12

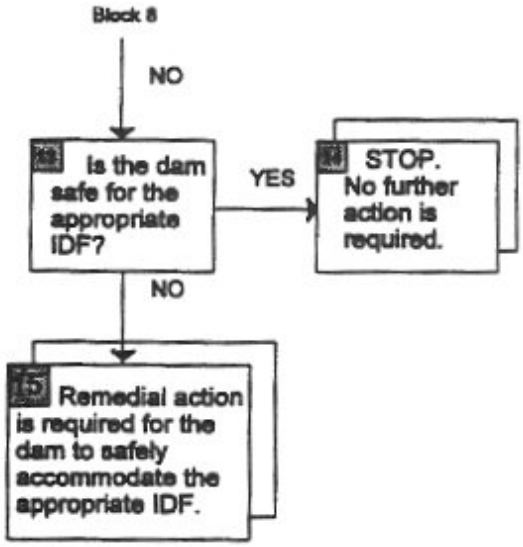


Once the new PMF is calculated, you should determine if the dam is safe for the new PMF.

If the dam is SAFE for the new PMF no further investigations or remedial actions for hydrologic conditions are required.

If the dam is NOT SAFE for the new PMF, remedial action is required for the dam to safely accommodate the PMF.

Blocks 13, 14, And 15



IF…

In Block 8 you determined that the PMF is NOT the appropriate IDF,

THEN…

You need to determine if the dam is safe for the appropriate IDF.

If the dam is SAFE for the appropriate IDF, no further investigations or remedial action for hydrologic conditions are required.

If the dam is NOT SAFE for the appropriate IDF, remedial action is required for the dam to safely accommodate the appropriate IDF.

Depending on the type of remedial action considered, it may be necessary to reevaluate the IDF to ensure that the appropriate IDF has been selected for the design of any modification.

IDF SELECTION PROCEDURES: PERFORMING A HAZARD EVALUATON

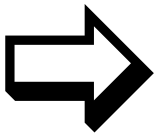
INTRODUCTION

As stated previously, if the PMF was not used for the original design of a dam, or if the PMF is not the appropriate IDF, an incremental hazard evaluation must be performed to determine the appropriate IDF.

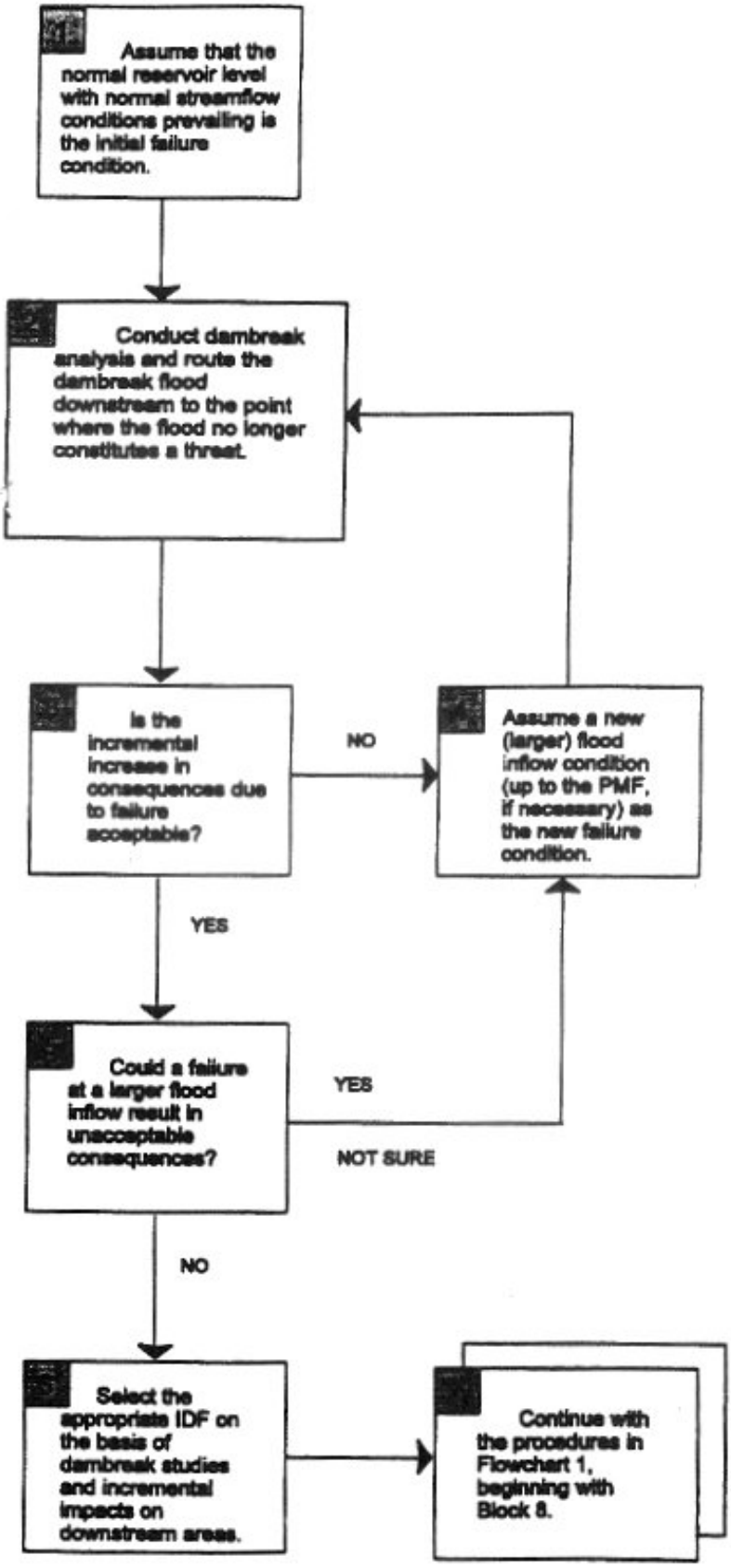
PROCEDURES FOR CONDUCTING AN INCREMENTAL HAZARD EVALUATION

Flowchart 2 shows the procedures for performing an incremental hazard evaluation. This flowchart is an expansion of Block 7 in Flowchart 1.

Flowchart 2 is on the next page.



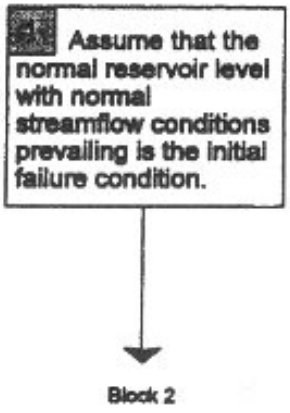
FLOWCHART 2 – PROCEDURES FOR CONDUCTING AN INCREMENTAL HAZARD EVALUATION



IDF SELECTION PROCEDURES: PERFORMING A HAZARD EVALUATON

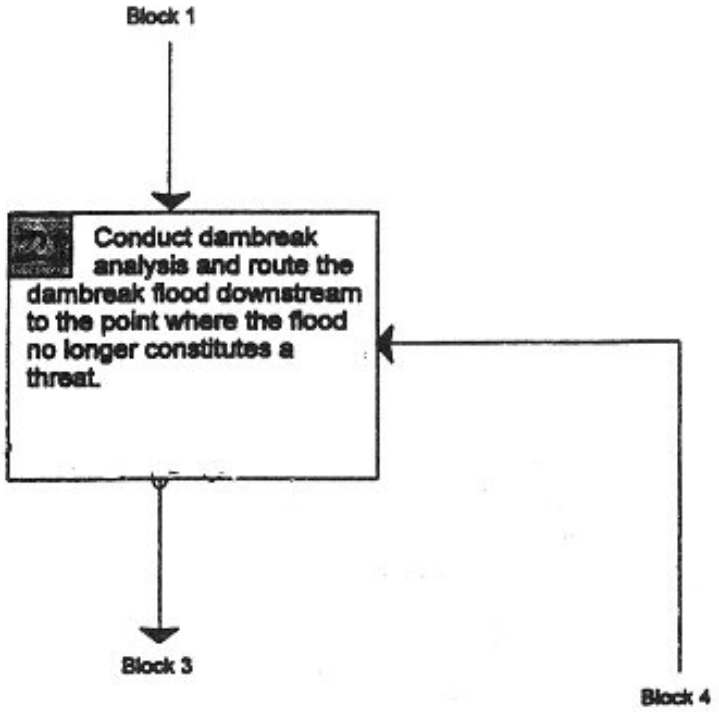
EXPLANATION OF FLOWCHART 2 **– An explanation of the Hazard Evaluation Flowchart is presented below.**

Block 1



Assume that the normal reservoir level with normal streamflow conditions prevailing is the initial failure condition. Starting at this point will ensure that the full range of flood inflow conditions will be investigated and will include the "sunny day" failure condition. It will also assist in verifying the initial hazard assigned to the dam. Using the normal maximum water surface level as the initial condition is particularly important if the initial hazard rating was low.

Block 2



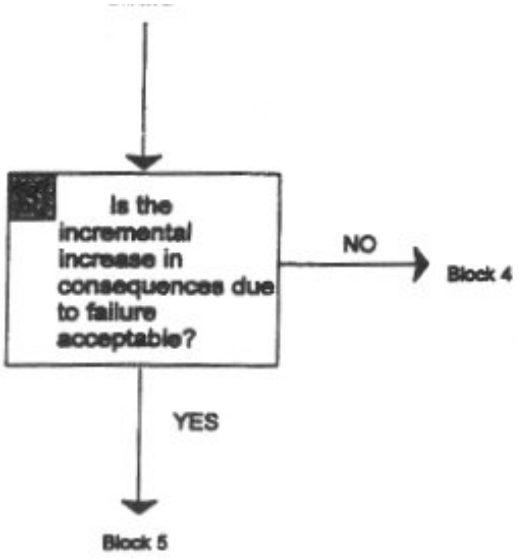
Next, conduct dambreak sensitivity studies (of various breach parameters) and route the dambreak flood to the point downstream where it no longer constitutes a threat to downstream life and property.

It is important to remember that the incremental increases should address the differences between the nonfailure condition with the dam remaining in place and the failure condition. Also, the dam should not be assumed to fail until the peak reservoir water surface elevation is attained for the assumed flood inflow condition being analyzed. Dams should be assumed to fail as described in these guidelines.

Continued…

IDF SELECTION PROCEDURES: PERFORMING A HAZARD EVALUATON

EXPLANATION OF FLOWCHART 2 (continued)

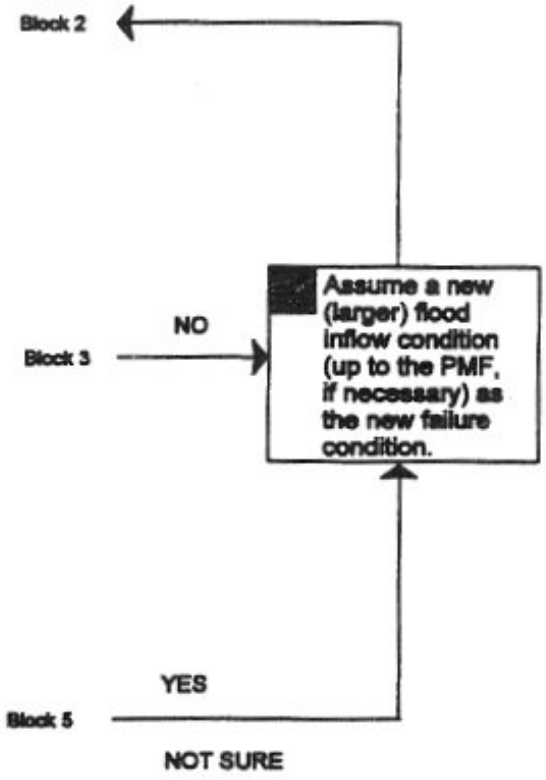


Now, determine – if the additional increase in consequences due to failure is acceptable. Answering this question is critical in the incremental hazard evaluation, and doing so involves an estimate of loss of life and property with and without dam failure.

If the consequences of failure under the assumed floodflow condition are NOT ACCEPTABLE go to Block 4.

If the consequences of failure ARE ACCEPTABLE, continue to Block 5.

Block 4



IF…

In Block 3 it was determined that the consequences of failure under the assumed floodflow conditions are NOT ACCEPTABLE,

THEN…

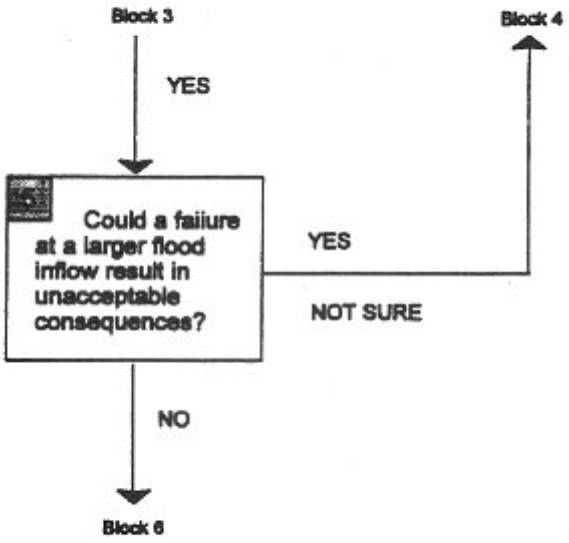
Assume a new (larger) flood inflow condition (*e.g.,* some percentage of the PMF) and perform a dambreak analysis (see Block 2). This procedure should be repeated until an acceptable level of flooding is identified, or the full PMF has been reached.

Continued…

IDF SELECTION PROCEDURES: PERFORMING A HAZARD EVALUATON

EXPLANATION OF FLOWCHART 2 (continued)

Block 5



IF…

In Block 3 you determined that the consequences of failure under the assumed floodflow conditions are ACCEPTABLE; *i.e.,* failure of the dam under "sunny day" conditions was insignificant,

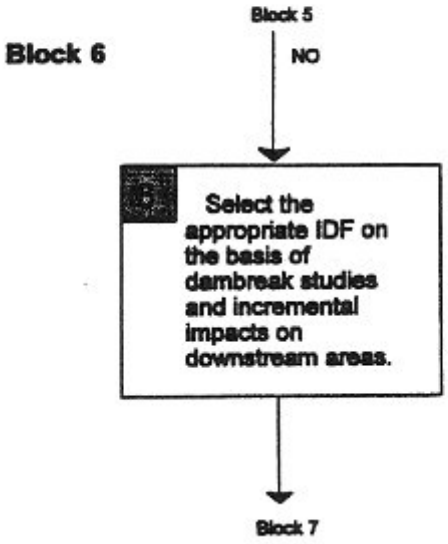
THEN…

Determine if failure at a larger flood inflow condition will result in unacceptable consequences. This question is very important. For example, situations exist where a failure during normal water surface conditions results in the flood wave being contained completely within the banks of a river and obviously would not cause a threat to life and property downstream. However, under some floodflow conditions, the natural river flows may go out-of-bank, and a failure on top of that flood condition will result in an additional threat to downstream life and property.

If failure at another flood level will result in UNACCEPTABLE additional incremental consequences, or if you are NOT SURE, return to Block 4. Assume larger flood inflow conditions and perform new dambreak studies. This procedure should be repeated to determine the acceptable level of flooding.

If failure at another flood level will NOT result in unacceptable consequences, continue to Block 6.

Block 6



You should now select the appropriate IDF based on the results of dambreak studies and incremental impacts on downstream areas.

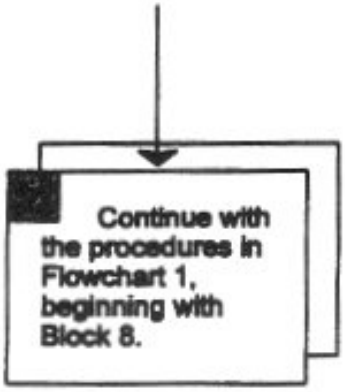
Continued …

IDF SELECTION PROCEDURES: PERFORMING A HAZARD EVALUATON

EXPLANATION OF FLOWCHART 2 (continued)

Block 7

Continue this process with the steps in Flowchart 1, starting with Block 8. In Block 8 you will answer the question: Based on the incremental hazard evaluation, is the PMF the appropriate IDF?



IDF SELECTION PROCEDURES: SUMMARY

SUMMARY: INFLOW DESIGN FLOOD (IDF) SELECTION PROCEDURES

This Appendix described the procedures used to select the appropriate IDF for a dam and to determine the need for remedial action.

The steps involved to select the appropriate IDF for a dam were presented in Flowchart 1. If you determine that the PMF was used for the original design of the dam, and that the PMF is the appropriate IDF, further investigation or remedial action for hydrologic, conditions is not necessary.

If you determine that the PMF was not used for the original design of the dam, or if the PMF was not the appropriate IDF, conduct an incremental hazard evaluation to determine the appropriated IDF. Flowchart 2 presented the procedures for conducting an incremental hazard evaluation.

Then, if it is determined that the dam is not safe for the new PMF or the appropriate IDF, remedial action must be taken.

FIGURE 1 – ILLUSTRATION OF INCREMENTAL INCREASE DUE TO DAM FAILURE

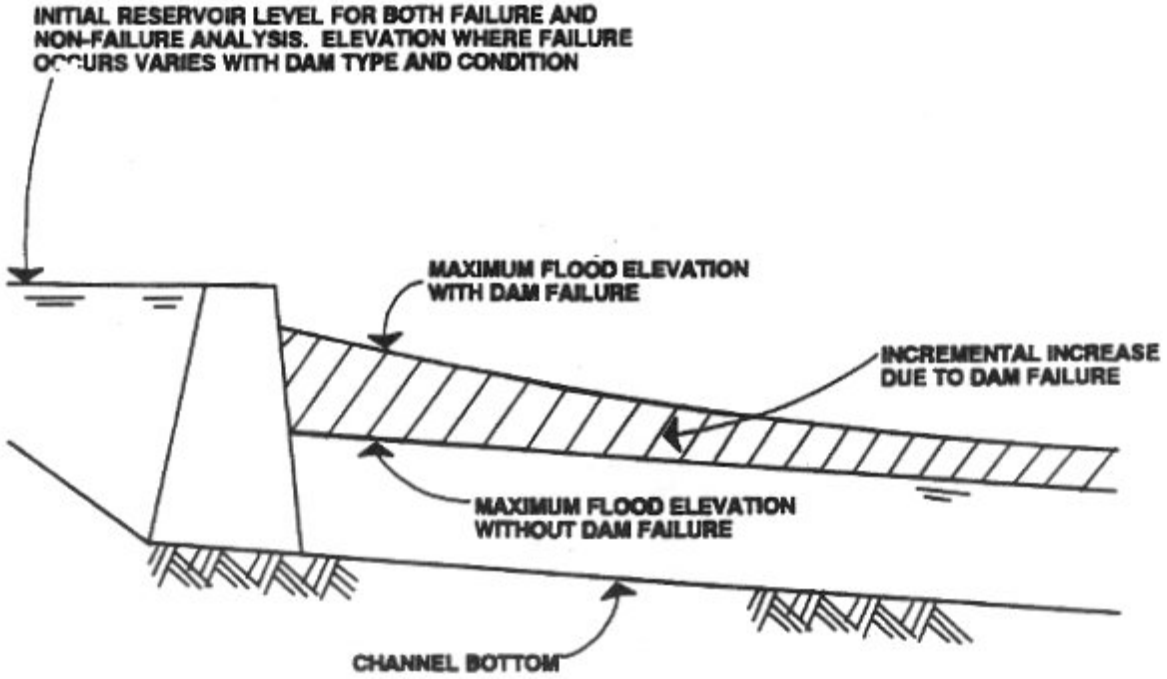


FIGURE 2 – ILLUSTRATION OF INCREMENTAL AREA FLOODED BY DAM FAILURE

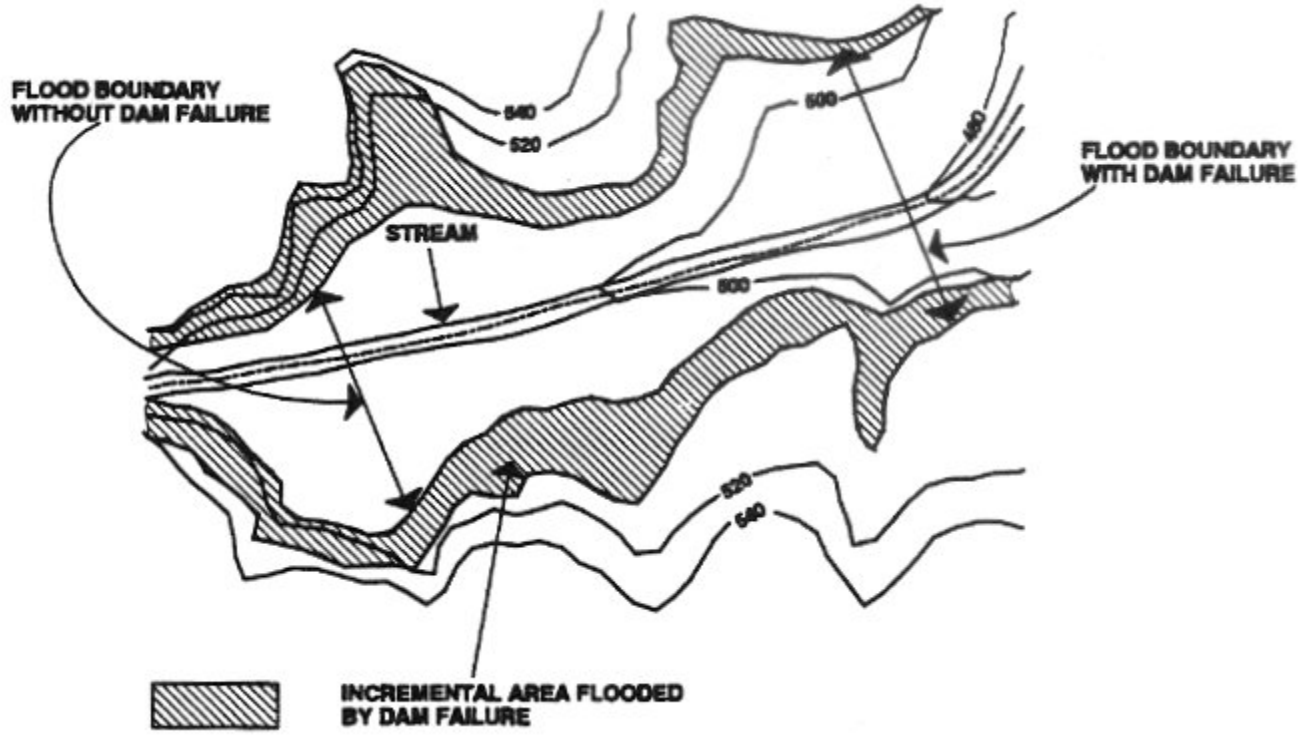
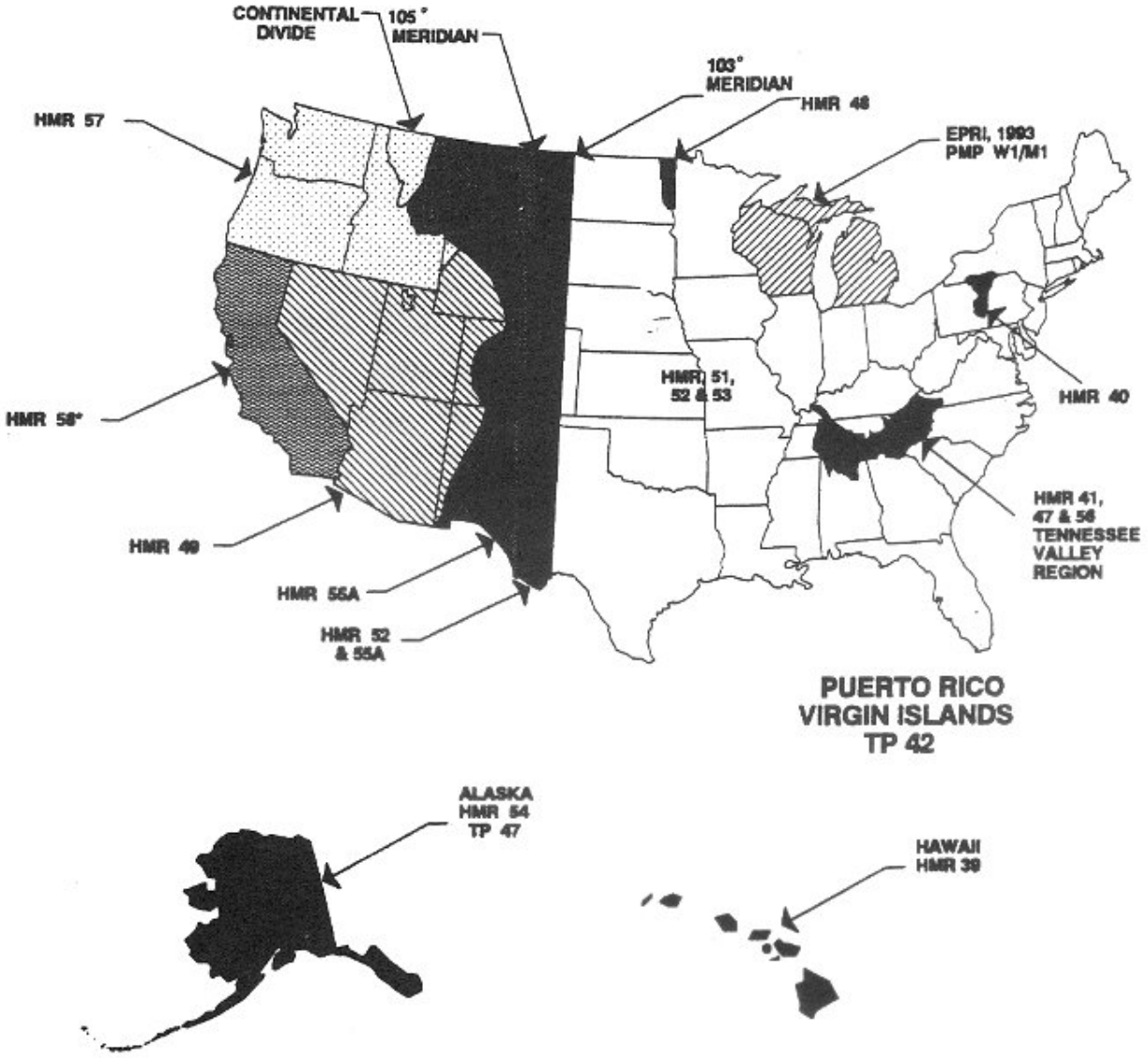


FIGURE 3 – REGIONS COVERED BY PMP STUDIES



Note:

* HMR 58 to be Published in 1997

FEMA Workshop on Hydrologic Research Needs for Dam Safety Analysis
Federal Energy Regulatory Commission

By
Michael S. Davis, P.E.[2]

The purpose of this paper is to discuss the Federal Energy Regulatory Commission's (Commission) current practice in evaluating the adequacy of the spillway capacity of hydroelectric projects under it's jurisdiction, and to suggest areas where future research would be a benefit to these projects.

Current Practice

Regulations and Procedures

Since Order 122 was issued in 1981[3], the current practice of the Commission to ensure that the spillway capacity of all high and most significant hazard potential project is adequate has been governed by Sections 12.35(b) and 12.35(b)(1) of the Commission's regulations, which are as follows:

> 12.35(b) *Evaluation of spillway adequacy.* The adequacy of any spillway must be evaluated by considering the hazard potential which would result from failure of the project works during flood flows.
>
> 1235(b)(1) If structural failure would present a hazard to human life or cause significant property damage, the independent consultant must evaluate (i) the ability of the project works to withstand the loading or overtopping which may occur from a flood up to the probable maximum flood (PMF), or (ii) the capacity of spillways to prevent the reservoir from rising to an elevation that would endanger the project works.

The Commission's regulations require that for all high hazard potential dams and most significant hazard potential dams[4], an independent consultant must inspect the project and evaluate its stability and spillway adequacy every five years. To give the Commission staff and the independent consultant guidance and criteria for this evaluation, the Commission developed the Engineering Guidelines for the Evaluation of Hydropower Projects.

---

[2] Lead Engineer, Federal Energy Regulatory Commission, Office of Energy Projects, Division of Dam Safety and Inspections, Chicago Regional Office.

[3] Order 122 established the current regulations for independent consultants inspecting and evaluating projects on a five-year cycle.

[4] Any significant hazard potential dam that is less than 32.8 feet high and impounds less than 2,000 acre-feet is not subject to this regulation.

For most projects, the first step for the independent consultant is to develop the PMF for the project and to evaluate the spillway capacity and stability of the project during the PMF. If the project can safely pass the PMF, then the spillway is adequate and no further studies are needed. If, however, the PMF exceeds the spillway capacity of the project, then the independent consultant is required to perform a dambreak analysis in accordance with Chapter 2 of our engineering guidelines, or the licensee may choose to modify the dam to safely pass the PMF.

If the dambreak analysis for all flood flows between the existing spillway capacity and the PMF show that the incremental increase in downstream flooding due to the failure is not a threat to downstream life or could cause significant property damage, then the spillway is adequate and no further studies are needed. However, this may need to be re-evaluated during future inspections if there are any changes downstream.

If there is a potential hazard to life or property downstream for these flood flows, then remedial measures are required to either increase the spillway capacity or increase the stability of the project structures to withstand the overtopping. Usually, an inflow design flood (IDF) analysis is done considering various alternatives for increasing the spillway capacity or the stability of the structures, and the IDF can vary depending on the type of fix. But once a fix is proposed for a flood less than the PMF, the license must demonstrate that the incremental increase in downstream flooding due to failure of the dam for all flood flows between the IDF and the PMF is not a threat to downstream life or could cause significant property damage.

In a few cases, a PMF study is not needed if the consultant can demonstrate through a dambreak analysis that either the spillway capacity is adequate or that the IDF will be considerably less than any estimates of the PMF. But in most cases, a PMF study is needed to establish the upper bound of the IDF.

Probable Maximum Flood Studies

Chapter 8 of the Commissions Engineering Guidelines, entitled, “Determination of the Probable Maximum Flood”, was first developed in 1993, and was recently revised in September 2001. The purpose of these guidelines is to provide systematic procedures that will consistently produce a reasonable PMF hydrograph and appropriate reservoir flood levels for evaluation of project safety, given the limitations of basic hydrologic and meteorological data. Although the guidelines give procedures and make recommendations for parameters, alternate procedures and parameters outside the recommended ranges can be used provided they are justified for the basin under study and supported with adequate documentation.

Runoff Model. This chapter recommends the use of the unit-hydrograph theory as the preferred runoff model. It also recommends that the Corps of Engineer’s HEC-1 or

HEC-HMS computer programs be used to model the runoff because of their widespread use and experience.

Channel Routing. Channel routing should be done using the Muskingum-Cunge method, which is incorporated into these computer models. However, any acceptable dynamic routing model such as the National Weather Service (NWS) DAMBRK computer program can be used instead if the consultant chooses to refine the model.

Probable Maximum Precipitation (PMP). The PMP should be developed from the latest NWS Hydrometeorological Reports (HMR). However, a licensee may choose to develop a site-specific PMP study, although this is usually very costly. This may done if the basin under study (1) is not adequately covered by the HMRs, has unusual site conditions that may not be addressed by the HMRs, or can benefit from a refinement of the HMR PMP values. To conduct a site-specific PMP study, the Commission requires that a Commission-approved Board of Consultants consisting of at least a hydrologist, a meteorologist, and a hydrometeorologist review the study. As an example of an approved study, the Commission accepted the 1993 EPRI PMP study for the States of Wisconsin and Michigan, which resulted in PMP values as much as 15 percent lower than HMR No. 51. The 1993 EPRI study also refined the procedures in HMR 52 for developing the probable maximum storm from the PMP values. As a result, the PMF's for many projects in these two States were reduced considerably, resulting in a significant cost savings to the licensee's of these projects. Figure 8.8-1 of Chapter 8 shows the limitations of the latest HMRs and the 1993 EPRI study.

Antecedent and Coincident Conditions. Rather than route an antecedent storm through the model, this chapter recommends that the reservoir level be assumed at its annual maximum operating level and that saturated conditions exist in the entire basin at the onset of the PMP. Several alternatives for the starting reservoir level may be considered which would required an analysis of the historical records or routing of the 100-year 24-hour antecedent storm 3 days prior to the start of the PMP. In most cases, using the annual maximum operating level gives satisfactory results.

Loss Rates This subject received the most attention when Chapter 8 was recently revised. The preferred method is to use the uniform loss rate method. Consistent with the premise that saturated antecedent conditions exist in the basin prior to the start of the PMP, it is acceptable to assume the initial loss rate is set to zero.

The losses in a basin can be developed either by the area-weighted basin-averaging of the loss rates of the hydrologic soil groups, or by a distributed loss rate method. The basin-averaged method is the traditional method that has been used for many years, and simply involves computing the average loss rate based on the percentage of the four hydrologic spoil groups. Chapter 8 recommends that the minimum loss rates from the National Resources Conservation Services (NRCS) 1955 Yearbook of Agriculture be used unless higher loss rates could be justified.

Instead of lumping the loss rates together in each basin, the distributed loss rate method divides each basin into pseudo subbasins corresponding to each loss rate class. The rainfall is then applied to each pseudo subbasin to determine the rainfall excess hyetographs. Then the rainfall excess hyetographs for all pseudo subbasins within a basin are summed to determine the rainfall excess hyetograph for that basin. These rainfall excess hyetographs are then input in HEC-1 with the loss rates set to zero for that basin. This method also works for larger basins that are subdivided into subbasins.

The distributed loss rate method was developed in the 1990's primarily to address an inconsistency with the basin-average method. Our procedures allows you to calibrate loss rates based on 3 to 5 historical events that meet certain criteria. However, loss rates calibrated using the basin-average method were found to be storm specific, particularly for basins with spatially diverse characteristics. A basin with a calibrated average loss rate for a specific storm may actually have a significantly higher loss rate for the PMF since significantly more portions of the basin contribute to the runoff during the PMF than did during the specific storm.

The second reason this method was developed was to incorporate the availability of the digitalization of soil databases such as NRCS State Soil Geographic (STATSGO) database. The STATSGO database contains many properties of the soil for several layers up to 60 inches deep. One such property is the hydraulic conductivity, which is the rate of flow through saturated soil, normally given as a range of values. The Commission's current criteria is to use the minimum value of the range for the least permeable layer, unless higher values can be justified through calibration or additional investigation of the geological make-up of the soils, the review of more detailed soils information such as county or local soils maps, or actual data obtained from any site investigations within the basin.

Dam Break Studies

Guidelines and Criteria

The Commission's criteria for conducting dam break studies is discussed in Chapter 2 of the Engineering Guidelines. The NWS DAMBRK and FLDWAV computer programs are the recommended unsteady flow model computer programs that can be used to route the flow downstream of the dam. However, the Commission has accepted studies using other programs as well. The NWS SMPDBK program has been accepted in a few cases where the accuracy of the results is not as critical. In some cases, if a field reconnaissance shows that there are no structures downstream, a computer analysis is not necessary.

In general, the consequences are considered to be acceptable when the incremental increase in flooding on downstream structures due to dam failure is approximately 2.0 feet or less. However, the 2.0-foot increment is not an absolute

decision-making point. Sensitivity analyses and engineering judgment are required. For instance, inhabited trailers sitting on blocks can be moved with less than 2.0 feet of rise, and should be considered in this evaluation.

The Commission's guidelines for breach parameters is given in Table 1 of Appendix A of Chapter 2. In general, the average breach width should be between 2 and 4 times the height of the dam for earth or rock fill dams, and one or more monoliths up to one-half the length of the dam for gravity dams. Failure times range from 0.1 to 1.0 hours for earth or rock fill dams, and from 0.1 to 0.3 hours for gravity dams. For arch dams, it's appropriate to assume the entire dam fails in 0.1 hours or less.

Because of the uncertainty of breaches, the consultant should perform a sensitivity analysis of these parameters. For projects with large reservoirs, conservative breach parameters should be adopted since the rate of draw down of the reservoir during a breach is significantly slower than it is for projects with smaller reservoirs. In some cases, larger breach widths with longer failure times should be considered, such as for a long 20-foot high earth embankment that impounds a large storage reservoir.

Common Modeling Problems

1. Failure to model the entire reservoir. If dynamic routing of the reservoir instead of level pool routing is done, the consultant needs to make sure the cross-sections extend upstream of the reservoir to the point where backwater effects no longer exist. The shape of the cross-sections also needs to be examined to make sure all the storage between the cross-sections is accounted for. In some cases, the consultant extended the cross-sections only part way into the reservoir, effectively negating the storage upstream that could be released through a breach.

2. No sensitivity studies. Although the selected breach width may be at the conservative end of the accepted range given in our criteria, a larger breach width may result in a substantially higher incremental rise downstream. If the incremental rise is highly sensitive to the breach width, then this needs to be considered when selecting the breach width.

3. Improper use of the Manning's n values. The NWS DAMBRK program requires the user to provide the composite Manning's n values at each elevation. Therefore, for out-of-bank flood elevations the consultant needs to compute the composite Manning's n value based on the weighted wetted perimeter. In many cases, the consultant will select too high of a Manning's value for the out-of-bank elevations. Although not a major factor, this can effect the results in some analyses.

4. Improper spillway rating curve. In some cases, the reservoir was allowed to draw down during the beginning of the routing because the consultant did not

adjust the rating curve for when the gates are closed to maintain the normal pool level. In other cases, the consultant adjusted the rating curve to correct this, but the simulation then appeared as though the licensee closed all the gates instantaneously when the reservoir receded below the normal maximum pool after the breach developed.

5. The breach was assumed to initiate on the rising limb of the inflow hydrograph. It's imperative that a non-failure case be run first so that the peak headwater elevation at the dam can be determined and used in the failure case. This becomes more complex when conducting a domino-type failure analysis of downstream dams.

Research Needs

The following items are research needs that should be considered:

Probable Maximum Flood Studies

1. PMP. Many of the HMR's cover very large areas that don't take into account local terrain affects that may reduce the PMP for that area. Other refinements can be done that could reduce the probable maximum storm such as the EPRI Wisconsin/Michigan study.

2. Snowmelt. The HMR's in the western states have very approximate methods for combining snowmelt with the PMP. More research is needed in this area as it may be too conservative in some cases to combine 100-year snowpack with extreme temperatures, and the PMP.

3. Loss Rates. The changes in our guidelines point out the need for more research in using the distributed loss rate method with STATSGO data, particularly since the PMF can be very sensitive to the selected loss rates.

Dam Break Studies.

1. Breach Parameters. More research is needed on the proper selection of breach parameters, particularly for earth and rock fill dams. The FEMA/USDA Workshop on Issues, Resolutions, and Research Needs Related to Dam Failure Analysis, in Oklahoma City, OK, June 26-28, 2001, addressed this concern.

2. Computer models. Research is needed on ways the current computer models for unsteady flow can be made easier to use and more flexible to allow users to model more complex dams with multiple spillways.

D.3. Mine Safety and Health Administration



Subscribe to E-mail Updates

Advanced Search
Find It In MSHA SEARCH

A-Z Index | Site Map | FAQs | MSHA Forms | About MSHA | Contact Us | Español

Print This Page

Mine Safety and Health Administration
MSHA - Protecting Miners' Safety and Health Since 1978

Title 30 Code of Federal Regulations

Parts 1-199 Mineral Resources
Department of Labor
Mine Safety and Health Administration

30 CFR § 56.20010
Retaining dams.

If failure of a water or silt retaining dam will create a hazard, it shall be of substantial construction and inspected at regular intervals.

FAQs | Freedom of Information Act | Privacy & Security Statement | Disclaimers | Customer Survey | Online Filing Help Desk | Contact Us

Mine Safety and Health Administration (MSHA) | 1100 Wilson Boulevard, 21st Floor Arlington, VA 22209-3939
www.msha.gov | Telephone: (202) 693-9400 | Fax-on-demand: (202) 693-9401

Subscribe to E-mail Updates

Advanced Search
Find It In MSHA SEARCH

A-Z Index | Site Map | FAQs | MSHA Forms | About MSHA | Contact Us | Español

Print This Page

Mine Safety and Health Administration
MSHA - Protecting Miners' Safety and Health Since 1978

[Federal Register: August 13, 2010 (Volume 75, Number 156)]
[Proposed Rules]
[Page 49429-49432]

DEPARTMENT OF LABOR
Mine Safety and Health Administration

30 CFR Parts 56 and 57

RIN 1219-AB70

Metal and Nonmetal Dams

AGENCY: Mine Safety and Health Administration, Labor.

ACTION: Advance Notice of Proposed Rulemaking (ANPRM).

SUMMARY: Dam failures at metal and nonmetal mines have exposed miners to life-threatening hazards. The Mine Safety and Health Administration (MSHA) is reviewing its existing metal and nonmetal standards for dams. The Agency is concerned that some dams pose hazards because they are not designed, constructed, operated, and maintained to accepted dam safety practices. MSHA is considering approaches to better protect miners from the hazards of dam failures and is soliciting information to help determine how best to proceed.

DATES: Comments must be received by midnight Eastern Daylight Saving Time on October 12, 2010.

ADDRESSES: Comments must be identified with ``RIN 1219-AB70'' and may be sent to MSHA by any of the following methods:
(1) Federal E-Rulemaking Portal: http://www.regulations.gov. Follow the on-line instructions for submitting comments.
(2) Electronic mail: zzMSHA-Comments@dol.gov. Include ``RIN 1219- AB70'' in the subject line of the message.
(3) Facsimile: 202-693-9441. Include ``RIN 1219-AB70'' in the subject line of the message.
(4) Regular Mail: MSHA, Office of Standards, Regulations, and Variances, 1100 Wilson Boulevard, Room 2350, Arlington, Virginia 22209- 3939.

(5) Hand Delivery or Courier: MSHA, Office of Standards, Regulations, and Variances, 1100 Wilson Boulevard, Room 2350, Arlington, Virginia. Sign in at the receptionist's desk on the 21st floor.

MSHA will post all comments on the Internet without change, including any personal information provided. Comments can be accessed electronically at http://www.msha.gov under the ``Rules and Regs'' link. Comments may also be reviewed in person at the Office of Standards, Regulations, and Variances, 1100 Wilson Boulevard, Room 2350, Arlington, Virginia. Sign in at the receptionist's desk on the 21st floor.

MSHA maintains a list that enables subscribers to receive e-mail notification when the Agency publishes rulemaking documents in the Federal Register. To subscribe, go to http://www.msha.gov/subscriptions/subscribe.aspx.

FOR FURTHER INFORMATION CONTACT: Patricia W. Silvey, Director, Office of Standards, Regulations, and Variances, MSHA, at silvey.patricia@dol.gov (E-mail), 202-693-9440 (Voice), or 202-693-9441 (Fax).

SUPPLEMENTARY INFORMATION:

I. Background

MSHA's database contains information on nearly 2000 dams at metal and nonmetal mines. Mine operators have constructed these structures for various purposes, such as disposing of tailings or mine waste, processing minerals, treating or supplying water, and controlling run- off and sediment. Although many of these dams are designed, constructed, operated, and maintained according to accepted dam safety practices, others are not and dam failures and near failures continue to occur.

Since 1990 to the present, MSHA investigated dam failures at metal and nonmetal mines in virtually every region of the country and at small and large operations. Failures or near failures have occurred at copper, phosphate, sand and gravel, trona, gypsum, and limestone mines, among others.

Failures have damaged property and equipment, but no deaths or serious injuries have occurred. Examples of dam failures include:

- A 1990 failure of a 100-foot high dam at a limestone mine in Puerto Rico released over 10 million gallons of water and tailings. The failure flooded eight lanes of a major highway, depositing tailings up to eight feet thick. The dam failed about 2 a.m. when no miners were present. The mine operator did not use an engineer to design the dam; several design and construction deficiencies, such as poor compaction, steep slopes, and absence of internal drains, contributed to the failure.
- A 70-foot high tailings dam failed at an andesite quarry in Wisconsin in 1992, tearing apart a railroad track and leveling a power line at the mine. The dam failed at 3 a.m. when no miners were present. The dam was not designed by an engineer. After a

slope failure in 1987, the mine operator installed instruments in the dam to monitor internal water pressures. Pressures beyond a certain level would lead to structural instability. In the 18 months before the 1992 failure, however, the operator checked the instruments only twice. A combination of steep slopes and high internal water pressure contributed to the failure.

- In 1997, a dam at an Arizona copper mine released tailings for over a half mile downstream and to depths of 30 feet. Four miners, one in a haul truck, one in a bulldozer, and two in a pickup truck, were carried down-slope with the slide. One miner injured his back running from the pickup but the others were not injured. The dam was designed by an engineer; however, the mine operator's rate of placement of waste rock on top of the tailings created pressures that contributed to the failure.
- In August 2002, a 450-foot section of dam failed at a sand and gravel mine in Georgia, sending a wave of water and tailings through the shop area. The 30-foot high dam failed shortly after 8 p.m. The wave of water and tailings moved a scraper, backhoe and front-end loader, which were parked in the area. Three miners, near the shop, saw the dam failing and escaped in a pickup truck. The dam, built without being designed by an engineer, had a weak foundation, among other deficiencies.
- In 2004, a dam failure at a sand and gravel mine in California released over 200 million gallons of water and tailings, inundating a hydraulic excavator in an adjacent pit. The failure occurred shortly after 6 p.m., at the start of the maintenance shift. About 15 minutes before the failure, the excavator operator had gone home and a bulldozer operator had parked his machine on the top of the dam. A miner who lubricated the equipment was driving into the pit when he noticed the rising water, halted his truck, and backed up the access road. The dam was not properly designed. The investigation revealed that the design of the dam failed to include an evaluation of the foundation and embankment material strengths, and stability analyses to verify that the slopes of the dam would have adequate factors of safety.

MSHA investigators have found that design, construction, operation, or maintenance deficiencies have contributed to failures of dams at metal and nonmetal mines and exposed miners to hazards.

Since the early 1970's, Congress has enacted laws to create a national program to reduce the risks of dam failures. The Federal Emergency Management Agency (FEMA) is charged with administering the national dam safety program and has issued a series of Federal Guidelines for Dam Safety (Guidelines) (http://www.fema.gov/library/ viewRecord.do?id=1578).

The Guidelines address, among other things, practices and procedures for the design, construction, operation, and maintenance of all types of dams. In the Guidelines, FEMA recommends that dams:

- Be designed by a competent engineer;
- Be constructed under the general supervision of a competent engineer knowledgeable about dam construction;
- Be inspected and monitored at frequent intervals by a person trained to recognize unusual conditions; be inspected by a competent engineer with knowledge of dam safety at a frequency consistent with the dam's hazard potential; and
- Have an emergency action plan, if dams are classified as having high or significant hazard potential in the event of failure. Every two years, MSHA reports on the status of its dam safety program to FEMA, which then sends Congress an evaluation of each Federal agency's program and how it complies with the Guidelines. FEMA has recommended, in biennial reports to Congress and in meetings of the Interagency Committee on Dam Safety, that MSHA promulgate standards to encompass all aspects of design, construction, and inspection for dams at metal and nonmetal mines.

The existing requirements for dams at metal and nonmetal mines, 30 CFR 56.20010 and 57.20010, are derived from the Metal and Nonmetallic Mine Safety Act of 1966. The standards state: ``If failure of a water or silt retaining dam will create a hazard, it shall be of substantial construction and inspected at regular intervals.'' The standards promulgated for coal mines under the Federal Coal Mine Health and Safety Act of 1969 were similar, but specified that the mine operator inspect the dams at least once per week and record inspection findings.

The requirements for coal mines were revised in 1975 after the Buffalo Creek dam failure. For dams which can present a hazard or are of a certain size, the existing standards require a coal mine operator to:

- Have a registered professional engineer certify the dam's design;
- Develop plans for the design, construction, maintenance, and abandonment of the dam and have the plans approved by MSHA;
- Have a qualified person inspect the dam weekly;
- Have instrumentation monitored weekly;
- Correct any hazardous conditions and make required notifications; and
- Submit an annual report with a registered, professional engineer's certification that construction, operation, and maintenance of the dam have been in accordance with approved plans.

II. Key Issues on Which Comment Is Requested

MSHA is asking interested parties to comment on measures to assure that mine operators design, construct, operate and maintain dams to protect miners against the hazards of a dam failure.

MSHA seeks comments on the questions below. If a commenter refers to a particular dam as an example, please identify the mine, or provide the number of miners and the mine's commodity. Also, include the dam's storage capacity, height, and hazard potential and characterize its complexity. Provide enough detail with the comments that the Agency can understand the issues raised and give them the fullest consideration. Comments should include alternatives, rationales, benefits to miners, technological and economic feasibility, impact on small mines, and supporting data. Please include any information that supports your conclusions and

recommendations: Experiences, data, analyses, studies and articles, and standard professional practices.

General Questions

1. MSHA is seeking information concerning current dam safety practices at metal and nonmetal mines. What measures do mine operators currently take to design, construct, operate, and maintain safe and effective dams? What measures do mine operators currently take to safely abandon their dams? For mine operators with dams, please provide your experiences.

2. MSHA is required to inspect every mine in its entirety, which includes dams of all sizes and hazard potential. A common approach for dam safety is to have tiered requirements based on a dam's size and hazard potential. How should MSHA determine safety requirements based on a dam's size and hazard potential? Please include specific recommendations and explain your reasoning.

3. What non-Federal authority regulates the safety of dams at metal and nonmetal mines in your state, territory, or local jurisdiction? Please discuss the specific requirements, including the principles that they address. If possible, please provide information about relevant non-federal dam safety requirements through a hyperlink or other means.

4. What records should be kept of activities related to the safety of dams? Please be specific and include your rationale. What records should be provided to miners if hazardous conditions are found?

Design and Construction of Dams

MSHA's existing standards do not include specific requirements for design of dams. MSHA found that inadequate design contributed to some of the metal and nonmetal dam failures. In responding to the following questions, please discuss how any requirements should vary according to the size or hazard potential of a dam, and why.

5. How should mine operators assure that dams are safely and effectively designed? Please suggest requirements that MSHA should consider for safe design of dams. Please be specific and include your rationale.

6. Please suggest requirements for review of dam designs by mine operators and MSHA and include your rationale for specific recommendations and alternatives.

7. With new standards, operators may need to evaluate and upgrade existing dams. Please elaborate on how the safety of existing dams should be addressed.

8. MSHA's existing standards for dams at metal and nonmetal mines do not address whether a dam is constructed as designed. What measures are necessary to ensure that mine operators construct dams as designed?

9. How should MSHA verify that dams have been constructed as designed? Please explain your rationale.

Operation and Maintenance of Dams

MSHA's existing standards do not contain specific requirements addressing the operation and maintenance of dams.

10. What should a mine operator do to operate and maintain a safe dam? How should MSHA verify that dams are safely operated and maintained? Please be specific.

MSHA's existing standards require dams to be inspected at regular intervals if failure would create a hazard. Inspections can identify hazardous conditions, allowing a mine operator to take corrective action to prevent a failure. The Agency will be referring to two types of inspections in this document, ``routine'' and ``detailed.'' Mine operators should perform frequent, routine dam inspections, which may include monitoring instrumentation, to identify unusual conditions and signs of instability. Personnel with more specialized knowledge of dam safety should conduct detailed inspections to identify less obvious problems and evaluate the safety of the dam. Detailed inspections, occurring less often, would include an examination of the dam and a review of the routine inspections and monitoring data. The Guidelines recommend that inspection personnel be qualified for their level of responsibility and trained in inspection procedures.

11. What measures should mine operators take to assure that dams are adequately inspected for unusual conditions and signs of instability?

12. How often are routine inspections of dams conducted? How often should they be conducted? What determines the frequency? Who conducts the routine inspections? Please be specific and include your rationale.

13. Instruments, such as weirs, provide information on the performance of a dam. How frequently should mine operators monitor dam instrumentation? Please provide your rationale.

14. What information should be documented during routine dam inspections? Please provide your rationale.

15. Does a competent engineer inspect your mine's dam? If so, at what frequency? Please explain the rationale for these

inspections and what is evaluated.

16. How often should detailed inspections be conducted? Please include your rationale.

17. What information and findings should be documented during detailed dam inspections? Please be specific and include your rationale.

18. How should MSHA verify that mine operators conduct routine and detailed inspections? Please explain how your suggestion would work.

Qualifications of Personnel

A mine operator is responsible for the design, construction, operation, and maintenance of dams. For an effective dam safety program, an operator must use personnel who are knowledgeable about dam safety.

19. What qualifications do mine operators currently require of persons who design, inspect, operate, and manage dams? In what capacities are engineers used? Please be specific in your response.

20. The Guidelines recommend that dams be designed by competent engineers. What specific qualifications or credentials should persons who design dams possess? Please include your rationale.

21. The Guidelines recommend that a dam be constructed under the general supervision of a competent engineer knowledgeable about dam construction. What specific qualifications or credentials should a person have who verifies that a dam is being constructed as designed? Please provide your rationale.

22. What training should personnel receive who perform frequent, routine inspections and who monitor instrumentation at dams? In your response, please suggest course content and the frequency of the training, including the rationale for your recommendations.

23. What qualifications or credentials should be required of persons who perform detailed inspections to evaluate the safety of a dam? Please be specific and include your rationale.

Abandonment of Dams

24. Some regulatory authorities require that dam owners obtain approval of a plan to cap, breach, or otherwise safely abandon dams. What actions should mine operators take to safely abandon dams? Please include specific suggestions and rationale.

25. How can MSHA verify that a mine operator has safely abandoned a dam?

Economic Impact

MSHA seeks information to assist the Agency in deriving the costs and benefits of any regulatory changes for dams at metal and nonmetal mines. In answering the following questions, please indicate the dam's storage capacity, height, and hazard potential and characterize the complexity of each dam referenced. Also, please include the state where each dam is located, and the number of employees at the mine.

26. What are the costs of designing a new dam? Please provide details such as hours, rates of pay, job titles, and any contractual services necessary. How often is the design of an existing dam changed? What are the costs of a redesign?

27. What are the costs of constructing a dam? Please provide details based on: Size of dam; labor costs, including hours, rates of pay, job titles; costs of equipment and materials; and any contractual services necessary.

28. Please describe the oversight you provide during dam construction to assure it complies with the design plan. How much does it cost per year per dam for oversight and quality control? What special knowledge, qualifications, or credentials do you require of those who provide oversight?

29. How often do you add height to an existing dam or modify it in some other way? Who supervises the design and construction of these modifications, for example, a professional engineer, competent engineer, contractor, etc? Please be specific and provide rationale for your answer. How much does it cost? Please provide details such as labor costs, including hours, rates of pay, job titles, and costs of equipment and materials and any contractual services necessary.

30. How much does it cost per year per dam for routine inspections? If you incur separate costs for monitoring instrumentation, how much is that cost? How often do you have a detailed inspection conducted? How much does it cost per year for these inspections?

31. Does the state or local jurisdiction in which you operate require you to use a professional engineer? If so, when is a professional engineer specifically required? (If you have dams in more than one state please identify which states require a professional engineer and which do not).

32. What are the costs associated with training personnel who conduct frequent, routine inspections and monitor instrumentation at dams?

33. What costs are involved in capping, breaching, or otherwise properly abandoning a dam? Please provide details of your experience and what was involved when you properly abandoned a dam. Describe any impact of a properly abandoned dam.

34. What are the costs to a mine operator if a dam fails? Please characterize other impacts such as loss of life, environmental damage, etc.

35. Do you have insurance against a dam failure? If so, please specify cost and coverage. Does the insurance carrier require the use of a professional engineer for specific dam activities? If a professional engineer is not required, does the insurance carrier give a discount if one is used? Does your insurance company have any other requirements related to dam safety?

36. What quantifiable and non-quantifiable costs and benefits for the downstream community are involved when a dam is properly designed and constructed? In addition, MSHA welcomes comments on other relevant indirect costs and benefits.

Dated: August 9, 2010.
Joseph A. Main,
Assistant Secretary of Labor for Mine Safety and Health.
[FR Doc. 2010-19960 Filed 8-12-10; 8:45 am]
BILLING CODE 4510-43-P

FAQs | Freedom of Information Act | Privacy & Security Statement | Disclaimers | Customer Survey | Online Filing Help Desk | Contact Us

Mine Safety and Health Administration (MSHA) | 1100 Wilson Boulevard, 21st Floor Arlington, VA 22209-3939
www.msha.gov | Telephone: (202) 693-9400 | Fax-on-demand: (202) 693-9401

D.4. National Park Service



UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

Dams and Appurtenant Works Maintenance, Operation, and Safety

Reference Manual 40

Release No. 1
April 2005

This guideline provides an outline of responsibilities for NPS personnel in the planning, design, preservation, rehabilitation/construction, maintenance and operation, inspection, acquisition or disposal of dams under NPS management. Instructions on recommended coordination with local officials and non−NPS dam owners are given also: It is not intended as a technical manual but as a management guideline. A list of recommended technical references is provided in Appendix B.

Application of the guideline by NPS personnel should be commensurate with each dam's size, complexity, operational importance, hazard potential classification, and ownership. Inquires about the application of the guideline may be made to the park, regional, or Washington Office NPS Maintenance, Operation, and Safety of Dams (MOSD) Program coordinators.

CONTENTS

Chapter 1. INTRODUCTION
A. General.....
B. Management Objectives.....
C. Applicability.....
D. Definitions.....

Chapter 2. ORGANIZATIONAL MANAGEMENT
A. Authorities.....
B. Management Responsibilities.....
C. Inventory Data Base Management.....
D. Staffing.....
E. Funding and Personnel Resources.....
F. Documentation.....
G. Technical Reviews.....

Chapter 3. NPS PLANNING AND ENVIRONMENTAL EVALUATION PROCESS FOR PROPOSED OR EXISTING DAMS
A. General.....
B. Acquisition, Holding, or Disposal.....
C. Floodplain and Wetland Protection.....
D. U.S. Army Corps of Engineers Section 404 Permit Program…

Chapter 4. MANAGEMENT OF TECHNICAL ACTIVITIES - SITE INVESTIGATION AND DESIGN FOR PROPOSED OR EXISTING DAMS
A. General.....
B. Hydrology.....
1. Hazard Evaluation.....
2. Flood Development.....
3. Flood Selection for Design (or Evaluation).....
4. Hydrologic Design of Reservoir.....
5. Downstream Effects.....
6. Warning Systems.....
C. Earthquake Investigation and Design.....
1. Investigation Factors.....
2. Selection of Design Earthquakes.....
3. Engineering Seismology.....
4. Need for Earthquake Analysis.....
5. Seismic and Geologic Studies.....
6. Design for Earthquake Forces.....

D. Geotechnics.....
1. General.....
2. Exploration and Identification of Geotechnical Problems
3. Geotechnical Design.....
4. Foundation Treatment.....
5. Instrumentation.....
6. Inspection and Continuing Evaluation During Construction
7. Reevaluation at Existing Structures
E. Hydraulic, Appurtenances.....,
1. General..:.....
2. Design Flood Releases.....
3. Other Water Releases.....
4. Reservoir Evacuation.....
5. Control of Flows During Construction.....
6. Design Criteria and Guidance.....
F. Concrete Dams and Concrete Elements of Embankment Dams....
1. Site Specific Design.....
2. Materials.....
3. Design of Structures.....
4. Definition of Loads.....
5. Design Methods.....
6. Design Evaluation.....

7. Instrumentation.....
8. Construction and Operational Follow-up.....
G. Embankment Dams.....
1. Site Specific Design.....
2. Materials.....
3. Design Constructability.....
4. Embankment Design.....
5. Instrumentation.....
6. Construction and Operational Follow-up.....

Chapter 5. MANAGEMENT OF TECHNICAL ACTIVITIES - CONSTRUCTION & REHABILITATION OF DAMS
A. Introduction.....
1. Construction Contracts.....
2. Construction/Design Interface.....
B. Evaluation During Construction.....
C. Orientation of Construction Engineers and Field Inspectors
1. Design Related.....
2. Foundation.....
3. Materials.....
4. Construction General.....
D. Construction Assurance.....
1. Construction Procedures.....
2. Construction Materials Testing.....
3. Quality Assurance.....

Chapter 6. MANAGEMENT OF TECHNICAL ACTIVITIES - OPERATION AND MAINTENANCE
FOR PROPOSED OR EXISTING DAMS AND APPURTENANT WORKS
A. General.....
B. Operation and Maintenance.....
1. General.....
2. Operating Procedures.....
3. Maintenance.....
C. Periodic Inspection Program.....
1. General.....
2. Types and Frequencies of Inspections.....
3. Instrumentation.....
4. Correction of Deficiencies.....
5. Documentation.....
6. NPS Observer Status at non-NPS Dams.....
D. Emergency Action Planning.....
1. General.....
2. Coordination with non-NPS Dam Owners.....
3. Evaluation of Emergency Potential.....
4. Actions to Prevent or Minimize Effects of Failure....
5. Actions upon Discovery of a Potentially Unsafe (Seriously Deficient) Condition…

APPENDICES
A. NPS Inventory of Dams
B. Recommended References For Maintenance, Operation, and Safety of Dams
C. Regional Coordinators and NPS Denver Service Center and Bureau of Reclamation Contacts
D. Data Book Listing
E. Example Emergency Action Plan
F. State Safety of Dams Officers
G. Example Letter To Non−NPS Dam Owner or Regulatory Agency (Preferably)
H. List of Official Technical Supplements to Director’s Order #40 and Reference Manual(RM)-40

CHAPTER ONE
INTRODUCTION

A. General

Dams and their appurtenant works represent a valuable resource to the National Park System and require careful management. The purpose of this guideline is to outline management responsibilities for the preservation/maintenance, operation, and safety of dams under NPS jurisdiction as respectively required by Statute 16 U.S.C. 1 and Departmental Manual Part 758.

These responsibilities include, but are not limited to, planning, design, preservation, rehabilitation/construction, maintenance and operation, inspection, acquisition or disposal of dams under NPS management, and coordination with local officials.

The guideline is not intended as a standard for technology of dams. Current references dealing with the technology of dams and appurtenant works are provided in Appendix B. The guideline may be used, as appropriate, when coordinating with non−NPS dam owners.

Application of this guideline by Regional Directors, Superintendents, and Manager, Denver Service Center (DSC), should be commensurate with each dam's size, complexity, operational importance, hazard potential, and ownership.

Non−NPS dams also will be monitored carefully and information about them kept within the NPS inventory data base management system. These are dams and appurtenant works for which NPS managers have no direct operational responsibility; but where their failure or misoperation could have a definite effect on park safety or operations. Regional Directors and Superintendents will request observer status during inspections and in the preparation and review of emergency action plans at non−NPS dams that significantly affect park areas. A list of such dams is available in the most current NPS Inventory of Dams, Appendix A.

The NPS Park Facility Management Division has overall responsibility for the coordination of the Maintenance, Operation, and Safety of Dams (MOSD) Program; however, there are many NPS programs−land acquisition, cultural resources management, design, construction, law enforcement, security, and public safety that are closely interrelated and should be properly coordinated. A qualified engineer should be assigned by each Regional Director to assure the implementation of all appropriate portions of this guideline when a major action is undertaken in the acquisition, advance planning; preservation/design/construction formal inspection, or disposal of either high (1) or significant (2) hazard potential dams under NPS management. Low (3) hazard potential dams will still receive periodic inspections to assess any changes in their hazard potential, to evaluate maintenance and repair needs, and to determine if they are still essential to park operations. Non−essential dams and appurtenant works should be dewatered and removed in an environmentally sound manner.

Regional Directors and Superintendents will provide, as appropriate for each type and size dam, documentation and reporting as indicated in Chapter Two, section F.

B. Management Objectives

The following objectives are given for the Maintenance, Operation, and Safety of Dams (MOSD) Program:

−Establishment of MOSD Program within WASO and Regional Park Facility Management Divisions with designated program coordinators and/or project engineers;

−Assure management control of technical activities;

Maintain inventory data base on any size, type, owner, or status dam that will affect or is affecting park operations or safety,

Conduct proper planning, design, construction management, or periodic inspection of all dams under NPS management,

Perform corrective action or disposal of deficient dams under NPS management,

−Provide sufficient funding and personnel to support these responsibilities;

−Integrate MOSD Program into other NPS activities, funding sources, and programs;

Routine Maintenance (park facility and maintenance staff),

Cyclic Maintenance (park facility and maintenance staff),

Repair and Rehabilitation (park facility and maintenance staff),

Cyclic Maintenance of Cultural Resources (cultural resources and facility/maintenance staff),

Cultural Resources Preservation Fund (cultural resources staff),

Construction and Major Rehabilitation (park facility/maintenance and Denver Service Center staff),

Risk Management (occupational and public type safety at dam as pertains to heights/depths, dangerous flows and equipment),

Visitor Services Division (guard against vandalism and coordinate emergency action plans at certain NPS and non−NPS dams),

Land and Structures Acquisition (purchase of dams and appurtenant works).

This is not an all−inclusive list. NPS managers should be constantly alert to what impact both NPS and non−NPS dams have on park safety and operations.

C. Applicability

Regional Directors and Superintendents will be responsible for the upkeep of the NPS inventory data base system (Appendix A) for any size, type, owner, or status dam (planned acquisition or disposal) that affects park maintenance, operations, resource, or safety. Where projects do not have any purpose, they should be dewatered and removed under the supervision of qualified personnel and project areas restored. For those dams that are used for park management and operations, NPS managers will annually schedule, as appropriate, funding and personnel to assure that their structures are properly planned, designed, rehabilitated, constructed, maintained, operated and periodically inspected. MOSD program personnel should be contacted immediately when a dam is planned for acquisition or disposal. They will be responsible for the evaluation and inventory of the structure into the MOSD program. A formal safety report including cost estimates to correct identified deficiencies should precede the appraisal of a dam site. The condition of the dam may have a bearing on the fair market value of the property.

D. Definitions

1. General. The following definitions apply to this guideline. More detailed definitions are provided in the explanation of terms used in the NPS inventory of dams database management system as given in Appendix A.

2. Dam or Project. Any artificial or natural barrier including appurtenant works (spillways, inlet and outlet works, tunnels, pipelines, penstocks, power stations, diversions. penstocks, canals, gates, conduits, navigation locks, instrumentation, or mechanical and electrical equipment) that impounds, controls, stores, or diverts streamflow and affects park maintenance, operation, resource, or safety. In some cases these structures will include embankments used for trails, roads, or railroads and during heavy runoff would act as dams and thus pose a possible hazard potential. Also landslides and ice formations need to be evaluated as a possible dam. For the management of NPS dams, there is no limitation to size, type, or status (proposed acquisition or disposal) in regard to these criteria. Dams not essential for environmental preservation, management, or operation of parks should be dewatered and breached under the supervision of qualified personnel and the project area restored. In some cases, the impoundment areas have become filled with sediment or covered by vegetation such that removal or restoration is too expensive or damaging to park resource. In these cases, the dam will still need to be maintained to prevent the impounded sediment or any other material from being discharged downstream if the dam were to fail. This guideline applies with equal force whether the dam has a permanent reservoir or is a detention dam for temporary storage of floodwaters.

In addition to conventional structures, this definition of "dam" specifically includes "tailing dams," embankments built by waste products disposal and retaining a disposal pond.

3. Hazard Potential. Potential loss of life or property or resource damage downstream of a dam from floodwaters released at the dam, or water released by partial or complete failure of the dam, and upstream of the dam from effects of rim slides or upstream dam failure. Also the effect of a failure, partial failure, or other incident should be considered for highways, roads, or trails crossing over the dam. A hazard potential is considered significant if there is a potential to cause loss of life or major damage to permanent structures, utilities, or transportation facilities. A detailed description of hazard potential is provided below. It is not an indicator of structural, maintenance, operational or safety condition.

HAZARD POTENTIAL CLASSIFICATION		
CATEGORY	**Loss of Life (Extent of Development)**	**Economic or Environmental Loss (Extent of Development or Resource)**
5=Deactivated	Not possible including any serious injury from remnants of	None Possible

		deactivated projects	
See Note 1	4 = Unknown	Unknown (A hazard assessment should be performed promptly)	Unknown (A hazard assessment should be performed promptly)
	3 = Low	None expected (No permanent facilities, campsites, or other visitor use areas)	Minimal (Undeveloped to occasional facilities or agriculture. No significant park resources)
See Notes 1 and 2	2 = Significant	Few (No urban developments and no more than a small number of inhabitable facilities, or visitor use areas)	Appreciable (Notable agriculture, industry structures, or park resources)
	1 = High	More than few	Excessive (Extensive community, industry or agriculture, or park resources)

Note 1: Annual Informal Inspection required. See Chapter 6, section C, 2, a.

Note 2: Formal Inspection required every five years. Intermediate Inspection required every two years. See Chapter 6; section C, 2, b and c.

4. Occupational and Public Type Safety. See Chapter 6, section B, 2. The following features or conditions may exist at a structurally sound dam but still pose a hazard potential to NPS personnel or public safety:

a. Waterways
(1) Spillways
(2) Sluices
(3) Intake and release structures
(4) Submerged objects

b. Structural Heights
(1) Embankments
(2) Walls
(3) Cat Walks

c. Mechanical or electrical equipment at dam

5. Dam Failure. Catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water. It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters which adversely affects a dam's primary function of impounding water is properly considered a failure. They are, however, normally amenable to corrective action.

6. Maintenance. Maintaining structures and equipment in intended operating condition; equipment repair and minor structure repair.

7. Listed are some of the essential National Park Service Operations for dams.

a. Irrigation
b. Hydroelectric Power Generation
c. Flood Control
d. Navigational Lockage
e. Water Supply
f. Recreation
(1) Camping, Sunbathing, or Sightseeing
(2) Swimming and Bathing
g. Conservation of Natural Habitat and Cultural Resources
h. As Bridges, Roadways, and Hiking Trails

8. Rehabilitation or Improvement. Repair of structural deterioration to restore original condition; alteration of structures to improve dam stability; enlarge reservoir capacity, or increase spillway and outlet works capacity; replacement of equipment.

9. Emergency Action Plan. Formal plan of procedures to alleviate dangers during construction of or after completion of a dam to reduce loss of life or damages if conditions develop in which dam failure or misoperation is likely or unpreventable.

CHAPTER TWO
ORGANIZATIONAL MANAGEMENT

A. Authorities

1. 16 U.S.C. 1. General legislative authority for the management and operation of park areas. It includes the maintenance and rehabilitation of those facilities as designated an integral part of the park operation.

2. Public Law 107-310 (The Dam Safety and Security Act of 2002) Re-authorization of the National Inventory for Federal and non−Federal dams, safety inspections of non−Federal dams, development of a comprehensive program for the inspection and regulation of dams for safety purposes, and inclusion of security.

3. Federal Guidelines for Dam Safety, June 25, 1979. Recommendations for a systematic program for the maintenance, operation, safety, or disposal (non-essential) of federal dams.

4. Executive Memorandum, October 4, 1979, Implements Federal Guidelines for Dam Safety as appropriate for each agency.

5. Departmental Manual Part 753 − Specific implementation of DOI program

a. Each agency has responsibility of operating own program.

b. Bureau of Reclamation coordination and advice on DOI agency programs.

c. Important objectives:

(1) Complete an accurate inventory,

(2) Initiate periodic inspections and necessary corrective action,

(3) Develop emergency action plans at appropriate dams.

6. NPS Management Policies, sections 1.5, External Threats and Opportunities; 8.2.5.2, Emergency Preparedness and Emergency Operations; and 9.5 Dams and Reservoirs

B. Management Responsibilities

1. General. The Director is responsible for the development and implementation of policy, resources, and procedures for the maintenance, operation, safety, or else deactivation (non-essential) of each dam under his control. The Associate Director of Park Planning, Facilities, and Lands, with her/his park facility management staff, assists the Director in discharging this responsibility and shares in it. The Maintenance, Operation, and Safety of Dams Program is established as a component of the Park Facility Management Division. The field directorate is responsible for obtaining compliance with this guideline and assuring that procedures are carried out.

Regional Directors, Superintendents, and Manager, Denver Service Center, will establish a Maintenance, Operation, and Safety of Dams Coordinator within their respective organizations as appropriate. See Appendix C for listing. The coordinator will be responsible for ensuring that every effort is made to enhance the maintenance, operation, and safety of dams under NPS control, and to coordinate with non−NPS dam owners about the condition of their structures if they affect park safety, operations, or resource.

Refer to Appendix G for an example letter for coordinating with non-NPS dam project owners and/or regulators. Duties of the office 'will include surveillance and evaluation of administrative, technical, and regulatory practices related to the acquisition, design, preservation/rehabilitation/ construction, maintenance and operations, inspection of dams, and upkeep of the NPS inventory for both NPS and non−NPS dams that affect park safety and operations. The coordinator will represent NPS in the field of dam structures, ownership, reconstruction, management, ecology and cultural significance. The coordinator will be a key spokesperson in resolving interagency water and related land resources conflicts as pertains to dams and appurtenant works.

2. Design Responsibility. The design function can never be considered finished as long as the dam remains in place; design involvement should continue throughout construction and operation of the project. Regional Directors should establish appropriate programs for on−site construction and operational inspections for review by appropriate design personnel and technical specialists.

The program will include frequent and mandatory inspections during construction to confirm that site conditions conform to those assumed for design or to determine if design changes may be required to suit the actual conditions.

The design function includes responsibility for planning any dam instrumentation to be installed during construction and/or operation to monitor conditions that could potentially threaten dam safety.

An initial reservoir filling and surveillance plan will be prepared by the design staff.

3. Construction Responsibility. The responsibility for administering construction and supply contracts, for understanding the design and contract intent, for maintaining technical coordination between design and construction engineers, and for managing the construction staff to assure compliance with specifications should be vested in an identified engineer at the construction project for important dams. Important dams are those classified as high (1) or significant (2) hazard potential, those whose failure would significantly impact park operations or resources, or involving substantial investment. The project engineer should have the administrative and technical control of all resources necessary to accomplish safe construction of the dam. Construction personnel should understand the conditions upon which the design is based and the relationship between these conditions and the design features. When unanticipated conditions are encountered, design personnel should be involved in determining their effect.

4. Maintenance and Operation. The responsibility for project maintenance and operation is assigned to the facility/maintenance or engineering staff. They will handle any requirements for coordination with the Denver Service Center Regional Team or an engineering firm. They will be responsible for preparing annual informal inspection reports for all dams and appurtenant works under NPS management and assure that periodic formal and intermediate type inspection reports are prepared by qualified and licensed engineers for high (1) and significant (2) hazard potential dams under NPS management responsibility.

5. Technical Coordination. A project engineer should be assigned technical coordination responsibility for each dam under NPS management that has either a high (1) or significant (2) hazard potential classification. He should handle necessary technical coordination within the agency and with private and public organizations.

6. Emergency Action Planning. An emergency plan should be formulated by the appropriate Park Manager and his maintenance and law enforcement staff for each NPS dam that has either a high (1) or significant (2) hazard potential. The plan should be in the detail warranted by the size and location of the dam and reservoir. It should evaluate inundation areas resulting from floods or dam failure, and upstream conditions that might result from major land displacements or increased flood flows, including the effects from failure of upstream dams. Regional Directors and Superintendents will coordinate with non−NPS dam owners when applicable to assure that appropriate emergency action plans are implemented for areas within park boundaries.

Where applicable, the plan should include inundation maps for the flows resulting from design floods and from possible failure of the dam. The complete emergency plan should be transmitted to appropriate local, state and Federal governmental bodies. The plan should be periodically reviewed and kept up to date, and periodically publicized to maintain awareness of its existence.
In addition to the emergency plan for the complete dam, a similar plan should be prepared for the construction period, including area facilities that may remain during the period and floods that may be anticipated.

7. Risk−Based Analysis During Floodplain Evaluations. NPS managers should evaluate potential losses due to failure or misoperation, particularly when considering non−structural alternatives in correcting dam deficiencies. Although the value of potential property losses can be estimated,, it is recognized that potential loss of lives can only be quantified, but not evaluated. On new dams, potential losses can be used in study of project alternatives and in assessment of additional safety incorporated into the dam facilities. On existing dams, a risk−based analysis should be considered in establishing priorities for examining and rehabilitating the dams for improving their safety or for the disposal of the dam.

C. Inventory Data Base Management (Reference Appendix A)

In compliance with Public Law 107-310 and Departmental Manual Part 753, the National Park Service has developed an inventory of dams based upon information from the U.S. Army Corps of Engineers National Inventory of Dams (NID), Bureau of Reclamation Inspections, and NPS field reports. See Appendix A. This inventory lists both NPS and non−NPS dams that are located within or immediately adjacent to park boundaries and affect safety, operations, property, or resource. Dams are sorted in the following sequence:

1. Regional codes in alphabetical order;
2. Park Codes in alphabetical order;
3. Hazard Potential classification
4. Size Classification;
5. Structural height in feet;
6. Maximum impounding capacity in acre feet.

The current inventory provides information about inspection results, corrective action, emergency action plans (EAP's) and financial information. This data base will be reviewed periodically by NPS field management for completeness and accuracy and any changes submitted annually by September 30 to the Washington Office of the Park Facility Management Division. More frequent updating should be performed whenever any formal inspection reports or corrective actions are completed on either high (1) or significant (2) hazard potential dams.

Dams in this inventory are classified primarily by their hazard potential which is an indicator of risk and not structural condition. Dams are classified as high (1) or significant (2) hazard potential when their failure or misoperation would jeopardize life or damage significant park resources or facilities. Low (3) hazard potential dams normally would not.

NPS structures will receive annual informal inspections to evaluate operational reliability, maintenance, and any changes in hazard potential classification. Inspection and other evaluation results will be used to update the NPS inventory of dams.

Information requests from, and coordination with, non−NPS dam owners should be well documented.

D. Staffing

1. Technical and Support. NPS managers should assure adequate and competent technical staffing or consultants from other agencies or engineering firms are available to perform the essential functions in planning, design, construction, operation and maintenance, acquisition, or disposal of dams under NPS management. These personnel should be well supported by administrative, clerical, and other elements to ensure that technical staff is not diverted from technical work.

Construction inspection staffing should assure quality as well as quantity inspection coverage. Staffing should be reviewed by higher authority than the local construction office.

The operating personnel must be qualified to perform the many functions required in the operation, including the recognition of conditions possibly detrimental to dam safety. Operation and maintenance staffing requires careful attention to personnel responsible for operating inspections, and to personnel who participate in the periodic inspection program. It is essential that support personnel and equipment are provided to accomplish needed maintenance activities.

2. Professional Advancement. NPS managers should maintain a positive program for advancement of technical personnel in recognition of acquired experience, training and education, and increased competence. It is essential that technical as well as the managerial expertise be required for safe, effective dam design, construction, and operating programs. Professional registration and active membership in professional and technical societies should be given due consideration in assessing qualifications for higher technical positions. Provision should be made for the establishment of procedures to screen and disseminate information on technical advances relating to dam design, construction, and maintenance and operation. Programs for continuing professional training should be oriented toward keeping the technical staff abreast of improved technology.

3. Training. To supplement technical staffing, NPS managers should provide internal personnel training. Provisions should be made for technical personnel to observe and participate in decision−making meetings and to make site visits with more experienced staff. Staff members should be allowed to attend consultants meetings in order to gain valuable experience.

Technically qualified maintenance personnel should be trained in problem detection and evaluation, and application of appropriate remedial (emergency and non-emergency) measures.

Personnel involved in inspections should be trained for the requirements of these duties. The training should cover the types of information needed to prepare for the inspections, critical features that should be observed, inspection techniques, and preparation of inspection reports.

MOSD coordinators, maintenance personnel, and park emergency action plan (EAP) coordinators should complete training every two years to assure they stay abreast of developments in the maintenance, operation and safety of dams. Training for the inspection of dams is normally provided by the Bureau of Reclamation (USBR) on an annual basis. These courses are geared to persons not familiar with engineering or geology but who are responsible for the safety and maintenance of small dams. Contact Inspections and Emergency Management Group, Bureau of Reclamation, 303-445-2740 for further details.

Designated park emergency operations plan coordinators should attend training in the preparation, exercising, or use of EAP's and ensure their integration into the park's overall emergency operations plan.

E. Funding and Personnel Resources

1. General. Continuity and adequacy of funding and personnel are essential to carry out the MOSD program objectives. The NPS budget formulation and execution system offers an opportunity for managers to identify funding priority for those activities, programs, staff levels, or other operating requirements to assure a sound MOSD program. Long−term programming objectives should be developed and adhered to in order to establish a systematic program. To meet these objectives, the following activities should be properly staffed, funded and scheduled by Regional Directors and Superintendents:

Period	**Activity/Resource**
As necessary	Staff
Every two years	Training
Annually	Update NPS Inventory of Dams

Periodic Inspections:	
Annually	Annual Informal Inspections − All dams under NPS management responsibility and essential to park management and operations.
Every two years	Intermediate Inspection − high (1) or significant (2) hazard potential dams only.
Every five years	Formal Inspections − same type as above.
As necessary	Acquisition
As necessary	Project engineer assigned to either high (1) or significant (2) hazard potential dam during major rehabilitation or construction.
As necessary	Design, Plans, Specifications
As necessary	Independent Review of Design.(high (1) or significant (2) hazard potential dams)
As necessary	Major preservation, rehabilitation, or construction
As necessary	Independent Review of Construction (high (1) or significant (2) hazard potential dams)
Annually	Maintenance and Operations
Prepare or update annually	Emergency Action Plans
As necessary	Disposal (sale or removal)

A base level program will be established in each applicable region, park, and DSC to assure that routine and recurring activities are properly funded and staffed. To assure cost effective management of NPS dams, the above sequence should be followed as closely as possible, particularly the periodic inspections which give a comprehensive evaluation of the dam's purpose and condition in relationship to park objectives.

2. Sources. The primary funding and personnel source for this program is the maintenance, repair/rehabilitation, or construction programs. Although Servicewide funding for the MOSD program has been made available out of the Washington Office Park Facility Management Division, it is now the responsibility of Regional Directors, Superintendents, and Manager, Denver Service Center, to assure adequate funding and personnel to meet: MOSD program objectives. There are several other funded programs which are interrelated to the maintenance, operation and safety of dams. The following list is provided to alert NPS managers as to the need for well coordinated and funded programs to prevent overlap and duplication of funding and personnel:

- −Cultural Resources Cyclic Maintenance
- −Preservation, Design and Construction
- −Risk Management Division (occupational and public type safety)
- −Law enforcement and ranger Activities (evacuation during imminent disasters)
- −Land Acquisition (acquire existing dams during land purchases).

3. Methods. There are several methods of requesting funding and personnel to assure the maintenance and safety of NPS dams. Reprogramming of funds/personnel is only for extremely, urgent action within the current fiscal year. This type of programmatic change would occur only when an NPS dam is found to be seriously deficient and poses an imminent threat to life and significant property, and immediate corrective action is necessary. Supplemental budget requests may be used during the current budget year to provide urgently needed funds or personnel, but some delay is allowable in performing corrective action. The regular budget formulation and execution process is used to program funds for routine but yet necessary activities. The NPS Operating Financial System (OFS) is used for preparing requests of annual operating type funding or personnel increases. Activities that would be programmed with this form are as follows:

- −Staff
- −Inventory Data Base Management −Training
- −Travel
- −Periodic Inspections
- −Routine Maintenance, Repairs, and Operation
- −Develop and Update Emergency Action Plans

The NPS Project Management Information System (PMIS) is normally used for multi−year funding for substantial development projects involving major rehabilitation, reconstruction, or acquisition. In developing these funding and personnel resources, close coordination should be made with the budget officer.

4. Cost Accounting. Cost accounting should be used to assure cost effective management of funds and manpower utilized in the

maintenance, operation, and safety of dams.

F. Documentation

1. General. Throughout project acquisition, development, and operation, all data, computations, engineering and management decisions should be documented for planning, site investigation, design, construction, initial reservoir filling, maintenance and operations, or disposal of dams under NPS management. The amount of documentation should vary with the level of hazard potential or operational importance of the structure. Dams under NPS management that have either a high (1) or significant (2) hazard potential classification will receive full documentation.

2. Design/Construction. Written documentation should be maintained in standardized format on all designs for the project. All phases of the construction should be documented, including reporting of routine and special activities. Changes in construction plans and departures from expected site conditions should be documented, with any consequent design changes. As−built drawings should be prepared as facilities are completed, and should be made available to operation and maintenance personnel and to the dam inspection staff. An initial reservoir filling and surveillance plan should be prepared by the design staff. Initial filling should be well documented, including a record of reservoir elevations arid controlled water releases during the filling.

3. Operation and Maintenance Log. Operation and maintenance should. be fully documented, including the routine activities and systematic inspection processes, and complete information on project maintenance, rehabilitation, and improvements. In addition to records on the actual operations, the operating record should include data on reservoir levels, inflow and outflow, drainage system discharge and structural behavior.

If there are maintenance problems that require continuing remedial work, a thorough record of the work should be maintained, and a final report made after complete remedy of the problem.

4. Data Books. Data Books will be prepared by the Bureau of Reclamation (USBR) or other inspecting organization for all NPS high (1) or significant (2) hazard potential dams which are scheduled for formal inspection. Appendix E is a checklist of the types of existing data which will be valuable for evaluating the safety, maintenance, and operation of these dams. Existing information for these Data Books should be prepared and distributed by Regional Directors or Superintendents to USBR or other inspecting organization two months prior to the actual on−site examination.

5. Required Reports. At the indicated times, Regional Directors and Manager, DSC, will submit the following reports or documents to the Director, Attention: Park Facility Management Division:

a. Immediately, report any partial or total dam or appurtenant works failure, misoperation, or uncontrolled release of reservoir affecting park resources, operations, or safety.

b. Immediately, report any injury, death, or significant property or resource loss because of dam failure, misoperation, or uncontrolled release of reservoir. Items wand b should be combined if appropriate.

c. Immediately, report any dam in seriously deficient condition, as so determined from a formal inspection, and whose failure or misoperation would affect park safety or operations. State what corrective action is being taken and when it will be completed.

d. Inventory update at least annually by September 30, on any size, type, owner or status dam (planned acquisition or disposal) 'that affects park resources, operations, or safety.

e. Report annually, by September 30, on any planned or actual major preservation, rehabilitation, construction, acquisition, or disposal of dams that affect park safety or operations.

f. Submit annually, by September 30, list of personnel responsible for coordination of maintenance, operation, and safety of dams program and any training that has been attended.

g. Submit annually, by September 30, a brief financial summary of funding, either programmed or spent by fiscal year, for this program. Items e and g should be combined if appropriate.

h. Distribute annually, by September 30, copies of completed and approved NPS Annual Informal Inspection (AII) reports.

i. Report annually, , by September 30, on the status of park emergency operations plans (EOP's) in which are integrated emergency action plans for any High or Significant hazard potential dams affecting the park. Also for NPS affected areas, an Early Flood Warning, Search/Rescue, Evacuation, and Recovery Plan (ESEP) should be integrated in the park's EOP.

G. Technical Reviews

1. Extent. All factors affecting the safety of high (1) or significant (2) hazard potential dams under NPS management will be reviewed during design, construction, and operation on a systematic basis. Reviews include those internal to the agency and those external to the agency by individuals or boards (consultants) with recognized expertise in dams.

2. Internal. Provision should be made for automatic internal review of all design and construction decisions, methods, and procedures related to dam safety. Reviews should be at levels of authority above the design section or designer−supervisor relation.

3. External. An appropriate level of independent review by a qualified engineering firm or other Federal agency (i.e., Bureau of Reclamation) with safety of dams expertise should be performed during design or construction of dams under NPS management.

CHAPTER THREE
NPS PLANNING AND ENVIRONMENTAL EVALUATION PROCESS
FOR PROPOSED OR EXISTING DAMS

A. General

Considerable information has been compiled in Appendix A about dams that affect park maintenance, operations and safety. Information on these facilities is updated periodically in the NPS inventory of dam data base which is discussed in Chapter Two, section C, and is readily available upon request. These dams should be appropriately considered during the NPS planning and environmental evaluation process in the following sequence of activities to assure their systematic management:

−Inventory of any size, type, owner, or status (proposed acquisition or disposal) dams that affect park maintenance, operations, or safety; −Periodic inspection of any of the above dams under NPS management, including dams proposed for acquisition. If possible, estimates of funding and personnel should be included for corrective action or disposal;

−Acquisition of dams. A formal safety report including cost estimates to correct identified deficiencies should precede the appraisal of a dam site. The condition of the dam may have a bearing on the fair value of the property.

−Qualified NPS project engineer or coordinator assigned to any high (1) or significant (2) hazard potential dam undergoing detailed investigation to assure coordination with guideline;

−Preparation of design, plans, and specifications for major preservation, rehabilitation, or construction;

−Independent review of design, plans, and specifications of high (1) or significant (2) hazard potential dams;

−Performing preservation, major repair or rehabilitation, reconstruction, or construction;

−Independent review of preservation, major repair or rehabilitation, reconstruction, or construction on any high (1) or significant (2) hazard potential dams;

−Maintenance and operations;

−Emergency action plans at either high (1) or significant (2) hazard potential dams; and

−Disposal (sale or removal and restoration of drained impoundment).

B. Acquisition, Holding, or Disposal

During the acquisition, holding, or disposal of dams at NPS administered areas, proper planning should be undertaken to assure compliance with the National Environmental Protection Act (NEPA) of 1969, Public Law 91−190, as amended; various Executive orders on floodplains, wetlands, and safety of dams; and the Section 404 Permit Program by the U.S. Army Corps of Engineers. The objectives of these regulatory requirements are to help provide a safe, ecologically and culturally complementary, and favorable benefit/cost ratio project. This guideline on the maintenance, operation and safety of dams should be properly integrated into the NPS planning and environmental evaluation process. Any dam, regardless of owner, that has a high (1) or significant (2) hazard potential or is/will be important to park management should be discussed in the General Management Plan and its associated environmental document in regard to is purpose and required care. Dams that are not essential to park management and operation should be properly disposed. Information should be requested from non−NPS dam owners during the NPS planning and environmental evaluation process to determine the safety and operational significance of their structures on NPS floodplain management and the need for any emergency action plans. Refer to Appendix G for an example letter for coordinating with non-NPS dam project owners and/or regulators. The Corps will assist in providing information about non−NPS dams and hydrologic and hydraulic analyses in determining the 100 and 500−year floodplains. When possible, the floodplain and emergency action plan inundation mapping should be combined. Flood profiles should be presented with the mapping. A current list of these dams by region and hazard potential is also given in Appendix A.

C. Floodplain Management and Wetland Protection

The NPS floodplain/wetland protection guidance should be carefully reviewed with proper consideration as to the effects of dam safety and operation on floodplains in NPS administered areas. Any dam having a high (1) or significant (2) hazard potential that is located upstream, at, or downstream of a particular floodplain study reach under NPS investigation will be evaluated as part of the environmental assessment process and reported in the "Statement of Finding" as to its safety and operational effects on floodplain

development. The Regional Dams Coordinator will provide the necessary evaluation. Many of the older high (1) or significant (2) hazard potential dams in or adjacent to park boundaries were not designed or maintained to safely operate during the 100 and 500−year base floods which are used for park planning in floodplains. Consequently, because the probable failure of these older dams would produce significant flooding above the natural 100 or 500−year floods, it is paramount that these types of structures receive periodic inspection and appropriate corrective action. For non−NPS dams whose operational safety cannot be ascertained, conservative design and operational procedures in park administered areas should be utilized to compensate for this condition. Inhabitable facilities, utilities or transportation systems will not be built or operated in floodplains subject to the effects of dams in seriously deficient conditions, and there are no active and funded programs for corrective action.

D. U.S. Army Corps of Engineers Section 404 Permit Program

The protection of wetlands is interrelated to the U.S. Army Corps of Engineers Section 404 Permit Program for dredging (digging) or filling in or near any significant stream, river, lake, or harbor. This dredging or filling permit requirement is applicable for new dams or existing dams proposed for modification or disposal. Requirements are based upon volume of material and other considerations. Local U.S. Army Corps of Engineer Districts will provide advice on the applicability of the Section 404 Permit Program for dams and appurtenant works under NPS management.

CHAPTER FOUR
MANAGEMENT OF TECHNICAL ACTIVITIES - SITE INVESTIGATION
AND DESIGN FOR PROPOSED OR EXISTING DAMS

A. General

This section of the guideline outlines the site investigation and design technical activities that Regional Directors, Superintendents, and Manager, Denver Service Center, should ensure are undertaken to obtain safe design or evaluation of dams. It is recognized that the extent of application of this guideline will vary depending on the size, function, and hazard potential classification of the dam.

B. Hydrology

1. Hazard Evaluation. Areas impacted by dam construction and existing dams should be examined for potential hazards to present and future developments in the event of major flooding by controlled flood discharges or flooding induced by dam failure or misoperation. This hazard evaluation is the basis for selection of the performance standards to be use in am design or in evaluation of existing dams. See Chapter 1, Section D, 3.

2. Flood Development. Hypothetical floods, generally of severe magnitude, should be developed for use in design or evaluation of major dam and reservoir features, including development of appropriate floods for the construction period.

3. Flood Selection for Design (or Evaluation). The selection of the design flood should be based on an evaluation of the relative risks and consequences of flooding, under both present and future conditions. Higher risks may have to be accepted for some existing structures because of irreconcilable conditions. Reference should be made to U.S. Army Corps of Engineers Publication, ER 1110-2-106, National Program for Inspection of Non-Federal Dams, Washington, D.C., September 26, 1979, page D-11, for assistance in making the determination.

When flooding could cause significant hazards to life or major property damage, the flood selected for design should have virtually no chance of being exceeded. If lesser hazards are involved, .a smaller flood may be selected for design. Ideally, spillway operation should be evaluated in such a way that dam failure resulting from overtopping would not-significantly increase the hazard to loss of downstream life or property from that flooding condition which would exist just before overtopping failure.

To reduce hydrologic and hydraulic engineering costs, systematized computer programs like HEC-1 Dam Break by U.S. Army Corps of Engineers could be utilized effectively for many small National Park Service dams. This computer program will generate an inflow design flood, route the flood through and/or over the dam (including outflow from any defined hypothetical dam failure), and then route the flood wave to a downstream damage reach for evaluation, all in a single operation. This systematic method allows for a rapid optimization of spillway requirement to adequately protect existing and any anticipated downstream development.

4. Hydrologic Design of Reservoir. In addition to selection of a design flood, the hydrologic design of a new reservoir or the evaluation of an existing project involves consideration of discharge and storage capacities, reservoir regulation plans including constraints, land requirements, and wind/wave effects.

Reservoir regulation plans should be developed in the planning of projects so that realistic release rates will be used in routing the design flood. Regulation plans should include the construction period.

The reservoir regulation plans; water control management plan, and data. Information systems should be periodically reviewed for deficiencies and potential for misoperation during both severe flood events and normal conditions. Necessary corrections should be made as soon as practicable.

5. Downstream Effects. Safety design includes studies to ascertain areas that would be flooded during occurrence of the design flood and in the event of dam failure. The areas downstream from the project should be evaluated to determine the need for land acquisition, flood plain management, Flood Insurance Program or other methods to prevent major damage. Information should be developed and documented suitable for releasing to downstream interests regarding remaining risks of flooding.

6. Warning Systems. Safety design should include an emergency flood warning system and action plan that would effectively notify all concerned in ample time for appropriate action.

C. Earthquake Investigation and Design

1. Investigation Factors. The following factors should−be considered in selection of design earthquakes.

a. Geologic and tectonic setting of the site area by analysis of the lithology, stratigraphy, structural geology, and tectonic history.

b. Historic earthquake record to include the size, location, and other seismological characteristics as available, and the relationship, if possible, with the tectonic setting of the area−in which the earthquakes have occurred.

c. Influence of the properties of the surficial materials on the determination of the size of historical earthquakes.

d. Influence of faulting or other tectonic features on the estimate of the occurrence, size and location of possible future earthquakes.

2. Selection of Design Earthquakes. From the above factors, earthquakes should be selected that have sufficient potential of occurring to require consideration in the dam design. Earthquake description should include estimates to the extent practical of' the size, location, depth, focal mechanism, and frequency of occurrence.

3. Engineering Seismology. Determination should be made of the characteristics of ground motion that would be expected from the design earthquakes, to the extent possible, to include amplitude (displacement, velocity and acceleration), frequency content, and duration.

4. Need for Earthquake Analysis. The probable effects of earthquakes on the dam and its appurtenant structures should be evaluated to determine the need for inclusion of earthquake forces in the structures analyses. Evaluation includes consideration of factors such as the project stage, hazard and risk factors, the size of the dam and reservoir, the potential ground motion at the site, site geology, and type of structure. Where determination is made that no earthquake forces are required in analysis, the determination should be justified.

5. Seismic and Geologic Studies.

a. Earthquake Sources. The essential first step is determination of the design seismic events (usually the maximum credible earthquakes) and an estimate of the ground motion: at the site due to these events. From a study of the regional tectonics and seismicity, and both regional and local− geology, potential sources for seismic events are identified, and the maximum credible earthquake magnitudes postulated.

b. Design Events. A maximum credible earthquake (MCE) is defined herein as the hypothetical earthquake from a given source that could produce the severest vibratory ground motion at the dam. Time histories of the estimated rock motion (accelerograms) at the dam for the various seismic events are selected to characterize the severity of the strong motions by their peak accelerations, frequency content, and duration.

6. Design for Earthquake Forces.

a. Safety Concerns. All earthquake−related safety concerns should be identified. Potential safety concerns include but should not be limited to dam foundation integrity stability, unacceptable stress levels, fault displacements; abutments stability; effects of dam overtopping; dam stability; susceptibility of embankment dams to embankment or foundation liquefaction, cracking or excessive deformation.

b. Analysis Method. Determination of appropriate earthquake analysis methods for evaluation of safety concerns may be, as appropriate, by qualitative evaluations, pseudostatic analysis, and dynamic analysis. The methods selected should be appropriate to the identified safety concerns in accordance with good engineering practice and with currently available technology.

c. Structural Adequacy. Structural adequacy assessments should be made of all safety−related components and concerns identified. These assessments should incorporate all applicable data and analysis.

D. Geotechnics

1. General.

a. Site specifics. After a site is selected, a program for the geotechnical exploration, design, and analysis of that specific site is required. No checklist can be made which would cover all eventualities at all sites, or at any one site, and attempts to formulate such a list would be counterproductive to the intent to ensure dam safety. The best insurance for adequate geotechnical work is a well−trained and experienced staff actively involved in field inspections throughout all phases of the development of the site.

b. Documentation. Because many evaluations are possible for a given set of geotechnical conditions, it is important that full documentation be made of the reasoning process involved in geotechnical decisions. General guidelines for documentation are given in Chapter Two, section F.

c. Management of Diverse Technical Expertise. Geotechnical work encompasses the expertise of geologists, geophysicists, and engineers−all with diverse experience, training, and technical terminology. The administrative and technical supervision

of these experts should be structured to optimize coordination and cooperation. Management should encourage intellectual curiosity and an inquisitive approach to all geotechnical work. Since the field of geotechniques is rapidly expanding, Regional Directors and Manager, Denver Service Center, should assure that those persons associated with site exploration and development, maintain currency with the state of the art.

2. Exploration and Identification of Geotechnical Problems. The exploration program needs to be site specific, flexible, and executed so as to obtain the maximum data from each part of the program. Regional Directors and Manager, Denver Service Center, should ensure sufficient funding for an orderly development of the exploration program in order to reduce uncertainties and to make adequate provisions for required corrective measures.

3. Geotechnical Design. Geotechnical design considerations for the dam foundation and reservoir area are essentially defined after the geologic conditions of the site, the type of dam, and the magnitude of the stresses imposed on the foundation by the dam and reservoir have been determined.

4. Foundation Treatment.

a. General. The preparation of the foundation, including the abutment, is one of the most important phases of construction. The primary purposes of foundation treatment are to provide stability, obtain positive control of seepage, and minimize adverse deformation. The geology, foundation conditions, foundation treatment, and proposed structure should be considered together.

b. Stability. Surfaces should be prepared to provide a satisfactory contact between the foundation and the overlying structure by removal of unsuitable materials. Deficiencies in the foundation which are not removed should either be treated by modification of the structure or by appropriate foundation treatment tailored to handle the conditions encountered.

c. Positive Control of Seepage. Highly permeable foundations should be treated by such measures as cutting off the pervious material, grouting, increasing the seepage path by upstream blankets, or controlling the seepage with drainage systems. Where appropriate, surficial cavities should be traced, cleaned out, and backfilled with material satisfying the design requirements. When cavities exist at depth, measures should be taken to ensure against the migration of cavity material.

d. Control of Piping. Silts and fine sands in the foundation, which are susceptible to piping, should be removed if practical, cut off near the downstream limits of the dam, covered with impervious material, or provided with filtered drainage systems. If pipable material is used in the dam, the foundation surface treatment should prevent migration of dam material into the foundation.

e. Deformation. Foundations subject to differential settlement or foundations having highly compressible anomalies can cause stress concentrations or cracking in dams. The foundation excavation should be shaped to remove abrupt changes in elevation to preclude excessive differential settlement or stress concentrations. Low shear strength material in a foundation can cause shear failure. Excavation and replacement of low strength material is a positive method for treating a foundation that has either or both of these unfavorable conditions.

5. Instrumentation. Although a well conceived foundation instrumentation program serves to monitor the foundation and give an indication of distress, it cannot of itself certify the safety of the foundation. , The expertise of the engineer/geologist to analyze, design and prepare a foundation that will safely carry the loads and water pressure imposed by the dam and the reservoir is fundamental to the design adequacy of the foundation. The purposes of foundation instrumentation are fourfold: to (1) provide data to validate design assumptions; (2) provide information on the continuing behavior of the foundation; (3) observe the performance of critical known features; and (4) advance the state of the art of foundation engineering.

6. Inspection and Continuing Evaluation During Construction. Those responsible for the investigation and design of the foundation should make on−site evaluations to confirm that actual conditions conform to those assumed in the design and to review documentation of site conditions.

7. Reevaluation at Existing Structures. Older dams under NPS jurisdiction may not have been designed to standards equal to current criteria. Also, a substantial portion of safety−related dam incidents are associated with foundation problems which develop in a time−dependent fashion after construction. For these reasons, systematic reevaluations of existing dams should be made for appropriate structures.

E. Hydraulic Appurtenances

1. General.

a. Protective Measures. All hydraulic appurtenances used for releasing water should be designed to preclude jeopardy to the damming provisions.

b. Blockage. Allowances for or preclusion of blockage of hydraulic facilities should be incorporated in the design.

c. Reliability. When operational failure of a gated passage would jeopardize the damming provisions, alternate capacity should be provided. When operation of a gated passage is essential to safety, reliable manpower, communications and accessibility should be assured.

d. Hydraulics and Hydrology. Hydraulics and hydrologic design considerations should be correlated with Chapter 4, B.

2. Design Flood Releases.

a. Spillway and Outlets. Gated spillways are the usual hydraulic appurtenances for control of all, or the major portion of, the design flood and major emergency releases. Outlets (sluiceways, conduits and tunnels) may be used alone or in conjunction with spillways to control flood discharges.

b. Selection of Type. Spillways and outlets should be selected to meet the site specific purposes of the project. For a drainage area with short concentration time combined with reservoir storage capacity that is small relative to the flood volume, especially for embankment dams, (1) the spillway should usually be uncontrolled, and (2) outlets should not normally be used for sole or part control of the design flood except in special cases where the outlet can be uncontrolled.

3. Other Water Releases. Other water release hydraulic appurtenances such as navigation facilities, locks, fish facilities, ice sluices, trash sluices, and water quality facilities should conform to the requirements of section E.1.

4. Reservoir Evacuation. Where practicable, reservoir release facilities ' should be provided to lower the pool to a safe level adequate to correct conditions that might threaten the integrity of the dam.

5. Control of Flows During Construction. The provisions of section E.1 also apply generally to the design of hydraulic appurtenances used during construction. The capacity of these appurtenances should be sufficient to satisfy the discharge requirements of the regulation plan for control of water during construction.

6. Design Criteria and Guidance. If existing design criteria and guidance from past projects and experience are used for design of the hydraulic appurtenances, their sufficiency should be documented.

F. Concrete Dams and Concrete Elements of Embankment Dams

1. Site Specific Design. Because all dam sites are unique, the type of dam and its appurtenances should be specifically matched to site conditions and project requirements. It is essential when reviewing the safety of−existing dams to consider conditions which may have changed physically, new concepts resulting from new technology, and additional project information since construction, i.e., foundation deterioration, increased flood hydrographs, or larger design earthquakes.

2. Materials. Concrete for the structures requires competent investigation of material sources and adequacy of supply testing of materials properties in accordance with accepted standards, and proper proportioning of concrete mixes (including additives) for strength, durability, control of thermal properties, and economy.

3. Design of Structures. There are three components of a dam which must be considered for safety; the foundation, the dam, and its appurtenant structures.

a. Foundation. Proper design of a concrete dam requires information on the foundation geological conditions and material properties to assure its capabilities to support the loads of the dam and reservoir, in its natural state or as improved by foundation treatment.

b. Dam. Concrete dams should be designed to be safe against overturning and sliding without exceeding allowable stresses of the foundation and the concrete for all loading conditions imposed on the dam. The shape and/or curvature of a dam and its contact with the foundation are extremely important in providing stability and favorable stress conditions. Proper consideration should be given to ensure the dam's safety in the event of overtopping.

c. Appurtenances. Safety−related appurtenances such as outlet works structures, spillways, penstocks, powerhouses, and navigation locks should be designed with the same degree of safety as the main dam. If the project has a powerhouse as an integral part of the dam, it should be designed for the same safety requirements as the dam.

4. Definition of Loads. The dam and appurtenances should be designed or evaluated for all static and dynamic loads to which they will be subjected.

5. Design Methods. The methods required for design of the several types of concrete dams and their appurtenances vary from simple to complex, depending on the type and size of the structure, the hazard potential, the site, the kinds of loading, and foundation conditions. The design process involves judgment and analytical expertise to select appropriate methods to analyze

a structure whether it requires a simple or complex analysis and to determine design input that is representative of the range and variation of foundation and structural material properties. The selection of input parameters is just as important as the mechanics of the analysis used.

6. Design Evaluation. Technically qualified supervisory personnel should assure that structures are designed to meet the requirements for safety. This includes confirmation of design input parameters, design methods, and utilization of allowable factors of safety against overturning, sliding, and stressing appropriate to the probability of the loading conditions.

7. Instrumentation. Knowledge of the behavior of structures and their foundations may be given by studying the service action of the structures using observations on embedded and other internal instrumentation and external measurements.

8. Construction and Operational Follow−up. It is necessary that the designers should be involved in the construction and operation processes to confirm that the design intent is carried out, and to allow changes and modifications resulting from redesign necessitated by differences between assumptions and actual field or operating conditions.

G. Embankment Dams

Section F contains general dam considerations. The following additional considerations are applicable to embankment dams:

1. Site Specific Design. Embankment design should be developed for specific site conditions and based on adequate exploration and testing to determine all pertinent geologic and material factors with particular emphasis on shear strength and stability, permeability and control of seepage, and consolidation and settlement

2. Materials. Embankments can generally be designed to utilize locally available construction materials; investigation of materials characteristics is required and problem materials should be either discarded or protected by defensive design. There is often a need for importing special materials for slope protection, filters, and drainage systems. Any embankment zoning should consider the properties and quantities of available materials and the effect of their characteristics on the construction process.

3. Design Constructibility. Embankment designs should be constructible with regard to such items as location of borrow areas with respect to flooding, in situ moisture conditions, climatic effects on construction schedules, width of zoning, and needs for special material processing Design should include protection of critical features from overtopping by floods during construction.

4. Embankment Design. The safety of an embankment is dependent on its continued stability without excessive deformation under all conditions of environment and operation, and on control of seepage to preclude adverse effects on stability and prevent migration of soil materials. Design considerations given below are specific to embankment dams.

a. Seismic. Where earthquake design is necessary, consideration should be given to earthquake−related concerns of soil liquefaction and cracking potential, stability and excessive deformation, abutment stability, overtopping effects, and required defensive measures.

b. Stability. Embankment stability should be analyzed for all pertinent static and dynamic loading conditions without exceeding allowable shearing stresses in the embankment or foundation.

c. Settlement and Cracking. The potential for transverse cracking of the embankment caused by differential settlement, tension zones, and possible hydraulic fracturing should be minimized by careful consideration of abutments, foundation and cutoff trenches, and their geometry and treatment.

d. Seepage. The design should attempt to prevent or minimize seepage through the embankment and its foundation and abutments; however, the designer should recognize that seepage usually occurs and that protective control measures must be provided. Filtering transition zones and foundation and abutment treatment to seal openings should be provided wherever necessary to preclude migration of soil materials into or out of all embankment element contacts both upstream and downstream. Filters, drainage blankets, and transitions should be of a quality and size to conservatively control and safely discharge seepage for all conditions for the life of the project. Particular attention should be given to contacts with foundation, abutments, embedded structures, and the end slope of closure sections to ensure adequate compaction and bonding to control seepage.

e. Zoning. Embankment zoning when used should ensure adequate stability for all pertinent conditions, and should control seepage through the embankment and provide filter action to prevent migration of material.

f. Erosion. Upstream and downstream slopes and foundation and abutment contacts should be protected against erosion from surface runoff, wave action, and impinging currents. Spillways and outlet works should be located and designed so that discharges do not erode the embankment or its foundation.

5. Instrumentation. Embankment design and prediction of embankment performance are based on an imprecise combination of theory and empirical procedure; consequently, performance during construction and operation should be monitored by a design system of external measurements and/or installed instrumentation.

6. Construction and Operational Follow−up: Stability should be evaluated during and after construction using strength parameters from as−placed materials and observations of pore pressure and seepage if and when condition, warrant. Designers should inspect and review performance of embankments during and after reservoir impoundment to detect and provide prompt remedial treatment for problems. While major emphasis is placed on initial impoundment the surveillance should continue for the life of the project

CHAPTER FIVE
MANAGEMENT OF TECHNICAL ACTIVITIES – CONSTRUCTION OR REHABILITATION OF DAMS

A. Introduction

This section of the guideline outlines the construction technical activities that Regional Directors, Superintendents, and Manager, Denver Service Center, should ensure are undertaken to obtain safe construction of dams. The principles and guideline are prepared in a broad sense to ensure that construction of a safe structure is the prime requisite. It is recognized that the extent of application of this guideline will vary depending upon the size, function, and hazard potential.

1. Construction Contracts. Construction contracts should be based on site conditions as interpreted at the time of contract award. All anticipated work on foundation cleanup, preparation, and treatment should be included as specified items of the work. Contract provisions should require the contractor to submit to the construction engineer advance notice of significant shift change to enable adequate inspection coverage of multi-shift operation.

2. Construction/Design Interface. Many aspects of construction directly overlap in design considerations. Reference is made below to numbered paragraphs in Chapter 4, Management of Technical Activities − Site Investigation and Design, which concern such common interests:

a. Geotechnics
- (1) General
  - (i)Site Specifics
- (2) Exploration and Identification of Geotechnical Problems
- (3) Geotechnical Design
- (4) Foundation Treatment
- (5) Instrumentation
- (6) Inspection and Continuing Evaluation During Construction

b. Hydraulic Appurtenances
- (1) Control of Flows During Construction

c. Concrete Dams and Concrete Elements of Embankment Dams
- (1) Site Specific Design
- (2) Materials
- (3) Design of Structures
  - (i) Foundation
- (4) Instrumentation
- (5) Construction and Operational Follow−up

d. Embankment Dams
- (1) Site Specific Design
- (2) Materials
- (3) Design Constructibility
- (4) Embankment Design
  - (i) Settlement and Cracking
    - (ii) Seepage
  - (5) Instrumentation
- (6) Construction and Operational Follow−up

B. Evaluation During Construction. Field personnel must be highly trained and experienced in the design principles and site

conditions are to be understood and a safe structure is to be constructed.

When differing site conditions (different from those anticipated) are encountered construction supervisory forces must have authority to suspend any or all portion of the work affected until the design engineers, with assistance as needed, can evaluate the condition and determine if design modification is required.

Construction milestones should be identified when the design engineers will inspect the work and concur with the progress of construction.

C. Orientation of Construction Engineers and Field Inspectors. Construction engineers need to e aware of design philosophies and assumptions as to site conditions and function of project structures, and must understand the designers' intent concerning technical provisions in the specifications.

Construction specifications, supplemental reports, and conferences to orient field personnel to the particular site, the features of the dam, and the designers' intent for construction should, as applicable, include the following:

1. Design Related

a. Design concepts. An explanation should be given of philosophies and assumptions and the reasons for special requirements in the specifications to assure accomplishment of design intent.

b. Construction sequence. Identification and explanation of the dates to which construction progress must conform to satisfy project requirements, and the special sequences for construction activities that are required by design.

c. Instrumentation systems. Description should be given of the instrument types, their purpose, the procedures for installation of each instrument type, the method and time interval for reading each instrument, and the importance of prompt data transmission for analysis and feedback.

d. Care and diversion of water. Description of the design features included to prevent and/or control flooding and turbidity and accomplish diversion and closure of the dam. This should also contain the design requirement for controlling normal flows through the work area to assure that construction is always accomplished under dry conditions. Critical aspects of the construction schedule related to flood problems should be emphasized.

2. Foundation

a. Description. Discussion of the type of foundation conditions expected to exist, i.e., overburden, general rock description, formation weaknesses (such as joints, shears and faults), and acceptable foundation conditions.

b. Excavation. Discussion of the depth and nature of materials expected to be encountered, the controls for dewatering and blasting, identification of critical areas, quantity estimates, and an acceptable foundation.

c. Preparation. Review of the methods of rock foundation preparations such as: cleaning; the use of wire mesh, mortar, shotcrete, or cock bolts; grouting, and treatment of faults, shears and joints; as well as subsequent exploration to assure desired results. Review of methods of earth foundation preparation.

3. Materials

a. Materials from required excavation. Definition should be given of acceptable and unacceptable properties of materials, the usage and the processing required if used, and identification of waste area locations.

b. Other excavated materials. Identification of the location and amount of useable material, "based on current test data," available from all designated areas, including borrow pits. Review of the blasting methods that are expected to produce the desired rock quality and sizes. Discussion should be given of the expected amounts of waste and the areas where borderline material may be used in lieu of wasting, such as in berms or certain zones of the downstream shell of an earthfill dam.

c. Embankment. Description should be given of both acceptable and unacceptable material properties, placement, and compaction procedures for each zone. Review of required procedures for areas adjacent to abutment, around instruments, and at interfaces between zones and/or structures.

d. Concrete and concrete materials. Identification should be given of acceptable aggregate sources and review of mix designs, joint and surface treatment, finish requirements, form tolerances, and placement procedures. Cooling as well as hot and cold weather protection requirements should be defined.

4. Construction General

a. Field control. Discussion of the quality assurance procedures required to control all phases of construction. Acceptable placement standards should be established for concrete, earth and rock materials, and embankments.

b. Structural. Discussion should be given of structural steel installation, reinforcing steel placement, and anticipated problem areas and specified treatment for such areas.

c. Mechanical−electrical. Description of equipment installation requirements, special procedures, performance tests, protective coatings, and protection devices such as ground fault indicators.

d. Environmental. Identification of those construction controls required to minimize environmental damage, comply with environmental regulations, and assure public involvement.

D. Construction Assurance

1. Construction Procedures. Criteria must assure that acceptable methods and procedures are specified and utilized to accomplish design requirements. At the time, the design and construction organizations must maintain the flexibility necessary to modify design, material requirements, and construction specifications as conditions dictate without altering the basic design intent.

2. Construction Materials Testing. A materials laboratory must be established at the field construction office that is adequately staffed and equipped to accomplish the on−site testing requirements set forth in the engineering considerations and instructions to field inspection personnel.

3. Quality Assurance. It is mandatory that adequate construction quality assurance systems and procedures be established to assure safe dam construction. The quality assurance system must guarantee, by direct inspection and testing, that construction is accomplished in compliance with the contract plans and specifications. Daily inspector's reports, laboratory test data records, and photographs are the minimum mandatory methods of documentation. General guidelines for documentation are given in Chapter two, section F.

As part of the quality assurance program, the contractor should normally be required to submit various plans for approval not limited to, but including, the following:

Construction Schedule
Safety Program
Care and Diversion of Water (including pollution control)
Fire Protection
Plant layout (including haulroads)
Environmental measures
Equipment Inventory
Dewatering Foundations and Borrow Areas
Excavation Sequence of Foundations and Borrow Areas
Drilling and Blasting Procedures
Concrete Placement
Restoration of Construction Area

CHAPTER SIX
MANAGEMENT OF TECHNICAL ACTIVITIES − OPERATION AND MAINTENANCE FOR PROPOSED OR EXISTING DAMS AND APPURTENANT WORKS

A. General

This section of the guideline outlines the management responsibilities for operation and maintenance, periodic inspection program, and emergency action planning that Regional Directors, Superintendents, and the Manager, Denver Service Center, should ensure are undertaken to obtain the safe and economic operation of dams under their jurisdiction. It is recognized that the extent of application of this guideline will vary depending on the size, function, and hazard potential classification of the dam.

B. Operation and Maintenance

1. General. All features of NPS dams and appurtenant works should receive maintenance or operation as recommended from

inspection reports−annual informal, intermediate, or formal. These reports should be prepared by trained and experienced engineers familiar with the maintenance and operation of small dams.

Unless it is an extenuating condition, extensive maintenance or testing of dam equipment should only be performed because of recommendations in an inspection report. These recommendations should be performed by personnel familiar with the maintenance and operation of small dams.

Serious maintenance, operational, or safety problems that are discovered during maintenance or operation work should be reported immediately to the Park Superintendent and personnel responsible for inspections as to the proper action to be taken. Maintenance and operations should be scheduled far enough in advance to take advantage of good weather periods, terrain conditions, and manpower and equipment availability to assure safe and economic work.

A log of maintenance and any required operation will be maintained and filed with the previous Annual Informal Inspection. The log will list the crew supervisor's name, date, activity accomplished or attempted, if incomplete, and total cost (overhead, materials, and labor, if readily available). Information about failures (partial or total), misoperation, accidents, floodings, or instrumentation readings should also be kept in the log.

2. Operating Procedures. Operations consist of the periodic testing of gates or any other type equipment to assure reliable use, establishing instrumentation as required, or reviewing any operating manuals or emergency action plans for completeness and accuracy. When appropriate, written operating instructions should be prepared for the dam and its associated structures and equipment. The instructions should cover the functions of the dam and reservoir and describe procedures to follow during flood conditions to ensure dam safety.

If appropriate for more critical NPS dams, reservoir operating rule curves should be available for each normal mode of operation and for emergency conditions.

An auxiliary power system, such as a gasoline, crane or diesel−operated generator, is essential if the outlet and spillway gates and other dam facilities are electrically operated.

All spillway and outlet gates should be tested on a regular schedule. The tests should include use of both the primary and the auxiliary power systems.

Project security is a matter of concern at important dams and appurtenant works. This includes preventing structural damage by vandals or saboteurs and unauthorized operation of outlet or spillway gates. In some cases restricting public access is essential and security patrols may be necessary.

Occupational and public type safety is of paramount importance at certain dams and reservoirs. Specifically, this type safety at the dam, appurtenant works, on and around reservoirs, and below the dam should be considered, particularly in recreational areas. Safety measures should include identification of high watermarks to indicate past or probable reservoir levels and streamflows, posting of safety instructions at highly visible and key locations, and providing audible safety warnings upstream of and below outlets as appropriate.

When applicable, occupational and public safety should be evaluated by personnel from the Safety Division. They should accompany the engineering team for the dam inspection to evaluate hazard potentials to personnel and visitors such as heights, depths, dangerous flows, mechanical and electrical equipment, and supplies. Their recommendations should be referenced in the inspection report.

Communication should be maintained among affected governmental bodies and with the public to enhance the safety aspects of the operation of the dam, if warranted. Communication alternatives include written communications, radio, telephone, television, and newspapers.

In the following sections, outlets or outlet gates refer to gates or valves on any outlets such as sluices, conduits or tunnels, pumps, generating units, and infrequently operated plant intake and discharge gates. If the project has a navigation lock, emergency closure and other infrequently operated equipment should also be included.

3. Maintenance. Maintenance is normally the preserving of structures, appurtenant works and equipment in intended operating condition by the proper control of vegetation, removal of debris and trash, equipment repair, and minor structural repair. It is not the repair of structural deterioration to restore original condition, improvements for dam safety, enlarging reservoir capacity, increased spillway and outlet capacity, or the replacement of equipment. Such major rehabilitation of construction should be carried out with the assistance of NPS, Denver Service Center (DSC), and Bureau of Reclamation (USBR).

The following list of typical maintenance work is provided:

−harmful vegetation, debris, and trash should be removed from the dam, appurtenant works, immediate upstream and

downstream areas, and access roads to assure structural integrity, reliable operation, visual observation, and accessibility. Undesirable material should be removed and properly disposed of so as to prevent problems during high water, winds, fire, or vandalism; −vegetation maintenance for erosion control and esthetics;

−large vegetation which has become an integral part of the dam or appurtenant works needs to be carefully evaluated to determine if removal is warranted;

−lubrication of equipment;

−painting;

−maintaining internal drainage systems; −minor mechanical and structural repairs;

−correcting minor deterioration of concrete and embankment surfaces;

−taking measurements from instrumentation;

−placement of signs warning of heights/depths, dangerous flows, and equipment, when applicable;

−placement of barriers to prevent unauthorized access;

−all maintenance work is to be performed in a safe manner. The use of personal−protective and safety devices is required when so determined by the supervisor or the Superintendent in consultation with the area safety officer or Regional Safety Manager.

C. Periodic Inspection Program

1. General. The purpose of the NPS periodic inspection program is to verify throughout the operating life of the project the structural integrity of the dam and appurtenant structures and assure the protection of human life and property.

All NPS dams will receive some level of evaluation based on current technical guidelines and criteria prior to any significant repairs, rehabilitation, or construction. New dams added to the inspection program should be planned, designed, and constructed in accordance with current technical criteria. Improvements in dam technology require that dams and appurtenant structures be reassessed to assure dam safety for more stringent design and materials criteria.

Regional Directors and Superintendents are responsible for assuring that the existing dams for which they are responsible are periodically inspected, and that new dams are inspected initially upon completion of construction and periodically thereafter.

2. Types and Frequencies of Inspections. The inspection types and intervals herein recommended are for guidance in developing inspection programs for all dams under NPS management. This guideline does not preclude other inspections or more frequent inspections if deemed necessary, depending on project history and importance of the facility.

Inspection personnel should be selected carefully, have qualifications commensurate with their assigned levels of responsibility, and receive training in the inspection procedures. Qualifications and training required for inspection personnel may vary with the complexity of the facility and with the level of the inspection.

a. Annual Informal Inspection. All dams and appurtenant works under NPS management will receive this type of inspection. Inspection is performed annually by NPS or contract personnel to evaluate hazard potential classification, maintenance, structural and mechanical integrity for operational reliability, visitor safety on or around the dam and updating or completing the NPS inventory of dams data base management system. Immediately after any unusual event such as large floods, earthquakes, suspected sabotage, vandalism, or structural or operational failure, an inspection will be performed by NPS personnel. Particular attention should be given to detecting evidence of (or changes in) leakage, erosion,−sinkholes, boils, seepage, slope instability, undue settlement, displacement, tilting, cracking, deterioration, and improper function of drains and relief wells.

The checklist given in Appendix C of Safety Evaluation of Existing Dams, USBR, 1980, or equivalent form, should be used to assure thoroughness. Previous inspection reports should be reviewed to see what earlier corrective action recommendations were or were not performed. −A brief explanation should be written as to why previously recommended maintenance or operations were not performed.

The annual informal inspection report package should consist of the following items:

−Map;

−Any photographs or drawings;

−Completed checklist of dam and appurtenant features

−Very brief memorandum with recommended corrective action for use by maintenance and operations personnel;

−Operational and maintenance condition code specified;

−Updated inventory listings or forms;

The following codes should be used to describe the operational and maintenance condition of structures and related equipment, and reported into the NPS Inventory:

1−Will fulfill intended purpose and required annual maintenance or operations are performed;

2−Will fulfill intended purpose but required maintenance, operations, or minor repairs is needed;

3−May not fulfill intended purpose and maintenance or major repair is needed;

4−Will not fulfill intended purpose and major repair or rehabilitation is needed.

Reports should receive review and be given signature approval, and the following distribution made:

1−Director (Park Facility Management Division)
1−Regional Director (Park Facility Management Division)
1−Park Superintendent

b. Intermediate Inspections. This type inspection is required of dams under NPS management that have either a high (1) or significant (2) hazard potential. For low hazard potential dams, intermediate inspections are not required. Intermediate inspections should include a thorough field inspection of the dam and appurtenant structures, and a review of the records of inspections made at, and following, the last formal inspection.

If unusual conditions are observed that−are outside the expertise of these inspectors, arrangements should be made for inspections to be conducted by specialists.

(1) Frequency of intermediate inspections. Intermediate inspections, should be performed every three years where there is a high probability that dam failure or misoperation could result in loss of life or significant property damage.

(2) Qualifications of personnel for intermediate inspections. Intermediate inspections should be performed by technically qualified engineers, experienced in the operation and maintenance of dams and trained to recognize abnormal conditions. The inspectors should have access to and be familiar with all pertinent histories for the dam, and should be directly responsible for and intimately familiar with the operating characteristics of the dam. The dam tender or operator should be a participant in these inspections.

(3) Currently this type of inspection will be performed by USBR personnel as deemed necessary.

c. Formal and Special Inspections. This type inspection is required of dams under NPS management that have either a high (1) or significant hazard (2) potential. Formal inspections will not be performed for dams under NPS jurisdiction and classified as low hazard potential. A formal inspection is required periodically to verify the safety and integrity of the dam and appurtenant structures. Formal inspections should include a review to determine if the structures meet current accepted design criteria and practices. The inspection should include a review of all pertinent documents including instrumentation, operation, and maintenance and, to the degree necessary, documentation of investigation, design, and construction. In making the detailed inspection of the dam, appurtenant structures and equipment, diving inspections of−underwater structures affecting the integrity of the dam should be included. All formal inspections should be conducted by a team of highly trained specialists. To assure that a dam and its appurtenant facilities are thoroughly inspected, checklists should be prepared to cover the condition of structural, electrical, and mechanical features. This inspection should also verify that operating instructions are available and understood, instrumentation is adequate and data assessed to

assure structures are performing as designed, and there are emergency provisions for access to and communication with all project operating facilities.

(1) Frequency of formal inspections. Formal inspections should be made periodically at intervals not to exceed 6 years. Depending on past experience or the project history, some dams may require more frequent formal inspections.

(2) Frequency of special inspections. Special inspections should be performed immediately after the dam has passed unusually large floods and after the occurrence of significant earthquakes, sabotage, or other unusual events reported by operating personnel.

(3) Qualifications of personnel for formal and special inspections Formal and special inspections should be conducted under the direction of licensed professional engineers experienced in the investigation, design, construction, and operation of dams. The inspection team should be chosen on a site−specific basis considering the nature and type of the dam. The inspection team should be comprised of individuals having appropriate specialized knowledge in structural, mechanical, electrical, hydraulic, and embankment design; geology; concrete materials; and construction procedures. They must be capable of interpreting structural performance and relating conditions found to current criteria and safety aspects. It is imperative that the inspection team adequately prepare for the inspections by reviewing and discussing all documents relative to the safety of the dam.

(4) The Bureau of Reclamation (USBR) is the preferred organization to perform both formal and intermediate inspections and any special studies or emergency services for NPS, particularly on either the high or significant hazard potential dams. However, NPS managers may, at their discretion, utilize other qualified agencies or contractor services when USBR would not be able to respond in sufficient time. NPS personnel will accompany the team and act as observers during this inspection.

(5) Data Books will be prepared by USBR or other inspecting organization for all NPS high (1) or significant (2) hazard potential dams which are scheduled for formal inspection. Appendix E is a checklist of the types of existing data which will be valuable for evaluating the safety, maintenance, and operation of NPS dams. Existing information for these Data Books should be prepared and distributed by Regional Directors or Superintendents to USBR or other inspecting organization two (2) months prior to the actual on−site examination.

(6) The following classification system will be used to describe safety of dam conditions. One of these classifications is assigned to a dam following an on−site examination and evaluation using available data and current state−of−the−art knowledge:

S−Satisfactory	No existing or potential dam safety deficiencies are recognized. All essential elements can be expected to function under all conditions, including such events as the maximum probable flood (MPF) or maximum creditable earthquake (MCE), which have only a remote chance of occurring;
F−Fair	No existing or potential dam safety deficiencies are recognized for normal operating conditions. All essential elements can be expected to function under normal operating conditions. Remotely occurring events of magnitudes approaching a MPF or MCE will likely cause a dam safety deficiency;
P−Poor	A potential dam safety deficiency for normal operating conditions is recognized. Major damage has occurred at one or more of the essential elements or may be anticipated to occur during normal operating conditions. Immediate corrective actions to resolve the deficiency(s) are recommended and reservoir or other project restrictions may be necessary until problem is resolved;
U−Unsatisfactory	A dam safety deficiency is recognized for normal operating conditions. One or more essential elements will not operate adequately under normal operating conditions. Problem resolution requires immediate action.

In association with any classification term, maintenance work to correct an existing condition of one or more essential elements, or installation of additional equipment to enhance dam safety and/or to monitor performance, may be advised. It is expected that adequate maintenance can prevent many dam safety deficiencies from occurring.

3. Instrumentation. Instrumentation or performance observation devices are used to supplement visual inspections in evaluating the performance and safety of dams. Careful examination of instrumentation data on a continuing basis may reveal a possible critical condition. Conversely, instrumentation may be a means of assuring that an observed condition is not serious and does not require immediate remedial measures.

a. Adequacy of Instrumentation. Instrumentation to monitor structural and functional performance should be installed in dams

where complex or unusual site conditions have been encountered or where there is a high probability that failure could result in loss of life or extensive property damages.

b. Observation of Monitoring Devices. The instrumentation data should be collected by personnel trained specifically for the purpose, including training to recognize and immediately report to those 'responsible for inspections any anomalies in the readings or measurements. Performance observation data should be properly established for record purposes. The frequency of instrument readings should be established at the time the instrumentation system is designed in order to give a timely warning of possible adverse conditions.

c. Data Analysis. It is essential that instrumentation data be processed, reviewed and assessed in a timely manner by a specialist familiar with the design, construction, and operation of the project. Operation manuals and design information should be referred to in the evaluation of possible adverse threats.

4. Correction of Deficiencies. The inspection program could reveal those deficiencies or potential deficiencies which, if uncorrected, could eventually lead to failure or misoperation of the dam. Deficiencies may vary from emergency type items where immediate action is required to non-emergency type items which must be corrected in a timely manner but do not present an immediate danger to the safety of the structure. In all cases, corrective action should be made under the supervision of qualified personnel. Emergency action plans to be implemented when failure has already occurred or is imminent are discussed in Emergency Action Planning.

a. High Priority Corrective Action. High priority corrective action is required for deficiencies which could result in failure of the dam within a short period of time. The Director will be notified immediately by the appropriate Regional Director of any dams (NPS or non−NPS) that are in this condition, and what action is being taken to remove the threat to park safety or operations.

b. Non-emergency Corrective Action. Non-emergency corrective action is action taken when there is no immediate threat to the safety or operation of the dam, or any threat to life or property downstream. The Director will be notified immediately by the Regional Director of any dams (NPS and non−NPS) that are in this condition. The corrective action should be scheduled in advance of the fiscal year in which the work is to be done to allow time for planning, funding through the normal budgeting process, and arranging for special reservoir operations when required. Some of these deficiencies may be corrected through the regular operation and maintenance program discussed in operations and maintenance.

c. Follow−up Action. Periodic inspection reports should continue to list identified deficiencies along with any newly discovered deficiencies and show the status of corrective action., Appropriate inspection personnel should make frequent field examinations, as long as the problem exists, to see that all corrective measures are being completed. When deficiencies are not corrected in a reasonable length of time, an investigation should be made to determine the reason for delay, and the Director should be notified of the findings.

5. Documentation. Proper documentation of the dam's current and past performance is necessary to assess the adequacy of operation, maintenance, surveillance, and proposed corrective actions. A complete record or history of the investigation, design, construction, operation, maintenance, surveillance, periodic inspections, modifications, repair, and remedial work should be established and maintained so that relevant data relating to the dam is preserved and readily available for reference. This documentation should commence with the initial site investigation for the dam and continue through the life of the structure. This information will be collected by NPS personnel and delivered to the USBR to develop Data Books on high (1) and significant (2) hazard potential dams. See Chapter Six, section C.2. The data base management system for NPS dams will be maintained to keep current all data elements.

a. Instrumentation. All instrumentation observation data and evaluation thereof should be properly tabulated and documented for record purposes.

b. Inspections. All inspection observations, especially as related to the safety of the dam, should be documented. The extent and nature of inspection reports required for the annual informal, intermediate formal, and special inspections, will vary in proportion to the intensity of the inspection and the nature of the findings. Informal inspection reports may range from memoranda to brief reports. Intermediate inspection reports may vary from memoranda or trip reports to more formal reports containing substantial records, detail, and recommendations. Formal and special inspections require complete, formal technical reports of all findings, corrective actions and recommendations for permanent record and reference purposes in order to form a basis for major remedial work when required. All reports should be in a self−explanatory form that permits their retention as permanent records and should carefully document times of inspections, inspection personnel, and findings of the inspection.

c. Correction of Deficiencies. All deficiencies corrected as a result of the recommendations contained in periodic inspection reports should be fully documented in report form and made a part of the permanent project record. Alterations made to the facility as a result of changes in criteria to meet current practices or changes in dam technology should be fully documented, including as-constructed drawings. Promptly perform corrective action on deficient dams. Dams listed as **SERIOUSLY DEFICIENT** should be corrected immediately. A dam is **SERIOUSLY DEFICIENT** if:

1 An official inspection report classifies the dam safety condition as:

a **POOR**—this classification is applied when major damage has occurred, or may be anticipated to occur, at one or more of the essential elements during normal operating conditions. Immediate corrective actions to resolve the deficiency(s) are recommended and reservoir or other restrictions may be necessary until problems are resolved; or

b **UNSATISFACTORY**—this classification is applied when one or more essential elements will not operate adequately under normal conditions. Problem resolution requires immediate corrective action; and/or

2 If the maintenance condition is rated:

a "**3"**, which indicates it may not fulfill intended purpose and maintenance or major repair is needed) or;

b "**4"**, which indicates it will not fulfill intended purpose and major repair or rehabilitation is needed.

6. NPS Observer Status at non−NPS Dams. Refer to Appendix G for an example letter for coordinating with non-NPS dam project owners and/or regulators.

a. General. Dams that NPS has no jurisdiction over, but are located immediately adjacent to or within park boundaries and affect safety or operations, will be carefully monitored. Regional Directors, Superintendents, and Manager, DSC, will report and maintain information about these non−NPS dams in our inventory data base system. Regional Directors should request the presence of NPS observers during the inspection of non−NPS dams located within or immediately adjacent to park boundaries and that are in the high (1) or significant (2) hazard potential classification. Such coordination will assure NPS awareness of their condition.

b. U.S. Army Corps of Engineers Safety Condition Codes. The following dam safety assessment codes are from the U.S. Army Corps of Engineers' National Inventory of Dams (NID) data base management system, circa 1981. These safety of dams condition classification are referenced here for non-NPS dams located either within or immediately adjacent to park boundaries.

−For non-NPS dams or appurtenant works may have been assessed as "Unsafe," if deficiencies are assessed to be of such a nature that, if not corrected, they could result in the failure or misoperation of the project with subsequent loss of life and/or substantial property damage. This classification is analogous to the National Park Service and Bureau of Reclamation safety of dams condition classification of Poor (Chapter 6, section C, 2, c, (6)).

−If the probable failure of an "Unsafe" dam or appurtenant works is judged to be an imminent threat to life or substantial property and immediate action is required to reduce or eliminate the deficiencies, the "Unsafe" condition of the dam should be considered an "emergency." . This classification is analogous to the National Park Service and Bureau of Reclamation safety of dams condition classification of Unsatisfactory (Chapter 6, section C, 2, c, (6)). If the probable failure is judged not to be imminent, the "Unsafe" condition should be considered a "non−emergency."

D. Emergency Action Planning

1. General. It is intended that this guideline will minimize the risk of future dam failures. Nevertheless, it is recognized that despite the adequacy of this guideline and its implementation, the possibility of dam failures still exists. Even though the probability of such failures is small, preplanning is required to identify conditions which could lead to failure, in order to initiate emergency measures to prevent such failures as a first priority, and, if this is not possible, to minimize the extent and effects of such failure. This guideline provides operating and mobilization procedures to be followed upon indication of an impending or possible dam failure or a major flood. Project information and inspection results will be used to keep the NPS inventory data base system current.

Emergency Action Plans (EAP) are required for all high (1) or significant' (2) hazard potential dams under Federal regulation or jurisdiction: The purpose of an EAP is to provide early warning and evacuation in the event of either a possible or actual dam failure or misoperation. An example EAP is provided in Appendix F for use by the parks. Superintendents should designate an EAP Coordinator, along with other individuals as given in Appendix F, at appropriate parks, with either NPS or non−NPS dams within the specified hazard potential category (see inventory in Appendix A). EAP coordinators should initiate EAP's for appropriate NPS dams or coordinate with non−NPS dams owners in the implementation of their EAP within park boundaries. Refer to Appendix G for an example letter for coordinating with non-NPS dam project owners and/or regulators.

Pertinent information about EAP's should be recorded into the NP$ Inventory of Dams. Since coordination is needed with state and local officials in implementing EAP's, a list of state dam safety officers has been, provided in Appendix G.

2. Coordination with non−NPS Dam Owners. In those regions where high or significant hazard potential non−NPS dams exist within or immediately adjacent to park boundaries, Superintendents will request from those owners coordination in the preparation and implementation of any Emergency Action Plans as appropriate for park areas.

3. Evaluation of Emergency Potential. Prior to development of an emergency action plan, consideration must be given to the extent of land areas, and types of development within the areas, that would be inundated as a .result of dam failure or flood, and the time available for emergency response.

a. Determination of Mode of Dam Failure. There are many potential causes and modes of dam failure, depending upon the type of structure and its foundation characteristics. Similarly, there are degrees of "failure" and, often, progressive stages of failure. Many dam failures can be prevented from reaching a final catastrophic stage by recognition of early indicators or precursor conditions, and by prompt, effective emergency actions. While emergency planning should emphasize preventive actions, recognition must be given to the catastrophic condition, and hazard potential should be evaluated in that light. Analysis should be made to determine the most likely mode of dam failure under the most adverse condition and the resulting peak water outflow following the failure. Where there is a series of dams on the stream, analyses should include consideration of the potential for progressive "domino" failure of the dams.

b. Inundation Maps. To evaluate the effects of dam failure, maps should be prepared delineating the area which would be inundated in the event of failure. Land uses and significant development or improvements within the area of inundation should be indicated. The maps should be equivalent to or more detailed than the United States Geological Survey (USGS) quadrangle maps, 7−1/2 minute series, or of sufficient scale and detail to identify clearly the area that should be evacuated if there is evident danger of failure of the dams. Since detailed inundation maps may not be readily available or easily used at a disaster area, a concise and clear word description should also be prepared for easy word−of−mouth communication−' The word description would tell potential evacuees how high they should elevate themselves above the river or by horizontal distance to an area known to be safe from inundation. Copies of the maps should be distributed to local government officials for use in the development of an evacuation plan.

c. Classification of Inundation Areas. To assist in the evaluation of hazard potential, areas delineated on inundation maps should be classified in accordance with the degree of occupancy and hazard potential. The potential for loss of life is affected by many factors, including, but not limited to, the capacity and number of exit roads to higher ground and available transportation.

d. Time Available for Response. Analyses should be made to evaluate the structural, foundation, and other characteristics of the dam and determine those conditions which could be expected to result in slow, rapid or practically instantaneous dam failure.

4. Actions to Prevent Failure or Minimize Effects of Failure.

a. Development of Emergency Action Plan. An emergency action plan should be developed for each dam that constitutes a hazard to life or property, incorporating preplanned emergency measures to be taken prior to and following assumed dam failure. The plan should be coordinated with local governmental and other authorities involved in public safety and approved by the Regional Director for NPS dams. To the extent possible, the emergency action plan should define emergency situations that require immediate notification of local officials. The emergency action plan should include notification plans, which are discussed below in section b. A procedure should be established for review and revision, as necessary, of the emergency action plan, including notification plans and evacuation plans, at least once every year.

b. Notification Plans. Plans for notification of key personnel and the public are an integral part of the emergency action plan and should be prepared for slowly developing, rapidly developing, and instantaneous dam failure conditions. Notification plans should include a list of names and position titles, addresses, office and home telephone numbers, and radio communication frequencies and call signals, if available, for Regional Director, Superintendents, and Managers, or non−NPS dam owner personnel, public officials, and other personnel and alternates who should be notified as soon as emergency situations develop.. A procedure should be developed to keep the list current.

Each type of notification plan should contain the order in which key agency or owner supervisory personnel or alternates should be notified. At least one−key supervisory level or job position should be designated to be manned, or the responsible person should be immediately available by telephone or radio 24 hours a day. A copy of each notification plan must be posted in a prominent place at the project site near a telephone and/or radio transmitter.

Where dams located upstream from the dam for which the plan is being prepared could be operated to reduce inflow or where the operation of downstream dams would be affected by failure of the dam, operators of those dams should be kept informed of the current and expected conditions of the dam as the information becomes available.

Civil defense officials having jurisdiction over all or part of the area subject to inundation should receive early notification. Local law enforcement officials and, when possible, local government officials and public safety officials should receive early notification.

The capabilities of the Civil Defense Preparedness Agency's National Warning System (NAWAS) should be determined for the project and utilized as appropriate. Information can be obtained from State or local civil defense organizations.

When it is determined that a dam may be in danger of failing, the public officials responsible for the decision to implement the evacuation plan should be kept informed of the developing emergency conditions.

The news media, including radio, television, and newspapers, should be utilized to the extent available and appropriate. Notification plans should define emergency situations for which each medium will be utilized and should include an example of a news release that would be the most effective for each possible emergency.

Notification of recreation users is frequently difficult because the individuals are often alone and away from any means of ready communication. Consideration should be given to the use of standard emergency warning devices, such as sirens, at the dam site. Consideration should be given to the use of helicopters with bullhorns for areas further downstream. Vehicles equipped with public address systems and helicopters with bullhorns are capable of covering large areas effectively.

c. Evacuation Plans. Evacuation plans should be prepared and implemented by the local jurisdiction controlling inundation areas. This would normally not be the dam agency or owner. Evacuation plans should conform to local needs and vary in complexity in accordance with the type and degree of occupancy of the potentially affected area. The plans may include delineation of area to be evacuated; routes to be used; traffic control measures; shelter; methods of providing emergency transportation; special procedures for the evacuation and care of people from institutions such as hospitals, nursing homes, and prisons; procedures for securing the perimeter and for interior security of the area; procedures for the lifting of the evacuation order and reentry to the area; and details indicating which organizations are responsible for specific functions and for furnishing the materials, equipment, and personnel resources required.

The assistance of local civil defense personnel, if available, should be requested in preparation of the evacuation plan. State and local law enforcement agencies usually will be responsible for the execution of much of the plan and should be represented in the planning effort. State and local laws and ordinances may require that other State, county, and local government agencies have a role in the preparation, review, approval, or execution of the plan. Before finalization, a copy of the plan should be furnished to the dam agency or owner for information and comment.

d. Stockpiling Repair Materials. Suitable construction materials should be stockpiled for emergency use. The amounts and types of construction materials needed for emergency repairs should be determined based on the structural, foundation, and other characteristics of the dam; design and construction history; and history of prior problems.

e. Locating Local Repair Forces. Arrangements should be made with, and a current list maintained of, local entities, including contractors, and Federal, State and local construction departments, for possible emergency use of equipment and labor.

f. Training Operating Personnel. Technically qualified project personnel should be trained in problem detection, evaluation, and appropriate remedial (emergency and non-emergency) measures.

g. Increasing Inspection Frequency. Frequency of appropriate surveillance activities should be increased when the reservoir level exceeds, a predetermined elevation. Piezometers, water level gages, and other instruments should be read frequently and on schedule. The project structures should be inspected as often as necessary to monitor conditions related to known problems and to detect indications of change or new problems that could arise. Hourly or continuous surveillance may be mandated in some instances. Any change in conditions should be reported promptly to the supervisor for further evaluation.

The supervisor should issue additional instructions, as necessary and alert repair crews and contractors for necessary repair work if developing conditions indicate that emergency repairs or other remedial measures may be required.

5. Actions Upon Discovery of a Potentially Unsafe (Seriously Deficient) Condition. Action to be taken will depend on the nature of the problem and the time estimated to be available for remedial or mitigating measures. As time permits, one or more of the following actions will be required.

a. Notification of Supervisory Personnel. This is essential, if time permits, since development of failure could vary in some or many respects from previous forecasts or assumptions, and advice may be needed.

b. Initiation of Predetermined Remedial Action. It is imperative that at least one technically qualified individual, previously trained in problem detection, evaluation, and remedial action, be at the project or on call at all−times. Depending on the nature and seriousness of the problem and the time available, emergency actions can be limited, such as lowering the reservoir and holding water in upstream reservoirs. Other actions to be taken include notifying appropriate highway and traffic control officials promptly of any rim slides or other reservoir embankment failures which may endanger public highways.

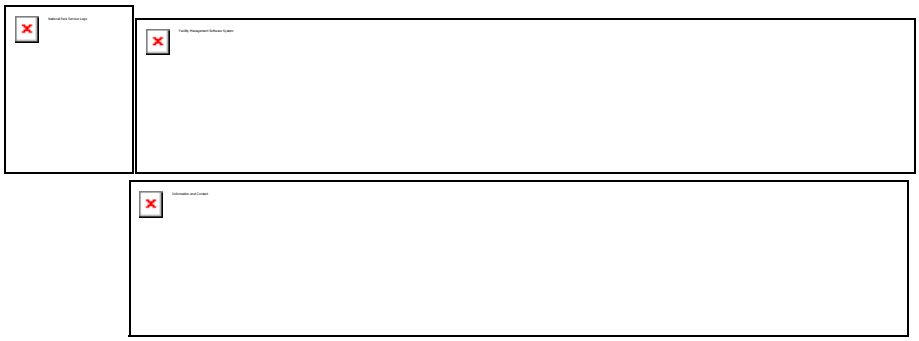
c. Determination of Need for Public Notification. To the extent possible, emergency situations that will require immediate notification of public officials in time to allow evacuation of the potentially affected areas should be predefined for the use of management and project personnel. If sufficient time is available, the decision to notify public officials that the dam can be

expected to fail will be made at a predetermined supervisory level within the agency or owner organization. If failure is imminent or has already occurred, project personnel at the dam site would be responsible for direct notification of the public officials. The urgency of the situation should be made clear so that public officials will take positive action immediately.

APPENDIX A
NPS NATIONAL INVENTORY OF DAMS ON-LINE DATABASE ACCESS

Access to database is only available to personnel listed in the NPS email directory

The URL is: **http://pfmd2.nps.gov/PRP/Dams/dams/index.cfm**



Been Here Before?	To Request an Account	Forgotten your password?
If you have previously registered, enter your user name and password	1. **Register** your name 2. Create a Password	If you have previously registered
Username:		**Click Here** to obtain your password
Password:		
Login		

APPENDIX B
RECOMMENDED REFERENCES FOR MAINTENANCE,
OPERATION, AND SAFETY OF DAMS

American Society of Civil Engineers. Proceedings, Engineering Foundation Conference, "Inspection, Maintenance, and Rehabilitation of Old Dams," Pacific Grove, California, September 23–28, 1973. New York: ASCE, 1974

American Society of Civil Engineers. Proceedings, Engineering Foundation Conference, "Safety of Small Dams," Henniker, N.H., August 4–9, 1974, New York: ASCE, 1975.

NOTE: ASCE publications may be obtained by contacting:
American Society of Civil Engineers
Attention: Publications
[New address needed]

Golze, Alfred R. (ed.). Handbook of Dam Engineering. Van Nostrand Reinhold., 1977.
NOTE: Reinhold publication may be obtained by contacting:
Van Nostrand Reinhold Co.
7625 Empire Drive
Florence, Kentucky 41042
Telephone: 606–525–6600

Hanna, Thomas H. Foundation Instrumentation. Trans Tech Publications, 1973.
NOTE: Trans Tech publication may be obtained by contacting:
Trans Tech Publications

16 Bearskin Neck
Rockport, Massachusetts 01966
Telephone: 617−546−6426

U.S. Department of Agriculture, Soil Conservation Service. Construction Inspection. National Engineering Handbook, Section 19.

U.S. Department of Agriculture, Soil Conservation Service. Engineering Geology. National Engineering Handbook, Section 8.

U.S. Department of Agriculture, Soil Conservation Service. Hydraulics. National Engineering Handbook, Section 5.

U.S. Department of Agriculture, Soil Conservation Service. Hydrology. National Engineering Handbook, Section 4.

U.S. Department of Agriculture, Soil Conservation Service. Structural design. National Engineering−Handbook, Section 6.

U.S. Department of Agriculture, Soil Conservation Service. Earth Dams and Reservoirs, Technical Release 60, revised August 1981.

NOTE: Soil Conservation Service publications may be obtained by request from SCS field offices or by contacting:
Records and Communications Branch
Administration Services Division
Soil Conservation Service
P.O. Box 2890
Washington, D.C. 20013
Telephone: 202−447−3907

U.S. Department of the Army, Office of the Chief of Engineers. National Program for Inspection of Non−Federal Dams, ER 1110−2−106, Washington: September 1979.

NOTE: Army publications may be obtained by contacting:
Office of the Chief of Engineers Publications Depot
890 South Pickett Street
Alexandria, Virginia 22304
Telephone: 202−272−7772

U.S. Department of the Interior, Bureau of Reclamation. Design of Small Dams, Second Edition, Engineering and Research Center, Stock No. 024−003−00119−8, Denver: 1977

U.S. Department of the Interior, Bureau of Reclamation. Operation and Maintenance Guidelines For Small Dams, Engineering and Research Center, Denver: 1982.

U.S. Department of the Interior, Bureau of Reclamation. Safety Evaluation of Existing Dams, Second Edition, Engineering and Research Center, Denver: .1983

NOTE: Reclamation publications may be obtained by contacting:
Bureau of Reclamation
Attention: Publications, Code 922
P.O. Box 25007
Denver, Colorado 80225
Telephone: 303−234−3000

APPENDIX C

LIST OF NATIONAL AND REGIONAL COORDINATORS AND CONTACTS
FOR THE NATIONAL PARK SERVICE (NPS) MAINTENANCE, OPERATION, AND SAFETY OF DAMS (MOSD) PROGRAM
U.S. DEPARTMENT OF THE INTERIOR
FOR ALL DAMS AND IMPOUNDMENTS AFFECTING THE NATIONAL PARK SYTEM

NATIONAL PARK SERVICE NATIONWIDE 24-HOUR COMMUNICATIONS

Name	**Mailing Address**	**Telephones (O) Office (H) Home**
Dispatch Office (They have 24-hour emergency numbers for all National Park System parks and offices)	Shenandoah National Park 3655 US Highway 211 East Luray, VA 22835-9051	(O) 540-999-3422

BUREAU OF RECLAMATION CONTACTS

Coordinator for Overall NPS Assistance Civil Engineer, Betty Dinneen 1/ Alternate: Sue Thompson 2/	Bureau of Reclamation Technical Service Center Attention: **Client and Support Scvs**, code 8010 P.O. Box 25007 Bldg. 67, Denver Federal Center **Denver, Colorado** 80225−0007	(O) 303-445-3029 1/ * (O) 303-445-2610 2/ * (fax) 303-445-6356
Dam Safety Program Chief, Bruce Muller 1/ Alternate: Civil Engineer, Rob Rocklin 2/	**Dam Safety Office**, code D-1440 (H) 303-978-9534 1/	(O) 303-445-2765 1/ * (O) 303-445-2770 2/ fax 303-445-6463
Coordinator for Examinations, Civil Engineer, Chris Danley 1/ Alternate: Civil Engineer, Chris Veesaert 2/	**Inspections and Emergency Mgmt. Group** code D-8470	(O) 303-445-2755 1/ * (O) 303-445-2742 2/ * fax 303-445-6381

*** Work hours vary; however, one of these individuals will be available from 7:00 a.m. to 4:00 p.m. (Rocky Mountain Time), Monday through Friday.**

NATIONAL PARK SERVICE WASHINGTON AND FIELD OFFICE
COORDINATORS AND CONTACTS

Civil Engineer, Charles Karpowicz 1/ Alternate: Mark Hartsoe 2/	National Park Service **Park Facility Management** **Division**, Org. Code 2420 Maintenance, Operation, Safety of Dams Program 1201 **I** (Eye) Street, N.W., 10th Floor, space 41 Washington, D.C. 20005-5905	(O) 202-513-7022 1/ (O) 202-513-7001 1/ (H) 703-493-8050 1/ O) 202-513-7025 2/
Civil Engineer, Bill Heubner 1/ Alternate: Facility Manager, Tim Hudson 2/	**Alaska Support Office** **Alaska Region** Planning, Design and Maintenance Division 240 West Fifth Avenue Anchorage, Alaska 99501-2327	(O) 907−644-3384 1/ (O) 907-644-3381 2/

LIST OF NATIONAL AND REGIONAL COORDINATORS AND CONTACTS
FOR THE NATIONAL PARK SERVICE (NPS) MAINTENANCE, OPERATION, AND SAFETY OF DAMS (MOSD) PROGRAM
U.S. DEPARTMENT OF THE INTERIOR
FOR ALL DAMS AND IMPOUNDMENTS AFFECTING THE NATIONAL PARK SYTEM

NATIONAL PARK SERVICE WASHINGTON AND FIELD OFFICE
COORDINATORS AND CONTACTS, continued

Name	**Mailing Address**	**Telephones (O) Office (H) Home**
Chief Ranger, Robert Gray 1/ Alternate: Park Manager, Pam Underhill 2/	National Park Service **Appalachian National Scenic Trail** Park Office	(0) 304-535-6171 1/ (H) 304-258-5637 1/ (O) 304-535-6278 2/

	C/O NPS Harpers Ferry Center Harpers Ferry, West Virginia 25425 Shipping Address: High Street, Civil War Story Bldg., 3rd Floor, Harpers Ferry, WV 25425	fax 304-535-6270
Environmental Engineer: Phil Ayers 1/ Alternate: Roger Maxwell, 2/	**Intermountain Support Office** **Intermountain Region** Facility Management, Design, and Engineering Division 12795 West Alameda Parkway P.O. Box 25287 Denver, Colorado 80225−0287	(O) 303-969-2606 1/ (H) 303-215-0979 1/ (O) 303-969-2859 2/
Civil Engineer, Allen Bengtson 1/ Alternate: Program Leader, Richard Niemeyer 2/	**Southwest Support Office** **Intermountain Region** Architecture, Design, and Engineering Office P.O. 728 Santa Fe, New Mexico 87504−0728 Shipping: 2968 Rodeo Park Dr. West Santa Fe, NM 87505-6351	(O) 505-988-6039 1/ (O) 505-988-6035 2/
Environmental Engineer, Dick Fisher 1/ Alternate: Civil Engineer, Sharon Busch, 2/	**Midwest Support Office** **Midwest Region** Maintenance and Engineering 1709 Jackson Street Omaha, Nebraska 68102−2571	(O) 402-221-3945 1/ (H) 402-333-2419 1/ (O) 402-221-4993 2/ fax 402-221-3465
Civil Engineer, Stan Tolman 1/ Alternate-1: Don Filsoof 2/ Alternate-2: Dave Hammers 3/	**National Capital Support Office** **National Capital Region** Maintenance and Design Room 358 1100 Ohio Drive, S.W. Washington, D.C. 20242	(O) 202-619-6383 1/ (O) 202-619-7060 2/ (O) 202-619-7270 3/

LIST OF NATIONAL AND REGIONAL COORDINATORS AND CONTACTS
FOR THE NATIONAL PARK SERVICE (NPS) MAINTENANCE, OPERATION, AND SAFETY OF DAMS (MOSD) PROGRAM
U.S. DEPARTMENT OF THE INTERIOR
FOR ALL DAMS AND IMPOUNDMENTS AFFECTING THE NATIONAL PARK SYTEM

NATIONAL PARK SERVICE WASHINGTON AND FIELD OFFICE
COORDINATORS AND CONTACTS, continued

Name	**Mailing Address**	**Telephones** **(O) Office (H) Home**
Civil Engineer, Mark Spadea 1/ Alternate: Facility Manager, Ross Flanagan 2/	**Northeast Region, Philadelphia Office** Maintenance, Design, and Engineering U.S. Custom House, Room 350 200 Chestnut Street Philadelphia, Pennsylvania 19106	**(O) 215-597-004**3 1/ (O) 215-597-5364 2/
Civil Engineer, David Price 1/ Alternate: Fred Bentley 2/	**Northeast Region, Boston Office** Engineering and Facility Management 15 State Street Boston, Massachusetts 02109−3572	(O) 617-223-5096 1/ fax 617-223-5260 1/ (O) 617-223-5296 2/
Steve Butterworth 1/ Alternate: Geoff Swan 2/	**Columbia Cascade Support Office** **Pacific West Region** Design and Engineering 909 First Avenue Seattle, Washington 98104-1060	(O) 206-220-4277 1/ (O) 206-220-4275 2/ (H) 425-643-7739 1/

Facility Management Chief, Jack Williams 1/ Steven Bosiljevac, Civil Engineer 2/	**Pacific Great Basin Support Office** **Pacific West Region** Jackson Center One 1111 Jackson Street, Suite 700 Oakland, CA 94607	(O) 510-817-1384 1/ (O) 510-817-1374
Civil Engineer, Gregory Robinson 1/ Alternate-1: Chief of Engineering, Fred Shott 2/ Alternate-2: Civil Engineer, John Gopaul 3/ Emergency Incidents: Chief Ranger, Judy Forte 4/	**Southeast Support Office** **Southeast Region** Facility Management Division 100 Alabama Street, S.W. Atlanta, Georgia 30303	(O) 404-562-3124, ext 692 1/ (O) 404-562-3124, ext 707 2/ cell 404-277-4040 2/ (H) 678-715-9450 2/ (O) 404-562-3124, ext 691 3/ (O) 404-562-3108, ext 617 4/ cell 404-909-2911 (H) 770-594-9021

NATIONAL PARK SERVICE DENVER SERVICE CENTER

Structural/Seismic Engineer, Rich Silva 1/ Alternate: Chief, Facility Design, Bruce Warneke, 2/	**National Park Service** **Denver Service Center** Facility Design Services, DSC-FDC 12795 West Alameda Parkway P.O. Box 25287 Denver, Colorado 80225−0287	(O) 303-969-2552 1/ (O) 303-969-2183 2/ fax 303-969-2736

LIST OF NATIONAL AND REGIONAL COORDINATORS AND CONTACTS
FOR THE NATIONAL PARK SERVICE (NPS) MAINTENANCE, OPERATION, AND SAFETY OF DAMS (MOSD) PROGRAM
U.S. DEPARTMENT OF THE INTERIOR
FOR ALL DAMS AND IMPOUNDMENTS AFFECTING THE NATIONAL PARK SYTEM
NATIONAL PARK SERVICE WASHINGTON AND FIELD OFFICE
COORDINATORS AND CONTACTS, continued

Name	**Mailing Address**	**Telephones** **(O) Office (H) Home**

OTHER CONTACTS

FEDERAL HIGHWAY ADMINISTRATION

Program Manager, Arthur E. Hamilton	Federal Lands Highway Program **Federal Highway Administration** 400 7th Street, S.W., room 6311, HL-1 Washington, D.C. 20590	(O) 202-366-9494

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

Federal Interagency Committee on Dam Safety (ICODS) Chris Doyle 1/ Alternate: Eugene Zeizel 2/ Alternate: Rita Henry 3/	National Dam Safety Program Mitigation Directorate Federal Emergency Management Agency 500 C Street, S.W., room 416 Washington, DC 20472	(O) 202-646-3035 1/ (O) 202-646-2802 2/ (O) 202-646-2704 3/

U.S. DEPARTMENT OF AGRICULTURE, NATURAL RESOURCES CONSERVATION SERVICE

National Design Engineer, William Irwin Alternate: Ronald Marlow 2/	National Dam Safety Program P.O. Box 2890, Room 6136S Washington, DC 20013-2890	(O) 202-720-5858 1/ (O) 202-720-2520 2/

ASSOCIATION OF STATE DAM SAFETY OFFICIALS (ASDSO)

Executive Director, Lori Spragens	**Association of State Dam Safety Officials**	(O) 859-257-5140

Conference Coordinator, Susan Sorrell
Information Resource Specialist, Sarah Mayfield
Administrative Assistant, Maureen Chinn
450 Old Vine Street, Second Floor
Lexington, KY 40507
fax 859-323-1958

APPENDIX D
DATA BOOK LISTING

I. TYPICAL DATA RECORDS

A. Typical Types of Records - The following outline represents information needed by the Bureau of Reclamation or other inspecting organization in the MOSD program to adequately prepare a Technical Data Book. The data book will be used to evaluate the safety, maintenance, and operation of a dam. Information should be presented to inspection teams 2 months prior to on-site inspection.

l. Document verifying NPS ownership or dam safety responsibility
2. Copy of any contractual agreements between NPS and lessee of NPS dams therein relating to acquisition, planning, safety inspections, design, maintenance, operation, construction, financial arrangements, disposal, or any other activity significantly affecting park safety, maintenance, or operations
3. Most current information from any type inventory of NPS dams
4. Aerial photographs of damsite and reservoir area
5. Design criteria and technical records
6. Construction reports
7. Project history
8. Correspondence
9. Previous Safety of Dams report
10. Emergency Preparedness Plan
11. Pertinent photographs
12. Hydrology studies (most recent inflow design flood, other floods considered at the time of design, and flood routings)
13. Instrumentation monitoring records
14. Operation and Maintenance Reports
15. Reservoir operation record
16. SOP (Standard Operating Procedures)
17. DOC (Designers' Operating Criteria)
18. Statistics of dam, powerplant (if applicable), and reservoir
19. Design and as-built drawings
20. Reservoir area and capacity curves
21. Discharge curves for all water control structures and conduits
22. Monthly maximum and minimum reservoir elevations since first filling
23. Average daily inflow to reservoir (include the source of the information and the period of record used)
24. Any current operating restrictions (maximum water surface elevation, maximum discharge of spillway(s) and outlet works, etc.)
25. Records of any known problems experienced in operating and maintaining the dam, spillway, and outlet works (seepage, sinkholes, sloughing of slopes, offsets, displacements, cracking, erosion, mechanical equipment failure, debris, etc.)

B. Geology

1. Topographic maps, USGS quadrangle maps
2. Geologic reports (general regional, specific data on damsite and reservoir, geologic profile along axis of dam, landslide surveillance data, and geologic interpretation)
3. Seismicity [shear and fault zone data, seismic risk zone, MCE (maximum credible earthquake), and seismic considerations in design]
4. Geologic and seismic maps and drawings
5. Liquefaction studies
6. Geophysical data
7. Volcanic activity in area
8. Local petrochemical activity

C. Concrete Dams

1. Drawings: section through crown cantilever including lines of centers for an arch dam, plan view of dam, profile of dam-foundation contact, and surface contour map (most detailed USGS map of damsite)
2. Tailwater data
3. Most recent reservoir silt survey data (including density of silt)
4. Maximum and minimum reservoir temperatures - relative to depth in reservoir
5. Most recent concrete tests and properties to include data on compressive, tensile and shear stresses, density, modulus of elasticity, Poisson's ratio, and diffusivity
6. Contraction joint grout closure temperatures
7. Depth of ice in reservoir at dam
8. Location and monitoring data for major cracks in dam
9. Design and measured uplift pressures

D. Embankment Dams

1. Type of dam (homogeneous, zoned, etc.)
2. Gradation of construction materials
3. Surface and internal drainage features
4. Upstream and downstream slope protection
5. Freeboard
6. Crest details (including camber)
7. Placement densities and moisture content
8. Materials testing (laboratory and field tests performed)
9. Filter design criteria
10. Toe drain system
11. Soil parameters (including strength, permeability, void ratio, etc.)
12. Foundation and abutment conditions
13. Stability, settlement, and seepage measurements and analyses
14. Preconstruction and postconstruction investigations (test pits, drill holes, etc.)
15. History of reservoir filling and drawdown rates
16. Piezometer data

E. Mechancial Equipment

1. Descriptions
2. Design data on gates, valves, etc.
3. Installation-related problems
4. Air venting system (including test results available)
5. Emergency gate closure report
6. Manual or automatic operation of equipment
7. Remote control
8. Auxiliary power
9. Steel pipe and its drainage system
10. Trashracks
11. Special operating conditions and restrictions
12. Control equipment
13. Corrosion protection
14. Additional equipment needed to pass the design flood or to evacuate the reservoir
15. History of gate or valve operation and associated problems

II. TYPICAL LOCATIONS OF RECORDS

Suggested locations for obtaining the engineering-related records are:

A. Washington, D.C. office
B. Regional office
C. District office
D. Subdistrict office
E. Area office
F. Agency office
G. Project office

H. State Department of Water Resources
I. State Engineer
J. State Dam Safety Program Officer (See Appendix C)
K. City and County Engineer
L. Private owners
M. Soil Conservation Service
N. National Archives
O. Consulting engineers
P. U.S. Army Corps of Engineers (Regional Hydrology, Floodplain and Flood Insurance Studies, Hydraulics, Geology, and hypothetical dam break studies)
R. Tennessee Valley Authority
S. Federal Energy Regulatory Commission
T. Federal Emergency Management Agency (National Flood Insurance Program)
U. NPS Regional and Park Historic or Cultural Divisions
V. NPS Denver Service Center, Graphic System Division (FTS 234-2654)

Suggested locations of obtaining geologic records are:

1. U.S. Geological Survey
2. State Geological Survey
3. U.S. Bureau of Mines
4. State Bureau of Mines
5. State and local university libraries
6. State, city and other local libraries
7. Consulting geologists

APPENDIX E
EXAMPLE EMERGENCY ACTION PLAN

The purpose of the EAP is to facilitate the early warning and, if necessary, evacuation of persons in areas that would be affected by possible dam or appurtenant works failure or misoperation. Superintendents should develop an appropriate EAP for either high (1) or significant (2) hazard potential dams under their jurisdiction or coordinate with non−NPS dam owners to assure implementation of their EAP in affected park areas. Personnel designations, mapping, and local government contacts should have been made by September 30, 1982, and recorded into the NPS Inventory of Dams.

BASIC SYSTEM ELEMENTS

An effective Emergency Action Plan incorporates several essential elements.

These are:

1. Dependable and responsible rainfall and staff gage observers. Their duties are to report to the Dam Operator the rainfall accumulation over− a given period of time and the elevation of the reservoir pool or flow in the emergency spillway, if any. One of these observers should also give the dam a brief visual inspection at each gage reading to see if it is in danger of failing from reasons other than overtopping. The equipment needed to make these measurements can be a simple plastic rain gage and some sort of pole or staff in the reservoir or spillway area with elevations indicated clearly on it. There are more elaborate instruments available such as automatic rain and water level gages, but at a respectively higher cost. Their use is optional, but not essential.

2. Reliable and rapid local communications system with an emergency backup. This system is used to communicate the data gathered by the gage observers to the Dam Operator and by the Dam Operator in notifying the proper authorities of the need to initiate the warning plan and the evacuation plan. It can be by telephone, ham radio, CB radio, or police, fire, and other emergency radio systems. It is important that any system chosen have an emergency backup.

3. Dam Operator and Alternate. These persons' duties are to interpret the rainfall, streamflow, and spillway flow data given to them by the observers and other available weather information and, when necessary, notify the park EAP Coordinator or other authorities of the need to initiate the warning and evacuation plan.

4. Dam Hydraulic and Hydrologic Data. This information developed by a qualified engineer or gathered from other competent sources is used to establish the various trigger points (rainfall measurements, pool or spillway flow elevations, or other pertinent facts) at which the several progressive phases of the emergency warning system are initiated. This information is obtained from an engineer study which com pares various rainfalls on the watershed with the spillway discharges they create and reservoir elevations. The Bureau of Reclamation is developing some of this type of information during their assessments of NPS Dams classified as high or significant hazard potential.

5. A Warning Dissemination Plan. This basically consists of a list of people to be notified if the conditions dictate. This should include the local government Emergency Services Coordinator or other designated local government officials who will in turn notify the people directly affected by flooding outside the park and carry out the Evacuation Plan, if that becomes necessary.

6. The Evacuation Plan. This consists of a list of homes, businesses, campsites, stream crossings, recreation activities, highways and roads, with their locations clearly identified on an inundation map, that are to be evacuated if necessary, and a means of transporting the people to a designated emergency shelter. Mapping should be of sufficient detail and scale to show where possible homes, businesses, campsites, stream crossings, highway and roads, and recreational activities are located in relationship to the dam and estimated flooding. Access routes should be clearly marked. Since detailed inundation maps may not be readily available or easily used at a disaster area, a concise and clear word description should also be prepared for easy word−of−mouth communication. Time word description would tell potential evacuees how high they should elevate themselves above the river or by horizontal distance to an area known to be safe from inundation. The EAP with the map should be filed with the park EAP Coordinator and the local Emergency Services Coordinator or other local government officials. The plan should also pro vide for the protection of the evacuated area until the residents can return to their areas. The local Emergency Services Coordinator or other local government officials are responsible for preparing and carrying out the Evacuation Plan if located outside the park. Proper coordination should be assured with these officials.

EXAMPLE EMERGENCY WARNING SYSTEM

The following is a fictitious example of a well−organized Emergency Action Plan for a city and is based on one prepared by the Tennessee Valley Authority for the City of Norton, Virginia. This is not necessarily the type of system that will be best suited to your situation, but it should give you a general idea of how one is set up.

STAGE I

1. Rain measuring equipment will be inspected and measurements begun initially upon notice of a flood watch or warning. This warning would come from the National Weather Service.

2. Rainfall measured by the gage observer will be compared by the Dam Operator with the rainfall of other weather observers such as local government Emergency Service officials during flood watches and warnings.

3. Rainfall will be monitored around the clock and reported to the Dam Operator on a 24−hour basis by the rainfall gage observer.

4. Upon receiving notice that two (2) inches of rain in any 24−hour period has fallen, the Dam Operator will initiate State II by notifying the EAP Coordinator who will notify the:
   A. Superintendent
   B. Park Ranger,
   C. Administrative Manager

STAGE II

1. Every four hours after Stage II is affected, the staff gage observer will personally read the gage at the spillway and record the reading and report it to the Dam Operator.

2. When a depth of two (2) feet in the spillway exists, the frequency of the readings will be increased every two flours, or will be made even more frequently if desired by the Dam Operator.

3. In the event the spillway readings reach three (3) feet, Stage III will be put into effect by the Dam Operator. The Dam Operator will notify the EAP Coordinator of Stage III, who will in turn notify the:
   A. Superintendent
   B. Park Ranger
   C. Administrative Manager
   D. Local Government Emergency Official

Stage III

1. The Emergency Action Plan Coordinator will initiate the Evacuation Plan.

2. The Evaluation Plan will be implemented by the Ranger Division under the direction of the Park Ranger, with assistance from all available Fire, Rescue, and other appropriate personnel.

3. Necessary transportation from the affected area will be provided by a school bus or other means as determined by the EAP Coordinator.

4. Evacuated persons will be sheltered as designated in the evacuation notice.

5. Once the area is evacuated, persons designed by the Park Ranger will secure the area from access except for official business.

6. Readings of the spillway level will continue to be, read by the gage observer and be reported hourly to the EAP Coordinator during Stage III until water recedes to one foot or less over the spillway.

CONCLUSION

The local government Emergency Services Coordinator in your city or county should be notified, if appropriate, of your plans to establish the EAP, and its development must be closely coordinated with him so that he will be completely familiar with it. Once the plan is established it should be reviewed annually and updated if the conditions downstream have changed enough, to dictate it.

The Warning Dissemination and Evacuation Plans can also be used if the dam is failing from reasons other than flooding and overtopping. On new or rehabilitated structures this Emergency Action Plan should be established prior to the beginning of

impoundment so that an evacuation can be carried out−if a failure prone situation develops. Hopefully you will never need to use it, but if the need ever arises, such a system will greatly reduce the chance of any loss of life.

APPENDIX F
STATE SAFETY OF DAMS OFFICERS

ALABAMA	**Leslie A. Durham** AL Department of Economic & Community Affairs Office of Water Resources 401 Adams Avenue P.O. Box 5696 Montgomery, AL 36104-5690 Tel: 334/242-5506 Fax: 334/242-0776 Email: **LeslieD@adeca.state.al.us**
ALASKA	**Charles F. Cobb** STATE DAM SAFETY ENGINEER AK Department of Natural Resources Division of Mining, Land & Water 550 West 7th Avenue, Ste. 1020 Anchorage, AK 99501-3577 Phone: 907/269-8636 Fax: 907/269-8947 Email: **charlesc@dnr.state.ak.us**
ARIZONA	**William C. Jenkins** Senior Engineer AZ Dept of Water Resources Office of Water Engineering 500 North Third Street Phoenix, AZ 85004-3921 Phone: 602/417-2400 x.7189 Fax: 602/417-2423 Email: **wcjenkins@adwr.state.az.us**
ARKANSAS	**Alvin Simmons, Jr.** Engineer Supervisor AR Soil & Water Conservation Commission 101 East Capitol, Suite 350 Little Rock, AR 72201 Tel: 501/682-3981 Fax: 501/682-3991 E-mail: **alvin.simmons@mail.state.ar.us**

CALIFORNIA	**David A. Gutierrez** Acting Chief DWR - Division of Safety of Dams 2200 X Street, Ste 200 Sacramento, CA 95818 Tel: 916/227-4660 Fax: 916/227-4500 Email: **daveg@water.ca.gov**
COLORADO	**Jack G. Byers** Deputy State Engineer Colorado Division of Water Resources 1313 Sherman Street, Rm 818 Denver, Colorado 80203 Tel: (303) 866-3581 x274 Fax: (303) 866-3589 Email: **jack.byers@state.co.us**
CONNECTICUT	**Wesley Marsh** SUPERVISING ENVIRONMENTAL ANALYST CT Department of Environmental Protection Bureau of Water Management 79 Elm Street Hartford, CT 06106-5127 Phone: 860/424-3706 Fax: 860/424-4075 Email: **wes.marsh@po.state.ct.us**
DELAWARE	**Frank M. Piorko** Environmental Program Manager II DE Department of Natural Resources & Environmental Control Division of Soil and Water Conservation 89 Kings Highway, Dover, DE 19901 Tel. (302) 739-4411 Fax. (302) 739-6724 e-mail **Frank.Piorko@state.de.us**
FLORIDA	**Stephen H. Partney** PROGRAM ADMIN. Bureau of Mine Reclamation Dept. of Environmental Protection 2051 E. Dirac Drive Tallahassee, FL 32310 Phone: 850/488-8217 Fax: 850/488-1254 Email: **Stephen.Partney@dep.state.fl.us**
GEORGIA	**Francis E. Fiegle, II** PROGRAM MANAGER GA Dept. of Natural Resources Safe Dams Program 4244 International Pkwy. Ste. 110 Atlanta, GA 30354 Phone: 404/362-2678 Fax: 404/362-2598 Email: **Ed_Fiegle@dnr.state.ga.us**
HAWAII	**Edwin Matsuda** Civil Engineer HI Dept. of Land & Natural Res. 1151 Punchbowl Street, Rm 221 Honolulu, HI 96813 Phone: 808/587-0268 Fax: 808/587-0283 Email: **edwin.y.matsuda@hawaii.gov**
IDAHO	**Guy E. Paul** Chief, Resource Protection Bureau ID Dept. of Water Resources 322 East Front Street

	PO Box 83720 Boise, ID 83720-0098 Phone: (208) 287-4923 Fax: (208) 287-6700 Email: **guy.paul@idwr.idaho.gov**
ILLINOIS	**Paul Mauer, Jr.** Dam Safety Engineer Dept. of Natural Resources One Natural Resources Way Springfield, IL 62702-1271 Tel: 217/782-3863 Fax: 217/524-1454 E-mail: **PMAUER@dnrmail.state.il.us**
INDIANA	**Kenneth E. Smith** ASSISTANT DIRECTOR IN Dept. of Natural Resources Division of Water 402 W. Washington St. Rm W264 Indianapolis, IN 46204 Phone: 317/232-4224 Fax: 317/233-4579 Email: **kesmith@dnr.state.in.us**
KANSAS	**Joe D. File** DAM SAFETY TEAM LEADER KS Dept. of Agriculture Division of Water Resources 109 SW 9th Street, 2nd Floor Topeka, KS 66612-1283 Phone: 785/296-5733 Fax: 785/296-4835 Email: **jfile@kda.state.ks.us**
KENTUCKY	**Art Clay** Environmental Engineer Branch Manager KY Division of Water Water Resources Branch 14 Reilly Road Frankfort, KY 40601 Tel: 502/564-3410, ext. 583 Fax: 502/564-9003 E-mail: **art.clay@mail.state.ky.us**
LOUISIANA	**Zahir 'Bo' Bolourchi** Deputy Assistant Secretary LA Dept. of Transportation & Development Public Works & Water Resources Division P.O. Box 94245, Room 506 Baton Rouge, LA 70804-9245 Phone: 225/274-4171 Fax: 225/274-4322 Email: **BoBolourchi@dotd.state.la.us**

MAINE	**Tony Fletcher** STATE DAM INSPECTOR ME Emergency Management Agency Dept. of Defense 72 State House Station Augusta, ME 04333-0072 Phone: 207/626-7824 Fax: 207/626-4460 Email: **Tony.Fletcher@state.me.us**
MARYLAND	**Ken Pensyl** Program Manager Sediment, Stormwater and Dam Safety Program Maryland Department of the Environment Water Management Administration Suite 440 Baltimore, Maryland 21230 Tel: 410/537-3561 Fax: 410/537-3553 **kpensyl@mde.state.md.us**
MASSACHUSETTS	**Michael D. Misslin** Deputy Chief Engineer Massachusetts Department of Conservation and Recreation 77 Great Road Maynard, MA 01754 Phone: 617/626-4927 Fax: 617/626-1349 Email: **Mike.Misslin@state.ma.us**
MICHIGAN	**David Hamilton** Chief, Water Mgmt Section MI Dept of Environmental Quality P.O. Box 30458 Lansing, MI 48909-7958 Tel: 517/335-3174 Fax: 517/373-9965 E-mail: **hamiltod@michigan.gov**
MINNESOTA	**Dana Gauthier** Dam Safety Engineer MN Dept of Natural Resources 500 Lafayette Road Box 32 St. Paul, MN, 55155-4032 Tel: 651/296-0521 Fax: 651/296-0445 Email: **dana.gauthier@dnr.state.mn.us**
MISSISSIPPI	**Mike Meadows** Dam Safety Coordinator MS Dept. of Environmental Quality Division of Dam Safety P.O. Box 10631 Jackson, MS 39289-0631 Phone: 601/961-5272 Fax: 601/354-6938 Email: **mike_meadows@deq.state.ms.us**
MISSOURI	**James L. Alexander** Program Director/Chief Engineer MO Department of Natural Resources Dam Safety Program 111 Fairgrounds Road PO Box 250 Rolla, MO 65401 Phone: 573/368-2175 Fax: 573/368-2111 Email: **jim.alexander@dnr.mo.gov**
MONTANA	**Laurence Siroky** CHIEF, WATER OPERATIONS

	MT Dept. of Natural Resources & Conservation PO Box 201601 Helena, MT 59620-1601 Phone: 406/444-6816 Fax: 406/444-0533 Email: lsiroky@state.mt.us
NEBRASKA	**Patrick Diederich** Chief of Dam Safety NE Department of Natural Resources 301 Centennial Mall South Lincoln, NE 68509 Phone: 402-471-2363 Fax: 402/471-2900 Email: **pdiederich@dnr.state.ne.us**
NEVADA	**Robert K. Martinez** CHIEF, ENGINEERING & DAM SAFETY NV Division of Water Resources 123 West Nye Lane Ste. 246 Carson City, NV 89706 Phone: 775/687-3861 Fax: 775/687-1393 Email: robertm@ndwr.state.nv.us
NEW HAMPSHIRE	**James W. Gallagher** CHIEF ENGINEER NH Dept. of Environmental Services Dam Bureau P.O. Box 95, 29 Hazen Drive Concord, NH 03302-0095 Phone: 603/271-1961 Fax: 603/271-7894 Email: jgallagher@des.state.nh.u
NEW JERSEY	**John H. Moyle** MANAGER NJ Department of Environmental Protection Dam Safety Section P.O. Box 419 Trenton, NJ 08625 Phone: 609/984-0859 Fax: 609/984-1908 Email: John.Moyle@dep.state.nj.us
NEW MEXICO	**Elaine C. Pacheco** CHIEF NM Office of the State Engineer Dam Safety Bureau PO Box 25102 Santa Fe, NM 87504-5102 Phone: 505/827-6111 Fax: 505/827-4692 Email: epacheco@seo.state.nm.us
NEW YORK	**Michael Stankiewicz** CHIEF NY State Dept. of Env. Conservation Flood Protection Structural Program Section 625 Broadway Albany, NY 12233-3507 Phone: 518/402-8127 Fax: 518/402-9029 Email: **mrstanki@gw.dec.state.ny**.

NORTH CAROLINA **Max Fowler**
State Dam Safety Engineer
NC Department of Environmental & Natural Resources
Division of Land Resources
1612 Mail Service Center
Raleigh, NC 27699
Phone: 919/733-4574
Fax: 919/733-2876
E-mail: **Max.Fowler@ncmail.net**

NORTH DAKOTA **Jason Boyle**
Head of the Construction Section
ND State Water Commission
900 East Blvd. Avenue
Dept. 770
Bismarck, ND 58505
Phone: 701/328-4948
Fax: 701/328-3747
Email: **jboyle@state.nd.us**

OHIO **Mark B. Ogden**
ADMINISTRATOR, DAM SAFETY ENG.
OH-DNR - Division of Water
2045 Morse Road, Building B-2
Columbus, OH 43229-6693
Phone: 614/265-6727
Fax: 614/447-9503
Email: **mark.ogden@dnr.state.oh.us**

OKLAHOMA **Cecil R. Bearden**
SENIOR ENGINEER
Oklahoma Water Resources Board
3800 North Classen Blvd
Oklahoma City, OK 73118
Phone: 405/530-8800
Fax: 405/530-8900
Email: **crbearden@owrb.state.ok.us**

OREGON **John A. Falk**
DAM SAFETY COORDINATOR
OR Water Resources Dept.
725 Summer Street NE, Suite A
Salem, OR 97310-1271
Phone: 503/986-0840
Fax: 503/986-0904
Email: **john.a.falk@wrd.state.or.us**

PENNSYLVANIA **Dennis R. Dickey**
Acting Chief
PA Department of Environmental Resources
Division of Dam Safety
P.O. Box 8554
Harrisburg, PA 17105-8554
Phone: 717/787-8568
Fax: 717/772-0409
Email: **dedickey@state.pa.us**

PUERTO RICO **Miguel A. Perez Garcia**
Administrator, Dams & Reservoirs Safety Program
PR Electric Power Authority
P.O. Box 364267
San Juan, PR 00936-4267
Tel: 787/289-3254
Fax: 787/289-3250
E-mail: **M-Perez-DSAD@prepa.com**

RHODE ISLAND **Paul Guglielmino**
SENIOR SANITARY ENGINEER
Dept. of Environmental Management
Office of Compliance & Inspection

	235 Promenade Street Providence, RI 02908 Phone: 401/222-1360 xt.7122 Fax: 401/222-3811 Email: **pgugliel@doa.state.ri.us**
SOUTH CAROLINA	**Steven M. Bradley** DAM SAFETY HYDROLOGIST SC Department of Health & Environmental Control Dam Safety Section 2600 Bull Street Columbia, SC 29201 Phone: 803/898-4027 Fax: 803/898-4095 Email: **bradlesm@dhec.sc.gov**
SOUTH DAKOTA	**Timothy G. Schaal** NATURAL RESOURCES ENGINEER SD Dept. of Environment & Natural Resources Water Rights Program 523 E. Capitol Ave., Joe Foss Bldg. Pierre, SD 57501 Phone: 605/773-3352 Fax: 605/773-4068 Email: tim.schaal@state.sd.us
TENNESSEE	**Lyle Bentley** CHIEF, DAM SAFETY PROGRAM TN Dept. of Environment & Cons. 6th Floor, L & C Tower 401 Church Street Nashville, TN 37243-1539 Phone: 615/532-0154 Fax: 615/532-0503 Email:Lyle.Bentley@state.tn.us
TEXAS	**Warren D. Samuelson** 4108 Mocha Trail Austin, TX 78728 Tel: 512/239-5195 Fax: 512/239-0404 E-mail: **wsamuels@tceq.state.tx.us**
UTAH	**David Marble** Engineer Utah Division of Water Rights 1594 West North Temple #220 Salt Lake City, UT 84116 Phone: 801/538-7376 Fax: 801/538-7467 Email: davemarble@utah.gov
VERMONT	**Robert B. Finucane** ASSISTANT DAM SAFETY ENGINEER VT Department of Environmental Conservation Facilities Engineering Division 103 South Main Street, Laundry Bldg. Waterbury, VT 05671-0411 Phone: 802/241-3454 Fax: 802/241-3273 Email: **bob.finucane@state.vt.us**

VIRGINIA	**Dianna C. Sheesley** 4117 Running Quail Trail Amissville, VA 20106 Phone: 540/351-1587 Fax: 540/347-6423 E-mail: **dianna.sheesley@dcr.virginia.gov**
WASHINGTON	**Douglas L. Johnson** SUPERVISOR, DAM SAFETY WA Dept. of Ecology PO Box 47600 Olympia, WA 98504-7600 Phone: 360/407-6623 Fax: 360/407-7162 Email: djsd461@ecy.wa.gov
WEST VIRGINIA	**Brian R. Long** Section Manager WV Department of Environmental Protection Division of Water and Waste Management Dam Safety Section 601 57th Street SE Charleston, West Virginia 25304-2345 Phone: 304/926-0499 ext 1005 Fax: 304/926-0496 E-mail: **blong@wvdep.org**
WISCONSIN	**Meg Galloway** STATE DAM SAFETY ENGINEER WI Dept of Natural Resources GEF 2, WT/6 101 S. Webster Madison, WI 53707-7921 Phone: 608/266-7014 Fax: 608/264-9200 Email: meg.galloway@dnr.state.wi.us
WYOMING	**David S. Benner** SAFETY OF DAMS ENGINEER Wyoming State Engineer's Office Herschler Building 4-E Cheyenne, WY 82002 Phone: 307/777-6153 Fax: 307/777-5451 Email: dbenne@state.wy.us

APPENDIX G
Example Letter To Non−NPS Dam Owner or Regulatory Agency (Preferably)

Certified Mail, Receipt Requested
Ms. Francis Doe, Chief, Engineering Division
South Lakes, Inc.
176 Water Street
Riverton, Texas 99999

Subject: Back River Dam

Dear Ms. Doe:

As discussed during our telephone conversation on July 15, 1982, certain information about your dam, which affects Waterway National Park, is needed.

As you can well understand, we need this information so that appropriate steps can be taken to assure that park visitors and resources are protected in those areas for which we have warning, rescue and evacuation responsibilities, in the event of spillway releases, possible dam failure, or accidents at the dam or reservoir.

Please send the following items to this park periodically and by certified mail:

1. A copy of your most current formal safety of dams inspection report, and if the dam has any serious deficiencies, an explanation of how and when corrective action will be performed. Please review and revise the attached NPS Inventory of Dams Report listing for your dam based upon this report. To be able to assign a safety of dams condition code [data element 27], this report will need to include a recent stability analysis including the use of criteria for the Maximum Probable Flood (MPF) and Maximum Credible Earthquake (MCE). If the project is proposed for construction or reconstruction, the National Park Service would appreciate the opportunity to review and comment on your design and construction documents.

2. Permission granting NPS observer status during your next formal safety of dams inspection.

3. Please incorporate the park into your Emergency Action Plan (EAP) and send us a copy. This EAP contains early warning, flood mapping, and evacuation procedures and is given to those jurisdictions that would be affected by spillway releases, possible dam failure, misoperation, or even an accident at the dam or reservoir. Your Notification Directory or Call-up List should state that the park is immediately affected and should be contacted directly by the dam operator/tender. Based upon these documents, the park will include your EAP into the park's Early Flood Warning, Search/Rescue, Evacuation, and Recovery Plan (ESEP) for those areas which it has warning, rescue, and evacuation responsibility. Your EAP and the park's ESEP will become part of the park's Emergency Operations Plan. This responsibility is described in the U.S. Department of the Interior, National Park Service Reference Manual -40 , Dams and Appurtenant Works, Chapter 6, Section D, and is in accordance with the Federal Guidelines for Dam Safety, pages 10 and 36.

If you have any questions or comments about this request, please contact (Park Official) at 999−999−9999.

Sincerely,

Regional Director/Superintendent

cc: NPS Regional Maintenance, Operations, and Safety of Dams Program Coordinator
NPS Washington Office, Park Facility Management Division, code 2420

APPENDIX H
List of Official Technical Supplements to Director's Order #40 and Reference Manual(RM)-40
for the National Park Service (NPS) Maintenance, Operation, and Safety of Dams (MOSD) Program
Reference WASO memorandum dated February 25, 1997, and subsequent February 25, 1997 email subject: "Availability of Guidelines and Training for NPS Dams Program and Related Flood Plain and Emergency Operations Management"

TITLE OF DOCUMENT	RELEASE DATE AND DISTRIBUTION	DESCRIPTION
OPERATIONS AND MAINTENANCE Operation and Maintenance Guidelines For Small Dams, Bureau of Reclamation, Dam Safety Office, Denver, Colorado, December 1982	WASO A7615 (610) memo, August 10, 1983, Regionwide	Reference Rm-40, Chapter 6. Maintenance and operational guidelines for all NPS and non-NPS dams that affect the National Park System and Related Areas
STATE COORDINATORS Dam Safety, Know the Potential Danger Federal Emergency Management Agency (FEMA), Earthquakes and Natural Hazards Program Division, Washington, D.C., May 1987	FEMA Letter dated August 1988, Servicewide	Reference RM-40, Appendix F. May 1987 listing of State Dam Safety Officers and Emergency Management Officers.
EMERGENCY ACTION PLANS Flood Plain Management = Availability of Guidelines on Community Local Flood Warning and Response System, National Park Service, Park Facility Management Division, Washington, D.C., February 10, 1986	February 10, 1986, Servicewide	Reference RM-40, Chapter 6, Section D. Early warning and response system for flooding, flash floods, and dam failures.
EMERGENCY ACTION PLANS Flood Warning and Preparedness Plans, Hydrology Subcommittee of the Federal Interagency Committee on Water Data, Washington, D.C., January 1990	WASO A7615(610) memo, May 17, 1990, Servicewide	Reference RM-40, Chapter 6, Section D Early warning and response system for flooding, flash floods, and dam failures

Appendix H

continued, List of Official Technical Supplements to Director's Order #40 and Reference Manual(RM)-40

INVENTORYING		Reference RM-40: Chapter 2, Section
NPS Inventory of Dams on-line database National Park Service, Park Facility Management Division, Washington, D.C., 2005	Servicewide	C and Appendix A
HAZARD POTENTIAL		Reference RM-40, Chapter 1, Section
Downstream Hazard Classification Guidelines, ACER Technical Memorandum No. 11, Bureau of Reclamation, Assistant Commissioner, Denver, Colorado, 1988 (Revised)	WASO A7615(610) memo, May 17, 1990, Regionwide	D, 3. Guideline for determining downstream hazard (risk) potential classification at and downstream of dam - not a classification of maintenance, structural, or public safety condition.
STRUCTURAL AND MAINTENANCE EXAMINATION		Reference RM-40, Chapter 6, Section
Safety Evaluation of Existing Dams, Bureau of Reclamation, Dam Safety Division, Denver, Colorado, 1983 (Revised) Regionwide	WASO A7615(670) memo, February 12, 1981, and subsequent releases,	C, 2, a. Manual for examining earth and concrete dams.
PUBLIC SAFETY EXAMINATION		Reference RM-40, Chapter 6, Section B
Public Safety Around Dams and Reservoirs, Interim Working Guideline, Dam Safety Inspection Section, Bureau of Reclamation, Denver, Colorado, June 1992	WASO A7615(610), memo, June 12, 1992, Regionwide	Manual for examining public safety around dams and reservoirs.

Appendix H

United States Department of the Interior

NATIONAL PARK SERVICE
P.O. BOX 37127
WASHINGTON, D.C. 20013-7127

IN REPLY REFER TO:
A5623(610)

October 9, 1987

Special Directive 87 - 4 Annual Review

To: Directorate, Field Directorate, Washington Office (WASO)
Division Chiefs, and All Superintendents

From: Acting Director

Subject: Dams and Appurtenant Works - Desk Reference Manual for Maintenance, Operation, and Safety

This Directive replaces and updates Staff Directive 86-2 of the same subject. It provides a brief explanation of the National Park Service (NPS) Maintenance, Operation, and Safety of Dams (MOSD) program responsibilities.

Complete management responsibilities are outlined in more detail in NPS-40, Dams and Appurtenant Works, Chapter 2. The key action responsibilities are as follows:

° Prepare, review, and update annually Emergency Action Plans (EAP's) for any NPS dams that are classified as Downstream HIGH or SIGNIFICANT Hazard Potential. Use NPS-40, Chapter 2, Section B, paragraph 6 and Chapter 6, Section D.

° Prepare, review, and update annually Emergency Action Plans for park areas that are affected by non-NPS dams. Information about contacting State dam safety officials regarding private dams that affect park areas is provided in NPS-40, Appendix F and attachment 2 of this Directive.

° Prepare or obtain official inspection reports for all NPS and non-NPS dams and incorporate findings into the Inventory of Dams. Use NPS-40, Chapter 6, Section C and Dam Inventory Users Guide, Revised February 1985.

° Promptly perform corrective action on deficient dams. Dams listed as SERIOUSLY DEFICIENT should be corrected immediately. A dam is SERIOUSLY DEFICIENT if an official inspection report classifies the safety condition as POOR or UNSATISFACTORY or the maintenance condition as 3, 4, or 5. Use the current Inventory of Dams and NPS-40, Chapter 3, Section C and Chapter 6, Section C, paragraph 4.

° Maintain accurately the NPS Inventory of Dams for any size, type, or owner (NPS or non-NPS) of dams that affect park resources, safety, maintenance, or operations. Dams that are proposed, existing, or deactivated and either within, adjacent to, or upstream of park areas will be included. Use NPS-40, Chapter 2, Section C and Dams Inventory Users Guide, revised February 1985.

° Dams and appurtenant works including adjacent areas out to 15 feet will be kept free of any woody vegetation, trees, roots, bushes, debris, or any other material which interferes with the access, visibility, inspection, operation, or maintenance of the facility. Grass will be mowed at prescribed intervals, particularly before inspections. Complete inspections cannot be performed when access or visibility is impaired by vegetation or debris. Spillways and other water control devices should be kept clear of obstructions and debris and seepage monitored on a regular basis. Use NPS-40, Chapter 6, Section B and the Operations and Maintenance Guidelines for Small Dams.

° Maintain operations and maintenance logs for NPS dams. Use NPS-40, Chapter 6, Section B and the Operations and Maintenance Guidelines for Small Dams, page 13 and Appendix B.

° Retain only essential dams. Dams, appurtenant works, and impoundments unauthorized by legislation or not approved in a General Management Plan should be deactivated, particularly if they are deficient. Deficient dams should not be acquired. Use NPS-40, Chapter 1, Section C and Chapter 3.

A list of official guidelines, an example letter for initiating contact with a non-NPS dam owner, and a list of NPS and Bureau of Reclamation engineers for special assistance, particularly during emergencies, are provided in attachments 1, 2, and 3 respectively.

For additional information, contact your Regional Dams Coordinator or Mr. Charles Karpowicz, NPS Dams Officer, at 202-565-1249 if you have any questions.

Attachments (3)

cc: Commissioner, Bureau of Reclamation

List of Official Guidelines and Manuals for the National Park Service (NPS)
Maintenance, Operation, and Safety of Dams (MOSD) Program

Title of Guideline or Manual	NPS ID	Release Date and Distribution	Description
Dams and Appurtenant Works, National Park Service, Engineering and Safety Services Division, Washington, D.C., February 1983	NPS-40 Guideline	June 1983, Servicewide	NPS management guideline for all NPS and non-NPS dams that affect the National Park System and Related Areas.
Technical Supplements to NPS-40 Management Guideline			
OPERATIONS AND MAINTENANCE Operation and Maintenance Guidelines For Small Dams, Bureau of Reclamation, Dam Safety Office, Denver, Colorado, December 1982	-	WASO A7615(610) memo, June 12, 1992, Regionwide	Reference NPS-40, Chapter 6. Maintenance and operational guidelines for all NPS and non-NPS dams that affect the National Park System and Related Areas.
STATE COORDINATORS Dam Safety, Know the Potential Danger - Federal Emergency Management Agency (FEMA), Earthquakes and Natural Hazards Program Division, Washington, DC 20472, May 1987	-	FEMA Letter dated August 1988, Servicewide	Reference NPS-40, Appendix F. May 1987 listing of State Dam Safety Officers and Emergency Management Officers.
EMERGENCY ACTION PLANS Flood Plain Management - Availability of Guidelines on Community Local Flood Warning and Response System, National Park Service, Engineering and Safety Service Division, Washington, D.C., February 10, 1986	NPS Staff Directive 86-1	February 10, 1986, Servicewide	Reference NPS-40, Chapter 6, Section D. Early warning and response system for flooding, flash floods, and dam failures.
EMERGENCY ACTION PLANS Flood Warning and Preparedness Plans, Hydrology Subcommittee of the Federal Interagency Committee on Water Data, Washington, DC, January 1990	-	WASO A7615(610) memo, May 17, 1990, Servicewide	Reference NPS-40, Chapter 6, Section D. Early warning and response system for flooding, flash floods, and dam failures.

List of Official Guidelines and Manuals for the National Park Service (NPS)
Maintenance, Operation, and Safety of Dams (MOSD) Program, continued

Title of Guideline or Manual	NPS ID	Release Date and Distribution	Description
INVENTORYING NPS Dams Inventory User Guide, National Park Service, Engineering and Safety Services Division, Washington, D.C., December 1992 (Revised)	-	WASO A7615(610) memorandum for 1993 Annual Dams Report Call, Servicewide	Reference NPS-40, Chapter 2, Section C. A users guide for NPS Dams and Related Flood Plain Inventory Report printouts.
HAZARD POTENTIAL Downstream Hazard Classification Guidelines, ACER Technical Memorandum No. 11, Bureau of Reclamation, Assistant Commissioner, Denver, Colorado, 1988 (Revised)	-	WASO A7615(610) memo, June 12, 1992, Regionwide	Reference NPS-40, Chapter 1, Section D, 3. Guideline for determining downstream hazard (risk) potential classification at and downstream of dam - not a classification of maintenance, structural, or public safety condition.
STRUCTURAL AND MAINTENANCE EXAMINATION Safety Evaluation of Existing Dams, Bureau of Reclamation, Dam Safety Division, Denver, Colorado, 1983 (Revised)	-	WASO A7615(610) memo, June 12,1992, Regionwide	Reference NPS-40, Chapter 6, Section C, 2, a. Manual for examining earth and concrete dams. Enlarged examination checklists provided in notebook for field office use.
PUBLIC SAFETY EXAMINATION Public Safety Around Dams and Reservoirs, Interim Working Guideline, Dam Safety Inspection Section, Bureau of Reclamation, Denver, Colorado, June 1992	-	WASO A7615(610), memo, June 12, 1992, Regionwide	Reference NPS-40, Chapter 6, Section B Manual for examining public safety around dams and reservoirs.
FINANCE Financial Work Sheet, SMOD Form 1	-	WASO A7615(610) memo June 12, 1992, Regionwide	Reference NPS-40, Chapter 2, Section E. Example financial work sheet for formulating budgets and tracking expenses in the management or monitoring of all dams.

Attachment 2, Example Letter
Example Letter To Non-NPS Dam Owner or Regulatory Agency (Preferably)

Certified Mail, Receipt Requested
South Lakes, Inc.
Attention: Ms. Francis Doe, Chief of Engineering Division
176 Water Street
Riverton, Texas 99999

Subject: Back River Dam

Dear Madam:

As discussed during our telephone conversation on July 15, 1982, certain information about your dam which affects Waterway National Park is needed.

You can well understand our need for this information so that appropriate steps can be taken to assure that park visitors and resources are protected in those areas for which we have warning, rescue, and evacuation responsibilities in the event of spillway releases, possible dam failure, or accidents at the dam or reservoir.

Please place this park on your mailing list to receive periodically and by certified mail the following items:

1. A copy of your most current formal safety of dams inspection report, and if the dam has any serious deficiencies, an explanation of how and when corrective action will be performed. Please review and revise the attached NPS Inventory of Dams Report listing for your dam based upon this report. To be able to assign a safety of dams condition code [data element 27], this report will need to include a recent stability analysis including the use of criteria for the Maximum Probable Flood (MPF) and Maximum Credible Earthquake (MCE). If the project is proposed for construction or reconstruction, the National Park Service would appreciate the opportunity to review and comment on your design and construction documents.

2. Permission granting NPS observer status during your next formal safety of dams inspection.

3. Incorporation of the park into and a copy of your Emergency Action Plan (EAP). This EAP has early warning, flood mapping, and evacuation procedures and is given to those jurisdictions who would be affected by spillway releases, possible dam failure, misoperation, or even an accident at the dam or reservoir. Your Notification Directory or Call-up List should state that the park is immediately affected and contacted directly by the dam operator/tender. Based upon these documents the park will prepare its own EAP for those areas which it has warning, rescue, and evacuation responsibility. The NPS prepared EAP is part of the park's Emergency Operations Plan. This responsibility is described in the U.S. Department of the Interior, National Park Service management guideline, NPS-40, Dams and Appurtenant Works..., Chapter 6, Section D, and is in accordance with the Federal Guidelines For Dam Safety, pages 10 and 36.

If you have any questions or comments about this request, please contact (Park Official) at commercial telephone 999-999-9999.

Sincerely,

Regional Director/Superintendent

cc: WASO Engineering and Safety Services Division, Code 610

LIST OF CONTACTS AND COORDINATORS FOR THE NATIONAL PARK SERVICE (NPS) MAINTENANCE, OPERATION, AND SAFETY OF DAMS PROGRAM

12/13/99, D:\document\damsr13.99

BUREAU OF RECLAMATION CONTACTS

Name	Mailing Address	Telephones (O) Office (H) Home
Coordinator for Overall NPS Assistance Civil Engineer, Betty Dinneen Alternate: Tom Luebke	Bureau of Reclamation Technical Service Center Attention: Client Business Svcs, D-8010 P.O. Box 25007 Bldg. 67, Denver Federal Center Denver, Colorado 80225-0007	(O) 303-445-3029 (O) 303-445-2594
Coordinator for Technical Advice for Dam Safety, Civil Engineer, Chuck Hennig 1/ Alternate: Dave Eubank 2/	Dam Safety Office, code D-6600	(O) 303-445-2771*1/ fax 303-445-6463 (O) 303-445-2769*2/ (H) 303-988-4557 1/
Coordinator for Examinations, Civil Engineer, Leon Faris Alternate: Civil Engineer, Chris Veesaert	Inspections and Emergency Mgmt. Group D-8470	(O) 303-445-2747 (O) 303-445-2742* fax 303-445-6381

* Work hours vary; however, one of these individuals will be available from 7:00 a.m. to 4:00 p.m.(Rocky Mountain Time), Monday through Friday.

NATIONAL PARK SERVICE WASHINGTON AND FIELD OFFICE COORDINATORS

NPS Dams Program Officer, Charles Karpowicz 1/ Alternate: Mark Hartsoe 2/	National Park Service Park Facility Management Division, Org. Code 2420 1849 C Street, N.W. room MIB 7252 Washington, D.C. 20240	(O) 202-565-1249 1/ (O) 202-565-1244 (H) 703-493-8050 1/ (O) 202-565-1244 2/
Civil Engineer, Bill Heubner 1/ Alternate: Supervisory General Engineer Bruce Sherwood 2/	Alaska SO (Support Office) Alaska Region Planning, Design and Maintenance Division 2525 Gamble Street, Room 107 Anchorage, Alaska 99503-2892	(O) 907-257-2675 1/ (H) 907-257-2878 2/
Chief Ranger, Robert Gray Alternate: Park Manager, Pam Underhill	National Park Service Appalachian National Scenic Trail Park Office C/O NPS Harpers Ferry Center Harpers Ferry, West Virginia 25425	(O) 304-535-6278 (H) 304-258-5637 fax 304-535-6270
Civil Engineer: Phil Ayers 1/ Alternate: Roger Maxwell, 2/ Tim Windle 3/	Denver SO Intermountain Region Facility Management, Design, and Engineering Branch 12795 West Alameda Parkway P.O. Box 25287 Denver, Colorado 80225-0287	(O) 303-969-2606 1/ (H) 303-215-0979 1/ (O) 303-969-2859 2/ (O) 303-969-2628 3/
Civil Engineer, Joe Bruno 1/ Alternate: Program Leader, Maintenance, Design, and Engineering, Richard Niemyer 2/ Alternate: Civil Engineer, Allen Bengtson	Southwest SO Intermountain Region Maintenance, Design, and Engineering Office P.O. Box 728 Santa Fe, New Mexico 87504-0728	(O) 505-988-6036 1/ (H) 505-471-0332 1/ (O) 505-988-6035 2/
Environmental Engineer, Dick Fisher 1/ Alternate: Civil Engineer, Wayne Vander Tuin 2/	Midwest SO Midwest Region Maintenance and Engineering 1709 Jackson Street Omaha, Nebraska 68102-2571	(O) 402-221-3945 1/ (H) 402-333-2419 1/ (O) 402-221-3491 2/ fax 402-221-3465

NATIONAL PARK SERVICE WASHINGTON AND FIELD OFFICE COORDINATORS, continued

Name	Mailing Address	Telephones (O) Office (H) Home
Civil Engineer, Stan Tolman 1/ Alternate-1: Don Filsoof 2/ Alternate-2: Dave Hammers 3/	National Capital SO National Capital Region Maintenance and Design Room 358 1100 Ohio Drive, S.W. Washington, D.C. 20242	(O) 202-523-1148 1/ (O) 202-619-7060 2/ (O) 202-619-7270 3/
Civil Engineer, Mark Spadea Alternate: Facility Manager, Ross Flanagan	Philadelphia SO Northeast Region Maintenance, Design, and Engineering U.S. Custom House, Room 306 200 Chestnut Street Philadelphia, Pennsylvania 19106	(O) 215-597-0043
Civil Engineer, David Price 1/ Alternate: Fred Bentley 2/	Boston SO Northeast Region Engineering and Facility Management 15 State Street Boston, Massachusetts 02109-3572	(O) 617-223-5096 1/ fax 617-223-5260 1/ (H) 508-896-9645 1/ (O) 617-223-5296 2/
Environmental Engineer, Noby Ikeda, 1/ Alternate: Facility Management Chief, Jack Williams, 2/	Pacific Great Basin SO Pacific West Region Facility Management 600 Harrison Street, Suite 600 San Francisco, CA 94107-1372	(O) 415-427-1377 1/ (H) 415-898-1402 1/ (O) 415-427-1384 2/
Civil Engineer, Richard Engle 1/ Alternate: Jeoff Swan 2/	Columbia Cascade SO Pacific West Region Design and Engineering 909 First Avenue Seattle, Washington 98104-1060	(O) 206-220-4274 1/ (O) 206-220-4275 2/ (H) 206-842-6153 1/
Civil Engineer, Simon Tran-M-Trung) 1/ Alternate-1: Dan Cockrum 2/ Alternate-2: Leon Folsom 3/	Southeast SO Southeast Region Education and Visitor Services Maintenance and Engineering Division 100 Alabama Street, S.W. Atlanta, Georgia 30303	(O) 404-562-3108 1/ fax 404-562-3257 1/ (O) 404-562-3124 2/ (O) 404-562-3124 3/

NATIONAL PARK SERVICE DENVER SERVICE CENTER

Geotechnical Engineer, Mike Casias 1/ Alternate: Chief, Engineering Services, Terry Wong, 2/	National Park Service Denver Service Center Engineering Services, DSC-EN 12795 West Alameda Parkway P.O. Box 25287 Denver, Colorado 80225-0287	(O) 303-969-2302 1/ (O) 303-969-2140 2/ fax 303-969-2930

OTHER CONTACTS

Name	Mailing Address	Telephones

FEDERAL HIGHWAY ADMINISTRATION

Program Manager, Arthur E. Hamilton	Federal Lands Highway Program Federal Highway Administration, Room 4136 400 7th Street,S.W. Washington, D.C. 20590	(O) 202-366-9494

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

Chairman, Federal Interagency Committee on Dam Safety, Bud Andress 1/ Alternate: Rita Henry 2/	National Dam Safety Program, MT-NDSP Mitigation Directorate Federal Emergency Management Agency, FEMA 500 C Street, S.W. Washington, DC 20472	(O) 202-646-2801 1/ (O) 202-646-2704 2/

ASSOCIATION OF STATE DAM SAFETY OFFICIALS (ASDSO)

Executive Director, Lori Spragens Conference Coordinator, Susan Sorrell Administrative Assistant, Carrie Wright	Association of State Dam Safety Officials 450 Old Vine Street, Second Floor Lexington, KY 40507	(O) 606-257-5140 fax 606-323-1958

3/3/1999, WP5.1, D:\Document\damsr10.99
S:\Doc\damsr10.99

D.5. Natural Resources Conservation Service



USDA United States Department of Agriculture

NRCS Natural Resources Conservation Service

Conservation Engineering Division

July 2005

Earth Dams and Reservoirs

TR–60



Issued July 2005

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, sexual orientation, or marital or family status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326W, Whitten Building, 14th and Independence Avenue, SW, Washington, DC 20250-9410 or call (202) 720-5964 (voice and TDD). USDA is an equal opportunity provider and employer.

Preface

This Technical Release (TR) describes design procedures and provides minimum requirements for planning and designing earth dams and associated spillways. This TR was developed to provide uniform criteria for earth dams and reservoirs. NRCS plans, designs, and constructs complex dams under widely varying conditions. It is essential that these dams be constructed with uniform criteria to ensure consistent performance. As new experience, materials, and knowledge become available, this document will be revised.

This TR applies to all Low Hazard Class dams with a product of storage times the effective height of the dam of 3,000 acre-feet[2] or more, those more than 35 feet in effective height, and all Significant and High Hazard Class dams. Requirements are stated as maximum or minimum limits and may not be satisfactory design criteria for all sites. In some cases, problems may arise where proven solutions are not available or alternate procedures may need to be evaluated before the best solutions can be developed and selected. Experience, state laws and regulations, investigations, analysis, expected maintenance, environmental considerations, or safety laws may dictate more conservative criteria to ensure satisfactory performance.

This edition of the TR incorporates all previously issued revisions and amendments, as well as significant changes in chapters 2 (24-hour Design Storms), 5 (Slope Stability Analysis), and 7 (New Earth Spillway Breach Model) that were widely distributed and reviewed. This edition also makes numerous editorial corrections, including SCS to NRCS; emergency spillway to auxiliary spillway; and Class a, b, c to Low, Significant, High Hazard Class, respectively.

Contents:

Part 1

General 1-1
Dam classification 1-1
Classes of dams 1-1
Peak breach discharge criteria 1-1
Utility cables and pipelines 1-2
Cut slope stability 1-2
Joint use of reservoir capacity 1-2
Visual resource design 1-3
Safety and protection 1-3
Water supply pipes 1-3
Streamflow diversion during construction 1-3
Reservoir conservation storage 1-4

Part 2

Hydrology 2-1
Precipitation and runoff amounts 2-1
Principal spillway 2-1
Auxiliary spillway and freeboard 2-1
Design hydrographs 2-5
Principal spillway hydrographs 2-5
Stability design (auxiliary spillway) and freeboard hydrographs 2-5
Dams in series 2-5
Upper dam 2-5
Lower dam 2-5
Large drainage areas 2-6

Part 3

Sedimentation 3-1

Part 4

Geologic investigations 4-1
Subsidence 4-1
Auxiliary spillways 4-1
Mass movements 4-1
Karstic areas 4-1
Multipurpose dams 4-1
Other 4-1

Part 5

Earth embankments and foundations 5-1
Height 5-1
Top width 5-1
Embankment slope stability 5-1
End of construction 5-2
Rapid drawdown 5-2
Steady seepage without seismic forces 5-4
Steady seepage with seismic forces 5-4
Seepage 5-4

Zoning....5-5
Surface protection....5-5
Vegetative protection....5-5
Structural protection....5-5

Part 6

Principal spillways....6-1
Capacity of principal spillway....6-1
Elevation of principal spillways....6-1
Single-purpose floodwater retarding dams....6-1
Other dams....6-1
Routing of principal spillway hydrographs....6-1
Design of principal spillways....6-2
Hydraulics....6-2
Risers....6-2
Conduit....6-2
Joints....6-4
Outlets....6-6
Trash racks....6-6
Antivortex device....6-6
High sulfate areas....6-6

Part 7

Auxiliary spillways....7-1
Closed type spillways....7-1
Spillway requirements....7-1
Capacity of auxiliary spillways....7-1
Elevation of the crest of the auxiliary spillway....7-1
Auxiliary spillway routings....7-1
Hydraulic design....7-2
Structural stability....7-2
Vegetated and earth auxiliary spillways....7-2
Layout....7-2
Stability design of earth and vegetated earth spillways....7-3
Integrity design of earth and vegetated earth spillways....7-3
Rock auxiliary spillway....7-4
Structural auxiliary spillways....7-4

Glossary

Glossary....A-1

Table 2-1	National Weather Service References: Precipitation Data	2-2
Table 2-2	Minimum principal spillway hydrologic criteria	2-3
Table 2-3	Principal spillway volume adjustments	2-7
Table 2-4	Minimum quick return flow for prinicipal spillway hydrographs	2-7
Table 2-5	Minimum auxiliary spillway hydrologic criteria	2-8
Figure 2-1	Principal spillway runoff volumes in north-central and southeastern states	2-9
Figure 2-2	Principal spillway runoff volumes in snowmelt producing flood areas	2-12
Figure 2-3	Areal adjustment, auxiliary spillway and freeboard	2-14
Figure 2-4	Dimensionless design storm distribution, auxiliary spillway and freeboard	2-14
Figure 4-1	Seismic zone map	4-2
Table 5-1	Minimum top width of embankment	5-1
Figure 5-1	Mohr-Coulomb Envelope for upstream drawdown	5-2
Table 5-2	Slope stability criteria	5-3
Figure 5-2	Mohr-Coulomb Envelope for downstream steady seepage	5-4

Technical Release Number 60

Earth Dams and Reservoirs

General

Dam classification

In determining dam classification, a number of factors must be considered. Consideration must be given to the damage that might occur to existing and future developments should the dam suddenly release large quantities of water downstream due to a breach, failure, or landslide into the reservoir. The effect of failure on public confidence is an important factor. State and local regulations and the responsibility of the involved public agencies must be recognized. The stability of the spillway materials, the physical characteristics of the site and the valley downstream, and the relationship of the site to industrial and residential areas including controls of future development all have a bearing on the amount of potential damage in the event of a failure.

Dam classification is determined by the above conditions. It is not determined by the criteria selected for design. The policy on classification is in 210-V-NEM (*National Engineering Manual*), Part 520, Subpart C, DAMS.

Classes of dams

The following classes of dams have been established by policy and repeated here for convenience of the user.

- Low Hazard Class—dams located in rural or agricultural areas where failure may damage farm buildings, agricultural land, or township and country roads.
- Significant Hazard Class—dams located in predominantly rural or agricultural areas where failure may damage isolated homes, main highways or minor railroads, or cause interruption of use or service of relatively important public utilities.
- High Hazard Class—dams located where failure may cause loss of life, serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads.

Peak breach discharge criteria

Breach routings are used to help delineate the area potentially impacted by inundation should a dam fail and can be used to aid dam classification.

Stream routings made of the breach hydrograph will be based upon topographic data and hydraulic methodologies mutually consistent in their accuracy and commensurate with the risk being evaluated.

The minimum peak discharge of the breach hydrograph, regardless of the technique used to analyze the downstream inundation area, is:

1. For depth of water at the dam at the time of failure where $H_w \geq 103$ ft

$$Q_{max} = (65) H_w^{1.85}$$

2. For depth of water at the dam at the time of failure where $H_w < 103$ ft

$$Q_{max} = (1{,}100) B_r^{1.35} \qquad \text{where } B_r = \frac{(V_s)(H_w)}{A}$$

but not less than $Q_{max} = (3.2) H_w^{2.5}$ nor more than $Q_{max} = (65) H_w^{1.85}$

3. When the width of the valley, L, at the water surface elevation corresponding to the depth, H_w, is less than,

$$T = \frac{(65) H_w^{0.35}}{0.416}$$

replace the equation, $Q_{max} = (65) H_w^{1.85}$, in 1 and 2 above with,

$$Q_{max} = (0.416)(L) H_w^{1.5}$$

where:

Q_{max} = the peak breach discharge, ft^3/sec

B_r = breach factor, acre

V_s = reservoir storage at the time of failure, acre-ft

H_w = depth of water at the dam at the time of failure; however, if the dam is overtopped, depth is set equal to the height of dam, ft

A = cross-sectional area of embankment at the assumed location of breach, usually the template section (normal to the dam longitudinal axis) at the general flood plain location, ft^2

T = theoretical breach width at the water surface elevation corresponding to the depth, H_w, for the equation, $Q_{max} = (65)H_w^{1.85}$, ft

L = width of the valley at the water surface elevation corresponding to the depth, H_w, ft

The peak discharge value determined by using principles of erosion, hydraulics, and sediment transport may be used in lieu of the peak discharge computed using the above equations.

Utility cables and pipelines

Existing pipelines, cables, and conduits of a wide variety of sizes, materials, and functions are frequently encountered at dam sites. These conduits are usually located at shallow depths in the flood plain. They constitute a hazard to the safety of the dam and must be either relocated away from the site or reconstructed or modified to provide the durability, strength, and flexibility equal in all aspects to the principal spillway designed for the site, in accordance with service criteria and procedures. Overhead cables or power lines must be relocated or raised as necessary to prevent damage or hazard to the public.

Every reasonable effort should be made to have such conduits, cables, and pipelines removed from the site. Most utilities and industries will want their facility removed from the site for easy maintenance. Only as a last resort and under the limitations imposed below are conduits permitted to remain under an earth dam embankment.

Conduits permitted to remain under any part of the embankment below the crest of the auxiliary spillway are to be:

- provided with seepage control against potential piping;
- properly articulated on all yielding foundations;
- encased in concrete or otherwise treated to ensure durability and strength equal to that of the principal spillway; and
- made watertight against leaking either into or out of the pipe.

Enclosure of the conduit cable or pipeline within another conduit that meets the requirements of this section and is positively sealed at the upstream end to prevent seepage into the enclosing conduit is acceptable. Such an enclosing conduit must extend the full distance through which the conduit, cable, or pipeline being enclosed is beneath the embankment.

Cut slope stability

Natural and excavation cut slopes must be planned and formed in a stable and safe manner. Spillways, inlet and outlet channels, borrow pits, reservoir edges, abutment areas, and foundation excavations are all locations where these considerations are needed. Field investigations, methods of analysis, design and construction requirements, and resultant specifications must recognize and provide for safe functional performance.

Joint use of reservoir capacity

A reservoir site may be used more efficiently where hydrologic conditions permit joint use of storage capacity by flood water and conservation storage. The following requirements must be met for joint use storage dams.

- There is reasonable assurance that water will be available to meet objectives.
- Flood protection objectives of the project are satisfied.
- Spillway conditions are such that the dam will perform safely.

Special hydrologic studies must be made to show that the requirements can be met. This may include hydrometeorologic instrumentation and analysis.

Hydraulic features must include an ungated spillway outlet at the top of the joint use pool. A gated opening must be provided at the bottom of the joint use pool adequate for use of the conservation storage and evacuation of the joint use pool.

Provisions must be made for operation of the joint use pool to ensure functioning of the dam as designed. These must include a competent operating and maintaining organization and a specific operation and maintenance plan. These requirements must be a part of the planning process and agreed to by the sponsors or owner.

Visual resource design

The public generally prefers lake or waterscape scenery. Therefore, when permanent pools are created by dam construction, they can enhance the visual resource if the water views are emphasized. A visual design objective must focus public views toward the permanent pool and reduce the visual focal effects of the structural elements.

Visual focus on the lake is achieved by locating roads and walkways so that the entering or first perceptions of the site are of the waterscape scenery. In most landscapes, the lake will automatically predominate if other elements are visually designed to be subordinate.

Borrow areas must be shaped to blend with the surrounding topography. These areas must be revegetated with herbaceous and woody plants to visually fit the existing surrounding vegetation. Fences must be constructed parallel to the contour as much as possible, be located behind existing vegetation, as seen from the major viewpoints, and be placed low in the landscape. Dams must be shaped to blend with the natural topography to the extent feasible.

Safety and protection

Many dams are hazardous to the public. Features designed for recreation or fish and wildlife are especially attractive to the public since they provide an opportunity to use the water. All dams must be designed to avoid hazardous conditions where possible. Open-top risers, steep-walled channels and chutes, plunge pools, and stilling basins are hazardous and require special attention. All dams must be provided with safety fences, guard rails, or other safeguards as necessary to protect the public and operation and maintenance personnel.

The embankment and spillways must be fenced where necessary to protect the dam from livestock and foot and vehicular traffic.

Water supply pipes

Water supply pipes or conduits for other purposes installed under any part of the embankment below the crest of the auxiliary spillway are to:

- provide durability, strength, and flexibility equivalent to the principal spillway;
- be watertight against anticipated pressures;
- be adequate for their intended use; and
- be provided with seepage control against potential piping.

Streamflow diversion during construction

Streamflow past the dam site, unless controlled, occurs at a somewhat random time with variable frequency and magnitudes. A hazard exists during dam construction beginning when the embankment, cofferdam, or other ancillary structures obstruct the natural streamflow. During construction, a greater risk usually exists for some time than after the dam is completed. The risk is different for each dam because of the varying factors of construction time, climate, watershed size, and diversion capacity. An evaluation should be made of the risk from embankment failure by overtopping and other similar hazards during construction. The risk involved in overtopping during construction increases with the following factors:

- dams of higher hazard class
- greater volume of reservoir storage
- dams with larger watersheds
- longer critical construction time periods
- smaller diversion “release” rates (less unit discharge per unit watershed area)

The consequence of overtopping during construction may vary from a slight amount of erosion on a homogeneous clay dam to a breach of an embankment including loss of a temporary diversion coffer dam. The erosion or breach causes increased inundation and sedimentation of downstream areas.

The risk may be evaluated based upon experience of comparable dams constructed in the same hydrologic setting. An evaluation may also be made using available streamflow records to obtain stage-duration-frequency information for a range of diversion rates. Streamflow data should be used when available; otherwise, an evaluation may be made using climatological record data for generation of synthetic hydrographs to develop stage duration-frequency information for a range of diversion rates.

The size of diversion must be designed to provide an acceptable level of risk. The probability required to protect against overtopping varies from 20 percent to 5 percent chance in any one year. A 10 percent chance probability is frequently used when the critical con-

struction period is limited to one construction season. An alternative to a larger diversion capacity is to provide protection against erosion to the embankment surface (reinforcement) up to the desired elevation of acceptable risk.

Reservoir conservation storage

Reservoirs with water stored for conservation purposes must be analyzed using a water budget to determine a dependable water supply.

For most purposes, a dependable water supply is defined as one that is available at least 8 out of 10 years or has a probability of 80 percent chance in any one year. A purpose such as municipal and industrial water may require a 95 percent chance probability of existing in any one year. Other purposes, such as recreation, require an analysis of the reservoir surface elevation fluctuation to evaluate the acceptable percent chance of occurrence.

Hydrology

This section describes hydrologic criteria for determining spillway discharges and floodwater storage volumes. Detailed procedures for developing principal spillway, auxiliary spillway, and freeboard hydrographs are found in the NRCS *National Engineering Handbook*, chapter 21, section 4, Hydrology (NEH-4). Methods of flood routing hydrographs through reservoirs and spillway systems are contained in chapter 17, NEH-4. Special studies, as used in this text, refer to all site-specific studies with prior concurrence of selected procedures.

Precipitation and runoff amounts

Principal spillway

Precipitation data must be obtained from the most recent National Weather Service (NWS) reference which is applicable to the area under study. References that contain precipitation data for return periods up to 100 years and for durations up to 10 days are listed in sections A and B of table 2-1.

The return period for design precipitation amounts is dependent on the dam classification, purpose, size, location, and type of auxiliary spillway. Table 2-2 shows minimum return period. The minimum allowable areal adjustment ratios for 1- and 10-day precipitation amounts are tabulated in table 2-3 (a).

A storm duration of not less than 10 days must be used for sizing the principal spillway. The procedure in chapter 21, NEH-4 for developing the storm distribution uses both the 1-day and 10-day runoff volumes.

The procedure for estimating runoff volumes must be selected based on which one requires the higher auxiliary spillway crest elevation when the principal spillway hydrograph is routed through the structure. Procedures to be used to estimate runoff volumes include:

- The runoff curve number (CN) procedure described in NEH-4. Use average antecedent runoff conditions (ARC II) or greater unless a special study shows that a different condition is justified. The CN adjustment for 10-day storm is estimated from table 2-3(b).
- Runoff volumes, based on stream gage studies which also account for snow melt, from figures 2-1(a) and (b) or 2-2(a) and (b).

A special study may show that local streamflow records can be used directly or regionalized to develop design runoff volumes.

Transmission losses reducing the runoff volume in arid and semiarid climatic areas may be used if the climatic index, as defined in chapter 21, NEH-4, is less than one. If transmission losses appear to be significant even though the climatic index is one or more, such as in cavernous areas, special studies are required.

Obtain quick return flow from the map, figure 2-1(c), or table 2-4, as appropriate.

Auxiliary spillway and freeboard

The most recent NWS references applicable to the location of the dam site shall be used to determine precipitation amounts, spatial distributions, and temporal distributions. Table 2-1 provides references current as of date of this publication. See the NWS Web site, *http://www.nws.noaa.gov/oh/hdsc/index.html*, for the most current references.

Minimum precipitation amounts shall be in accordance with table 2-5.

The discharge capacity, stability (surface erosion potential), and integrity (breaching potential) of the auxiliary spillway shall be evaluated as follows:

- Both a short duration (6 hour or longer) and a long duration (24 hour or longer) storm shall be analyzed and the most critical results used to check the discharge capacity and the integrity of the auxiliary spillway.
- Only the short duration storm shall be used to check the stability of the auxiliary spillway.
- For locations where NWS references provide estimates of local storm and general storm values, both storms shall be analyzed. For other locations, at least a 6-hour and a 24-hour duration storm shall be analyzed.

In areas without applicable NWS references for spatial distribution, minimum areal adjustment ratios shown in figure 2-3 may be used. Spatial adjustments shall not be applied for drainage areas less than 10 square miles.

In areas without applicable NWS reference for temporal distribution, the dimensionless auxiliary and freeboard storm distribution shown in figure 2-4 may be used. Alternately, the 24-hour storm can be constructed by critically stacking incremental rainfall amounts of successive 6-, 12-, and 24-hour durations as described in Hydrometeorological Report 52 (HMR52).

Table 2-1 National Weather Service References[1/]: Precipitation Data

A. Durations to 1 day and return periods to 100 years

Technical Memorandum HYDRO-35. Durations 5 to 60 minutes for the eastern and central states (1977)

Technical Paper 40. 48 contiguous states (1961) (Use for 37 contiguous states east of the 105th meridian)

Technical Paper 42. Puerto Rico and Virgin Islands (1961)

Technical Paper 43. Hawaii (1962)

Technical Paper 47. Alaska (1963)

NOAA Atlas 2. Precipitation Atlas of the Western United States (1973).

Vol. I, Montana	Vol. II, Wyoming	Vol. III, Colorado
Vol. V, Idaho	Vol. VI, Utah	Vol. IX, Washington
Vol. X, Oregon	Vol. XI, California	

B. Durations from 2 to 10 days and return periods to 100 years

Technical Paper 49. 48 contiguous states (1964)

Technical Paper 51. Hawaii (1965)

Technical Paper 52. Alaska (1965)

Technical Paper 53. Puerto Rico and Virgin Islands (1965)

C. Durations from 5 minutes to 60 days and return periods to 100 years

NOAA Atlas 14 Volume 1. Precipitation Frequency Atlas for the Semiarid Southwest United States (2003)

NOAA Atlas 14 Volume 2. Precipitation Frequency Atlas for the Ohio River Basin and Surrounding States (2004)

D. Probable maximum precipitation (PMP)

Hydrometeorological Report 49. Colorado River and Great Basin Drainages (1977)

Hydrometeorological Report 51. For 37 contiguous states east of the 105rd meridian (1978)

Hydrometeorological Report 52. Application of PMP estimates, states east of the 105th Meridian (1982)

Hydrometeorological Report 53. Seasonal variation of 10 square-mile PMP estimates, states east of the 105th meridian (1980)

Hydrometeorological Report 54. PMP and snowmelt criteria for southeast Alaska (1983)

Hydrometeorological Report 55A. Between the Continental Divide and the 103rd meridian (1988)

Hydrometeorological Report 56. Tennessee Valley (1986)

Hydrometeorological Report 57. Pacific Northwest (1994)

Hydrometeorological Report 59. California (1999)

Technical Report 42. Puerto Rico and Virgin Islands (1961)

Technical Report 47. Alaska (1963)

1/ National Weather Service, National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce

Table 2-2 Minimum principal spillway hydrologic criteria

Class of dam	Purpose of dam	Product of storage X effective height	Existing or planned upstream dams	Precipitation data for maximum frequency of use of auxiliary spillway types: [1]	
				Earth	Vegetated
Low	single irrigation only [2]	less than 30,000	none	1/2 design life	1/2 design life
		greater than 30,000		3/4 design life	3/4 design life
	single or multiple [4]	less than 30,000	none	P_{50}	P_{25} [3]
		greater than 30,000		1/2 (P_{50} + P_{100})	1/2 (P_{25} + P_{50})
		all	any [5]	P_{100}	P_{50}
Significant	single or multiple	all	none or any	P_{100}	P_{50}
High	single or multiple	all	none or any	P_{100}	P_{100}

[1] Precipitation amounts by return period in years. In some areas, direct runoff amounts determined by figure 2-1 and 2-2 or procedures in chapter 21, NEH-4 should be used in lieu of precipitation data.

[2] Applies to irrigation dams on ephemeral streams in areas where the annual rainfall is less the 25 inches.

[3] The minimum criteria are to be increased from P_{25} to P_{100} for a ramp spillway.

[4] Low Hazard Class dams involving industrial or municipal water are to be designed with a minimum criteria equivalent to that of Significant Hazard Class.

[5] Applies when the upstream dam is located so that its failure could endanger the lower dam.

The maximum 6-hour rainfall should occur in the second 6-hour quadrant. The next highest 6-hour incremental rainfall should occur in the third 6-hour quadrant, the next highest in the first, etc.

The NRCS runoff curve number procedure defined in NEH-630 and NEH-4 shall be used to determine runoff volumes. Antecedent runoff condition (ARC) II or greater shall be assumed. The same curve number shall apply throughout the entire storm.

Special probable maximum precipitation (PMP) studies can be considered and may be conducted by NWS or other hydrometeorologists with experience in such work. Useful special studies may have been conducted by federal or state agencies or major dam owners. Special studies should be considered especially for large drainage areas, areas of significant variation in elevation, or areas located at the boundary of two studies where discontinuities occur.

Methods in the *Federal Guidelines for Dam Safety – Inflow Design Floods*, FEMA 94, may alternately be used to proportion the embankment and auxiliary spillway, provided downstream land use controls exist to prevent voiding incremental risk assumptions after the dam is completed.

Design hydrographs

Principal spillway hydrographs
Procedures in chapters 16 and 21, NEH-4 and applicable national computer programs shall be used to develop the principal spillway hydrograph using precipitation and runoff amounts as described in the preceding section.

When the area above a proposed dam is hydrologically complex, the area should be divided into two or more hydrologically homogeneous sub-basins for developing the design hydrograph.

Streamflow records may be used to develop the principal spillway hydrograph where a special study shows they are adequate for this purpose.

Stability design (auxiliary spillway) and freeboard hydrographs
Procedures in chapters 16 and 21, NEH-4 and applicable national computer programs shall be used to develop stability design (auxiliary spillway) and freeboard hydrographs using precipitation and runoff amounts and sub-basins, if necessary, as described in the preceding sections.

Dams in series

Upper dam
The hydrologic criteria and procedures for the design of an upper dam in a system of dams in series must be the same as, or more conservative than, those for dams downstream if failure of the upper dam could contribute to failure of the lower dam. The dam breach criteria described earlier will be used to develop the breach hydrograph peak discharge.

Lower dam
For the design of a lower dam, hydrographs shall be developed for the areas controlled by the upper dams based on the same hydrologic criteria as the lower dam. The hydrographs are routed through the spillways of the upstream dams and the outflows routed to the lower dam where they are combined with the hydrograph from the intermediate uncontrolled drainage area. The combined principal spillway hydrograph is used to determine the capacity of the principal spillway and the floodwater retarding storage requirement for the lower site. The combined stability design (auxiliary spillway) hydrograph is used to evaluate the stability (erosion resistance) of any vegetated or earth spillway at the lower site. The combined freeboard hydrograph is used to determine the height of dam and to evaluate the integrity of any vegetated or earth spillway at the lower site.

If upon routing a hydrograph through the upper dam, the dam is overtopped, or its safety is questionable, it is considered breached. For design of the lower dam, the breach hydrograph must be routed downstream to the lower dam and combined with the uncontrolled area hydrograph.

In design of the lower dam, the time of concentration (T_c) of the watershed above an upper dam is used to develop the hydrographs for the upper dam. The T_c of the uncontrolled area above the lower site is used to develop the uncontrolled area hydrographs. If the T_c for the total area exceeds the storm duration, the precipitation amounts for the stability design (auxiliary spillway) and freeboard hydrographs must be increased by the values in the applicable NWS references (table 2-1).

The minimum precipitation amounts for each of the required hydrographs may be reduced by the areal reduction factor for the total drainage area of the dam system.

Large drainage areas

When the area above a proposed dam approaches 50 square miles, it is desirable to divide the area into hydrologically homogeneous sub-basins for developing the design hydrographs. Generally, the drainage area for a sub-basin should not exceed 20 square miles. Watershed modeling computer programs, such as the NRCS Technical Release (TR) 20 – Project Formulation-Hydrology or NRCS SITES – Water Resources Site Analysis, may be used for inflow hydrograph development. This software can be downloaded from *http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models.html*.

If the T_c for the entire drainage area is greater than 24 hours, storm durations longer than the T_c should be tested to determine the duration that gives the maximum reservoir stage for the routed stability design (auxiliary spillway) and freeboard hydrographs.

Precipitation amounts may exhibit marked variation in a large watershed. This variation is based upon topographical and meteorological parameters such as aspect, orientation, mean elevation of sub-basin, and storm orientation. Consideration shall be given to having the NWS make a special PMP study for large watersheds with drainage areas more than 100 square miles. Individual watershed PMP studies can take into account orographic features that are smoothed in the generalized precipitation studies. A special study also may be warranted in areas where significant snowmelt can occur during the design storms.

Studies to make use of available stream flow records are encouraged for purposes such as unit hydrograph development, watershed storage and timing effects, and calibration of watershed models.

Table 2-3 Principal spillway volume adjustments

(a)

Area (m^2)	–Area/point ratio– 1 day	10 days	Area (m^2)	–Area/point ratio– 1 day	10 days
10	1.000	1.000	45	0.951	0.976
15	0.977	0.991	50	0.948	0.974
20	0.969	0.987	60	0.944	0.972
25	0.965	0.983	70	0.940	0.970
30	0.961	0.981	80	0.937	0.969
35	0.957	0.979	90	0.935	0.977
40	0.954	0.977	100	0.932	0.966

* If area is greater than 100 square miles, request PMP from Conservation Engineering Division (CED).

(b)

Runoff curve numbers					
1 day	10 days	1 day	10 days	1 day	10 days
100	100	80	65	60	41
99	98	79	64	59	40
98	96	78	62	58	39
97	94	77	61	57	38
96	92	76	60	56	37
95	90	75	58	55	36
94	88	74	57	54	35
93	86	73	56	53	34
92	84	72	54	52	33
91	82	71	53	51	33
90	81	70	52	50	32
89	79	69	51	49	31
88	77	68	50	48	30
87	76	67	49	47	29
86	74	66	47	46	28
85	72	65	46	45	28
84	71	64	45	44	27
83	69	63	44	43	26
82	68	62	43	42	25
81	66	61	42	41	24

* This table is used only if the 100-year frequency 10-day point rainfall is 6 or more inches. If it is less, the 10-day CN is the same as that for the 1-day CN.

Table 2-4 Minimum quick return flow for prinicipal spillway hydrographs

Ci	QRF		Ci	QRF	
	in/d	$ft^3/sec/mi^2$		in/d	$ft^3/sec/mi^2$
1.00	0	0	1.50	0.233	6.28
1.02	0.011	0.30	1.52	0.239	6.42
1.04	0.022	0.60	1.54	0.244	6.56
1.06	0.033	0.90	1.56	0.249	6.70
1.08	0.045	1.20	1.58	0.254	6.83
1.10	0.056	1/50	1.60*	0.259	6.95
1.12	0.067	1.80	1.65	0.270	7.26
1.14	0.078	2.10	1.70	0.280	7.53
1.16	0.089	2.40	1.75	0.290	7.79
1.18	0.100	2.70	1.80	0.299	8.05
1.20	0.112	3.00	1.85	0.309	8.30
1.22	0.122	3.29	1.90	0.318	8.54
1.24	0.133	3.58	1.95	0.326	8.77
1.26	0.144	3.86	2.00	0.335	9.00
1.28	0.153	4.12	2.05	0.343	9.22
1.30	0.163	4.37	2.10*	0.351	9.44
1.32	0.171	4.61	2.20	0.367	9.86
1.34	0.180	4.83	2.30	0.382	10.26
1.36	0.188	5.05	2.40	0.396	10.65*
1.38	0.195	5.25	2.50	0.410	11.02
1.40	0.202	5.44	2.60	0.423	11.38
1.42	0.209	5.63	2.70	0.436	11.73
1.44	0.216	5.80	2.80	0.449	12.07
1.46	0.222	5.97	2.90	0.461	12.41
1.48	0.228	6.13	3.00**	0.473	12.73

* Change in tabulation interval

** For Ci greater than 3, use:

$QRF\ (ft^3/sec/mi^2) = 9(Ci-1)^{0.5}$

or

$QRF\ (in/d) = 0.03719\ [QRF\ (ft^3/sec/mi^2)]$

where:

QRF = quick return flow
Ci = climatic index
in/d = inches per day

Table 2-5 Minimum auxiliary spillway hydrologic criteria

Class of Dam	Product of storage X effective height	Existing or planned upstream dams	Precipitation data for [1]	
			Auxiliary spillway hydrograph	Freeboard hydrograph
Low [2]	less than 30,000	none	P_{100}	$P_{100} + 0.12(PMP - P_{100})$
	greater than 30,000		$P_{100} + 0.06(PMP - P_{100})$	$P_{100} + 0.26(PMP - P_{100})$
	all	any [3]	$P_{100} + 0.12(PMP - P_{100})$	$P_{100} + 0.40(PMP - P_{100})$
Significant	all	none or any	$P_{100} + 0.12(PMP - P_{100})$	$P_{100} + 0.40(PMP - P_{100})$
High	all	none or any	$P_{100} + 0.26(PMP - P_{100})$	PMP

[1] P_{100} = Precipitation for 100-year return period. PMP = Probable maximum precipitation
[2] Dams involving industrial or municipal water are to use minimum criteria equivalent to that of Significant Hazard Class.
[3] Applies when the upstream dam is located so that its failure could endanger the lower dam

Figure 2-1 Principal spillway runoff volumes in north-central and southeastern states

(a) 100-year, 10-day runoff (inches), principal spillway hydrograph

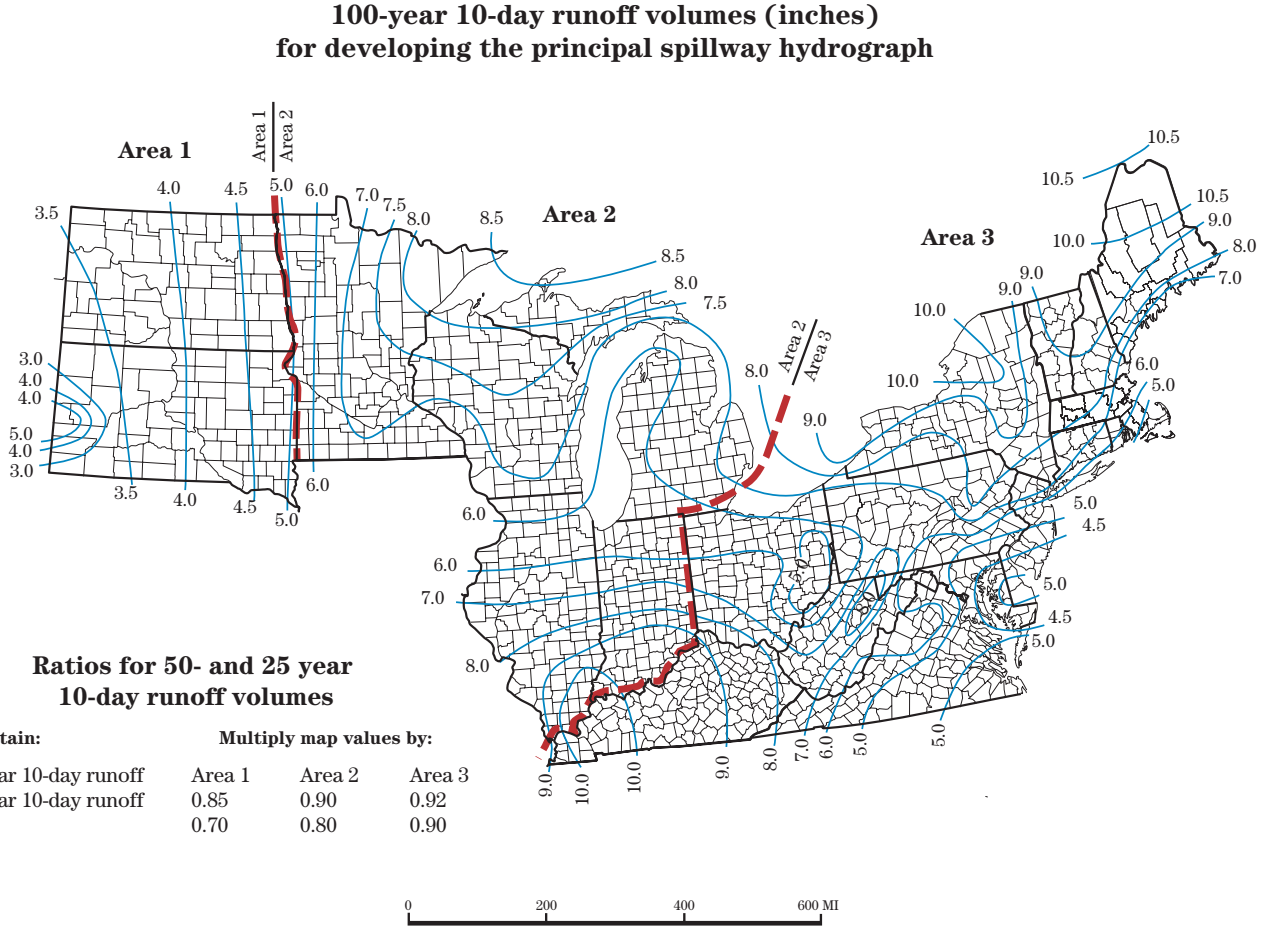


Figure 2-1 Principal spillway runoff volumes in north-central and southeastern states–continued

(b) Ratios of volumes of runoff (A1/Q10), principal spillway hydrograph

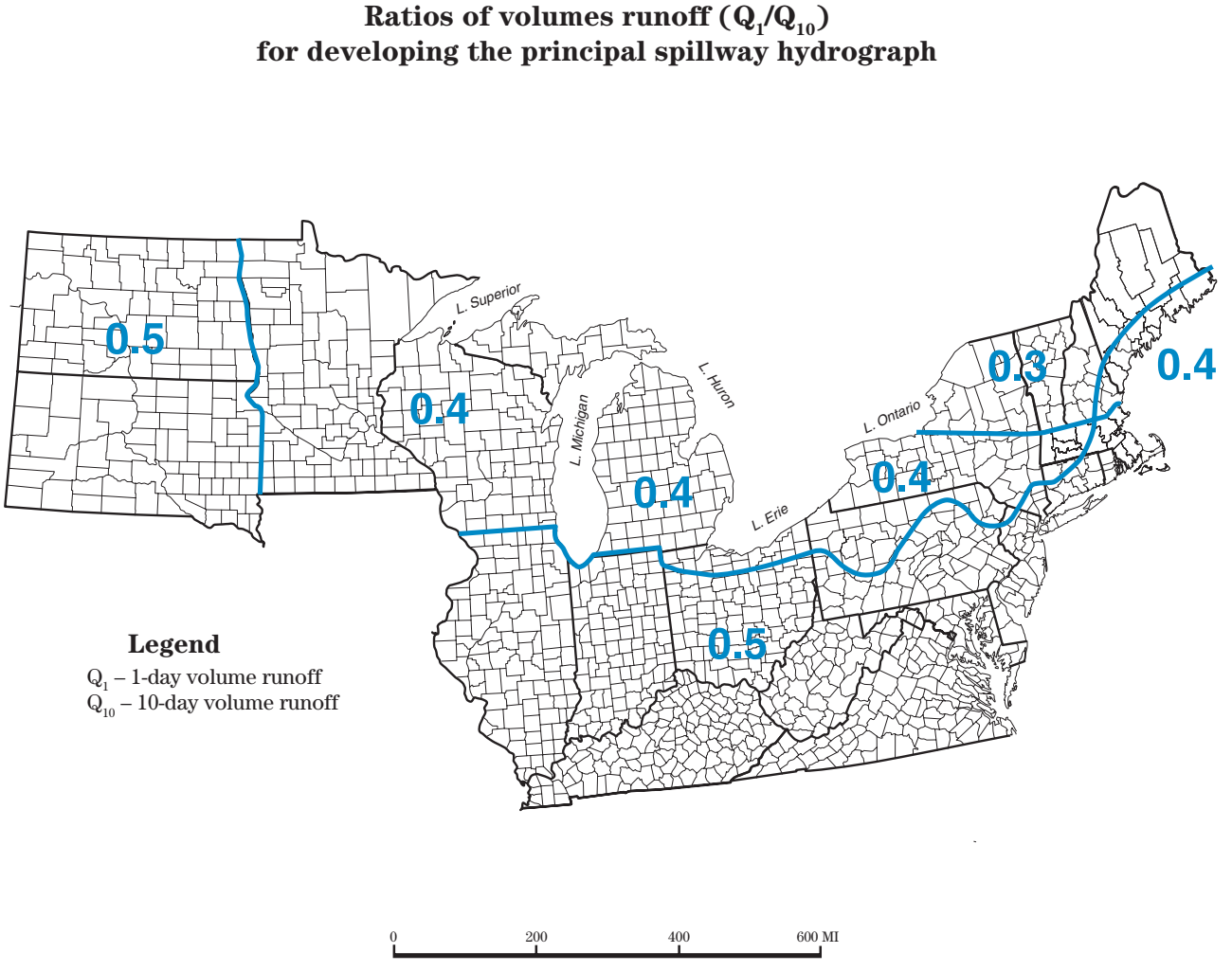


Figure 2-1 Principal spillway runoff volumes in north-central and southeastern states–continued

(c) Quick return flow

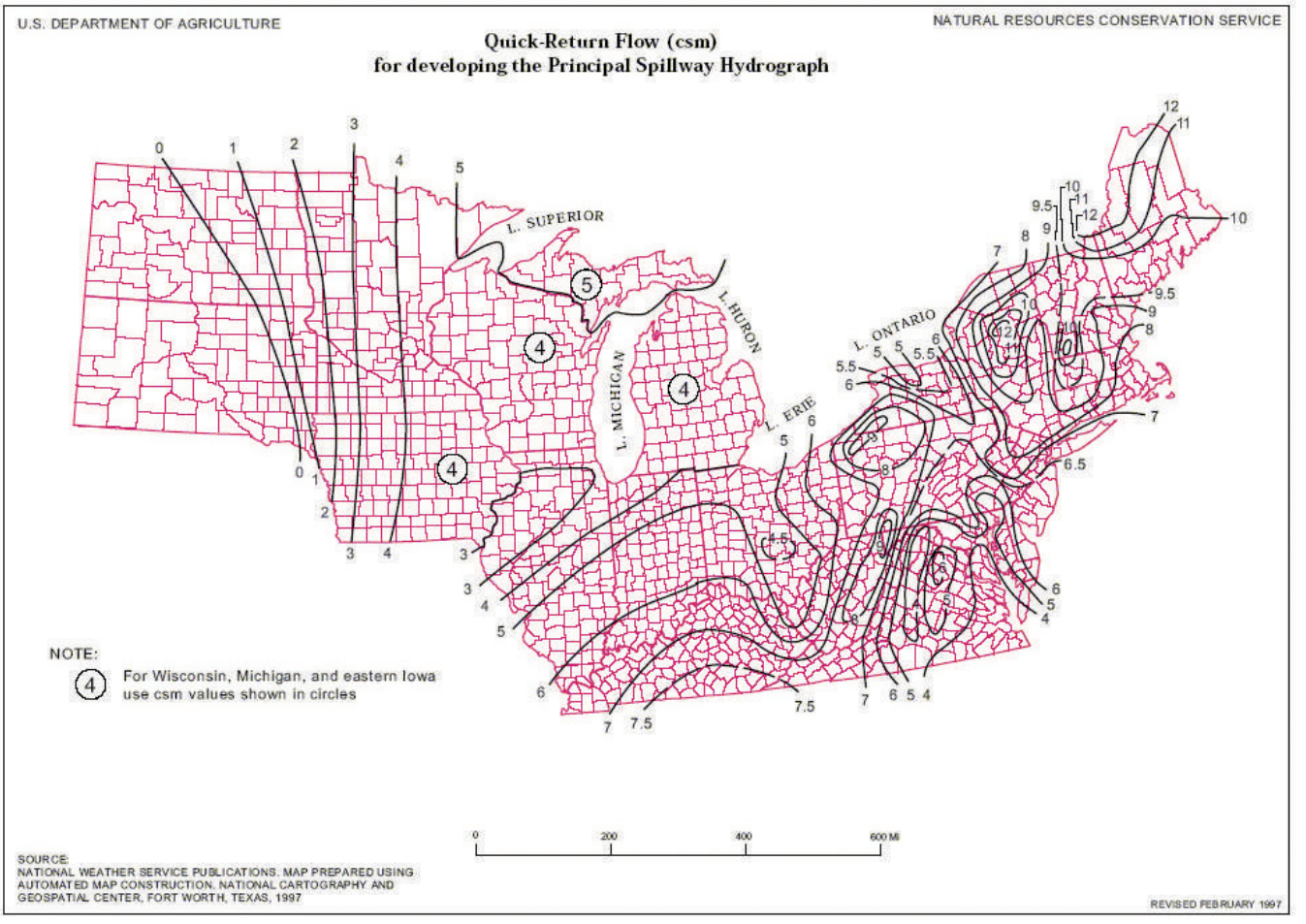


Figure 2-2 Principal spillway runoff volumes in snowmelt producing flood areas

(a) 100-year, 10-day runoff (inches)

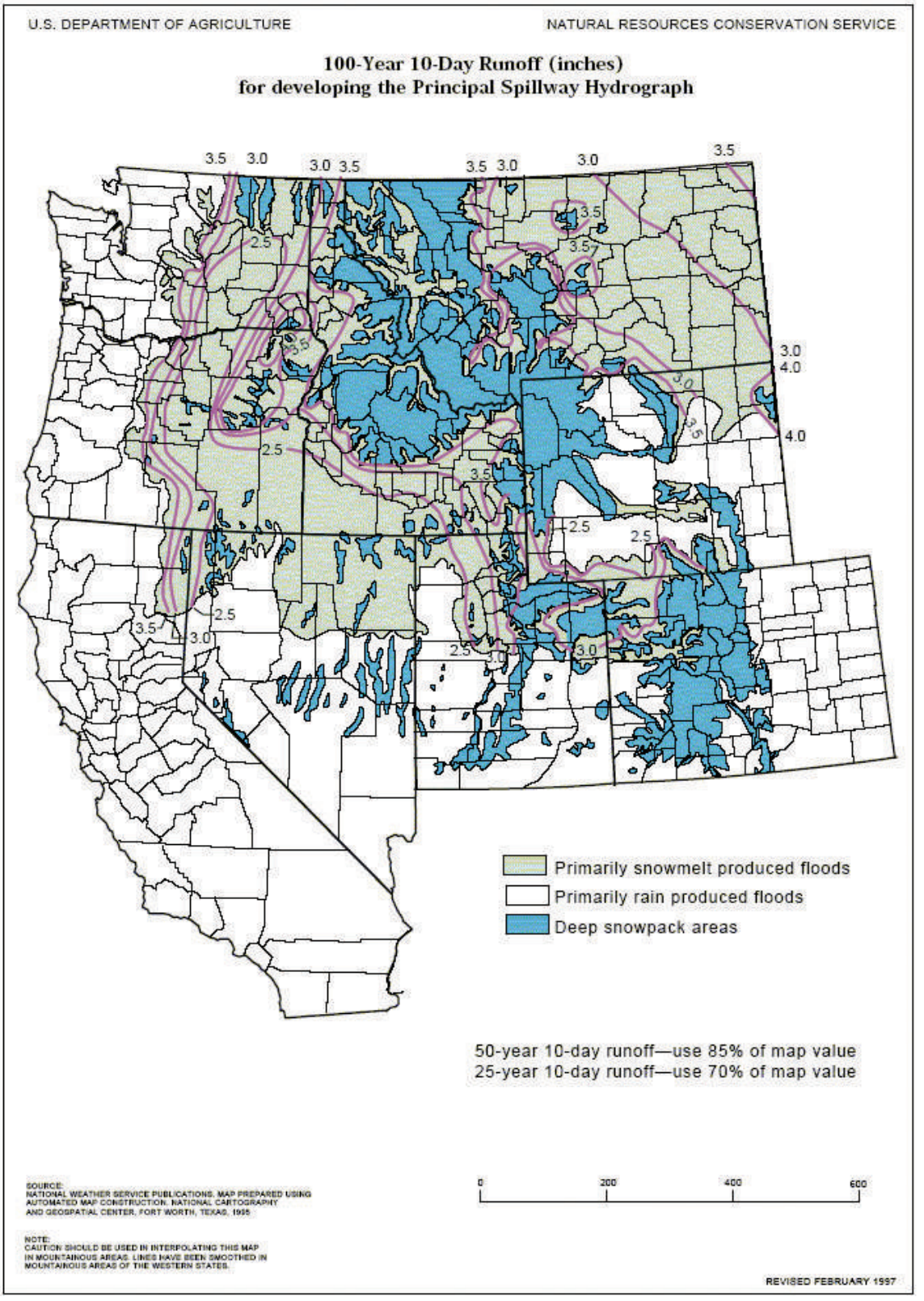


Figure 2-2 Principal spillway runoff volumes in snowmelt producing flood areas—continued

(b) Ratios of volumes of runoff (Q_1/Q_{10})

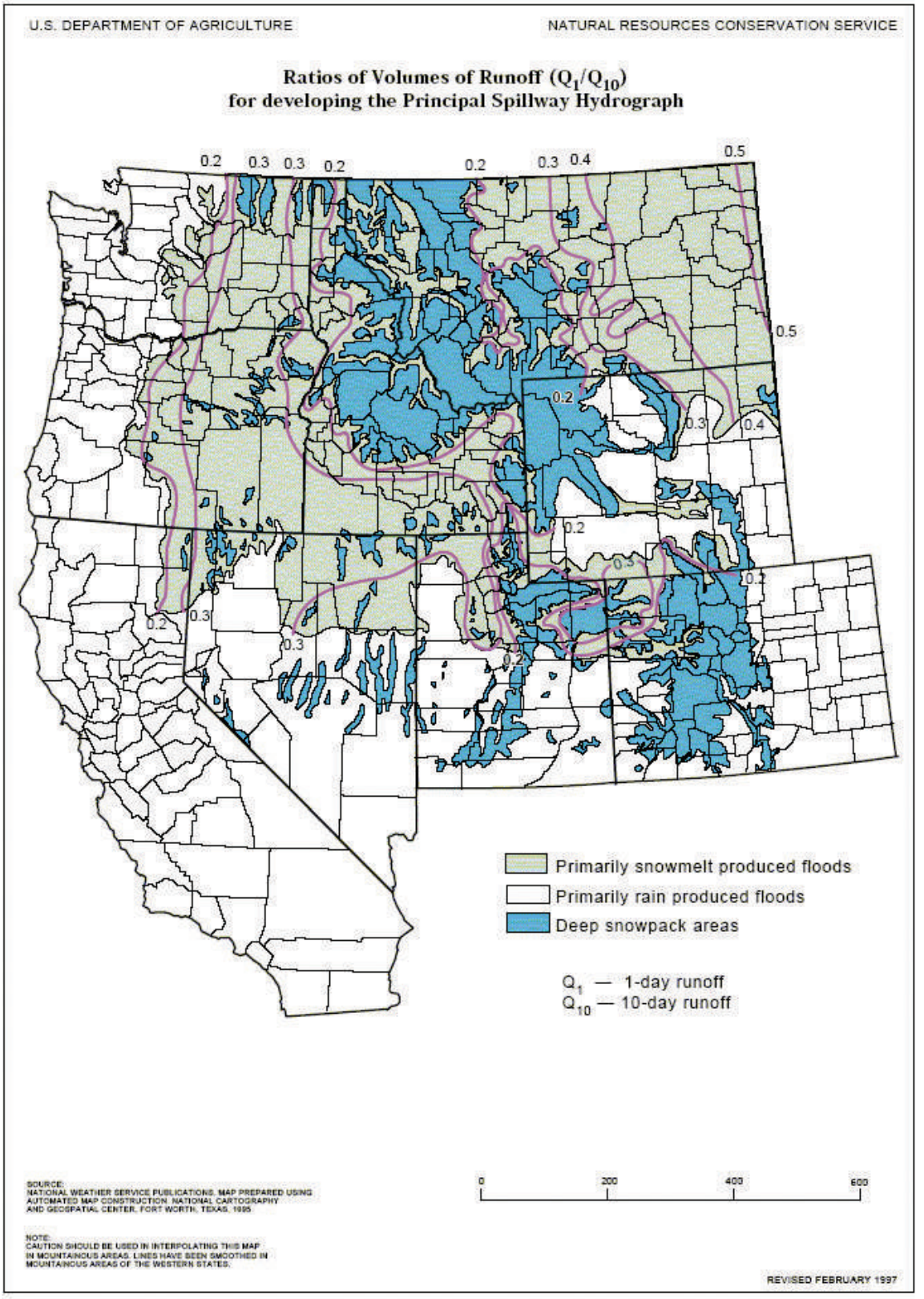


Figure 2-3 Areal adjustment, auxiliary spillway and freeboard

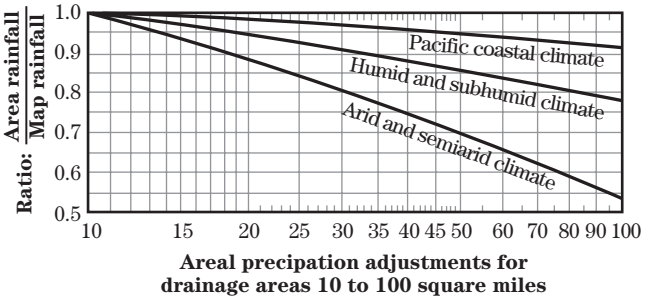
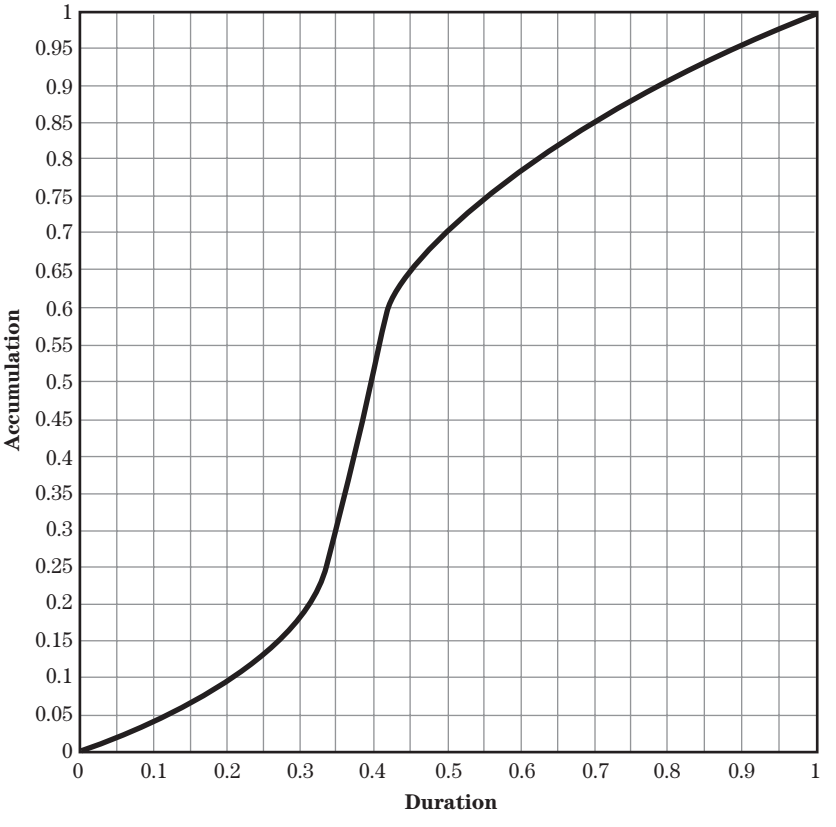


Figure 2-4 Dimensionless design storm distribution, auxiliary spillway and freeboard



Sedimentation

Reservoirs used to store or retard water from surface runoff will trap and store a large portion of the sediment in the runoff water. Therefore, allocate storage capacity for the calculated sediment accumulation during the design life of the reservoir. Criteria and general procedures needed to determine the volume required for sediment accumulation and its allocation in the reservoir are contained in NEH-3, Sedimentation. The latter also includes procedures for determining:

- sediment yield for present conditions and for the future after planned land treatment and other measures are applied in the drainage area of the dam;
- trap efficiency of the reservoir;
- distribution and types of sediment expected to accumulate;
- proportion of the sediment that will be continuously submerged vs. that aerated; and
- densities to which the sediment will become compacted.

If the amount of sediment accumulation calculated exceeds two watershed inches in 50 years for the uncontrolled drainage area of the dam, reevaluate the entire watershed to determine if more economical methods of reducing sediment yield or trapping sediment may be feasible and applicable.

Geologic investigations

The intensity and detail of geologic site investigations shall be consistent with the class of dam, complexity of site geology, and the data needed for design. General requirements, procedures, and criteria are set forth in the NEM-531 and NEH-8.

Following are the geologic conditions that require special consideration beyond the minimum investigations spelled out in the above reference.

Seismic assessment

Dams in zones 3 and 4, Alaska, Puerto Rico, and the Virgin Islands, and High Hazard Class dams in zone 2 (fig. 4-1) require special investigations to determine liquefaction potential of noncohesive strata, including very thin layers, and the presence at the site of any faults active in Holocene time. As part of this investigation, a map must be prepared showing the location and intensity of magnitude of all intensity V or magnitude 4 or greater earthquakes of record, and any historically active faults, within a 100-kilometer (62-mile) radius of the site. (Obtain earthquake information for this map from NOAA at *www.ngdc.noaa.gov/seg/hazard/int_srch.shtml* and USGS at *wwwneic.cr.usgs.gov/*.) The report should also summarize other possible earthquake hazards such as ground compaction, landslides, excessive shaking of unconsolidated soils, seiches, and in coastal areas, tsunamis.

Subsidence

Investigate the potential for surface subsidence due to past or future solid, liquid (including ground water) or gaseous mineral extraction. NEM-531, subpart B sets forth criteria for these evaluations.

Evaluate the impact of the preemption of mineral deposits, including sand and gravel, by dams and reservoirs.

In arid and semiarid areas and in eolian deposits, determine the potential of moisture deficient soil materials to collapse upon saturation or wetting. If the potential exists, make extensive and intensive site investigations to provide quantitative information for design and construction.

Auxiliary spillways

Large dams with auxiliary spillways in soft rock or cemented soil materials that cannot be classified as soil as defined in NEH-628, chapter 52 or as rock, as generally defined for engineering purposes, and spillways in rocks with extraordinary defects require a special individual evaluation.

Mass movements

Evaluate landslides and landslide potential at dam and reservoir sites, especially those in shales and where unfavorable dip-slope or other adverse rock attitudes occur. Summarize the history of mass movement in the project area. Auxiliary spillway cuts and reservoir effects must be given careful consideration.

Karstic areas

Limestone and gypsum in reservoirs and at dam sites require special investigational methods and careful evaluation of subsidence, leakage hazards, and construction costs. Multipurpose structures in these areas are especially critical.

Multipurpose dams

Investigate the ground water regime and hydraulic characteristics of the entire reservoir area of water storage dams and evaluate for leakage. Use the water budgets to determine the need for reservoir sealing.

Other

Special studies and evaluations may be necessary where compaction shales; some types of siliceous, calcareous or pyritic shales; rebound joints; dispersed soils; or artesian waters occur at a site.

Figure 4-1 Seismic zone map

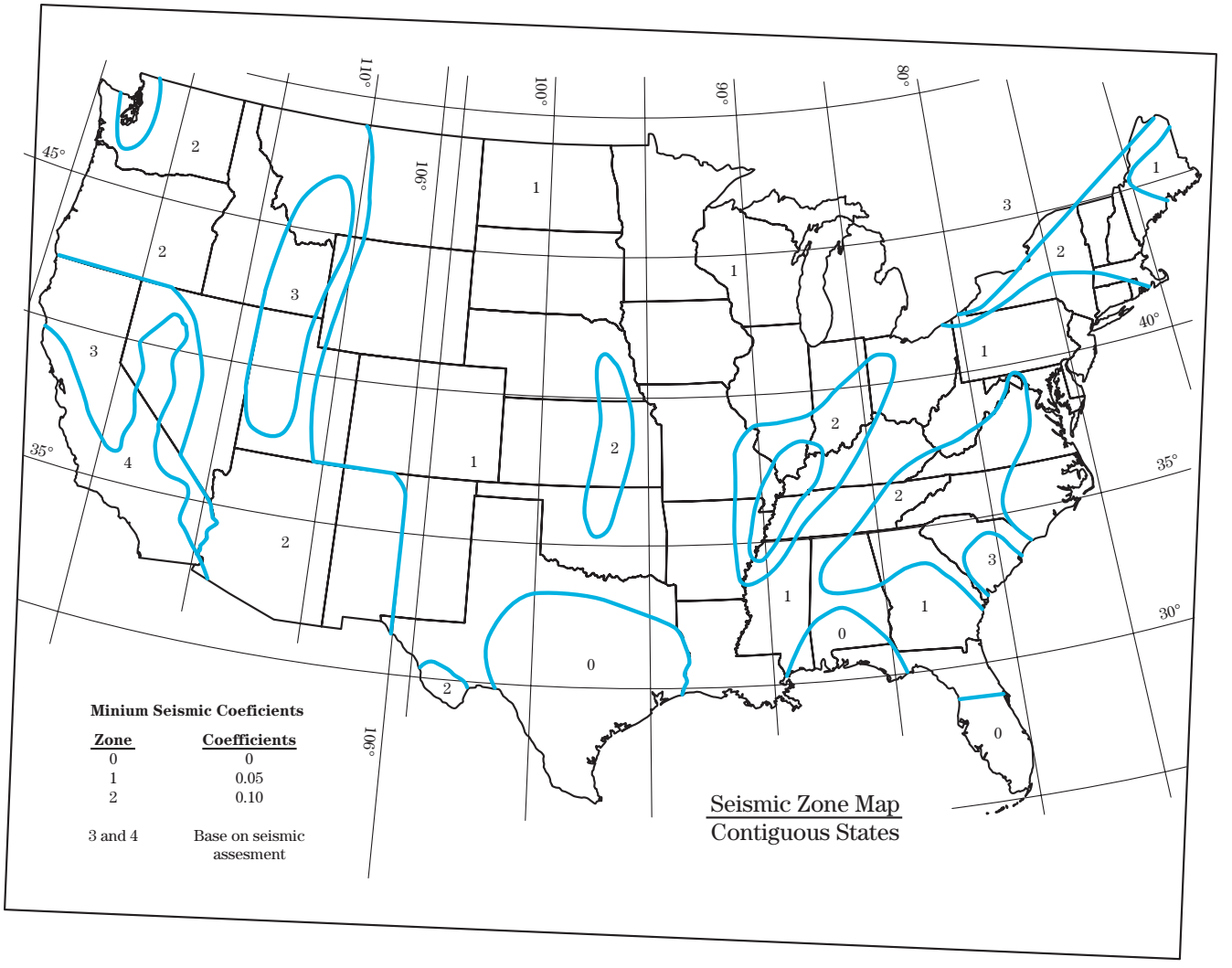
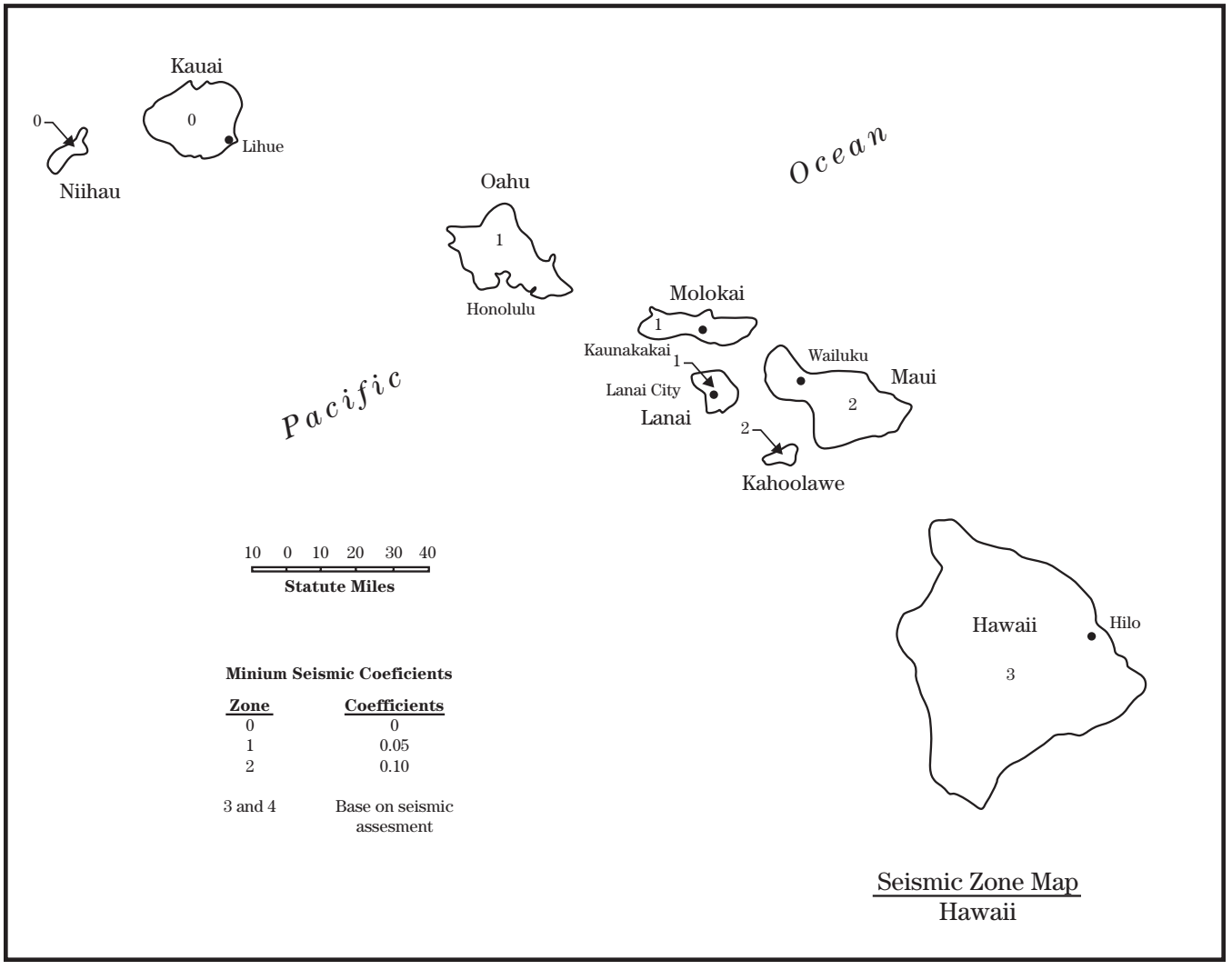


Figure 4-1 Seismic zone map—continued



Earth embankments and foundations

Earth embankments constructed of soil and rock are the principal means of impounding water. The earth embankment and its foundation must withstand the anticipated loads without movements leading to failure. Measures must be provided for adequate seepage control.

Height

The design height of an earth embankment must be sufficient to prevent overtopping during passage of either the freeboard hydrograph or stability design hydrograph plus the freeboard required for frost conditions or wave action, whichever is larger. The design height must also meet the requirements for minimum auxiliary spillway depth. The design height of the dam must be increased by the amount needed to compensate for settlement.

Top width

The minimum top width of embankment is shown in table 5-1.

The width may need to be greater than the above minimums to:

- meet state and local standards;
- accommodate embankment zoning;
- provide roadway access and traffic safety; and
- provide structural stability.

An increase in top width is a major design feature in preventing breaching after embankment slumping caused by earthquake ground motion.

When the embankment top is used as a public roadway, the minimum width shall be 16 feet for one-way and 26 feet for two-way traffic. Guardrails or other safety measures shall be used and must meet the requirements of the responsible road authority.

Embankment slope stability

Analyze the stability of embankment slopes using generally accepted methods based on sound engineering principles. Document all analyses including assumptions regarding shear strength parameters for each zone of the embankment and each soil type or horizon in the foundation. Documentation should include methods used for analyses and a summary of results. Design features necessary to provide required safety factors should be noted.

Table 5-1 Minimum top width of embankment

Total height of embankment, H, (ft)	Top Width (ft)		
	All dams	Single purpose floodwater retarding	Multipurpose or other purposes
14 or less	8	N/A	N/A
15–19	10	N/A	N/A
20–24	12	N/A	N/A
25–34	14	N/A	N/A
35–95	N/A	14	(H+35)/5
Over 95	N/A	16	26

Use the appropriate degree of conservatism in the analysis that is consistent with the adequacy of the site investigation and the soil-testing program. Consider the complexity of the site and consequences of failure in determining the level of detail in the analyses. Minimum required safety factors are summarized in table 5-2 for each condition analyzed.

Evaluate the effect of seismicity on each site. Determine whether the site is in a seismically active area, its proximity to active faults, and the predicted ground motion intensity at the site. If the site is located in zone 3 or 4 shown in figure 4-1, perform special seismic studies. Otherwise, use the horizontal acceleration factors shown in figure 4-1 in a pseudo-static stability calculation using conditions summarized in table 5-2.

Analyze embankment stability for each of the following conditions in the design life of the structure that are appropriate to the site. If a condition is not analyzed, clearly document the reasons. Document any correlated shear strength parameters, including correlations to field performance, used to justify a lack of detailed analyses of a particular condition.

End of construction

This case should be analyzed when either embankment or foundation soils (or both) are predicted to develop significant pore pressures during embankment construction. Factors determining the likelihood of this occurring include the height of the planned embankment, the speed of construction, the saturated consistency of foundation soils, and others. Perform appropriate shear tests to model placement conditions of embankment soils, as summarized in table 5-2. Consider the highest likely placement water content of embankment soils in the shear-testing program. Either field vane shear tests or laboratory tests should determine the unconsolidated/undrained strength of slowly permeable foundation soils. The undrained strength of foundation clays should be corrected for plasticity index when field vane shear tests are used for measurement.

Rapid drawdown

Analyze the stability of the upstream embankment slope for the condition created by a rapid drawdown of the water level in the reservoir from the reservoir level from which a phreatic line is likely to develop. Ordinarily, assume a phreatic line has developed from the normal full reservoir elevation. Then, assume the water in the reservoir is rapidly lowered to the elevation of the lowest gated or ungated outlet and analyze the stability of the embankment following this drawdown. For rare situations, the upstream drawdown condition should be analyzed assuming that soils are saturated from temporary pool storage to the elevation of the auxiliary spillway. This condition should be analyzed if it is possible that in the future the riser could become plugged or other circumstances could cause the temporary impoundment to this higher elevation. For this condition, assume a zone of saturated soils in the embankment occurs based on transient flow nets that determine the portion of the embankment likely to become saturated during the temporary storage. Transient flow nets may be used to examine the temporary saturation of the portion of the embankment above permanent normal pool. Select shear parameters for the analyses according to table 5-2, as illustrated in figure 5-1.

Use infinite slope equations and appropriate safety factors in analyzing the stability of zones in the exterior slope of the embankment with soils having zero effective cohesion parameters, when the critical failure is wholly within soils of this character. If cohesionless zones occur with other soil types in a cross section being analyzed, circular arc or wedge-shaped surfaces should also be explored that intersect the soil zones with cohesion to locate the minimum safety factor. Note that different safety factors are considered adequate for infinite slope analyses than for failure surfaces that are deeper within the profile. See table 5-2 for details.

Figure 5-1 Mohr-Coulomb Envelope for upstream drawdown

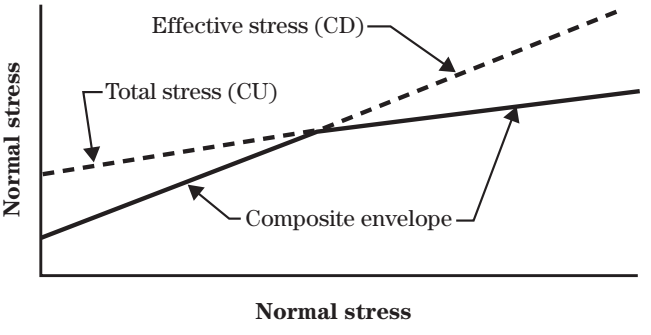


Table 5-2 Slope stability criteria

Design condition	Primary assumption	Remarks	Shear strength to be used	Minimum safety factor
1. End of construction (upstream or downstream slope)	Zones of the embankment or layers of the foundation are expected to develop significant pore pressures during construction	Embankment soils that are slowly permeable should be tested at water contents that are as wet as likely during construction (usually wet of optimum) Saturated slowly permeable foundation soils that are not predicted to fully consolidate during construction Permeable embankment zones and/or foundation strata	UU – includes triaxial UU tests, unconfined compression (qu) tests, and field vane shear tests CU' or CD	1.4 for failure surfaces extending into foundation layers 1.3 for embankments on stronger foundations where the failure surface is located entirely in the embankment
2. Rapid drawdown (upstream slope)	Drawdown from the highest normal pool to the lowest ungated outlet	Consider failure surfaces both within the embankment and extending into the foundation	Lowest shear strength from a composite envelope of CU and CD envelopes (fig. 5-1)	1.2 1.1 for infinite slope analysis
3. Steady seepage without seismic forces (downstream slope)	Phreatic line developed from pool at the principal spillway crest Uplift pressure simulated by phreatic line developed from auxiliary spillway crest applied to saturated embankment and foundation soils	Consider failure surfaces both within the embankment and extending into the foundation	Lowest shear strength from a composite envelope of CU and (CU+CD)/2 envelopes (fig. 5-2)	1.5 1.1 for infinite slope analysis
4. Steady seepage with seismic forces (downstream slope)	Phreatic line developed from principal spillway crest with no uplift	Consider failure surfaces both within the embankment and extending into the foundation	Lowest shear strength from a composite envelope of CU and (CU+CD)/2 envelopes (fig. 5-2)	1.1

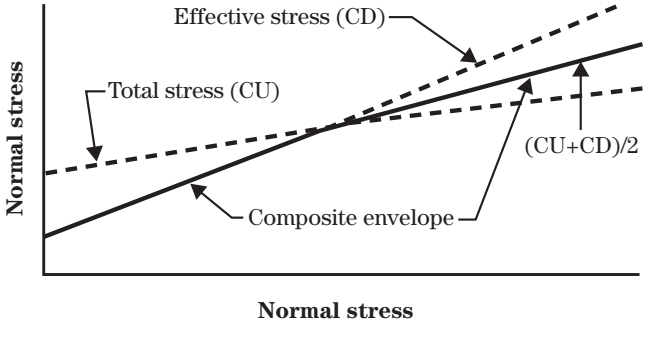
Steady seepage without seismic forces
Using shear parameters, as specified in table 5-2 and illustrated in figure 5-2, analyze the downstream slope considering a phreatic line developed from the reservoir at the principal spillway crest. Subject saturated soils below the phreatic line to an uplift force simulated by a phreatic surface developed from the auxiliary spillway crest. Phreatic surfaces for the analyses may be developed using flow nets or Casagrande procedures.

Use infinite slope equations and appropriate safety factors as under Rapid Drawdown condition.

Steady seepage with seismic forces
Using shear parameters, as specified in table 5-2, analyze the downstream slope considering a phreatic line developed from a pool at the principal spillway crest. Apply a horizontal acceleration constant appropriate to the seismic zone in which the site is located, as specified in figure 4-1. Do not use uplift forces due to a reservoir stage at the auxiliary spillway because the likelihood of a simultaneous occurrence of an earthquake and an auxiliary spillway flow event is extremely remote.

Use infinite slope equations and appropriate safety factors in analyzing the stability of zones in the exterior slope of the embankment with soils having zero effective cohesion parameters. The equations should incorporate the horizontal acceleration constant specified in figure 4-1.

Figure 5-2 Mohr-Coulomb Envelope for downstream steady seepage



Consider following additional guidance in analyzing slope stability.

- Only effective stress (CD) parameters are appropriate for soils that will consolidate as rapidly as load is applied. These parameters are applicable for all conditions of stability analyzed for these soil types.
- The end of construction condition is usually the one that controls the design of embankments when it is applicable. Special designs including staged construction or monitoring pore pressures during construction may be required to achieve objectives for some site conditions such as soft clay foundation soil horizons.
- Total stress parameters used in the construction of composite shear strength envelopes should not consider large negative pore pressures that may develop during shear testing. Either maximum deviator stress or maximum principal effective stress ratio failure criteria should usually be used to define total stress parameters. Total stress parameters interpreted from maximum arbitrary strain criteria should be used only when other criteria are less limiting.
- Infinite slope equations should model the predicted seepage pattern in the slope being analyzed. The three equations used are for no seepage, for horizontal seepage paths, and for seepage paths parallel to the slope face.
- Residual effective stress parameters should be used for modeling slope stability analyses involving fissured clays or shales if pre-existing movements have occurred. These parameters are based on drained shear strength tests where stresses are determined at high strain values beyond the peak strength. Residual parameters may also be considered for designing against shallow slope failures in desiccated clay embankments.

Seepage

To the extent needed, an analysis shall be made of anticipated seepage rates and pressures through the embankment, foundation, abutments, and reservoir perimeter (when storage is desired). Controls and treatment should be adequate to:

- accomplish the intended reservoir function;
- provide a safely operating structure; and
- prevent damage to downstream property.

Zoning

Embankment zoning can be used when needed to:

- obtain a stable structure with the most economical use of available materials;
- control seepage in a safe manner; or
- reduce to a minimum the uncertainties of material strengths and resultant stability.

Embankment zones should be a minimum of 10 feet wide except for filters and drains with specified and controlled gradation. Drains and filters should meet the requirements contained in Soil Mechanics Notes.

Soil materials which exhibit significant shrinkage, swell or dispersion should be used only with extreme care. If possible, they should not be used for embankment construction. When there is no economical alternative to their use, they must be:

- treated to improve their performance;
- placed in zones where effects will not be detrimental; or
- protected by use of filters and drains or self-healing transition zones.

Surface protection

Embankment surfaces must be protected against surface erosion. Protection may be vegetative, gravel, rock riprap, soil cement, structural, or similar treatment of durable quality and proven satisfactory performance.

Vegetative protection

Vegetative protection may be used on surfaces where the following conditions can be met:

- inundation of the surfaces is of such frequency that vegetative growth will not be inhibited;
- vigorous growth can be sustained under average climatic conditions by normal maintenance without irrigation; and
- stable protection can be designed according to the procedures in TR-56.

Structural protection

Protection against wave erosion by riprap or other structural measures shall be provided for:

- dams where vegetation will not provide effective control;
- multiple purpose dams; and
- dams with fluctuating normal water levels.

Protection must extend from the lowest drawdown elevation that presents an erosion hazard, to a few feet above the crest of the lowest ungated spillway. The upper limit shall be based on an analysis of anticipated wave height and run up.

Quality of riprap and other structural protection must be consistent with the anticipated life of the dam and designed to be structurally stable.

Principal spillways

The structural design and detailing of principal spillways must conform to the recommendations of NEH-6, Structural Design, and NRCS standard drawings. All component parts of principal spillways except easily replaceable parts such as gates and trash racks shall be equally durable.

Capacity of principal spillway

The required capacity of the principal spillway depends on the:

- purpose of the dam;
- amount of storage provided by the retarding pool;
- kind of auxiliary spillway;
- stream channel capacity and stability downstream;
- potential damage from prolonged storage in the retarding pool;
- potential damage downstream from prolonged high outflow rates;
- possibility of substantial runoff from two or more storms in the time required to empty the retarding pool;
- limitations imposed by water rights or other legal requirements;
- environmental concerns;
- planned or potential alterations of the channel downstream; and
- necessity to pass base and flood flows during construction.

The principal spillway may be single-stage, having an ungated inlet at only one elevation, or multiple-stage, having inlets at two or more elevations. In the case of multiple-stage spillways, the lower stage or stages usually perform the primary flood control function, and the high stage has the capacity needed to prevent the auxiliary spillway from functioning more frequently than permissible.

The principal spillway capacity should be adequate to empty the retarding pool in 10 days or less. This requirement is considered met if 15 percent or less of the maximum volume of retarding storage remains after 10 days. Where low release rates are required to meet the objectives of the project, a longer period than 10 days may be needed. For these situations, additional storage is required to minimize the opportunity for increased frequency of auxiliary spillway flow due to recurring storms.

Compute the 10-day drawdown from the time the maximum water surface elevation is attained during the passage of the principal spillway hydrograph. The entire design inflow hydrograph including quick return flow, upstream releases, and outflow must be considered in determining the evacuation time of the retarding storage. The inflow from storm runoff must be considered for the entire evacuation time.

For dams where more than 15 percent of the retarding storage volume remains after 10 days, the elevation of the crest of the auxiliary spillway must raised. The raised crest elevation is determined by adding the remaining retarding storage volume to the initial retarding storage volume.

Elevation of principal spillways

Single-purpose floodwater retarding dams
The crest of the principal spillway or of the low stage inlet of a two-stage principal spillway shall be set at the submerged sediment pool elevation. For dry dams, the elevation of the principal spillway inlet shall be placed as described above and provisions made to drain the reservoir in a reasonable time and, thus, satisfy the functional or legal requirements of the dam.

Other dams
When conservation storage will be provided, the elevation of the crest of the lowest ungated inlet of the principal spillway is determined by the volume, area, or depth of water required for the planned purpose or purposes and the required sediment storage. The lowest crest may be the crest of the low-stage inlet, single-stage inlet, or an open spillway.

Routing of principal spillway hydrographs

Reservoir flood routing used to proportion dams and associated spillways shall be based on the assumption that all sedimentation expected in the reservoir during its design life has occurred. The reservoir stage-storage curve used for routing should reflect the anticipated accumulation of sediment. The initial reservoir stage for principal spillway hydrograph routing shall be at the crest of the lowest ungated inlet or (if not subtracted from the stage-storage curve) the anticipat-

ed elevation of the sediment storage, whichever is higher, except as provided below.

- For dams with significant base flow, principal spillway hydrograph routings must start not lower than the elevation of the water surface associated with the base flow. Significant base flow is average annual or seasonal flow that would produce at least 0.5 feet of head over the lowest principal spillway inlet immediately prior to a flood or occupy more than 10 percent of the floodwater storage capacity.
- For dams with joint use storage capacity, when one of the uses is floodwater detention, routing of the principal spillway hydrograph may begin at the lowest anticipated elevation of the joint use pool in accordance with the operation plan.
- Single purpose, low hazard class irrigation dams with gated outlets and earth or vegetated auxiliary spillways, which are located on ephemeral streams in areas where the average annual precipitation is less than 25 inches, may be considered to have discharged up to 70 percent of the storage, exclusive of sediment storage in determining the elevation to start routing.

Design of principal spillways

Hydraulics

The principal spillway must be designed to carry the planned flow for expected head and tailwater conditions. TR-29, Design Note No. 8, NEH-5, the Engineering Field Handbook for Conservation Practices and other appropriate references shall be used for hydraulic design.

Risers

Risers for drop inlet spillways must be designed to maintain the reservoir pool level at or near the inlet crest elevation during low flow periods, to establish full pipe flow at as low a head over the crest as practical, and to operate without excessive surging, noise, vibration, or vortex action at any reservoir stage. This requires the riser to have a larger cross-sectional area than the conduit. Standard risers have an inside width equal to the width (diameter) D, of the conduit and an inside length equal to three times the width (diameter) of the conduit (D x 3D cross section).

Risers shall be designed to exclude trash too large to pass freely through the spillways, including the outlet structure, and to facilitate the passage of smaller trash. Standard D x 3D risers tend to line up longer pieces of trash and facilitate their passage into and through the conduit. Covered risers with standard skirted or baffle inlets should be used in most cases because they are most effective in excluding trash without becoming clogged. Skirted inlets, having a cover with skirts extending below the weir crest elevation, are applicable where backfill or settlement levels will be at least two times the conduit width (diameter) below the crest. Baffle inlets are applicable for risers that will be backfilled to the crest elevation or where sediment is expected to build up to the crest elevation.

Risers shall be designed structurally to withstand all water, earth, ice, and earthquake loads to which they may be subjected. Articulation must be provided to allow movement of the riser with respect to the conduit.

Risers with low-stage inlets at or near the bottom must be provided with concrete aprons to prevent erosion of soil and undermining of the riser footing by high velocity flow approaching the inlet.

Standard risers must be used where applicable for low hazard class dams with an effective height of more than 35 feet and for all significant and high hazard class dams. Prefabricated pipe risers are permissible, where hydraulically and structurally adequate, for low hazard class dams not more than 35 feet in effective height. The riser pipe must be of the same material as the conduit and at least one standard pipe size larger than the conduit pipe.

Special riser designs are required for spillways having maximum conduit velocities more then 30 feet per second and for spillways having conduits larger then 48 inches in width (diameter). Generally, these should be similar to standard risers, but a special elbow and transition is required at the junction of the riser and conduit, and special design of the inlet may be necessary. Hydraulic model testing should be considered if the maximum total head on the spillway is more than 75 feet or the conduit velocity exceeds 50 feet per second.

Conduit

The conduit should be straight in alignment when viewed in plan. Changes from straight alignment, if required, must be accomplished by watertight angle changes at joints or by special elbows having a radius equal to or greater than the diameter or width of the conduit. Thrust blocks of adequate strength must be provided if special pipe elbows are used. They must be designed to distribute the thrust due to change in direction for the maximum possible discharge. Drop inlet

conduits shall be installed with enough slope to ensure free drainage to the outlet of all parts of the conduit (including camber) at the time of construction and under the maximum anticipated settlement.

All conduits under earth embankments must support the external loads with an adequate factor of safety. They must withstand the internal hydraulic pressures without leakage under full external load and settlement. They must convey water at the design velocity without damage to the interior surface of the conduit.

Principal spillway conduits under earth dams may be designed to support fill heights greater than the original constructed height if there is a reasonable possibility that the embankment height may be raised later to incorporate additional storage for some approved beneficial use.

Rigid principal spillway conduits shall be designed as positive projecting conduits in accordance with the principles and procedures given in TR-5.

Principal spillway conduits must be of reinforced concrete pressure pipe or cast-in-place reinforced concrete, unless corrugated steel or welded steel pipe is used.

Cast-in-place rectangular reinforced concrete conduits must be designed in accordance with principles and procedures in TR-42, TR-45 or other appropriate design aids.

For Reinforced Concrete Water Pipe—Steel Cylinder Type, Prestressed, meeting specification AWWA Standard C301, the 3-edge bearing strength at the first 0.001-inch crack shall be used with a safety factor of at least one.

For Reinforced Concrete Water Pipe—Steel Cylinder Type, Not Prestressed, meeting specification AWWA Standard C300; for Reinforced Concrete Water Pipe Noncylinder Type, Not Prestressed, meeting specification AWWA Standard C302, and for other types of reinforced concrete pipe, the 3-edge bearing strength at the first 0.01-inch crack shall be used with a safety factor of at least 1.33.

Elliptical or other systems of reinforcement requiring special orientation of pipe sections are not permitted in spillway conduits.

Reinforced concrete pipe must be designed to support at least 12 feet of earth fill above the pipe at all points along the conduit.

- Reinforced Concrete Pipe
  - Minimum inside diameters on yielding foundations

    Low hazard class dams: The minimum diameter of the principal spillway conduit must be 30 inches, unless a joint extension safety margin of at least 1.5 inches is used, in which case, the minimum diameter shall be 18 inches for maximum fill heights up to 50 feet at the centerline of the dam and 24 inches for greater fill heights.

    Significant hazard class dams: The minimum diameter of the principal spillway conduit must be 30 inches, unless a joint extension safety margin of 1.5 inches is used, in which case, the minimum diameter shall be 24 inches.

    High hazard class dams: The minimum diameter of the principal spillway conduit must be 30 inches.

  - Minimum inside diameters on nonyielding foundations: The minimum diameter of the principal spillway conduit for low hazard class dams must be 18 inches for heights up to 50 feet at the centerline of the dam and 24 inches for heights greater than 50 feet, and 24 inches for all significant and high hazard class dams. The conduit and cradle or bedding must rest directly on firm bedrock thick enough so that there is essentially no foundation consolidation under the conduit. Under these conditions, the cradle or bedding under the conduit need not be articulated.
- Corrugated steel pipe or welded steel pipe

  Principal spillways of corrugated steel or welded steel pipe may be used for single purpose low hazard class dams with the product of storage times effective height of dam less than 10,000. While installation costs of steel pipes may be less, concrete may compare favorably with steel when replacement costs and associated problems are considered.

In each case, the following limitations apply:

- diameter of pipe not less than 18 inches;
- height of fill over the pipe not more than 25 feet;
- provision for replacement if the materials will not last for the design life of the structure;
- pipe structurally strong enough to withstand outside loads and hydraulic pressure; and

- pipe watertight.

Corrugated steel pipe shall be polymer-coated with watertight connecting bands. The minimum gage must be designed for 35 feet of fill over the pipe.

Welded steel pipe conduits must be structurally designed as rigid pipe. A joint extension safety margin of 1.5 inches shall be provided for conduits on yielding foundation. Welded steel pipe must be protected by a Class A exterior coating as defined in Conservation Practice Standard 430-FF, Irrigation Water Conveyance, Pipeline, Steel, or by an exterior coating of coal tar-epoxy paint conforming to Paint System F, Construction Specification 82 (NEH-645).

Joints between lengths of corrugated steel or welded steel pipe, other than welded joints, are to be electrically bridged on the outside of the pipe with insulated copper wire, #6 AWG or larger, securely attached to the uncoated pipe metal at both sides of the joint. This requirement applies whether or not the cathodic protection is completed by the installation of anodes, etc. The wire should have a tough, waterproof insulation designed for direct burial, with a rating of at least 600 volts. Bare wire and exposed pipe metal at the points of connection are to be thoroughly coated with a coating equivalent to the original pipe coating to prevent the entry of moisture.

Soil investigations for resistivity and pH of the subgrade and backfill materials to be adjacent to the conduit shall be made. The resistivity measurements are made on saturated samples.

Cathodic protection must be provided for welded steel pipe conduits according to the criteria in Conservation Practice Standard 432-FF in the National Handbook of Conservation Practices (NHCP).

Cathodic protection meeting the above requirements must be provided for corrugated steel pipe in soil whose resistivity in a saturated condition is less than 4000 ohms-cm or whose pH is lower than 5.0.

If cathodic protection is not required according to the above criteria and anodes are not installed during construction of the dam, pipe-to-soil potentials must be measured within the first 2 years after construction or after the water level has stabilized and when the soil around the conduit is estimated to be at its normal post-construction moisture content. Cathodic protection must be installed at this time if such measurements indicate it is needed.

Joints

Conduit joints shall be designed and constructed to remain watertight under maximum anticipated hydrostatic head and maximum probable joint opening as computed from Standard Drawing ES-146 and related procedures of TR-18, including the effects of joint rotation and the required margin of safety. The required joint extensibility is equal to the unit horizontal strain in the earth adjacent to the conduit multiplied by the length (in inches) of the section of conduit between joints plus the extension (in inches) due to calculated joint rotation plus a margin of safety.

A margin of safety of not less than 0.5 inch shall be used. The required joint extensibility plus the maximum permissible joint gap equals the required joint length. The required joint extensibility depends on the maximum potential foundation consolidation under the spillway barrel. For significant and high hazard class dams, the consolidation must be estimated from adequate foundation borings and samples, soil mechanics laboratory tests, and engineering analysis. For low hazard class dams where undisturbed foundation samples are not taken for other purposes, approximate procedures based on soil classification and experience may be used for estimating foundation consolidation.

Only joints incorporating a round rubber gasket set in a positive groove which will prevent its displacement from either internal or external pressure under the required joint extensibility shall be used on precast concrete pipe conduits. Concrete pipe must have steel joint rings providing rubber to steel contact in the joint.

Articulation of the conduit (freedom for required rotation) shall be provided at each joint in the conduit, at the junction of the conduit with the riser and any outlet structure. Concrete bedding for pipe conduits need not be articulated. Cradles must be articulated if on yielding foundations. Welded steel pipe conduits need not be articulated if the pipe and bedding rest directly on firm bedrock.

Piping and seepage control—Use a filter and drainage diaphragm around any structure that extends through the embankment to the downstream slope. Design the diaphragm with single or multiple zones to meet the requirements of NEH-633, chapter 23.

Locate the diaphragm aligned approximately parallel to the centerline of the dam or approximately perpendicular to the direction of seepage flow. Extend the diaphragm horizontally and vertically into the adjacent

embankment and foundation to intercept potential cracks, poorly compacted soil zones or other discontinuities associated with the structure or its installation.

Design the diaphragms to extend the following minimum distances from the surface of rigid conduits:

- horizontally and vertical upward 3 times the outside diameter of circular conduits or the vertical dimension of rectangular box conduits except that:
  - vertical extension need be no higher than the crest of the auxiliary spillway, or higher than 2 feet below the embankment surface, and
  - horizontal extension need be no further than 5 feet beyond the sides and slopes of any excavation made to install the conduit.
- vertically downward:
  - for conduit settlement ratios (δ) of 0.7 and greater (reference NRCS Technical Release No. 5), the greater of (1) 2 feet or (2) 1 foot beyond the bottom of the trench excavation made to install the conduit. Terminate the diaphragm at the surface of bedrock when it occurs within this distance. Additional control of general seepage through an upper zone of weathered bedrock may be needed.
  - 1.5 times the outside diameter of circular conduits or the outside vertical dimension of box conduits for conduit settlement ratios (δ) less than 0.7.

Design the diaphragms to extend in all directions a minimum of two times the outside diameter from the surface of flexible conduits, except that the diaphragm need not extend beyond the limits in the above or beyond a bedrock surface beneath the conduit.

Provide minimum diaphragm thickness of 3 feet and minimum thickness of 1 foot for any zone of a multizone system. Use larger thickness when needed for capacity, tying into embankment or foundation drainage systems, accommodating construction methods, or other reasons.

For homogeneous dams, locate the diaphragm in the downstream section of the dam such that it is:

- downstream of the cutoff trench;
- downstream of the centerline of the dam when no cutoff trench is used; and
- upstream of a point where the embankment cover (upstream face of the diaphragm to the downstream face of the dam) is at least one-half of the difference in elevation between the top of the diaphragm and the maximum potential reservoir water level.

For zoned embankments, locate the diaphragm downstream of the core zone and/or cutoff trench, maintaining the minimum cover as indicated for homogeneous dams. When the downstream shell is more pervious than the diaphragm material, locate the diaphragm at the downstream face of the core zone.

It is good practice to tie these diaphragms into the other drainage systems in the embankment or foundation. Foundation trench drains and/or embankment chimney drains that meet the minimum size and location limits are sufficient and no separate diaphragm is needed.

Design the minimum capacity of outlets for diaphragms not connected to other drains by assuming the coefficient of permeability (k) in the zone upstream of the diaphragm is 100 times the coefficient of permeability in the compacted embankment material. Assume this zone has a cross-sectional area equal to the diaphragm area and the seepage path distance equal to that from the embankment upstream toe to the diaphragm. This higher permeability simulates a sealed filter face at the diaphragm with partially filled cracks and openings in the upstream zone.

For channels, chutes or other open structures, seepage and piping control can be accomplished in conjunction with drainage for reduction of uplift and water loads. The drain, properly designed to filter the base soils, is to intercept areas of potential cracking caused by shrinkage, differential settlement, or heave and frost action. These structures usually require the use of footings, keywalls and counterforts, and drainage is properly located immediately downstream of these features. This drainage when properly designed can control piping and provide significant economies due to the effect on soil loads, uplift pressures, overturning forces and sliding stability.

Outlets

The choice of outlet is to be based on a careful consideration of all site and flow conditions that may affect operation and energy dissipation.

- Cantilever outlet and plunge pools may be

installed where their use:

- does not create a piping hazard in the foundation of the structure.
- is compatible with other conditions at the site.

Plunge pools shall be designed to dissipate the energy and be stable. Unless the pool is to be in bedrock or very erosion resistant materials, riprap will be necessary to insure stability. Design Note 6, Armored Scour Hole for Cantilever Outlet, shall be used for design.

Cantilever outlets shall be supported on bents or piers and must extend a minimum of 8 feet beyond the bents or piers. The bents must be located downstream from the intersection of the downstream slope of the earth embankment with the grade line of the channel below the dam. They must extend below the lowest elevation anticipated in the plunge pool. The invert of the cantilever outlet must be at least 1 foot about the tailwater elevation at maximum discharge.

- SAF basins may be used when there is adequate control of tailwater. Use TR-54 for structural design and NEH-14 for hydraulic design.
- Impact basins may be used where positive measures are taken to prevent large debris from entering the conduit. TR-49 is to be used for hydraulic design.

Trash racks

Trash racks shall be designed to provide positive protection against clogging of the spillway under any operating level. The average velocity of flow through a clean trash rack must not exceed 2.5 feet per second under the full range of stage and discharge. Velocity must be computed on the basis of the net area of opening through the rack.

If a reservoir outlet with a trash rack or a ported concrete riser is used to keep the sediment pool drained, the trash rack or riser must extend above the anticipated sediment elevation at the riser to provide for full design flow through the outlet during the design life of the dam. The velocity through the net area of the trash rack above the maximum sediment elevation must not exceed 2 feet per second when the water surface in the reservoir is 5 feet above the top of the trash rack or riser inlet.

Antivortex device

All closed conduit spillways designed for pressure flow must have adequate antivortex devices.

High sulfate areas

Under certain conditions, concrete is susceptible to deterioration from sulfate ions, especially those derived from sodium and magnesium sulfates. In areas where experience or soil tests indicate the potential for problems, the following shall be used for design purposes.

Sulfate concentration [1/] (parts per million)	Hazard	Corrective measures
0 – 150	Low	None
150 – 1,000	Moderate	Use Type II Cement. (ASTH C-150). Adjust mix to protect against sulfate action.
1,000 – 2,000	High	Use Type V Cement (ASTM C-150). Adjust mix to protect against sulfate action. Use soils in contact with concrete surfaces that are low in sulfates.
2,000 – UP		Do not use concrete materials unless measures are taken to protect concrete surfaces from sulfates. Product manufacturers should be consulted.

[1/] Sulfate concentration is for soil water at the concrete surface.

Auxiliary spillways

Auxiliary spillways are provided to convey excess water through, over, or around a dam. They are usually open channels excavated in natural earth, earthfill, rock, or constructed of reinforced concrete.

Closed type spillways

An open channel auxiliary spillway must be provided for each dam except as provided below:

- Low hazard class dams with a product of storage times the effective height of the dam of less than 10,000 – a closed conduit principal spillway having a conduit with a cross-sectional area of 12 square feet or more, an inlet which will not clog, an elbow designed to facilitate the passage of trash, and large enough to pass the routed freeboard hydrograph is the minimum acceptable design without an open channel auxiliary spillway.
- Dams with drainage areas of 10 square miles or less (except those covered by item 1) – a closed conduit principal spillway having a conduit with a cross-sectional area of 20 square feet or more, an inlet which will not clog, an elbow designed to facilitate the passage of trash and large enough to pass the routed freeboard hydrograph peak discharge without overtopping the dam is the minimum acceptable design without an open channel auxiliary spillway.
- Dams with drainage areas greater than 10 square miles (except those covered by item 1) – a closed type primary auxiliary spillway may be used in lieu of an open channel auxiliary spillway. Drop inlet spillways with a standard two-way covered top inlet must have a minimum unobstructed cross-sectional area of each opening of the conduit of 40 square feet. All other closed type primary auxiliary spillways must have a minimum unobstructed cross-sectional area of each opening of 80 square feet. The ratio of width to height in both cases is must be between 0.75 and 1.33. The spillways must be large enough to pass the routed freeboard hydrograph peak discharge without overtopping the dam.

Spillway requirements

Capacity of auxiliary spillways

Auxiliary spillways must be proportioned so they will pass the stability design hydrograph at the safe velocity determined for the site. They must have sufficient capacity to pass the freeboard hydrograph with the water surface in the reservoir at or below the elevation of the design top of the dam. In no case is the capacity of the auxiliary spillway to be less than 200 ft^3/sec or 237 $DA^{0.493}$. The minimum difference in elevation between the crest of the auxiliary spillway and the settled top of the dam is 3 feet. State law may establish minimum capacity or depth greater than those given above.

Elevation of the crest of the auxiliary spillway

Table 2-2 gives the maximum allowable frequency of use of earth and vegetated auxiliary spillways. The minimum retarding storage volume and the associated principal spillway discharge must be such that the discharge through the auxiliary spillway will not occur during the routing of the principal spillway hydrograph and the 10-day drawdown requirement is met or the crest elevation of the auxiliary spillway is raised as noted under Capacity of Principal Spillway.

For earth spillways, it refers to sites where peak flows of short duration may be expected and where erosion resistant soils and moderate slopes exist. When vegetated spillways are used, the sites must have these same characteristics, and in addition, conditions must be such that vigorous vegetation can be maintained without irrigation. When conditions are less favorable, auxiliary spillways shall be designed for less frequent use. This may be done by raising the crest elevation, increasing the capacity of the principal spillway, adding a structural primary auxiliary spillway, or a combination of the above.

The maintenance required for the auxiliary spillway will be increased as the frequency and duration of flow increase. Good design requires balancing the spillway maintenance cost against the increased cost of modifying the other elements of the dam to reduce the flow frequency.

Auxiliary spillway routings

The stability design and the freeboard hydrographs must be routed through the reservoir starting with the water surface at the elevation of the lowest ungated principal spillway inlet, the anticipated elevation of the sediment storage, the elevation of the water surface associated with significant base flow or the pool elevation after 10 days of drawdown from the maximum

stage attained when routing the principal spillway hydrograph, whichever is higher, except as provided in the following:

- dams with gated spillways and joint use storage capacity – stability design and freeboard hydrograph routings are to be started at or above the elevation of the lowest ungated outlet or at the elevation of the water surface associated with the average annual base flow, whichever is higher.
- single purpose, low hazard class irrigation dams – stability design and freeboard hydrograph routings are to be started at or above the water surface elevation of the irrigation storage.

Hydraulic design
The relationship between the water surface elevation in the reservoir and the discharge through the auxiliary spillway shall be evaluated by computing the head losses in the inlet channel upstream of the control section or, if a control section is not used, by computing the water surface profile through the full length of the spillway. Bernoulli's equation and Manning's formula shall be used to evaluate friction losses, compute water surface profiles and determine velocities. Policy on the selection of flow resistance values is given in the discussion of the various types of auxiliary spillways.

Structural stability
The spillway must be investigated, analyzed, designed and constructed adequately to establish and maintain stability during the passage of design flows without blockage or breaching. Excavated open cut spillways must have cut and fill slopes in earth and rock which are stable against sliding. Cut slope stability must be evaluated for the long-term weathered, natural moisture condition and for adverse moisture conditions associated with rapid drawdown from the auxiliary spillway design discharge.

Vegetated and earth auxiliary spillways

Vegetated and earth auxiliary spillways are open channels and usually consist of an inlet channel, a control section, and an exit channel. Subcritical flow exists in the inlet channel and the flow is usually supercritical in the exit channel.

Vegetated auxiliary spillways are usually trapezoidal in cross-section and are protected from damaging erosion by a grass cover. They are adapted to sites where a vigorous grass growth can be sustained by normal maintenance without irrigation.

Earth spillways are used in those areas where vegetative growth cannot be maintained. They are similar to vegetated spillways, but are designed for lower velocities, lower stresses, and less frequent use. Normally, they require more maintenance after a flow occurs.

Earth and vegetated auxiliary spillways are designed on the basis that some erosion or scour will occur during passage of infrequent storms, but the spillway will not breach during passage of the freeboard storm.

Hydraulic data in TR-39 Hydraulics of Broad Crested Spillways can be used in the design of vegetated or earth auxiliary spillways. A minimum vegetal retardance curve index of 5.6 as defined in Agriculture Handbook 667 (AH-667) Stability Design of Grass-Lined Open Channels shall be used to determine hydraulic capacity and vegetal stress in vegetated spillways. A minimum Manning's n of 0.02 shall be used for earth spillways. Actual hydraulic capacity of the spillway will be based on an appraisal of the roughness condition at the site.

Layout
Guidance on the layout of auxiliary spillways is provided in NEH-628.50, Earth Spillway Design. Spillways must be located away from the dam whenever possible. The layout and profile of vegetated or earth spillways should provide safety against breaching of the spillway during the passage of the freeboard hydrograph. Both extending the length and flattening the grade of the exit channel to delay or prevent headcut formation, and maximizing the bulk of material to contain any headcut advancement should be considered.

The inlet channel must be level for a minimum distance of 30 feet upstream from the exit channel. This level part of the inlet channel (control section) must be the same width as the exit channel, and its centerline must be straight and coincident with the centerline of the exit channel. A curved centerline is permissible in the inlet channel upstream from the level part, but it must be tangent to the centerline of the level part. Any curved inlet channel should be depressed below the level part to reduce velocities.

The exit channel must be straight and perpendicular to the level part of the inlet channel for a distance equal to at least one-half of the maximum base width of the dam. Curvature may be introduced below this point if it is certain that the flowing water will not impinge on the dam should the channel fail at the curve.

When the upstream edge of the exit channel is considered as a control section for hydraulic calculations, the exit channel grade shall be sufficient to ensure supercritical flow for all discharges equal to or greater than 25 percent of the maximum discharge through the spillway during the passage of the freeboard hydrograph. However, the slope in the exit channel need not exceed 4 percent (s = 0.04 ft/ft) to meet this requirement.

The exit channel can be terminated at some point above the maximum tailwater elevation, or can be extended to the principal spillway outlet or natural stream channel below the dam. The exit channel can contain several different grades. In either layout, erosion will occur wherever allowable stresses are exceeded and maintenance is required to protect the integrity of the spillway. Land rights must be considered in making the decision on how to handle the return flow to the natural or constructed stream channel downstream from the dam, and where eroded materials will be deposited.

Stability design of earth and vegetated earth spillways

Limitations during routing of the stability design (auxiliary spillway) hydrograph – the maximum stress limitations given below for vegetated or earth spillways apply to the exit channel. They must not be exceeded in the reach where an exit channel failure might cause the flow to impinge on the toe of the dam. The stress limitations are based on the maximum discharge in routing the stability design (auxiliary spillway) hydrograph and the assumption that uniform flow conditions exist in the exit channel.

When the anticipated average use of an earth or vegetated spillway is more frequent than once in 50 years, the allowable stress will be determined in accordance with AH-667. The allowable values may be increased 20 percent when the anticipated average use is once in 50 years, or 50 percent when the anticipated average use is once in 100 years. The allowable stress shall be determined for the actual vegetal cover conditions that can be reasonably expected to exist at the time of the flow. Values for grasses or mixtures not included in AH-667 shall be determined by comparing their characteristics with those that are described. Where special studies or investigations have been made to determine the allowable stress for a species, soil, and condition, those values may be used in lieu of those shown in the handbook.

Ramp spillways are not generally favored by the dam engineering profession, but may be used where alternate solutions are not practical. Ramp spillways shall not be steeper than 10 per cent. Ramp spillways must be constructed with the same compaction procedures and quality control as the earth embankment. The upper one foot of vegetated ramp spillways should be top soil.

Integrity design of earth and vegetated earth spillways

The spillway shall be evaluated for headcut development and advancement during passage of the freeboard storm using the procedures in NEH-628.51, Earth Spillway Erosion Model, and NEH-628.52, Field Procedures Guide for the Headcut Erodibility Index. The spillway design must be such that the spillway will not breach (i.e., headcut will not advance beyond the upstream edge of the level part of the inlet channel) during passage of the freeboard storm.

Special precautions for high hazard class dams— Special consideration must be given to the layout of spillways on high hazard class dams to assure the spillway will not breach under the most extreme conditions of flow. The length of the exit channel is to be increased to the maximum extent possible so that the area most susceptible to erosion is at a considerable distance from the dam. Within the limitations of the site, the profile of the spillway is to be such that a maximum bulk of material is provided.

It is preferable that the flow be confined without the use of levees, but when they are necessary they are to be high enough to contain the peak flow of the routed freeboard hydrograph. Levees must be constructed of erosion resistant materials and compacted to the degree necessary to develop this resistance. They must have a top width not less than 12 feet and, if not protected with riprap, have side slopes not steeper than 3 horizontal to 1 vertical on the side where water flows. When constructed on a foundation subject to piping or undermining, they must be keyed into the foundation with a compacted core having a bottom width not less than the top width of the levee and of sufficient depth to reach sound material, or to a depth equal to the height of the levee, whichever is less.

Crest control structures shall be provided to maintain a uniform surface where the soils are highly erodible from on-site runoff and very low flows through the spillway. The effective bulk length may be increased by installing barriers that will effectively stop a gully advancing through the spillway. Consideration should be given to the reduction of the duration and volume

of flow through the auxiliary spillway by raising the elevation of the crest of the spillway, thereby increasing the volume of storage in the retarding pool. An alternate or complementary procedure is to increase the capacity of the principal spillway by means of a two stage inlet of sufficient size to carry an appreciable amount of the outflow hydrograph.

Rock auxiliary spillway

Some of the principles used for the layout of earth auxiliary spillways are applicable to rock auxiliary spillways. Allowable average frequency of use and permissible velocities must be ascertained for the specific site based on knowledge of the hardness, condition, durability, attitude, weathering characteristics, and structure of the rock formation. An individual appraisal is necessary to determine the proper roughness coefficient, n. The design is to be such that the auxiliary spillway will not breach during passage of the freeboard storm.

Structural auxiliary spillways

Structural spillways shall be designed so that the passage of the freeboard hydrograph will not cause serious damage to the embankment or the structures themselves. The configuration of a structural spillway must be compatible with the foundation conditions at the site, the channel stability downstream from the spillway, the possible range of tailwater depth, and the proximity of the spillway to the embankment. The inlet portion of a chute spillway shall consist of a straight inlet, a box drop inlet, an ogee crest, or other appropriate hydraulic structure which will produce critical flow at the crest and result in a determinate stage-discharge relationship.

The hydraulic design of structural auxiliary spillways shall be in accordance with the principles set forth in NEH-5, Hydraulics; NEH-11, Drop Spillways; NEH-14, Chute Spillways; and U.S. Department of Interior, Bureau of Reclamation publications, or based on model studies, with consideration given to the effects of air entertainment by water traveling at supercritical velocities.

The design discharge for hydraulic proportioning of structural auxiliary spillway must not be less than two-thirds of the planned structure capacity during passage of the routed freeboard hydrograph, except that all headwalls and sidewalls shall be designed to prevent overtopping during passage of the full maximum freeboard discharge. When the magnitude of a structural auxiliary spillway exceeds that of structures commonly designed by NRCS, model studies or other special studies shall be made.

The outlet section of concrete chute spillways must consist of a hydraulic jump basin, such as a SAF, deflector bucket, roller bucket, or other appropriate hydraulic structure which will dissipate the energy of the high velocity discharge.

Structural auxiliary spillways must be designed to withstand lateral earth pressures, uplift, seepage and other hydrostatic and hydrodynamic pressures. They must be structurally designed for the full maximum freeboard discharge with uplift and sliding safety factors of not less than 1.0 and in accordance with the principles set forth in NEH-6, Structural Design; NEH-11, Drop Spillways and NEH-14, Chute Spillways, utilizing TR-50, TR-54; and other appropriate and available design working aids.

Glossary

Auxiliary spillway. The spillway designed to convey excess water through, over, or around a dam.

Auxiliary spillway system. A single auxiliary or combination of auxiliary spillways designed to work together.

Base flow. The sustained or fair-weather discharge which persists after storm runoff and associated quick return flow have been depleted. It is usually derived from groundwater discharge or gradual snow or ice melt over extended periods of time, but need not be continuous flow. (It can be based on annual or seasonal periods, depending upon when major floods usually occur.)

Breach hydrograph. The outflow hydrograph attributed to the sudden release of water in reservoir storage due to a dam breach.

Conservation storage. Water impounded for consumptive uses such as municipal, industrial and irrigation and nonconsumptive uses such as recreation and fish and wildlife.

Control section. In an open channel spillway, it is that section where accelerated flow passes through critical depth.

Dam. An artificial barrier together with any associated spillways and appurtenant works that do or may impound or divert water.

Design life. A period of time during which a dam is designed to perform its assigned functions satisfactorily.

Dry dam. A dam that has an ungated outlet positioned so that essentially all stored water will be drained from the reservoir by gravity. The reservoir will normally be dry.

Earth dam. A dam in which the principal barrier is an embankment of earth or rock fill or combination of earth and rock fill.

Earth spillway. An open channel spillway in earth materials without vegetation.

Economic life. The period of time during which economic benefits accrue to a dam.

Effective height of dam. The difference in elevation in feet between the lowest open channel auxiliary spillway crest and the lowest point in the original cross section on the centerline of the dam. If there is no open channel auxiliary spillway, the top of the dam becomes the upper limit.

Exit channel of an open channel spillway. The portion downstream from the control section which conveys the flow to a point where it may be released without jeopardizing the dam.

Freeboard hydrograph. Used to evaluate the total spillway flow capacity of the dam and, consequently, establish the minimum settled elevation of the top of the dam. It is also used to evaluate the integrity (breaching resistance) of a vegetated or earth auxiliary spillway.

Inlet channel of an open channel spillway. The portion upstream from the control section.

Joint extensibility. The amount of a pipe joint that can be extended from the fully engaged position without losing strength or watertightness. In case of rubber gasket joints, it is measured from the center of the gasket to the point of flare of the bell ring or collar when the joint is fully closed.

Joint gap. The longitudinal dimension between the end face of the spigot end of a pipe joint and the corresponding face of the bell end of the connecting pipe. It does not include the beveled portion designed for sealing compounds.

Joint use pool. The portion of a reservoir which serves two or more purposes; for instance, conservation storage and floodwater storage.

Primary auxiliary spillway. The spillway with the lowest crest elevation in an auxiliary spillway system.

Principal spillway. The lowest ungated spillway designed to convey water from the reservoir at predetermined release rates.

Principal spillway hydrograph. The hydrograph used to determine the minimum crest elevation of the auxiliary spillway. It is used to establish the principal spillway capacity and determine the associated minimum floodwater retarding storage.

Quick return flow. The diminishing discharge directly associated with a specific storm that occurs after surface runoff has reached its maximum. It includes base flow, prompt subsurface discharge (commonly called interflow), and delayed surface runoff.

Ramp spillway. A vegetated spillway constructed over an earth dam in a manner such that the spillway is a part of the embankment.

Retarding pool. The portion of the reservoir allotted to the temporary impoundment of floodwater. Its upper limit is the elevation of the crest of the auxiliary spillway.

Retarding storage. The volume in the retarding pool.

Rock spillway. An open channel spillway through competent, nonerodible, natural rock materials.

Sediment pool. The portion of the reservoir allotted to the accumulation of submerged sediment during the design life of the dam.

Sediment pool elevation. The elevation of the surface of the anticipated submerged sediment accumulation at the dam.

Sediment storage. The reservoir capacity allocated to total sediment (submerged and aerated) accumulation during the life of the dam.

Spillway. An open or closed channel, conduit or drop structure used to convey water from a reservoir. It may contain gates, either manually or automatically controlled, to regulate the discharge of water.

Stability design hydrograph. The hydrograph used to establish the dimensions of the auxiliary spillway.

Storage. The capacity of the reservoir below the elevation of the crest of the auxiliary spillway.

Vegetated spillway. A vegetated open-channel spillway in earth materials.

Visual focal. An element in the landscape upon which the eyes automatically focus because the element's size, form, color, or texture contrasts clearly with its surroundings.

D.6. Nuclear Regulatory Commission



Revision 1
September 1976

U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 1.102

FLOOD PROTECTION FOR NUCLEAR POWER PLANTS

A. INTRODUCTION

General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as floods, tsunami, and seiches without loss of capability to perform their safety functions. Criterion 2 also requires that the design bases for these structures, systems, and components reflect:

1. Appropriate consideration of the most severe natural phenomena that have been historically reported for the site and surrounding region, with sufficient margin for the limited accuracy and quantity of the historical data and the period of time in which the data have been accumulated;

2. Appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena; and

3. The importance of the safety functions to be performed.

Paragraph 100.10(c) of 10 CFR Part 100, "Reactor Site Criteria," requires that physical characteristics of the site, including seismology, meteorology, geology, and hydrology, be taken into account in determining the acceptability of a site for a nuclear power reactor.

Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," to 10 CFR Part 100 identifies the investigations necessary for a detailed study of seismically induced floods and water waves. The appendix requires that design bases for seismically induced floods and water waves take into consideration the results of geologic and seismic investigations and that these design bases be taken into account in the design of the nuclear power plant.

Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants," describes acceptable methods of determining the design basis flood conditions that nuclear power plants located on sites along streams must withstand without loss of safety-related functions. It also discusses the phenomena producing comparable design basis floods for coastal, estuary, and Great Lakes sites. The guide states that examples of the type of flood protection to be provided for nuclear power plants will be the subject of a separate regulatory guide.

This guide describes types of flood protection acceptable to the NRC staff for the safety-related structures, systems, and components identified in Regulatory Guide 1.29.* In addition, this guide describes acceptable

*Regulatory Guide 1.29, "Seismic Design Classification," identifies structures, systems, and components of light-water-cooled nuclear power plants that should be designed to withstand the effects of the Safe Shutdown Earthquake and remain functional. These structures, systems, and components are those necessary to ensure (1) the integrity of the reactor coolant pressure boundary, (2) the capability to shut down the reactor and maintain it in a safe shutdown condition, or (3) the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guideline exposures of 10 CFR Part 100. These structures, systems, and components should also be designed to withstand conditions resulting from the design basis flood and remain functional.

It is expected that safety-related structures, systems, and components of other types of nuclear power plants will be identified in future regulatory guides. In the interim, Regulatory Guide 1.29 should be used as guidance when identifying safety-related structures, systems, and components of other types of nuclear power plants that need to be protected from floods by methods such as those suggested in this guide.

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience. This guide was revised as a result of substantive comments received from the public and additional staff review.

Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Section.

The guides are issued in the following ten broad divisions:

1. Power Reactors
2. Research and Test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siting
5. Materials and Plant Protection
6. Products
7. Transportation
8. Occupational Health
9. Antitrust Review
10. General

Copies of published guides may be obtained by written request indicating the divisions desired to the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Director, Office of Standards Development.

methods of protecting nuclear power plants from the effects of Probable Maximum Precipitation (PMP) falling directly on the site.*

B. DISCUSSION

Nuclear power plant structures, systems, and components important to safety should be designed to withstand, without loss of capability to perform their safety functions, the most severe flood conditions that can reasonably be postulated to occur at a site as a result of severe hydrometeorological conditions, seismic activity, or both. The flood protection features necessary to protect the safety-related structures, systems, and components should be designed for the range of precipitation, wind, and seismically induced flood conditions identified in Regulatory Guide 1.59. The water-induced effects, both static and dynamic, on the flood protection features are considered to constitute normal environmental forces for use in the design of such features. The forces are developed from the hydrologic engineering analysis of the flood conditions.

For purposes of this guide, the Design Basis Flooding Level (DBFL) is defined as the maximum water elevation attained by the controlling flood, including coincident wind-generated wave effects. The wind-generated wave component of elevation is generally controlled by fetch and water depth and may differ at locations around the plant. Further distinction must be made between estimates of "structural" effects (i.e., static and dynamic forces) and flooding or inundation effects. Additionally, the controlling flood event may be different for evaluating structural effects than for evaluating inundation effects. For example, the Probable Maximum Flood (PMF) may produce the highest water level and static forces on a given structure, but the total static and dynamic forces on the structure may be greater during a smaller (in elevation) flood wave from the seismically induced failure of an upstream dam.

For structural purposes, the significant wave height is used; for inundation considerations, the one-percent wave height is used. *Significant wave height* (H_s) is the average of the highest one-third of wind-generated waves in a representative spectrum. *One-percent wave height* (H_1), sometimes erroneously called the *maximum wave height*, is the average of the highest 1 percent of wind-generated waves in a representative spectrum. Use of the relation $H_1 = 1.67H_s$ is acceptable for determining the one-percent wave height.

Methods of flood protection for nuclear power plants fall into one of the following three types (local flooding induced by severe local precipitation will be discussed later):

1. Dry Site

The plant is built above the DBFL, and therefore safety-related structures, systems, and components are not affected by flooding.

2. Exterior Barrier

Safety-related structures, systems, and components are protected from inundation and static and dynamic forces thereof by engineered features external to the immediate plant area. Such features may, when properly designed and maintained, produce the equivalent of a dry site, although care must be taken to ensure that safety-related structures, equipment, and components are not adversely affected by the differential hydraulic head.

3. Incorporated Barrier

Safety-related structures, systems, and components are protected from inundation and static and dynamic effects by engineered features in the structure/environment interface.

Regulatory Position 2 of Regulatory Guide 1.59 provides that those structures, systems, and components necessary for safe shutdown and maintenance thereof should be protected against the DBFL. The position also suggests that, if sufficient warning time is shown to be available to bring the plant to a safe shutdown condition, some of the other safety-related structures, systems, and components identified in Regulatory Guide 1.29 do not require protection against a flood as severe as the DBFL. Use of this method of protection as an acceptable alternative requires development of emergency procedures and technical specifications. Substantiation of the adequacy of the time available will require, in part:

1. Estimating the time required to bring the plant from full-power operation to a safe shutdown mode.

2. Establishing the warning indicators that will initiate shutdown procedures. Flood stage and rate of rise are common and generally acceptable indicators. However, sites along streams downstream from the confluence of major tributaries may require an assessment of flooding potential from floods that are less than the PMF, but could exhibit faster rates of rise than the PMF.

*Suggested criteria for the consideration of localized severe precipitation are contained in Section 2.4.2.3 of Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants." The definition of Probable Maximum Precipitation is contained in Regulatory Guide 1.59.

**Lines indicate substantive changes from previous issue.

3. Documenting that sufficient time will remain after the warning for the safe shutdown to be accomplished before water can flood any safety-related structures, systems, or components.

The regulatory positions of this guide identify several key items to be considered in developing acceptable flood-related emergency procedures.

Local PMP may produce flooding at sites otherwise considered immune from flooding. The intensity of this rainfall and the usual design of the drainage system may result in ponding in the plant yard that could produce the DBFL. Also, roofs may receive more precipitation than the roof drains are designed to discharge.

Final plant grading is usually designed to cause ponded water to flow away from safety-related buildings. Even so, some temporary ponding is to be expected. Such ponding is generally accommodated by locating penetrations above the level of temporary ponding. Plant structures, systems, and components subject to ponding are also subject to the static and dynamic forces of the ponded water. These forces are usually less, however, than the forces from other design basis events.

C. REGULATORY POSITION

1. The following paragraphs provide working definitions of the various types of flood protection acceptable to the NRC staff.

a. Dry Site

The dry site may be the result of natural terrain or it may be constructed using engineered fill. The latter type refers to the "plant island" concept, rather than the minor fill used to dress plant grade. When fill is required to raise the plant access level above design basis flood conditions, the fill is safety related and must be protected from flood effects in the same manner as safety-related dams, dikes, etc.

b. Exterior Barriers

(1) *Levee.* "A dike or embankment to protect land from inundation."* Levees are generally earthen structures, trapezoidal in cross section, and protected from erosion by armor on the face exposed to waves and current.

(2) *Seawall or Floodwall.* "A structure separating land and water areas, primarily designed to prevent erosion and other damage due to wave action."* Seawalls are massive structures designed to take the full impact of the design wave. The seawall dissipates wave energy by throwing the water upward and downward. The upward deflection may result in wind-blown overtopping; the downward deflection can cause severe erosion at the toe of the seawall.

(3) *Bulkhead.* Similar to a seawall. The prime purpose is to restrain the land area. A bulkhead should not be used where it may be subject to direct wave attack.

(4) *Revetment.* "A facing of stone, concrete, etc., built to protect a scarp, embankment, or shore structure against erosion by wave action or currents."* Revetments are alternatives to seawalls and bulkheads. They protect the shore from direct wave attack by absorbing the wave energy in their interstices and on the surface of the revetment material. In this regard, riprap is more effective than smoother surfaces. Wave runup on the revetment is a function of incident wave height, revetment slope, and the nature of the revetment material. Rough surfaces reduce runup. When riprap is used, the placement of the material is critical to the effectiveness of the feature. Filling of the interstices with finer material destroys much of the energy-absorbing capabilities of the installation and may result in overtopping a structure that is otherwise adequate to prevent such overtopping.

(5) *Breakwater.* "A structure protecting a shore area, harbor, anchorage, or basin from waves."* Breakwaters may be connected to the shore or may be located entirely offshore. Wave energy is dissipated in the same manner as it is by revetments. Offshore breakwaters are used principally to reduce the wave effects that might otherwise reach safety-related structures, facilities, or components. Shore-connected breakwaters may serve the same purpose and also may be used to train discharge or intake water flow paths to limit recirculation.

c. Incorporated Barriers

Protection is provided by special design of walls and penetration closures. Walls are usually reinforced concrete designed to resist the static and dynamic forces of the DBFL and incorporate special waterstops at construction joints to prevent inleakage. Penetrations include personnel access, equipment access, and through-wall piping. Pipe penetrations are usually sealed with

*Definition from the U.S. Army Coastal Engineering Research Center, "Shore Protection Manual," Kingman Building, Fort Belvoir, Virginia 22060. Copies may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

special rubber boots and flanges. Personnel access closures that have been found acceptable include submarine doors and hatches. The hydraulic and seismic design bases for all types of closures, including waterstops, boots, and flanges, are the same as for the wall (i.e., water tightness and resistance to static and dynamic forces). In addition, the doors should open outward to ensure closure if the door is inadvertently opened during the flood event. Additionally, the plant should be designed and operated to keep doors necessary for flood protection closed during normal operation. Penetrations that are too large to close with a single door (e.g., equipment and fuel loading access) generally require stop logs or flood panels for closure. The design bases for these features are the same as above, as is the need to maintain them normally in a closed position.

Temporary flood barriers, such as sandbags, plastic sheeting, portable panels, etc., which must be installed prior to the advent of the DBFL, are not acceptable for issuance of a construction permit. However, unusual circumstances could arise after construction that would warrant consideration of such barriers. One example of unusual circumstances that might justify use of temporary barriers is a post-construction change in the flood-producing characteristics of the drainage area, as discussed in Regulatory Position 3 of Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants." In such circumstances, and with strong justification, the staff may accept temporary barriers.

2. Past experience suggests the need for guidance in establishing the shutdown technical specifications or emergency operating procedures necessary to utilize Regulatory Position 2 of Regulatory Guide 1.59. The following should be used in establishing the necessary procedures:

a. Stage (elevation)-time relations should be developed using the appropriate flood hydrograph (with coincident wind-generated wave effects) and site characteristics. River sites downstream from the confluence of major tributaries may require assessment of the flood potential from less severe flood events that may exhibit faster rates of rise than the PMF.

b. The flood stage, including design basis wind-generated wave effects and the time of occurrence within the flood event, at which any safety-related structure, system, or component (as defined in Regulatory Guide 1.29) may become degraded or inoperative should establish the completion time for all shutdown procedures.

c. Estimates of the time required for safe shutdown should be based on average rather than best-time operator performance. This time interval should be less than the time for occurrence of the event in Regulatory Position 2.b to establish the limiting values of the selected warning indicators. The procedures should consider the total DBFL; however, the indicators (usually flood stage and rate of rise) should be based on the stillwater level (i.e., DBFL less wind-generated wave effects). This precludes the masking of flood potential by less than design basis wind at the time of observation.

d. A communication system should be established to alert both onsite and offsite company personnel of flood conditions that may require subsequent shutdown of the plant. Such a system may use offsite facilities and services, such as upstream river gages and flood forecasting services, as well as direct communication between onsite and offsite company personnel.

e. The procedures in 2.c should specify that onsite plant personnel will initiate a safe shutdown on their own volition when the limiting values of the indicators are attained. Only those warning systems located at the site and under control of plant personnel should be needed to determine the limiting values of the indicators.

3. Analysis supporting the invulnerability of safety-related structures, systems, and components from the effects of local PMP should be performed using the point rainfall value of the PMP for the site area.

a. Regulatory Guide 1.59 provides guidance on obtaining PMP estimates. An analysis of the estimated depth of ponding in the plant area should also be made.

b. Roofs are usually provided with drains designed to discharge precipitation intensities considerably less than that of the PMP. The following methods of preventing undesirable buildup of standing water on the roofs of safety-related buildings have been found acceptable to the NRC staff:

(1) The parapets (a common architectural feature of nuclear power plant structures) may be deleted on one or more sides of the building. This is the most common method.

(2) The parapet height may be limited to preclude buildup of water in excess of the structural capacity of the roof for design loads.

(3) Scuppers may be installed through the parapets to discharge the standing water over the edge of the building.

(Note that limiting the parapet height or lip of the scupper to, for example, 6 inches above the roof will not necessarily limit the depth of water on the roof to 6 inches. Consideration should be given to the hydraulic head necessary to initiate flow.)

c. The load induced by the maximum depth of standing water on the roofs (including antecedent or coincident snow or ice) during the design basis event should be less than the structural capacity of the roof for design loads, and the discharge capacity of roof drains should be compared with the design basis discharge.

D. IMPLEMENTATION

The purpose of this section is to provide information to license applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

This guide reflects current NRC staff practice. Therefore, except in those cases in which the license applicant or licensee proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein is being and will continue to be used in the evaluation of submittals for operating license or construction permit applications until this guide is revised as a result of suggestions from the public or additional staff review.

U.S. NUCLEAR REGULATORY COMMISSION

Revision 2
August 1977

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 1.59

DESIGN BASIS FLOODS FOR NUCLEAR POWER PLANTS

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience. This guide was revised as a result of substantive comments received from the public and additional staff review.

Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch.

The guides are issued in the following ten broad divisions:

1. Power Reactors
2. Research and Test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siting
5. Materials and Plant Protection
6. Products
7. Transportation
8. Occupational Health
9. Antitrust Review
10. General

Requests for single copies of issued guides (which may be reproduced) or for placement on an automatic distribution list for single copies of future guides in specific divisions should be made in writing to the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Director, Division of Document Control.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

July 30, 1980

ERRATA

Regulatory Guide 1.59, Revision 2, August 1977

"Design Basis Floods for Nuclear Power Plants"

New information that affects the Probable Maximum Flood (PMF) isolines for the Upper Ohio River for drainage areas of 10,000 and 20,000 square miles has been identified. The changes to the isolines affect only a small area in the Upper Ohio River Basin and do not have any significant impact on the Design Basis Flood for existing plants.

As a result of the new information, revised Figures B.6 and B.7 transmitted herewith should be used in future PMF discharge determinations when the simplified methods presented in Appendix B to the Regulatory Guide are being used. In addition, appropriate changes have been made to the PMF data on pages 28 and 30 of Table B.1, which are also transmitted herewith.

TABLE OF CONTENTS

	Page
A. INTRODUCTION	1.59-5
B. DISCUSSION	1.59-5
C. REGULATORY POSITION	1.59-7
D. IMPLEMENTATION	1.59-8
APPENDIX A—Probable Maximum and Seismically Induced Floods on Streams and Coastal Areas	1.59-9
APPENDIX B—Alternative Methods of Estimating Probable Maximum Floods	1.59-11
APPENDIX C—Simplified Methods of Estimating Probable Maximum Surges	1.59-41

*Lines indicate substantive changes from previous issue.

A. INTRODUCTION

General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires, in part, that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as floods, tsunami, and seiches without loss of capability to perform their safety functions. Criterion 2 also requires that design bases for these structures, systems, and components reflect (1) appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding region, with sufficient margin for the limited accuracy and quantity of the historical data and the period of time in which the data have been accumulated, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of the safety functions to be performed.

Paragraph 100.10(c) of 10 CFR Part 100, "Reactor Site Criteria," requires that physical characteristics of the site, including seismology, meteorology, geology, and hydrology, be taken into account in determining the acceptability of a site for a nuclear power reactor.

Section IV(c) of Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," to 10 CFR Part 100 suggests investigations for a detailed study of seismically induced floods and water waves. The appendix also suggests [Section IV(c)(iii)] that the determination of design bases for seismically induced floods and water waves be based on the results of the required geologic and seismic investigations and that these design bases be taken into account in the design of the nuclear power plant.

This guide discusses the design basis floods that nuclear power plants should be designed to withstand without loss of capability for cold shutdown and maintenance thereof. The design requirements for flood protection are the subject of Regulatory Guide 1.102, "Flood Protection for Nuclear Power Plants."

The material previously contained in Appendix A, "Probable Maximum and Seismically Induced Floods on Streams," has been replaced by American National Standards Institute (ANSI) Standard N170-1976, "Standards for Determining Design Basis Flooding at Power Reactor Sites,"[1] which has been endorsed as acceptable by the NRC staff with the exception noted in Appendix A. In addition to information on stream flooding, ANSI N170-1976 contains methodology for estimating probable maximum surges and seiches at estuaries and coastal areas on oceans and large lakes. Appendix B gives timesaving alternative methods of estimating the probable maximum flood along streams, and Appendix C gives a simplified method of estimating probable maximum surges on the Atlantic and Gulf coasts. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

[1]Copies of ANSI Standard N170-1976 may be purchased from the American Nuclear Society, 555 North Kensington Avenue, La Grange Park, IL 60525.

B. DISCUSSION

Nuclear power plants should be designed to prevent the loss of capability for cold shutdown and maintenance thereof resulting from the most severe flood conditions that can reasonably be predicted to occur at a site as a result of severe hydrometeorological conditions, seismic activity, or both.

The Corps of Engineers for many years has studied conditions and circumstances relating to floods and flood control. As a result of these studies, it has developed a definition for a Probable Maximum Flood (PMF)[2] and attendant analytical techniques for estimating, with an acceptable degree of conservatism, flood levels on streams resulting from hydrometeorological conditions. For estimating seismically induced flood levels, an acceptable degree of conservatism for evaluating the effects of the initiating event is provided by Appendix A to 10 CFR Part 100.

The conditions resulting from the worst site-related flood probable at the nuclear power plant (e.g., PMF, seismically induced flood, seiche, surge, severe local precipitation) with attendant wind-generated wave activity constitute the design basis flood conditions that safety-related structures, systems, and components identified in Regulatory Guide 1.29[3] should be

[2]Corps of Engineers' Probable Maximum Flood definition appears in many publications of that agency such as Engineering Circular EC 1110-2-27, Change 1, "Engineering and Design—Policies and Procedures Pertaining to Determination of Spillway Capacities and Freeboard Allowances for Dams," dated 19 Feb. 1968. The Probable Maximum Flood is also directly analogous to the Corps of Engineers' "Spillway Design Flood" as used for dams whose failures would result in a significant loss of life and property.

[3]Regulatory Guide 1.29, "Seismic Design Classification," identifies structures, systems, and components of light-water-cooled nuclear power plants that should be designed to withstand the effects of the Safe Shutdown Earthquake and remain functional. These structures, systems, and components are those necessary to ensure (1) the integrity of the reactor coolant pressure boundary, (2) the capability to shut down the reactor and maintain it in a safe shutdown condition, or (3) the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guideline exposures of 10 CFR Part 100. These same structures, systems, and components should also be designed to withstand conditions resulting from the design basis flood and retain capability for cold shutdown and maintenance thereof of other types of nuclear power plants. It is expected that safety-related structures, systems, and components of other types of nuclear power plants will be identified in future regulatory guides. In the interim, Regulatory Guide 1.29 should be used as guidance when identifying safety-related structures, systems, and components of other types of nuclear power plants.

designed to withstand and retain capability for cold shutdown and maintenance therof.

For sites along streams, the PMF generally provides the design basis flood. For sites along lakes or seashores, a flood condition of comparable severity could be produced by the most severe combination of hydrometeorological parameters reasonably possible, such as may be produced by a Probable Maximum Hurricane[4] or by a Probable Maximum Seiche. On estuaries, a Probable Maximum River Flood, a Probable Maximum Surge, a Probable Maximum Seiche, or a reasonable combination of less severe phenomenologically caused flooding events should be considered in arriving at design basis flood conditions comparable in frequency of occurrence with a PMF on streams.

In addition to floods produced by severe hydrometeorological conditions, the most severe seismically induced floods reasonably possible should be considered for each site. Along streams and estuaries, seismically induced floods may be produced by dam failures or landslides. Along lakeshores, coastlines, and estuaries, seismically induced or tsunami-type flooding should be considered. Consideration of seismically induced floods should include the same range of seismic events as is postulated for the design of the nuclear plant. For instance, the analysis of floods caused by dam failures, landslides, or tsunami requires consideration of seismic events of the severity of the Safe Shutdown Earthquake occurring at the location that would produce the worst such flood at the nuclear power plant site. In the case of seismically induced floods along rivers, lakes, and estuaries that may be produced by events less severe than a Safe Shutdown Earthquake, consideration should be given to the coincident occurrence of floods due to severe hydrometeorological conditions, but only where the effects on the plant are worse than and the probability of such combined events may be greater than an individual occurrence of the most severe event of either type. Appendix A contains acceptable combinations of such events. For the specific case of seismically induced floods due to dam failures, an evaluation should be made of flood waves that may be caused by domino-type dam failures triggered by a seismically induced failure of a critically located dam and of flood waves that may be caused by multiple dam failures in a region where dams may be located close enough together that a single seismic event can cause multiple failures.

Each of the severe flood types discussed above should represent the upper limit of all potential phenomenologically caused flood combinations considered reasonably possible. Analytical techniques are available and should generally be used for prediction at individual sites. Those techniques applicable to PMF and seismically induced flood estimates on streams are presented in Appendices A and B of this guide. For sites on coasts, estuaries, and large lakes, techniques are presented in Appendices A and C of this guide.

Analyses of only the most severe flood conditions may not indicate potential threats to safety-related systems that might result from combinations of flood conditions thought to be less severe. Therefore, reasonable combinations of less-severe flood conditions should also be considered to the extent needed for a consistent level of conservatism. Such combinations should be evaluated in cases where the probability of their existing at the same time and having significant consequences is at least comparable to that associated with the most severe hydrometeorological or seismically induced flood. For example, a failure of relatively high levees adjacent to a plant could occur during floods less severe than the worst site-related flood, but would produce conditions more severe than would result during a greater flood (where a levee failure elsewhere would produce less severe conditions at the plant site).

Wind-generated wave activity may produce severe flood-induced static and dynamic conditions either independent of or coincident with severe hydrometeorological or seismic flood-producing mechanisms. For example, along a lake, reservoir, river, or seashore, reasonably severe wave action should be considered coincident with the probable maximum water level conditions.[5] The coincidence of wave activity with probable maximum water level conditions should take into account the fact that sufficient time can elapse between the occurrence of the assumed meteorological mechanism and the maximum water level to allow subsequent meteorological activity to produce substantial wind-generated waves coincident with the high water level. In addition, the most severe wave activity at the site that can be generated by distant hydrometeorological activity should be considered. For instance, coastal locations may be subjected to severe wave action caused by a distant storm that, although not as severe as a local storm (e.g., a Probable Maximum Hurricane), may produce more severe wave action because of a very long wave-generating fetch. The most severe wave activity at the site that may be generated by conditions at a distance from the site should be considered in such cases. In addition, assurance should be provided

[4]See References 2 and 5, Appendix C.

[5]Probable Maximum Water Level is defined by the Corps of Engineers as "the maximum still water level (i.e., exclusive of local coincident wave runup) which can be produced by the most severe combination of hydrometeorological and/or seismic parameters reasonably possible for a particular location. Such phenomena are hurricanes, moving squall lines, other cyclonic meteorological events, tsunami, etc., which, when combined with the physical response of a body of water and severe ambient hydrological conditions, would produce a still water level that has virtually no risk of being exceeded."

that safety systems necessary for cold shutdown and maintenance thereof are designed to withstand the static and dynamic effects resulting from frequent flood levels (i.e., the maximum operating level in reservoirs and the 10-year flood level in streams) coincident with the waves that would be produced by the Probable Maximum Gradient Wind[6] for the site (based on a study of historical regional meteorology).

C. REGULATORY POSITION

1. The conditions resulting from the worst site-related flood probable at a nuclear power plant (e.g., PMF, seismically induced flood, hurricane, seiche, surge, heavy local precipitation) with attendant wind-generated wave activity constitute the design basis flood conditions that safety-related structures, systems, and components identified in Regulatory Guide 1.29 (see footnote 3) must be designed to withstand and retain capability for cold shutdown and maintenance thereof.

a. The PMF on streams, as defined in Appendix A and based on the analytical techniques summarized in Appendices A and B of this guide, provides an acceptable level of conservatism for estimating flood levels caused by severe hydrometeorological conditions.

b. Along lakeshores, coastlines, and estuaries, estimates of flood levels resulting from severe surges, seiches, and wave action caused by hydrometeorological activity should be based on criteria comparable in conservatism to those used for Probable Maximum Floods. Criteria and analytical techniques providing this level of conservatism for the analysis of these events are summarized in Appendix A of this guide. Appendix C of this guide presents an acceptable method for estimating the still-water level of the Probable Maximum Surge from hurricanes at open-coast sites on the Atlantic Ocean and Gulf of Mexico.

c. Flood conditions that could be caused by dam failures from earthquakes should also be considered in establishing the design basis flood. Analytical techniques for evaluating the hydrologic effects of seismically induced dam failures discussed herein are presented in Appendix A of this guide. Techniques for evaluating the effects of tsunami will be presented in a future appendix.

d. Where upstream dams or other features that provide flood protection are present, in addition to the analyses of the most severe floods that may be induced by either hydrometeorological or seismic mechanisms, reasonable combinations of less-severe flood conditions and seismic events should also be considered to the extent needed for a consistent level of conservatism. The effect of such combinations on the flood conditions at the plant site should be evaluated in cases where the probability of such combinations occurring at the same time and having significant consequences is at least comparable to the probability associated with the most severe hydrometeorological or seismically induced flood. For relatively large streams, examples of acceptable combinations of runoff floods and seismic events that could affect the flood conditions at the plant are contained in Appendix A. Less-severe flood conditions, associated with the above seismic events, may be acceptable for small streams that exhibit relatively short periods of flooding.

e. The effects of coincident wind-generated wave activity to the water levels associated with the worst site-related flood possible (as determined from paragraphs a, b, c, or d above) should be added to generally define the upper limit of flood potential. Acceptable procedures are contained in Appendix A of this guide.

2. As an alternative to designing *hardened protection*[7] for all safety-related structures, systems, and components as specified in Regulatory Position 1 above, it is permissible not to provide hardened protection for some of these features if:

a. Sufficient[8] warning time is shown to be available to shut the plant down and implement adequate emergency procedures;

b. All safety-related structures, systems, and components identified in Regulatory Guide 1.29 (see footnote 3) are designed to withstand the flood conditions resulting from a Standard Project event[8] with attendant wind-generated wave activity that may be produced by the worst winds of record and remain functional;

c. In addition to the analyses in paragraph 2.b above, reasonable combinations of less-severe flood conditions are also considered to the extent needed for a consistent level of conservatism; and

[6]Probable Maximum Gradient Wind is defined as a gradient wind of a designated duration, which there is virtually no risk of exceeding.

[7]*Hardened protection* means structural provisions incorporated in the plant design that will protect safety-related structures, systems, and components from the static and dynamic effects of floods. In addition, each component of the protection must be passive and in place, as it is to be used for flood protection, during normal plant operation. Examples of the types of flood protection to be provided for nuclear power plants are contained in Regulatory Guide 1.102.

[8]For sites along streams, this event is characterized by the Corps of Engineers' definition of a Standard Project Flood. Such floods have been found to produce flow rates generally 40 to 60 percent of the PMF. For sites along seashores, this event may be characterized by the Corps of Engineers' definition of a Standard Project Hurricane. For other sites, a comparable level of risk should be assumed.

d. In addition to paragraph 2.b above, at least those structures, systems, and components necessary for cold shutdown and maintenance thereof are designed with *hardened* protective features to remain functional while withstanding the entire range of flood conditions up to and including the worst site-related flood probable (e.g., PMF, seismically induced flood, hurricane, surge, seiche, heavy local precipitation) with coincident wind-generated wave action as discussed in Regulatory Position 1 above.

3. During the economic life of a nuclear power plant, unanticipated changes to the site environs which may adversely affect the flood-producing characteristics of the environs are possible. Examples include construction of a dam upstream or downstream of the plant or, comparably, construction of a highway or railroad bridge and embankment that obstructs the flood flow of a river and construction of a harbor or deepening of an existing harbor near a coastal or lake site plant.

Significantly adverse changes in the runoff or other flood-producing characteristics of the site environs, as they affect the design basis flood, should be identified and used as the basis to develop or modify emergency operating procedures, if necessary, to mitigate the effects of the increased flood.

4. Proper utilization of the data and procedures in Appendices B and C will result in PMF peak discharges and PMS peak stillwater levels which will in many cases be approved by the NRC staff with no further verification. The staff will continue to accept for review detailed PMF and PMS analyses that result in less conservative estimates than those obtained by use of Appendices B and C. In addition, previously reviewed and approved detailed PMF and PMS analyses will continue to be acceptable even though the data and procedures in Appendices B and C result in more conservative estimates.

D. IMPLEMENTATION

The purpose of this section is to provide information to license applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

This guide reflects current NRC practice. Therefore, except in those cases in which the applicant or licensee proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the methods described herein are being and will continue to be used in the evaluation of submittals for construction permit applications until this guide is revised as a result of suggestions from the public or additional staff review.

APPENDIX A

PROBABLE MAXIMUM AND SEISMICALLY INDUCED FLOODS ON STREAMS AND COASTAL AREAS

The material previously contained in Appendix A has been replaced by American National Standards Institute (ANSI) Standard N170-1976, "Standards for Determining Design Basis Flooding at Power Reactor Sites," with the following exception:

Sections 5.5.4.2.3 and 5.5.5 of ANSI N170-1976 contain references to methods for evaluating the erosion failure of earthfill or rockfill dams and determining the resulting outflow hydrographs. The staff has found that some of these methods may not be conservative because they predict slower rates of erosion than have historically occurred. Modifications to the models may be made to increase their conservatism. Such modifications will be reviewed by the NRC staff on a case-by-case basis.

APPENDIX B

ALTERNATIVE METHODS OF ESTIMATING PROBABLE MAXIMUM FLOODS

TABLE OF CONTENTS

Page

B.1 INTRODUCTION 1.59-12

B.2 SCOPE 1.59-12

B.3 PROBABLE MAXIMUM FLOOD PEAK DISCHARGE 1.59-12

B.3.1 Use of PMF Discharge Determinations 1.59-12
B.3.2 Enveloping Isolines of PMF Peak Discharge 1.59-12

B.3.2.1 Preparation of Maps 1.59-12
B.3.2.2 Use of Maps 1.59-13

B.3.3 Probable Maximum Water Level 1.59-13
B.3.4 Wind-Wave Effects 1.59-13

B.4 LIMITATIONS 1.59-13

REFERENCES 1.59-14

FIGURES 1.59-15

TABLE 1.59-23

FIGURES

Figure B.1—Water Resources Regions 1.59-15
B.2—Probable Maximum Flood (Enveloping Isolines)—100 Sq. Mi. 1.59-16
B.3—Probable Maximum Flood (Enveloping Isolines)—500 Sq. Mi. 1.59-17
B.4—Probable Maximum Flood (Enveloping Isolines)—1,000 Sq. Mi. 1.59-18
B.5—Probable Maximum Flood (Enveloping Isolines)—5,000 Sq. Mi. 1.59-19
B.6—Probable Maximum Flood (Enveloping Isolines)—10,000 Sq. Mi. 1.59-20
B.7—Probable Maximum Flood (Enveloping Isolines)—20,000 Sq. Mi. 1.59-21
B.8—Example of Use of Enveloping Isolines 1.59-22

TABLE

Table B.1—Probable Maximum Flood Data 1.59-23

B.1 INTRODUCTION

This appendix presents timesaving alternative methods of estimating the probable maximum flood (PMF) peak discharge for nuclear facilities on nontidal streams in the contiguous United States. Use of the methods herein will reduce both the time necessary for applicants to prepare license applications and the NRC staff's review effort.

The procedures are based on PMF values determined by the U.S. Army Corps of Engineers, by applicants for licenses that have been reviewed and accepted by the NRC staff, and by the staff and its consultants. The information in this appendix was developed from a study made by Nunn, Snyder, and Associates, through a contract with NRC (Ref. 1).

PMF peak discharge determinations for the entire contiguous United States are presented in Table B.1. Under some conditions, these may be used directly to evaluate the PMF at specific sites. In addition, maps showing enveloping isolines of PMF discharge for several index drainage areas are presented in Figures B.2 through B.7 for the contiguous United States east of the 103rd meridian, including instructions for and an example of their use (see Figure B.8). Because of the enveloping procedures used in preparing the maps, results from their use are highly conservative.

Limitations on the use of these generalized methods of estimating PMFs are identified in Section B.4. These limitations should be considered in detail in assessing the applicability of the methods at specific sites.

Applicants for licenses for nuclear facilities at sites on nontidal streams in the contiguous United States have the option of using these methods in lieu of the more precise but laborious methods of Appendix A. The results of application of the methods in this appendix will in many cases be accepted by the NRC staff with no further verification.

B.2 SCOPE

The data and procedures in this appendix apply only to nontidal streams in the contiguous United States. Two procedures are included for nontidal streams east of the 103rd meridian.

Future studies are planned to determine the applicability of similar generalized methods and to develop such methods, if feasible, for other areas. These studies, to be included in similar appendices, are anticipated for the main stems of large rivers and the United States west of the 103rd meridian, including Hawaii and Alaska.

B.3 PROBABLE MAXIMUM FLOOD PEAK DISCHARGE

The data presented in this section are as follows:

1. A tabulation of PMF peak discharge determinations at specific locations throughout the contiguous United States. These data are subdivided into water resources regions, delineated on Figure B.1, and are tabulated in Table B.1.

2. A set of six maps, Figures B.2 through B.7, covering index drainage areas of 100, 500, 1,000, 5,000, 10,000, and 20,000 square miles, containing isolines of equal PMF peak discharge for drainage areas of those sizes east of the 103rd meridian.

B.3.1 Use of PMF Discharge Determinations

The PMF peak discharge determinations listed in Table B.1 are those computed by the Corps of Engineers, by the NRC staff and their consultants, or computed by applicants and accepted by the staff.

For a nuclear facility located near or adjacent to one of the streams listed in the table and reasonably close to the location of the PMF determination, that PMF may be transposed, with proper adjustment, or routed to the nuclear facility site. Methods of transposition, adjustment, and routing are given in standard hydrology texts and are not repeated here.

B.3.2 Enveloping Isolines of PMF Peak Discharge

B.3.2.1 Preparation of Maps

For each of the water resources regions, each PMF determination in Table B.1 was plotted on logarithmic paper (cubic feet per second per square mile versus drainage area). It was found that there were insufficient data and too much scatter west of about the 103rd meridian, caused by variations in precipitation from orographic effects or by melting snowpack. Accordingly, the rest of the study was confined to the United States east of the 103rd meridian. For sites west of the 103rd meridian, the methods of the preceding section may be used.

Envelope curves were drawn for each region east of the 103rd meridian. It was found that the envelope curves generally paralleled the Creager curve (Ref. 2), defined as

$$Q = 46.0\ CA^{(0.894A^{-0.048})-1}$$

where

Q is the discharge in cubic feet per second (cfs)
C is a constant, taken as 100 for this study
A is the drainage area in square miles.

Each PMF discharge determination of 50 square miles or more was adjusted to one or more of the six selected index drainage areas in accordance with the slope of the Creager curve. Such adjustments were made as follows:

PMF Within Drainage Area Range, sq. mi.	Adjusted to Index Drainage Area, sq. mi.
50 to 500	100
100 to 1,000	500
500 to 5,000	1,000
1,000 to 10,000	5,000
5,000 to 50,000	10,000
10,000 or greater	20,000

The PMF values so adjusted were plotted on maps of the United States east of the 103rd meridian, one map for each of the six index drainage areas. It was found that there were areas on each map with insufficient points to define isolines. To fill in such gaps, conservative computations of approximate PMF peak discharge were made for each two-degree latitude-longitude intersection on each map. This was done by using enveloped relations between drainage area and PMF peak discharge (in cfs per inch of runoff), and applying appropriate probable maximum precipitation (PMP) at each two-degree latitude-longitude intersection. PMP values, obtained from References 3 and 4, were assumed to be for a 48-hour storm to which losses of 0.05 inch per hour were applied. These approximate PMF values were also plotted on the maps for each index drainage area and the enveloping isolines were drawn as shown on Figures B.2 through B.7.

B.3.2.2 Use of Maps

The maps may be used to determine PMF peak discharge at a given site with a known drainage area as follows:

1. Locate the site on the 100-square-mile map, Figure B.2.

2. Read and record the 100-square-mile PMF peak discharge by straight-line interpolation between the isolines.

3. Repeat Steps 1 and 2 for 500, 1,000, 5,000, 10,000, and 20,000 square miles from Figures B.3 through B.7.

4. Plot the six PMF peak discharges so obtained on logarithmic paper against drainage area, as shown on Figure B.8.

5. Draw a smooth curve through the points. Reasonable extrapolations above and below the defined curve may be made.

6. Read the PMF peak discharge at the site from the curve at the appropriate drainage area.

B.3.3 Probable Maximum Water Level

When the PMF peak discharge has been obtained as outlined in the foregoing sections, the PMF stillwater level should be determined. The methods given in Appendix A are acceptable for this purpose.

B.3.4 Wind-Wave Effects

Wind-wave effects should be superimposed on the PMF stillwater level. Criteria and acceptable methods are given in Appendix A.

B.4 LIMITATIONS

1. The NRC staff will continue to accept for review detailed PMF analyses that result in less conservative estimates. In addition, previously reviewed and approved detailed PMF analyses at specific sites will continue to be acceptable even though the data and procedures in this appendix result in more conservative estimates.

2 .The PMF estimates obtained as outlined in Sections B.3.1 and B.3.2 are peak discharges that should be converted to water level to which appropriate wind-wave effects should be added.

3. If there are one or more reservoirs in the drainage area upstream of the site, seismic and hydrologic dam failure[1] flood analyses should be made to determine whether such a flood will produce the design basis water level. Criteria and acceptable methods are included in Appendix A.

4. Because of the enveloping procedures used, PMF peak discharges estimated as outlined in Section B.3.2 have a high degree of conservatism. If the PMF so estimated casts doubt on the suitability of a site, or if protection from a flood of that magnitude would not be physically or economically feasible, consideration should be given to performing a detailed PMF analysis, as outlined in Appendix A. It is likely that such an analysis will result in appreciably lower PMF levels.

[1] In this context, "hydrologic dam failure" means a failure caused by a flood from the drainage area upstream of the dam.

REFERENCES

1. Nunn, Snyder, and Associates, "Probable Maximum Flood and Hurricane Surge Estimates," unpublished report to NRC, June 13, 1975 (available in the public document room).

2. W.P. Creager, J.D. Justin, and J. Hinds, "Engineering for Dams," J. Wiley and Sons, Inc., New York, 1945.

3. U.S. Weather Bureau (now U.S. Weather Service, NOAA), "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian," Hydrometeorological Report No. 33, 1956.[1]

4. U.S. Department of Commerce, NOAA, "All-Season Probable Maximum Precipitation—United States East of the 105th Meridian, for Areas from 1,000 to 20,000 Square Miles and Durations from 6 to 72 Hours," draft report, July 1972.[1]

[1]Note: References 3 and 4 are being updated and combined into a single report by NOAA. This report is expected to be published in the near future as Hydrometeorological Report No. 51 with the title "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian."



FIGURE B.1 WATER RESOURCES REGIONS

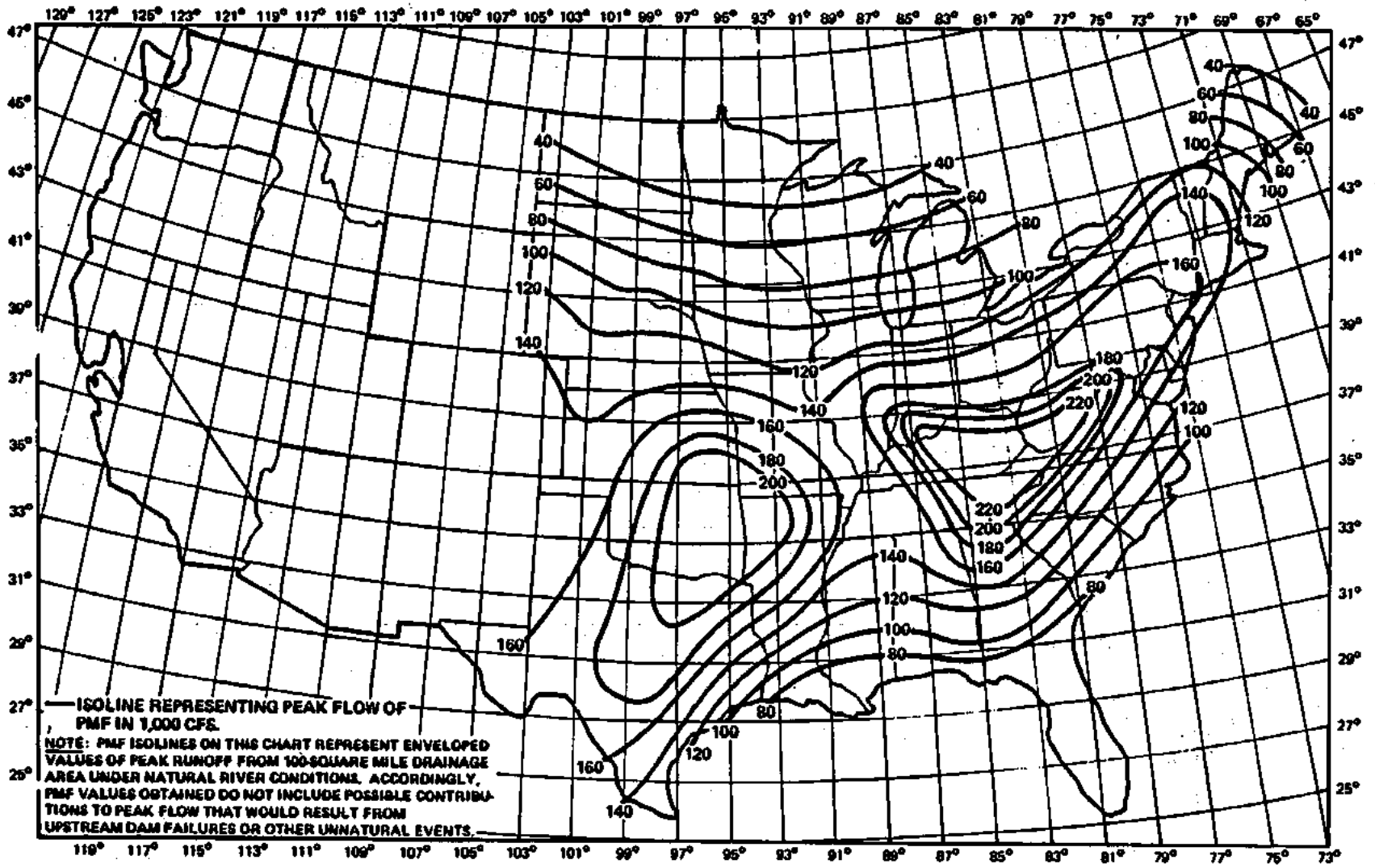


FIGURE B.2 PROBABLE MAXIMUM FLOOD (ENVELOPING PMF ISOLINES) FOR 100 SQUARE MILES

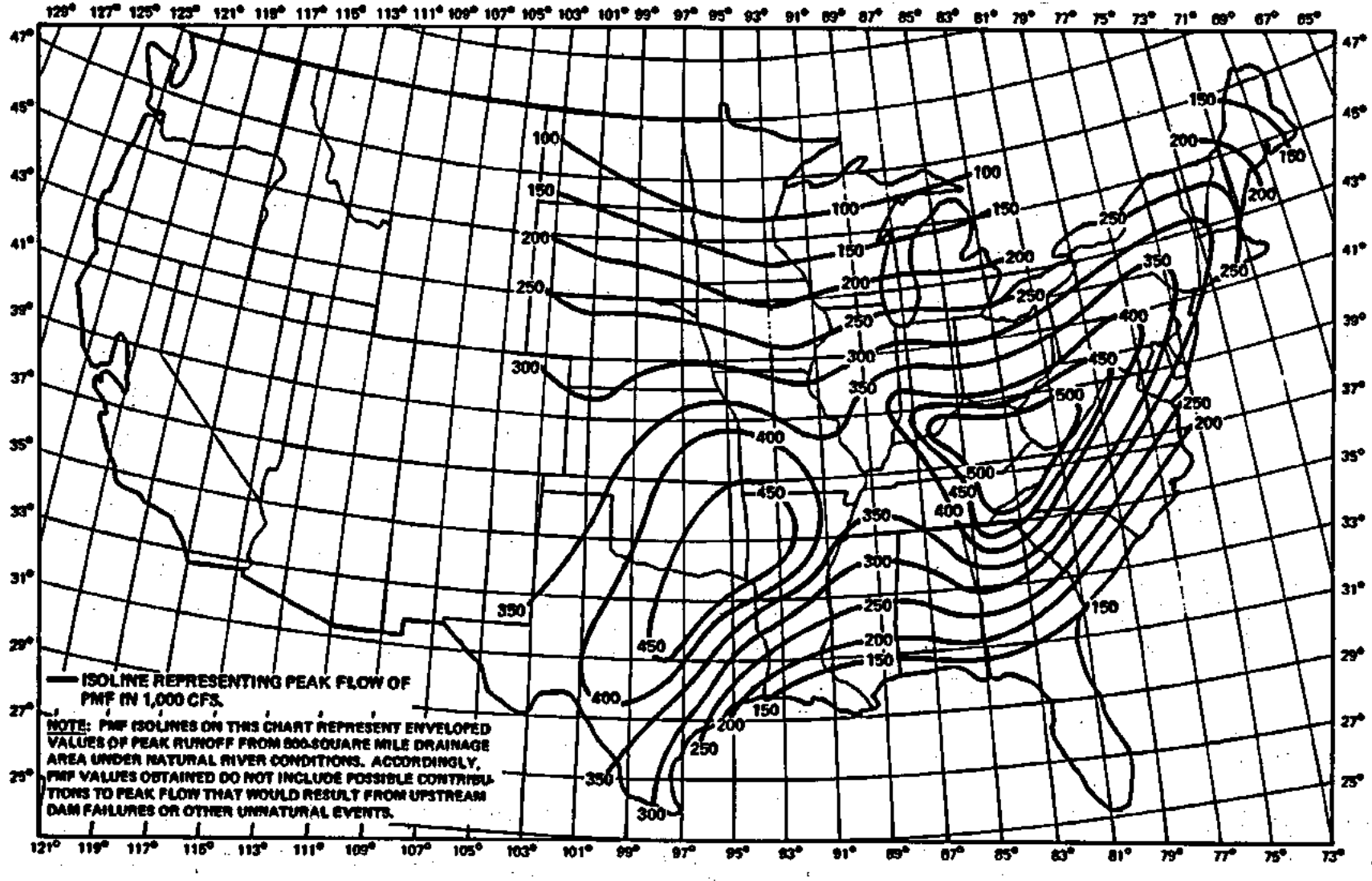


FIGURE 8.3 PROBABLE MAXIMUM FLOOD (ENVELOPING PMF ISOLINES) FOR 500 SQUARE MILES

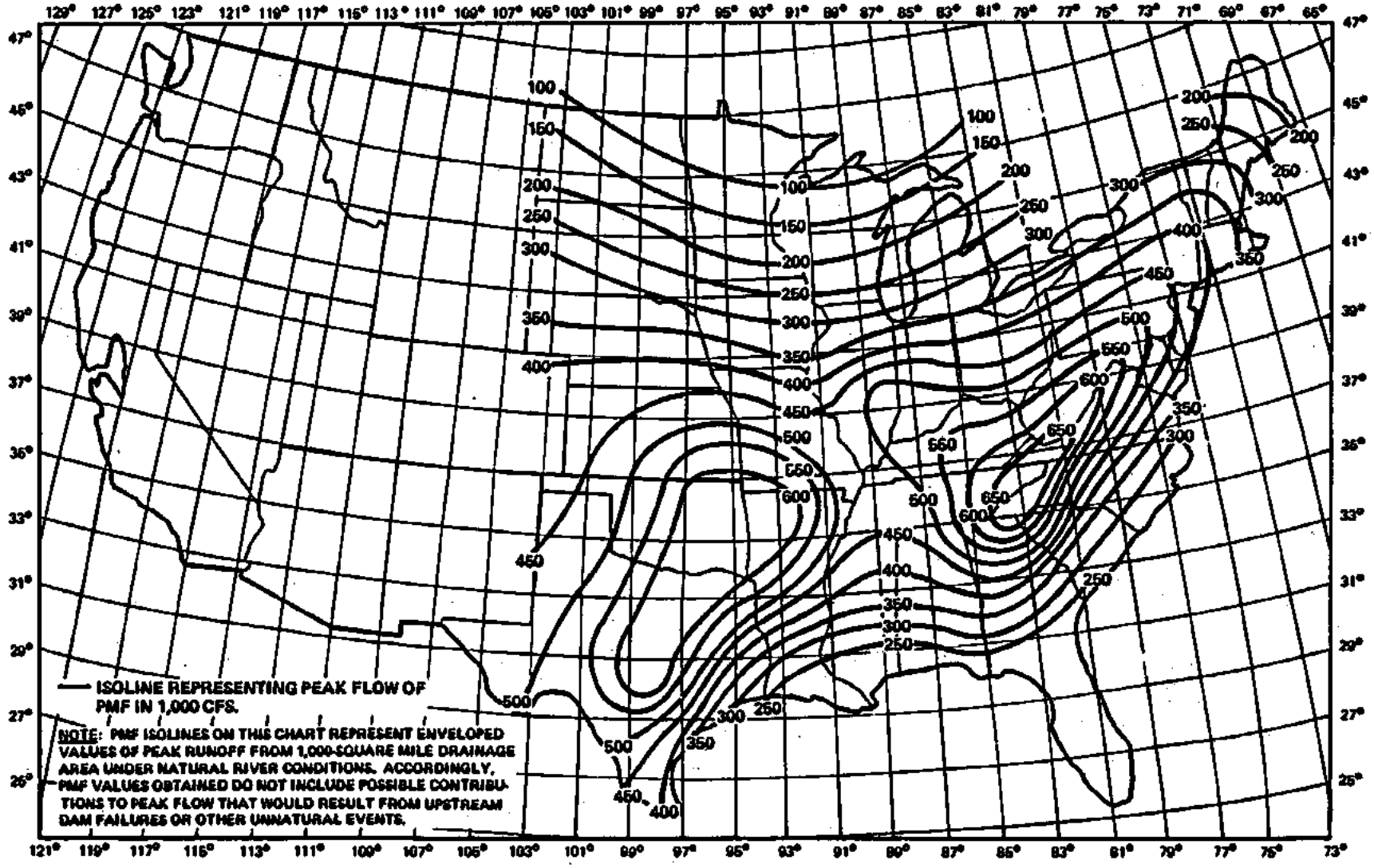


FIGURE B.4 PROBABLE MAXIMUM FLOOD (ENVELOPING PMF ISOLINES) FOR 1,000 SQUARE MILES

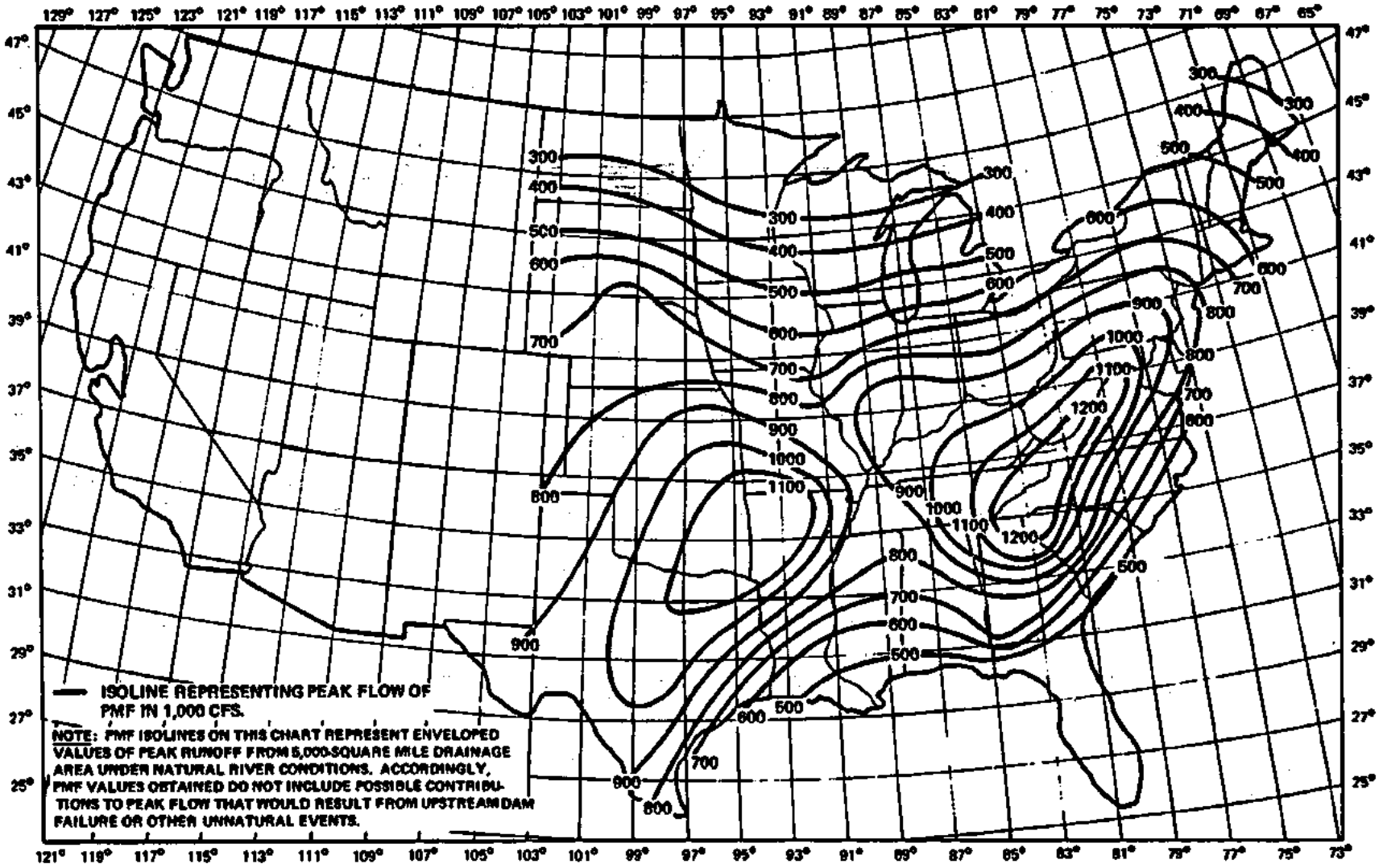


FIGURE B.5 PROBABLE MAXIMUM FLOOD (ENVELOPING PMF ISOLINES) FOR 5,000 SQUARE MILES

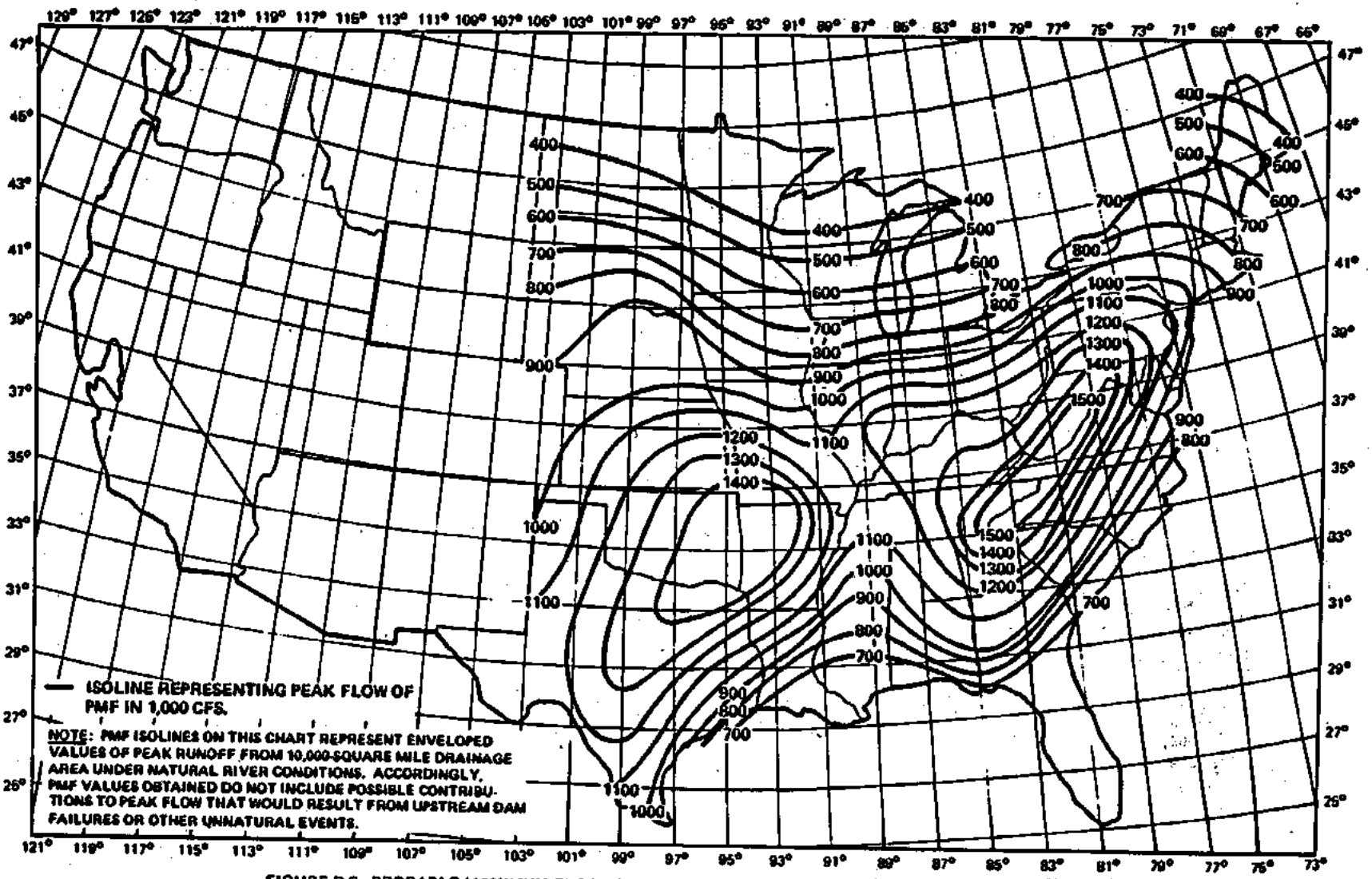


FIGURE B.6 PROBABLE MAXIMUM FLOOD (ENVELOPING PMF ISOLINES) FOR 10,000 SQUARE MILES

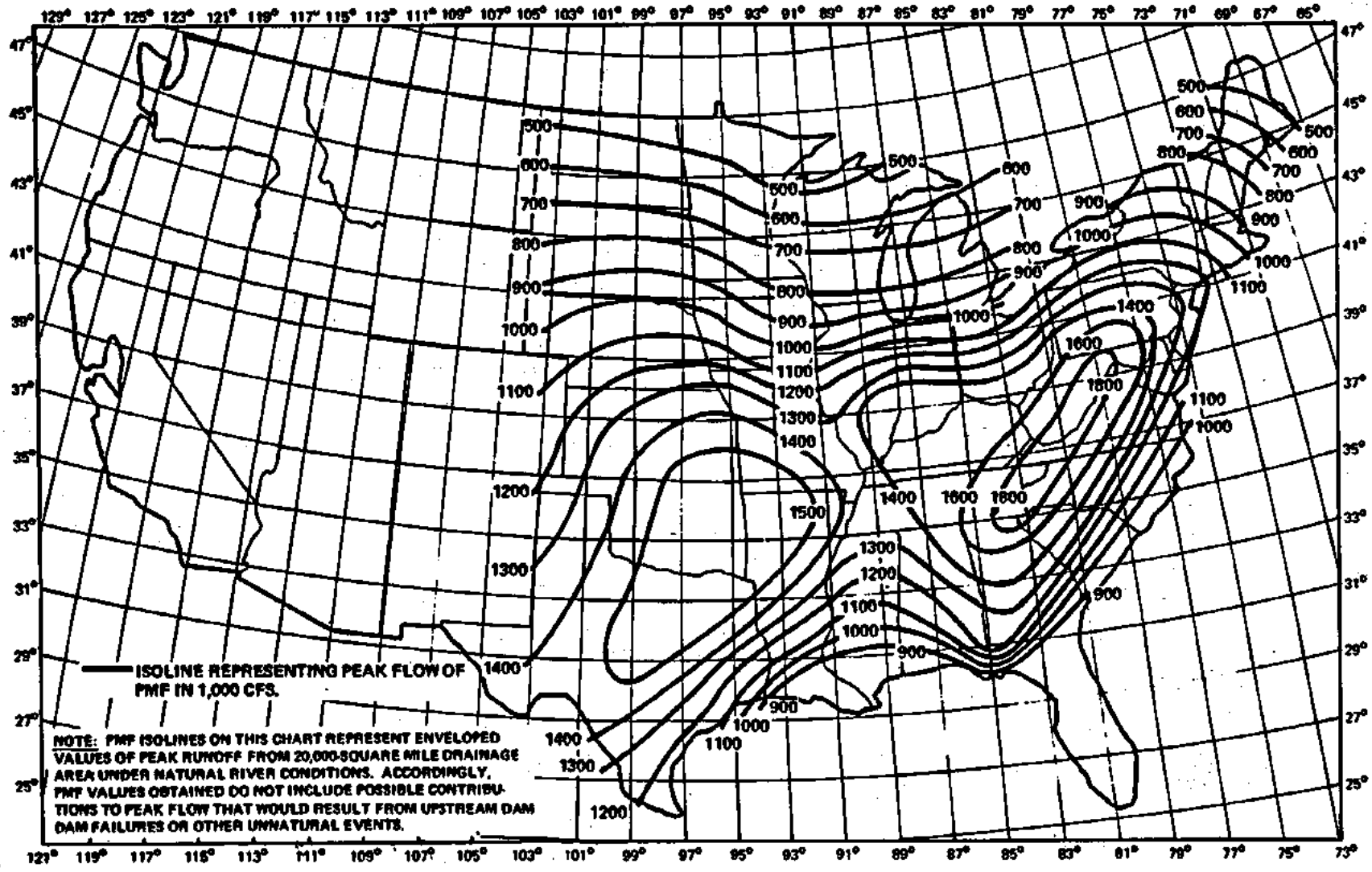


FIGURE 8.7 PROBABLE MAXIMUM FLOOD (ENVELOPING PMF ISOLINES) FOR 20,000 SQUARE MILES

1.59-21

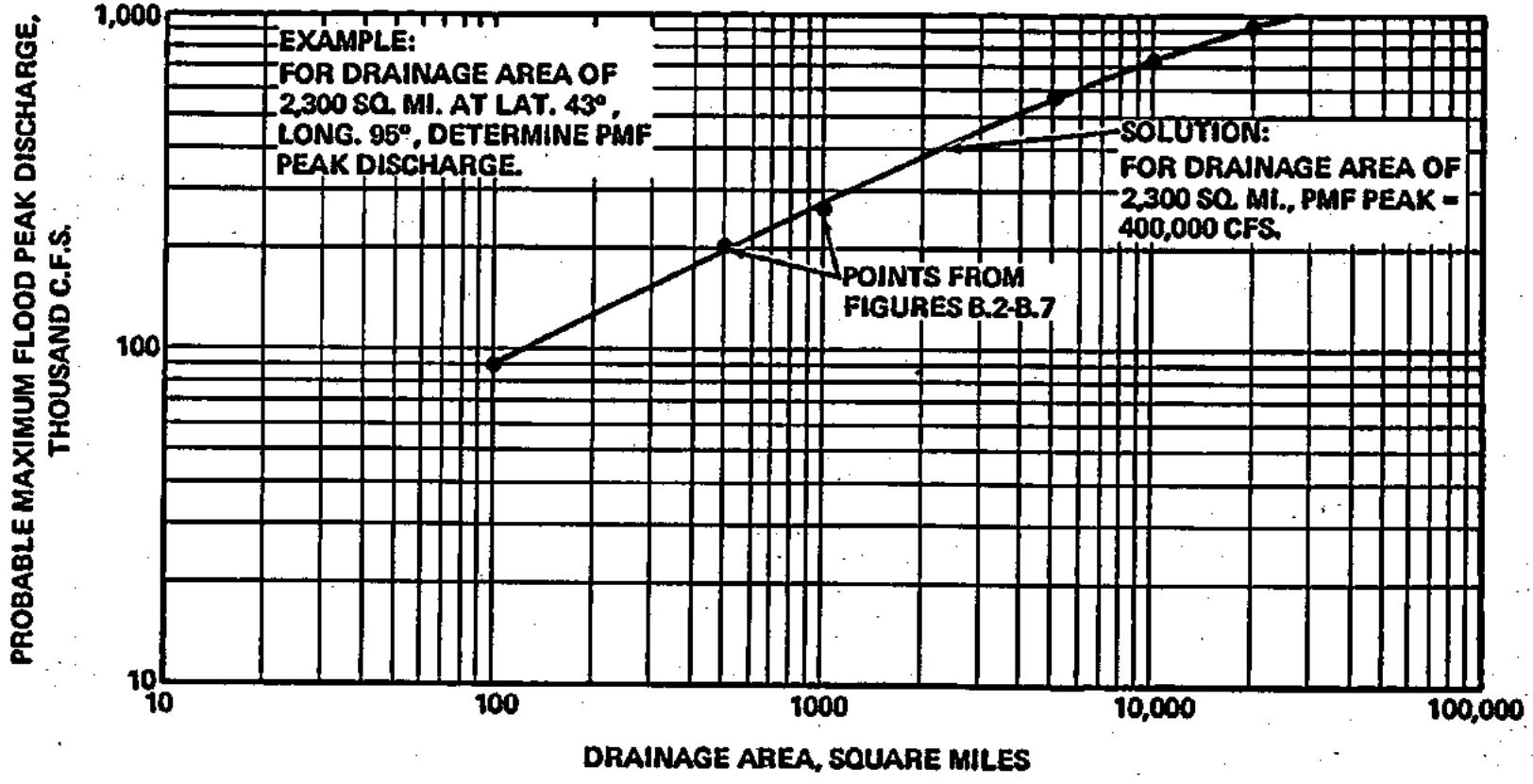


FIGURE B.8 EXAMPLE OF USE OF ENVELOPING ISOLINES

TABLE B.1

PROBABLE MAXIMUM FLOOD DATA (Page 1 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
North Atlantic Region (Northeast Atlantic Sub-region)							
Ball Mountain	Vt.	Connecticut	West River	172	20.6	18.1	190,000
Barre Falls	Mass.	Connecticut	Ware River	55	20.1	18.9	61,000
Beaver Brook	N. H.	Connecticut	Beaver Brook	6.0	21.3	19.7	10,400
Birch Hill	Mass.	Connecticut	Millers River	175	18.3	17.1	88,500
Black Rock	Conn.	Housatonic	Branch Brook	20	22.2	20.6	35,000
Blackwater	N. H.	Merrimack	Blackwater River	128	18.3	16.4	95,000
Buffumville	Mass.	Thames	Little River	26	26.6	25.3	36,500
Colebrook	Conn.	Connecticut	Farmington River	118	22.7	21.1	165,000
Conant Brook	Mass.	Connecticut	Conant Brook	7.8	24.4	23.2	11,900
East Barre	Vt.	Winooski	Jail Branch	39	21.5	18.6	52,500
East Branch	Conn.	Housatonic	Naugatuck River	9.2	24.0	22.8	15,500
East Brimfield	Mass.	Thames	Quinebaug River	68	24.2	22.9	73,900
Edward McDowell	N. H.	Merrimack	Nubanusit River	44	19.5	18.3	43,000
Everett	N. H.	Merrimack	Piscataquog River	64	20.7	18.2	68,000
Franklin Falls	N.H.	Merrimack	Pemigewasset River	1,000	15.8	13.3	300,000
Hall Meadow	Conn.	Connecticut	Hall Meadow Brook	17	24.0	22.8	26,600
Hancock	Conn.	Housatonic	Hancock Brook	12	24.0	22.8	20,700
Hodges Village	Mass.	Thames	French River	31	26.2	22.3	35,600
Hop Brook	Conn.	Housatonic	Hop Brook	16	25.0	23.8	26,400
Hopkinton	N. H.	Merrimack	Contoocook River	426	17.4	14.7	135,000
Knightville	Mass.	Connecticut	Westfield River	162	18.8	17.6	160,000
Littleville	Mass.	Connecticut	Westfield River	52	25.1	22.4	98,000
Mad River	Conn.	Connecticut	Mad River	18	24.0	22.8	30,000
Mansfield Hollow	Conn.	Thames	Natchaug River	159	19.8	18.5	125,000
Nookagee	Mass.	Merrimack	Phillips Brook	11	21.8	20.2	17,750
Northfield	Conn.	Housatonic	Northfield Brook	5.7	24.4	23.2	9,000
North Hartland	Vt.	Connecticut	Ottauquechee River	220	19.3	17.2	199,000
North Springfield	Vt.	Connecticut	Black River	158	20.0	18.3	157,000
Otter Brook	N. H.	Connecticut	Otter Brook	47	19.1	17.9	45,000
Phillips	Mass.	Merrimack	Phillips Brook	5.0	24.2	23.0	7,700
Sucker Brook	Conn.	Connecticut	Sucker Brook	3.4	22.4	21.4	6,500
Surry Mountain	N. H.	Connecticut	Ashuelot River	100	22.2	19.6	63,000
Thomaston	Conn.	Housatonic	Naugatuck River	97	24.5	22.4	158,000

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
Townshend	Vt.	Connecticut	West River	278	21.3	17.2	228,000
Trumbull	Conn.	Pequonnock	Pequonnock River	14	23.0	21.8	26,700
Tully	Mass.	Connecticut	Tully River	50	20.0	16.6	47,000
Union Village	Vt.	Connecticut	Ompompanoosuc River	126	17.0	15.8	110,000
Vermont-Yankee	Vt.	Connecticut	Connecticut River	6,266			480,000
Waterbury	Vt.	Winooski	Waterbury River	109	18.9	16.0	128,000
West Hill	Mass.	Blackstone	West River	28	28.0	25.6	26,000
West Thompson	Conn.	Thames	Quinebaug River	74	20.4	17.5	85,000
Westville	Mass.	Thames	Quinebaug River	32	25.4	22.8	38,400
Whitemanville	Mass.	Merrimack	Whitman River	18	21.4	19.8	25,000
Wrightsville	Vt.	Winooski	North Branch	68	20.2	17.3	74,000
		North Atlantic Region (Mid-Atlantic Sub-region)					
Almond	N. Y.	Susquehanna	Canacadea Creek	56	22.0	18.8	59,000
Alvin R. Bush	Pa.	Susquehanna	Kettle Creek	226	24.0	21.1	154,000
Aquashicola	Pa.	Delaware	Aquashicola Creek	66	28.0	24.2	42,500
Arkport	N. Y.	Susquehanna	Canister River	31	22.5	17.7	33,400
Aylesworth	Pa.	Susquehanna	Aylesworth Creek	6.2	23.8	22.0	13,700
Baird	W. Va.	Potomac	Buffalo Creek	10	34.0	30.2	14,600
Beltzville	Pa.	Delaware	Pohopoco Creek	97	27.1	25.6	68,000
Bloomington	Md.	Potomac	North Branch	263	22.2	17.6	196,000
Blue Marsh	Pa.	Delaware	Tulpehockan Creek	175	24.0	21.3	110,600
Burketown	Va.	Potomac	North River	375	24.3	21.2	272,200
Cabins	W. Va.	Potomac	South Branch	314	20.8	16.8	195,900
Chambersburg	Md.	Potomac	Conococheague River	141	28.9	26.0	81,400
Christiana	Del.	Delaware	Christiana River	41	32.1	28.3	39,200
Cootes Store	Va.	Potomac	North Fork River	215	22.5	19.1	140,200
Cowanesque	Pa.	Susquehanna	Cowanesque River	298	21.9	18.5	285,000
Curwensville	Pa.	Susquehanna	Susquehanna River	365	22.0	18.9	205,000
Dawsonville	Md.	Potomac	Seneca Creek	101	29.4	27.1	161,900
Douglas Point	Md.	Potomac	Potomac River	13,117	13.4	10.2	1,490,000
East Sidney	N. Y.	Susquehanna	Oulelot River	102	24.0	22.1	99,900
Edes Fort	W. Va.	Potomac	Cacapon River	679	21.2	17.3	410,800
Fairview	Md.	Potomac	Conococheague Creek	494	22.9	18.8	150,100
Foster Joseph Sayers	Pa.	Susquehanna	Bald Eagle Creek	339	21.8	19.0	251,000
Francis E. Walter	Pa.	Delaware	Lehigh River	288	22.4	19.8	170,000

TABLE B.1 (Page 3 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
Franklin	W. Va.	Potomac	South Branch	182	24.2	20.6	174,000
Frederick	Md.	Potomac	Monocacy River	817	23.2	20.9	363,400
Front Royal	Va.	Potomac	S.Fk.Shenandoah River	1,638	18.0	14.3	419,000
Fulton (Harrisburg)	Pa.	Susquehanna	Susquehanna River	24,100	12.7	8.2	1,750,000
Gathright	Va.	James	Jackson River	344	24.4	21.3	246,000
Gen. Edgar Jadwin	Pa.	Delaware	Dyberry Creek	65	24.8	24.0	119,700
Great Cacapon	W. Va.	Potomac	Cacapon River	677	21.2	17.3	373,400
Harriston	Va.	Potomac	South River	222	29.6	26.5	153,700
Hawk Mountain	Pa.	Delaware	E.Br. Delaware River	812	16.5	12.7	202,000
Headsville	W. Va.	Potomac	Patterson Creek	219	23.4	19.0	176,000
John H. Kerr	Va.	Roanoke	Roanoke River	7,800	16.8	12.9	1,000,000
Karo	W. Va.	Potomac	South Branch	1,577	18.9	14.9	430,000
Keyser	W. Va.	Potomac	North Branch	495	21.5	16.3	279,200
Kitzmiller	Md.	Potomac	North Branch	225	22.3	17.1	120,200
Leesburg	Va.	Potomac	Goose Creek	338	26.5	24.2	340,900
Lewistown	Md.	Potomac	Fishing Creek	7.1	34.8	32.7	12,200
Licking Creek	W. Va.	Potomac	Licking Creek	158	29.0	26.1	125,800
Little Cacapon	W. Va.	Potomac	Little Cacapon River	101	29.7	27.4	122,700
Maiden Creek	Pa.	Delaware	Maiden Creek	161	27.3	23.5	118,000
Martinsburg	W. Va.	Potomac	Opequon Creek	272	27.2	24.1	174,600
Mikville	W. Va.	Potomac	Shenandoah River	3,040	16.2	11.7	592,000
Moorefield	W. Va.	Potomac	South Branch	1,173	18.0	14.0	389,700
Moorefield	W. Va.	Potomac	So. Fk. South Branch	283	21.1	17.1	173,800
Newark	Del.	Delaware	White Clay River	66	29.8	26.0	103,000
North Anna	Va.	Pamunkey(York)	North Anna River	343	25.0	21.3	220,000
North Mountain	W. Va.	Potomac	Back Creek	231	27.9	24.8	256,000
Peach Bottom	Pa.	Susquehanna	Susquehanna River	27,000	12.7	8.2	1,750,000
Perryman	Md.	Chesapeake Bay	Bush River	118			87,400
Petersburg	W. Va.	Potomac	South Branch	642	19.3	15.3	208,700
Philpott	Va.	Roanoke	Smith River	212	27.5	24.3	160,000
Prompton	Pa.	Delaware	Lackawaxen River	60	25.0	24.2	87,190
Raystown	Pa.	Susquehanna	Juniata River (Br.)	960	21.4	17.5	353,400
Royal Glen	Md.	Potomac	South Branch	640	19.3	15.3	208,700
Salem Church	Va.	Rappahannock	Rappahannock River	1,598	23.6	19.6	552,000
Savage River	Md.	Potomac	Savage River	105	26.3	22.2	107,400
Seneca	Md.	Potomac	Potomac River	11,400	13.5	10.3	1,393,000
Sharpsburg	Md.	Potomac	Antietem Creek	281	26.6	23.5	154,900

TABLE B.1 (Page 4 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
Sherrill Drive	Md.	Potomac	Rock Creek	62	30.6	28.3	111,900
Six Bridge	Md.	Potomac	Monocacy River	308	27.1	24.0	225,000
Springfield	W. Va.	Potomac	South Branch	1,471	17.5	15.5	405,000
Staunton	Va.	Potomac	South Branch Shen.	325	25.0	21.3	226,000
Stillwater	Pa.	Susquehanna	Lacawanna River	37	27.3	24.1	39,600
Summit	N. J.	Delaware	Delaware River	11,100			1,000,000
Surry	Va.	James	James River	9,517			1,000,000
Tioga-Hammond	Pa.	Susquehanna	Tioga River	402	23.5	19.2	318,000
Tocks Island	N. J.	Delaware	Delaware River	3,827	13.3	10.5	576,300
Tonoloway	Md.	Potomac	Tonoloway Creek	112	29.9	26.8	117,600
Town Creek	Md.	Potomac	Town Creek	144	27.5	25.2	102,900
Trenton	N. J.	Delaware	Delaware River	6,780			830,000
Trexler	Pa.	Delaware	Jordon Creek	52	25.2	22.6	55,500
Tri-Towns	W. Va.	Potomac	North Branch	478	21.6	16.4	268,000
Verplanck	N. Y.	Hudson	Hudson River	12,650	14.0	9.7	1,100,000
Washington, D. C.	Md.	Potomac	Potomac River	11,560	13.4	10.2	1,280,000
Waynesboro	Va.	Potomac	South River	136	29.6	26.5	116,000
West Branch	W. Va.	Potomac	Conococheague River	78	30.7	27.0	78,700
Whitney Point	N. Y.	Susquehanna	Otselic River	255	20.7	19.1	102,000
Winchester	Va.	Potomac	Opequon Creek	120	28.9	25.8	142,100
York Indian Rock	Pa.	Susquehanna	Codorus Creek	94	22.1	17.7	74,300
			South Atlantic-Gulf Region				
Allatoona	Ga.	Alabama-Coosa	Etowah River	1,110	22.2	19.8	440,000
Alvin W. Vogtle	Ga.	Savannah	Savannah River	6,144	21.8	14.5	1,001,000
Bridgewater	N. C.	Santee	Catawba River	380			187,000
Buford	Ga.	Apalachicola	Chattahoochee River	1,040	21.7	19.7	428,900
Carters	Ga.	Alabama-Coosa	Coosawattee River	376	26.6	22.3	203,100
Catawba	N. C.	Santee	Catawba River	3,020		16.6	674,000
Cherokee	N. C.	Congaree-Santee	Broad River	1,550			560,000
Claiborne	Ala.	Alabama-Coosa	Alabama River	21,520	14.9	12.3	682,500
Clark Hill	Ga.	Savannah	Savannah River	6,144	21.8	14.5	1,140,000
Coffeeville	Ala.	Tombigbee	Black Warrior River	18,600	13.6	11.2	743,400
Cowans Ford	N. C.	Santee	Catawba River	1,790			636,000
Demopolis	Ala.	Tombigbee	Tombigbee River	15,300	16.7	14.3	1,068,000
Falls Lake	N. C.	Neuse	Neuse River	760	23.2	21.2	323,000

TABLE B.1 (Page 5 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
Gainsville	Ala.	Tombigbee	Tombigbee River	7,142	19.6	16.8	702,400
Hartwell	Ga.	Savannah	Savannah River	2,088	24.8	18.8	875,000
Holt	Ala.	Warrior	Warrior River	4,232	22.1	19.2	650,000
Howards Mill	N. C.	Cape Fear	Deep River	626	26.8	24.2	305,000
Jim Woodruff	Fla.	Apalachicola	Apalachicola River	17,150	17.6	12.3	1,133,800
John H. Bankhead	Ala.	Tombigbee	Black Warrior River	3,900	22.3	19.4	670,300
Jones Bluff	Ala.	Alabama	Alabama River	16,300	14.2	11.6	664,000
Lazer Creek	Ga.	Apalachicola	Lazer Creek	1,410	24.6	20.7	303,600
Lookout Shoals	N. C.	Santee	Catawba River	1,450			492,000
Lower Auchumpkee	Ga.	Apalachicola	Flint River	1,970	23.7	19.8	355,600
McGuire	N. C.	Santee	Catawba River	1,770			750,000
Millers Ferry	Ala.	Alabama	Alabama River	20,700	14.7	12.1	844,000
Mountain Island	N. C.	Santee	Catawba River	1,860			362,000
New Hope	N. C.	Cape Fear	New Hope River	1,690	22.0	19.4	511,000
Oconee	S. C.	Savannah	Keowee River	439	26.5	23.5	450,000
Oconee	S. C.	Savannah	Little River	148		26.6	245,000
Okatibbee	Miss.	Pascagoula	Okatibbee Creek	154	33.0	28.4	87,700
Oxford	N. C.	Santee	Catawba River	1,310			479,000
Perkins	N. C.	Pee Dee	Yadkin River	2,473			440,600
Randleman	N. C.	Cape Fear	Deep River	169	28.6	26.0	126,000
Reddies	N. C.	Pee Dee	Reddies River	94	28.0	24.8	174,200
Rhodhiss	N. C.	Santee	Catawba River	1,090			379,000
Shearon Harris	N. C.	Cape Fear	White Oak Creek	79			163,500
Sprewell Bluff	Ga.	Apalachicola	Flint River	1,210	25.8	21.3	318,000
Trotters Shoals	Ga.	Savannah	Savannah River	2,900	24.0	19.1	800,000
Walter F. George	Ga.	Apalachicola	Chattahoochee River	7,460	16.6	15.2	843,000
Warrior	Ala.	Tombigbee	Black Warrior River	5,828	19.5	16.6	554,000
West Point	Ga.	Apalachicola	Chattahoochee River	3,440	21.9	17.4	440,000
W. Kerr Scott	N. C.	Pee Dee	Yadkin River	348	25.6	21.5	318,000
			Great Lakes Region				
Bedford	Ohio	Cuyahoga	Tinkers Creek	91	28.6	25.9	79,000
Bristol	N. Y.	Oswego	Mud Creek	29	29.9	28.1	64,900
Fall Creek	N. Y.	Oswego	Fall Creek	123	17.1	16.1	63,400
Ithaca	N. Y.	Oswego	Six Mile Creek	43	26.9	25.1	77,900
Jamesville	N. Y.	Oswego	Buttermut Creek	37	26.0	24.1	35,200
Linden	N. Y.	Niagara	Little Tonawanda Creek	22	30.8	29.0	64,400

TABLE 8.1 (Page 6 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
Mount Morris	N. Y.	Genesee River	Genesee River	1,077	17.0	14.6	385,000
Onondago	N. Y.	Lake Ontario	Onondago Creek	68	24.2	23.3	61,800
Oran	N. Y.	Oswego	Limestone Creek	47	25.1	23.4	80,790
Portageville	N. Y.	Genesee	Genesee River	983	17.8	15.8	359,000
Quanicassee	Mich.	Saginaw Bay	Saginaw River	6,260			440,000
Quanicassee	Mich.	Saginaw Bay	Tittabawassee River	2,400			270,000
Quanicassee	Mich.	Saginaw Bay	Quanicassee River	70			46,000
Standard Corners	N. Y.	Genesee	Genesee River	265	22.3	20.3	189,900
			Ohio Region				
Alum Creek	Ohio	Ohio	Alum Creek	123	24.6	21.8	110,000
Barkley	Ky.	Ohio	Cumberland River	8,700	22.6	21.5	1,000,000
Barren	Ky.	Ohio	Barren River	940	17.6	16.9	531,000
Beaver Valley	Pa.	Ohio	Ohio River	23,000			1,500,000
Beech Fork	W. Va.	Ohio	Twelve Pole Creek	78	26.4	23.5	84,000
Big Blue	Ind.	Ohio	Big Blue River	269	23.5	21.2	161,000
Big Darby	Ohio	Ohio	Big Darby Creek	441	24.1	21.3	294,000
Big Pine	Ind.	Ohio	Big Pine Creek	326	22.4	20.4	174,000
Big Walnut	Ind.	Ohio	Big Walnut Creek	197	24.0	22.0	144,000
Birch	W. Va.	Ohio	Birch River	142	28.4	25.2	102,000
Bluestone	W. Va.	Ohio	New River	4,565		13.8	410,000
Booneville	Ky.	Ohio	So. Fk. Kentucky River	665	23.2	21.0	425,000
Brookville	Ind.	Ohio	Whitewater River	379	24.2	22.1	272,000
Buckhorn	Ky.	Ohio	N. Fk.Kentucky River	408	23.8	21.5	239,000
Burnsville	W. Va.	Ohio	Little Kanawha River	165	24.8	22.3	138,800
Caesar Creek	Ohio	Ohio	Caesar Creek	237	24.1	21.9	230,200
Cagles Mill	Ind.	Ohio	Mill Creek	295	24.6	22.7	159,000
Carr Fork	Ky.	Ohio	No. Fk. Kentucky River	58	27.4	25.0	132,500
Cave Run	Ky.	Ohio	Licking River	826	22.8	20.6	510,000
Center Hill	Tenn.	Ohio	Caney Fork	2,174	22.3	21.8	696,000
Clarence J. Brown	Ohio	Ohio	Buck Creek	82	29.0	26.7	121,000
Claytor	Va.	Ohio	New River	2,382	22.3	18.0	1,109,000
Clifty Creek	Ind.	Ohio	Clifty Creek	145	24.9	23.0	112,900
Dale Hollow	Tenn.	Ohio	Obey River	935	23.8	23.3	435,000
Deer Creek	Ohio	Ohio	Deer Creek	278	22.9	20.1	160,000
Delaware	Ohio	Ohio	Olentangy River	381	22.7	20.4	296,000
Dewey	Ky.	Ohio	Big Sandy River	207	25.0	22.6	75,500

TABLE B.1 (Page 7 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
Dillon	Ohio	Ohio	Licking River	748	19.8	16.3	246,000
Dyes	Ohio	Ohio	Dyes Fork	44	30.7	27.8	49,500
Eagle Creek	Ky.	Ohio	Eagle Creek	292	24.7	22.1	172,800
E. Br. Clarion	Pa.	Ohio	E. Br. Clarion River	72	22.7	18.9	41,500
East Fork	Ohio	Ohio	E. Fk. Little Miami River	342	23.8	21.2	313,200
East Lynn	W. Va.	Ohio	Twelve Pole Creek	133	29.4	26.5	72,000
Fishtrap	Ky.	Ohio	Levisa Fk. Sandy River	395	26.1	23.2	320,000
Grayson	Ky.	Ohio	Little Sandy River	196	27.5	24.7	83,300
Green River	Ky.	Ohio	Green River	682	26.5	23.9	409,000
Helm	Ill.	Ohio	Skillet Fk. Wabash River	210	24.8	22.6	152,800
John W. Flannagan	Va.	Ohio	Pound River	222	27.6	24.9	235,800
J. Percy Priest	Tenn.	Ohio	Stones River	892	25.9	18.8	430,000
Kehoe	Ky.	Ohio	Tygarts Creek	127	26.0	23.4	105,900
Kinzua	Pa.	Ohio	Allegheny River	2,180	16.4	12.8	115,000
Lafayette	Ind.	Ohio	Wildcat Creek	791	20.6	18.5	182,000
Laurel	Ky.	Ohio	Laurel River	282	25.9	20.7	120,000
Leading Creek	W. Va.	Ohio	Leading Creek	146	25.0	22.5	131,000
Lincoln	Ill.	Ohio	Embarras River	915	21.2	19.0	502,000
Logan	Ohio	Ohio	Clear Creek	84	29.5	27.0	78,000
Louisville	Ill.	Ohio	Little Wabash River	661	22.1	19.9	310,000
Mansfield	Ind.	Ohio	Raccoon Creek	216	25.9	23.0	175,800
Martins Fork	Ky.	Ohio	Cumberland River	56	27.9	22.7	61,800
Meigs	Ohio	Ohio	Meigs Creek	72	29.5	26.6	72,100
Meigs	Ohio	Ohio	Meigs Creek	27	32.2	29.3	45,500
Mill Creek	Ohio	Ohio	Mill Creek	181	24.0	21.4	92,000
Mississinewa	Ind.	Ohio	Mississinewa River	809	20.6	18.4	196,000
Michael J. Kirwin	Ohio	Ohio	Mahoning River	80	26.0	20.1	51,800
Monroe	Ind.	Ohio	Salt Creek	441	25.9	25.4	366,000
Muddy Creek	Pa.	Ohio	Muddy Creek	61	22.8	19.6	59,300
Nolin	Ky.	Ohio	Nolin River	703	14.2	13.2	158,000
N. Br. Kokosing	Ohio	Ohio	N. Br. Kokosing River	44	25.4	22.6	50,000
N. Fk. Pound River	Va.	Ohio	N. Fk. Pound River	18	35.3	32.2	51,200
Paint Creek	Ohio	Ohio	Paint Creek	573	21.8	18.8	305,000
Paintsville	Ky.	Ohio	Paint Creek	92	26.3	23.8	77,500
Panthers Creek	W. Va.	Ohio	Panther Creek	24	36.7	33.9	59,800
Patoka	Ind.	Ohio	Patoka River	168	25.6	23.5	292,000
R. D. Bailey	W. Va.	Ohio	Guyandotte River	540	23.1	20.3	349,000
Rough River	Ky.	Ohio	Rough River	454	27.6	25.1	358,000

TABLE B.1 (Page 8 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
Rowlesburg	W. Va.	Ohio	Cheat River	936	21.2	18.4	331,000
Salamonia	Ind.	Ohio	Salamonia River	553	21.3	19.0	201,000
Stonewall Jackson	W. Va.	Ohio	West Fork River	102	24.?	22.2	85,500
Summersville	W. Va.	Ohio	Gauley River	803	23.8	21.1	412,000
Sutton	W. Va.	Ohio	Elk River	537	20.4	20.4	222,400
Taylorville	Ky.	Ohio	Salt River	353	24.8	22.2	426,000
Tom Jenkins	Ohio	Ohio	Hocking River	33	26.?	25.8	43,000
Union City	Pa.	Ohio	French Creek	222	20.3	17.8	87,500
Utica	Ohio	Ohio	N. Fk. Licking River	112	24.7	22.1	73,700
West Fork	W. Va.	Ohio	W. Fk. Little Kanawha	238	24.4	21.8	156,400
West Fk. Mill Ck.	Ohio	Ohio	Mill Creek	30	31.9	30.0	81,600
Whiteoak	Ohio	Ohio	Whiteoak Creek	214	24.5	21.6	134,000
Wolf Creek	Ky.	Ohio	Cumberland River	5,789	20.6	20.0	996,000
Woodcock	Pa.	Ohio	Woodcock Creek	46	23.5	20.9	37,700
Yatesville	Ky.	Ohio	Blaine Creek	208	25.2	22.6	118,000
Youghiogheny	Pa.	Ohio	Youghiogheny River	434		25.4	151,000
Zimmer, Wm. H.	Ohio	Ohio	Ohio River	70,800			2,150,000
			Tennessee Region				
Bellefonte	Ala.	Ohio	Tennessee River	23,340			1,160,000
Browns Ferry	Tenn.	Ohio	Tennessee River	27,130			1,200,000
Sequoyah	Tenn.	Ohio	Tennessee River	20,650			1,205,000
			Upper Mississippi Region				
Ames	Iowa	Upper Miss.	Skunk River	314	21.3	18.4	87,200
Byron	Ill.	Upper Miss.	Rock River	8,000			308,000
Bear Creek	Mo.	Upper Miss.	Bear Creek	28	29.0	26.2	38,000
Blue Earth	Minn.	Upper Miss.	Minnesota River	11,250	14.2	10.9	283,000
Blue Earth	Minn.	Upper Miss.	Blue Earth River	3,550	18.4	14.8	206,000
Carlyle	Ill.	Upper Miss.	Kaskaskia River	2,680	19.2	15.8	246,000
Clarence Cannon	Mo.	Upper Miss.	Salt River	2,318	21.8	15.7	476,200
Clinton	Ill.	Upper Miss.	Salt Creek	296			99,500
Coralville	Iowa	Upper Miss.	Iowa River	3,084	20.8	14.4	326,000
Duane Arnold	Iowa	Upper Miss.	Cedar River	6,250			316,000
Farmdale	Ill.	Upper Miss.	Farm Creek	26	24.0	22.1	67,300
Fondulac	Ill.	Upper Miss.	Fondulac Creek	5.4	21.4	19.9	21,200
Friends Creek	Ill.	Upper Miss.	Friends Creek	133	27.8	21.6	83,160

TABLE B.1 (Page 9 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
Jefferson	Iowa	Upper Miss.	Raccoon River	1,532	21.7	19.0	267,300
LaFarge	Wisc.	Upper Miss.	Kickapoo River	266	22.8	18.9	128,000
Mankato	Minn.	Upper Miss.	Minnesota River	14,900	13.9	10.6	329,000
Meramec Park	Mo.	Upper Miss.	Meramec River	1,497	22.9	17.5	552,000
Montevideo	Minn.	Upper Miss.	Minnesota River	6,180	15.2	11.6	263,000
Monticello	Minn.	Upper Miss.	Mississippi River	13,900			365,000
New Ulm	Minn.	Upper Miss.	Minnesota River	9,500	14.4	11.1	263,000
New Ulm	Minn.	Upper Miss.	Cottonwood River	1,280	21.2	17.6	128,000
Oakley	Ill.	Upper Miss.	Sangamon River	808	23.5	17.2	178,000
Prairie Island	Minn.	Upper Miss.	Mississippi River	44,755			910,000
Red Rock	Iowa	Upper Miss.	Des Moines River	12,323	12.1	7.5	613,000
Rend	Ill.	Upper Miss.	Big Muddy River	488	27.5	21.5	308,200
Saylorville	Iowa	Upper Miss.	Des Moines River	5,823	13.8	10.3	277,800
Shelbyville	Ill.	Upper Miss.	Kaskaskia River	1,030	22.1	19.1	142,000
			Lower Mississippi Region				
Arkabutla	Miss.	Lower Miss.	Coldwater River	1,000	22.5	21.2	430,000
Enid	Miss.	Lower Miss.	Yacona River	560	25.4	24.7	204,900
Grenada	Miss.	Lower Miss.	Yalobusha River	1,320	24.0	23.1	390,800
Sardis	Miss.	Lower Miss.	Tallahatchia River	1,545	32.5	26.0	290,400
Union	Mo.	Lower Miss.	Bourbeuse River	771	25.0	19.9	264,000
Wappapello	Mo.	Lower Miss.	St. Francis River	1,310	13.9	11.7	344,000
			Souris-Red-Rainy Region				
Burlington	N. D.	Souris	Souris River	9,490	13.2	5.7	89,100
Fox Hole	N. D.	Souris	Des Lacs River	939	19.9	12.4	52,700
Homme	N. D.	Red of North	Park River	229	15.2	12.3	35,000
Kindred	N. D.	Red of North	Sheyenne River	3,020	13.4	8.6	58,700
Lake Ashtabula	N. D.	Red of North	Sheyenne River	983	12.4	9.5	86,500
Orwell	Minn.	Red of North	Otter Tail River	1,820	17.1	14.7	25,500
			Missouri Region				
Bear Creek	Colo.	Missouri	Bear Creek	236	24.4	6.7	225,000
Big Bend	S. D.	Missouri	Missouri River	5,840		9.0	725,000
Blue Springs	Mo.	Missouri	Blue Springs Creek	33	26.5	23.8	42,400
Blue Stem	Nebr.	Missouri	Olive Br. Salt Creek	17	25.0	21.7	69,200
Bowman-Haley	N. D.	Missouri	Grand River	446	15.5	12.7	110,000
Branched Oak	Nebr.	Missouri	Oak Creek	89	20.1	16.8	93,600

TABLE B.1 (Page 10 of 17)

Project	State	River Basin	Stream	Drainage Area (sq. mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
Braymer	Mo.	Missouri	Shoal Creek	390	24.7	22.2	173,800
Brookfield	Mo.	Missouri	West Yellow Creek	140	24.5	22.0	64,500
Bull Hook	Mont.	Missouri	Bull Hook Creek	54		10.8	26,200
Chatfield	Colo.	Missouri	South Platte River	3,018	13.2	2.0	584,500
Cherry Creek	Colo.	Missouri	Cherry Creek	385	23.9	9.5	350,000
Clinton	Kans.	Missouri	Wakarusa River	367	23.6	22.4	153,500
Cold Brook	S. D.	Missouri	Cold Brook	70		6.4	95,700
Conestoga	Nebr.	Missouri	Holmes Creek	15	25.2	21.9	52,000
Cottonwood Springs	S. D.	Missouri	Cheyenne River	26	18.7	11.1	74,700
Dry Fork	Mo.	Missouri	Fishing River	3.2	26.1	22.5	19,460
East Fork	Mo.	Missouri	Fishing River	19	25.7	24.1	62,700
Fort Scott	Kans.	Missouri	Marmaton River	279	23.8	22.7	198,000
Fort Peck	Mont.	Missouri	Missouri River	57,725		3.2	360,000
Fort Randall	S. D.	Missouri	Missouri River	14,150		3.7	849,000
Fort St. Vrain	Colo.	Missouri	South Platte River	4,700			500,000
Garrison	N. D.	Missouri	Missouri River	123,215		2.7	1,026,000
Gavins Point	Nebr.	Missouri	Missouri River	16,000		3.3	642,000
Grove	Kans.	Missouri	Soldier Creek	259	23.8	22.7	79,800
Harlan County	Nebr.	Missouri	Republican River	7,141	7.6	2.8	485,000
Harry S. Truman	Mo.	Missouri	Osage River	7,856		13.1	1,060,000
Hillsdale	Kans.	Missouri	Big Bull Creek	144	25.4	24.3	190,500
Holmes	Nebr.	Missouri	Antelope Creek	5.4	27.1	23.8	41,600
Kanopolis	Kans.	Missouri	Smoky Hill River	2,560	6.9	3.6	456,300
Linneus	Mo.	Missouri	Locust River	546	23.7	21.2	242,300
Long Branch	Mo.	Missouri	E. Fk. Little Chariton	109	24.5	21.9	66,500
Longview	Mo.	Missouri	Blue River	50	26.2	23.4	74,800
Melvern	Kans.	Missouri	Marias des Cygnes River	349	23.1	22.1	182,000
Mercer	Mo.	Missouri	Weldon River	427	21.0	17.8	274,000
Milford	Kans.	Missouri	Republican River	3,620	8.8	5.0	757,400
Mill Lake	Mo.	Missouri	Mill Creek	9.5	27.7	26.4	13,000
Oahe	S. D.	Missouri	Missouri River	62,550		6.5	946,000
Olive Creek	Nebr.	Missouri	Olive Br. Salt Creek	8.2	26.0	22.7	36,650
Onag	Kans.	Missouri	Vermillion Creek	301	23.5	22.2	251,000
Pattonsburg	Mo.	Missouri	Grand River	2,232	18.8	16.3	400,100
Pawnee	Nebr.	Missouri	Pawnee Br. Salt Creek	36	23.5	20.2	59,000
Perry	Kans.	Missouri	Delaware River	1,117	21.5	18.4	387,400
Pioneer	Colo.	Missouri	Republican River	918	15.0	8.3	390,000
Pomme de Terre	Mo.	Missouri	Pomme de Terre River	611	23.9	21.6	362,000

TABLE B.1 (Page 11 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
Pomona	Kans.	Missouri	110 Mile Creek	322	26.2	25.2	186,000
Rathbun	Iowa	Missouri	Chariton River	549	23.7	21.1	188,000
Smithville	Mo.	Missouri	Little Platte River	213	23.9	20.2	185,000
Stagecoach	Nebr.	Missouri	Hickman Br. Salt Creek	9.7	26.0	22.7	50,500
Stockton	Mo.	Missouri	Sac River	1,160	19.7	18.9	470,000
Thomas Hill	Mo.	Missouri	Little Chariton River	147	25.0	23.0	79,000
Tomahawk	Kans.	Missouri	Tomahawk Creek	24	26.4	24.8	26,800
Trenton	Mo.	Missouri	Thompson River	1,079	22.6	20.1	342,400
Tuttle Creek	Kans.	Missouri	Big Blue River	9,556	14.5	8.1	798,000
Twin Lakes	Nebr.	Missouri	S. Br. Middle Creek	11	25.9	22.6	56,000
Wagon Train	Nebr.	Missouri	Hickman Br. Salt Creek	16	25.2	21.9	53,500
Wilson	Kans.	Missouri	Saline River	1,917	20.2	10.8	252,000
Wolf-Coffee	Kans.	Missouri	Blue River	45	26.1	24.5	58,000
Yankee Hill	Nebr.	Missouri	Cardwell Br. Salt Creek	8.4	26.0	22.7	58,400
			Arkansas-White-Red Region				
Arcadia	Okla.	Arkansas	Deep Fork River	105	28.5	24.9	144,000
Bayou Bodcau	La.	Red	Bayou Bodcau	656	35.3	33.6	168,700
Beaver	Ark.	White	White River	1,186	24.3	22.4	480,000
Bell Foley	Ark.	Arkansas	Strawberry River	78	26.4	23.5	57,000
Big Hill	Kans.	Arkansas	Big Hill Creek	37	25.4	23.6	47,500
Big Pine	Tex.	Red	Big Pine Creek	95	31.3	29.3	86,000
Birch	Okla.	Arkansas	Birch Creek	66	29.0	26.0	91,000
Blakely Mountain	Ark.	Red	Ouachita River	1,105	21.5	19.6	418,000
Blue Mountain	Ark.	Arkansas	Petit Jean River	500	21.8	18.2	258,000
Boswell	Okla.	Red	Boggy Creek	2,273	27.6	20.8	405,000
Broken Bow	Okla.	Red	Mountain Fork	754	32.5	29.4	569,000
Bull Shoals	Ark.	White	White River	6,036	15.2	13.0	765,000
Candy	Okla.	Arkansas	Candy Creek	43	29.3	27.5	67,500
Canton	Okla.	Arkansas	North Canadian River	7,600	12.4	4.1	371,000
Cedar Point	Kans.	Arkansas	Cedar Creek	119	25.4	22.6	208,000
Clayton	Okla.	Red	Jackfort Creek	275	31.3	29.3	240,000
Clearwater	Mo.	White	Black River	898	16.0	13.8	432,000
Conchas	N. Mex.	Arkansas	South Canadian River	7,409	4.8	3.0	582,000
Cooper	Tex.	Red	South Sulphur River	476	30.9	29.2	194,400
Copan	Okla.	Arkansas	Little Caney River	505	26.2	21.1	169,000
Council Grove	Kans.	Arkansas	Grand River	246	25.5	22.7	250,000
County Line	Mo.	White	James River	153	27.2	25.3	133,000

TABLE B.1 (Page 12 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
DeGray	Ark.	Red	Caddo River	453	28.4	26.0	397,000
Denison	Okla.	Red	Red River	33,783	12.9	6.5	1,830,000
DeQueen	Ark.	Red	Rolling Fork	169	35.5	32.5	254,000
Dierks	Ark.	Red	Saline River	113	36.2	33.2	202,000
Douglas	Kans.	Arkansas	Little Walnut Creek	238	26.7	22.9	156,000
El Dorado	Kans.	Arkansas	Walnut River	234	26.8	22.8	196,000
Elk City	Kans.	Arkansas	Elk River	634	23.0	20.3	319,000
Eufaula	Okla.	Arkansas	Canadian River	8,405	15.9	10.9	700,000
Fall River	Kans.	Arkansas	Fall River	556	27.1	23.0	442,000
Ferrells Bridge	Tex.	Red	Cypress Creek	880	31.1	28.1	367,000
Fort Gibson	Okla.	Arkansas	Grand River	9,477	16.2	12.6	865,000
Fort Supply	Okla.	Arkansas	Wolf Creek	1,494	20.5	15.7	547,000
Gillham	Ark.	Red	Cossatot River	271	34.6	31.5	355,000
Great Salt Plains	Okla.	Arkansas	Salt Fk. Arkansas River	3,200	16.7	9.3	412,000
Greers Ferry	Ark.	Red	Little Red River	1,146	17.9	17.5	630,000
Heyburn	Okla.	Arkansas	Polecat Creek	123	26.3	24.2	151,000
Hugo	Okla.	Red	Kiamichi River	1,709	27.1	25.8	339,000
Hulah	Okla.	Arkansas	Caney River	732	16.5	13.5	239,000
John Martin	Colo.	Arkansas	Arkansas River	18,130	7.4	2.0	630,000
John Redmond	Kans.	Arkansas	Grand River	3,015	18.2	15.6	638,000
Kaw	Okla.	Arkansas	Arkansas River	7,250	14.5	9.9	774,000
Keystone	Okla.	Arkansas	Arkansas River	22,351	12.9	6.7	1,035,000
Lake Kemp	Tex.	Red	Wichita River	2,086	23.7	19.2	566,000
Lukfata	Okla.	Red	Glover Creek	291	34.6	31.5	349,000
Marion	Kans.	Arkansas	Cottonwood River	200	24.8	21.9	160,000
Millwood	Ark.	Red	Little River	4,144	28.4	25.3	442,000
Narrows	Ark.	Red	Little Missouri River	237	25.0	23.0	194,000
Neodesha	Kans.	Arkansas	Verdigris River	1,160	18.7	16.6	287,000
Nimrod	Ark.	Arkansas	Fourche La Fave River	680	20.2	17.2	228,000
Norfolk	Ark.	White	North Fork White River	1,765	15.7	12.8	372,000
Oologah	Okla.	Arkansas	Verdigris River	4,339	17.8	13.9	451,000
Optima	Okla.	Arkansas	North Canadian River	2,341	13.8	9.0	386,000
Pat Mayse	Tex.	Red	Sanders Creek	175	31.8	29.4	150,000
Pine Creek	Okla.	Red	Little River	635	32.8	29.8	523,000
Robert S. Kerr	Okla.	Arkansas	Arkansas River	64,386	10.0	5.8	1,884,000
Sand	Okla.	Arkansas	Sand Creek	137	31.3	28.3	154,000
Shidler	Okla.	Arkansas	Salt Creek	99	27.3	24.0	104,100
Skiatook	Okla.	Arkansas	Hominy Creek	354	27.8	23.8	147,800
Table Rock	Mo.	White	White River	4,020	18.3	15.4	657,000

TABLE B.1 (Page 13 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
Tenkiller Ferry	Okla.	Arkansas	Illinois River	1,610	20.4	17.6	406,000
Texarkana	Tex.	Red	Sulphur River	3,400	26.6	20.1	451,000
Toronto	Kans.	Arkansas	Verdigris River	730	23.9	21.1	400,000
Towanda	Kans.	Arkansas	Whitewater River	422	24.3	20.5	198,000
Trinidad	Colo.	Arkansas	Purgatorie River	671	10.0	4.5	296,000
Tuskahoma	Okla.	Red	Kiamichi River	347	16.5	14.6	188,400
Wallace Lake	La.	Red	Cypress Bayou	260	38.4	35.6	197,000
Waurika	Okla.	Red	Beaver Creek	562	26.5	22.2	354,000
Webbers Falls	Okla.	Arkansas	Arkansas River	48,127	10.7	6.1	1,518,000
Wister	Okla.	Arkansas	Poteau River	993	25.9	23.2	339,000
			Texas-Gulf Region				
Addicks	Tex.	San Jacinto	South Mayde Creek	129	29.7	27.9	68,670
Aquilla	Tex.	Brazos	Aquilla Creek	294	31.2	28.6	283,800
Aubrey	Tex.	Trinity	Elm Fork Trinity River	692	28.5	26.0	445,300
Bardwell	Tex.	Trinity	Waxahachie Creek	178	31.1	28.3	163,500
Barker	Tex.	San Jacinto	Buffalo Bayou	150	29.4	27.9	55,900
Belton	Tex.	Brazos	Leon River	3,560	29.4	20.6	608,400
Benbrook	Tex.	Trinity	Clear Fork Trinity River	429	28.2	21.1	290,100
Big Sandy	Tex.	Sabine	Big Sandy Creek	196	36.2	32.2	125,200
Blieders Creek	Tex.	Guadalupe	Blieders Creek	15	43.8	34.6	70,300
Brownwood	Tex.	Colorado	Pecan Bayou	1,544	27.8	21.0	676,200
Canyon Lake	Tex.	Guadalupe	Guadalupe River	1,432	24.5	16.9	687,000
Carl L. Estes	Tex.	Sabine	Sabine River	1,146	34.5	30.4	277,000
Coleman	Tex.	Colorado	Colorado River	287	30.9	24.1	267,800
Comanche Peak	Tex.	Brazos	Squaw Creek	64	39.1	34.1	149,000
Ferguson	Tex.	Brazos	Navasota River	1,782	26.0	22.4	355,800
Gonzales	Tex.	Guadalupe	San Marcos River	1,344	24.9	15.4	633,900
Grapevine	Tex.	Trinity	Denton Creek	695	26.5	21.5	319,400
Hords Creek	Tex.	Colorado	Hords Creek	48	28.9	23.4	92,400
Lake Fork	Tex.	Sabine	Lake Fork Creek	507	33.8	29.7	247,600
Lakeview	Tex.	Trinity	Mountain Creek	232	31.6	28.8	335,000
Laneport	Tex.	Brazos	San Gabriel River	709	28.9	23.7	521,000
Lavon	Tex.	Trinity	East Fork, Trinity River	770	26.2	23.4	430,300
Lewisville	Tex.	Trinity	Elm Fork, Trinity River	1,660	23.2	20.5	632,200
Millican	Tex.	Brazos	Navasota River	2,120	25.5	22.4	393,400
Navarro Mills	Tex.	Trinity	Richland Creek	320	33.6	30.5	280,500
Navasota	Tex.	Brazos	Navasota River	1,341	27.2	24.2	327,400

TABLE B.1 (Page 14 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
North Fork	Tex.	Brazos	N. Fk. San Gabriel River	246	31.7	26.6	265,800
Pecan Bayou	Tex.	Colorado	Pecan Bayou	316	30.7	23.8	236,200
Proctor	Tex.	Brazos	Leon River	1,265	27.0	21.4	459,200
Roanoke	Tex.	Trinity	Denton Creek	604	28.9	24.1	313,600
Rockland	Tex.	Neches	Neches River	3,557	21.0	17.2	150,400
Sam Rayburn	Tex.	Neches	Angelina River	3,449	23.7	20.6	395,600
San Angelo	Tex.	Colorado	North Concho River	1,511	21.2	13.1	614,500
Somerville	Tex.	Brazos	Yegua Creek	1,006	22.0	13.6	415,700
South Fork	Tex.	Brazos	S. Fk. San Gabriel River	123	32.6	27.4	145,300
Stillhouse Hollow	Tex.	Brazos	Lampasas River	1,318	27.7	22.5	686,400
Tennessee Colony	Tex.	Trinity	Trinity River	12,687	25.1	20.4	575,600
Town Bluff	Tex.	Neches	Neches River	7,573	18.9	15.7	326,000
Waco Lake	Tex.	Brazos	Bosque River	1,670	25.7	20.6	622,900
Whitney	Tex.	Brazos	Brazos River	17,656	15.7	7.7	700,000
			Rio Grande Region				
Abiquiu	N. M.	Rio Grande	Rio Grande	3,159		8.2	130,000
Alamogordo	N. M.	Rio Grande	Pecos River	3,917		1.9	277,000
Cochita	N. M.	Rio Grande	Rio Grande	4,065	4.6	1.9	320,000
Jemez Canyon	N. M.	Rio Grande	Jemez Canyon	1,034	9.2	3.7	220,000
Los Esteros	N. M.	Rio Grande	Pecos River	2,434	12.2	4.7	352,000
Two Rivers	N. M.	Rio Grande	Rio Hondo	1,027			281,400
			Lower Colorado Region				
Alamo	Ariz.	Colorado	Bill Williams River	4,770	12.0	3.5	580,000
McMicken	Ariz.	Colorado	Aqua Fria River	247		3.3	52,000
Whitlow Ranch	Ariz.	Colorado	Queen Creek	143	11.5	9.7	230,000
Painted Rock	Ariz.	Colorado	Gila River	50,800	7.7	2.8	620,000
			Great Basin Region				
Little Dell	Utah	Jordon (Great)	Dell Creek	16	8.1	6.0	23,000
Mathews Canyon	Nev.	Great Basin	Mathews Canyon	34	8.6	7.4	35,000
Pine Canyon	Nev.	Great Basin	Pine Canyon	45	8.2	6.6	38,000
			Columbia-North Pacific Region				
Applegate	Oreg.	Rogue	Applegate River	223		28.9	99,500
Blue River	Oreg.	Columbia	S. Fk. McKenzie River	88		22.7	39,500

TABLE 8.1 (Page 15 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Basin Average (in inches) Runoff	PMF Peak Discharge (cfs)
Bonneville	Oreg.	Columbia	Columbia River	240,000		22.1	2,720,000
Cascadia	Oreg.	Columbia	South Santiam River	179		42.2	115,000
Chief Joseph	Wash.	Columbia	Columbia River	75,000		29.0	1,550,000
Cottage Grove	Oreg.	Columbia	Coast Fk. Willamette River	104		29.7	45,000
Cougar	Oreg.	Columbia	S. Fk. McKenzie River	208		34.2	98,000
Detroit	Oreg.	Columbia	North Santiam River	438		36.0	203,000
Dorena	Oreg.	Columbia	Row River	265		34.6	131,600
Dworshak	Ida.	Columbia	N. Fk. Clearwater River	2,440		70.5	280,000
Elk Creek	Oreg.	Rogue	Elk Creek	132		32.6	63,500
Fall Creek	Oreg.	Columbia	Willamette River	184		33.8	100,000
Fern Ridge	Oreg.	Columbia	Long Tom River	252		20.3	48,600
Foster	Oreg.	Columbia	South Santiam River	494		40.8	260,000
Green Peter	Oreg.	Columbia	Middle Santiam River	277		41.3	160,000
Gate Creek	Oreg.	Columbia	Gate Ck. McKenzie River	50		46.3	37,000
Hills Creek	Oreg.	Columbia	Middle Fk. Willamette River	389		33.0	197,000
Holley	Oreg.	Columbia	Calapooia River	105		35.8	59,000
Howard A. Hanson	Wash.	Green	Green River	225		26.8	164,000
Ice Harbor	Wash.	Columbia	Snake River	109,000		13.9	954,000
John Day	Oreg.	Columbia	Columbia River	226,000		21.1	2,650,000
Libby	Mont.	Columbia	Kootenai River	9,070		35.5	282,000
Little Goose	Wash.	Columbia	Snake River	103,900		14.6	850,000
Lookout Point	Oreg.	Columbia	Middle Fk. Wilamette River	991		30.8	360,000
Lost Fork	Oreg.	Rogue	Lost Fk. Rogue River	674		27.7	169,000
Lower Granite	Wash.	Columbia	Snake River	103,400		14.7	850,000
Lower Monumental	Wash.	Columbia	Snake River	108,500		14.0	850,000
Lucky Peak	Ida.	Columbia	Boise River	2,650		32.5	123,000
McNary	Oreg.	Columbia	Columbia River	214,000		23.0	2,610,000
Mud Mountain	Wash.	Puyallup	White River	400		33.9	186,000
Ririe	Ida.	Columbia	Willow Ck. Snake River	620		5.4	47,000
The Dalles	Oreg.	Columbia	Columbia River	237,000		21.1	2,660,000
Wynoochee	Wash.	Chechalis	Wynoochee River	41		69.9	52,500
Zintel	Wash.	Columbia	Zintel Canyon Snake River	19		7.8	40,500
			California Region				
Bear	Cal.	San Joaquin	Bear Creek	72	13.6	13.6	30,400
Big Dry Creek	Cal.	San Joaquin	Big Dry Creek	91	19.0	13.8	17,000
Black Butte	Cal.	Sacramento	Stony Creek	741	19.7	12.3	154,000
Brea	Cal.	Santa Ana	Brea Creek	23	10.4	6.6	37,000

TABLE B.1 (Page 16 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Basin Average (in inches) Runoff	PMF Peak Discharge (cfs)
Buchanan	Cal.	San Joaquin	Chowchilla River	235	26.0	20.1	127,000
Burns	Cal.	San Joaquin	Burns Creek	74	17.4	10.6	26,800
Butler Valley	Cal.	Mad	Mad River	352		35.2	137,000
Carbon Canyon	Cal.	Santa Ana	Santa Ana River	19	10.4	10.3	56,000
Cherry Valley	Cal.	San Joaquin	Cherry Creek	117	24.3	23.1	60,000
Comanche	Cal.	San Joaquin	Mokelumne River	618	25.0	19.9	261,000
Coyote Valley	Cal.	Russian	East Fk. Russian River	105		22.9	57,000
Dry Creek	Cal.	Russian	Dry Creek	82	21.3	15.6	45,000
Farmington	Cal.	San Joaquin	Little John Creek	212	11.3	10.9	56,000
Folsom	Cal.	Sacramento	American River	1,875	21.2	17.5	615,000
Fullerton	Cal.	Santa Ana	Fullerton Creek	5.0	9.0	6.8	16,000
Hansen	Cal.	Los Angeles	Tujunga Wash	147		9.8	130,000
Hidden Lake	Cal.	San Joaquin	Fresno River	234	27.9	18.4	114,000
Isabella	Cal.	San Joaquin	Kern River	2,073	27.1	6.5	235,000
Knights Valley	Cal.	Russian	Franz-Maacama Creek	59	31.6	28.9	44,300
Lakeport	Cal.	Sacramento	Scotts Creek	52	30.9	24.0	36,100
Lopez	Cal.	Los Angeles	Pacoima Creek	34		20.8	32,000
Mariposa	Cal.	San Joaquin	Mariposa Creek	108	18.6	13.0	43,000
Martis Creek	Cal.	Truckee	Martis Creek	39	26.5	12.7	12,400
Marysville	Cal.	Sacramento	Yuba River	1,324	38.9	27.0	460,000
Mojave River	Cal.	Mojave	Mojave River	215	40.4	30.4	186,000
New Bullards Bar	Cal.	Sacramento	North Yuba River	489	38.9	25.7	226,000
New Exchequer	Cal.	San Joaquin	Merced River	1,037	27.1	15.9	396,000
New Hogan	Cal.	San Joaquin	Calaveras River	362		18.3	132,000
New Melones	Cal.	San Joaquin	Stanislaus River	897	25.8	16.3	355,000
Oroville	Cal.	Sacramento	Feather River	2,600	23.3	22.8	720,000
Owens	Cal.	San Joaquin	Owens Creek	26	14.4	9.2	11,400
Pine Flat	Cal.	San Joaquin	Kings River	1,542	28.5	14.4	437,000
Prado	Cal.	Santa Ana	Santa Ana River	2,233	26.3	13.0	700,000
San Antonio	Cal.	Santa Ana	San Antonio Creek	27		13.0	60,000
Santa Fe	Cal.	San Gabriel	San Gabriel River	236		35.5	194,000
Sepulveda	Cal.	Los Angeles	Los Angeles River	152		15.0	220,000

TABLE B.1 (Page 17 of 17)

Project	State	River Basin	Stream	Drainage Area (sq.mi.)	Basin Average (in inches) Prec.	Runoff	PMF Peak Discharge (cfs)
Success	Cal.	San Joaquin	Tule River	383	32.5	12.6	200,000
Terminus	Cal.	San Joaquin	Kaweah River	560	40.1	24.8	290,000
Tuolumne	Cal.	San Joaquin	Tuolumne River	1,533	25.1	20.2	602,000
Whittier Narrows	Cal.	San Gabriel	San Gabriel River	554	17.4	13.7	305,000

APPENDIX C

SIMPLIFIED METHODS OF ESTIMATING PROBABLE MAXIMUM SURGES

TABLE OF CONTENTS

Page

C.1 INTRODUCTION 1.59-42

C.2 SCOPE 1.59-42

C.3 PROBABLE MAXIMUM SURGE LEVELS FROM HURRICANES 1.59-42

C.3.1 Methods Used 1.59-42
C.3.2 Use of Data in Estimating PMS 1.59-42
C.3.3 Wind-Wave Effects 1.59-43

C.4 LIMITATIONS 1.59-43

REFERENCES 1.59-43

FIGURES 1.59-44

TABLES 1.59-46

FIGURES

Figure C.1—Probable Maximum Surge Estimates, Gulf Coast 1.59-44
C.2—Probable Maximum Surge Estimates, Atlantic Coast 1.59-45

TABLES

Table C. 1—Probable Maximum Surge Data 1.59-46
C. 2—Probable Maximum Hurricane, Surge, and Water Level—Port Isabel 1.59-47
C. 3—Probable Maximum Hurricane, Surge, and Water Level—Freeport 1.59-48
C. 4—Probable Maximum Hurricane, Surge, and Water Level—Eugene Island 1.59-49
C. 5—Probable Maximum Hurricane, Surge, and Water Level—Isle Dernieres 1.59-50
C. 6—Probable Maximum Hurricane, Surge, and Water Level—Biloxi 1.59-51
C. 7—Probable Maximum Hurricane, Surge, and Water Level—Santa Rosa Island 1.59-52
C. 8—Probable Maximum Hurricane, Surge, and Water Level—Pitts Creek 1.59-53
C. 9—Probable Maximum Hurricane, Surge, and Water Level—Naples 1.59-54
C.10—Probable Maximum Hurricane, Surge, and Water Level—Miami 1.59-55
C.11—Probable Maximum Hurricane, Surge, and Water Level—Jacksonville 1.59-56
C.12—Probable Maximum Hurricane, Surge, and Water Level—Jeckyll Island 1.59-57
C.13—Probable Maximum Hurricane, Surge, and Water Level—Folly Island 1.59-58
C.14—Probable Maximum Hurricane, Surge, and Water Level—Raleigh Bay 1.59-59
C.15—Probable Maximum Hurricane, Surge, and Water Level—Ocean City 1.59-60
C.16—Probable Maximum Hurricane, Surge, and Water Level—Atlantic City 1.59-61
C.17—Probable Maximum Hurricane, Surge, and Water Level—Long Island 1.59-62
C.18—Probable Maximum Hurricane, Surge, and Water Level—Watch Hill Point 1.59-63
C.19—Probable Maximum Hurricane, Surge, and Water Level—Hampton Beach 1.59-64
C.20—Probable Maximum Hurricane, Surge, and Water Level—Great Spruce Island 1.59-65
C.21—Ocean-Bed Profiles 1.59-66

C.1 INTRODUCTION

This appendix presents timesaving methods of estimating the maximum stillwater level of the probable maximum surge (PMS) from hurricanes at open-coast sites on the Atlantic Ocean and Gulf of Mexico. Use of the methods herein will reduce both the time necessary for applicants to prepare license applications and the NRC staff's review effort.

The procedures are based on PMS values determined by the NRC staff and its consultants and by applicants for licenses that have been reviewed and accepted by the staff. The information in this appendix was developed from a study made by Nunn, Snyder, and Associates, through a contract with NRC (Ref. 1).

The PMS data are shown in Tables C.1 through C.21 and on maps of the Atlantic and Gulf Coasts (Figures C.1 and C.2). Suggestions for interpolating between these values are included.

Limitations on the use of these generalized methods of estimating PMS are identified in Section C.4. These limitations should be considered in detail in assessing the applicability of the methods at specific sites.

Applicants for licenses for nuclear facilities at sites on the open coast of the Atlantic Ocean or the Gulf of Mexico have the option of using these methods in lieu of more precise but laborious methods contained in Appendix A. The results of application of the methods in this appendix will in many cases be accepted by the NRC staff with no further verification.

C.2 SCOPE

The data and procedures in this appendix apply only to open-coast areas of the Gulf of Mexico and the Atlantic Ocean.

Future studies are planned to determine the applicability of similar generalized methods and to develop such methods, if feasible, for other areas. These studies, to be included in similar appendices, are anticipated for the Great Lakes and the Pacific Coast, including Hawaii and Alaska.

C.3 PROBABLE MAXIMUM SURGE LEVELS FROM HURRICANES

The data presented in this appendix consist of all determinations of hurricane-induced PMS peak levels at open-coast locations computed by the NRC staff or their consultants, or by applicants and accepted by the staff. The data are shown in Tables C.1 through C.21 and on Figures C.1 and C.2. All represent stillwater levels for open-coast conditions.

C.3.1 Methods Used

All PMS determinations in Table C.1 were made by NRC consultants for this study (Ref. 1) or for earlier studies except Pass Christian, Brunswick, Chesapeake Bay Entrance, Forked River—Oyster Creek, Millstone, Pilgrim, and Hampton Beach.

The computations by the consultants were made using the NRC surge computer program, which is adapted from References 2, 3, and 4. Probable maximum hurricane data were taken from Reference 5. Ocean bottom topography for the computations was obtained from the most detailed available Nautical Charts published by the National Ocean Survey, NOAA. The traverse line used for the probable maximum hurricane surge estimate was drawn from the selected coastal point to the edge of the continental shelf or to an ocean depth of 600 feet MLW and was one hurricane radius to the right of the storm track. The radius to maximum winds was oriented at an angle of 115° from the storm track. The traverse was oriented perpendicular to the ocean-bed contours near shore. The ocean-bed profile along the traverse line was determined by roughly averaging the topography of cross sections perpendicular to the traverse line and extending a maximum of 5 nautical miles to either side. The 10-mile-wide cross sections were narrowed uniformly to zero at the selected site starting 10 nautical miles from shore. It was assumed that the peak of the PMS coincided with the 10% exceedance high spring tide[1] plus initial rise.[2] Slightly different procedures were used for postulating the traverse lines and profiles for the Crystal River and St. Lucie determinations.

In each case the maximum water level resulted from use of the high translation speed for the hurricane in combination with the large radius to maximum wind as defined in Reference 5. Detailed data for the computed PMS values are shown in Tables C.1 through C.20. Ocean-bed profile data for Pass Christian, Crystal River, St. Lucie, Chesapeake Bay Mouth, and Hampton Beach are shown in Table C.21.

The water levels resulting from these computations are open-coast stillwater levels upon which waves and wave runup should be superimposed.

C.3.2 Use of Data in Estimating PMS

Estimates of the PMS stillwater level at open-coast sites other than those shown in Tables C.1 through C.21 and on Figures C.1 and C.2 may be obtained as follows:

[1]The 10% exceedance high spring tide is the predicted maximum monthly astronomical tide exceeded by 10% of the predicted maximum monthly astronomical tides over a 21-year period.

[2]Initial rise (also called forerunner or sea level anomaly) is an anomalous departure of the tide level from the predicted astronomical tide.

1. Using topographic maps or maps showing soundings, such as the Nautical Charts, determine an ocean bed profile to a depth of 600 ft MLW, using the methods outlined above. Compare this profile with the profiles of the locations shown in Tables C.2 through C.21. With particular emphasis on shallow water depths, select the location or locations in the general area with the most similar profiles. An estimate of the wind setup may be interpolated from the wind setup data for these locations.

2. Pressure setup may be interpolated between locations on either side of the site.

3. Initial rise, as shown in Table C.1, may be interpolated between locations on either side of the site.

4. The 10% exceedance high spring tide may be computed from predicted tide levels in Reference 6; it may be obtained from the Coastal Engineering Research Center, U.S. Army Corps of Engineers, Ft. Belvoir, Va.; it may be interpolated, using the tide relations in Reference 6; or it may be obtained from Appendix A.

5. An estimate of the PMS open-coast stillwater level at the desired site will be the sum of the values from Steps 1 through 4, above.

C.3.3 Wind-Wave Effects

Coincident wave heights and wave runup should be computed and superimposed on the PMS stillwater level obtained by the foregoing procedures. Acceptable methods are given in Reference 2 and in Appendix A.

C.4 LIMITATIONS

1. The NRC staff will continue to accept for review detailed PMS analyses that result in less conservative estimates. In addition, previously reviewed and approved detailed PMS analyses at specific sites will continue to be acceptable even though the data and procedures in this appendix result in more conservative estimates.

2. The PMS estimates obtained as outlined in Section C.3.2 are maximum stillwater levels. Coincident wind-wave effects should be added.

3. The PMS estimates obtained from the methods in Section C.3.2 are valid only for open-coast sites, i.e., at the point at which the surge makes initial landfall. If the site of interest has appreciably different off-shore bathymetry, or if the coastal geometry differs or is complex, such as for sites on an estuary, adjacent to an inlet, inshore of barrier islands, etc., detailed studies of the effect of such local conditions should be made. Reference 2 provides guidance on such studies.

REFERENCES

1. Nunn, Snyder, and Associates, "Probable Maximum Flood and Hurricane Surge Estimates," unpublished report to NRC, June 13, 1975 (available in the public document room).

2. U. S. Army Coastal Engineering Research Center, "Shore Protection Manual," Second Edition, 1975.

3. B. R. Bodine, "Storm Surge on the Open Coast: Fundamental and Simplified Prediction," Technical Memorandum No. 35, U.S. Army Coastal Engineering Research Center, 1971.

4. George Pararas-Caryannis, "Verification Study of a Bathystrophic Storm Surge Model," Technical Memorandum No. 50, U.S. Army Coastal Engineering Research Center, May 1975.

5. U. S. Weather Bureau (now U.S. Weather Service, NOAA), "Meteorological Characteristics of the Probable Maximum Hurricane, Atlantic and Gulf Coasts of the United States," Hurricane Research Interim Report, HUR 7-97 and HUR 7-97A, 1968.

6. U. S. Department of Commerce, NOAA, "Tide Tables," annual publications.

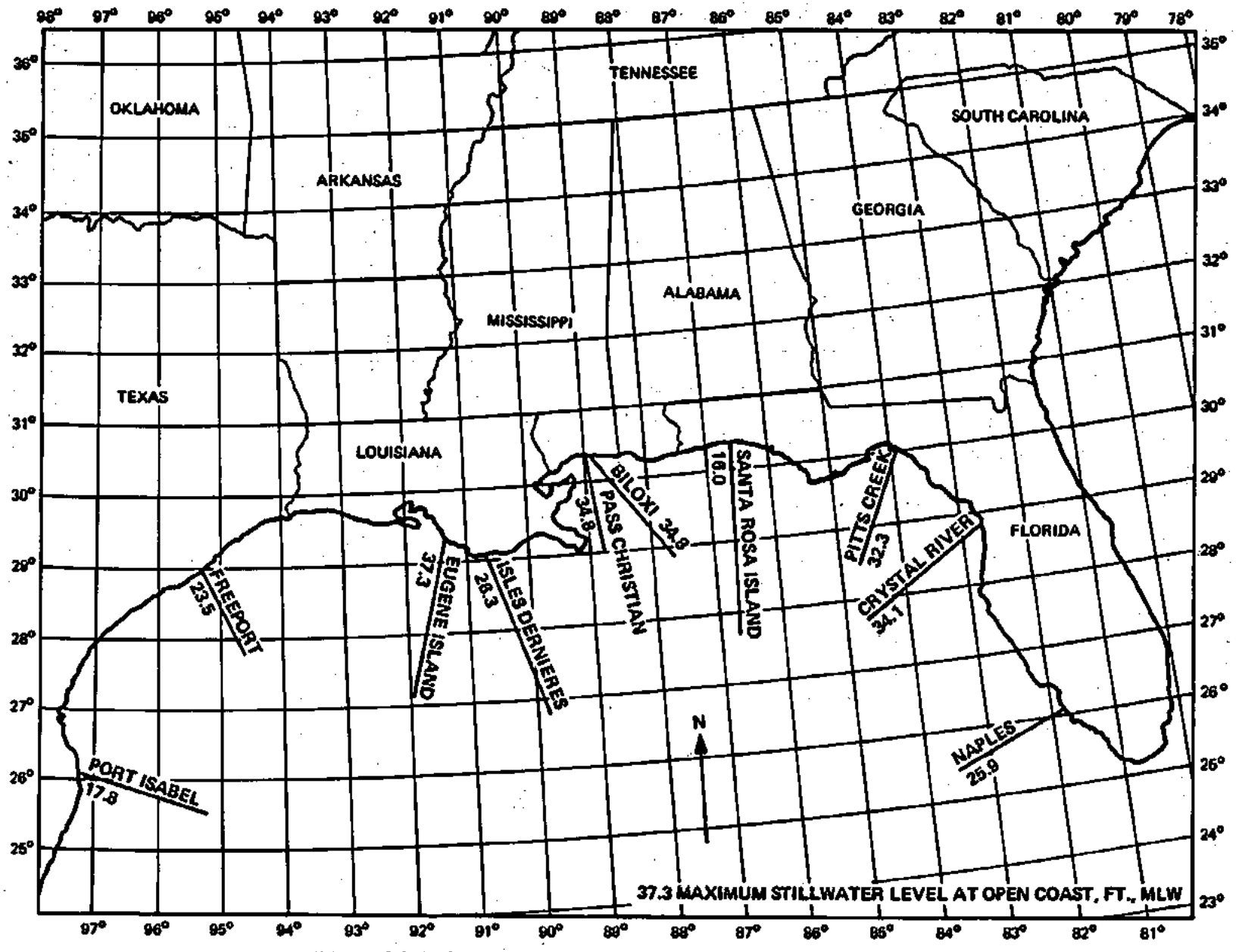


FIGURE C.1 PROBABLE MAXIMUM SURGE ESTIMATES – GULF COAST

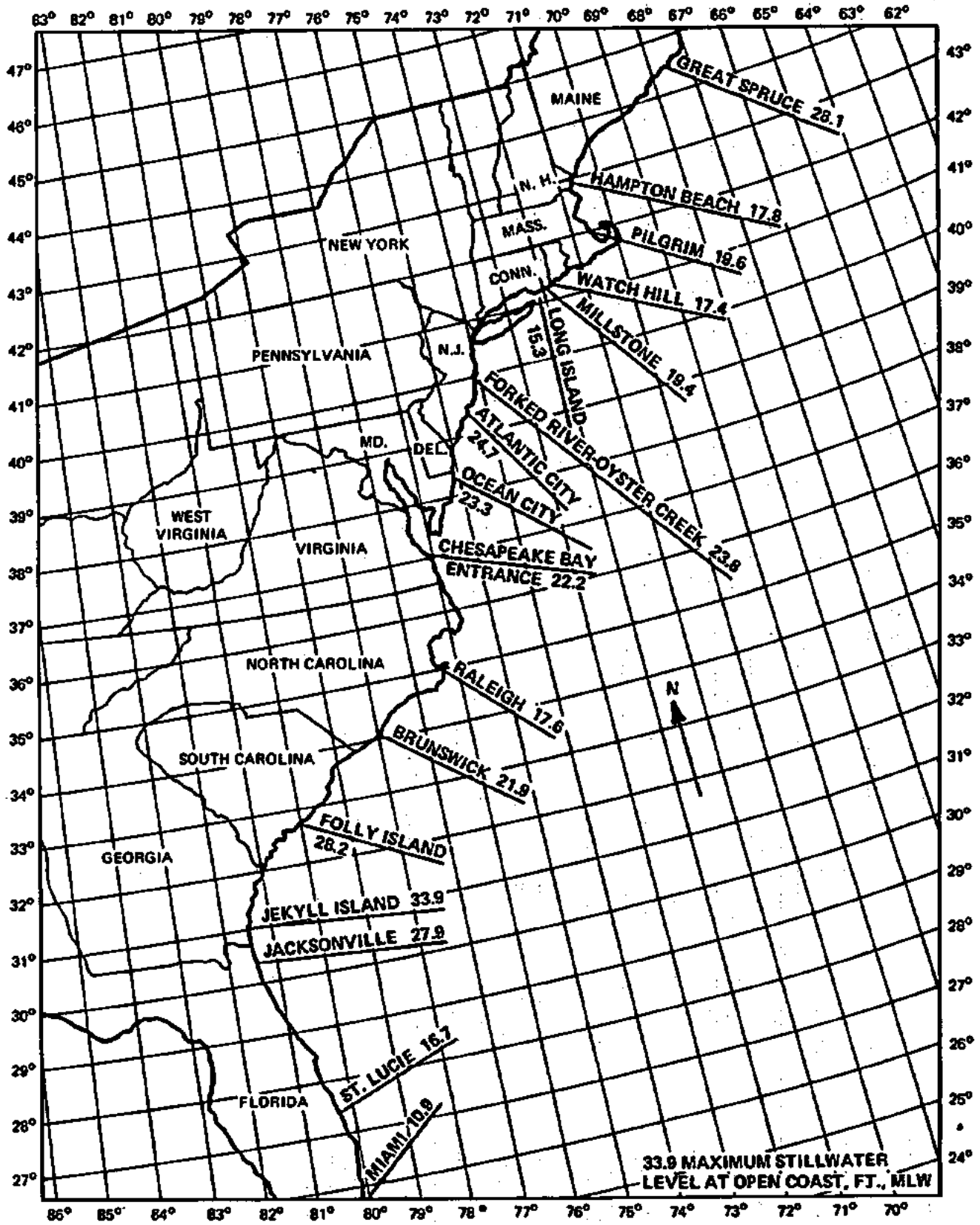


FIGURE C.2 PROBABLE MAXIMUM SURGE ESTIMATES – ATLANTIC COAST

TABLE C.1

PROBABLE MAXIMUM SURGE DATA

(LOCATIONS INDICATED ON FIGURES C.1 and C.2)

OPEN-COAST LOCATION AND TRAVERSE	TRAVERSE AZIMUTH DEG. - MIN.		DISTANCE FROM SHORELINE, NAUTICAL MILES, FOR SELECTED WATER DEPTHS, FEET MLW: DEPTH, FEET, ALONG TRAVERSE FROM OPEN COAST SHORE LINE — 10	20	50	100	200	600 DISTANCE, NAUTICAL MILES, TO DEPTH INDICATED	PROBABLE MAXIMUM SURGE AT OPEN COAST SHORE LINE: WIND SETUP, FT.	PRESSURE SETUP, FT.	INITIAL 10% EXC. HIGH TIDE, FT. MLW (c)	TOTAL SURGE, FT. MLW (c)
PORT ISABEL	86	30	0.23	0.49	1.94	11.10	33.10	44.0	10.07	3.57	2.50	1.70	17.84
FREEPORT	152	00	0.20	0.55	5.50	24.0	55.5	70.9	15.99	2.89	2.40	2.20	23.48
EUGENE ISLAND	192	30	2.00	20.00	30.00	44.1	60.0	90.0	29.74	3.29	2.00	2.30	37.34
ISLE DERNIERES	165	00	0.62	1.75	11.90	30.4	45.3	58.5	18.61	3.29	2.00	2.40	26.30
PASS CHRISTIAN (a)								77.0	28.87	2.88	0.80	2.30	34.85
BILOXI	160	00	3.40	11.20	30.00	50.1	69.2	78.0	27.77	2.98	1.50	2.50	34.76
SANTA ROSA ISLAND	183	00	0.09	0.18	0.48	11.9	20.9	45.0	9.12	3.25	1.50	2.10	15.97
PITTS CREEK	205	00	8.84	9.23	24.30	69.4	107.0	132.0	24.67	2.31	1.20	4.10	32.28
CRYSTAL RIVER (a)			2.31		31.40			127.0	26.55	2.65	0.60	4.30	34.10
NAPLES	248	00	0.17	0.79	15.70	45.6	85.8	145.0	18.47	2.90	1.00	3.50	25.87
MIAMI	100	00	0.17	0.94	2.01	2.2	2.7	3.9	2.51	3.90	0.90	3.60	10.91
ST. LUCIE (a)			0.10					18.7	8.25	3.80	0.98	3.70	16.73
JACKSONVILLE	90	00	0.10	0.20	2.58	30.0	55.0	62.5	16.46	3.23	1.30	6.90	27.90
JEKYLL ISLAND	108	00	2.60	4.00	15.60	39.6	64.3	72.6	20.63	3.34	1.20	8.70	33.87
FOLLY ISLAND	150	00	0.19	2.17	12.00	32.8	47.0	57.6	17.15	3.23	1.00	6.80	28.18
BRUNSWICK									12.94	2.20	1.00	5.80	21.94
RALEIGH	135	00	0.12	0.30	1.75	12.0	25.4	35.2	8.84	3.09	1.00	4.70	17.63
CHESAPEAKE BAY ENTRANCE (a)								62.0	17.30(b)	(b)	1.10	3.80	22.20
OCEAN CITY	110	00	0.12	0.26	3.67	17.8	45.0	59.0	14.30	2.83	1.14	5.00	23.27
ATLANTIC CITY	146	00	0.20	0.85	5.00	23.1	58.4	70.0	15.32	2.57	1.10	5.70	24.70
FORKED RIVER - OYSTER CREEK									18.08(b)	(b)	1.00	4.70	23.78
LONG ISLAND	166	00	0.09	0.18	1.35	4.8	27.2	68.4	8.73	2.46	0.97	3.10	15.26
MILLSTONE									12.41	2.20	1.00	3.80	19.41
WATCH HILL POINT	166	00	0.07	0.14	0.64	1.6	34.3	84.0	10.01	2.42	0.96	4.00	17.39
PILGRIM												11.90	19.60
HAMPTON BEACH (a)	115	00	0.22	0.31	0.71	2.0	7.2	40.0	4.25	2.23	0.83	10.50	17.81
GREAT SPRUCE ISLAND	148	00	0.04	0.08	0.20	1.1	6.3	173.0	9.73	1.82	0.56	16.00	28.11

a. See Table C.21 for ocean-bed profile.
b. Combined wind and pressure setup.
c. Most values in these columns have been updated by the U.S. Army Coastal Engineering Research Center and differ from those in the original documents.

TABLE C.2

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION PORT ISABEL LAT. 26°04.3' LONG. 97°09.4': TRAVERSE-AZIMUTH86°-30°DEGREE; LENGTH 42.1 NAUTICAL MILES
TEXAS

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE C AT LOCATION 26° 04' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	26.42	26.42	26.42
PERIPHERAL PRESSURE P_n INCHES	31.30	31.30	31.30
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	20	20	20
TRANSLATION SPEED V_f (FORWARD SPEED) KNOTS	4	11	28
MAXIMUM WIND SPEED V_x M.P.H.	147	151	161
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	398	374	318

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	9.0
0.5	20.5
1.0	35.0
1.5	43.0
2.0	51.0
3.0	58.5
5.0	69.0
10	95.5
15	116
20	138
30	171
40	266
44	600
50	1,850

LATITUDE ϕ 26° 05' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES			
COEFFICIENTS			
BOTTOM FRICTION FACTOR 0.0030			
WIND STRESS CORRECTION FACTOR 1.10			
WATER LEVEL DATA			
(AT OPEN COAST SHORELINE)			
COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	FEET		
WIND SETUP			10.07
PRESSURE SETUP			3.57
INITIAL WATER LEV.			2.50
ASTRONOMICAL TIDE LEVEL			1.70
TOTAL-SURGE STILL WATER LEV. FEET MLW			17.84

TABLE C.3

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION FREEPORT, TEXAS LAT. 28° 56' LONG. 95° 22': TRAVERSE-AZIMUTH 152 DEGREES LENGTH 70.9 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE C AT LOCATION 28° 56' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	26.69	26.69	26.69
PERIPHERAL PRESSURE P_n INCHES	31.25	31.25	31.25
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	26.0	26.0	26.0
TRANSLATION SPEED V_y (FORWARD SPEED) KNOTS	4	11	28.0
MAXIMUM WIND SPEED V_x M.P.H.	139	143	153
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	491	458	390

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
1.0	30
2.0	32
3.0	37
4.0	40
5.0	47
10.0	66
15.0	78
20.0	90
30.0	114
40.0	132
50.0	168
60.0	240
70.0	570
70.9	600

LATITUDE ϕ 28° 26' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES

COEFFICIENTS

BOTTOM FRICTION FACTOR 0.0030

WIND STRESS CORRECTION FACTOR 1.10

WATER LEVEL DATA

(AT OPEN COAST SHORELINE)

COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
WIND SETUP			15.99
PRESSURE SETUP			2.89
INITIAL WATER LEV.			2.40
ASTRONOMICAL TIDE LEVEL			2.20
TOTAL-SURGE STILL WATER LEV. FEET MLW			23.48

TABLE C.4

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION EUGENE ISLAND, LOUISIANA LAT. 29° 20' LONG. 91° 21': TRAVERSE-AZIMUTH 192°30' DEGREE: LENGTH 90 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE B AT LOCATION 29° 20' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	26.87	26.87	26.87
PERIPHERAL PRESSURE P_n INCHES	31.24	31.24	31.24
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	29.0	29.0	29.0
TRANSLATION SPEED F_v (FORWARD SPEED) KNOTS	4	11	28.0
MAXIMUM WIND SPEED V_x M.P.H.	141	144	153
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	534	484	412

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0.0	0
1.0	5
2.0	10
3.0	12
5.0	15
10.0	15
15.0	18
20.0	20
30.0	50
40	60
50	140
60	200
70	260
80	320
90	600

LATITUDE ϕ 28° 40' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES			
COEFFICIENTS			
BOTTOM FRICTION FACTOR 0.0030			
WIND STRESS CORRECTION FACTOR 1.10			
WATER LEVEL DATA			
(AT OPEN COAST SHORELINE)			
COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	FEET		
WIND SETUP			29.74
PRESSURE SETUP			3.29
INITIAL WATER LEV.			2.00
ASTRONOMICAL TIDE LEVEL			2.30
TOTAL-SURGE STILL WATER LEV. FEET MLW			37.34

TABLE C.5

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION ISLE DERNIERES, LOUISIANA LAT. 29°02.9' LONG. 90°42.5'; TRAVERSE-AZIMUTH 165 DEGREES LENGTH 58.5 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE B AT LOCATION 29° 03' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	26.88	26.88	26.88
PERIPHERAL PRESSURE P_n INCHES	31.25	31.25	31.25
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	29	29	29
TRANSLATION SPEED F_v (FORWARD SPEED) KNOTS	4	11	28
MAXIMUM WIND SPEED V_x M.P.H.	140	144	153
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	528	487	394

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	6.0
0.5	9.0
1.0	13.0
1.5	17.5
2.0	22.5
3.0	26.0
5.0	32.0
7.0	34.0
7.5	28.0
8.0	25.5
8.5	25.0
9.0	28.5
9.5	34.0
10.0	42.5
15.0	62.0
20.0	56.0
30.0	97.9
40.0	152.0
50.0	243
58.5	600
60.0	688
LATITUDE ø 28°34.4 DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH	

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES

COEFFICIENTS

BOTTOM FRICTION FACTOR 0.0030

WIND STRESS CORRECTION FACTOR 1.10

WATER LEVEL DATA

(AT OPEN COAST SHORELINE)

COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	F	E	E T
WIND SETUP			18.61
PRESSURE SETUP			3.29
INITIAL WATER LEV.			2.00
ASTRONOMICAL TIDE LEVEL			2.40
TOTAL-SURGE STILL WATER LEV. FEET MLW			26.30

TABLE C.6

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION BILOXI MISSISSIPPI LAT. 30°23.6' LONG. 88°53.6'; TRAVERSE-AZIMUTH 160 DEGREES LENGTH 77 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE B AT LOCATION 30° 24' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	26.9	26.9	26.9
PERIPHERAL PRESSURE P_n INCHES	31.23	31.23	31.23
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	30	30	30
TRANSLATION SPEED F_v (FORWARD SPEED) KNOTS	4	11	28
MAXIMUM WIND SPEED V_x M.P.H.	139	143	153
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	525	498	396

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	3.0
0.5	2.0
1.0	6.5
1.5	9.0
2.0	9.0
3.0	9.5
5.0	12.0
9.0	9.5
9.5	11.0
10.0	14.0
10.5	18.5
11.0	17.5
11.5	23.0
12.0	29.0
13	34.5
15	41.5
20	45.0
25	47.0
30	50.0
40	65.0
50	99.0
60	164
70	203
78	600
80	744
LATITUDE ϕ 29° 50' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH	

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES

COEFFICIENTS

BOTTOM FRICTION FACTOR 0.0030

WIND STRESS CORRECTION FACTOR 1.10

WATER LEVEL DATA

(AT OPEN COAST SHORELINE)

COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	FEET		
WIND SETUP			27.77
PRESSURE SETUP			2.98
INITIAL WATER LEV.			1.50
ASTRONOMICAL TIDE LEVEL			2.50
TOTAL-SURGE STILL WATER LEV. FEET MLW			34.76

TABLE C.7

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION SANTA ROSA ISLAND, ALABAMA LAT. 30°23.7' LONG. 86°37.7': TRAVERSE-AZIMUTH 183 DEGREES LENGTH 44.7 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE B AT LOCATION 30° 24' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	26.88	26.88	26.88
PERIPHERAL PRESSURE P_n INCHES	31.20	31.20	31.20
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	29	29	29
TRANSLATION SPEED F_v (FORWARD SPEED) KNOTS	4	11	28
MAXIMUM WIND SPEED V_x M.P.H.	140	144	153
INITIAL DISTANCE-NAUT.MI.[1] FROM 20 MPH WIND AT SHORE TO MAX. WIND	528	487	394

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

[1] Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	22
0.5	52
1.0	66
1.5	66
2.0	66
3.0	73
5.0	76
10	88
15	120
20	182
30	377
40	510
45	600
50	756

LATITUDE ϕ 30°1.3' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES

COEFFICIENTS

BOTTOM FRICTION FACTOR 0.0030

WIND STRESS CORRECTION FACTOR 1.10

WATER LEVEL DATA

(AT OPEN COAST SHORELINE)

COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	F	E	E T
WIND SETUP			9.12
PRESSURE SETUP			3.25
INITIAL WATER LEV.			1.50
ASTRONOMICAL TIDE LEVEL			2.10
TOTAL-SURGE STILL WATER LEV. FEET MLW			15.97

TABLE C.8

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION PITTS CREEK FLORIDA LAT. 30°01.1' LONG. 83° 53'; TRAVERSE-AZIMUTH 205 DEGREE; LENGTH 110 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE A AT LOCATION 30° 01' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	26.79	26.79	26.79
PERIPHERAL PRESSURE P_n INCHES	30.22	30.22	30.22
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	26	26	26
TRANSLATION SPEED F_v (FORWARD SPEED) KNOTS	4	11	21
MAXIMUM WIND SPEED V_x M.P.H.	138	142	146
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	354	322	278

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	1.0
0.5	2.0
1.0	3.0
1.5	4.0
2.0	5.0
3.0	6.5
5.0	9.0
10	22.0
15	31.0
20	41.0
30	62.0
40	78.0
50	81.0
60	84.0
70	101.0
80	117.0
90	144.0
100	180.0
110	210.0
120	280.0
130	543.0
132	600.0
140	846
LATITUDE ϕ 29° 03' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH	

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES			
COEFFICIENTS			
BOTTOM FRICTION FACTOR 0.0030			
WIND STRESS CORRECTION FACTOR 1.10			
WATER LEVEL DATA			
(AT OPEN COAST SHORELINE)			
COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	FEET		
WIND SETUP			24.67
PRESSURE SETUP			2.31
INITIAL WATER LEV.			1.20
ASTRONOMICAL TIDE LEVEL			4.10
TOTAL-SURGE STILL WATER LEV. FEET MLW			32.28

TABLE C.9

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION NAPLES FLORIDA LAT. 26°01.4' LONG. 81°46.2'; TRAVERSE-AZIMUTH 248 DEGREES LENGTH 145 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE A AT LOCATION 26° 01' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	26.24	26.24	26.24
PERIPHERAL PRESSURE P_n INCHES	31.30	31.30	31.30
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	15	15	15
TRANSLATION SPEED F_v (FORWARD SPEED) KNOTS	4	11	17
MAXIMUM WIND SPEED V_x M.P.H.	150	154	158
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	292	270	256

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	12.0
0.5	18.0
1.0	21.5
1.5	22.0
2.0	24.5
3.0	27.0
5.0	30.0
10	41.0
15	48.5
20	59.5
30	75.0
40	90.0
50	108
60	144
70	165
80	186
90	210
100	228
110	249
120	252
130	432
140	452
145	600
150	1,200
LATITUDE ϕ 25° 35' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH	

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES

COEFFICIENTS

BOTTOM FRICTION FACTOR 0.0030

WIND STRESS CORRECTION FACTOR 1.10

WATER LEVEL DATA

(AT OPEN COAST SHORELINE)

COMPONENTS	PMH SPEED OF TRANSLATION ST (SLOW)	MT (MODERATE)	HT (FAST)
WIND SETUP	13.49	15.87	18.47
PRESSURE SETUP	3.29	2.87	2.90
INITIAL WATER LEV.	1.00	1.00	1.00
ASTRONOMICAL TIDE LEVEL	3.60	3.60	3.50
TOTAL-SURGE STILL WATER LEV. FEET MLW	21.38	23.35	25.87

TABLE C.10

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION MIAMI FLORIDA LAT. 25°47.2' LONG. 80°07.8'; TRAVERSE-AZIMUTH 100 DEGREES LENGTH 3.9 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE 1 AT LOCATION 25° 47.2' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	26.09	26.09	26.09
PERIPHERAL PRESSURE P_n INCHES	31.30	31.30	31.30
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	14	14	14
TRANSLATION SPEED F_v (FORWARD SPEED) KNOTS	4	11	17
MAXIMUM WIND SPEED V_x M.P.H.	152	156	160
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	274	258	243

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	12
0.5	16
1.5	25
2.0	47
3.0	266
3.9	600
5.0	822

LATITUDE ϕ 25°46.8' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES			
COEFFICIENTS			
BOTTOM FRICTION FACTOR 0.0025			
WIND STRESS CORRECTION FACTOR 1.10			
WATER LEVEL DATA (AT OPEN COAST SHORELINE)			
COMPONENTS	PMH SPEED OF TRANSLATION ST (FEET)	MT (FEET)	HT (FEET)
WIND SETUP	2.06	2.37	2.51
PRESSURE SETUP	3.97	3.82	3.90
INITIAL WATER LEV.	0.90	0.90	0.90
ASTRONOMICAL TIDE LEVEL	3.60	3.60	3.60
TOTAL-SURGE STILL WATER LEV. FEET MLW	10.53	10.68	10.91

TABLE C.11

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION JACKSONVILLE FLORIDA LAT. 30° 21' LONG. 81° 24.5'; TRAVERSE-AZIMUTH 90 DEGREES LENGTH 62.5 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE 2 AT LOCATION 30° 21' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	26.67	26.67	26.67
PERIPHERAL PRESSURE P_n INCHES	31.21	31.21	31.21
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	38	38	38
TRANSLATION SPEED V_y (FORWARD SPEED) KNOTS	4	11	22
MAXIMUM WIND SPEED V_x M.P.H.	138	142	149
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	407	372	334

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	20
0.5	25
1.0	32
1.5	37
2.0	43
3.0	55
5.0	59
10.0	66
12.0	66
14.0	72
15.0	73
20.0	80
30.0	100
40.0	117
50.0	131
60.0	270
62.5	600
70.0	948

LATITUDE ϕ 30° 21' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES

COEFFICIENTS

BOTTOM FRICTION FACTOR 0.0025

WIND STRESS CORRECTION FACTOR 1.10

WATER LEVEL DATA

(AT OPEN COAST SHORELINE)

COMPONENTS	PMH SPEED OF TRANSLATION ST (FAST)	MT (SLOW)	HT (STATIONARY)
WIND SETUP			16.46
PRESSURE SETUP			3.23
INITIAL WATER LEV.			1.30
ASTRONOMICAL TIDE LEVEL			6.90
TOTAL-SURGE STILL WATER LEV. FEET MLW			27.90

TABLE C.12

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION JEKYLL ISLAND, GEORGIA LAT. 31° 05' LONG. 81° 24.5'; TRAVERSE-AZIMUTH 108 DEGREES LENGTH 72.6 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE 2 AT LOCATION 31° 05' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	26.72	26.72	26.72
PERIPHERAL PRESSURE P_n INCHES	31.19	31.19	31.19
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	40	40	40
TRANSLATION SPEED V_f (FORWARD SPEED) KNOTS	4	11	23
MAXIMUM WIND SPEED V_x M.P.H.	135	141	147
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	400	380	336

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	3.0
0.5	4.0
1.0	6.0
1.5	6.5
2.0	7.0
3.0	12.0
4.0	20.0
5.0	23.5
6.0	29.5
7.0	35.5
8.0	35.0
10.0	39.5
15.0	49.0
20.0	57.0
25.0	65.0
30.0	73.0
40.0	101.0
50.0	115.0
60.0	131.0
70.0	291.0
72.6	600.0
80.0	1,030.0

LATITUDE ϕ 30° 53' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES

COEFFICIENTS

BOTTOM FRICTION FACTOR 0.0025

WIND STRESS CORRECTION FACTOR 1.10

WATER LEVEL DATA

(AT OPEN COAST SHORELINE)

COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	FEET		
WIND SETUP			20.63
PRESSURE SETUP			3.34
INITIAL WATER LEV.			1.20
ASTRONOMICAL TIDE LEVEL			8.70
TOTAL-SURGE STILL WATER LEV. FEET MLW			33.87

TABLE C.13

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION FOLLY ISLAND LAT. 32° 39' LONG. 79° 56.6': TRAVERSE-AZIMUTH 150 DEGREES LENGTH 57.6 NAUTICAL MILES
SOUTH CAROLINA

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE 2 AT LOCATION 32° 39' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	26.81	26.81	26.81
PERIPHERAL PRESSURE P_n INCHES	31.13	31.13	31.13
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	40	40	40
TRANSLATION SPEED F_v (FORWARD SPEED) KNOTS	4	13	29
MAXIMUM WIND SPEED V_x M.P.H.	134	139	148
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	400	364	311

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE:	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	10.5
0.5	12.0
1.0	14.0
1.5	16.5
2.0	18.0
3.0	29.5
5.0	39.0
10.0	46.0
15.0	56.0
20.0	65.0
30.0	85.0
40.0	138.0
50.0	227.0
57.6	600.0
60.0	1,800.0

LATITUDE ϕ 32° 25' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES

COEFFICIENTS

BOTTOM FRICTION FACTOR 0.0025

WIND STRESS CORRECTION FACTOR 1.10

WATER LEVEL DATA

(AT OPEN COAST SHORELINE)

COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	F	E	E T
WIND SETUP			17.15
PRESSURE SETUP			3.23
INITIAL WATER LEV.			1.00
ASTRONOMICAL TIDE LEVEL			6.80
TOTAL-SURGE STILL WATER LEV. FEET MLW			28.18

TABLE C.14

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION RALEIGH BAY, LAT. 34° 54' LONG. 76° 15.3': TRAVERSE-AZIMUTH 135 DEGREES LENGTH 35.2 NAUTICAL MILES
NORTH CAROLINA

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE 3 AT LOCATION 34° 54' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	26.89	26.89	26.89
PERIPHERAL PRESSURE P_n INCHES	31.00	31.00	31.00
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	35	35	35
TRANSLATION SPEED V_f (FORWARD SPEED) KNOTS	5	17	38
MAXIMUM WIND SPEED V_x M.P.H.	130	137	149
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	385	346	280

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	16
0.5	28
1.0	40
1.5	46
2.0	54
3.0	64
5.0	72
10.0	92
15.0	112
20.0	124
30.0	264
35.2	600
40.0	900

LATITUDE ϕ 34°41.4 DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES

COEFFICIENTS

BOTTOM FRICTION FACTOR 0.0025

WIND STRESS CORRECTION FACTOR 1.10

WATER LEVEL DATA

(AT OPEN COAST SHORELINE)

COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	FEET		
WIND SETUP			8.84
PRESSURE SETUP			3.09
INITIAL WATER LEV.			1.00
ASTRONOMICAL TIDE LEVEL			4.70
TOTAL-SURGE STILL WATER LEV. FEET MLW			17.63

TABLE C.15

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION OCEAN CITY, LAT. 38° 20' LONG. 75° 04.9': TRAVERSE-AZIMUTH 110 DEGREES LENGTH 59 NAUTICAL MILES
MARYLAND

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE 4 AT LOCATION 38° 20' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	27.05	27.05	27.05
PERIPHERAL PRESSURE P_n INCHES	30.77	30.77	30.77
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	38	38	38
TRANSLATION SPEED F_v (FORWARD SPEED) KNOTS	10	26	48
MAXIMUM WIND SPEED V_x M.P.H.	124	133	146
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	350	293	251

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	17
0.5	32
1.0	29
1.5	35
2.0	45
3.0	38
4.0	56
5.0	61
6	71
7	56
8	60
9	58
10	59
11	65
12	64
13	70
14	62
15	70
16	78
18	103
20	90
25	134
30	121
35	134
40	146
50	255
58	600
60	840

LATITUDE ϕ 38°14.3' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES

COEFFICIENTS

BOTTOM FRICTION FACTOR 0.0025

WIND STRESS CORRECTION FACTOR 1.10

WATER LEVEL DATA

(AT OPEN COAST SHORELINE)

COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	FEET		
WIND SETUP			14.30
PRESSURE SETUP			2.83
INITIAL WATER LEV.			1.14
ASTRONOMICAL TIDE LEVEL			5.00
TOTAL-SURGE STILL WATER LEV. FEET MLW			23.27

TABLE C.16

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION ATLANTIC CITY, NEW JERSEY LAT. 39° 21' LONG. 74° 25'; TRAVERSE-AZIMUTH 146 DEGREES LENGTH 70 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE 4 AT LOCATION 39° 21' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES			27.12
PERIPHERAL PRESSURE P_n INCHES			30.70
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.			40
TRANSLATION SPEED V_f (FORWARD SPEED) KNOTS			49
MAXIMUM WIND SPEED V_x M.P.H.			142
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND			

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	10.0
0.5	15.0
1.0	22.0
2.0	38.0
5.0	50.0
10.0	72.0
20.0	90.0
30.0	120.0
40.0	138.0
50.0	162.0
60.0	210.0
65.0	258.0
70.0	600.0

LATITUDE ϕ 38° 53' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES			
COEFFICIENTS			
BOTTOM FRICTION FACTOR 0.0025			
WIND STRESS CORRECTION FACTOR 1.10			
WATER LEVEL DATA (AT OPEN COAST SHORELINE)			
COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	FEET		
WIND SETUP			15.32
PRESSURE SETUP			2.57
INITIAL WATER LEV.			1.10
ASTRONOMICAL TIDE LEVEL			5.70
TOTAL-SURGE STILL WATER LEV. FEET MLW			24.70

TABLE C.17

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION LONG ISLAND, CONNECTICUT LAT. 41° 00' LONG. 72° 01.8': TRAVERSE-AZIMUTH 166 DEGREES LENGTH 68.4 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE 4 AT LOCATION 41° 00' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	27.26	27.26	27.26
PERIPHERAL PRESSURE P_n INCHES	30.56	30.56	30.56
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	48	48	48
TRANSLATION SPEED V_f (FORWARD SPEED) KNOTS	15	34	51
MAXIMUM WIND SPEED V_x M.P.H.	115	126	136
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	346	293	259

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	22
0.5	38
1.0	43
1.5	53
2.0	67
3.0	82
5.0	102
10.0	132
15.0	145
20.0	170
30.0	212
40.0	240
50.0	260
60.0	302
68.4	600
70.0	870

LATITUDE ϕ 40° 27' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES

COEFFICIENTS

BOTTOM FRICTION FACTOR 0.0025

WIND STRESS CORRECTION FACTOR 1.10

WATER LEVEL DATA

(AT OPEN COAST SHORELINE)

COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	F	E	E T
WIND SETUP			8.73
PRESSURE SETUP			2.46
INITIAL WATER LEV.			0.97
ASTRONOMICAL TIDE LEVEL			3.10
TOTAL-SURGE STILL WATER LEV. FEET MLW			15.26

TABLE C.18

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION WATCH HILL LAT. 41°18.9' LONG. 71 50': TRAVERSE-AZIMUTH 166 DEGREES LENGTH 84 NAUTICAL MILES
POINT, RHODE ISLAND

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE 4 AT LOCATION 41° 19' DEGREE MONTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	27.29	27.29	27.29
PERIPHERAL PRESSURE P_n INCHES	30.54	30.54	30.54
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	49	49	49
TRANSLATION SPEED V_t (FORWARD SPEED) KNOTS	15	35	51
MAXIMUM WIND SPEED V_x M.P.H.	113	126	134
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	348	284	255

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	28
0.5	40
1.0	77
1.5	98
2.0	119
3.0	117
4.0	114
5.0	128
6.0	114
7.0	113
8.0	117
9.0	118
10.0	93
11.0	70
12.0	65
13.0	51
14.0	56
15.0	77
20.0	131
30.0	191
40.0	222
50.0	245
60.0	254
70.0	283
80.0	336
84.0	600
90.0	1,488

LATITUDE ϕ 40° 38' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES			
COEFFICIENTS			
BOTTOM FRICTION FACTOR 0.0025			
WIND STRESS CORRECTION FACTOR 1.10			
WATER LEVEL DATA (AT OPEN COAST SHORELINE)			
COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	FEET		
WIND SETUP			10.01
PRESSURE SETUP			2.42
INITIAL WATER LEV.			0.96
ASTRONOMICAL TIDE LEVEL			4.00
TOTAL-SURGE STILL WATER LEV. FEET MLW			17.39

TABLE C.19

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL[1]

LOCATION HAMPTON BEACH, NEW HAMPSHIRE LAT. 42° 57' LONG. 70° 47.1'; TRAVERSE-AZIMUTH 115 DEGREES LENGTH 40 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE 4 AT LOCATION 42° 57' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	27.44	27.44	27.44
PERIPHERAL PRESSURE P_n INCHES	30.42	30.42	30.42
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	57	57	57
TRANSLATION SPEED V_f (FORWARD SPEED) KNOTS	17	37	52
MAXIMUM WIND SPEED V_x M.P.H.	107	118	127
INITIAL DISTANCE-NAUT.MI.[1/] FROM 20 MPH WIND AT SHORE TO MAX. WIND	353	290	262

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

[1/] Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	8
0.5	40
1.0	64
1.5	82
2.0	100
3.0	105
5.0	156
10.0	258
15.0	336
20.0	266
25.0	210
30.0	322
35.0	433
40.0	600

LATITUDE ϕ 42° 48' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES

COEFFICIENTS

BOTTOM FRICTION FACTOR 0.0025

WIND STRESS CORRECTION FACTOR 1.10

WATER LEVEL DATA

(AT OPEN COAST SHORELINE)

COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	F	E	E T
WIND SETUP			4.25
PRESSURE SETUP			2.23
INITIAL WATER LEV.			0.83
ASTRONOMICAL TIDE LEVEL			10.50
TOTAL-SURGE STILL WATER LEV. FEET MLW			17.81

TABLE C.20

SUMMARY-PERTINENT PROBABLE MAXIMUM HURRICANE (PMH), STORM SURGE COMPUTATIONAL DATA AND RESULTANT WATER LEVEL

LOCATION GREAT SPRUCE ISLAND, MAINE LAT. 44°33.4' LONG. 67° 30'; TRAVERSE-AZIMUTH 148 DEGREES LENGTH 178.6 NAUTICAL MILES

PROBABLE MAXIMUM HURRICANE INDEX CHARACTERISTICS ZONE 4 AT LOCATION 44° 33' DEGREE NORTH			
PARAMETER DESIGNATIONS	SPEED OF TRANSLATION SLOW (ST)	MODERATE (MT)	HIGH (HT)
CENTRAL PRESSURE INDEX P_o INCHES	27.61	27.61	27.61
PERIPHERAL PRESSURE P_n INCHES	30.25	30.25	30.25
RADIUS TO MAXIMUM WIND LARGE RADIUS NAUT. MI.	64	64	64
TRANSLATION SPEED V_f (FORWARD SPEED) KNOTS	19	39	53
MAXIMUM WIND SPEED V_x M.P.H.	102	114	122
INITIAL DISTANCE-NAUT.MI.1/ FROM 20 MPH WIND AT SHORE TO MAX. WIND	352	288	262

Note: Maximum wind speed is assumed to be on the traverse that is to right of storm track a distance equal to the radius to maximum wind.

1/ Initial distance is distance along traverse from shoreline to maximum wind when leading 20 mph isovel intersects shoreline. Storm diameter between 20 mph isovels is approximately double the initial distance.

OCEAN BED PROFILE	
TRAVERSE DISTANCE FROM SHORE (NAUT.MI.)	WATER DEPTH BELOW MLW (FEET)
0	0
0.2	50
0.5	96
1.0	95
1.5	125
2.0	125
3.0	165
4.0	247
5.0	188
10.0	233
15.0	438
20.0	570
30.0	271
40.0	511
50.0	443
60.0	377
70.0	334
80.0	228
90.0	168
100.0	250
110.0	301
120.0	345
130.0	258
140.0	249
150.0	288
160.0	291
170.0	318
178.6	600
180.0	1,620

LATITUDE ϕ 43°17.8' DEGREE AT TRAVERSE MID-POINT FROM SHORE TO 600-FOOT DEPTH

PMH COMPUTATIONAL COEFFICIENT AND WATER LEVEL (SURGE) ESTIMATES			
COEFFICIENTS			
BOTTOM FRICTION FACTOR 0.0025			
WIND STRESS CONNECTION FACTOR 1.10			
WATER LEVEL DATA (AT OPEN COAST SHORELINE)			
COMPONENTS	PMH SPEED OF TRANSLATION ST	MT	HT
	FEET		
WIND SETUP			9.73
PRESSURE SETUP			1.82
INITIAL WATER LEV.			0.56
ASTRONOMICAL TIDE LEVEL			16.00
TOTAL-SURGE STILL WATER LEV. FEET MLW			28.11

TABLE C.21

OCEAN BED PROFILES

PASS CHRISTIAN		CRYSTAL RIVER		ST. LUCIE		CHESAPEAKE BAY MOUTH		HAMPTON BEACH*	
Nautical Miles from Shore	Depth, ft, MLW	Nautical Miles from Shore	Depth, ft, MLW	Nautical Miles from Shore	Depth, ft, MLW	Nautical Miles from Shore	Depth, ft, MLW	Nautical Miles from Shore	Depth, ft, MLW
1	3	0.55	3	0.1	10	5	44	0.5	20
2	9	2.31	10	10	90	10	56	4	120
5	12	6.25	14	16	390	30	102	10	250
10	13	8.33	9	18.7	600	50	178	25	250
15	35	31.4	50			55	240	44	600
20	36	100	180			62	600		
30	40	113	300						
40	52	127	600						
50	90								
60	160								
70	335								
77	600								

* As developed for Seabrook

D.7. Tennessee Valley Authority



4.20 Dam Safety

4.20.1 Introduction

The factors associated with dam safety relative to the proposed changes in system operations include:

Resource Issues

- Reservoir-triggered seismicity
- Dam stability
- Leakage from dams

- Effects on reservoir-triggered seismicity (RTS) due to changes in filling or drawdown rates, or higher than normal reservoir levels;
- Effects on dam stability of changes in seismicity, higher reservoir levels, filling or drawdown rates; and,
- Leakage from dams in response to higher reservoir levels in areas of carbonate rocks with karst development.

Potential impacts on these key elements of dam safety are all indirect effects of the policy alternatives.

4.20.2 Regulatory Programs and TVA Management Activities

The Federal Guidelines for Dam Safety require that dams with a direct federal interest, which includes all dams in the TVA's system, must be designed, inspected, and maintained throughout their operating life to verify and protect the structural integrity of the dam and appurtenant structures to ensure protection of human life and property.

The requirements for design floods for dams that are the responsibility of federal agencies are contained in the following documents:

- Federal Guidelines for Dam Safety, Federal Emergency Management Agency Publication FEMA 93, November 1998.
- Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams, Federal Emergency Management Agency Publication FEMA 94, October 1998.

4.20.3 Seismology

Existing Conditions

Reservoir-triggered seismicity is the initiation of earthquakes by the impoundment or operation of a reservoir. Reservoir-triggered earthquakes can be identified by a change in the pattern of earthquake activity in the immediate vicinity of a reservoir that usually begins during or shortly

after (days to a few years) initial filling of the reservoir. Rapid reservoir elevation changes can also trigger earthquakes.

The mechanisms that control RTS—primarily increased pore pressures in fractured rock surrounding or beneath the reservoir and increased load due to water volume—are generally agreed upon. The relative importance of these mechanisms on a site-specific basis and whether individual reservoirs exhibit RTS are not as clear.

While at least four reservoirs in the Southeastern United States exhibit RTS, the evidence for RTS at TVA reservoirs is weak at best. Many of the TVA reservoirs are located within the Southern Appalachian Seismic Zone, a zone that was active before the introduction of TVA reservoirs and continues to be active today (Reinbold and Johnston 1987). Earthquakes typically associated with RTS are more shallow than most southern Appalachian earthquakes. There have been a few instances of small, shallow earthquakes near TVA reservoirs (e.g., the February 1990 sequence of earthquakes near Tellico Reservoir); there have also been similar sequences of shallow earthquakes in the Southern Appalachians well removed from reservoirs (e.g., Bristol, Virginia in February 1988 and Greeneville, Tennessee in March 1995).

If TVA reservoirs do exhibit RTS, it appears to be rare and would be difficult to confirm. To determine whether RTS is occurring or has occurred at any TVA reservoir, detailed seismic activity records would be required in the vicinity of all reservoirs for a few years before and for several years after the initial filling of the reservoirs. This type of seismic documentation is not available. The question of RTS at TVA reservoirs cannot be answered with confidence. If RTS does occur, however, it is not obvious based on earthquake data collected over the past 20 years (Chapman and Mathena 2001).

Future Trends

No trends have been identified relative to RTS; therefore, future trends are expected to be the same as existing conditions.

4.20.4 Reservoir Levels

Existing Conditions

Water levels at TVA reservoirs fluctuate under normal operations (see Section 2.2). In addition to the normal operating levels, the reservoirs are designed to withstand forces associated with a flood condition. All TVA dams classified as either high or significant hazard potential are capable of passing the applicable inflow design flood (IDF) as required by the federal guidelines with the exception of Chickamauga. Dams classified as high hazard potential are those dams where failure or improper operation probably would cause loss of human life. Dams classified as significant hazard potential dams are those dams where failure or improper operation would result in no probable loss of human life but could cause economic loss, environmental damage, disruption of lifeline facilities, or could affect other concerns. Dams that are classified as significant hazard potential are often located in predominantly rural or agricultural areas but

could be located in areas with higher population and significant infrastructure. The hydrologic design for Chickamauga is under review to determine the applicable IDF and needed modifications, if any.

Future Trends

Reservoirs levels are variable year to year but fall within the flood guides for each reservoir. Levels would not be allowed to fluctuate such that dam safety was compromised.

4.20.5 Reservoir Drawdown Rates

Existing Conditions

Water pressure from a reservoir causes water to gradually infiltrate the surrounding reservoir rimrock, soil embankments, or foundations. Over time, internal pressures, called pore pressures, are created within the surrounding area. These pressures increase until the surrounding area reaches equilibrium. If the reservoir is rapidly drawn down after pore pressures are established, they may create unstable conditions in the surrounding rim that can cause slides or sloughing of the rim material.

The structures that surround reservoirs that are subject to fill and drawdown cycles are designed to withstand the expected fluctuations of external water pressures and internal pore pressures. The design is based on an upper limit on the allowable rate of drawdown. Table 4.20-01 lists the maximum allowable drawdown rates necessary to ensure the stability of the dams within the scope of the EIS.

Future Trends

Under the existing operations policy, future drawdown rates would continue to be maintained within present limits.

4.20.6 Leakage

Existing Conditions

Some leakage, or unintended flow, is expected to occur at all dams either through structural joints, earthen embankments, reservoir rims, or foundation materials. Any leakage is evaluated during periodic dam inspections and a determination is made as to whether the volume, rate of change, and sediment content (if any) of the leak poses structural concerns. When necessary, the leakage is periodically measured and recorded so that trends can be defined. Changes in these trends can indicate that a more detailed evaluation of the seepage is warranted.

Table 4.20-01 Drawdown Limits for Tributary Reservoirs

Project[1]	Description	Drawdown Limits[2]
Apalachia	Concrete	3 feet per day not to exceed 12 feet per week
Blue Ridge	Hydraulic fill	2 feet per day not to exceed 7 feet per week for 28 feet, then 3 feet per week
Chatuge	Impervious rolled fill	2 feet per day not to exceed 7 feet per week for 28 feet, then 3 feet per week
Cherokee	Concrete and impervious rolled fill	2 feet per day not to exceed 7 feet per week for 28 feet, then 3 feet per week
Douglas	Concrete and impervious rolled fill	2 feet per day not to exceed 7 feet per week for 28 feet, then 3 feet per week
Fontana	Concrete	2 feet per day not to exceed 7 feet per week for 28 feet, then 3 feet per day not to exceed 12 feet per week
Great Falls	Concrete	2 feet per day not to exceed 12 feet per week
Hiwassee	Concrete	2 feet per day not to exceed 7 feet per week
Norris	Concrete and earth fill	2 feet per day not to exceed 7 feet per week for 28 feet, then 3 feet per week
Nottely	Impervious rolled fill	2 feet per day not to exceed 7 feet per week for 28 feet, then 3 feet per week
South Holston	Impervious rolled fill	2 feet per day not to exceed 7 feet per week for 28 feet, then 3 feet per week
Watauga	Impervious rolled fill	2 feet per day not to exceed 7 feet per week for 28 feet, then 3 feet per week

[1] For those reservoirs not shown, the drawdown rate would follow the rate shown for Blue Ridge.

[2] Restrictions are based on dam safety and slope stability considerations.

Source: TVA files - Dam Safety Group 2003.

Table 4.20-02 details TVA reservoirs within the scope of the EIS that have been monitored for leakage. This table also indicates whether the amount of leakage would increase as the reservoir headwater elevation increases and, where known, describes the cause of the leakage. The data are reviewed periodically to assess the leakage and ensure the continued safety of the structures. Periodically, an Instrumentation Project Performance Report is issued, which reviews the history of the project, evaluates the appropriateness of the instrumentation and frequency of observation, identifies conditions that might threaten dam safety, and evaluates the structural and geotechnical performance of the dam.

Table 4.20-02 Leakage Monitored at Non-Power and Power Projects

Project	Leakage Increases with Increasing Headwater	Bedrock	Leakage Mechanism
Non-Power Projects			
Bear Creek	Yes	Limestone and shale	Karst
Cedar Creek	No, seasonal	Sandstone	Unknown
Little Bear Creek	No, seasonal	Limestone and shale	Karst
Normandy	Yes	Limestone	Karst
Tellico	No, seasonal	Limestone and shale	Karst
Upper Bear Creek	No, seasonal	Sandstone, shale and conglomerate	Unknown
Power Projects			
Blue Ridge	Yes	Schist and metagraywacke	Spring along abutment/ embankment interface
Chatuge	Yes	Biotite Gneiss	Unknown
Douglas (Dandridge Dike)	Yes	Unknown	Foundation of dike
Fort Patrick Henry	Inconclusive	Limestone, dolomite, shale	Unknown
Great Falls	Yes	Limestone and chert	Karst
Guntersville	No	Limestone	Karst
Melton Hill	Yes	Dolomite	Karst
Norris	Yes	Dolomite	Karst
Nottely	Yes	Schist, metagraywacke, metaconglomerate	Unknown
Tims Ford	Yes	Limestone and shale	Karst
Wheeler	Yes	Limestone	Karst
Wilson	No, seasonal	Limestone	Karst

Source: TVA files - Dam Safety Group 2003.

Future Trends

The trends exhibited by the leakage observed at TVA dams are shown in Table 4.20-02. These trends are expected to continue through 2030 due to the continued operation of TVA reservoirs under the existing reservoir operations policy.

This page intentionally left blank.

Hydrologic Research Needs for Dam Safety Analysis At the Tennessee Valley Authority

By
R. Cris Hughes, P.E., and Gregory W. Lowe, P.E.[1]

Background

The Tennessee Valley Authority (TVA) was created in 1933 to provide for the unified development of the Tennessee River Valley. The purpose of the Act is stated as follows:

"That for the purpose of . . . and to improve navigation in the Tennessee River and to control the destructive flood waters in the Tennessee River and Mississippi River Basins, there is hereby created . . . the 'Tennessee Valley Authority' " - Preamble.

With respect to planning, Section 23 requires the President to recommend to Congress such legislation as he deems proper " . . . for the especial purpose of bringing about . . . in conformity with said general purposes (1) the maximum amount of flood control, (2) the maximum development of said Tennessee River for navigation purposes, (3) the maximum generation of electric power consistent with flood control and navigation; . . ."

On the subject of operation of reservoirs, Section 9a states: "The (TVA) Board is hereby directed in the operation of any dam or reservoir . . . to regulate the stream flow primarily for the purposes of promoting navigation and controlling floods. So far as may be consistent with such purposes, the Board is authorized to provide and operate facilities for the generation of electric energy . . . and the Board is further authorized, whenever an opportunity is afforded, to provide and operate facilities for the generation of electric energy in order to avoid the waste of water power, . . ."

TVA's structural approach to minimizing flood risk was the construction of dams with flood control allocations to "keep the floods away from the people." Today, TVA operates an integrated reservoir system of 49 dams (1 project in the Cumberland River basin), in the 41,000-square mile Tennessee River drainage basin covering portions of seven states. Since these dams were built, significant flood reduction benefits have been realized along the Tennessee River and its tributaries, and along the lower Ohio and Mississippi Rivers. TVA dams also provide additional benefits to the region including navigation, hydropower generation, water supply, recreation, water quality, and land use for economic development.

TVA's reservoir system has been effective in providing over $5B in flood damage reduction benefits. TVA also recognized that structural measures could not eliminate flooding, and that there were about 350 communities in the Tennessee Valley with some degree of flood risk and damage potential.

[1] Tennessee Valley Authority

In response to this situation, TVA initiated a floodplain management assistance program in 1953 based on the concept of averting local flood damages by careful land use planning. This approach of working with state and local governments to deal with flood problems was applied throughout the Tennessee River watershed. During this period, TVA promoted the concept of avoiding development within the 100-year floodplain and encouraging to the extent possible the adoption of higher setback and elevation standards.

In the late 1960s, TVA utilized its floodplain management experience to assist the Federal Emergency Management Agency (FEMA) with the development of what is today the National Flood Insurance Program (NFIP). TVA served as a contractor to FEMA for several years to develop flood information for many communities within the Tennessee Valley. During this period, TVA also demonstrated several different flood damage reduction measures at different communities including channel restoration/modifications, flood warning systems, acquisition and relocation, and flood proofing.

Current Floodplain Management Activities

Since 1994, TVA's floodplain management efforts have focused on the lands and projects that TVA holds in stewardship, and on the floodplains along the rivers and streams, which are affected by regulation from TVA dams. The objective of the program is to minimize flood damages, ensure the safety of floodplain residents (by keeping the people away from the water), preserve TVA's reservoir operating flexibility for flood control purposes, and ensure consistency with local floodplain regulations. TVA's reservoirs and the river reaches below the dams have seen substantial development over the last several years. Thus, flood risk is expected to continue to increase in the future from this one factor alone.

Dam Safety Program Development

TVA has maintained a dam safety program since its establishment in 1933. Following the failure of Teton Dam, President Jimmy Carter issued a 1976 memorandum to all Federal Agencies with responsibilities for dams to develop and implement formal guidelines for dam safety. After participating in the development of the interagency document, *Federal Guidelines for Dam Safety* (Reference 1), TVA formalized its dam safety program in 1982. At that time, TVA evaluated all of its dams for hydrologic and seismic safety, and determined that 23 of its then 53 dams had some degree of deficiency and could be made even safer, consistent with these guidelines. Since that time, TVA has spent more than $75M modifying these dams, with work underway at the remaining two projects to ensure its dams meet these guidelines. Because most of TVA's dams are high hazard structures with significant potential for loss of life and property damage, TVA chose to modify its dams to safely pass the Probable Maximum Flood (PMF).

TVA recognized the need to have an outside authority provide estimates of the Probable Maximum Precipitation (PMP). Further, TVA recognized the need to have studies performed specific to the region rather than using generalized estimates for PMP. The National Weather Service (NWS) was funded by TVA to study two categories of extreme precipitation for the Tennessee Valley which included PMP and a standardized less extreme rainfall referred to as the "TVA precipitation." At this time, the NWS completed Hydrometeorological Reports (HMR) 41 (Reference 2); 47 (Reference 3); and 56 (Reference 4). HMR 45, superseded by HMR 56 in 1986, was used in studies prior to HMR 56. These reports provided estimates of precipitation for large areas such as that above the City of Chattanooga (approximately 21,400 square miles) and for basins up to 3,000 square miles. These reports defined depth-area-duration characteristics and antecedent storm potentials.

Current Research Needs

One of the most controversial aspects of the TVA reservoir system is the annual operating cycle for the tributary projects. There are 10 tributary projects, which have a summer-to-winter fluctuation of from 35 to as much as 90 feet. The seasonally varying allocation of flood storage was designed primarily to provide flood protection for the City of Chattanooga, the major damage center in the Tennessee Valley. These reservoirs provide over 4 million acre-feet of flood storage space needed during the flood season from mid-December through early April. However, the economic benefits attributable to use of these reservoirs have changed over the years and now include enhanced lake front property value, recreational boating, fishing, swimming, wildlife habitat, minimum flow and dissolved oxygen (DO) enhancements, and related functions.

Stakeholders, for many years, have questioned the need for this flood storage (saying it is too conservative) and have requested a delay of the drawdown of these reservoirs until later in the fall. These reservoirs are typically at their highest level by June 1 of each year depending on rainfall/runoff. During June and July, they are gradually drawn down to support downstream water quality and hydropower generation. After August 1 of each year, the reservoirs have an unrestricted drawdown to lower them to their January 1 flood storage levels.

In 1991, TVA completed the *Tennessee River and Reservoir System Operation and Planning Review*, an Environmental Impact Statement (EIS) that resulted in changes to its reservoir operating policies. This was the first comprehensive re-evaluation of reservoir operating policy since the projects were built. However, the focus of this review was on maintaining minimum flow below dams at critical times and locations, increasing DO below 16 dams by aerating releases, and to delay unrestricted summer drawdown until August 1 on ten tributary reservoirs. While flood control was a consideration in review of these alternatives, no alternatives were considered which would change the winter flood storage allocations. However, the review did formalize the requirements for a minimum of one inch of flood storage space during the summer months at 10 of the tributary reservoirs.

TVA established a Regional Resource Stewardship Council in March 2000 under the Federal Advisory Committee Act (FACA). The purpose of the Council was to provide advice to TVA on policies, priorities, and practices for managing its land and water resources and programs as part of its public responsibilities. The Council is made up of 20 representatives from across the Valley. They represent a range of interests in TVA's stewardship activities, including representatives of the Governors of the seven TVA states, power distributors, industry, business, environment, recreation, consumers, and educational and community leadership.

This summer (2001) the Council recommended that TVA undertake a study of its reservoir operating policy to determine if changes could create greater overall value for TVA customers and stakeholders without reducing gains which had been realized in water quality. The study will include evaluation of costs and benefits. The TVA Board responded to this recommendation in October with a commitment to perform a comprehensive evaluation of reservoir operating policy in two years. This study will be conducted within the National Environmental Policy Act (NEPA) framework as an (EIS).

One of the major issues to be addressed will be the evaluation of potential change in flood risk that could result from a change in reservoir operating policy. The evaluation must ensure that the tools and analysis process must be capable of providing a clear understanding of how the flood risks could change. This should include impacts on flood frequency throughout the full range of flood potential from the annual event through the PMF, effect on local floodplain regulations as part of the NFIP, elevation and flow duration, and impact on dam safety.

At this time there are several studies underway to address similar issues across the country (Upper Mississippi River Flow Frequency, Savannah River, and Lower Colorado River Authority). Many factors are driving this need including: (1) the Nation's floodplains continue to be developed increasing the flood risk and damage potential; (2) advances in weather forecast capabilities are viewed by the public as a reliable basis for reservoir operations well in advance of actual events; (3) studies raise questions about previously completed flood frequency analysis and whether these changes in turn should result in changes to published information used for local floodplain regulations for 100- and 500-year flood boundaries and floodways; (4) the hydrologic period of records are increasing, coupled with more sophisticated computational methods and modeling capabilities; and (5) a growing interest on the part of the stakeholders that live along or use the water resource to change the allocation of benefits based on economics.

Conclusion

Research is needed to focus on flood risk assessment methodology that can be supported by the technical community, general public, and local, state, and federal land- and water-use decision makers.

References:

1. Ad Hoc Interagency Committee on Dam Safety, Federal Coordinating Council for Science, Engineering and Technology, "Federal Guidelines for Dam Safety," June 1979.

2. U.S. Weather Bureau, "Probable Maximum and TVA Precipitation Over the Tennessee River Basin Above Chattanooga," Hydrometeorological Report No. 41, 1965.

3. National Oceanic and Atmospheric Administration, "Meteorological Criteria for Extreme Floods for Four Basins in the Tennessee and Cumberland River Watersheds," Hydrometeorological Report No. 47, 1973.

4. National Weather Service, "Probable Maximum and TVA Precipitation Estimates with Area l Distribution for Tennessee River Drainages Less than 3000 Square Miles in Area," Hydrometeorological Report No. 56, October 1986.

D.8. U.S. Army Corps of Engineers



CECW-CE Engineer Regulation 1110-2-1156	DEPARTMENT OF THE ARMY U.S. Army Corps of Engineers Washington, DC 20314-1000	ER 1110-2-1156 28 October 2011
	Engineering and Design SAFETY OF DAMS – POLICY AND PROCEDURES	
	Distribution Restriction Statement Approved for public release; distribution is unlimited.	

ER 1110-2-1156
28 October 2011

US Army Corps
of Engineers

ENGINEERING AND DESIGN

SAFETY OF DAMS - POLICY AND PROCEDURES

ENGINEER REGULATION

This Page Left Blank

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

CECW-CE

ER 1110-2-1156

Regulation
No. 1110-2-1156

28 October 2011

Engineering and Design
SAFETY OF DAMS – POLICY AND PROCEDURES

TABLE OF CONTENTS

	Paragraph	Page
PART I – Overview of Dam Safety Program		
Chapter 1 Dam Safety Program - Introduction, Overview, and Guiding Principles		
Purpose	1.1	1-1
Applicability	1.2	1-1
Distribution Statement	1.3	1-1
References	1.4	1-1
Glossary	1.5	1-1
Dam Safety Definition	1.6	1-1
Dam Safety Program	1.7	1-1
Dam Safety Officers	1.8	1-2
Transition to a Risk Informed Dam Safety Program	1.9	1-2
Principles for Dam Safety Portfolio Risk Management	1.10	1-2
Principles for Implementing Interim Risk Reduction Measures at High Risk Dams	1.11	1-3
History of Dam Safety	1.12	1-6
Federal Guidelines for Dam Safety	1.13	1-6
Levels of USACE Responsibility for Dam Safety	1.14	1-6
Chapter 2 Dam Safety Program Framework		
Scope	2.1	2-1
OMB Risk Analysis Principles	2.2	2-1
Dam Safety Risk Framework	2.3	2-3
Risk Assessment – An Elaboration	2.4	2-4
Risk Management – An Elaboration	2.5	2-6
Risk Communication – An Elaboration	2.6	2-7

This regulation supersedes ETL 1110-2-231 dated 30 March 1979, EP 1110-2-13 dated 28 June 1996, ER 1110-2-50 dated 22 August 1975, ER 1110-2-100 dated 1 December 1998, ER 1110-2-101 dated 31 January 1993, ER 1110-2-110 dated 8 July 1985, ER 1110-2-1155 dated 12 September 1997, and ER 1110-2-1156 dated 31 July 1992.

	Paragraph	Page
Chapter 3 Dam Safety Portfolio Risk Management		
Purpose/Objective	3.1	3-1
Dam Safety Action Classification System	3.2	3-1
Dam Safety Portfolio Risk Management Process	3.3	3-2
Scope of Risk Assessments in Support of Dam Safety Evaluations	3.4	3-8
Risk Reporting and Data Management	3.5	3-10
Water Storage and Risk Reduction Measures	3.6	3-11
PART II - Decision Guidelines and Procedures		
Chapter 4 Management of Corps of Engineers Dam Safety Program		
General	4.1	4-1
Overall Responsibility for Dam Safety Program	4.2	4-1
Headquarters, US Army Corps of Engineers	4.3	4-2
Major Subordinate Commands (MSC) (Regional Headquarters)	4.4	4-7
District Commands	4.5	4-9
Professional Registration	4.6	4-12
Dam Safety Officer Selection Process	4.7	4-13
Chapter 5 Tolerable Risk Guidelines		
Introduction	5.1	5-1
Background on Tolerable Risk Guidelines	5.2	5-1
USACE Tolerable Risk Guidelines	5.3	5-3
Considerations in Risk Estimation for Risk Assessment and Risk Evaluation	5.4	5-16
Example Presentations of USACE Tolerable Risk Guidelines	5.5	5-17
Chapter 6 Dam Safety Risk Management Prioritization		
Purpose	6.1	6-1
Organizational Roles and Responsibilities in the Prioritization Process	6.2	6-1
General Philosophy on Prioritization	6.3	6-1
Prioritization Queues and Related Issues	6.4	6-3
Chapter 7 Interim Risk Reduction Measures for Dam Safety		
Purpose	7.1	7-1

	Paragraph	Page
Principles for Implementing Interim Risk Reduction Measures at High Risk Dams	7.2	7-1
General	7.3	7-3
Funding for IRRMP and IRRM	7.4	7-3
Interim Risk Reduction Measures Plan (IRRMP)	7.5	7-4
EAP and Emergency Exercises	7.6	7-5
Decision Process for USACE Dam Safety Interim Risk Reduction Actions	7.7	7-5
Interim Risk Reduction Measures (IRRM)	7.8	7-7
Evaluation Factors for IRRM	7.9	7-11
Communications Plan	7.10	7-12
Approval and Implementation of IRRMP	7.11	7-12
Chapter 8 Issue Evaluation Studies		
Purpose of Issue Evaluation Studies (IES)	8.1	8-1
Objectives of Issue Evaluation Studies	8.2	8-1
Issue Evaluation Study Plan	8.3	8-3
Funding for Issue Evaluation Study Plans	8.4	8-3
Schedules for Submittal of Issue Evaluation Study Plans	8.5	8-3
Approval Authority	8.6	8-4
Submittal Requirements	8.7	8-4
Issue Evaluation Studies – Phase 1	8.8	8-5
Issue Evaluation Studies – Phase 2	8.9	8-6
Use of Tolerable Risk Guidelines	8.10	8-7
Issue Evaluation Study Documentation	8.11	8-8
Roles and Responsibilities	8.12	8-9
Funding	8.13	8-10
Schedule	8.14	8-10
Decision Process; Submittal, Review, and Approvals of IES	8.15	8-10
Chapter 9 Dam Safety Modification Studies and Documentation		
Purpose	9.1	9-1
Change from Previous Guidance	9.2	9-1
Eligibility	9.3	9-1
DSM Study Objectives	9.4	9-2
Basic Approach and Principles for Execution of a DSM Study	9.5	9-3
Dam Safety Modification Study Project Management Plan and Tasks	9.6	9-9
Dam Safety Modification Decision Document	9.7	9-12

	Paragraph	Page
Submittal, Policy Compliance Review, and Approval Process	9.8	9-13
ASA(CW) Notification and Concurrence with Construction	9.9	9-14
Supplemental DSM Decision Documents	9.10	9-14
Funding of Dam Safety Modification Studies, Reports, and Construction Projects	9.11	9-15
Cost Sharing Requirements	9.12	9-18
Sponsor Identification	9.13	9-21
Cost Recovery	9.14	9-22

Chapter 10 Dam Safety Risk Communication

Purpose/Objective	10.1	10-1
USACE Dam Safety Risk Communication Philosophy	10.2	10-1
Understanding Tolerable Risks	10.3	10-2
Communication Planning	10.4	10-3
Communication of the USACE Dam Safety Action Classifications	10.5	10-3
DSAC I and II Communication Strategies	10.6	10-4
Public Meetings and Stakeholder Involvement	10.7	10-5
Emergency Risk Communications	10.8	10-5
Internal PDT Communications	10.9	10-6

PART III – Periodic Assessments, Inspections, and Other Items

Chapter 11 Periodic Inspection, Periodic Assessment, and Continuing Evaluation

Applicability and Policy	11.1	11-1
Institutional Knowledge and Technical Expertise	11.2	11-1
Inspection and Assessment Policy	11.3	11-2
Program Implementation	11.4	11-3
Instrumentation	11.5	11-7
Responsibilities	11.6	11-8
Program Review	11.7	11-10
Reporting Distress	11.8	11-10
Funding	11.9	11-10

Chapter 12 Operations and Maintenance Activities

General	12.1	12-1
Operations and Maintenance Manual	12.2	12-1

	Paragraph	Page
Project Geotechnical and Concrete Materials Completion Report for Major USACE Projects	12.3	12-1
Instrumentation and Monitoring	12.4	12-1
Reporting Distress	12.5	12-2
Operations and Maintenance Program	12.6	12-3
Chapter 13 Reporting Evidence of Distress in Civil Works Structures		
Purpose	13.1	13-1
General	13.2	13-1
Discussion	13.3	13-1
Procedures	13.4	13-1
Signs of Distress	13.5	13-2
Inspections	13.6	13-4
Chapter 14 Instrumentation for Safety Evaluations of Civil Works Structures		
Policy	14.1	14-1
Risk Informed Instrumentation Monitoring	14.2	14-1
Planning	14.3	14-2
Installation and Maintenance	14.4	14-4
Data Collection, Interpretation, and Evaluation	14.5	14-4
Reporting	14.6	14-6
Funding	14.7	14-6
Chapter 15 Dam Safety Training		
Overview	15.1	15-1
Corps of Engineers Training Course on Dam Safety	15.2	15-1
National Dam Safety Conferences	15.3	15-1
Exchange Training – District to District	15.4	15-1
Training Program for Operations and Maintenance Personnel	15.5	15-2
Sample Dam Safety Training Course Outline for Project Personnel	15.6	15-2
Dam Safety Training Courses	15.7	15-3
Risk Assessment Training	15.8	15-4
Consequence Training	15.9	15-4
Chapter 16 Emergency Action Plans		
General	16.1	16-1
Requirements	16.2	16-2

	Paragraph	Page
Emergency Exercises	16.3	16-3
Modeling, Mapping, and Consequence Center	16.4	16-5
Security Provisions	16.5	16-5
Communications	16.6	16-5
Dam Owner's Responsibilities	16.7	16-6
Responsibility for Evacuation (Non-Federal)	16.8	16-7
Chapter 17 Reservoir Filling Plans		
Applicability	17.1	17-1
Introduction	17.2	17-1
Reservoir Filling Plan	17.3	17-1
Plan Approval	17.4	17-3
Performance Report	17.5	17-3
Chapter 18 Risk Assessment Methodology		
General	18.1	18-1
Philosophy and Approach	18.2	18-1
Best Practices	18.3	18-2
Combining and Portraying Risks	18.4	18-2
Risk Assessment Documentation	18.5	18-3
Qualitative and Semi-Quantitative Risk Assessments	18.6	18-4
Facilitating Risk Assessments	18.7	18-4
Chapter 19 Program Administration and Funding Process		
Purpose	19.1	19-1
Program Documentation	19.2	19-1
Funding Process	19.3	19-1
Funding Appropriations	19.4	19-2
Chapter 20 Asset Management and Condition Assessments		
Purpose	20.1	20-1
General	20.2	20-1
Policy	20.3	20-1
Chapter 21 Dam Safety Policy for Planning and Design		
Purpose and Status	21.1	21-1
General	21.2	21-1
Project Delivery Team	21.3	21-1
Dam Safety Items for the Planning Phase	21.4	21-2

	Paragraph	Page
Dam Safety Items for the PED Phase	21.5	21-3
Consulting with State Dam Safety Officials	21.6	21-5
Chapter 22 Dam Safety During Construction (Remediation and New Dams)		
Purpose	22.1	22-1
Design/Pre-Construction Phase	22.2	22-1
Construction Phase	22.3	22-4
Post Construction Phase	22.4	22-8
Chapter 23 Physical Security for Dams		
Purpose and Status	23.1	23-1
Policy	23.2	23-1
General	23.3	23-1
Physical Security Program	23.4	23-1
Antiterrorism	23.5	23-1
Security Portfolio Prioritization	23.6	23-2
Security Risk Assessment	23.7	23-2
Security Training and Resources	23.8	23-3
PART IV – Appendices, Annexes, Glossary, Tables, and Figures		
Appendix A – References		
References		A-1
Appendix B – Dam Safety in The Corps of Engineers		
Background	B.1	B-1
Introduction	B.2	B-2
History of Dam Safety	B.3	B-2
Appendix C – Summary of the Federal Guidelines for Dam Safety		
1977 Presidential Memorandum	C.1	C-1
Publication of Guidelines	C.2	C-1
Implementation of Guidelines	C.3	C-1
Appendix D – Levels of USACE Responsibility for Dams		
Involvement Categories	D.1	D-1
Category 1	D.2	D-1
Category 2	D.3	D-1

	Paragraph	Page
Category 3	D.4	D-1
Category 4	D.5	D-1
Category 5	D.6	D-2
Category 6	D.7	D-2
Appendix E – Essential Agency Guidelines		
Policy	E.1	E-1
Hydrology and Hydraulics Minimum Requirements	E.2	E-1
Geotechnical and Materials Minimum Requirements	E.3	E-3
Structural Minimum Requirements	E.4	E-5
Appendix F – Background Information on the USACE Dam Safety Action Classification System		
Policy	F.1	F-1
Dam Safety Action Classes	F.2	F-2
Actions	F.3	F-7
Documentation	F.4	F-7
Appendix G – Dam Safety Program Management Tools		
Purpose	G.1	G-1
Introduction	G.2	G-1
Discussion	G.3	G-2
DSPMT Overview	G.4	G-3
USACE DSPMT Implementation Specifics	G.5	G-4
Dam Safety Scorecard for Routine Dam Safety	G.6	G-4
Summary	G.7	G-5
Appendix H – Dams Exempt from Portfolio Management Process		
Purpose	H.1	H-1
References	H.2	H-1
Background	H.3	H-1
Policy	H.4	H-1
Criteria for ‘Insignificant or No Consequences’	H.5	H-2
Confirmation of Meeting Exemption Criteria	H.6	H-3
Authorities and Actions	H.7	H-3
Funding	H.8	H-5

	Paragraph	Page
Appendix I – Screening Portfolio Risk Assessment Process		
SPRA Process	I.1	I-1
SPRA Spreadsheet	I.2	I-1
SPRA Methodology	I.3	I-1
DSAC Binning	I.4	I-1
Rating and Review of Rating	I.5	I-3
Appendix J – Corps of Engineers Dam Safety Community of Practice Steering Committee (DSSC)		
Authority and Responsibilities	J.1	J-1
Objectives and Goals	J.2	J-1
Scope of Steering Committee Activities	J.3	J-1
Composition	J.4	J-1
General	J.5	J-2
Appendix K - Observations on How Reclamation Uses Their Guideline		
Basis for Decision Making	K.1	K-1
Risk Estimates Related to Tolerable Risks	K.2	K-1
Appendix L - Calculation of the Cost to Save a Statistical Life (CSSL)		L-1
Appendix M - Interim Risk Reduction Management Plan Development Sequence		
General	M.1	M-1
Development Sequence	M.2	M-1
Submission and Approval	M.3	M-2
Appendix N - Interim Risk Reduction Management Plan Review Checklist		
Overall Project Description and Purposes	N.1	N-1
Overview of Identified “Credible and Significant” Potential Failure Modes	N.2	N-1
General Consequences Associated with Each Identified Potential Failure Mode	N.3	N-1
Structural and Non-Structural IRRM Alternatives	N.4	N-1
Discussion of Probability of Failure and Consequences	N.5	N-1
Recommendations and Risk Informed Justification for IRRM to be Implemented	N.6	N-2
Schedules and Costs for Implementation of IRRM Recommendations	N.7	N-2

	Paragraph	Page
Estimate of Benefits and Costs for IRRM	N.8	N-2
ATR Comments and Comment Resolutions	N.9	N-2
Updated EAP	N.10	N-2
Communication Plan (Internal and External)	N.11	N-2
PFMA Report	N.12	N-3
MSC Internal Review Coordination	N.13	N-3
Appendix O - Seepage Failure Mode Continuum		
The Seepage Failure Mode Continuum	O.1	O-1
Stages	O.2	O-1
Risk Reduction Strategies	O.3	O-2
Appendix P - Format and Content for Issue Evaluation Study Documents		
Issue Evaluation Study Summary of Findings (IESSF)	P.1	P-1
IES Report	P.2	P-5
Appendix Q – Dam Safety Modification Investigations, Studies, and Reports		
Format of Dam Safety Modification Report	Q.1	Q-1
Dam Safety Action Decision Summary (DSADS)	Q.2	Q-1
Executive Summary	Q.3	Q-1
Background	Q.4	Q-1
DSM Study Findings and Recommendations	Q.5	Q-2
Cost Sharing Considerations	Q.6	Q-5
Real Estate Plan(s)	Q.7	Q-5
Environmental Compliance Documentation	Q.8	Q-6
Summary of Independent External Peer Review	Q.9	Q-6
Dam Safety Modification Report Appendices	Q.10	Q-6
Appendix R – Instructions for the "Dam Safety Action Decision Summary for a Dam Safety Modification Study”		
Overview	R.1	R-1
Document Content	R.2	R-1
DSADS Instructions	R.3	R-1
Appendix S – Dam Safety Modification Report Issue Checklist		
Sensitive Policy Areas	S.1	S-1
General Project Information	S.2	S-1

	Paragraph	Page
General Questions	S.3	S-2
Concurrence	S.4	S-7
Appendix T – Post-Authorization Decision Document Checklist		
Basic Information	T.1	T-1
Project Documents	T.2	T-1
Cost Sharing Summary	T.3	T-2
Funding History	T.4	T-2
Certification for Delegated Decision Documents	T.5	T-3
Authentication	T.6	T-4
Appendix U – Dam Safety Communication		
Sample Frequently Asked Questions and Answers	U.1	U-1
Appendix V – Periodic Inspection Program – Inspection and Evaluation Procedures		
Periodic Inspection Program	V.1	V-1
Composition and Qualifications of the Inspection and District Quality Control Review Teams	V.2	V-5
Executive Summary and Content	V.3	V-5
Inspection Report Content	V.4	V-6
Inspection Report Format	V.5	V-9
Project Documentation	V.6	V-11
Appendix W – Periodic Assessments		
Periodic Assessment Purpose	W.1	W-1
Periodic Assessment Reports	W.2	W-2
Overall Workflow for PA	W.3	W-3
PA District Versus Risk Cadre Responsibilities	W.4	W-4
Updated Consequences	W.5	W-5
Potential Failure Modes Analysis (PFMA) Session	W.6	W-6
PA Risk Assessment	W.7	W-6
Quality Control	W.8	W-6
Periodic Assessment Schedule	W.9	W-6
Periodic Assessment Funding	W.10	W-6
Approval Process of Periodic Assessment Report	W.11	W-6

	Paragraph	Page
Appendix X – Potential Failure Mode Analysis (PFMA) for Dams		
Purpose/Applicability	X.1	X-1
PFMA Overview	X.2	X-1
Outcomes	X.3	X-1
PFMA Process Description	X.4	X-2
Subject Matter Expert Facilitator Requirements /Corps Qualifications	X.5	X-2
Development of Supporting Data for PFMA	X.6	X-3
Identifying and Describing Potential Failure Modes	X.7	X-3
Evaluating a Potential Failure Mode	X.8	X-3
Performance Monitoring Enhancements, Data Collection Needs, Analyses, and Risk Reduction Measures	X.9	X-3
Major Findings and Understandings	X.10	X-3
Documentation	X.11	X-4
Appendix Y – Dam Safety Vegetation Management		
Purpose	Y.1	Y-1
References	Y.2	Y-1
Background	Y.3	Y-1
Policy	Y.4	Y-2
Implementation	Y.5	Y-3
Remediation Procedures	Y.6	Y-3
Establishment of Vegetation	Y.7	Y-4
Waivers	Y.8	Y-4
Appendix Z – Hazard Potential Classification		
Discussion	Z.1	Z-1
Classification System	Z.2	Z-1
Classification Table	Z.3	Z-2
Appendix AA – Management Controls		
Function	AA.1	AA-1
Purpose	AA.2	AA-1
Instructions	AA.3	AA-1
Test Questions	AA.4	AA-1

	Paragraph	Page
Appendix AB – Seismic Safety Evaluation Process for Embankment Dams and Foundations		
Introduction	AB.1	AB-1
Seismic Safety Evaluation Process	AB.2	AB-1
Funding	AB.3	AB-2
Seismic Safety Review	AB.4	AB-2
Phase I Special Study	AB.5	AB-4
Phase II Special Study	AB.6	AB-6
Appendix AC – Seismic Safety Evaluation Process for Concrete Structures and Foundations		
Seismic Safety Review	AC.1	AC-1
Phase I – Special Study Content	AC.2	AC-2
Phase II – Special Study Guidelines for Dynamic Analysis of Concrete Structures	AC.3	AC-2
Phase II – Special Study Content	AC.4	AC-3
Glossary		
Abbreviations and Terms		Glossary-1
List of Tables		
Table 3.1 – USACE Dam Safety Action Classification Table		3-13
Table 3.2 – Primary and Secondary Use of Risk Assessment Outcomes		3-14
Table 5.1 – Guidance on ALARP Justification for Risks Just Below the Tolerable Risk Limit		5-14
Table 5.2 – Guidance on ALARP Justification for Risks Just Above the Broadly Acceptable Region		5-14
Table 6.1 – Prioritization Factors		6-5
Table 7.1 – Decision Levels for Interim Risk Reduction Actions		7-6
Table 8.1 – Issue Evaluation Study Plan - Review & Approval Requirements		8-4

Page

Table 8.2 – Issue Evaluation Study Report – Review & Approval Requirements 8-11

Table 9.1 – Dam Safety Modification Study Project Management Plan - Review & Approval 9-10

Table 9.2 – DSM Report Submission 9-13

Table 9.3 – Dam Safety Modification Study Report – Review & Approval Requirements 9-15

Table 16.1 – Emergency Exercise Frequency 16-4

Table 20.1 – Applicable Feature Codes 20-2

Table I.1.a – Guidelines for determining USACE Dam Safety Action Classification using SPRA I-3

Table I.1.b – Dam Safety Action Class Adjustment Guidelines I-4

Table M.1 – Interim Risk Reduction Measures Development Sequence M-1

Table P.1 – Standard Text for IESSF Section 1 P-2

Table P.2 – Standard Text for IESSF Section 3 P-3

Table R.1 – Standard Text for DSADS Section 1 R-2

Table R.2 – Standard Text for DSADS Section 3 R-3

Table V.1 – O&M Dam Safety Work Item Funding Priority Levels and Description V-8

Table Z.1 – Hazard Potential Classification for Civil Work Projects Z-3

List of Figures

Figure 2.1 – OMB Risk Analysis Principles 2-2

Figure 2.2 – Dam Safety Risk Framework 2-4

Figure 2.3 – Proposed Generalized Federal Dam Safety Portfolio Risk Management Process 2-9

Page

Figure 3.1 – Corps of Engineers Dam Safety Portfolio Risk Management Process 3-12

Figure 4.1 – Example Dam Safety Officer Appointment Order 4-15

Figure 5.1 – Generalized and Project Specific Tolerability of Risk Framework (Adapted from HSE, 2001) 5-4

Figure 5.2 – Abstract Illustration of Incremental Consequences for Flood Induced Dam Failure 5-6

Figure 5.3 – f-N Chart for Displaying Annual Probability of Failure and Annualized Life Loss 5-7

Figure 5.4.a – Individual Risk Guidelines for Existing Dams 5-10

Figure 5.4.b –Societal Risk Guidelines for Existing Dams 5-10

Figure 5.5.a – Individual Risk Guideline for New Dams and Major Modification Under Section 216 5-11

Figure 5.5.b – Societal Risk Guideline for New Dams and Major Modification Under Section 216 5-11

Figure 5.6 – Plot of f-N Data Pairs for Individual Failure Modes and Exposure Scenarios on the Annualized Life Loss and Annual Probability of Failure Tolerable Risk Guidelines Format 5-18

Figure 5.7 – Example Illustrating the Plotting of the Same f-N Data Pairs for Individual Failure Modes and Exposure Scenarios in a Probability Distribution of Potential Life Loss f-N Chart 5-19

Figure 8.1 – Graphical Representation that Shows the Work Flow Process for Issue Evaluation Studies 8-12

Figure 8.2 – How the Issue Evaluation Study Fits Into the Overall Portfolio Risk Management Process 8-13

Figure 8.3 – Flowchart of the IES Decision, Review, and Approval Process 8-14

Page

Figure 9.1 – DSM Study, Review, Decision and Approval Process 9-16

Figure I.1.a – DSAC Binning Chart for FDR Dams I-2

Figure I.1.b – DSAC Binning Chart for Navigation Dams I-2

Figure K.1 – Reclamation's Public Protection Guidelines K-2

Figure K.2 – Example of an f-N Diagram for a Facility K-3

Figure K.3 – The Risk Profile for One Region in Reclamation K-5

Figure O.1 – Seepage Failure Mode Development Continuum O-3

Figure AB.1 -- Seismic Analysis Process AB-12

CHAPTER 1

Dam Safety Program – Introduction, Overview, and Guiding Principles

1.1 Purpose. This regulation prescribes the guiding principles, policy, organization, responsibilities, and procedures for implementation of risk-informed dam safety program activities and a dam safety portfolio risk management process within the United States Army, Corps of Engineers (USACE). Risk is defined as a measure of the probability and severity of undesirable consequences or outcome. The purpose and intent of this regulation is to ensure that responsible officials at all levels within the Corps of Engineers implement and maintain a strong dam safety program in compliance with *"Federal Guidelines for Dam Safety"* (reference A.71). The program ensures that all dams and appurtenant structures are designed, constructed, and operated safely and effectively under all conditions, based on the following dam safety and dam safety program purposes, as adopted by the Interagency Committee on Dam Safety (ICODS).

1.2 Applicability. This regulation applies to Headquarters, United States Army, Corps of Engineers (HQUSACE) elements, major subordinate commands (MSC), districts, and the Engineer Research and Development Center (ERDC), having responsibility for planning, site selection, design, construction, operation, maintenance, inspection, evaluation, and rehabilitation of dams and appurtenant structures.

1.3 Distribution Statement. This regulation is approved for public release; distribution is unlimited.

1.4 References. Required references are listed in Appendix A.

1.5 Glossary. Abbreviations and terms, which may not be familiar to the reader, are defined in the Glossary.

1.6 Dam Safety Definition. Dam safety is the art and science of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment. It requires the collective application of engineering principles and experience, and a philosophy of risk management that recognizes that a dam is a structure whose safe functioning is not explicitly determined by its original design and construction. It also includes all actions taken to routinely monitor, evaluate, identify or predict dam safety issues and consequences related to failure, and to document, publicize, and reduce, eliminate, or remediate, to the extent reasonably practicable, any unacceptable risks.

1.7 Dam Safety Program. The purposes of a dam safety program are to protect life, property, and the environment by ensuring that all dams are designed, constructed, operated, and maintained as safely and effectively as is reasonably practicable. The Corps has had an active Dam Safety Program since the 1970's. The program was last evaluated using an external peer review in 2001. The results of that evaluation using the Association of State Dam Safety Official Peer Review procedures were published in

a report entitled “Peer Review of the Dam Safety Program of the U.S. Army Corps of Engineers” dated September 30, 2001 (Reference A.81).

1.8 Dam Safety Officers. To comply with the Federal Guidelines for Dam Safety (Reference A.71), the Chief of Engineers has designated a USACE Dam Safety Officer by General Order. This regulation further defines the requirements and responsibilities of the Dam Safety Officers at each level of the command. Commanders and Dam Safety Officers at all levels are responsible to ensure that sufficient highly qualified personnel are available to meet project purposes and that programs related to dam safety are established and funded to achieve compliance with the requirements herein. These responsibilities are further defined in Chapter 4.

1.9 Transition to a Risk Informed Dam Safety Program. USACE is moving from a solely standards-based approach for its dam safety program to a dam safety portfolio risk management approach. The standards-based or essential guidelines approach is included in the risk-informed approach to the dam safety program and dam safety program decisions will now be risk-informed. One of the bases for a risk-informed decision, and prioritization of the work, is a consideration of the achievement of tolerable risk guidelines following implementation of risk reduction measures. In addition, it should be recognized that other non-quantitative factors will influence practical decision making for the dam safety program.

> "There was previously a view in some quarters that risk assessment was a means to justify less costly safety upgrades of dams than those required by the traditional approach. It is now recognized that such a view seriously misunderstands the true aim of risk assessment, which is more informed decision-making than would be possible from reliance on the traditional approach alone. It may be that the additional understanding that comes from the risk assessment process, will reveal that a less costly solution to a dam safety problem could be justified, though a decision that way should be made with great care and having regard to all of the community risk and business risk considerations. But it could as easily be the case that risk assessment shows that a more stringent safety level, and thus a more costly solution, ought to be implemented." (Guidelines on Risk Assessment, Australian National Committee on Large Dams (ANCOLD), October 2003, Reference A.80).

1.10 Principles for Dam Safety Portfolio Risk Management. The following guiding principles, which represent a paradigm shift for USACE, have been established for the USACE Dam Safety Portfolio Risk Management process:

1.10.1 Life Safety is Paramount. A key mission of the USACE dam safety program is to achieve an equitable and reasonably low level of risk to the public from its dams.

1.10.2 Do No Harm. The principle of ‘Do no harm’ should underpin all actions intended to reduce dam safety risk. Applying this principle will ensure that proposed IRRM implementation, emergency or permanent construction, or a temporary or

permanent change in regulation schedules would not result in the dam safety being compromised at any point in time or during measure implementation.

1.10.3 Risk-Informed Corporate Approach. The USACE dam safety program will be managed from a risk-informed USACE-wide portfolio perspective applied to all features of all dams on a continuing basis.

1.10.4 Urgency of Dam Safety Actions. The urgency of actions, including funding, to reduce risks in the short term (i.e., Interim Risk Reduction Measures) and in the long term (i.e., Dam Safety Modifications) will be commensurate with the level of risk based on current knowledge. This may require first addressing only those failure modes that contribute significantly to the overall risk.

1.10.5 Risk Communications. USACE will provide risk information to internal and external stakeholders. An informed and engaged public is an empowered public that understands risk, can contribute to the evaluation of risk reduction options and can take some degree of responsibility for its safety.

1.10.6 Prioritization of Studies and Investigations. Studies and investigations will be scoped with the goal of confirming dam safety issues and prioritized to reduce knowledge uncertainties and risk across the portfolio of dams in a cost effective and timely manner.

1.10.7 Formulation and Prioritization of Risk Management Measures. Where practical, risk reduction measures will be formulated as separable measures and these will be prioritized to achieve tolerable risk as quickly as practicable and in a cost-effective manner across the portfolio of dams.

1.10.8 Level of Detail of Risk Assessments. The level of effort and scope of risk assessments will be scaled to provide an appropriate level of confidence considering the purpose of the risk management decision.

1.10.9 Routine Dam Safety Activities. Execution of inspections, instrumentation, monitoring, Periodic Assessments, operations and maintenance, emergency action planning and other routine dam safety activities are an essential part of effective dam safety risk management for all USACE dams.

1.10.10 Risk Reporting. The current level of risk for USACE dams will be documented and routinely reported. The basis for decisions will be documented.

1.11 Principles for Implementing Interim Risk Reduction Measures at High Risk Dams.

1.11.1 Public Safety. USACE executes its project purposes guided by its commitment and responsibility to public safety. In this context, it is not appropriate to refer to balancing or trading off public safety with other project benefits. Instead, it is after public safety tolerable risk guidelines are met that other purposes and objectives

will be considered. Dam Safety Officers are the designated advisors and advocates for life safety decisions.

1.11.2 Do No Harm. The principle of 'Do no harm' should underpin all actions intended to reduce dam safety risk. Applying this principle will ensure that proposed IRRM implementation would not result in the dam safety being compromised at any point in time or during IRRM implementation.

1.11.3 Risk-Informed – Not Risk Based. Decisions should be risk-informed, not risk-based. Risk-informed decisions integrate traditional engineering analyses with numerical risk estimations of risk through the critical foundation of experience-based engineering judgment. (We no longer refer to risk-based decisions because of the inappropriate implication that life-safety decisions can be reduced to simple, numerical solutions).

1.11.4 Congressional Authorizations. Our projects provide us with specific Congressional authorizations and legal responsibilities that often cover a broad array of purposes and objectives. Because of the complexity of these authorities, the public safety responsibility is critical to informing how we implement these statutory responsibilities. The public safety responsibility requires USACE to assure our projects are adequately safe from catastrophic failure that results in uncontrolled release of the water in the reservoir. We have specific public safety responsibility, when a project has known safety issues, to take appropriate interim risk reduction measures - including reservoir releases - to assure safety of the project and to protect the public. Our statutory responsibilities do not give us authority to operate our dams in a manner that increases the project's probabilities of failure when there are known issues with the integrity of the project.

1.11.5 Manage Flood Waters. We manage risks of flood waters, we do not control them. Our projects do not have unlimited operational capacity to control extreme floods, as Mother Nature can always up the ante. Our outlet works have limited capacity to release flows in a controlled manner, and thus all properly designed projects have a capacity above which the inflow is passed through without attenuation. These are very large releases that may cause damage downstream of the dam but not to a greater degree than would have occurred under pre-project conditions. Decision makers must understand these limitations and operational constraints.

1.11.6 Unique Dynamics Over Time. All projects have unique geographic, physical, social, and economic aspects that are subject to dynamics over time. Decision making within Interim Risk Reduction Measure Plans should not be overly prescriptive because of these complexities.

1.11.7 Tension Between Loss of Life and Economic Damage. The operations of a high risk (unsafe or conditionally unsafe) dam during flood conditions can create a dynamic tension between the potential for loss of life and economic damage resulting from an uncontrolled release due to failure and the surety of economic damages

resulting from operational release to prevent failure. Operational releases can be accompanied with planning, advanced warnings, and evacuations with the goal of avoiding loss of life. Economic impacts may be incurred and options for mitigating these impacts can be explored. The advanced planning and execution of mitigating measures is far more effective with planned, controlled release of the pool than with the case of unplanned, uncontrolled release resulting from failure of the project.

1.11.8 Interim Risk Reduction Measure Plan. The IRRMP, including the supporting Water Control Plan (modified by approved temporary deviations as necessary), is the key document that frames operational decision making for unsafe dams (DSAC I, II, and III). This plan establishes the specific threshold events, decision points, and actions required. As such, the IRRM Plans set the sideboards for decision making, including changes in the regulation schedule from that of the approved Water Control Manual. The IRRM Plan should recognize the need for two primary water control management controls.

1.11.8.1 A recommended safe operating reservoir level that is maintained for the vast majority of time through non damaging releases.

1.11.8.2 A threshold event for which emergency measures such as rapid reservoir drawdown and recommendations on evacuation must occur.

1.11.8.3 This approach to water control management recognizes that pool restrictions established for safety purposes cannot and should not be viewed as “must meet” requirements in all flood events, but that there does come a point when emergency measures are necessary.

1.11.9 In the centrally-led and decentrally-executed USACE Dam Safety Program, responsibilities and decision making for Interim Risk Reduction Measures are vertically distributed:

1.11.9.1 Districts develop IRRM Plans, coordinate plans, and execute all IRRM plans for DSAC III dams.

1.11.9.2 Divisions coordinate, review, and approve plans for DSAC Class I, II, and III dams. In particular, divisions are critical in assuring system and watershed issues are considered and coordinated.

1.11.9.3 Headquarters in consultation with the RMC establishes DSAC class for all dams, reviews and concurs on IRRM Plans for DSAC class I, II, and III dams, and aligns investment strategies for all unsafe dams.

1.12 History of Dam Safety. A history of dam safety within USACE, and how it relates to dam safety in the nation, is provided in Appendix B.

1.13 Federal Guidelines for Dam Safety. A summary of the guidelines is provided in Appendix C. The guidelines are referenced at A.71.

1.14 Levels of USACE Responsibility for Dam Safety. Appendix D provides guidance on USACE responsibility for dam safety at dams where USACE has been involved in one way or another with the dam.

CHAPTER 2

Dam Safety Program Framework

2.1 Scope. This chapter presents the guiding principles and policy for implementation of risk-informed dam safety program within the United States Army, Corps of Engineers (USACE), Office of Management and Budget (OMB) principles for risk analysis, a generalized dam safety framework based on the OMB principles with an elaboration of the concepts of risk assessment, risk management, and risk communication, and the presentation of a generalized dam safety portfolio risk management process.

2.2 OMB Risk Analysis Principles.

2.2.1 Risk is a measure of the probability and severity of undesirable consequences. In 1995 (Principles for Risk Assessment, Management, and Communication, January 12, 1995 (reference A.82) and again in September 2007 (Updated Risk Principles (M07-24), September 19, 2007 (reference A.84) the Office of Management and Budget (OMB) set forth a set of principles to guide policymakers in assessing, managing, and communicating policies to address environmental, health, and safety risk. The OMB intent in presenting these principles was “to provide a general policy framework for evaluating and reducing risk.” Evaluating and reducing risk requires a decision-making framework that explicitly evaluates the level of risk if no action is taken and recognizes the monetary and non-monetary costs and benefits of reducing risks when making decisions. This risk decision framework requires separating the whole of risk into its component tasks by assessing the risk and related uncertainties for the purpose of successful management of the risk, facilitated by effective communication about the risks. In this way, risk analysis comprises three tasks: risk assessment, risk management, and risk communication.

2.2.2 Figure 2.1 shows the interrelatedness of the three OMB risk analysis principles and the notion that risk communication is a vital and joining activity that must take place to achieve an effective risk decision. Note that the technical scientific work takes place in the risk assessment while risk management is more concerned with applying social values and policy to sort through options and tradeoffs revealed in the risk assessment.

2.2.3 Risk Assessment.

2.2.3.1 Risk assessment is a broad term that encompasses a variety of analytic techniques that are used in different situations, depending upon the nature of the risk, the available data, and needs of decision makers. It is a systematic, evidence based approach for quantifying and describing the nature, likelihood, and magnitude of risk associated with the current condition and the values of the risk resulting from a changed condition due to some action.

2.2.3.2 Uncertainty is the result of imperfect knowledge concerning the present or future state of a system, event, situation, or (sub) population under consideration. Uncertainty leads to lack of confidence in predictions, inferences, or conclusions. Here

we distinguish uncertainty that results from a lack of knowledge from variability, although many consider variability a specific source of uncertainty. For example, a risk assessor may be very certain that stream flows vary over a year but may be uncertain about the amount of that variability. Collecting more and better data can often reduce uncertainty, whereas variability is an inherent property of the system/population being evaluated. Variability can be better characterized and addressed quantitatively with more data but it cannot be reduced or eliminated. Efforts to clearly distinguish between variability and uncertainty are important because they can influence risk management decisions.

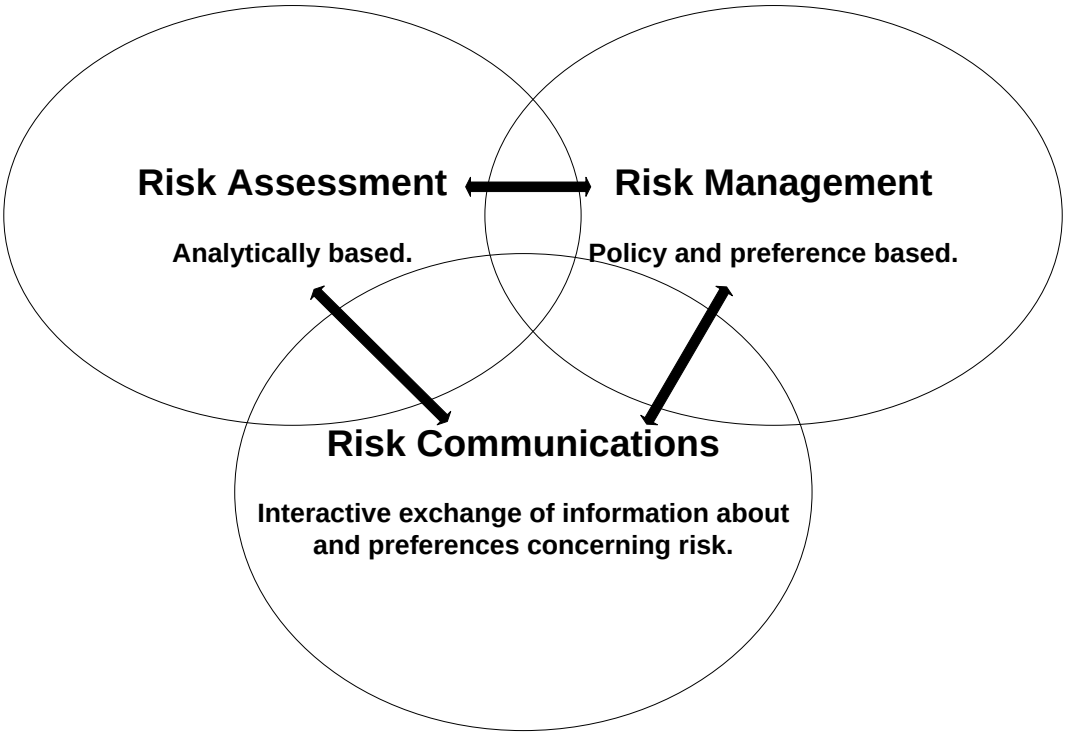


Figure 2.1 OMB Risk Analysis Principles

2.2.4 Risk Management.

2.2.4.1 Risk management is the process of problem finding and initiating action to identify, evaluate, select, implement, monitor and modify actions taken to alter levels of risk, as compared to taking no action. The purpose of risk management is to choose and implement those technically sound integrated actions to reduce risks after consideration of the costs of each increment of risk reduction. Environmental, social, cultural, ethical, political and legal considerations all factor into the decision made on how much cost will be incurred for each increment of risk reduction (how safe is safe enough?). Risk management for dams includes short-term Interim Risk Reduction Measures, long-term structural risk reduction measures, and strengthening recurrent

activities - such as monitoring and surveillance, emergency action planning, operations and maintenance, and staff training.

2.2.4.2 OMB stated, “In choosing among alternative approaches to reducing risk, agencies should seek to offer the greatest net improvement in total societal welfare, accounting for a broad range of relevant social and economic consideration such as equity, quality of life, individual preference, and the magnitude and distribution of benefits and costs (both direct and indirect, both quantifiable and non-quantifiable).” (OMB 2007 memorandum, Subject: Updated Principles for Risk Analysis, Page 10 (reference A.84)).

2.2.4.3 Equity considers placing all members of society on a (more) equal footing in terms of the risks faced. The equity objective is addressed by requiring that all risks higher than a limit value be brought down to below the limit, except in exceptional circumstances.

2.2.4.4 Efficiency considers the following:

2.2.4.4.1 Ensuring that resources and expenditures directed to safety improvements are cost-effective;

2.2.4.4.2 Ensuring an appropriate balance between the monetary and non-monetary benefits and the monetary and non-monetary costs; and

2.2.4.4.3 Achieving the greatest reductions in risk for each unit of resources committed.

2.2.4.4.4 The efficiency objective is recognized by allowing risks to be assessed and addressed on a dam portfolio basis to assign priority and urgency to risk reduction actions, thereby making best use of resources. It can also be addressed for an individual dam through consideration of the cost effectiveness of risk reduction below limit values in tolerable risk guidelines.

2.2.5 Risk Communication. Risk communication is the open, two-way exchange of information and opinion about hazards and risks leading to a better understanding of the risks and better risk management decisions. Risk communication is integrated into the assessment and management processes. It is not a task that occurs only after decisions have been made. Risk communication ensures that the decision makers, other stakeholders and affected parties understand and appreciate the process of risk assessment and in so doing can be fully engaged in and responsible for risk management.

2.3 Dam Safety Risk Framework. A further refinement and consolidation of activities associated with these principles for evaluating and reducing risk in the area of dam safety are presented in Figure 2.2.

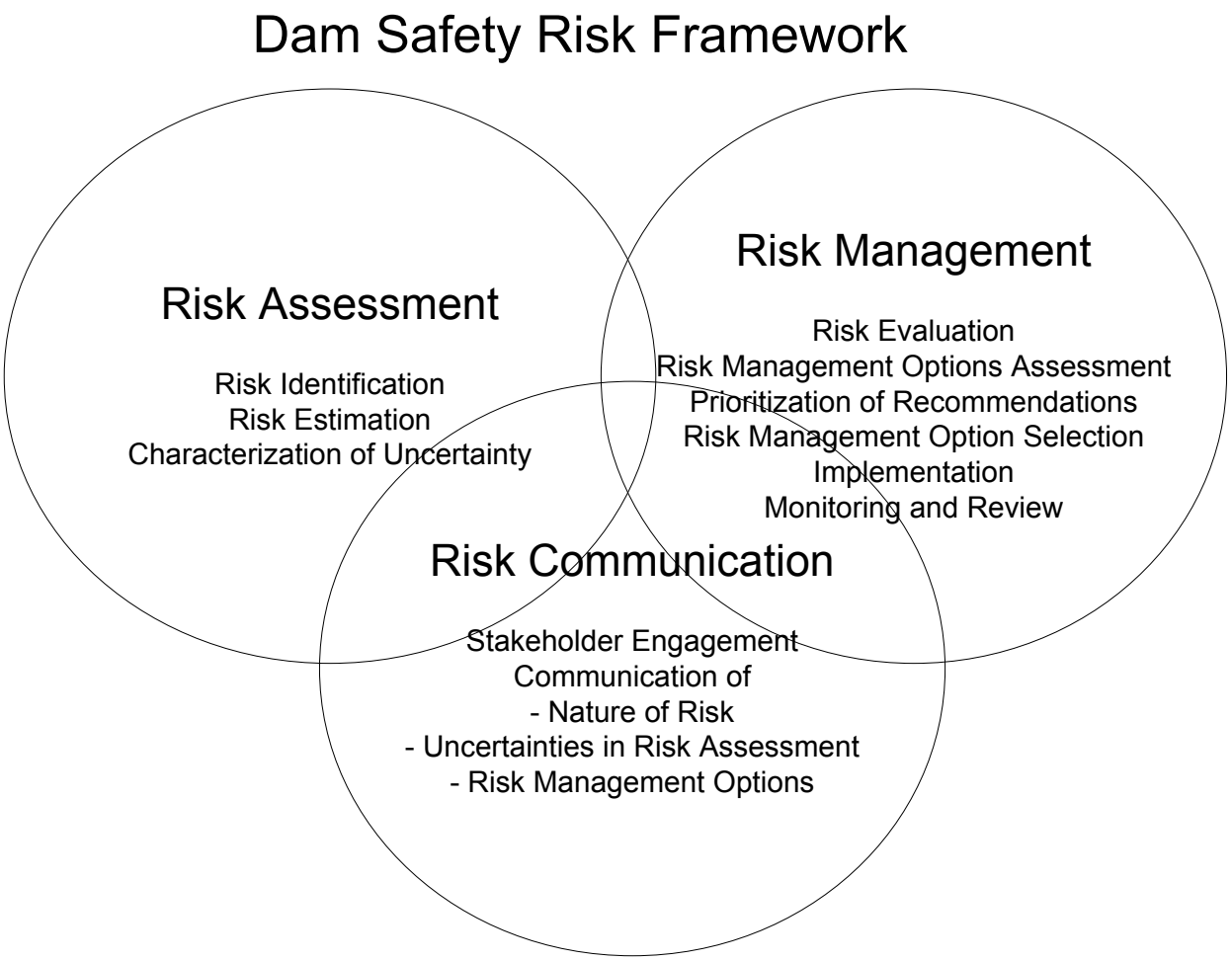


Figure 2.2 – Dam Safety Risk Framework

2.4 Risk Assessment – An Elaboration.

2.4.1 The risk assessment process attempts to answer the following four questions:

2.4.1.1 What can go wrong?

2.4.1.2 How can it happen?

2.4.1.3 What is the likelihood?

2.4.1.4 What are consequences?

2.4.2 Risk assessment has a somewhat different meaning than the USACE terminology of "risk-informed" or "risk and uncertainty." It may be characterized as a more formal and focused effort to describe and define the impacts of risk to facilitate

their effective management. The draft OMB Proposed Risk Assessment Bulletin (January 2006) (reference A.83) defined the term:

> '"risk assessment" means a scientific and/or technical document that assembles and synthesizes scientific information to determine whether a potential hazard exists and/or the extent of possible risk to human health, safety, or the environment."'

2.4.3 Risk assessment would augment the technical work done throughout USACE. An update of the traditional definition of risk assessment taken from the 1983 National Research Council's *Risk Assessment in the Federal Government: Managing the Process* (the so-called "Redbook") (reference A.91) includes the following steps:

2.4.3.1 Hazard Identification (Risk Identification)

2.4.3.2 Hazard Characterization (Risk Identification)

2.4.3.3 Exposure Assessment (Risk Estimation)

2.4.3.4 Risk Characterization (Risk Estimation)

2.4.4 Hazards are the focal point of this process and the major change would be to add an explicit hazard identification step to the various tasks. In a general sense, "hazard" is anything that is a potential source of harm to a valued asset (human, animal, natural, economic, social). It is important that one not limit the notion of a hazard to a natural hazard. So in this sense, a hazard can be thought of as an assumption about some uncertain value or parameter that, if incorrect, can result in the undesirable consequence of the failure to achieve the economic return anticipated.

2.4.4.1 Hazard Identification (Risk Identification). This identifies all biological, chemical, social, economic, and physical agents or natural/anthropogenic events capable of causing adverse effects on people, property, economy, culture, social structure, or environment. The hazard identification step explicitly identifies the hazards that will be of concern in the risk management activity.

2.4.4.2 Hazard Characterization (Risk Identification). Hazard characterization is the qualitative and/or quantitative evaluation of the nature of the adverse effects associated with the identified hazard(s), which may be present in the situation of interest. The hazard characterization step describes the harm that can be done when the hazard is present.

2.4.4.3 Exposure Assessment (Risk Estimation). Exposure occurs when a susceptible asset comes in contact with a hazard. An exposure assessment, then, is the determination or estimation (which may be qualitative or quantitative) of the magnitude, frequency, or duration, and route of exposure. This task describes how the asset/entity/receptor of interest comes in contact with the hazard.

2.4.4.4 Risk Characterization (Risk Estimation). Risk characterization is the qualitative and/or quantitative estimation, including attendant uncertainties, of the probability of occurrence and severity of known or potential adverse effects in a given watershed or decision problem based on the evidence gathered in hazard identification, hazard characterization and exposure assessment. In the dam safety arena the term risk estimation is used due to the significant influence of subjective probability in the risk characterization.

2.5 Risk Management – An Elaboration.

2.5.1 Risk management may be understood as the work required to answer the following questions:

2.5.1.1 What is the problem?

2.5.1.2 What can be done to reduce the likelihood or severity of the risk described?

2.5.1.3 What are the tradeoffs in terms of costs, benefits, and risks among the available options both now and in the future?

2.5.1.4 What is the best way to address the described risk?

2.5.2 In sum, risk management is the process of problem finding and initiating action to identify, evaluate, select, implement, monitor and modify actions taken to alter levels of risk. Figure 2.3 shows a generalized risk management process for dams developed to describe a common approach proposed for use by the Corps of Engineers, Bureau of Reclamation, and the Federal Energy Regulatory Commission. The risk management process emphasizes its ongoing and iterative nature and the usefulness of adapting to new information.

2.5.3 Thinking of risk management as part of risk analysis, some broad categories of risk management activities can be identified as described below.

2.5.3.1 Assess Risk Management Options. Options assessment activities include the process of identifying (optioneering), evaluating, and selecting, actions that can be taken to alter levels of risk. This is a deliberate process of systematically considering all options and their associated trade-offs. Risk management means deciding the level of risk that is tolerable including the consideration of the costs and other consequences of different risk reduction actions. Risk management also means giving appropriate consideration to inherent variability and knowledge uncertainties identified during the risk assessment and other evaluations.

2.5.3.2 Implement Risk Management Decisions. Implementation activities include executing all steps necessary to make the chosen risk management alternative a reality. Part of implementation may include adaptive management processes to learn while

acting when uncertainties identified in the preceding steps are significant and the costs of making a “wrong” decision (economic regret) are deemed to be high.

2.5.3.3 Monitoring and Review. Monitoring and review activities are undertaken to improve understanding and reduce uncertainty over time through learning to assure the success of the implemented risk management measure(s). Over time, with experience, even the goals of the risk management measure(s) may be adjusted. Risk management policies may induce changes in human behaviors that can alter risks (i.e., reduce, increase, or change their character), and these linkages must be incorporated into evaluations of the effectiveness of such policies. (OMB 2007) (reference A.84)

2.6 Risk Communication – An Elaboration.

2.6.1 Beginning with an informal definition, risk communication is the work that must be done to answer the following questions for a risk management activity.

2.6.1.1 Why are we communicating?

2.6.1.2 Who is our audience?

2.6.1.3 What do we want to learn from our audience?

2.6.1.4 What do they want to know?

2.6.1.5 What do we want to get across?

2.6.1.6 How will we communicate?

2.6.1.7 How will we listen?

2.6.1.8 How will we respond?

2.6.2 Effective two-way risk communication has both internal and external communication components. Internal risk communication requires early and continuing communication, coordination, and collaboration among risk assessors and agency officials throughout the decision making process.

2.6.3 Stakeholder Engagement.

2.6.3.1 The external process includes all communication between the agency analysts, officials and affected stakeholders. Stakeholder involvement goes beyond the traditional public participation process of conveying information to the public. It supports decision-making and ensures that public values are considered in the decision making process. Public perceptions are an important source of information.

2.6.3.2 Involvement of stakeholders improves the knowledge base for decision-making and can reduce the overall time and expense involved in decision-making. It may improve the credibility of the agencies responsible for managing risks. It should generate better-accepted, more readily implemented risk management decisions. Furthermore, it is irresponsible and dangerous not to engage stakeholders in meaningful input and feedback opportunities in the risk management process.

2.6.3.3 Successful risk communication leads to a common recognition and understanding of the hazards, risk management options, and shared acceptance of the risk management decisions.

2.6.4 Communicating About the Nature of Risk.

2.6.4.1 Constituents and stakeholders need awareness and an understanding of the characteristics and importance of the hazard of concern. It is important to convey the magnitude and severity of the risk, as well as the urgency of the situation. People must understand whether the risk is becoming greater or smaller (trends) as well the probability of exposure to the hazard.

2.6.4.2 The geographic, temporal, and specific distribution of exposure to the hazard needs to be understood as well as the amount of exposure that constitutes a significant risk. For flood hazards, this is easy to imagine. The nature and size of the population at risk as well as knowledge of who is at the greatest risk all need to be conveyed to stakeholders.

2.6.4.3 Risk is only one part of the issue. People accept higher risk (e.g., living in floodplains) for many good reasons. The actual or expected benefits associated with each risk should be identified and understood. It is important to know who benefits and in what ways. The magnitude and importance of those benefits need to be weighed to find the appropriate tradeoff between risks and benefits.

2.6.5 Communicating Uncertainties in Risk Assessment.

2.6.5.1 One of the challenges of risk communication is conveying the existence and significance of uncertainties encountered in the assessment of the risks to both decision makers and stakeholders as appropriate. The methods used to assess the risk should be described and made available. Significant uncertainties need to be explicitly and specifically identified. The importance of each of the uncertainties, as well as the weaknesses of, or inaccuracies in, the available data need to be communicated. The assumptions on which estimates are based must be identified. Sensitivity analysis of the risk estimates and other decision-making criteria must be conducted and the results communicated. The effects of changes in assumptions on risk management decisions must be thoroughly explored. It is important to objectively assess and convey the assessors' level of confidence in the results of the risk assessment.

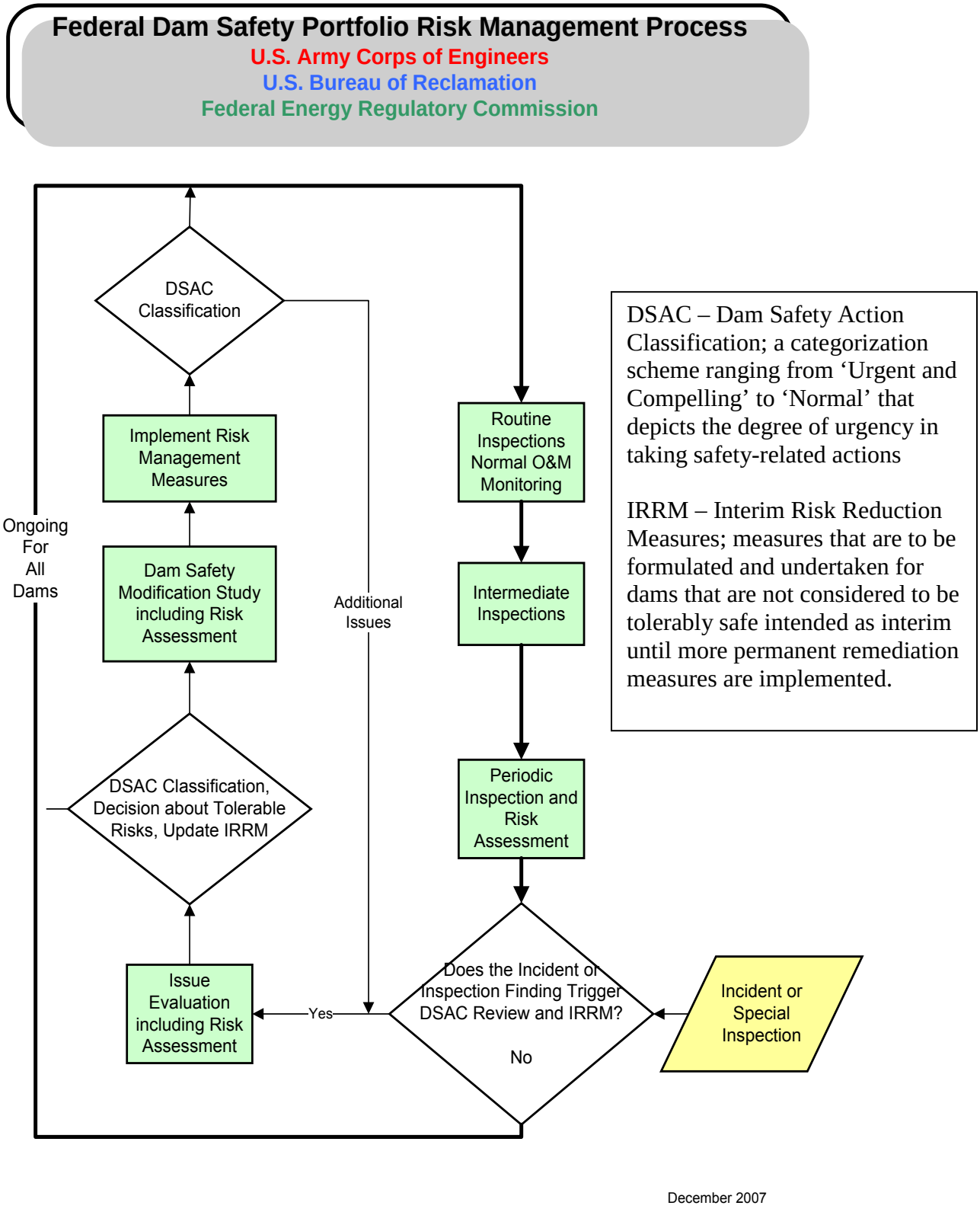


Figure 2.3 – Proposed Generalized Federal Dam Safety Portfolio Risk Management Process

2.6.5.2 The risk assessment should convey the extent and significance of uncertainty in the technical aspects of a decision process. Management needs to weigh its importance in the decision process.

2.6.6 Communicating Risk Management Options.

2.6.6.1 The action(s) taken to control or manage the risk must be carefully communicated and a common understanding about the risk management actions needs to be developed among the affected public. The safety case for justifying the choice of a specific risk management option must be made explicit, transparent, and based on a shared responsibility for the choice made. The effectiveness of a specific option and any residual, transformed or substitute risks must be recognized. The actions individuals may take to reduce personal risk should be carefully communicated as a part of the risk management alternative that is chosen.

2.6.6.2 The benefits of a specific option, the cost of managing the risk, and who pays for each option considered are essential information. The residual risks that remain after a risk management option is implemented need to be clearly understood by all affected parties and decision makers.

CHAPTER 3

Dam Safety Portfolio Risk Management

3.1 Purpose/Objective.

3.1.1 This chapter presents an overview of the USACE Dam Safety Portfolio Risk Management for the USACE portfolio of dams and Dam Safety Action Classification (DSAC) System using the principles outlined in Chapter 2.

3.1.2 The overall Dam Safety portfolio risk management process is a series of hierarchical activities that are used to assess, classify (DSAC), and manage the risks associated with the USACE inventory of dams. The accompanying hierarchical documentation generated by the portfolio risk management process documents the USACE risk assessment and risk management decisions for each dam and facilitates risk communication. The set of documents consists of the reports generated by the normal operations and maintenance (O&M) activities and those documents generated when USACE addresses a dam safety issue. The routine day-to-day dam safety and O&M reports are periodic inspections and periodic assessments; reservoir or water management plans; general operations and maintenance plans; emergency action plans; and instrumentation, monitoring and evaluation plans and reports. The documents generated when addressing a dam safety issue are Screening Portfolio Risk Assessment report; Interim Risk Reduction Measure Plans; Issue Evaluation Study reports; and Dam Safety Modification Reports.

3.2 Dam Safety Action Classification System.

3.2.1 The Dam Safety Action Classification system provides consistent and systematic guidelines for appropriate actions to address the dam safety issues and deficiencies of USACE dams. USACE dams are placed into a Dam Safety Action Classification (DSAC) class based on their probability of failure or the individual dam safety risk estimate considered as a combination of probability of failure and potential life safety, economic, environmental, or other consequences. Until fully evaluated no dam will be considered a DSAC class V, therefore all dams will initially be assigned to classes I - IV. The intent is that the classification of a dam is dynamic over time, changing as project characteristics are modified or more refined information becomes available affecting the loading, probability of failure, or consequences of failure.

3.2.2 DSAC Table Structure. The DSAC table presents different levels and urgencies of actions that are commensurate with the different classes of the safety status of USACE dams. These actions range from immediate recognition of an urgent and compelling situation requiring extraordinary and immediate action for unsafe dams through normal operations and dam safety activities for adequate safe dams.

3.2.3 Reconciliation with Past Dam Safety Management Practices. In the past, the USACE dam safety program essentially recognized two categories of actions: those for dams considered safe, which comprised routine dam safety activities, normal operation

and maintenance; and those for dams that were considered in need of remediation, for which investigations, remediation funding justification documents, and design and construction of remediation measures were additional activities. However, these two categories do not provide formal recognition of an adequate range of actions and degrees of urgency, especially for dams with issues that are very high or extremely high risks, which warrant heightened actions that are not provided for in the traditional standards-based approach. The choice of five action classes is to provide adequate parsing in the range of levels of actions.

3.2.4 DSAC Classes. The five action classes used by the USACE dam safety portfolio risk management program are summarized in Table 3.1 and described below. The five classes depict the range of dams from those critically near failure to those considered adequately safe. Between these two extremes are three classes that define distinctly different levels of actions and urgencies of action that are commensurate with a transition in safety status from critically near failure to adequately safe.

3.2.4.1 Class I (Urgent and Compelling). Class I is for those dams where progression toward failure is confirmed to be taking place under normal operations and the dam is almost certain to fail under normal operations within a time frame from immediately to within a few years without intervention; or, the combination of life or economic consequences with probability of failure is extremely high.

3.2.4.2 Class II (Urgent). Class II is for dams where failure could begin during normal operations or be initiated by an event. The likelihood of failure from one of these occurrences, prior to remediation, is too high to assure public safety; or, the combination of life or economic consequences with probability of failure is very high.

3.2.4.3 Class III (High Priority). Class III dams have issues where the dam is significantly inadequate or the combination of life, economic, or environmental consequences with probability of failure is moderate to high.

3.2.4.4 Class IV (Priority). Class IV dams are inadequate with low risk such that the combination of life, economic, or environmental consequences with a probability of failure is low and the dam may not meet all essential USACE guidelines.

3.2.4.5 Class V (Normal). Class V is for dams considered adequately safe, meeting all essential agency guidelines (see Appendix E) and the residual risk is considered tolerable.

3.2.4.6 Background information on the USACE Dam Safety Action Classification System along with examples of dams in the various classes in provided in Appendix F.

3.3 Dam Safety Portfolio Risk Management Process.

3.3.1 Overview. The flow chart in Figure 3.1 incorporates all USACE dams at the various stages of dam safety portfolio risk management. Exceptions are dams found to have insignificant or no consequences should they fail. At this time, such structures are

to be tagged as exceptions and are exempt from the portfolio management process. These dams will be later considered for decommissioning or transfer.

3.3.2 DSAC Class Assignment. Starting at the top of figure 3.1, the ‘classification’ bar or decision point 1a (D 1a) can be viewed as the sorting or binning point that includes all USACE dams, each of which is classified into one of the five Dam Safety Action Classification (DSAC) classes as presented in Table 3.1. Note that dams in each DSAC class are managed in accordance with their safety status as reflected by their assigned DSAC class.

3.3.3 Role of Prioritization and Queues.

3.3.3.1 There are three prioritization processes and associated queues.

3.3.3.1.1 Prioritization of Issue Evaluation Studies (P1)

3.3.3.1.2 Prioritization of Dam Safety Modification Studies (P2)

3.3.3.1.3 Prioritization of approved remediation projects awaiting design and construction funding (P3).

3.3.3.2 Prioritization and queues are necessary due to resource limitations and the desire to reduce overall portfolio risk as efficiently as possible. The associated queues contain the set of dams awaiting studies or processing to the next step, reflecting their prioritization. While the intent is that the queues are eventually cleared, it is certainly possible that a higher priority dam, from a dam safety issue viewpoint, could come into a queue and move ahead of others already there based on the individual dam’s safety status and circumstance.

3.3.3.3 The responsibility for the management of the prioritization process is presented in chapter 4 - Management of Corps of Engineers Dam Safety Program, the tolerable risk guidelines are presented in chapter 5 - Tolerable Risk Guidelines, and the prioritization for risk management is presented in chapter 6 – Dam Safety Risk Management Prioritization.

3.3.4 Dam Safety Decision Points.

3.3.4.1 There are four major decision points in the dam safety portfolio risk management process.

3.3.4.1.1 Approve Dam Safety Action Classification,

3.3.4.1.2 Selection of Interim Risk Reduction Measures or heightened monitoring,

3.3.4.1.3 Determination if Dam Safety Modification Studies are justified based on the results of the Issue Evaluation Study, and

3.3.4.1.4 Approval of Dam Safety Modification Reports.

3.3.4.2 Decisions dealing with the DSAC determination are located at the following points in the dam safety portfolio risk management process:

3.3.4.2.1 Decision Point D 1a. DSAC classification.

3.3.4.2.2 Decision Point D 1c. Reclassification as a result of an Issue Evaluation Study where the dam can be reclassified to any of the other classes.

3.3.4.2.3 Decision Point D 1d. Incident triggers DSAC review.

3.3.4.2.4 Decision Point D 1e. Post implementation DSAC review and modification of DSAC class as appropriate. Review IRRM plan and modify as appropriate.

3.3.4.3 Decisions dealing with the implementation of IRRM recommendations for DSAC I, II and III dams are located at Decision Point D 2a. The decision related to heighten monitoring for Class IV dams is located at Decision Point D 2b.

3.3.4.4 Decision Point D 3 relates to the determination of the justification of Dam Safety Modification studies for DSAC II, III and IV dams.

3.3.4.5 Decision Point D 4 deals with the approval of Dam Safety Modification study reports.

3.3.5 Screening. Initially, all dams in the USACE inventory will be subjected to a screening level risk assessment called the Screening Portfolio Risk Assessments (SPRA), defined later, and assigned a DSAC class at decision point D 1a.

3.3.6 Routine dam safety activities and normal operations and maintenance (O&M).

3.3.6.1 The outer loop of the chart depicts continuing and recurrent actions of routine dam safety activities and normal O&M, periodic assessments (PA), potential incident identification, review and update of the Dam Safety Program Management Tools data (See Appendix G), and review of the DSAC class. All USACE dams are in the outer loop regardless of their DSAC class. Exceptions are those dams found to have insignificant or no consequences should they fail (see paragraph 3.3.15). The ideal end state for all USACE dams is that they are classified DSAC V and therefore they are only in the outer loop of the Dam Safety Portfolio Risk Management process diagram.

3.3.6.2 Periodic Assessments and Periodic Inspections. All USACE dams will undergo PA on a routine and systematic schedule not to exceed ten years. Periodic Assessments include a revised Periodic Inspections (PI) process (details in Chapter 11) and baseline risk assessment, including potential failure mode analysis. The PI will occur more frequently than PA, typically not more than five year intervals. This ensures that all dams in the USACE portfolio are systematically and routinely evaluated leading to a high

likelihood of detecting dam safety issues in a timely manner. Periodic assessments are described in more detail later in chapter 11.

3.3.7 Interim Risk Reduction Measures Plans and Implementation. Interim Risk Reduction Measure (IRRM) plans will be developed for all DSAC I, II, and III dams. The IRRM plan addresses identified potential failure modes, defines general consequences associated with each identified potential failure mode, quantifies risks for each likely failure mode to the detail required to support the decisions to be made, evaluates loss in project benefits due to the IRRM measures, and evaluates the potential of the IRRM alternatives considered to reduce the probability of failure and/or consequences associated with the failure modes. A risk assessment, scaled to a level of effort related to the decision to be made, may be performed during development of the IRRM plan. Preparation of an Interim Risk Reduction Measures Plan (IRRMP) is required as per guidance associated with the DSAC table and discussed in detail in chapter 7.

3.3.8 DSAC Class I Expedited Process. Because of their urgent and compelling safety issues, dams in DSAC Class I are immediately processed through several key steps to formulate, approve (Decision Point D 2a), and implement interim risk reduction measures. At Decision Point D 2a the USACE Dam Safety senior oversight group (SOG) will review DSAC documentation and make a recommendation to the USACE senior leadership that the agency does or does not accept the DSAC I classification for that dam. The IRRM plan should be developed and implemented as quickly as possible for DSAC I dams. For DSAC I dams the Dam Safety Modification study will be prioritized and scheduled at Prioritization Point P 2 and sent to the funding and resource queue. The next step is the Dam Safety Modification study and decision document process to determine the appropriate risk management measures. See Figure 9.1 for a detailed flow chart of the DSM study and report development, review and approval process. The Dam Safety Modification study report will then be reviewed and approved or returned for more studies and investigation (Decision Point D 4). If the decision is for additional study and investigation the project will be prioritized and scheduled with the other dams recommended for Dam Safety Modification studies (Prioritization Point P 2). If the decision is to approve the report, and risk reduction measures are required, the project will be prioritized for funding (Prioritization Point P 3) and moved to the resource queue to wait for funding to implement the risk reduction measures. Once the approved risk reduction measures are implemented the DSAC class will be reviewed and modified as appropriate and the IRRM plan will be reviewed and modified. This action is taken at Decision Point D1e in the flow chart. The use of approved incremental risk reduction measures may not move a dam from a DSAC I class all the way to a DSAC V.

3.3.9 DSAC Classes II and III Process. All dams placed into DSAC II and III (Decision Point 1a) will have IRRM plans developed and implemented. The IRRM plans identify the risk reduction measures that should be submitted for approval (Decision Point 2a) to the MSC Dam Safety Officer. After the IRRM plan is approved the district is to develop and submit an Issue Evaluation Study Plan for DSAC II and III dams which are prioritized and scheduled for Issue Evaluation Studies (Prioritization Point 1). Once scheduled, the individual projects are put into the funding and resource queue. After the Issue Evaluation Study is completed and based on the results of the study the DSAC is

reviewed and modified as appropriate at Decision Point 1c (D 1c). Based on the risk assessment performed during the Issue Evaluation Study a dam could be reclassified into any DSAC. If a dam is put into the DSAC I, it will then be addressed using the DSAC I Expedited Process. If a dam is in DSAC II, III, or IV it will be reviewed to determine if a Dam Safety Modification study is justified (Decision Point D 3). If the determination is that a Dam Safety Modification study is justified, then the project is prioritized and scheduled (Prioritization Point P 2) and sent to the funding and resource queue. From that point forward the process is the same as for DSAC I dams.

3.3.10 DSAC IV Process. For DSAC IV class dams an IRRM plan is not required but a decision has to be made related to heightened monitoring (Decision Point 2b). From this point forward the process is the same for a DSAC IV class dam as it is for a DSAC II or III class dam.

3.3.11 DSAC V Process. To place a dam in the DSAC V class requires a risk assessment estimate with as low as reasonably practicable (ALARP) considerations included to determine residual risk and an evaluation of compliance with all essential USACE guidelines with no unconfirmed dam safety issues. The risk assessment to determine residual risk and the evaluation of essential guideline compliance can be performed either at the time of the periodic assessment or after the approved risk reduction measures from the DSM report are implemented. The latter should just entail an evaluation of the performance of the risk reduction measures to assure that the risk reduction measures meet the prescribed performance levels and guidelines as outlined in the DSM report.

3.3.12 Baseline risk estimate. The baseline risk estimate is the risk estimate at a point in time. It may change based on changes in: a) information; b) the condition of the dam; c) factors affecting the consequences, or d) from proposed implementation of risk reduction measures. Incorporating any of these changes or a change in the scope, purpose, or decision to be made will result in a new baseline risk estimate.

3.3.12.1 Baseline risk estimates shall encompass all significant failure modes and factors affecting the consequences of failure (*e.g. exposure conditions*). Significant failure modes are a subset of credible failure modes (*i.e. physically possible*). The number of significant failure modes to be considered in a risk assessment should be judged in the context of the purpose of the risk assessment and the decisions that it will inform. The cumulative effect of multiple low risk failure modes shall be considered on the baseline risk estimate. It is important to identify and list all credible failure modes and factors affecting consequences that are not considered “significant” for a risk assessment. These failure modes may be justified as significant in a subsequent risk assessment.

3.3.12.2 Factors to consider include Dam Safety Action Classification, comparisons with tolerable risk guidelines, scoping the next level of study, portfolio roll-up of the risk estimates, the level of confidence in risk estimates, representation of uncertainty in estimates, and prioritization for next phase of work. For example credible failure mode

should be considered significant if the probability of failure and associated consequences approach closely or exceed a tolerable risk limit guideline.

3.3.12.3 Periodic Assessments (PA) and Phase 1 Issue Evaluation Study (IES) baseline risk estimates will use currently-available information for the loading functions, the determination of component and system response curves (conditional probability of failure), and development of the consequence estimate. Additional information and analysis to reduce uncertainty and increase confidence in the baseline risk estimate may be justified to support the Phase 2 IES and the Dam Safety Modification study. In all cases the baseline risk estimate should be obtained with the minimum expenditure of time and resources. The scope of the risk assessment shall be determined on the basis of the decisions to be made.

3.3.13 Issue Evaluation Studies. Issue Evaluation studies (IES) for dams classified in DSAC Classes II, III, and IV are studies to better determine the nature of the safety issue and the degree of urgency for action within the context of the full USACE inventory of dams. The intent of an Issue Evaluation Study is to perform a more robust and detailed level of risk assessment, than used in the SPRA and possibly more robust than the risk assessment used in a periodic assessment, that will enable informed decisions about the need for a Dam Safety Modification study, further investigations, the DSAC reclassification, and interim risk reduction measures implementation. However, the level of detail should only be what is needed to justify the decision to pursue or not to pursue a Dam Safety Modification study. Based on the results of previous or current investigations and an Issue Evaluation Study, a dam could be reclassified as DSAC Class I and thus warrant the expedited process for a DSAC Class I dam as shown on the left side of Figure 3.1. The report documenting the Issue Evaluation Study will have an Agency Technical Review (ATR) performed to include Dam Safety Risk Management Center representatives. The IES report presents the rationale and the justification for a Dam Safety Modification Study and changes to the IRRM plan. The IES report shows the current condition of the dam with respect to the tolerable risk guidelines. Issue Evaluation Studies are discussed in detail in Chapter 8.

3.3.14 Dam Safety Modification Studies and Decision Documentation. Dam Safety Modification Studies may require, beyond the Issue Evaluation Study, additional data gathering and detailed studies. Formulation and evaluation for a full range of risk reduction alternatives with preliminary level cost estimates will be performed at this time. A detailed risk assessment is required and will look at incremental risk reduction alternatives that together meet the tolerable risk guidelines (details in Chapter 5) and cost effectiveness of additional risk reduction below the tolerable risk limit guidelines. However, the level of detail for the risk assessment and DSM study should only be what is needed to justify the modification decision. Related NEPA and ESA studies will be conducted at this time in support of the recommended risk reduction measures. The DSM decision document presents the rationale for the alternative recommended, to include life, economic and environmental risk reduction, and other non-tangible aspects. The report will show how this alternative complies with the tolerable risk guidelines. The Dam Safety Modification decision document will present a comparison of alternatives and the recommended plan to include actions, components, risk reduction by increments,

evaluation of the risk in relation to the tolerable risk guidelines, implementation plan, detailed Risk Cost and Schedule Assessment (per ER 1110-2-1302, Civil Works Cost Engineering (reference A.53), National Environmental Policy Act (NEPA) (reference A.109), and the Endangered Species Act (ESA) determinations). This document will have an ATR performed to include Risk Management Center representatives. Dam Safety Modification Studies process, content, and the approval process are discussed in detail in Chapter 9.

3.3.15 Dams Exempt from the Dam Safety Portfolio Risk Management Process. The Corps inventory has a number of dams and associated structures that no longer serve a beneficial purpose or have been found to have insignificant or no consequences should they fail. At this time, such structures are to be tagged exceptions and are exempt from the portfolio management process. These dams will be handled in accordance with Appendix H and may be considered for decommissioning or transfer.

3.3.16 At any point in the portfolio risk management process a determination may be made that resolution of a dam safety deficiency will cost less than the major rehabilitation threshold funding cap (see annual budget guidance Engineering Circular) or the work can be accomplished in one construction season. If this is the case the district DSO should consider going directly to a major maintenance action. Such minor modifications for dam safety would be funded as major maintenance with Operations and Maintenance funds. If significant risk reduction can be made at high risk dams for amounts less than the major rehabilitation threshold funding cap districts should coordinate with the MSC and HQ dam safety program managers and the O&M appropriation program managers to determine if Operations and Maintenance funds are available.

3.4 Scope of Risk Assessments in Support of Dam Safety Evaluations. There are five specific instances of evaluations in the process- Screening Portfolio Risk Assessment (SPRA), Interim Risk Reduction Measures Plans (IRRMP), Periodic Assessments, Issue Evaluation Studies, and Dam Safety Modification Studies. The USACE Dam Safety Portfolio Risk Management process uses risk assessments in each of the five instances of evaluations. These risk assessments vary in purpose and therefore in the data required, detail and robustness of analysis, and in uncertainty and confidence in the results. Table 3.2 shows the relationships of the primary and secondary uses of the outcomes of the risk assessments with the purpose of the various studies or evaluations. However, in all cases the level of detail should only be what is needed to justify the decision(s) that will be informed by the risk assessment.

3.4.1 General Steps in Risk Assessment. The general steps of a risk assessment (listed below) are scalable to fit the purpose of the risk assessment.

3.4.1.1 Potential failure mode analysis;

3.4.1.2 Develop event trees for potential failure modes;

3.4.1.3 Develop the loading function for each failure mode carried forward in the assessment;

3.4.1.4 Determine the conditional probability of failure and system response curve for each failure mode carried forward in the assessment;

3.4.1.5 Estimate the consequences associated with each failure mode carried forward in the assessment;

3.4.1.6 Risk estimate calculations; and

3.4.1.7 Compare to the USACE tolerable risk guidelines.

3.4.2 Screening for Portfolio Risk Assessment (SPRA). This assessment screens projects to expeditiously identify the dams requiring urgent and compelling action (Dam Safety Action Classification Classes I and II Dams) with low chance of missing any such dams. Also, the SPRA is to provide information for preliminary classification of the remainder of the USACE dams into Dam Safety Action Classes III – IV. SPRA does not provide sufficient information to confirm a dam can be placed in Dam Safety Action Classification Class V. The intent is that SPRA will be performed only once for every dam in the USACE inventory. Once all dams are screened using SPRA, the SPRA DSAC rating will remain the official rating unless a more detailed assessment leads to a reclassification. The SPRA process is described in Appendix I.

3.4.3 Interim Risk Reduction Measures Plans (IRRMP). The risk assessment supporting the IRRM plan will use existing information and easily obtained consequence data. The primary purpose is to support and justify interim risk reduction measures. The risk assessment will have to be scaled depending on the significance of the dam safety issue and the impact of the interim risk reduction measures.

3.4.4 Periodic Assessments (PA). PA's will normally be conducted for all dams on a 10 year cycle, but more frequently as justified. The periodic assessment will consist of a periodic inspection, a potential failure modes analysis, and a risk assessment based on existing data and limited analyses to estimate consequences. The primary purposes of the Periodic Assessment are as follows.

3.4.4.1 Confirm or revise the DSAC classification of a project;

3.4.4.2 Justify interim risk reduction measures;

3.4.4.3 Provide initial input for quantitative risk reporting;

3.4.4.4 Identify needed issue evaluation studies;

3.4.4.5 Provide data to prioritize issue evaluation studies;

3.4.4.6 Identify operations and maintenance, monitoring, emergency action plan, training and other recurrent needs; and

3.4.4.7 Develop or update the baseline risk and confirm that essential USACE dam safety guidelines are or are not met.

3.4.5 Issue Evaluation Study. Risk assessments in support of the Issue Evaluation studies (IES) are conducted for the purposes:

3.4.5.1 Primary. Confirm that dam safety issues do or do not exist and determine if a Dam Safety Modification study is justified.

3.4.5.2 Secondary.

3.4.5.2.1 Verify or reclassify the current DSAC rating based on these findings;

3.4.5.2.2 Determine if a dam should be reclassified as DSAC I and thus warrants the expedited process for a DSAC I dam as shown on the left side of Figure 3.1;

3.4.5.2.3 Verify the adequacy of current or need for additional interim risk reduction measures;

3.4.5.2.4 Provide information to support prioritization of Dam Safety Modification studies; and

3.4.5.2.5 Develop or update the baseline risk estimate.

3.4.5.3 The methodology of this risk assessment/study must be more rigorous than the SPRA methodology. The IES risk assessment is intended to achieve a defensible, risk informed justification for initiating Dam Safety Modification studies with the minimal expenditure of time and resources. This risk assessment will use the USACE dam safety risk assessment and evaluation tools.

3.4.6 Dam Safety Modification Study. The risk assessment supporting the Dam Safety Modification study leads to definitive decisions and documentation to justify dam safety actions to achieve reduction in life, economic, and environmental risk. Additional data will be gathered as justified by the decision to be made. The Dam Safety Modification study will use the USACE dam safety risk assessment and evaluation tools which provide results of increased robustness of and confidence in the risk assessment over the Issue Evaluation Study due to an increase in the level of confidence in the input data used in the study. The primary purposes of the Dam Safety Modification study are the determination or update of the baseline risk estimate; identification, evaluation, justification, and recommendation of long-term risk reduction remedial measures; and the estimation of the residual risk of the remediated project. The risk assessment shall be updated after implementation of the risk reduction remedial measures and evaluated to determine if the risk reduction objectives were achieved.

3.5 Risk Reporting and Data Management. The following will be tracked and reported on per guidance in Appendix G using the Dam Safety Program Management Tools (DSPMT).

3.5.1 SPRA ratings and findings,

3.5.2 Current DSAC Classification,

3.5.3 Listing of dam safety issues,

3.5.4 Residual risk of current conditions and confidence of the risk estimate (range of risk),

3.5.5 Previous reports and summary of recommendations,

3.5.6 Current IRRM,

3.5.7 Findings of the most recent Potential Failure Mode Analysis,

3.5.8 Findings of last PA and PI,

3.5.9 Results of the essential agency guidelines (Appendix E) evaluation,

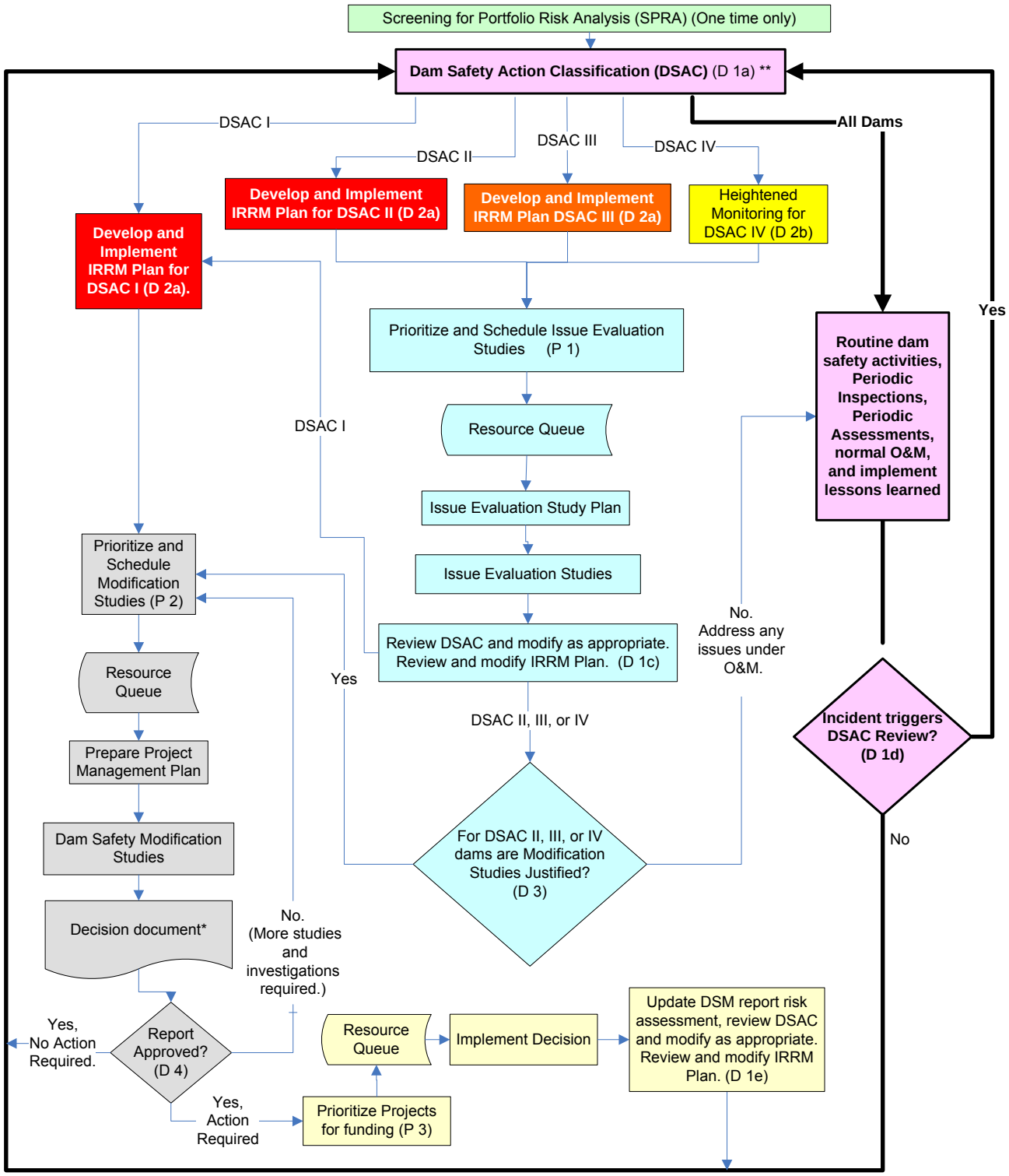
3.5.10 Consequences - list estimated consequences related to the identified potential failure modes,

3.5.11 Issue Evaluation Study results, recommendations and final decisions, and

3.5.12 Dam Safety Modification study results, recommendation, and final decisions.

3.6 Water Storage and Risk Reduction Measures. Dam safety must be on the critical path of all decisions regarding water supply storage in USACE reservoirs. When water supply is requested by non-Federal customers, USACE decision makers at all levels must fully consider the condition of the dam, DSAC of the dam, associated risks, and their impacts on inspection, operation and maintenance of the project. While public safety is paramount, the benefits of providing safe and reliable water supply storage to non-Federal customers also must be considered. A reallocation that would require raising the conservation pool is not permitted while a project is classified DSAC I, II, or III. (See EC 1165-2-210 for further guidance, Reference A.6)

Figure 3.1 -- Corps of Engineers Dam Safety Portfolio Risk Management Process



Decision Points are label as (D 1a), Prioritization Points are labeled as (P 1), and the details for each point is explained in Chapter 3.
*** Independent External Peer Review requirements are to be addressed per guidance in the Dam Safety Modification chapter.**
**** Regardless of DSAC classification, dams with insignificant or no consequences should they fail are considered exceptions; will be so tagged, and are exempt from the dam safety portfolio management process depicted here in Figure 3.1.**

Table 3.1 – USACE Dam Safety Action Classification Table*			
Dam Safety Action Class		**Characteristics of this class**	**Actions for dams in this class**
I **URGENT AND COMPELLING** (Unsafe)		**CRITICALLY NEAR FAILURE** Progression toward failure is confirmed to be taking place under normal operations. Almost certain to fail under normal operations from immediately to within a few years without intervention. **OR EXTREMELY HIGH RISK** Combination of life or economic consequences with probability of failure is extremely high.	Take immediate action to avoid failure. Implement interim risk reduction measures, including operational restrictions, ensure that emergency action plan is current, and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite investigations to support justification for remediation using all resources and funding necessary. Initiate intensive management and situation reports.
II **URGENT** (Unsafe or Potentially Unsafe)		**FAILURE INITIATION FORESEEN** For confirmed (unsafe) and unconfirmed (potentially unsafe) dam safety issues, failure could begin during normal operations or be initiated as the consequence of an event. The likelihood of failure from one of these occurrences, prior to remediation, is too high to assure public safety. **OR VERY HIGH RISK** The combination of life or economic consequences with probability of failure is very high.	Implement interim risk reduction measures, including operational restrictions as justified, and ensure that emergency action plan is current, and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite confirmation of classification. Give very high priority for investigations to support justification for remediation.
III **HIGH PRIORITY** (Conditionally Unsafe)		**SIGNIFICANTLY INADEQUATE OR MODERATE TO HIGH RISK** For confirmed and unconfirmed dam safety issues, the combination of life, economic, or environmental consequences with probability of failure is moderate to high.	Implement interim risk reduction measures, including operational restrictions as justified, ensure that emergency action plan is current, and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Prioritize for investigations to support justification for remediation considering consequences and other factors.
IV **PRIORITY** (Marginally Safe)		**INADEQUATE WITH LOW RISK** For confirmed and unconfirmed dam safety issues, the combination of life, economic, or environmental consequences with probability of failure is low and may not meet all essential USACE guidelines.	Conduct elevated monitoring and evaluation. Give normal priority to investigations to validate classification, but no plan for risk reduction measures at this time.
V **NORMAL** (Adequately Safe)		**ADEQUATELY SAFE** Dam is considered adequately safe, meeting all essential USACE guidelines with no unconfirmed dam safety issues, **AND RESIDUAL RISK IS CONSIDERED TOLERABLE**.	Continue routine dam safety activities, normal operation, and maintenance.

* At any time for specific events a dam, from any action class, can become an emergency requiring activation of the emergency plan

Table 3.2 – Primary and Secondary Use of Risk Assessment Outcomes

Use of the Outcomes from Risk Assessment	Screening	Interim Risk Reduction Measures	Periodic Assessment	Issue Evaluation Study	Modification Study
Identify DSAC I & II with low chance of missing any such dams	P				
Preliminary classification of DSAC III - IV	P				
IRRM Decisions including justification		P	s	s	s
DSAC Confirmation or Reclassification			P	s	s
Initial Portfolio Input for quantitative risk reporting			P	s	s
Portfolio Update			P	s	s
Identify all potential failure modes		s	P	s	P
Develop baseline risk estimate			P	s	P
Identify needed Issue Evaluation Studies	P		P		
Identify O&M, monitoring, EAP, and staff training and other recurrent needs		P	P	s	s
Prioritization of Issue Evaluation Studies	s	s	P		
Tolerable risk evaluation for existing dam			P	s	P
Identify representative, potential long term risk reduction measures (incremental)					P
Prioritization of Dam Safety Modification Studies (incremental)				P	
Confirmation that all essential USACE Dam Safety guidelines are met and residual risk is considered tolerable for an existing dam (DSAC V confirmation)			P		P
Tolerable risk evaluation for Modification Alternatives					P
Modification decision and justification					P
Prioritization of projects for funding			s	P	P

P = Primary s = Secondary

CHAPTER 4

Management of Corps of Engineers Dam Safety Program

4.1 General. The Corps of Engineers maintains a three-level decentralized organization, HQUSACE, MSC (Regional) and district. Each level shall be staffed with qualified personnel in areas of design, construction, inspection and operations of dams and appurtenant structures, with appropriate training and experience in dam safety risk assessment, risk management, and risk communications. Each organizational level shall have a Dam Safety Officer (DSO) with supporting organization as outlined in this chapter. The Corps of Engineers utilizes risk-informed procedures to aid in the prioritization of dam safety deficiency corrections on a nation-wide basis with budgeting for dam safety studies and modifications managed at the HQUSACE level. National oversight is furnished by the Dam Safety Steering Committee and the Senior Oversight Group, which are further described herein. Prioritization of all risk assessments, studies and remediation are managed on behalf of HQUSACE by the Risk Management Center (RMC) with oversight by the Senior Oversight Group and Special Assistant for Dam Safety. Routine day-to-day operation, maintenance and safety evaluations of dams shall remain the primary responsibility of the district command. Periodic assessments of dams are accomplished with assistance from regional and national risk and reliability cadres and the RMC.

4.2 Overall Responsibility for Dam Safety Program. The Commanders at each level of the Corps of Engineers have the ultimate responsibility for dam safety within their commands. Each District Commander having responsibility for dams shall ensure that the organization has a dam safety program which complies with Corps of Engineers policy and criteria, assuring compliance with the “Federal Guidelines for Dam Safety” (reference A.71). Commanders exercise this responsibility through officially designated Dam Safety Officers at each level. Although the DSO is located in the technical element of each organizational level, dam safety crosses all business lines and office elements, and the DSO must coordinate dam safety issues and activities with the leaders of those business lines and office elements as they manage the dam safety activities in their areas of responsibility. This includes coordination between the district office and the project field offices (that serve as the first line of defense for dam safety) concerning such issues as emergency action plans, dam safety training, and control of project documentation (discussed in subsequent chapters as well as ER 1130-2-530 (reference A.63)).

4.2.1 For the Corps of Engineers Dam Safety program to be fully successful, it is imperative that technically and managerially qualified personnel who are passionate advocates of dam safety be in place at every key level of the organization. This is even more vital for a Dam Safety Officer because of the implications that their decisions can have on life safety. Their decision-making must be based solely on the best technical approach which protects life and property and cannot be clouded by political considerations. Technical capability/experience alone, while vitally important, does not assure that a person is qualified to function as a Dam Safety Officer. That person must

also possess the desire to be an advocate for the program, possess excellent communications skills, and be capable of sound decision-making under pressure. If any of these is lacking, then the person is not fully qualified even if they are extremely qualified technically.

4.2.2 For these reasons, all leaders who appoint Dam Safety Officers at the HQ, MSC, and District shall thoroughly review and verify the qualifications and suitability for a person to function in this key role. Paragraph 4.7 provides the procedures for selecting and appointing a DSO.

4.2.3 If the highest ranking technical individual in the command lacks a particular skill set (or needs additional development in an area) in order to meet the DSO qualifications, it is the responsibility of the leader with appointment responsibilities to put a developmental plan in place which will assure the full skill set is achieved within a reasonable (12 to 18 months) time frame. This developmental plan might include formal training coursework, conferences, mentor relationships with other Dam Safety Officers, and short-term assignments in districts where key dam safety decisions are being made.

4.3 Headquarters, US Army Corps of Engineers.

4.3.1 Organization. The Corps of Engineers Dam Safety Officer (DSO) is appointed by the Chief of Engineers based upon qualifications and is typically the Senior Executive Service (SES) member in charge of the Engineering and Construction Community of Practice. A Special Assistant for Dam Safety and the Corps Dam Safety Program Manager support the Corps DSO. The Corps of Engineers Dam Safety Steering Committee (DSSC) and the HQUSACE Dam Safety Committee provide additional advice and support to the Corps DSO concerning the program. The Corps Dam Safety Committee includes the Senior Oversight Group (SOG), Corps DSO, the National Inventory of Dams (NID) Program Manager, and other members with extensive knowledge and expertise in the programming, planning, design, construction, operations, and maintenance of dams. Other individuals from the various communities of practice within the Corps of Engineers may be included as members of the committee.

4.3.2 Responsibilities and Qualifications. The roles, responsibilities, and qualifications presented below are based on “Dam Safety Officer Roles, Responsibilities, Qualifications, and Professional Registration Requirements” (reference A.79).

4.3.2.1 Corps of Engineers Dam Safety Officer: The Corps (DSO) shall be a registered professional engineer with civil engineering background and with management abilities and be competent in the areas related to the design, construction, operation, maintenance, inspection or evaluation of dams and understand adverse dam incidents and the potential causes and consequences of dam failure. As Corps DSO, this individual is responsible directly to the Chief of Engineers for all dam safety

activities and shall be appointed by written order of the Chief of Engineers. The Corps DSO coordinates dam safety activities with the various elements of the Directorate of Civil Works and informs the Director concerning the condition of Corps dams. The Corps DSO is responsible for ensuring that the Corps of Engineers maintains a proactive dam safety program, implementing all practices and procedures outlined in the "Federal Guidelines for Dam Safety" (reference A.71). The Corps DSO is responsible for establishing policy and technical criteria for dam safety, and prioritizing dam safety related work. The Corps DSO or designated representative(s) shall represent the Department of Defense on the National Dam Safety Review Board (NDSRB) and Interagency Committee on Dam Safety (ICODS). The Corps DSO ensures that programs to implement dam safety needs and to monitor the activities at the various levels of the Corps are established. The Corps DSO serves as chair of the Corps Dam Safety Committee. The Corps DSO shall assess the Corps dam safety activities utilizing the best available techniques and programs, and periodically report to the Director of Civil Works and Chief of Engineers.

4.3.2.2 Special Assistant for Dam and Levee Safety. The Special Assistant acts for the Corps DSO in the execution of daily program activities and serves as Chairman of the Corps of Engineers DSSC and the SOG. The Special Assistant shall be a registered professional engineer with civil engineering background and with management abilities, be competent in the areas related to the design, construction, operation, maintenance, inspection or evaluation of dams and understand adverse dam incidents and the potential causes and consequences of dam failure. The Special Assistant works for and reports directly to the Corps DSO. The director of the RMC shall report directly to the Special Assistant. The Special Assistant represents the Corps DSO in the development of the budget submission, working with the appropriate Business Line Managers to ensure that dam safety priorities are addressed. The Special Assistant serves as the Department of Defense and/or Corps of Engineers representative on various national teams as directed by the Corps DSO.

4.3.2.3 Corps Dam Safety Program Manager. The Corps Dam Safety Program Manager (DSPM) shall be a registered professional engineer with civil engineering background (or registered professional geologist as described in paragraph 4.6) and with management abilities and have knowledge and experience in the design, construction, operation, maintenance, inspection, or evaluation of dams. The DSPM conducts the daily activities of the overall dam safety program. The DSPM coordinates the HQ review of dam safety reports and prepares Corps-wide dam safety budget submissions in coordination with the DSSC and the RMC, and works in close coordination with the Special Assistant for Dam Safety. The DSPM serves as the Department of Defense and/or Corps of Engineers representative on various national teams as directed by the Corps DSO or the Special Assistant. The Corps DSPM shall maintain an updated membership list of the Corps Dam Safety Committee, the Corps of Engineers DSSC, the SOG, and all USACE DSOs and DSPMs.

4.3.2.4 Risk Management Center: The Corps of Engineers is currently transitioning to risk-informed dam safety program management to more effectively evaluate, prioritize

and justify dam safety decision making. In order to realize the full benefits of risk-informed program management, the RMC has been established to provide technical expertise and advisory services to assist in managing and facilitating the USACE-wide dam safety program. The RMC is a support organization, partially project funded, and located within the Institute of Water Resources (IWR). The director of the RMC reports through the IWR Director to the Director of Civil Works. The RMC has close ties to the Chief of Engineering and Construction and to the Special Assistant for Dam Safety. The RMC assists the Special Assistant in implementation of dam safety policy using a combination of centralized staff as well as other national, regional, and district resources.

4.3.2.4.1 The RMC Director shall be a registered professional engineer with civil engineering background and with management abilities, be competent in the areas related to the design, construction, or evaluation of dams and understand adverse dam incidents and the potential causes and consequences of dam failure. The director shall have knowledge of risk management concepts and implementation.

4.3.2.4.2 Specific functions performed by the RMC in support of HQUSACE dam safety program management:

4.3.2.4.2.1 Maintains the 10-year plan for Periodic Assessments and Inspections of dams and pertinent structures in coordination with the MSC DSPM's.

4.3.2.4.2.2 Manages the resource queues (see the Dam Safety Portfolio Risk Management Process Chart, figure 3.1).

4.3.2.4.2.3 Supports the Agency Technical Review (ATR) and Independent External Peer Review (IEPR) (EC 1165-2-209) (Reference A.5) process, as applicable, for Dam Safety Modification Reports. The RMC shall be the Review Management Organization (RMO) for Dam Safety Modification Reports and perform the RMO functions required in EC 1165-2-209 (reference A.5). The RMC may be consulted for the names of qualified individuals who have worked with the national risk cadres and are experienced in the needed area to serve on ATR teams. The RMC shall manage the IEPR process for all dam safety modification reports.

4.3.2.4.2.4 Supports the Corps DSPM in the development of annual budget requests. The RMC communicates directly with districts and MSCs on program planning, priorities, funding and implementation. It provides workload input/commitments to resource providers regarding the future year program.

4.3.2.4.2.5 Plans and evaluates dam safety-related risk activities for all phases of the life-cycle of a project.

4.3.2.4.2.6 Manages the documentation, maintenance and publication of the Corps Dam Safety Portfolio Risk Rankings and DSAC.

4.3.2.4.2.7 Integrates dam safety portfolio risk management activities with other asset management activities.

4.3.2.4.2.8 Represents Dam Safety on the Civil Works Research and Development team.

4.3.2.4.2.9 Maintains dam safety standard engineering technology (SET) programs, and automated information systems (AIS) to include reviewing usage by various districts of the programs within SET. Reviews requests for additions to and deletions from SET and makes recommendations to the SOG.

4.3.2.4.2.10 Performs metrics roll up and interpretation of Corps-wide Dam Safety Program Performance Measures (DSPPM) and the dam safety scorecard (Appendix G) using Dam Safety Program Management Tools (DSPMT) and other dam safety AIS tools.

4.3.2.4.2.11 Assists DOD member participation on the National Dam Safety Review Board (NDSRB) and the Interagency Committee on Dam Safety (ICODS), including nominating individuals for various tasks and work groups.

4.3.2.4.2.12 Provides an individual to participate as a member of the Senior Oversight Group, Dam Safety Steering Committee, and other Ad Hoc Groups as deemed necessary.

4.3.2.4.2.13 Manages national level external peer review panels and their reports for DSAC I dams.

4.3.2.4.2.14 Coordinates special Working Groups in the Risk Management Center such as the Methodology (interim) and Policy and Procedures Work Groups (interim). It coordinates the work between RMC and Regional Cadres to include scheduling and budgeting. Other activities include assisting Dam Safety policy development and guiding Dam Safety Risk and Reliability Training Management with RA and RA facilitation. Maintains updated membership list of the cadres and other national teams.

4.3.2.5 Dam Safety Steering Committee (DSSC). The DSSC is a committee charged with facilitating and promoting dam safety as a fundamental USACE mission in all levels of the organization, promoting dam safety career development, disseminating pertinent information throughout the Corps, and reviewing and evaluating policy, technical criteria and practices, administrative procedures, and regulatory functions to support the dam safety program. The DSSC shall also review experience and qualifications of dam safety staffing at all levels within the Corps to assess competency, review MSC funding requirements for achieving program requirements, and make recommendations for future research and development in areas related to dam safety. The team shall meet as required, and shall provide advice and information to the Special Assistant for Dam and Levee Safety.

4.3.2.5.1 The DSSC shall be composed of the following members: Special Assistant for Dam Safety (Lead), Corps DSPM, one member each from HQUSACE Operations, Planning, and Program Integration Division (the Corps Operations, Planning, and Program Integration Division Chiefs may designate individuals from one of the MSCs to represent their community of practice in lieu of a member of their staff), each MSC DSPM, one ERDC individual appointed by the ERDC Director, a representative from the RMC, and four (4) district representatives with experience in the safety of dams who shall be nominated by the DSSC as at-large members with final selection by the Corps DSO. At least one of the district representatives shall be from an operating element, one should be a DSPM and one should be a DSO. Public Affairs Office (PAO), Emergency Management, and Homeland Security Office representatives should be invited to the DSSC meetings. Additional information on the DSSC is provided in Appendix J.

4.3.2.6 The Senior Oversight Group (SOG) generally consists of the following members: Special Assistant for Dam Safety (Chair); CoP & Regional Representatives to include Geotechnical and Materials CoP Leader, Structural CoP Leader, Hydraulics and Hydrologic CoP Leader, Planning CoP Leader, and Construction CoP Leader; Regional representatives determined by Special Assistant for Dam Safety; Corps Business Line & Program Representatives to include DSPM, Flood Damage Reduction, Navigation, Programs, and Director, Risk Management Center; and any other Representatives determined by the Special Assistant for Dam Safety. A current list of members and charter will be posted on the USACE Technical Excellence Network (TEN). The Corps Dam Safety Program Manager shall serve as recording secretary. The SOG shall elect a Vice Chair.

4.3.2.6.1 The SOG will review Dam Safety Action Classifications (DSAC), dam safety risk assessment reports prepared by the RA cadres and other decision documents, confirm dam safety work priorities based on portfolio risk findings, and make recommendations on dam safety modifications to the Special Assistant for Dam Safety and the Corps DSO.

4.3.2.6.2 The Special Assistant may assign additional ad hoc members to act as reviewers for the SOG for any decision documents as required. These ad hoc members will meet as necessary to accomplish these reviews in a timely fashion to prevent delays in the execution of risk reduction measures.

4.3.2.7 The Modeling, Mapping, and Consequences (MMC) Production Center supports both the USACE Dam Safety and Critical Infrastructure Protection & Resilience (CIPR) Programs. In support of HQUSACE management of the dam safety program, the MMC performs hydraulic modeling, mapping, and consequences analysis for USACE dams in support of the Dam Safety and CIPR programs. The MMC is led by a district with a core staff that is supplemented by a virtual staff of Hydraulic Engineers, Economist, and GIS professionals from across USACE. The MMC leverages H&H modeling, consequences analysis, and GIS mapping capabilities/resources via close coordination with USACE RMC to accomplish national mapping, hydraulic analysis, and

consequences requirements for the Dam Safety and CIPR Programs. The following are the major initiatives for the MMC: Develop consistent and scalable hydraulic models and consequence data for USACE dams, develop consistent mapping for Emergency Action Plans (EAP), and develop standards for GIS, consequence Analysis, and, modeling and mapping. The MMC is located within the Vicksburg District supplemented by a USACE wide virtual staff. The MMC Program Manager receives guidance from the MMC Steering Committee.

4.3.2.7.1 The Modeling, Mapping, and Consequence Production Center (MMC) Steering Committee is charged with providing oversight and guidance to the MMC program manager. The committee reviews and interprets policy, technical criteria and best practices, administrative procedures, and performs other functions as required to support the MMC mission. The committee shall also review experience and qualifications to assess agency competency in the areas of dam failure modeling, inundation mapping, and consequence estimating. The committee shall provide input to the scope, cost, schedule, and priority of MMC activities including an overall review of resource requirements. The committee shall meet as required and shall provide advice and information to the Risk Management Center Director.

4.3.2.7.2 As a minimum, the MMC steering committee shall be composed of the following members: Special Assistant for Dam Safety, HH&C CoP Lead, Planning CoP Lead, GIS CoP Lead, CIPR program manager, RMC Director (committee chair), and MMC program manager. Committee members may delegate membership to individuals within their organization or CoP in accordance with the committee charter.

4.4 Major Subordinate Commands (MSC) (Regional Headquarters).

4.4.1 Organization and Qualifications. The roles, responsibilities, and qualifications presented below are based on “Dam Safety Officer Roles, Responsibilities, Qualifications, and Professional Registration Requirements” (reference A.79).

4.4.1.1 MSC Dam Safety Officer (DSO). The MSC DSO shall be a registered professional engineer with civil engineering background and with management abilities and be competent in the areas related to the design, construction, operation, maintenance, inspection, or evaluation of dams and understand adverse dam incidents and the potential causes and consequences of dam failure. The MSC DSO should be the SES or MSC technical lead who is responsible for the engineering elements of the organization. The Commander shall ensure the DSO meets the technical qualifications and experience. The MSC DSO shall be appointed by written order of the MSC Commander following the process identified in paragraph 4.7. A copy of the appointment order for each DSO shall be forwarded to the Corps DSO. The DSO shall serve as the Chair of the MSC Dam Safety Committee.

4.4.1.2 MSC Dam Safety Committee. The MSC Dam Safety Committee shall include the DSO and DSPM plus additional members as required. The members should include the various technical engineering disciplines as well as Operations,

Water Management, and Programs from within the MSC headquarters. Other disciplines and areas of expertise, e.g., Security, Public Affairs, Construction, Emergency Management, Planning, and Office of Counsel, may be represented, as required by the DSO or Commander. The MSC Dam Safety Committee should meet at least annually and preferably twice a year.

4.4.1.3 MSC Dam Safety Program Manager. The MSC Dam Safety Program Manager shall be appointed by the MSC DSO. The DSPM shall be a registered professional engineer with civil engineering background (or registered professional geologist as described in paragraph 4.6) and with management abilities and be competent in the areas of design, construction, operation, maintenance, inspection or evaluation of dams. The DSPM conducts the daily activities for the MSC dam safety program, coordinates the review of dam safety reports, and provides support to districts within the MSC.. The DSPM works with the programs budget managers to ensure that dam safety requirements are included and properly prioritized in budget submissions. The DSPM serves on various national teams as requested by the Corps DSO and on the DSSC. The DSPM shall maintain an updated membership list of the MSC Dam Safety Committee. The MSC DSPM shall report directly to the MSC DSO on dam safety matters.

4.4.2 Responsibilities. The MSC DSO is responsible for quality assurance, coordination, and implementation of the MSC dam safety program. In this capacity the MSC DSO must establish procedures to ensure that the MSC DSO is fully advised on all dam safety issues. Quality assurance responsibilities include:

4.4.2.1 Ensuring that the organization is staffed with qualified personnel for program implementation and to meet program requirements.

4.4.2.2 Establishing dam safety related work priorities and ensuring that these priorities are addressed during budget development.

4.4.2.3 Ensuring that an appropriate technical review is conducted of the inspection, evaluation, and design for all features of dam safety projects.

4.4.2.4 Ensuring, in technically complex cases, that the project development team includes members from the MSC and RMC starting early in the process to ensure that the analytical methods and processes used by the district comply with policy and criteria.

4.4.2.5 Ensuring that adequate performance monitoring and evaluations of all dams are conducted and documented. Participating in periodic inspections and field visits to ensure that the district programs are conducted in accordance with the district quality control plans and requirements of this regulation. Reviewing and approving periodic inspection reports in accordance with Chapter 11 of this regulation.

4.4.2.6 Ensuring that Emergency Action Plans are maintained and regularly updated.

4.4.2.7 Ensure districts establish and execute a public awareness program and coordinate with State and local agencies as required.

4.4.2.8 Ensuring that adequate dam safety training and dam safety exercises are being conducted.

4.4.2.9 Monitoring the accuracy of data that are submitted for the inventory of Corps dams and DSPMT.

4.4.2.10 Monitoring and participating in district dam safety exercises.

4.4.2.11 Conducting quality assurance activities for all features of civil works dam projects, including review of district dam safety related plans.

4.4.2.12 Perform reviews and approve Interim Risk Reduction Measures Plans and related decision documents and coordinate results with HQ and the SOG for consistency.

4.4.2.13 Monitoring the performance of district dam safety programs including DSPMT, upward reporting, and submitting data to HQ for NID and biennial reports to Congress.

4.4.3 Coordination with District Commands. District DSOs and DSPMs should be invited to MSC Dam Safety Committee meetings for interaction on regional dam safety issues. The MSC Dam Safety Committee should periodically meet at a district or project location. A representative from the MSC Dam Safety Committee should participate in district Dam Safety Committee meetings whenever possible.

4.5 District Commands.

4.5.1 Organization and Qualifications. The roles, responsibilities, and qualifications presented below are based on “Dam Safety Officer Roles, Responsibilities, Qualifications, and Professional Registration Requirements” (reference A.79).

4.5.1.1 District Dam Safety Officer (DSO). The District Dam Safety Officer (DSO) shall be a registered professional engineer with civil engineering background and with management abilities and be competent in the areas related to the design, construction, operation,, maintenance, inspection or evaluation of dams and understand adverse dam incidents and the potential causes and consequences of dam failure. The District DSO shall generally be the chief of the engineering organization. The Commander shall ensure the DSO meets the technical qualifications and experience. The District DSO shall be appointed by written order of the District Commander after completion of the process outlined in paragraph 4.7. A copy of the appointment order for each DSO shall

be forwarded to the Corps DSO and the MSC DSO. The DSO shall serve as the Chair of the District Dam Safety Committee.

4.5.1.2 District Dam Safety Committee. The District Dam Safety Committee shall include the DSO and DSPM plus additional members as required. The members should include the various technical engineering disciplines as well as Operations, Water Management, and Programs. Other disciplines and areas of expertise, e.g., Security, Public Affairs, Construction, Emergency Management, Planning, and Office of Counsel, may be represented, as required by the DSO or Commander. The District Dam Safety Committee should meet at least twice a year.

4.5.1.3 District Dam Safety Program Manager (DSPM). The District Dam Safety Program Manager (DSPM) shall be appointed in writing by the District DSO. The DSPM shall be a registered professional engineer with civil engineering background (or registered professional geologist as described in paragraph 4.6) and with management abilities and be competent in the areas of design, construction, operation, maintenance, inspection or evaluation of dams. The DSPM conducts the daily activities for the District dam safety program and coordinates the review of dam safety reports. The DSPM works with the programs budget managers to ensure that dam safety requirements are included and properly prioritized in budget submissions. The DSPM shall maintain an updated membership list of the District Dam Safety Committee. The District DSPM shall report directly to the District DSO on dam safety matters.

4.5.2 Responsibilities. The District DSO is responsible for ensuring that the dam safety program is fully implemented and documented, in accordance with the District Dam Safety Program Management Plan. The Dam Safety Committee, advisory to the DSO, should meet at least twice annually and forward meeting minutes electronically to the MSC. The districts shall notify the MSC DSPM of the date and time of upcoming committee meetings and invite the MSC to send representative(s) to the meeting. District DSO responsibilities include, but are not limited to:

4.5.2.1 Ensuring that organizational staff of qualified technical and field personnel is sufficient for program implementation.

4.5.2.2 Monitoring and evaluating the performance of all dams and appurtenant structures and recommending remedial measures when necessary. Collecting data for the NID and biennial reports to Congress. Monitoring and reporting dam safety items using the Dam Safety Program Management Tools (DSPMT). A description of the DSPMT database is given in Appendix G.

4.5.2.3 Establishing priorities for dam safety related work. The DSO, as a member of the district Corporate Board, shall defend the list of dam safety work priority items. Dam safety work items are any work items impacting the safety, operation, and structural integrity of the project. The DSPMT can be used to track priorities over time.

4.5.2.4 Ensuring that dam safety training of technical staff and project operation and maintenance personnel is conducted.

4.5.2.5 Ensuring each dam has an adequate surveillance plan, and updated and fully implemented IRRMP if applicable.

4.5.2.6 Ensuring adequate and appropriate independent technical reviews for inspection, evaluation, and design for dams and appurtenant structures are accomplished. The District DSO shall certify that all design documents and periodic inspection reports have been subjected to district quality control (DQC) reviews and that the documents and reports are technically adequate.

4.5.2.7 Ensuring that adequate exploration and testing are accomplished during design and construction of civil works water control projects.

4.5.2.8 Performing periodic assessments and inspections, other supplemental inspections, and field visits. Periodically evaluating the district dams, appurtenant structures, and other water control projects using current criteria.

4.5.2.9 Coordinating and participating with local and State dam safety officials in the inspection and evaluation of non-Federal dams, upon request.

4.5.2.10 Ensuring that dam safety products are developed in accordance with documented district Project Management Business Processes as outlined in ER 5-1-11 (reference A-35) and ER 1110-2-1150 (reference A-51). A Project Delivery Team (PDT) consists of a project manager and personnel from engineering, planning, operations, public affairs office, and others necessary to develop the project. When more than one individual from the engineering organization is on the PDT, the technical chief shall designate a "lead engineer". While not necessarily appropriate for later phases of a project when the administrative requirements significantly increase, the lead engineer should be strongly considered for assignment as the project manager during the Issue Evaluation Study phase. The lead engineer may change as the project moves through the different phases of development, however continuity is important and changes should only be made after careful consideration. Because of the complexity and life safety implications of dam safety projects it is vitally important that the district DSO ensures that qualified registered professional engineer or engineering geologist are assigned as the lead engineer. In addition, they shall also ensure that the assigned project manager possesses adequate understanding of the dam safety business prior to their assignment to the project. Communication within the PDT can be particularly challenging as it routinely involves internal district coordination as well as coordination with several vertical elements (MSC, HQ, RMC, etc…). For this reason both positions require a solid combination of technical and communication skills.

4.5.2.11 Monitoring the dam safety aspects of the district’s Water Control Management Program.

4.5.2.12 Monitoring and reporting any evidence of operational restrictions or distress, including earthquake effects, of dams and appurtenant structures.

4.5.2.13 Ensuring that each dam owned by the district has an up-to-date Emergency Action Plan in accordance with Chapter 16 of this ER. Maintaining emergency notification procedures for utilization in a dam safety emergency situation and for use during dam safety exercises. Ensuring that annual coordination and review is accomplished, including review of emergency notification procedures. Emergency Action Plans should be distributed to and coordinated with all affected local agencies to use as a basis for preparing their evacuation plans. Ensuring emergency exercises are conducted.

4.5.2.14 Establishing dam safety public awareness programs and coordinating them with local interests.

4.5.2.15 Maintaining awareness of security related activities, issues, and initiatives at dams and related structures. Ensuring that the security program and the dam safety program activities and initiatives are coordinated.

4.5.2.16 Monitoring ongoing planning, design, and construction of project modifications for dam safety for adequate funding, and ensuring that they are executed in accordance with applicable regulations.

4.5.2.17 Coordinating with local and State dam safety officials concerning their review requirements for projects initiating the design phase.

4.5.2.18 Reviewing proposed design changes to district water control projects under construction and providing dam safety input at design change meetings.

4.5.2.19 Ensuring that the district has an up-to-date Dam Safety Program Management Plan.

4.5.2.20 Ensuring that each dam safety related report or design has a Quality Control Plan and that the final product is certified with a Quality Control Certificate upon completion.

4.5.2.21 Developing, reviewing and approving IRRMP as described in Chapter 7.

4.5.2.22 Ensure structural and operational modifications to Corps-owned dam projects do not diminish factors of safety or limit the ability to make flood releases.

4.6 Professional Registration. Dam Safety Officers, Dam Safety Program Managers, and various other positions providing final approval of engineering products and services to ensure the protection of life, property and the environment, are required by ER 690-1-1212 (reference A.41) to be registered professionally. It is intended and desirable that the DSPM at every level be a registered professional engineer with civil

engineering background; however, the DSO may approve the selection of a highly qualified registered professional geologist as the DSPM when filling the position. Persons holding a Dam Safety Program Manager position without appropriate professional registration at the time this regulation takes effect may continue in the position until they move to another position or retire.

4.7 Dam Safety Officer Selection Process. An individual being considered for appointment as a DSO must meet the qualifications listed in paragraph 4.3.2.1, 4.4.1.1, or 4.5.1.1. The individual should generally be the highest qualified person in the technical chain meeting the qualifications.

4.7.1 Process for District Dam Safety Officer. The District Commander should forward the name and qualifications of the individual that is being considered for the District DSO to the MSC DSO for review and comments. The individual should be in a position not lower than a branch chief within the engineering organization.

4.7.1.1 The MSC DSO will review the recommendation, request comments from the other District DSOs within the region, consolidate comments, and furnish a recommendation to the District Commander.

4.7.1.2 If no one at the District level is qualified, the District Commander and the MSC DSO will coordinate the assignment of the DSO duties to another District DSO on an interim basis.

4.7.1.3 The District Commander shall develop a plan for filling position at the District level in accordance with paragraph 4.2.3. This plan could include training, mentoring, or recruitment from outside the district. Progress on this plan will be reported to the MSC DSO at least twice annually.

4.7.2 Process for Division (MSC) Dam Safety Officer. The MSC Commander should forward the name and qualifications of the individual that is being considered for the MSC DSO to the Corps DSO at HQUSACE for review and comments. The individual should be in a position not lower than the chief of the technical directorate (or GS-15 level).

4.7.2.1 The Corps DSO will review the recommendation, request comments from the other MSC DSOs across the Corps, consolidate comments, and furnish a recommendation to the MSC Commander.

4.7.2.2 If no one at the MSC level is qualified, the MSC Commander and the Corps DSO will coordinate the assignment of the DSO duties to another MSC DSO or a District DSO within the region on an interim basis.

4.7.2.3 The MSC Commander will develop a plan for filling position at the MSC level in accordance with paragraph 4.2.3. This plan could include training, mentoring, or

recruitment from outside the MSC. Progress on this plan will be reported to the Corps DSO at least twice annually.

4.7.3 Process for Designation of Corps (HQUSACE) Dam Safety Officer. The SOG, with input from MSC DSO's, will review the qualifications of candidates at HQUSACE and furnish a recommendation through the Special Assistant for Dam Safety to the Chief of Engineers. The individual should be in a position not lower than GS-15 level.

4.7.3.1 If no one at HQUSACE is qualified, the Chief of Engineers and the SOG Chair shall coordinate the assignment of the Corps DSO duties to an MSC DSO on an interim basis.

4.7.3.2 The SOG in coordination with the Chief of Engineers will develop a plan for filling position at HQUSACE in accordance with paragraph 4.2.3. This plan could include training, mentoring, or recruitment from outside HQUSACE. Progress on this plan will be reported to the Chief of Engineers by the SOG at least twice annually.

4.7.4 An example of a Dam Safety Officer Appointment order is provided in Figure 4.1. This format may also be used to appoint interim or temporary DSO's.

Example Dam Safety Officer Appointment Order
Figure 4.1



DEPARTMENT OF THE ARMY
U.S. Army Corps Of Engineers
WASHINGTON DC 20314-1000

REPLY TO
ATTENTION OF
CECG

SEP 0 9 2009

MEMORANDUM FOR Chief, Engineering and Construction, ATTN: Mr. James C. Dalton, P.E.

SUBJECT: Appointment of Dam Safety Officer

1. Effective 1 October 2009, you are appointed as the U.S. Army Corps of Engineers Dam Safety Officer (DSO) in accordance with the Federal Guidelines for Dam Safety (FEMA 93).

2. As DSO you will report directly to the Chief of Engineers on Dam Safety matters. The duties of the DSO are as published in the following guidance.

a. Federal Guidelines for Dam Safety, FEMA 93, June 1979

b. ER 1110-2-1155, Dam Safety - Organization, Responsibilities, and Activities, 31 July 1992

3. This appointment is effective until rescinded.

R. L. VAN ANTWERP
Lieutenant General, USA
Commanding

CF: Mr. Steven L. Stockton

This page left blank.

CHAPTER 5

Tolerable Risk Guidelines

5.1 Introduction.

5.1.1 The Role of Tolerable Risk Guidelines in Risk Assessment and Risk Management. Tolerable risk guidelines are used in risk management to guide the process of examining and judging the significance of estimated risks obtained using risk assessment. The outcomes of risk assessment are inputs, along with other considerations, to the risk management decision process. Tolerable risk guidelines should not be used alone to prescribe decisions on “How safe is safe enough?" Meeting or achieving the tolerable risk guidelines is the goal for all risk reduction measures including permanent and interim measures. The available options for IRRM may be limited by time, available funding, and potential negative effects on public health and safety due to the IRRM. (The loss of project benefits should not override the need to reduce risk to public safety.)

5.1.2 Development of Tolerable Risk Guidelines for The Corps of Engineers. USACE is working with the Bureau of Reclamation (Reclamation) and the Federal Energy Regulatory Commission (FERC), to craft common risk management guidelines. Reclamation had been using “Guidelines for Achieving Public Protection in Dam Safety Decision making” (reference A.100), which were originally issued as interim guidance in 1997 and subsequently in final form in 2003. Guidelines are also being used in other countries, such as the Australian National Committee on Large Dams (ANCOLD) - Guidelines on Risk Assessment (2003) (reference A.80). Although these guidelines have some fundamental common characteristics, there are some subtle and important differences.

5.1.3 Continued Development of Guidelines. As USACE works with Reclamation and FERC to achieve a common risk management framework and guidelines, USACE will use an adaptation of the 2003 Reclamation public protection guidelines and the risk evaluation guidelines published by Australian National Committee On Larger Dams (ANCOLD) in 2003 (reference A.80) and some adaptations of the ANCOLD guidance implemented by the New South Wales Government Dam Safety Committee (NSW DSC) Risk Management Policy Framework for Dam Safety, 2006 (reference A.106).

5.1.4 Definition of an “Adequately Safe” Dam. USACE will use the concept that a dam is considered adequately safe (DSAC Class V) when residual risk is considered tolerable and it meets all essential USACE guidelines with no dam safety issues.

5.2 Background on Tolerable Risk Guidelines.

5.2.1 Definition of Tolerable Risk. Tolerable risks are:

5.2.1.1 Risks that society is willing to live with so as to secure certain benefits;

5.2.1.2 Risks that society does not regard as negligible (broadly acceptable) or something it might ignore;

5.2.1.3 Risks that society is confident are being properly managed by the owner; and

5.2.1.4 Risks that the owner keeps under review and reduces still further if and as practicable (Adapted from HSE, 2001) (reference A.105).

5.2.2 Definition of Broadly Acceptable Risk. “Broadly acceptable risk” is contrasted with tolerable risk. "Risks falling into this region are generally regarded as insignificant and adequately controlled. The levels of risk characterising this region are comparable to those that people regard as insignificant or trivial in their daily lives. They are typical of the risk from activities that are inherently not very hazardous or from hazardous activities that can be, and are, readily controlled to produce very low risks" (HSE, 2001) (reference A.105). By the nature of the hazard that dams pose it is inappropriate to attempt to manage them as a broadly acceptable risk and therefore the concept of the broadly acceptable risk level or limit does not apply to dams.

5.2.3 Definition of Tolerable Risk Range. Figure 5.1 shows how in general tolerable risk is a range between unacceptable, where the risk cannot be justified except in extraordinary circumstance, and broadly acceptable, where the risk is regarded as negligible (Adapted from HSE, 2001) (reference A.105). This figure illustrates the point at which the residual risk for a specific dam is tolerable within the general range of tolerability as defined by meeting the as-low-as-reasonably-practicable (ALARP) considerations.

5.2.4 Equity and Efficiency.

5.2.4.1 Two fundamental principles, from which tolerability of risk guidelines are derived, are described as follows in ICOLD (2005) (reference A.101):

5.2.4.1.1 Equity. The right of individuals and society to be protected, and the right that the interests of all are treated with fairness, with the goal of placing all members of society on an essentially equal footing in terms of levels of risk that they face; and

5.2.4.1.2 Efficiency. Efficiency is the need for society to distribute and use available resources so as to achieve the greatest benefit.

5.2.4.2 Conflict Between Equity and Efficiency. There can be conflict in achieving equity and efficiency. Achieving equity justifies the establishment of maximum tolerable risk limits for individual and societal risk. Efficiency is defined by the risk level where marginal benefits equal or exceed the marginal cost. Equity requires that a tolerable risk limit should be met regardless of the lack of economic justification or the magnitude of the cost. Equity implies the need for this limit even if efficiency does not support reducing risks to meet the maximum tolerable risk limit. There is, therefore, a need to

obtain an appropriate balance between equity and efficiency in the development of tolerable risk guidelines. In general, society is more averse to risks if multiple fatalities were to occur from a single event and hence impact on society as a whole, creating a socio-political response. In contrast, society tends to be less averse to risks that result from many individual small loss accidents involving only one or two fatalities, even if the total loss from the sum of all of the small loss accidents is larger than that from the single large loss accident. This leads to the notion that tolerable risk should consider both societal and individual risks as an integral part of the framework for managing risks.

5.2.5 “As-Low-As-Reasonably-Practicable”. The “as-low-as-reasonably-practicable” (ALARP) considerations provide a way to address efficiency aspects in both individual and societal tolerable risk guidelines. The ALARP considerations apply below the tolerable risk limit of Figure 5.1. The concept for the use of ALARP considerations is that risks lower than the tolerable risk limit are tolerable only if further risk reduction is impracticable or if the cost is grossly disproportional to the risk reduction. The related concept of disproportionality is related to the legal obligation of the owner of a hazard to protect life and property from the risks associated with a hazard. ALARP only has meaning in evaluating risk reduction measures: it cannot be applied to an existing risk without considering the options to reduce that risk. ALARP is an explicit consideration under ANCOLD (2003) (reference A.80) and NSW DSC (2006) (reference A.106) tolerable risk guidelines. Determining that ALARP is satisfied is ultimately a matter of judgment. In making a judgment on whether risks are ALARP, the following factors should be taken into account (adapted from NSW DSC, 2006) (reference A.106):

5.2.5.1 The level of risk in relation to the tolerable risk limit and the broadly acceptable risk level (not applicable to dams);

5.2.5.2 The disproportion between the sacrifice (money, time, trouble and effort) in implementing the risk reduction measures and the subsequent risk reduction achieved;

5.2.5.3 The cost-effectiveness of the risk reduction measures;

5.2.5.4 Any relevant recognized good practice; and

5.2.5.5. Societal concerns as revealed by consultation with the community and other stakeholders.

5.3 USACE Tolerable Risk Guidelines.

5.3.1 Risk Measurement. Four risk measures will be evaluated under the USACE tolerable risk guidelines:

5.3.1.1 Annual probability of failure

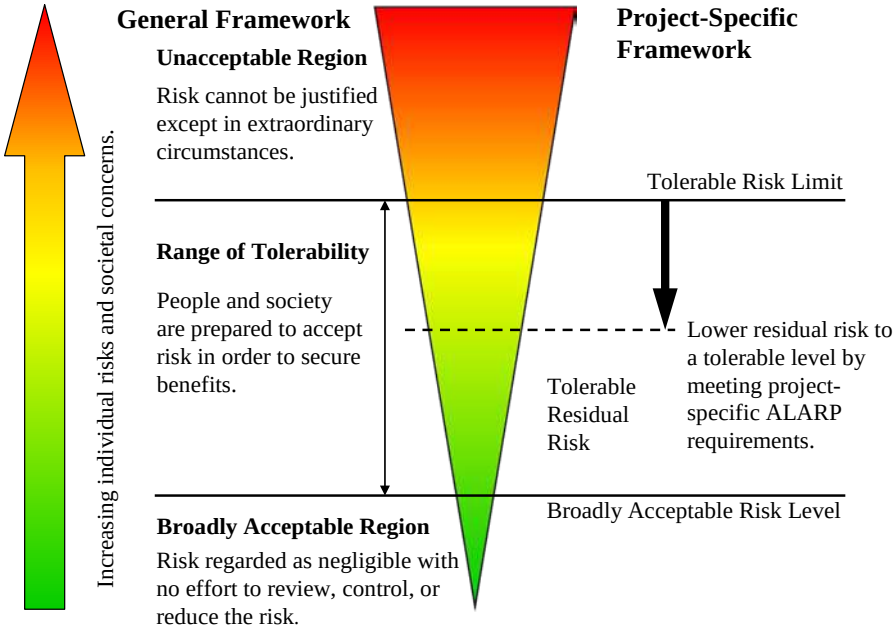


Figure 5.1 - Generalized and Project Specific Tolerability of Risk Framework (Adapted from HSE, 2001) (Reference A.105)

5.3.1.2 Life safety risk

5.3.1.3 Economic risk

5.3.1.4 Environment and other non-monetary risk

5.3.2 Additional Considerations. In addition to the tolerable risk limit guidelines, the ALARP considerations will be applied to determine when the risk is considered to be tolerable. All of these measures together will be considered when evaluating a dam and making risk management decisions; but life safety risk and the annual probability of failure will be given preference, with economic and environmental risk being given due consideration. For those projects where there is very low or no life safety risk, economic consequences and annual probability of failure will be the primary considerations along with environmental risk in making risk management decisions.

5.3.3 Incremental Consequences. In applying these tolerable risk guidelines, the incremental consequences will be considered. Incremental consequences are defined as follows:

Incremental consequences	=	Consequences associated with the estimated performance of the project with *failure*	-	Consequence associated with the estimated performance of the project *without failure*

5.3.3.1 This definition, when applied to flood-induced failure, is illustrated in Figure 5.2 and distinguishes between the following:

5.3.3.1.1 The structural design capacity, which is the maximum loading condition that the project was planned to withstand (original design loads), although the project may fail at a lesser loading condition; and

5.3.3.1.2 The flood regulation design capacity, which is the maximum loading condition above which the project no longer provides any flood damage reduction benefits, defined as a reduction in flood levels in the area protected by the project at loading levels below the structural design capacity.

5.3.3.2 Figure 5.2 also distinguishes between the following:

5.3.3.2.1 The planned or intended condition, for which failure does not occur until the loading level exceeds the structural design capacity (vertical line shading); and

5.3.3.2.2 The condition that failure may occur at loading levels less than the structural design capacity (diagonal line shading).

5.3.3.3 Incremental consequences for other initiating events such as seepage and seismic-induced dam failure are the differences due to the event with and without dam failure.

5.3.4 Annual Probability of Failure Guideline.

5.3.4.1 Annual probability of failure will be evaluated based on Reclamation’s value for its annual probability of failure (APF) Public Protection Guideline applied to the total estimated annual probability of failure from all failure modes associated with all loading or initiating event types. For a detailed discussion on the Reclamation's process see Appendix K. Although only the total annual probability of failure is to be evaluated against this guideline, it is important that the contributions to the total APF from the individual failure modes, loading types, loading ranges, exposure scenarios, etc, are analyzed. The analysis and evaluation of the individual failure modes can lead to an improved understanding of the failure modes that affect the total annual probability of failure. It can also provide insights that can lead to the identification of both structural and non-structural risk reduction measures, including interim measures.
.

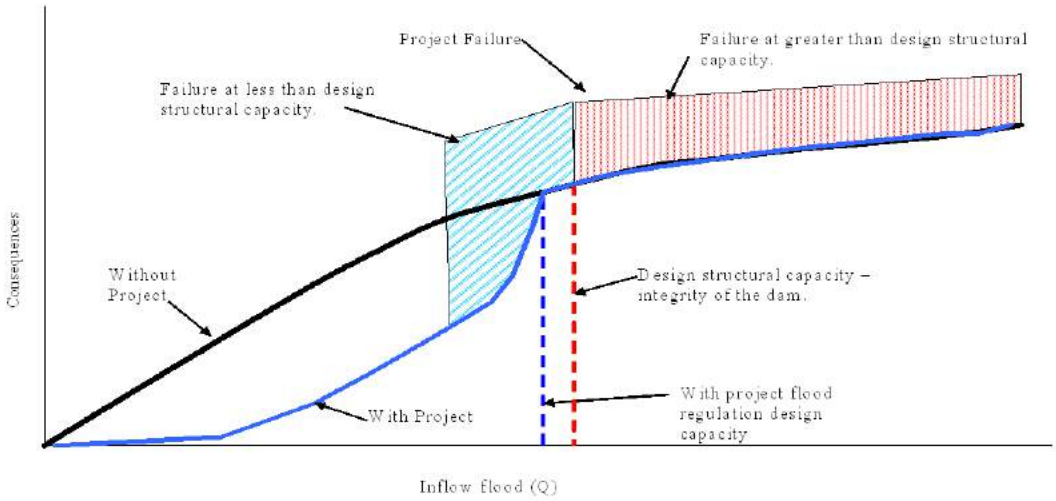


Figure 5.2 – Abstract Illustration of Incremental Consequences for Flood Induced Dam Failure

5.3.4.2 The policy for the estimated APF under USACE tolerable risk guidelines is:

5.3.4.2.1 APF > 1 in 10,000 (0.0001) Per Year. Annual probability of failure in this range is unacceptable except in exceptional circumstances. Reclamation states, "The justification to implement risk reduction actions increases as the estimates become greater than 0.0001 per year. Actions considered reasonable and prudent should be considered for implementation when the annual probability of failure estimate is in this range" (Reclamation 2003) (Reference A.100).

5.3.4.2.2 APF < 1 in 10,000 (0.0001) Per Year. Annual probability of failure in this range will be considered tolerable provided the other tolerable risk guidelines are met. Reclamation states, "The justification to implement risk reduction actions diminishes as the estimates become smaller than 0.0001 per year. Risk reduction action costs, uncertainties in the risk estimates, scope of consequences, operational and other water resources management issues play an increased role in decision-making. Actions considered reasonable and prudent should be considered for implementation when the annual probability of failure is in this range" (Reclamation 2003) (Reference A.100).

5.3.4.3 This guideline is illustrated in Figure 5.3 as the horizontal dashed line at 1×10^{-4} per year.

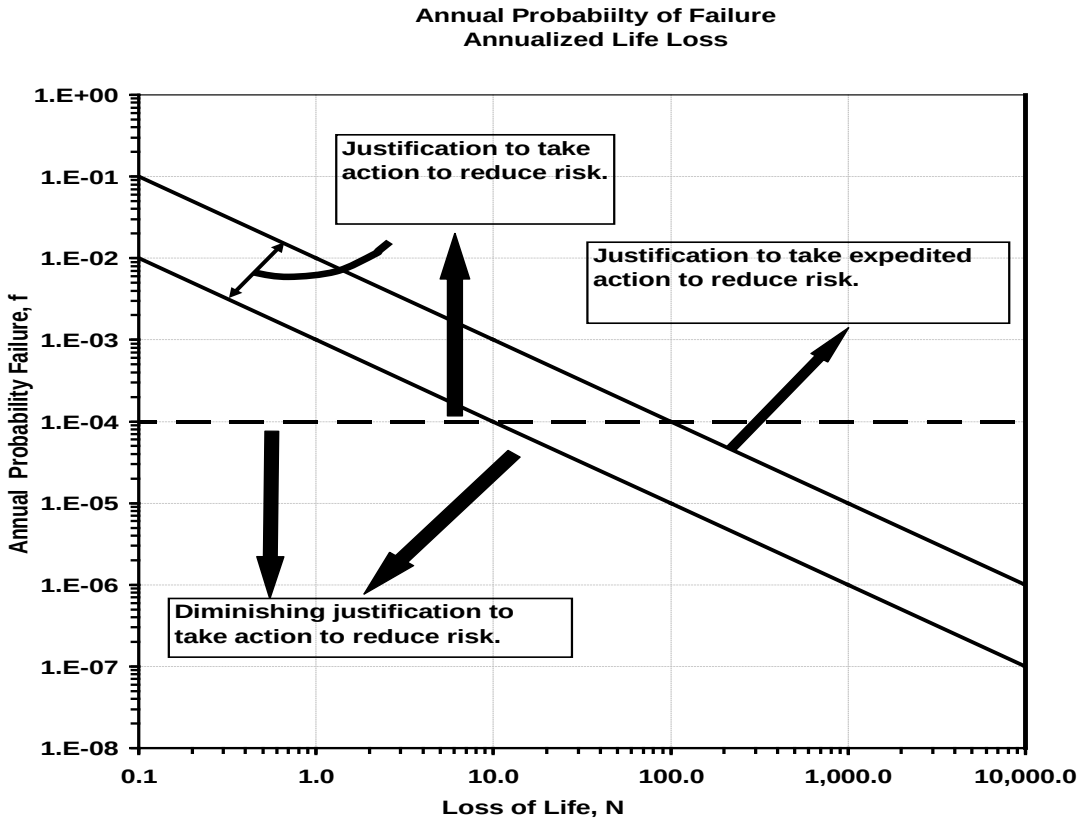


Figure 5.3 – f-N Chart for Displaying Annual Probability of Failure and Annualized Life Loss

5.3.5. Life Safety Risk Guidelines.

5.3.5.1 Life Safety Risk Guidelines. Three types of life safety risk guidelines will be used under the USACE tolerable risk guidelines.

5.3.5.1.1 Individual incremental life safety risk using probability of life loss

5.3.5.1.2 Societal incremental life safety risk expressed in two different ways –

5.3.5.1.2.1 Probability distribution of potential life loss (F-N chart as discussed in the section on *Probability Distribution of Potential Life Loss)*

5.3.5.1.2.2 Annualized Life Loss (ALL)

5.3.5.2 Evaluation of Total Life Safety Risk. As with APF, it is the total life safety risk that is to be evaluated against the life safety guidelines. However, it is important

that the contributions to the total from all individual failure modes, loading types, loading ranges, exposure conditions, subpopulations at risk, etc, are analyzed. This analysis can lead to an improved understanding of the failure modes and the exposure conditions that affect the total life safety risk. It can also provide insights that can lead to the identification of both structural and non-structural risk reduction measures, including interim measures.

5.3.5.3 Individual Incremental Life Safety Tolerable Risk Guideline. The individual risk is represented by the probability of life loss for the identifiable person or group by location that is most at risk. This is combined over all modes of failure with due regard for non-mutually exclusive failure modes, for the purpose of tolerable risk evaluation.

5.3.5.3.1 Existing Dams. For existing dams, the individual risk to the identifiable person or group by location, that is most at risk, should be less than a limit value of 1 in 10,000 per year, except in exceptional circumstances. This follows the ANCOLD (2003) (reference A.80) individual life safety risk guideline. The individual life risk is computed from all failure modes associated with all loading or initiating events, with due regard for non-mutually exclusive failure modes (Figure 5.4.a).

5.3.5.3.2 New Dams and Major Modifications. For new dams or major modifications under Section 216 (reference A.94)[1], the individual risk to the person or group, which is most at risk, should be less than a limit value of 1 in 100,000 per year, except in exceptional circumstances, following the ANCOLD (2003) (reference A.80) individual life safety risk guideline (Figure 5.5.a). Application of the new dam tolerable risk guidelines for major modifications will be decided on an individual project basis in coordination with HQUSACE.

5.3.5.3.3 All Dams. For existing dams, new dams, or Section 216 modifications (reference A.94), individual risks are to be lower than the limit values to an extent determined in accordance with the ALARP considerations. NWS DSC (2006) states that if individual risk is below 1 in 1,000,000 per annum there is no need to pursue further risk reduction. However, it is USACE policy to consider ALARP below 1 in 1,000,000 per annum although it is unlikely to justify further risk reduction.

5.3.5.3.4 Multiple Dams. Individual risk should be checked below the main and each auxiliary dam to verify that the person or group, which is most at risk, is provided a level of protection that satisfies this individual incremental life safety tolerable risk guideline.

5.3.5.3.5 Probability of Individual Life Loss and Probability of Failure. The probability of individual life loss, which is used in the evaluation of individual incremental life safety risk, is not necessarily the same as the probability of failure that is used in the evaluation of the APF guideline, which is described in Section 5.3.4. The probability of life loss is based on the probability of failure, a consideration of exposure factors to

[1] A Section 216 study addresses major modification of a dam that changes authorized purposes of that dam.

characterize the day-night, seasonal, or other exposure scenarios, and the conditional probability of life loss given exposure to the dam failure flood. The level of detail that is appropriate for characterizing exposure factors should be "decision driven."

5.3.5.4 Probability Distribution of Potential Life Loss. The societal risk is represented by a distribution of the estimated annual probability of potential life loss from dam failure for all loading types and conditions and all failure modes and all population exposure scenarios. This is displayed as an F-N chart which is a plot of the annual probability of exceedance (greater than or equal to) of potential life loss (F) vs. incremental potential loss of life (N)[2] due to failure compared to the no failure condition. Thus, the F-N chart displays the estimated probability distribution of life loss for a reservoir encompassing all failure modes and all population exposure scenarios for a particular dam.

5.3.5.4.1 Existing Dams. For existing dams, the societal risk should be less than the tolerable risk limit line shown in Figure 5.4.b, except in exceptional circumstances, following an adaptation of the ANCOLD (2003) (reference A.80) and NSW (2006) (Reference A.106) societal life safety risk guideline.

5.3.5.4.2 New Dams and Major Modifications. For new dams or major modifications under Section 216 (reference A.94), the societal risk should be less than the tolerable risk limit line shown in Figure 5.5.b, except in exceptional circumstances, following an adaptation of the ANCOLD (2003) (reference A.80) and NSW (2006) (Reference A.106) societal life safety risk guideline. Application of the new dam tolerable risk guidelines for major modifications will be decided on an individual project basis in coordination with HQUSACE.

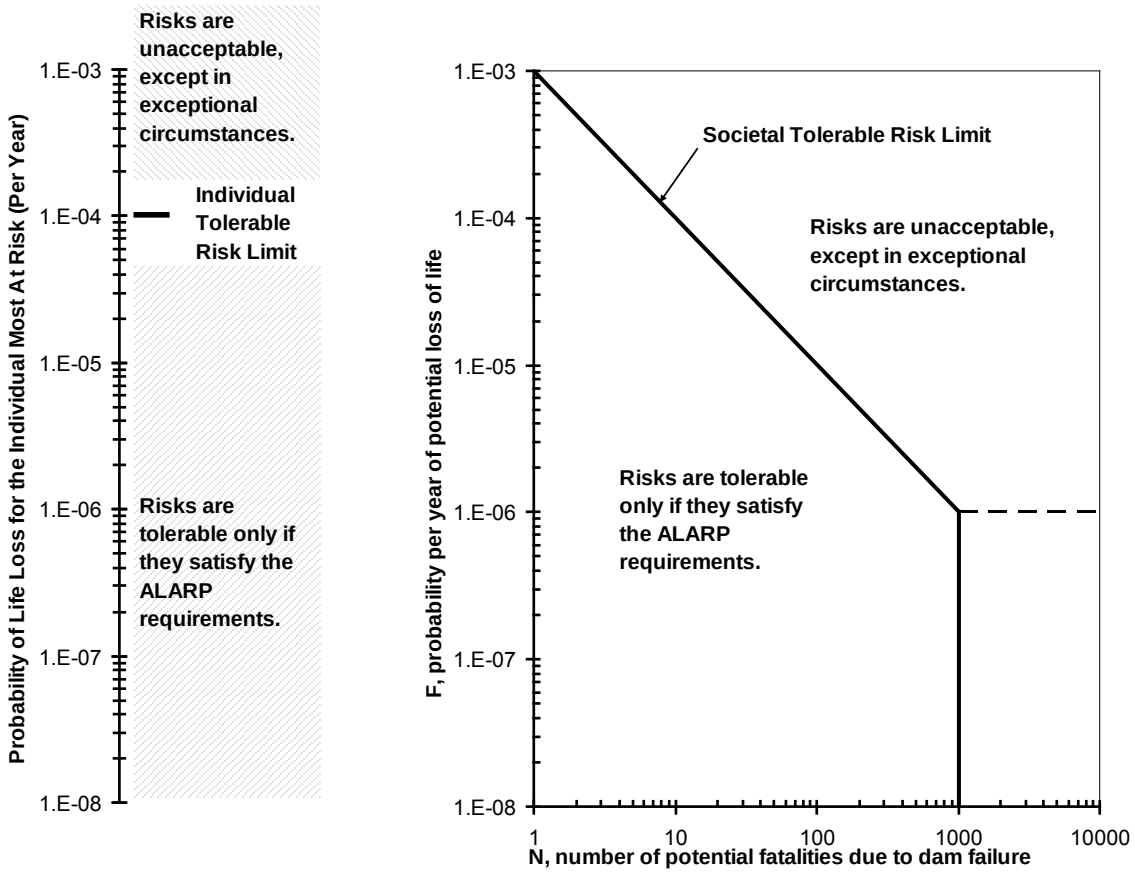
5.3.5.4.3 All Dams. For existing dams, new dams, or major modifications under Section 216 (reference A.94), societal risk are to be lower than the tolerable risk limit lines to an extent determined in accordance with the ALARP considerations.

5.3.5.4.4 Dams with Unacceptable Level of Risk. Dams with failure risks that plot above a tolerable risk limit on an F-N chart are considered to have an unacceptable level of risk. As with the individual tolerable risk limit, risks should be reduced to the tolerable risk limit regardless of cost considerations and then further until ALARP is satisfied, except in exceptional circumstances.

5.3.5.4.5 Special Evaluation of the Tolerability of Risk. If incremental life loss is estimated to exceed 1,000 lives or is above the minus 1 sloping limit line the evaluation of the tolerability of risk shall be based on an official review of the benefits and risks as described in the "Except in Exceptional Circumstances" section (paragraph5.3.6).

[2] In probability textbooks a cumulative (probability) distribution function (CDF) is defined to have probability "less than or equal to" on the vertical axis and a complementary cumulative (probability) distribution function (CCDF) is defined to have probability "greater than" on the vertical axis. Although similar to a CCDF, an F-N chart is subtly, but in some cases importantly, different because it has probability "greater than or equal to" on the vertical axis rather than "greater than" as in the CCDF.

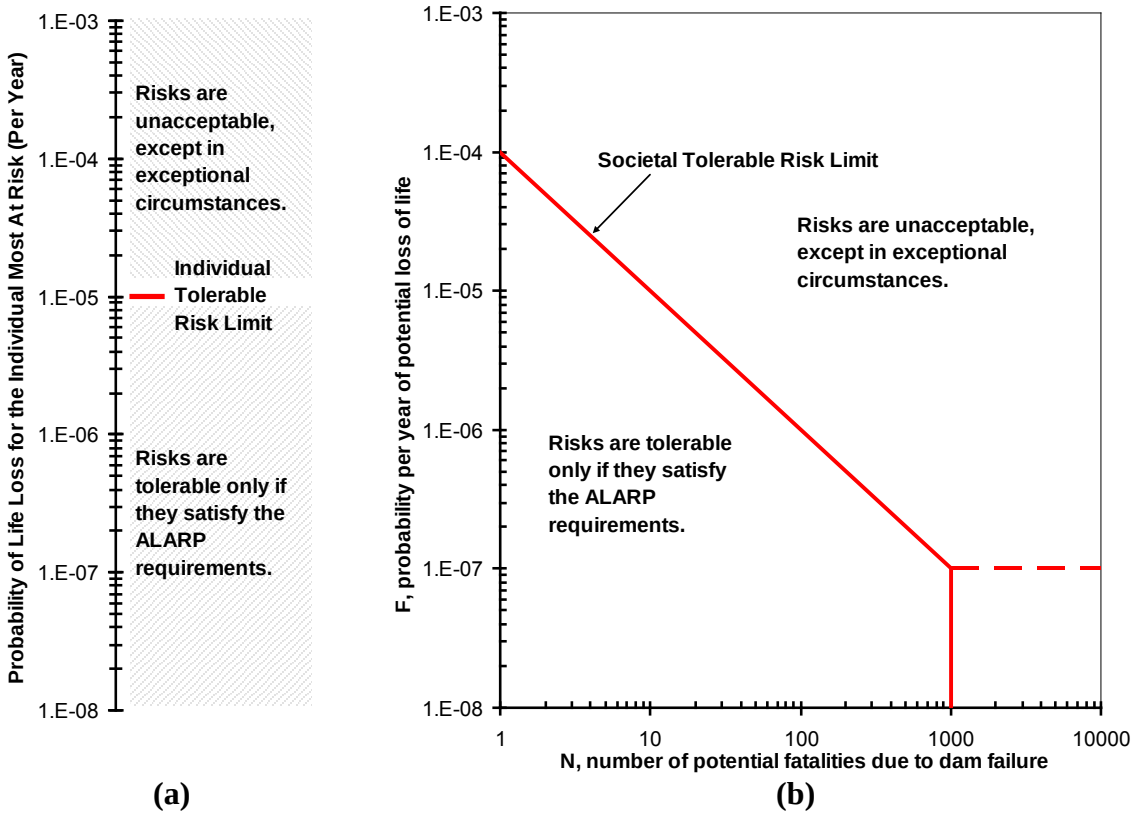
5.3.6 Except in Exceptional Circumstances. The qualifier “except in exceptional circumstances” refers to a situation in which government, acting on behalf of society, may determine that risks exceeding the tolerable risk limits may be tolerated based on special benefits that “the dam brings to society at large”. "The justification for tolerating



Figures 5.4.a – Individual Risk Guidelines for Existing Dams
and 5.4.b – Societal Risk Guidelines for Existing Dams

such high risks is the wider interests of society. Risks, which would normally be unacceptable, can be tolerated on account of the special benefits, which the dam brings to society." (ANCOLD, October 2003) (reference A.80). This is an example of the conflict between the fundamental principles of equity and efficiency. Specifically, the maximum risk level that satisfies equity considerations can be at the expense of reducing efficiency. The equity consideration might be relaxed because of special benefits are deemed to outweigh the increased residual risk. This exception might be made where the residual potential life loss and economic consequences are large, but where the probability of failure is very low and state of the practice risk reduction measures have been implemented. For dams in this area on Figures 5.4.b and 5.5.b USACE will look critically at the confidence in the estimate of the risk. Full compliance

with essential guidelines will be expected. The adequacy of potential failure modes analysis and risk assessment will be carefully examined. The USACE is to demonstrate that risks are ALARP. HQUSACE would reach a decision based on the merits of the case.



Figures 5.5.a – Individual Risk Guideline for New Dams and Major Modification Under Section 216
and 5.5.b -- Societal Risk Guideline for New Dams and Major Modification Under Section 216

5.3.7 Annualized Incremental Life Loss (ALL) Public Protection Guideline. Annualized Life Loss (ALL) guideline is the expected value (average annual) of incremental potential life loss resulting from dam failure as shown in the f-N chart.

5.3.7.1 Annualized Incremental Societal Life Loss. Annualized incremental societal life loss will be evaluated based on the limit values as shown in the ALL guideline (Figure 5.3). This should be applied to the total estimated annualized incremental life loss from all failure modes associated with all loading or initiating event types and considering all exposure conditions associated with life loss.

5.3.7.2 Policy for Estimating ALL. The policy for the estimated ALL under the USACE tolerable risk guidelines is:

5.3.7.2.1 ALL > 0.01 Lives/Year. ALL risk in this range is unacceptable except in exceptional circumstances and is reason for urgent actions to reduce risk. Reclamation states, "… there is justification for taking expedited action to reduce risk." This is represented by the upper minus 1 sloping line in Figure 5.3 (Reclamation 2003) (reference A.100).

5.3.7.2.2 ALL Between 0.01 and 0.001 Lives/Year. ALL risk in this range is unacceptable except in exceptional circumstances and is reason for actions taken to reduce risk. Reclamation states, "…there is justification for taking action to reduce risk." This is represented by the area between the two minus 1 sloping lines in Figure 5.3 (Reclamation 2003) (reference A.100).

5.3.7.2.3 ALL < 0.001 Lives/Year. ALL risk in this range may be considered tolerable provided the other tolerable risk guidelines are met. Reclamation states, "The justification to implement risk reduction actions or conduct additional studies diminishes as estimated risks become smaller than 0.001 lives/year. Risk reduction action costs, uncertainties in the risk estimates, scope of consequences, operational and other water resources management issues play an increased role in decision making. Actions considered reasonable and prudent should be considered for implementation when the risk is in this range" (Reclamation 2003) (reference A.100).

5.3.8 As-Low-As-Reasonably-Practicable Considerations.

5.3.8.1 The ANCOLD (2003) (reference A.80) individual and societal risk guidelines include an important consideration that the risk is to be lower than the limit values to an extent determined in accordance with the ALARP considerations. Reclamation's Public Protection Guidelines do not specifically address ALARP. The ANCOLD (2003) (reference A.80) guidelines provide some overall guidance on evaluating whether risks have been reduced to ALARP. Determination is both qualitative and quantitative in nature.

5.3.8.2 In making a judgment on whether risks are ALARP, the USACE shall take the following into account: the level of risk in relation to the tolerable risk limit and the broadly acceptable risk level (not applicable to dams); the disproportion between the sacrifice (money, time, trouble and effort) in implementing the risk reduction measures and the subsequent risk reduction achieved; the cost-effectiveness of the risk reduction measures; compliance with essential USACE guidelines; and societal concerns as revealed by consultation with the community and other stakeholders. The specific ALARP considerations to be used by the USACE are listed, with commentary, below.

5.3.8.2.1 The level of risk in relation to the tolerable risk limit. When the estimated life safety risk has been reduced to the tolerable risk limit the ALARP consideration leads to the question, "How far below that limit is the level of risk to be reduced?" The

further below the tolerable risk limit the weaker the ALARP justification for further risk reductions.

5.3.8.2.2 The cost-effectiveness of the risk reduction measures.

5.3.8.2.3 The disproportion between the sacrifice (money, time, trouble and effort) in implementing the risk reduction measures and the subsequent risk reduction achieved.

5.3.8.2.3.1 Disproportionality is used as a justification to reduce the risk below the tolerable risk limit. The disproportion between the sacrifice (money, time, trouble and effort) in implementing the risk reduction measures and the subsequent risk reduction achieved is to be evaluated using the disproportionality between the sacrifice and the risk reduction achieved. This entails the use of the following two measures: 1) a cost effectiveness measure called, the "cost-to-save-a-statistical-life" (CSSL); and 2) a "willingness-to-pay-to-prevent-a-statistical-fatality" (WTP), commonly referred by the Office of Management and Budget (OMB 2003) and other federal agencies as the "value-of-statistical-life" (VSL). VSL is used by OMB, the United States Department of Transportation (USDOT) (references A.110 and A.111), and other federal agencies to evaluate the case for regulating risk or investing in life-saving risk reduction measures. The risk measure for disproportionality is the ratio of the CSSL divided by WTP. The quantitative ANCOLD (2003) (reference A.80) guidance is based on estimating the incremental CSSL for any risk reduction options that could reduce the risk below the limit values, starting at or below the limit values, and assigning a “strength of ALARP justification” to proceed with the risk reduction measure based on the magnitude of the estimated CSSL. This approach has it roots in work by the Health Safety Executive, United Kingdom (HSE 2001) (reference A.105) and by Bowles and Anderson (2003) (Reference A.85). CSSL calculations are shown in Appendix L.

5.3.8.2.3.2 The ANCOLD approach has been adapted for application to USACE dams as represented in Tables 5.1 and 5.2 that show the disproportionality ratio of the CSSL to the WTP.

$$\text{Disproportionality ratio} = \text{CSSL} / \text{WTP}$$

5.3.8.2.3.3 The value to use for WTP in USACE dam safety risk assessments will be the current value used by USDOT. As of January 2009 USDOT (2008) uses a value for WTP of US$5.8M with a standard deviation of US$2.6M or a range of US$3.2M - US$8.4M, which is equivalent to a range of plus and minus one standard deviation. (Reference A.110 and A.111)

5.3.8.2.3.4 The disproportionality ratios in Tables 5.1 and 5.2[3] have been calculated from the ANCOLD CSSL values using a WTP of $5M/statistical fatality prevented. The

[3] Tables 5.1 and 5.2 refer to the tolerable risk limit and broadly acceptable region, respectively. Based on their original use by HSE, the tolerable risk limit for individual risk may be considered to be 1 in 10,000 per year and the broadly acceptable limit may be considered to be 1 in 1,000,000 per year. However, the concept of broadly acceptable risk does not apply to dams as discussed elsewhere in this paper.

disproportionality ratio will be calculated, as described in the next paragraph, for each risk reduction alternative and compared with the ANCOLD values below for illustrative purposes.

5.3.8.2.4 Compliance with Essential USACE Guidelines. The dam will be evaluated on its ability to meet essential USACE guidelines. The USACE essential guidelines list will be developed from the published and draft design criteria documented in the USACE engineering regulations and engineering manuals. The evaluation will be

Table 5.1 – Guidance on ALARP Justification for
Risks just below the Tolerable Risk Limit

ALARP Justification Rating	Range of Disproportionality Ratios	
	Greater than or equal to	Less than
Very Strong	Zero	1
Strong	1	4
Moderate	4	20
Poor	20	

Table 5.2 – Guidance on ALARP Justification for
Risks just above the Broadly Acceptable Region

ALARP Justification Rating	Range of Disproportionality Ratios	
	Greater than or equal to	Less than
Very Strong	Zero	0.3
Strong	0.3	1
Moderate	1	6
Poor	6	

presented as pass, apparent pass, apparent no pass, or no pass tabulation with a detailed evaluation for apparent pass, apparent no pass, or no pass ratings.

5.3.8.2.5 Societal concerns as revealed by consultation with the community and other stakeholders. Societal concerns in terms of community expectations are to be identified, documented, and resolved in a public meeting and comment process modeled after similar procedures already established by USACE.

5.3.9 Economic Consequences.

5.3.9.1 Economic considerations to help inform risk management decisions include both the direct losses of the failure of a dam and other economic impacts on the regional or national economy. Part of the direct losses is the damage to property located downstream from the dam due to the failure. Items in this category include those commonly computed for the National Economic Development (NED) account in any USACE flood risk management study (USACE 2000). These include damage to

private and public buildings, contents of buildings, vehicles, public infrastructure such as roads and bridges, public utility infrastructure, agricultural crops, agricultural capital, and erosion losses to land. Direct losses also include the value from the loss in services provided by the dam such as hydropower (incremental cost to replace lost power), water supply, flood damage reduction, navigation (incremental cost for alternate transportation - if available), and recreation. Another category of NED values is the emergency response for evacuation and rescue and the additional travel costs associated with closures of roads and bridges. The sudden loss of pool due to a dam failure could result in losses to property and infrastructure within the pool area. The NED value of these losses should be included in computing direct economic loss due to dam failure. (NOTE: one potential direct loss is the cost of repairing the damage to the dam. This is a complicated issue and to some degree depends on the extent of damage to the dam. If the dam can be repaired, these repair costs could be counted as an economic cost. In the case of catastrophic failure, these rebuilding costs should not be included in the direct costs, as the decision to rebuild the dam depends on the post-failure benefits which would be a separate analysis.)

5.3.9.2 These direct economic losses can be compared to costs of any dam modification to display a measure of the economic efficiency of the modification. Additionally, these direct economic losses are used to net against the cost of remediation measures in the calculation of CSSL.

5.3.9.3 Indirect economic impacts are those associated with the destruction of property and the displacement of people due to the failure. The destruction due to the failure flood can have significant impacts on the local and regional economy as businesses at least temporarily close resulting in loss of employment and income. Similarly, economic activity linked to the services provided by the dam will also have consequences. These would include economic impacts on business that provide goods and services for the recreation activities associated with the reservoir. All these indirect losses then have ripple or multiplier effects in the rest of the regional and national economy due to the resulting reduction in spending on goods and services in the region. In this way, a dam failure can have widespread economic losses throughout the region. These losses are the increment to flood losses above those that would have occurred had the dam not failed.

5.3.10 Environment and Other Non-Monetary Consequences.

5.3.10.1 A dam failure has both direct and indirect consequences that cannot be measured in monetary terms. These stem from the impacts of the dam failure flood and loss of pool on environmental, cultural, and historic resources. In most cases, the assessment of the impacts of dam failure will be the reporting of area and type of habitat impacted, habitat of threatened and endangered species impacted, number and type of historic sites impacted, and the number and type of culturally significance areas impacted.

5.3.10.2 An additional indirect non-monetary consequence could be the exposure of people and the ecosystem to hazardous and toxic material released from landfills, warehouses, and other facilities. An estimate of the locations and quantities should be compiled identifying where significant quantities are concentrated. A potential additional source of hazardous and toxic material is the sediment accumulated behind the dam. Identifying and enumerating these indirect hazards could be important enough to require additional risk assessments including estimating additional fatalities due to exposure to theses hazards. Although these non-monetary consequences may not provide the sole basis for risk reduction, they can provide additional risk information for decision making. They can also be used to identify risks to be managed separately from dam modifications.

5.3.10.3 Intangible consequences are those that have no directly observable physical dimensions but exist in the minds, individually and collectively, of those affected. Such consequences are real and can support decisions. Intangible consequences identified in ANCOLD (2003) (reference A.80) include such things as:

5.3.10.3.1 The grief and loss suffered by relatives and friends of those who die;

5.3.10.3.2 The impact of multiple deaths on the psyche of the community in which they lived;

5.3.10.3.3 The stress involved in arranging alternative accommodations and income;

5.3.10.3.4 The sense of loss by those who enjoyed the natural landscape destroyed; and

5.3.10.3.5 The fear of lost status and reputation of the dam owning organization and its technical staff.

5.3.10.4 The effect of these intangible consequences can be observed more tangibly in terms of increased mental health expenditures and increased suicides.

5.4 Considerations in Risk Estimation for Risk Assessment and Risk Evaluation.

5.4.1 Assessing Ability to Reduce Uncertainty. The quantification of risk estimates is dependent on data and analysis regarding the design, construction, and current condition of a dam, as well as the identified loads to which the dam could be subjected to over its operating life. When making a decision regarding future actions, one should consider the risk estimates, the issues most influencing the risks, the sensitivity of the risks to particular inputs, the cost of additional actions, and the potential for reducing uncertainty. Uncertainty may be reduced by performing additional actions such as collecting more data, by performing more analysis, or by performing a more detailed analysis of the risks. However, there are occasions when additional efforts may not result in significant reduction in uncertainty. It is important to recognize when this is the

case and consider the anticipated value of the additional efforts to reduce uncertainty as a factor in selecting a course of action.

5.4.2 Risk Estimate Ranges (range of means) Straddling the Guidelines. When significant uncertainties or assumptions related to a lack of data or interpretations of data result in a range of risk estimates, the results may straddle the guideline values with portions of the risk estimates range portrayed both above and below the guidelines. In these cases, it is important for decision-makers to assess the portion of the risk estimate range that exceeds the guidelines to determine if it is significant enough to warrant further action or studies. The entire range should be used to assess the need for future actions as well as an aid in setting the priority for initiating the actions. If the range extends into the zone that justifies expedited risk reduction, studies to better define the risk should be the minimum response of the agency.

5.4.3 Risk Estimate With and Without Intervention. All risk estimates must give due consideration for intervention. The risk estimates for with and without intervention scenarios will be plotted on the tolerable risk guidelines. Further guidance is provided in Chapter 18 - Risk Assessment Methodology.

5.5 Example Presentations of USACE Tolerable Risk Guidelines. An example set of f-N data points are used in the figures below. Figure 5.6 illustrates the plotting of data using the annual probability of failure and ALL guidelines on the f-N chart. In addition the expected life loss is plotted versus sum of the APF for all failure modes and exposure scenarios are shown as a single data point on the chart. Figure 5.7 illustrates plotting the same f-N data pairs on the societal risk guideline F-N or probability distribution chart.

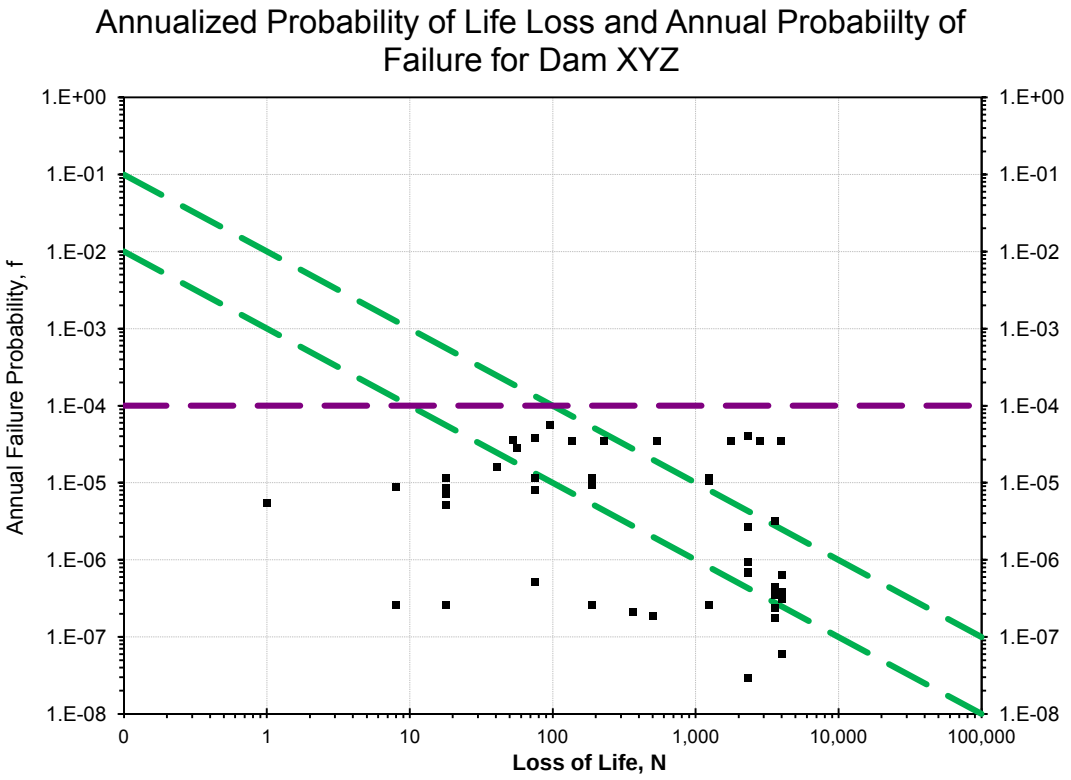


Figure 5.6 – Plot of f-N Data Pairs for Individual Failure Modes and Exposure Scenarios on the Annualized Life Loss and Annual Probability of Failure Tolerable Risk Guidelines Format

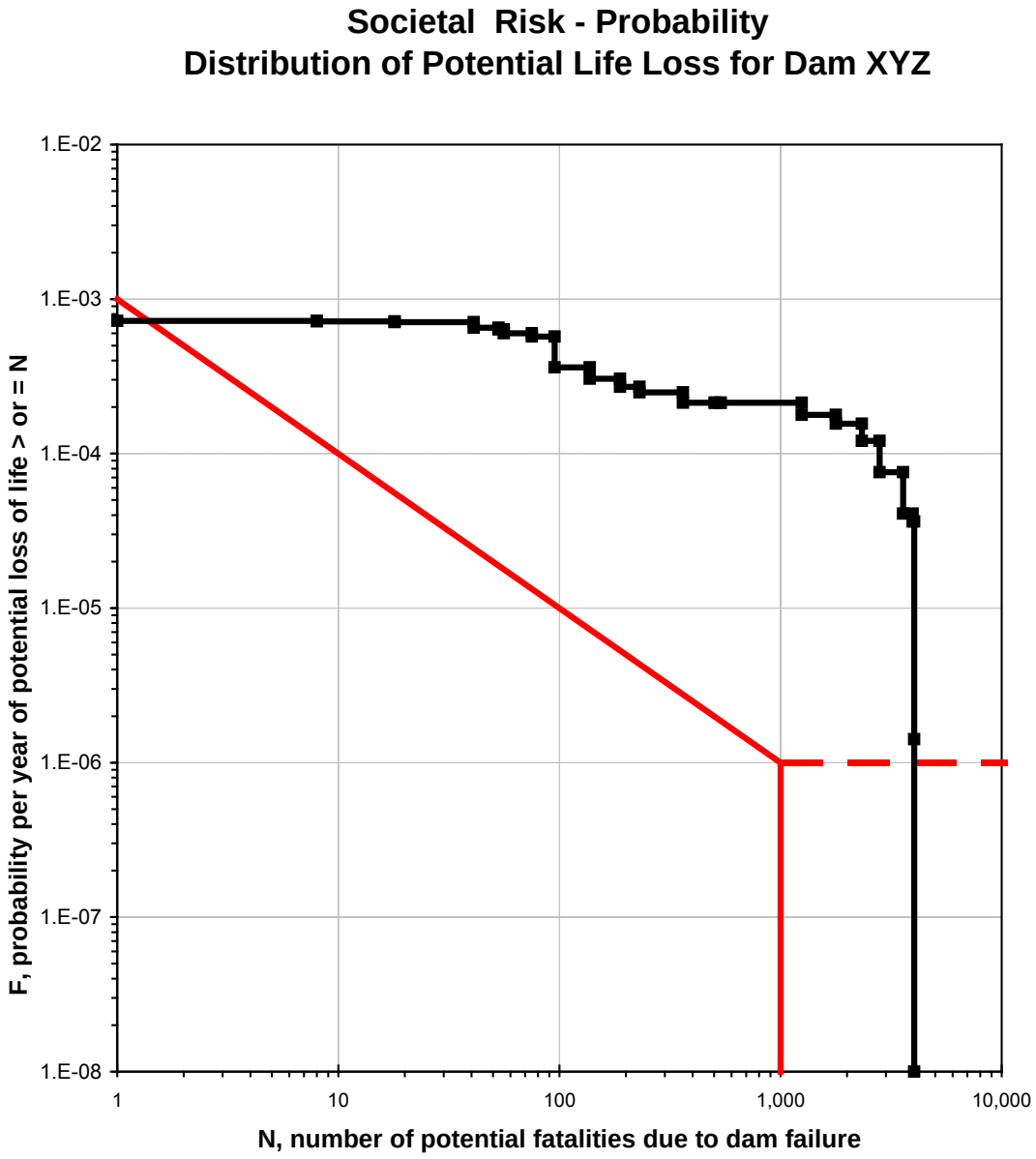


Figure 5.7 – Example Illustrating the Plotting of the Same f-N Data Pairs for Individual Failure Modes and Exposure Scenarios in a Probability Distribution of Potential Life Loss f-N Chart

This page left blank.

CHAPTER 6

Dam Safety Risk Management Prioritization

6.1 Purpose. This chapter provides guidance for the prioritization processes at the three primary prioritization queues in USACE Dam Safety Portfolio Risk Management Process shown in Figure 3.1. Each queue contains a subset of USACE dams that are waiting for funding to proceed to the next step in the Portfolio Risk Management Process. The queues are:

6.1.1 Prioritization of Issue Evaluation Studies (P1);

6.1.2 Prioritization of Dam Safety Modification Studies (P2); and

6.1.3 Prioritization of approved remediation projects awaiting engineering design and construction funding (P3).

6.2 Organizational Roles and Responsibilities in the Prioritization Process. The Dam Safety Risk Management Center, in coordination with the Senior Oversight Group (SOG), will assist the HQUSACE dam safety officer with the prioritization of Issue Evaluation Studies (IES) and Dam Safety Modification Studies (DSM), and the implementation of Risk Reduction action queues. The ultimate goal is to prioritize the national inventory, manage risks across the entire portfolio of structures, and reduce the overall portfolio risk as quickly as possible. The decision on priorities in these queues will be risk informed and done at the national level.

6.3 General Philosophy on Prioritization.

6.3.1 Clearance of Queues. While the intent is that the dams in the queues are eventually cleared in the priority order assigned, a more urgent issue may arise due to new information such as a dam safety incident or a significant change in that state of the art. This new information may introduce a dam into the queue and move it ahead of other dams in the queue. Thus, prioritization within the queues will be an iterative process with changes in priority being affected by other dams in the queue and the availability of new information.

6.3.2 DSAC Class, Priority, and Urgency.

6.3.2.1 DSAC I dams have been determined to have a confirmed urgent and compelling issue that requires taking immediate and expedited actions to reduce and manage the risk. Therefore, DSAC I dams will automatically be given first priority for DSM studies and will not require an issue evaluation study.

6.3.2.2 Dams will be prioritized within their DSAC class. For example not all DSAC II dams have the same priority.

6.3.2.3 Priority and urgency are different but should be compatible, thus higher priority dams are normally associated with the more urgent DSAC class dams.

6.3.2.4 With the exception of DSAC I dams, prioritization decisions for Issue Evaluation Studies (P1) and Dam Safety Modification Studies (P2) can have a significant impact on the speed and efficiency of risk reduction for the overall portfolio of USACE dams. Therefore, there may be times when a lower risk dam will be funded ahead of a dam with higher risk when it is demonstrated that this action will be a more effective and expeditious in reducing the overall portfolio risk.

6.3.3 Quantitative and Qualitative Factors. Significant weight will be given to the quantitative tolerable risk guidelines, but other non-quantitative considerations, including ALARP, will also be used to provide a more complete basis for prioritization of the queues.

6.3.3.1 Quantitative Factors.

6.3.3.1.1 The level of risk in relation to the tolerable risk limit. The greater the estimated annual probability of failure and the further the estimated life risk is above the tolerable risk limit the greater the urgency to act. The more cost-effective a risk management plan is in reducing the annual probability of failure and the life safety risk below the tolerable limit, the greater the justification to select that plan;

6.3.3.1.2 The disproportion between the sacrifice (money, time, trouble and effort) in implementing the risk reduction measures and the subsequent risk reduction achieved (the lower the ratio for a given measure that reduces the life safety risk below tolerable risk limits the greater justification to implement those risk reduction measures);

6.3.3.1.3 The cost-effectiveness of the risk reduction; (the project with lower overall cost for the same level of risk reduction would be given higher priority);

6.3.3.1.4 Net benefits achieved;

6.3.3.1.5 Any relevant recognized good practice (essential USACE guidelines) (risk reduction measures that satisfy all essential USACE guidelines would be given more weight than those that do not).

6.3.3.1.6 The magnitude or severity of the economic and environmental impacts.

6.3.3.2 Non-Monetary Considerations.

6.3.3.2.1 Societal concerns as revealed by consultation with the community and other stakeholders.

6.3.3.2.2 Impacts on any facilities critical to national security and well being,

6.3.3.2.3 The magnitude of impact on community, regional, or national well being.

6.3.3.3 For more detail, see the following sections of Chapter 5 - 'Economic Consequences' (5.3.9) and 'Environment and Other Non-Monetary Consequences' (5.3.10).

6.4 Prioritization Queues and Related Issues.

6.4.1 Issue Evaluation Studies Queue (P1).

6.4.1.1 Within the Issue Evaluation study queue are those projects awaiting approval to begin the Issue Evaluation study (Phase 1 IES) as well as those projects awaiting approval for an additional Phase 2 IES effort where supplemental information and study is needed for confirmation of issue(s) that have arisen from the Phase 1 Issue Evaluation Study. For some dams, no Phase 2 study will be needed and for others it is possible that more than one Phase 2 study may be needed. All of these studies will be prioritized for approval and funding based on the information obtained from risk assessments and tolerable risk limits evaluations performed as part of overall dam safety portfolio risk management process.

6.4.1.2 At any time during an Issue Evaluation study, if evidence is obtained that justifies an ‘urgent and compelling’ need for action, the dam should be promptly recommended for reclassification as a DSAC I and moved to the expedited process that is associated with a DSAC I dam.(See Figure 3.1)

6.4.1.3 Phase 1 IES are based on existing available information except for estimating consequences. Since the basis for continuing IES into Phase 2 is that dam safety issues are not confirmed with adequate confidence, it may be useful to perform sensitivity or bounding analysis on the risk analysis to explore the range of uncertainty in risk estimates and the comparison to the tolerable risk guidelines. The resulting range of risk estimate and associated risk evaluations may be useful in assigning priority to Phase 2 IES.

6.4.1.4 Information that shall be considered, if available, for use in prioritizing dams for IES includes:

6.4.1.4.1 Information developed in the Screening Portfolio Risk Analysis (SPRA);

6.4.1.4.2 Information from a Periodic Assessment (PA);

6.4.1.4.3 Evaluations performed as part of recommending Interim Risk Reduction Measures, and;

6.4.1.4.4 Evaluations against tolerable risk guidelines and USACE essential guidelines, inspection records, previous studies for prior project remediation, project

engineering documents prepared during design and construction, and other studies as may have been performed.

6.4.1.5 See Table 6.1 for a summary of P1 prioritization factors.

6.4.2 Dam Safety Modification Studies Queue (P2). Dam Safety Modification Studies (DSM) will be performed for all dams that do not satisfy the tolerable risk limits as determined by the issue evaluation study, unless the dam has been classified as a DSAC I dam. In general DSAC I dams, except those with low life risk, are given the highest priority for starting the DSM studies. DSAC I dams are prioritized based on available data such as the SPRA report, incident report, the External Peer Review report, and periodic assessment report (if available). DSM studies for the DSAC II, III and IV dams are prioritized based on information available from Issue Evaluation studies and periodic assessments. See Table 6.1 for a summary of P2 prioritization factors.

6.4.3 Prioritize Approved Projects for Funding Queue (P3). Approved dam safety risk reduction actions from the DSM studies are prioritized for Construction funding. The ultimate decision to fund implementation of the DSM study recommendation shall be based on the results of the DSM studies and the priorities of the USACE DSO considering all approved DSM reports. The decision on construction priority will be risk informed based on the magnitude and relative importance of the life, economic, and environmental risks and the cost-effectiveness of the proposed risk reduction measures for each dam in relationship to other dams of the same DSAC class. Estimates of the reduction in annual probability of failure, reduction in the estimated life safety risk, evaluations of risk reduction measures against tolerable risk guidelines, disproportionality ratio for the recommended risk reduction alternatives, and the cost effectiveness of risk reduction alternatives will be available from the DSM report. Staged risk reduction alternatives should be developed in DSM studies, where appropriate and practicable. These staged risk reduction alternatives will be used to assist the prioritization. See Table 6.1 for a summary of P3 prioritization factors. When funding is provided to implement the approved DSM report recommendations, the district will commence pre-construction engineering and design (PED) and construction once design is completed.

Table 6.1 Prioritization Factors

Prioritization Queue	What is being prioritized?	Prioritization Factors	RA and other information available for Prioritization
P1) Issue Evaluation Studies (IES)	Phase 1 IES to confirm a dam safety issue exists that warrants a DSM study	DSAC class SPRA evaluations and ratings if no PA or IRRM PFMA or risk assessment is available. From a PA use the APF for individual failure modes and total APF of all failure modes, individual life risk, and the societal life risk for the credible PFMs. Critical infrastructure, economic and environmental aspects of the estimated consequences and risk. Recommendations from the RA team	SPRA or PA, and IRRM plan. Possibly a PFMA performed in support of the IRRM plan.
	Phase 2 IES to confirm a dam safety issue exists that warrants a DSM study for any issues for which insufficient confidence exists after a Phase 1 IES or previous Phase 2 IES	DSAC class For the issue(s) being evaluated: the APF, individual life safety risk, and the societal life safety risk for the credible PFMs. Sensitivity analysis to identify the effect of current uncertainty on DSAC and risk evaluations. Critical infrastructure, economic and environmental aspects of the estimated consequences and risk. Recommendations from the RA team	Phase I IES risk assessment

Prioritization Queue	What is being prioritized?	Prioritization Factors	RA and other information available for Prioritization
P2) Dam Safety Modification (DSM) studies	Studies and other work required to support completion of a DSM report	DSAC class From the IES or PA report use the APF for individual failure modes and total APF of all failure modes, individual life safety risk, and the societal life safety risk for the credible PFMs. Consideration of the range of uncertainty in baseline risk estimates. Critical infrastructure, economic and environmental aspects of the estimated consequences and risk. Recommendations from the RA team	IES report PA risk assessment (if done) For a DSAC I dam - SPRA report, incident report, and other available information.
P3) Risk Reduction Projects	Funding of design and implementation of risk reduction measures	DSAC class Total and individual PFM estimated baseline risk showing APF, individual life safety risk, and societal life safety risk Magnitude of the reduction in and the residual total and individual PFM risk showing APF, individual life safety risk, and societal life safety risk Cost-effectiveness as measured by the Cost of a Statistical Life Saved. Disproportionality ratio Benefit cost ratio (BCR) Critical infrastructure, economic and environmental aspects of the estimated consequences and risk.	DSM study report

CHAPTER 7

Interim Risk Reduction Measures for Dam Safety

7.1 Purpose. This chapter provides guidance and procedures for developing and implementing Interim Risk Reduction Measures required for all DSAC I, II, and III dams based upon the USACE Dam Safety Action Classification Table 3.1 of Chapter 3, except for those dams as noted in paragraph 3.3.1 and referenced in Figure 3.1. Interim Risk Reduction Measures (IRRM) are developed, prepared, and implemented, to reduce the probability and consequences of catastrophic failure to the maximum extent that is reasonably practicable while long term remedial measures are pursued.

7.2 Principles for Implementing Interim Risk Reduction Measures at High Risk Dams.

7.2.1 Execution of Project Purposes. USACE executes its project purposes guided by its commitment and responsibility to public safety. In this context, it is not appropriate to refer to balancing or trading off public safety with other project benefits. Instead, it is after public safety principles are met that other purposes can be considered. Dam Safety Officers are the designated advisors and advocates for life safety decisions.

7.2.2 Do No Harm. The principle of ‘Do no harm’ should underpin all actions intended to reduce dam safety risk. Applying this principle will ensure that proposed IRRM implementation would not result in the dam safety being compromised at any point in time or during IRRM implementation.

7.2.3 Risk-Informed Decisions. Decisions should be risk-informed, not risk-based. Risk-informed decisions integrate traditional engineering analyses with numerical estimations of risk through the critical experience-based engineering judgment. We no longer refer to risk-based decisions because of the inappropriate implication that life safety decisions can be reduced to simple, numerical solutions.

7.2.4 Congressional Authorizations. USACE projects provide specific Congressional authorizations and legal responsibilities that often cover a broad array of purposes and objectives. The public safety responsibility is critical to informing how we implement these statutory responsibilities and requires USACE to assure projects are adequately safe from catastrophic failure has specific public safety responsibility, when a project has known safety issues, to take appropriate interim risk reduction measures including reservoir releases USACE statutory responsibilities require operation of dams in a manner that reduces the project's probabilities of failure when there are known issues with the integrity of the project.

7.2.5 Flood Risk Management. We manage risks of flood waters, we do not control them. Our projects do not have unlimited operational capacity to control extreme floods. Our outlet works have limited capacity to release flows in a controlled manner, and thus all properly designed projects have a capacity above which the inflow is passed through

without attenuation. These are very large releases that may cause damage downstream of the dam but not to a greater degree than would have occurred under pre-project conditions. Decision makers must understand these limitations and operational constraints.

7.2.6 Unique Projects Over Time. All projects have unique geographic, physical, social, and economic aspects that are subject to dynamics over time. Decision making within Interim Risk Reduction Measure Plans should consider these complexities and be modified as required over time.

7.2.7 Loss of Life Versus Economic Damages. The operations of a high risk (unsafe or conditionally unsafe) dam during flood conditions can create a conflict between the potential for loss of life and economic damages resulting from an uncontrolled release due to failure and associated economic damages resulting from operational release to prevent failure. Operational releases can be accompanied with planning, advanced warnings, and evacuations with the goal of avoiding loss of life. Economic impacts may be incurred and options for mitigating these impacts can be explored. The advanced planning and execution of mitigating measures is usually more effective with planned, controlled release of the pool than with the case of unplanned, uncontrolled release resulting from failure of the project.

7.2.8 Interim Risk Reduction Measure Plan. The Interim Risk Reduction Measure (IRRM) Plan, including changes to the supporting Water Control Plan, is the key document that frames operational decision making for DSAC I, II, and III dams. This plan establishes the specific threshold events, decision points, and actions required. The IRRM Plan should recognize the need for two primary water control management objectives.

7.2.8.1 A recommended safe operating reservoir level that is maintained for the vast majority of time through non damaging releases to restore the reservoir to restricted level as quickly as reasonable.

7.2.8.2 A plan for which emergency measures such as rapid reservoir drawdown and recommendations on evacuation of the reservoir storage must occur.

7.2.8.3 This approach to water control management recognizes that pool restrictions established for safety purposes cannot and should not be viewed as “must meet” requirements in all flood events, but that there does come a point when emergency measures are necessary.

7.2.9 Centrally Led – Decentrally Executed Program. In the centrally led and decentrally executed USACE Dam Safety Program, responsibilities and decision making for Interim Risk Reduction Measures are vertically distributed.

7.2.9.1 Districts. Develop IRRM Plans, coordinate plans, and execute all plans.

7.2.9.2 Divisions. Coordinate, review, and approve plans for DSAC I, II and III dams. In particular, divisions are critical in assuring system and watershed issues are considered and coordinated.

7.2.9.3 HQS. Establishes, in consultation with the RMC, the DSAC class for all dams, reviews and concurs on IRRM Plans for DSAC class I and II dams, and aligns investment strategies for all unsafe dams.

7.2.10 Risk Communications. Familiarity with IRRM Plan is the key to effective risk communications. It is important that managers and leaders discuss issues consistently and openly with affected stakeholders.

7.3 General. IRRMs shall be established for DSAC I, II and III dams. The DSAC Table (Table 3.1) provides the characteristics and actions for each DSAC, including preparation of an Interim Risk Reduction Measures Plan (IRRMP), considerations for preparation of the plan, and example interim measures. All dams are unique and have specific vulnerabilities and potential failure modes that require expert judgment in the development of the IRRM plans. Interim Risk Reduction Measures are a temporary approach to reduce Dam Safety risks while long-term solutions are being pursued. However, they should not (unless otherwise approved) take the place of long-term approaches. Guidelines for determining if the planned interim risk reduction measure is an interim or a more permanent measure are explained in Section 7.8. In establishing IRRM, the prevention of loss of life is the first and foremost objective, followed by prevention of catastrophic economic or environmental losses. The process of identifying and evaluating IRRM shall be conducted as expeditiously as possible and shall be a collaborative effort between all district elements as well as technical experts within the MSC, RMC, and HQUSACE. The dialogue and coordination between district technical elements, Operations, and Programs is particularly important. After initial assessment within USACE, early involvement with the project stakeholders (e.g., project sponsors, project beneficiaries, local emergency response agencies, power marketing agencies, etc.) will be established with the goal of coordinating support for the IRRM. The public trust must be established through frequent and early interaction and maintained through an effective Communication Plan. A risk assessment may be required as part of the IRRM plan to justify significant restrictions in project storage and release regulation schedules. Pool restrictions should not be held up or delayed waiting for this risk assessment.

7.4 Funding for IRRMP and IRRM. Funding for IRRMP preparation for DSAC I, DSAC II and DSAC III dams is from the O&M account (or the Maintenance portion of the MR&T account). Funding for IRRMP implementation for DSAC I, DSAC II and DSAC III dams is from the O&M account. Studies and planning leading to a Dam Safety Modification Report are funded from the Construction account as part of the Dam Safety Assurance and Seepage/Stability Correction Program. For example, Program funds can be used for inundation maps since that will provide information to advance the Dam Safety Modification study. Design and implementation of permanent risk reduction measures described in the Dam Safety Modification Report are funded from the Construction

account, beginning with the Dam Safety Assurance and Seepage/Stability Correction Program until line-item Construction funds become available. For the O&M account, the work category code (WCC) for IRRMP and IRRM is 61130 for navigation, 61230 for flood damage reduction, and 61630 for joint activities. While these budgeted items will be fully coordinated with program management and operations funding personnel, it is the job of the technical team to make sound, reasonable recommendations on the correct IRRMs and implementation schedules without making compromises due to perceived funding shortfalls. While funding challenges are often a reality, dealing with them is a secondary action that comes only after reaching agreement on the right technical course of action. For the Construction account, use category class subclass code (CCS) 240, 540, or 640 based on the type project. Construction funds will not be used for maintenance repairs, IRRMP, or IRRM. O&M funds will not be used for the Dam Safety Modification study or implementation. The Mapping, Modeling, and Consequence Production Center (MMC) has overall responsibility for developing dam failure, inundation mapping, and consequence models for USACE dams in support of the IRRMP. Districts must seek O&M funds, through the budget process and/or reprogramming, for IRRMP and IRRM. HQUSACE will seek Construction funds for the Dam Safety Assurance and Seepage/Stability Correction Program and will allocate Program funds among projects for Issue Evaluation Studies and Dam Safety Modification work.

7.5 Interim Risk Reduction Measures Plan (IRRMP). Districts with DSAC I, II, and III dams shall develop and submit to the MSC Dam Safety Officer (MSC DSO an IRRMP outlining the proposed risk reduction measures for approval. IRRMP's for DSAC I dams shall be submitted within a 60-day period after being designated as DSAC I , or within 90 days after being designated as a DSAC II, or within 120 days after being designated as a DSAC III. Prior to submission of the IRRMP, the plan shall be subjected to a district Quality Control Review (DQC) with Regional Technical Specialists, or other appropriate specialists. NEPA coordination should be started early in the IRRMP process and be continued to avoid later problems (See Appendix M). Stakeholders should also be engaged in developing the plan to the extent possible. Submission of the IRRMP shall include a formal briefing to the HQ DSO for DSAC I, II and III dams if requested. The IRRMP should as a minimum include the following:

7.5.1 Overall project description, brief construction history, operational history, and purposes.

7.5.2 Overview of identified potential failure modes.

7.5.3 General consequences associated with each identified potential failure mode.

7.5.4 Structural and nonstructural IRRM alternatives considered to reduce the probability of failure and/or consequences associated with the failure modes (reservoir pool restrictions, modification of reservoir regulation plan and updating of EAPs must always be included as an option that is addressed).

7.5.5 General discussion of predicted reduction in the probability of failure and associated consequences, impact on project purposes, environmental impacts, and economic impact to region associated with potential IRRM, both positive and negative.

7.5.6 Recommendations and risk informed justification for IRRM to be implemented.

7.5.7 Schedules and costs to the USACE and others for implementation of IRRM recommendations.

7.5.8 If necessary, proposed cost and schedules for conducting a risk assessment to estimate the benefits and costs for incremental evaluation of IRRM. Risk may justify significant restrictions in project storage and release schedules. Pool restrictions should not be held up or delayed waiting for this risk assessment.

7.5.9 DQC comments and comment resolutions.

7.5.10 Hyperlink to electronic version of current EAP which reflects site specific risks, and which includes emergency exercises for DSAC I, II, and III dams conducted in manners that are appropriate for the risk involved (See paragraph 7.6 for more information on the appropriate level of emergency response exercise).

7.5.11 Communication Plan (Internal and External).

7.6 EAP and Emergency Exercises. The frequency of emergency exercises should correspond directly to the Dam Safety Action Classification (DSAC) rating and hazard potential of the project. The completion of these exercises should be incorporated into the official Interim Risk Reduction Measures Plan for the project if applicable. Refer to Chapter 16 for guidance on the appropriate type and frequency of exercises.

7.7 Decision Process for USACE Dam Safety Interim Risk Reduction Actions. The decision process associated with Dam Safety-related actions will depend on the nature of the action under consideration, the consequences of the action in both the short and long term, and the potential for national and international interest and attention. The decisions will be made based on life safety first, economic risk second, and other considerations last.

7.7.1 Long-term life-safety tolerable risk guidelines should be met by IRRMs wherever available non-structural and appropriate structural options exist to do so. Because life safety is paramount, this implies that the economic and other impacts of IRRMs will not influence meeting long-term life-safety tolerable risk guidelines except in exceptional circumstances. The life safety tolerable risk guideline is intended to influence only the speed with which IRRMs are developed and implemented and not to be a lower level of public safety for short- and medium-term exposure to dam safety risks. See Chapter 5 for more information on tolerable risk guidelines.

7.7.2 Fundamentally, decisions within USACE are the responsibility of the district Commander. Technical decisions related to Dam Safety are generally delegated to the district Dam Safety Officer (DSO). IRRMP and associated decisions require MSC approval and require HQ USACE concurrence; and there are certain USACE actions that are executed by warranted officials, such as procurement, that function outside the usual Commander's chain.

7.7.3 In the Dam Safety area, the principal team members involved in the decision process are the district Dam Safety Officer and Dam Safety Program Manager, the MSC Dam Safety Officer and Dam Safety Program Manager, and at the HQ USACE level, the USACE Dam Safety Officer, the Special Assistant for Dam Safety, and the Dam Safety Program Manager (DSPM). These principals inform and at times execute decisions on behalf of the Commanders in whom the decision authority is vested.

7.7.4 For non-controversial Dam Safety-related actions, following routine review within the local district, MSC, and Headquarters Dam Safety staff, the decision by the district Dam Safety Officer, acting on behalf of the Commander, would be expected. As the level of controversy and potential consequences and attention escalates, a more thorough review would progressively include Commanders at the District, MSC, and HQ USACE levels, perhaps informed by outside experts, and engaging Public Affairs officers. The decision may then be retained by the district Commander and in the case of highly significant dam safety problems, the MSC Commander. While the decision authority lies with the Commanders, the process leading to the final choice for action is informed by technical, policy, and management staff at the district, MSC, and HQ USACE levels.

7.7.5 Table 7.1 depicts a summary of the principal participants in the decisions involving IRRMP formulating, informing and reviewing, and final solution selection and implementation. An electronic copy of the IRRMP (review copy) shall be uploaded to the Risk Management Center's centralized data repository at the time of review copy submittal. A copy of the final IRRMP reflecting all updates and revisions required from the review process shall be uploaded after IRRMP approval.

Table 7.1
Decision Levels for Interim Risk Reduction Actions

DSAC	District	MSC	HQ USACE
I, II, and III (including significant changes)	Formulate, recommend, and implement	Concurrent Review Followed by MSC Approval	
I and II (Annual Review)	Annual Review and update required.	Annual Review	No action required.

7.7.6 An annual review of all DSAC I and II IRRMP's is required unless some event occurs that would trigger an earlier review, e.g., rise in piezometers readings, completion of a remediation phase, etc.

7.7.7 A standard IRRMP review checklist is provided in Appendix N to assist developers and reviewers in the completion of approvable plans.

7.8 Interim Risk Reduction Measures (IRRM).

7.8.1 Types of IRRM that should be considered include, but are not limited to, the items listed below. Practical options will vary from dam to dam, and therefore a creative effort may be needed to identify the options that exist for a specific project. The imperative objective is to reduce the probability of catastrophic failure and associated consequences to the maximum extent reasonably practicable while long-term remedial measures are pursued. IRRMP must be developed on an aggressive timeline to reduce the probability of failure or potential for loss of life once a major dam safety issue is identified. IRRMPs are mandatory for DSAC I, II, and III dams. IRRMP development timeline guidance outlining development, review, and implementation requirements is detailed in Table M.1 in Appendix M. Seepage and internal erosion have been identified as the primary failure mode governing risk for the USACE' dam inventory. Seepage and internal erosion can be a lengthy failure continuum (progressive failure) which may lead to catastrophic loss of pool with little or no warning. An example of a seepage failure development continuum is shown in Figure O.1 in Appendix O. As such, expert judgment is required to match IRRM with the identified potential failure modes, geology, dam design and loading, and determination of where the dam is on a failure line continuum.

7.8.2 Interim risk reduction measures are not intended to be the process for permanently remediating dam safety concerns. The following principles (and associated questions) can be used to determine if a proposed interim risk reduction measure is appropriate.

7.8.2.1 Timely. Will the measure be implemented in a timely manner to reduce risk? Taking several years to implement a measure may mean it is not an interim risk reduction measure. Efforts that require significant investment in time and money for studies and investigations should most likely be included in the Dam Safety Modification Study as a potential alternative.

7.8.2.2 Cost. Is the cost of the measure within budgetary threshold for major maintenance or O&M as outlined in the current budget EC? Measures exceeding the threshold for major rehabilitation modifications are generally not appropriate for interim risk reduction measures.

7.8.2.3 No New Risk. Does the measure increase the overall risk from the dam to the downstream public? This may be a concern for measures that involve changes to

the current approved water control plan and may require a risk estimate to be developed to adequately assess the proposed changes.

7.8.2.4 Emergency Actions. An action done during a response to a dam safety emergency is not an interim risk reduction measure.

7.8.3 Examples of non-structural Interim Risk Reduction Measures.

7.8.3.1 Reservoir pool restrictions or change in water control plan the district should begin immediate action to update the water control plan to reflect the operational change or pool restriction.

7.8.3.1.1 Guidance is provided in ER 1110-2-240, Water Control Management (Reference A.49) for water control plan deviations and updates. In the interim a deviation from the current water control plan should be implemented until the water control plan is updated to reflect the operational change or pool restriction. Regulation plan changes must be documented, and formal deviation requests from the Water Control Plan must be approved by the MSC.

7.8.3.1.2 Annual command level reviews of IRRM implementation are required for DSAC I, II, and III dams and revision to the IRRM plan are to be made as necessary. These reviews should also include review of the communication plans with stakeholder engagement and public involvement plans.

7.8.3.2 Pre-position emergency contracts for rapid supply of other needed items/equipment.

7.8.3.3 Stockpiling emergency materials, e.g., rock, sand, sand bags, emergency bulkheads, or other operating equipment, etc.

7.8.3.4 Use of other reservoirs in the system may be required to mitigate the impact of regulation schedule changes. If the change in regulation schedule is required for other dams in the system, then a regulation deviation for those dams would be required as well.

7.8.3.5 Improved and/or increased inspection and monitoring to detect evidence of worsening conditions to provide an earlier warning to the public for evacuation.

7.8.3.6 Update the Emergency Action Plan and the inundation mapping to include project-specific failure mode(s). The NWS must be included in the EAP to take advantage of their television/radio announcement and stream forecasting capabilities. The Modeling, Mapping, and Consequence Production Center (MMC) has overall responsibility for developing dam failure, inundation mapping, and consequence models for USACE dams in support of the EAP.

7.8.3.7 Explicit procedures, communications systems, and training of appropriately skilled team members for prompt and effective emergency response by the USACE in the event of the detection of worsening or catastrophic conditions. Refer to Chapter 16 for guidance on the appropriate type and frequency of exercises.

7.8.3.8 Conduct appropriate emergency exercises that plan for a range of failure scenarios (including the combined effects of multiple failure modes and different timing of detection) to improve warning and evacuation times.

7.8.3.9 Coordination with local interests and Federal and non-Federal agencies, including the National Weather Service (NWS) and local Emergency Management Agencies (EMA), with a focus on the specific failure mode(s) and the effectiveness of response including appropriate response exercises.

7.8.3.10 Identify instrumentation/monitoring “trigger” or threshold pools that would initiate more urgent monitoring or emergency response. In addition, threshold values should be established for instrument readings where possible.

7.8.3.11 Installation of early warning systems to increase evacuation percentage and time.

7.8.3.12 Preventive maintenance and repairs such as cleaning drains and improving spillway gate reliability where non-functioning components would exacerbate the existing conditions in an emergency.

7.8.3.13 Acquisition of real estate (if possible) that would preclude damages and potential loss of life from a potential dam failure or other IRRM.

7.8.4 Examples of Structural Interim Risk Reduction Measures (Some Can be Incorporated in Long Term Remedial Measures).

7.8.4.1 Isolate problem area (e.g., cofferdam around problem monolith(s) or other project feature).

7.8.4.2 Improve seepage collection system.

7.8.4.3 Lower the spillway crest to aid in prevention of failure (A consequence estimate may be warranted to ensure overall risk is not increased by this measure).

7.8.4.4 Increase spillway capacity/construct another spillway. (A consequence estimate may be warranted to ensure overall risk is not increased by this measure).

7.8.4.5 Breach/lower saddle dams along the reservoir perimeter. (A consequence estimate may be warranted to ensure overall risk is not increased by this measure).

7.8.4.6 Strengthen weak areas (e.g., upstream or downstream blanket to cut off/slow seepage; install tie-backs/anchors; and install additional buttresses).

7.8.4.7 Construct a downstream dike to reduce head differential.

7.8.4.8 Construct stability berm.

7.8.4.9 Increase dam height. (A consequence estimate may be warranted to ensure overall risk is not increased by this measure).

7.8.4.10 Modify outlet discharge capability such as by installing temporary siphon(s).

7.8.4.11 Increase erosion protection where necessary.

7.8.4.12 Protect downstream critical facilities (e.g., medical and emergency services).

7.8.4.13 Construct shallow cutoff trench to slow seepage.

7.8.4.14 Target grout program specifically for suspected problem area(s) to slow seepage.

7.8.4.15 Remove significant flow restrictions (downstream bridge conditions may restrict maximum discharge from the outlet works. Upstream bridges or small dams may restrict flow caused by debris buildup that could result in a large release).

7.8.5 Contrasting Interim Measures with Permanent Measures. The above examples of IRRMs are a good guide for how interim measures differ from permanent measures; however, there are always situations for which judgment must be used in determining what measures are appropriate. Following are principles for making such distinctions:

7.8.5.1 Interim measures should not induce additional risks beyond what the dam safety deficiency present;

7.8.5.2 Interim measures should be timely (i.e. implemented within 6 months or less);

7.8.5.3 Some interim measures – whether structural or non-structural - may become permanent based on the recommendations of an Issue Evaluation Study or Modification Report;

7.8.5.4 Interim measures are funded out of the operations and maintenance account and are subject to the dollar limitations for O&M described in the Major Rehabilitation guidance; and

7.8.5.5 Emergency measures may exceed the dollar and scope limitations established for the O&M account.

7.9 Evaluation Factors for IRRM. Some types of IRRM may significantly impact authorized project purposes (e.g., water supply, recreation, hydropower, etc), project beneficiaries, and others who depend indirectly on the project. Additionally, some IRRM may result in more frequent discharges from the dam and from lower pool elevations than originally designed, impacting stakeholder interests. Public safety must always be given a higher priority over all other project purposes and benefits. In evaluating and formulating IRRM, it must be kept in mind that each project has its own unique attributes that have to be addressed on a case by case basis using expert judgment. The following shall be considered and addressed:

7.9.1 Providing protection of life, property and the environment. Examples to consider are loss of life; increased sickness and disease; employment losses; business income losses; private property damage; infrastructure damage including roads and utilities; losses in social and cultural resources including community effects and historical resources; environmental losses including aquatic and riparian habitat, threatened and endangered species; and HTRW (such as flooding a Superfund site). Early and frequent NEPA coordination with IRRMP is recommended.

7.9.2 Reducing the probability of failure and consequences of uncontrolled pool releases. Increasing the confidence that any changes associated with the dam that are related to development of a failure mode will be promptly detected.

7.9.3 Increasing the confidence that emergency management agencies will be notified promptly.

7.9.4 Increasing the warning time and effectiveness of evacuation of the populations at risk.

7.9.5 Reducing the probability of the initiating loading (critical pool levels).

7.9.6 Improving the organizational capability to implement IRRM (resources, time, funding, technology, etc.).

7.9.7 Preserving the public trust.

7.9.8 Addressing stakeholder issues and impacts.

7.9.9 Understanding the degree of confidence in the scope of the problem and effectiveness of the interim solution.

7.9.10 Capability for incorporating IRRM into the permanent solutions.

7.9.11 Impacting authorized project purposes or other project benefits.

7.9.12 Maximizing cost effectiveness.

7.9.13 Minimizing social disruption and environmental impacts.

7.10 Communications Plan. A communication plan is to be submitted for review as part of the Interim Risk Reduction Measures Plan. Information about the communication plan is in Chapter 10 of this document.

7.11 Approval and Implementation of IRRMP. Approval of the IRRMP for DSAC I, II, and III dams shall be by the MSC DSO with concurrent review by HQUSACE (see Table 7.1). If significant changes are made to a previously approved IRRMP, the revised plan is to be submitted for review and approval as a new plan.

CHAPTER 8

Issue Evaluation Studies

8.1 Purpose of Issue Evaluation Studies (IES).

8.1.1 This chapter provides guidance and procedures for developing the IES report that presents the risk assessment, documentation, and justification for conducting a Dam Safety Modification study at completed USACE projects. In addition, this chapter provides guidance for completing Issue Evaluation Study plans, Issue Evaluation studies, and Issue Evaluation Study reports. Figure 8.1 is a graphical representation that shows the work flow process for Issue Evaluation Studies. Figure 8.2 shows how the Issue Evaluation Study and Periodic Assessments fit into the overall portfolio risk management process for dam safety.

8.1.2 Issue Evaluation Studies for dams rated as DSAC II, III and, IV are studies to determine the nature of a safety issue or concern, and the degree of urgency for action within the context of the entire USACE inventory of dams. The purpose of an Issue Evaluation Study (IES) is to focus on significant potential failure modes when evaluating risk, verify the current DSAC rating, guide the selection and gauge the effectiveness of interim risk reduction measures, and justify the need to pursue or not pursue Dam Safety Modification studies. Issue Evaluation Study results are used to assist dam safety officials with making risk informed decisions, and prioritize dam safety studies and investigations within the context of the entire USACE inventory of dams.

8.2 Objectives of Issue Evaluation Studies**.** The overall objective of an IES is to evaluate a dam safety issue found during an incident, inspection, or study, in relation to the USACE tolerable risk guidelines and determine if the issue justifies further actions either through interim measures, formal study, or both. The scope of the issue evaluation study is to evaluate both confirmed and unconfirmed issues related to the performance, maintenance, and operational concerns of the dam.

8.2.1 Confirmed Dam Safety Issues. Confirmed issues are those that pose a significant risk (approaching or exceeding tolerable risk limits) with a high level of confidence (due regard for uncertainty) such that additional studies and investigations are not likely to change the decision that dam safety modifications are justified. Confirmed dam safety issues are manifested or obvious issues that impact the safe operation of a dam. Examples of confirmed issues can be described as performance concerns, such as a lack of spillway capacity, or deficiencies that are demonstrated by signs of seepage and piping, known flaws or defects, component distress or malfunction, unusual settlement, unsatisfactory instrument readings, etc. that can be specifically linked to one or more potential failure modes. Confirmed dam safety issues are typically addressed in Phase I Issue Evaluation Studies, where there is sufficient performance data and documentation to prepare a risk estimate that contains minimum uncertainty and provides an adequate level of confidence that a Dam Safety Modification Study is warranted.

8.2.2 Unconfirmed Dam Safety Issues. Unconfirmed issues are issues that are judged to pose a high probability of unsatisfactory performance, but are based on data with such high uncertainty that the conclusions may be significantly influenced or changed if additional data was obtained. Examples of unconfirmed dam safety issues can be described as performance concerns where the contributing factors are unclear due to limited or outdated design documentation, or subtle changes in performance that cannot be visually inspected or obviously linked to a potential failure mode. In these cases, additional studies, investigations, and analysis may be needed to clearly identify the potential failure mode, or more accurately predict the system response probabilities of the potential failure mode causing the concern. Unconfirmed issues are typically addressed in Phase 2 Issue Evaluation Studies where additional funding and time is justified to further investigate the dam safety issue prior to finalizing the risk estimate.

8.2.3 Scope of Issue Evaluation Studies. The scope and level of rigor required for a Issue Evaluation Study will be based upon the complexity of the dam safety issue, and the ability to evaluate these issues and potential failure modes using existing data, analyses, and performance history. As the risk management process develops over time, a baseline risk estimate will be prepared for every dam in the portfolio either through a Periodic Assessment, or through other risk informed studies. For projects where a baseline risk estimate has been prepared during a previous Periodic Assessment or other risk informed study, the risk estimate should be updated to address the current issue or concern. For projects where a baseline risk estimate has not been performed, an initial risk estimate for issue evaluation will be prepared to determine if the issues of concern approach or exceed the tolerable risk limits.

8.2.4 Based on the results of an Issue Evaluation Study, the following actions can be taken:

8.2.4.1 Confirm that dam safety issues do or do not exist;

8.2.4.2 Verify or reclassify the current DSAC rating based on these findings;

8.2.4.3 Determine if a dam should be reclassified as DSAC I and thus warrants the expedited process for a DSAC I dam as shown on the left side of Figure 8.2;

8.2.4.4 Gauge the effectiveness, and guide the selection, of current and additional risk reduction measures;

8.2.4.5 Use the Issue Evaluation Study results to develop effective risk management plans, identify data deficiencies, develop study plans, and prioritize dam safety modification studies; and

8.2.4.6 Determine if there is justification (or not) to proceed to a Dam Safety Modification study.

8.3 Issue Evaluation Study Plan. The Issue Evaluation Study Plan shall include, at a minimum, the following sections:

8.3.1 Overall project description and purposes;

8.3.2 Overview of the previous findings and reason(s) for the current DSAC rating;

8.3.3 Description of the specific dam safety issues of concern, and how these dam safety issues were identified. Include narrative that explains if these issues are a result of identified defects, flaws, or unsatisfactory performance, or if these are unconfirmed dam safety issues that require additional data, analysis or site investigations to confirm the dam safety issue does or does not exist;

8.3.4 Description of the interim risk reduction measures that were implemented as a result of previous risk estimates and PFMA;

8.3.5 A listing of all PFMA reports or risk estimates that have been performed for the project to date, the names of the lead facilitator and lead risk estimator who completed these efforts, and the dates they were completed. This would include reference to prior PFMA's conducted by the district for the development of IRRMP's, Issue Evaluation studies, Periodic Assessments, etc.;

8.3.6 A description of the proposed work plan/scope of work and funding estimate for the district to complete the Issue Evaluation Study. The district will coordinated with the RMC and obtain RMC concurrence of the scope of work prior to the development of the plan. The will help the district develop the scope of work and deliverables for each IES plan. The plan should then be submitted for review and approval.

8.3.7 A listing of the proposed key district team members and disciplines who will participate in the proposed PFMA and Issue Evaluation Study, the district team lead engineer who will be responsible for preparing the issue evaluation report, and a listing of the specialties required to be part of the ATR team.

8.3.8 Phase 1 study plan examples from other USACE projects are available upon request by contacting the Risk Management Center.

8.4 Funding for Issue Evaluation Study Plans. The preparation of Issue Evaluation study plans will be funded from Dam Safety Assurance, Seepage/Stability Correction Program (“Wedge Funds”). The 5 to 7 page Issue Evaluation Study plan will be used to ensure the scope and cost of the proposed study is appropriate, and will act as the official requesting document that enters the project into the dam safety program funding queue for Issue Evaluation Studies.

8.5 Schedules for Submittal of Issue Evaluation Study Plans. Preparation of Issue Evaluation Study plans for DSAC II, III, & IV dams shall begin when the project receives a priority rating and the district is notified by the RMC/HQUSACE to proceed with

preparation of the IES Study plan. The plan study plan shall be submitted to the MSC DSO within 60 days after such notification.

8.6 Approval Authority. Issue Evaluation Study Plans for Phase 1 and addendums to Phase 1 plans for Phase 2 studies shall be prepared by the district and approved by the district's dam safety officer. The study plan will contain a District Quality Control plan as per EC 1165-2-209 (reference A.5). The need for Phase 2 studies will be determined by the vertical team based on findings documented in the IES draft report. The execution strategy for incremental Phase 2 efforts must be formulated during a collaborative meeting between the risk assessment cadre and district to assure that the district obtains the information required to complete the risk estimate with the minimal expenditure of time and resources. Due to the complexity of work efforts and funding required for Phase 2 efforts, Phase 2 work scope must be approved by the Risk Management Center, and the funding request will require budgetary approval for Wedge Funds from the HQUSACE Dam Safety Program Manager. Table 8.1 depicts a summary of the principal participants in the decisions involving the development, review, and approval of study plans.

Table 8.1 Issue Evaluation Study Plan - Review & Approval Requirements

<table>
<tr><th>Study Phase</th><th>DSAC II, III, & IV</th><th>District</th><th>MSC</th><th>RMC</th><th>HQ-DSO</th></tr>
<tr><td rowspan="2">Issue Evaluation Study Plan</td><td rowspan="2">Phase 1</td><td>Study Plan Approval by DSO</td><td>Concurrent Quality Assurance Review</td><td>Concurrent Risk Cadre Review</td><td>Concurrent Policy & Compliance Review</td></tr>
<tr><td colspan="3">District will coordinate with the RMC and obtain RMC concurrence on the scope of work prior to development of the study plan.</td><td></td></tr>
<tr><td rowspan="2">Issue Evaluation Study Plan</td><td rowspan="2">Phase 2</td><td>Addendum to Study Plan Approval by DSO</td><td>Concurrent Quality Assurance Review</td><td>Concurrent Risk Cadre Review

Approval of Work Scope</td><td rowspan="2">Concurrent Policy & Compliance Review

HQ DSPM Budgetary Approval</td></tr>
<tr><td colspan="3">Collaborative meeting with Risk Assessment Cadre, and joint approval of work scope with RMC is required for incremental Phase 2 efforts</td></tr>
</table>

8.7 Submittal Requirements. Issue Evaluation Study plans shall be submitted electronically to the MSC DSO, HQ USACE DSPM, and the Dam Safety Risk Management Center. An electronic copy of the study plan (review copy) shall be uploaded to the Risk Management Center's centralized data repository site (RADS II) at the time of hard copy submittal. A copy of the final study plan reflecting all updates and revisions shall be uploaded after approval.

8.8 Issue Evaluation Studies - Phase 1.

8.8.1 Risk Estimates. Risk estimates in support of the Issue Evaluation Studies (IES) are conducted to determine if the total project risk approaches or exceeds the Corp's tolerable risk limits, and if Dam Safety Modification (DSM) studies are justified. Phase 1 efforts utilize existing data and information. The risk estimate resulting from an issue evaluation study is used to verify or reclassify the current DSAC, guide the selection and gauge the effectiveness of interim risk reduction measure requirements, and provide information to support prioritization of Dam Safety Modification Studies from a national portfolio level.

8.8.2 Scope of Risk Estimates. The scope of the risk estimate must be more rigorous than the level of detail executed in SPRA estimates, may be more or less rigorous than a Periodic Assessment, and is intended to achieve a defensible, risk informed justification for initiating Dam Safety Modification Studies. Typically, risk estimates for confirmed issues can be established with existing data and performance history because the physical manifestations are visual and measurable. Unconfirmed issues may require the collection of additional data if the missing data required to assess performance is not available or cannot be linked to a specific failure mode or observation.

8.8.3 Data for Risk Estimates. For dams with no baseline risk estimate (see Chapter 3) the IES risk estimate should be conducted using existing data and should include as many significant failure modes as are necessary to determine that the estimated risk justifies going on to a DSM study. For dams where a previous risk estimate has been calculated from a Periodic Assessment or other dam safety study, the potential failure modes should be reviewed, and the risk estimate should be updated based on any changes in condition or new information that may have become available since the last risk estimate was performed.

8.8.4 Finding of Urgent and Compelling. At anytime during the conduct of an Issue Evaluation Study, if a finding of major concern or evidence is identified requiring an ‘urgent and compelling’ need for action, such as if the dam is judged to be in the failure continuum, the project should immediately be moved to the expedited process as outlined in Chapter 9, Dam Safety Modification Studies and Documentation.

8.8.5 Minimum Phase 1 Study Tasks. As a minimum, the following tasks must be performed to develop a risk estimate for Phase 1 Issue Evaluation Studies:

8.8.5.1 Perform a facilitated Potential Failure Mode Analysis.

8.8.5.2 Evaluate potential failure modes, using existing information and data, based on the collective knowledge and expertise of the facilitator, risk assessment cadres, regional technical specialists, district dam safety engineers, and the project staff. Potential failure modes that cannot be confirmed without additional analysis or investigations should be identified and documented.

8.8.5.3 For all potential failure modes that pose significant risk to the project, identify the initiators, the failure progression mechanisms, and the resulting impacts.

8.8.5.4 Estimate load-frequency and load-response probabilities for a full range of pools using the best available methodology and risk tools

8.8.5.5 Utilize consequence estimates provided by the Modeling, Mapping, and Consequence Production Center (MMC).

8.8.5.6 Prepare a risk estimate for issue evaluation (that typically addresses four or five significant failure modes), and determine if the issues of concern approach or exceed the tolerable risk limits.

8.8.6 Dam Safety Risk Assessment Tools. Corps of Engineers Dam Safety Risk Assessment Tools along with Expert Elicitation can be used to calculate load-frequency and load-response probabilities for all potential failure modes included in the risk estimate. The Risk Management Center will provide guidance on selection of the most appropriate risk estimating tools and methodologies to be employed, prior to the start of the Issue Evaluation Study.

8.9 Issue Evaluation Studies - Phase 2.

8.9.1 Additional Study. When existing data and design documentation is either unavailable or insufficient to reduce the uncertainties in the computation of load-response probabilities and resulting risk estimate, parametric (sensitivity) studies should be conducted to determine what influence the data has on the load-response probabilities and resulting risk computations. The need for additional information, studies and investigations to resolve uncertainty should be determined after the parametric studies are completed and insight is gained as to what improvements in the confidence of the risk estimate can be gained from the additional expenditure of time and resources.

8.9.2 Phase 2 Justifications. Phase 2 efforts should be considered when there is a lack of confidence in the ability to make a decision regarding whether to proceed to a DSM study. Phase 2 studies are justified when it can be clearly demonstrated that additional reductions in uncertainty or a greater level of confidence can be achieved in the IES risk estimate from the additional time, resources, investigations, and analyses that are proposed. Phase 2 efforts will be incrementally funded to support increasing levels of rigor until the uncertainties are sufficiently minimized. Figure 8.2 of the Issue Evaluation Study process shows the incremental approach and decision making process as the levels of rigor are increased.

8.9.3 Study Plan Addendums. Study plan addendums for Phase 2 efforts shall be prepared and submitted to the Risk Management Center if issues require further analysis or field investigations that are beyond the scope of completing a Phase 1 study. A parametric study should clearly show the likelihood of better defining an issue,

and determine if it is a problem or not, with a high degree of confidence or certainty with the additional studies, analyses, and investigation efforts. The addendum should clearly summarize the following information:

8.9.3.1 Results from the risk estimate performed during the initial Issue Evaluation Study.

8.9.3.2 A detailed description of specific uncertainties in the existing data, analyses, and site conditions, that appears to be major risk drivers in the initial risk estimate.

8.9.3.3 A detailed description of proposed studies, analysis, and investigations that are required to reduce uncertainty or investigate the unconfirmed issues.

8.9.3.4 A description of how these additional work efforts will reduce uncertainty or confirm a hidden flaw or defect.

8.9.3.5 A detailed description of how these efforts will be phased, and how the results of these studies will be incrementally assessed prior to advancing to the next phase of study.

8.9.3.6 Results of sensitivity analysis or other appropriate uncertainty analysis methods to explicitly show how the uncertainty influences the risk estimate.

8.9.3.7 The estimated cost and schedule duration to complete these more detailed studies.

8.10 Use of Tolerable Risk Guidelines.

8.10.1 The results of the risk estimate in an Issue Evaluation Study will assist the vertical team in determining what additional actions are justified and the urgency of such actions.

8.10.2 Projects with an approved Issue Evaluation Study that concludes that the estimated risk exceeds the USACE tolerable risk limits will undergo a DSAC review and be recommended for a Dam Safety Modification study. The project will be prioritized, scheduled, and moved into the resource queue for funding.

8.10.3 If the Issue Evaluation Study concludes that the risk estimate is significantly below the tolerable risk limits, the study should recommend that an evaluation of the tolerability of the residual risk and compliance with Essential Agency Guidelines be conducted accordance with Chapter 5. The DSAC reclassification will then be reviewed.

8.10.4 Prioritization of projects for Dam Safety Modification Studies will be based on the following three criteria as well as additional criteria listed in Chapter 6, Dam Safety Risk Management Prioritization:

8.10.4.1 The total annual probability of all failure modes;

8.10.4.2 The incremental risk estimate above the limit line for life safety; and

8.10.4.3 The total annualized (mean) risk estimates for life safety for all failure modes.

8.11 Issue Evaluation Study Documentation.

8.11.1 Objective. The document for this phase of the dam safety portfolio risk management process shall be called Issue Evaluation Study report. The IES report will be used to present information that confirms the dam safety issues and support the need for a dam safety modification study (DSM), or states the case to revise the current DSAC rating. Therefore the dam safety issue or issues must be clearly defined and supported by the related risk estimate. In the event that a Dam Safety Modification study is not justified, or a determination is made at any point during the study that the issues can be remediated under the major rehabilitation threshold funding cap , the Issue Evaluation Study is stopped and documented, and project is assigned to the routine O&M processes as defined in Figure 3.1. At the minimum a potential failure mode analysis will be conducted. The IES document shall include information that provides the rationale for the decisions presented in the report and shows how this dam does or does not comply with the tolerable risk guidelines, and describes the recommended plan and why it is justified.

8.11.2 Organization and Scope. The IES report shall consist of two separate documents, the Issue Evaluation Study Summary of Findings (IESSF) report, and the IES Report. These documents shall be prepared in a standardized modular format to allow for relative ease of assembly and updating. This approach allows for the district to provide concise and consistent reports to the MSC, RMC, SOG, and HQ and allows for studies to be easily prioritized on a national level. This will also support rapid reevaluation of a project if adverse incidents occur or criteria changes at a later date that would warrant review of the risk estimate and the priority given the dam.

8.11.2.1 The IESSF for an Issue Evaluation Study is intended to be a stand-alone component of the IES report that provides information to senior USACE officials to make dam safety decisions. The IESSF for an Issue Evaluation Study is an internal working document and not intended for public release.

8.11.2.2 The IESSF for an Issue Evaluation Study concisely summarizes the following: The USACE dam safety program; the history and status of safety issues and actions for the subject dam; the recommended actions and supporting facts; the outcomes from analysis and assessment; and the degree of confidence in the basis for the recommendations. The document will be ten to fifteen pages, well formed and will comprise text, tables, diagrams, and photos.

8.11.2.3 The Issue Evaluation Study shall contain all background data, risk computations, findings, conclusions, and recommendations, and supporting documentation. It will act as the technical reference and supporting document for the IESSF Report.

8.11.2.4 The format and content of these two complimentary IES Report documents are detailed in Appendix P.

8.12 Roles and Responsibilities.

8.12.1 Risk Management Center (RMC). The Risk Management Center will provide support to the HQUSACE DSO and the Senior Oversight Group (SOG) for the formulation of dam safety policy, actions, and budgets, for risk informed management of USACE national portfolio of dams. The RMC will coordinate with the SOG, MSC, and district offices to prioritize the Issue Evaluation and Dam Safety Modification Studies from a national perspective. The RMC will schedule and budget all centralized resources needed for the execution of Issue Evaluation Studies based on the SOG's prioritization and assign facilitators and regional cadre members to perform the PFMA and risk estimate. The Risk Management Center will also assign a separate risk assessment cadre to assist with the agency technical review requirements. Risk assessment cadre members shall not be assigned to work on projects that are located within the boundaries of their home district.

8.12.2. Risk Assessment Cadre. A risk assessment cadre and an approved PFMA facilitator, with support from the district, will be responsible for conducting the potential failure mode analysis and performing the risk estimate. The regional cadre will provide the district with recommendations on implementing or revising Interim Risk Reduction Measures, provide recommendations for Phase 2 studies when warranted, and collaborate with the district staff concerning the scope of the recommended phase 2 work efforts. The Risk Assessment Cadre will also provide limited consulting services to the district during formulation of the Risk Management Plan, and during preparation of the IES report. The risk assessment cadre will also perform a quality control review of the final IES and companion IESSF report prior to the agency technical review.

8.12.3 District. The district is responsible for the overall management and execution of Issue Evaluation Studies. This includes formation and management of an Issue Evaluation Study Product Delivery Team as directed in ER 5-1-11 (reference A.35). The PDT will coordinate the development of the IES plan scope of work with the RMC; prepare and submit the Issue Evaluation Study plans; collect, compile, and present project data in support of the PFMA and risk assessment; support the risk assessment cadre during the PFMA, the risk estimate; conduct additional investigations required to reduce uncertainty; conduct parametric studies required to support development of additional IRRM; funds requests addendums; and schedule the various work efforts required to complete the Issue Evaluation Study. The districts are also encouraged to utilize the PFMA and risk estimate work efforts conducted by the risk assessment cadres as risk management training opportunities for additional members

of their technical staff who are not specifically assigned to the Issue Evaluation Study PDT. The makeup of the PDT is critical to the expeditious accomplishment of the IES. The PDT will have one or more engineer members, one of which will be designated as the team's 'lead engineer' in ER 1110-2-1150 (reference A.51). Care should be taken that the appointed 'lead engineer' has the experience and qualification to perform as the coordinator of engineering activities and serve as the single-point-of contact within the PDT on engineering technical matters for the IES.

8.12.4 Agency Technical Review. The Risk Management Center is responsible for coordinating and managing agency technical review of the IES reports in accordance with EC 1165-2-209 (reference A.5).

8.13 Funding. Issue Evaluation Studies will be funded by HQUSACE from the Dam Safety Assurance and Seepage/Stability Correction Program ("Wedge") funds. Projects will be prioritized and funded based on the prioritization policies outlined in Chapter 6.

8.14 Schedule. The schedule for completion of an Issue Evaluation Study is dependent on the complexity and urgency of the project being studied, and its position in the national funding priority queue. Once funding is received, work should be accomplished in accordance with the schedule presented in the Issue Evaluation Study plan. Phase 1 Issue Evaluation Studies should be completed within 6 months from receipt of funds. For projects where Phase 1 efforts find that a Phase 2 study is justified, the study should be executed in accordance with the approved study plan addendum for the Phase 2 efforts.

8.15 Decision Process; Submittal, Review, and Approvals of IES.

8.15.1 Decision Process. The decision process: submittal, review and approvals of IES involve both sequential and concurrent actions by a number of participants. This process includes: the PDT; the district, MSC and RMC; ATR team; and HQUSACE. It is therefore imperative that the vertical teaming efforts are proactive and well coordinated to assure collaboration of the report findings, conclusions, and recommendations, and that there is consensus at all levels of the organization with the recommended path forward. The dam safety program will follow the policy review process described in EC 1165-2-209, Civil Works Review Policy. The RMC will be the review management office for the ATR, and the RMC must certify that the risk assessment was completed in accordance with the USACE current guidelines and best risk management practices. A Quality Control and Consistency (QCC) review will be conducted including the district, MSC, and RMC. The district and the risk assessment cadre present the IES risk assessment, IES findings, conclusions, and recommendations for review. After resolution of QCC review comments, the MSC and HQUSACE will complete quality assurance and policy compliance review. Then the district will present the report findings and recommendations to the Senior Oversight Group (SOG). Once any SOG comments are resolved the district DSO, MSC DSO, and the SOG Chair will sign a joint memorandum approving the findings and recommendations of the IES report. By

formal memorandum the SOG Chair will notify the USACE DSO and the MSC commander that the IES report is approved. (See Figure 8.3)

8.15.2 Table 8.2 depicts a summary of the principal participants in the decisions involving approval of Issue Evaluation Studies.

Table 8.2 Issue Evaluation Study Report - Review and Approval

Study Phase	For DSAC II, III, & IV	District	MSC	RMC	HQUSACE DSO
Issue Evaluation Study Report	Includes: Report, Appendices, to include Risk Estimate	ATR w/Risk Assessment Cadre Cert Joint Approval by DSO	Quality Assurance Review Joint Approval by DSO	QCC Risk Cadre Review & Approval of Risk Estimate Concurrence with Recommendations	Policy & Compliance Review Joint Approval by SOG Chairman

8.15.3. Report submittal requirements are as follows:

Review Center	Number of Paper Copies	Number of CD-R Copies
MSC DSO	1	2
HQ USACE DSPM	1	2
Risk Management Center	1	3

An electronic copy of the IES report (review copy) shall be uploaded to the Risk Management Center's centralized data repository (RADS II) at the time of hard copy submittal. A copy of the final IES Report reflecting all updates and revisions required from the review process shall be uploaded after report approval.

8.15.4 Following joint approval of the Issue Evaluation Study, the RMC, MSC, and district will be notified, and the project will be placed in the national priority queue for Dam Safety Modification study funds.

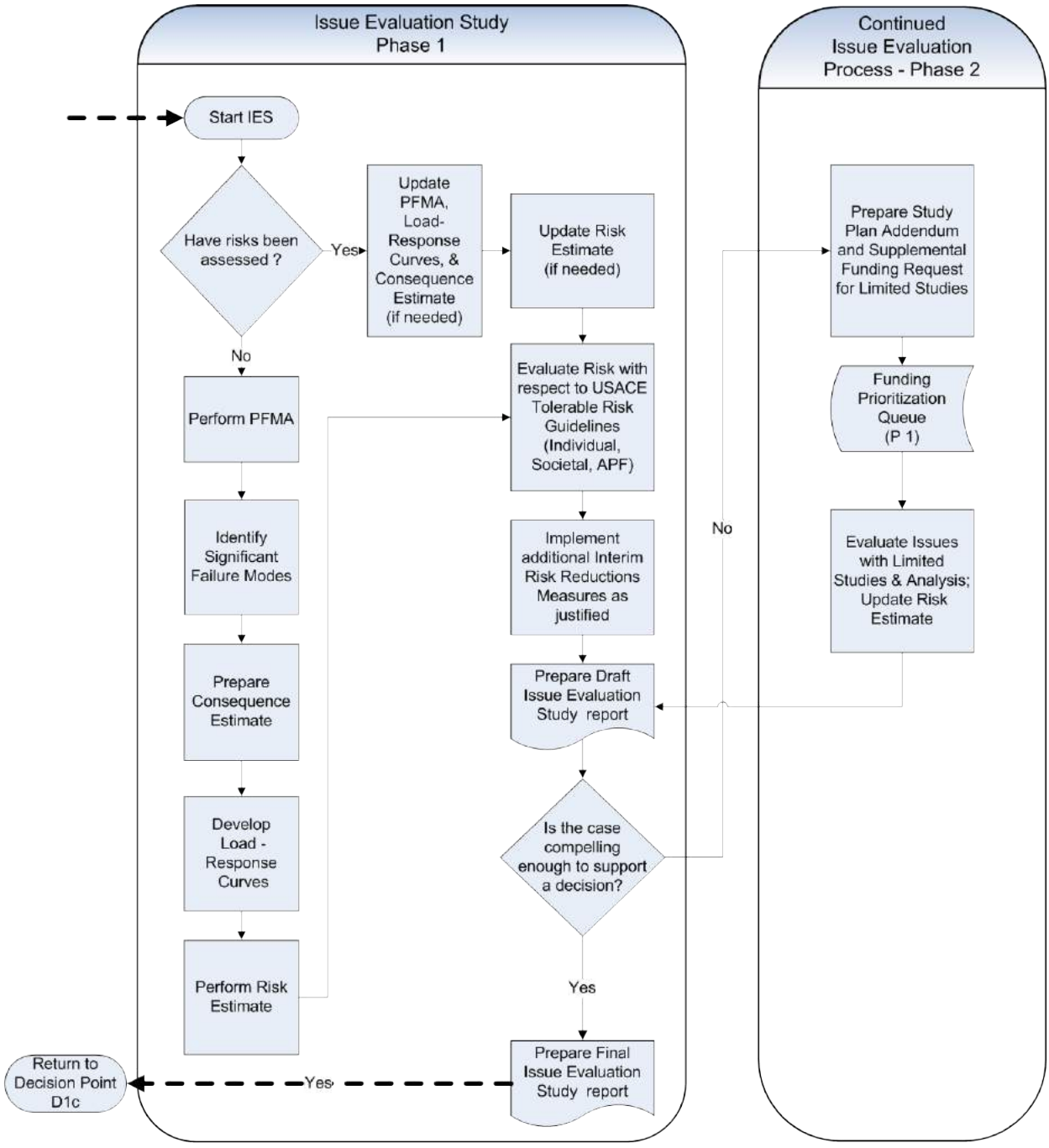
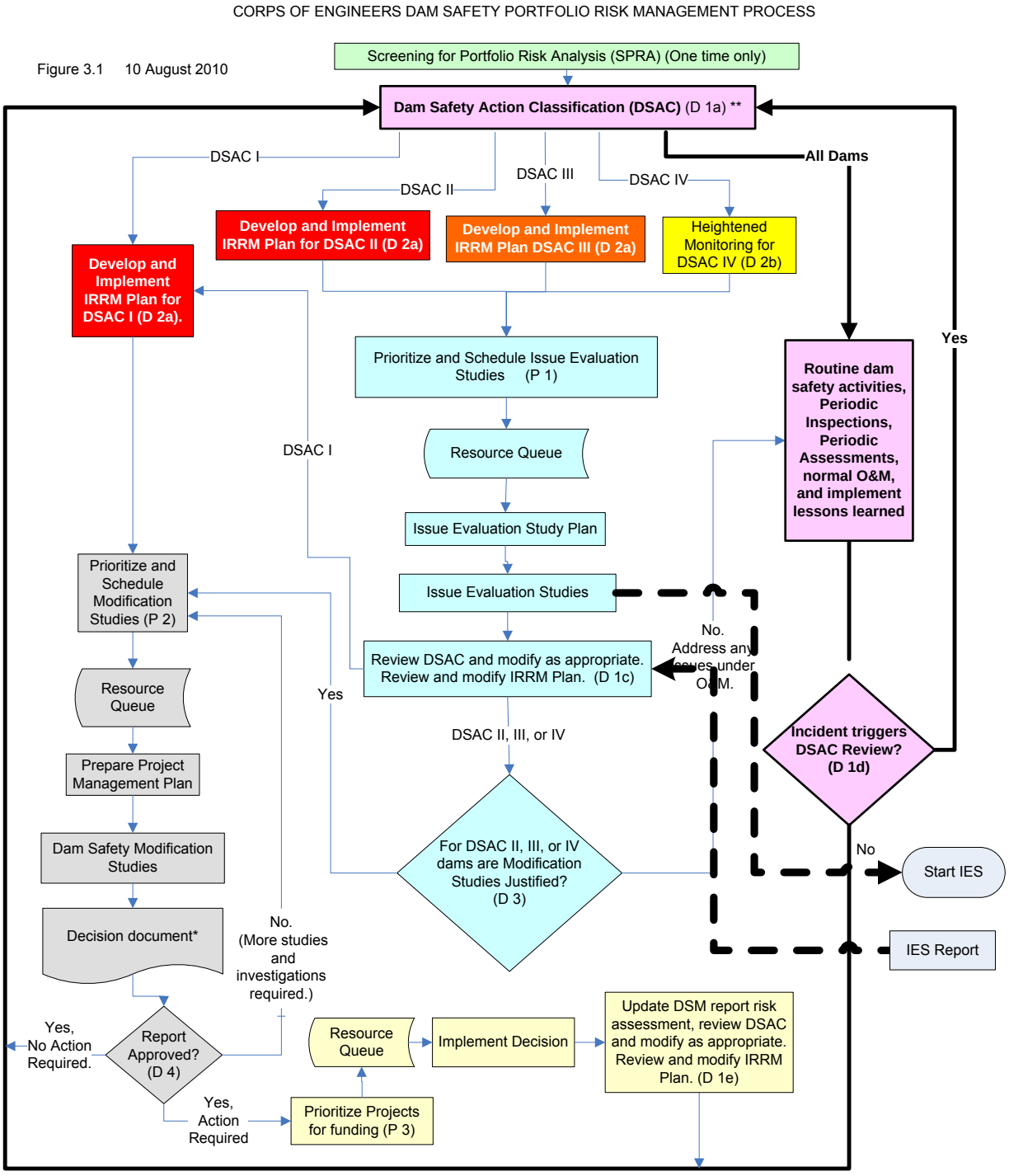


Figure 8.1 - Graphical Representation that Shows the Work Flow Process for Issue Evaluation Studies



Decision Points are label as (D 1a), Prioritization Points are labeled as (P 1), and the details for each point is explained in Chapter 3.
*** Independent External Peer Review requirements are to be addressed per guidance in the Dam Safety Modification chapter.**
**** Regardless of DSAC classification, dams with insignificant or no consequences should they fail are considered exceptions; will be so tagged, and are exempt from the dam safety portfolio management process depicted here in Figure 3.1.**

Figure 8.2 - How the Issue Evaluation Study Fits Into the Overall Portfolio Risk Management Process

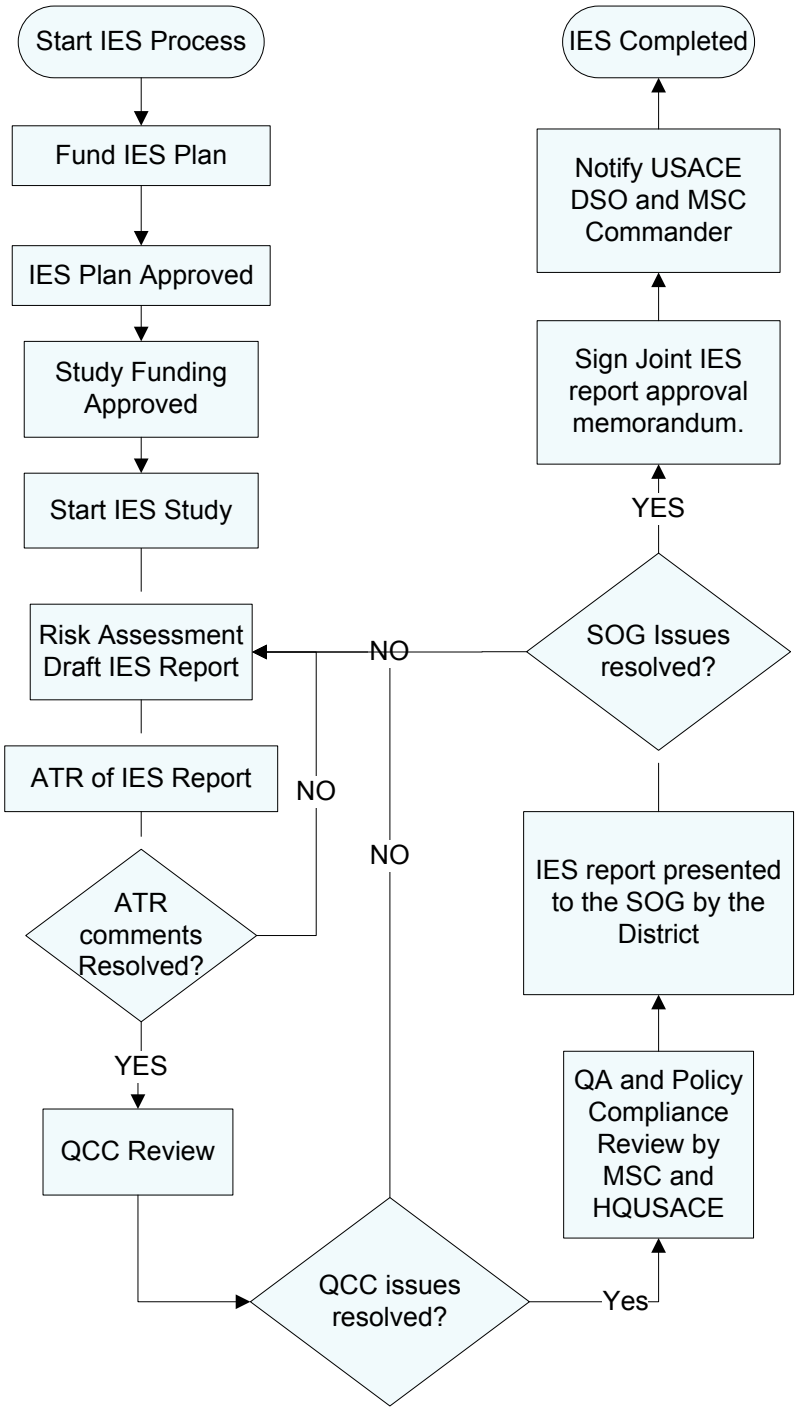


Figure 8.3 – Flowchart of the IES Decision, Review, and Approval Process

CHAPTER 9

Dam Safety Modification Studies and Documentation

9.1 Purpose. This chapter provides guidance and procedures for developing the dam safety modification report that presents the investigation, documentation, and justification of modifications for dam safety at completed USACE projects. This chapter provides a description of the requirements to obtain approval to modify a dam to address the risks associated with a dam safety issue(s) and to meet USACE tolerable risk guidelines. A dam safety issue is any condition at a dam that results in unacceptable life safety, economic, and environmental risks posed by the failure of the dam (See Glossary for definition of dam failure). A single type of decision document – Dam Safety Modification (DSM) report – will be used for all dam safety modification projects not requiring additional authorization by Congress. The DSM report shall be prepared for any Dam Safety Action Classification (DSAC) Class I, II, III, and IV dams upon the approval of the Dam Safety Senior Oversight Group (SOG) in accordance with national priorities. Figure 3.1, Corps of Engineers Dam Safety Portfolio Risk Management Process, depicts the process by which dams can be identified, approved, and prioritized for a Dam Safety Modification study. Figure 9.1 presents the DSM study, review, decision and approval process flowchart. The DSM report shall include a risk assessment for all potential failure modes (PFM) that have been determined to contribute to significant risk for that dam. The report must also document additional efforts (if any) to further define the dam safety issue. The risk assessment in support of the Dam Safety Modification study shall address the life safety, economic, and environmental consequences associated with the identified significant failure modes. The goal of the risk management alternatives, including potential staged implementation options, is to achieve the tolerable risk guidelines presented in Chapter 5. The report format and additional technical guidance is contained in Appendix Q.

9.2 Change from Previous Guidance. The Dam Safety Modification study process described in this chapter replaces the Major Rehabilitation Evaluation report for Dam Safety and the Dam Safety Assurance Evaluation reports described in previous regulations (ER 1110-2-1155, “Dam Safety Assurance Program” (reference A.52); and ER 1130-2-500, “Project Operations - Partners and Support (Work Management Policies)” (reference A.62). Note - for projects with currently approved Dam Safety Assurance reports or major rehabilitation reports a DSM report will not be required.

9.3 Eligibility. This guidance encompasses all structural and non-structural project modifications to address dam safety issues. Potential operational failures, identified by the DSM risk assessment, such as the failure of operating equipment not directly impacting dam safety, will generally not be addressed with a DSM Report. Those actions should follow normal O&M or major rehabilitation paths for funding. Only projects that have received approval as a national priority project by the USACE SOG, based on an assessment of risk, shall be funded to go through the DSM study process. The decision to modify a dam should be based upon the magnitude of existing life, economic, and environmental risks; the effectiveness of the proposed alternatives to

reduce the risk to tolerable levels, and meeting essential USACE guidelines. Funding for preparation of the report and implementation of the action(s) is addressed in a following paragraph.

9.3.1 Eligibility Requirements.

9.3.1.1 In order to qualify, the modifications must be within the Chief of Engineers' discretionary authority to operate and maintain the dam. Guidance that will assist in making this determination is contained in ER 1110-2-240 “Water Control Management” dated 8 October 1982. Essentially, the requirement is that the proposed modification must not significantly impact the congressionally authorized purposes. Further guidance is provided in ER 1105-2-100, Appendix E, Section 57 ‘Other Authorities’, paragraph d. ‘Reallocation of Storage.’

9.3.1.2 At such time during execution of the DSM study that it is determined that the likely recommended alternative will significantly impact authorized purposes, the study process should transition to “Additional Authorization” as described in paragraph 9.3.2 below. A DSM report will be used to approve projects to be funded with Construction appropriation funding. A DSM study is not required for major maintenance work under the Operation and Maintenance appropriation (generally items costing less than the current cap for major maintenance in the budget EC and that can be completed in one construction season). Once a DSM report is prepared and approved, budget justification and other supporting data will be prepared in accordance with directions from the USACE DSO in coordination with the business line managers.

9.3.2 Additional Authorization. Project modifications that require additional authorization should be studied under the authority of Section 216 of the Rivers and Harbors Act of 1970 (reference A.94), following the guidance in Chapter 2 of ER 1105-2-100 (reference A.42).

9.4 DSM Study Objectives. The objective of a dam safety modification study is to identify and recommend an alternative risk management plan that supports the expeditious and cost effective reduction of risk within the overall USACE portfolio of dams. Recommended risk management alternatives are to be technically feasible and acceptable following current best practices, comply with applicable laws, and satisfy applicable tolerable risk and essential USACE guidelines for remediation of existing dams. The risk associated with each failure mode being addressed by a risk management alternative must be reduced to a level that satisfies the tolerable risk guidelines in Chapter 5 on an individual failure mode basis, including considerations for ALARP. The intent is to achieve a complete remediation of those individual failure mode(s) being addressed by the plan to support the ultimate goal of having an adequately safe dam where the dam meets essential USACE guidelines and the total residual risk for the dam is considered tolerable (DSAC V). Each alternative risk management plan must be formulated to support effective and efficient risk reduction within the USACE portfolio of dams which may require a staged implementation

approach. The principle of “Do No Harm” (see paragraph 1.10.2.) must be respected in development of the risk management plan.

9.4.1 DSAC I and II Dams.

9.4.1.1 The DSM report for DSAC I and II dams will support expedited risk reduction for urgent dam safety issues. The objective is to identify and recommend an alternative risk management plan that addresses all failure modes that contribute to the DSAC I or II classification such that the failure modes being addressed would be completely remediated and the dam would be reclassified after implementation of the plan.

9.4.1.2 The DSM study for DSAC I and II dams will focus on those individual failure mode(s) that collectively contribute to the DSAC I or II classification. Other significant failure modes should be included in the study if they can be expeditiously and cost effectively addressed at the same time without impacting the schedule for completion of the study and the timeframe for implementation of the alternative risk management plan. All significant failure modes still need to be identified during the PFMA and quantified for the baseline risk estimate even though they may not be addressed by an alternative risk management plan. Resources allocated to the evaluation of failure modes that will not be part of an alternative risk management plan should be kept to a minimum relying primarily on existing information.

9.4.1.3 After implementation of the alternative risk management plan, the dam will be reclassified and inserted back into the portfolio risk management process at the appropriate location for national prioritization of any remaining dam safety issues.

9.4.2 DSAC III and IV. The DSM report for DSAC III and IV dams will support risk reduction for priority dam safety issues. The objective is to identify and recommend an alternative risk management plan that addresses all failure modes that contribute to the DSAC III or IV classification such that the failure modes being addressed would be completely remediated and the dam would be reclassified after implementation of the plan. All significant failure modes need to be identified during the PFMA, quantified for the baseline risk estimate, and addressed by the alternative risk management plan. The intent is to achieve a complete remediation of those individual failure mode(s) being addressed by the plan to support the ultimate goal of having an adequately safe dam (DSAC V).

9.5 Basic Approach and Principles for Execution of a DSM Study.

9.5.1 DSM studies will be undertaken following the six step framework of civil works planning presented in ER 1105-2-100 "Planning Guidance Notebook" (reference A.42) as adapted herein for addressing dam safety issues.

9.5.1.1 Identify dam safety issues and opportunities;

9.5.1.2 Estimate baseline risk condition;

9.5.1.3 Formulate alternative risk management plans;

9.5.1.4 Evaluate alternative risk management plans;

9.5.1.5 Compare alternative risk management plans; and

9.5.1.6 Select a risk management plan.

9.5.1.7 A description of each step is presented in subsequent paragraphs. USACE dam safety decision making is generally based on the accomplishment and documentation of all of these steps. It is important to stress the iterative nature of this process, and the need to tailor the scope and detail of the study to the specific dam and its suspected safety issue, and its evidenced urgency for action. As more information is acquired and developed, it may be necessary to reiterate some of the previous steps. The six steps, though presented and discussed in a sequential manner for ease of understanding, usually occur iteratively and sometimes concurrently. Iterations of steps are conducted as necessary to formulate efficient, effective, complete and acceptable plans. The results of and data from previous interim risk reduction measures (IRRM) studies, Issue Evaluation studies (IES), and periodic assessments (PA) completed under Chapters 7, 8, and 11 shall form the beginnings of the DSM study.

9.5.1.8. Environmental Compliance. DSM studies and modifications should be in compliance with all applicable Federal environmental statutes and regulations and with applicable State laws and regulations where the Federal government has clearly waived sovereign immunity. The National Environmental Policy Act (NEPA) requires Federal agencies, including the USACE, to comply with a process that includes the inventory and assessment of the environmental resources within the study area. NEPA also requires the evaluation and comparison of alternatives to determine the impacts to those ecological, cultural, and aesthetic resources identified and investigated. Involvement by resource agencies and the general public during the study process is also required. USACE NEPA guidance can be found in ER 200-2-2. The NEPA process will be integrated with the USACE six step planning process. This should also include all measures required for compliance with other applicable environmental statutes, such as the Endangered Species Act, the Clean Air Act, the Clean Water Act, the Fish and Wildlife Coordination Act, and the Historic Preservation Act, among others. (See ER 1105-2-100, Appendix C for compliance requirements.) This integration is intended to reduce process overlap and duplication. The integrated process will help assure that well-defined study conditions and well-researched, thorough assessments of the environmental, social, and economic resources affected by the proposed dam safety activity are incorporated into dam safety decisions.

9.5.2 Identify Dam safety issues and opportunities (Step 1). Dam safety issues and opportunities statements will be framed in terms of the USACE dam safety program objectives, identified dam safety issues (significant potential failure modes), and tolerable risk and essential USACE engineering guidelines. Issues and opportunities

should be defined in a manner that does not preclude the consideration of all potential alternatives to resolve the dam safety issues. Problems and opportunities statements will generally encompass just current conditions, but in some instances, may need to encompass future conditions (changes in consequences, on-going changes in site, downstream, and reservoir pool terrain conditions, etc.) as well if they are expected to be significantly different from the current conditions and thus be relevant to 'fix' decisions and risk characterization. Thus, they can be, and usually are, re-evaluated and modified in subsequent steps and iterations of the DSM study process.

9.5.2.1 Properly defined statements of dam safety issues and opportunities will reflect the priorities and preferences of the Federal Government, the non-Federal sponsors and other groups participating in the DSM study process; thus active participation of all stakeholders in this process is strongly recommended. Proper identification of dam safety issues and opportunities (risk management measures) are the foundation for scoping the DSM study process.

9.5.2.2 Once the dam safety issues and opportunities are properly defined, the next task is to define the DSM study risk reduction objectives and the constraints that will guide efforts to resolve these safety issues and achieve these opportunities. Dam safety risk reduction objectives are statements that describe the desired results of the DSM study process by resolving the dam safety issues and taking advantage of the opportunities identified. Objectives must be clearly defined based on tolerable risk guidelines and essential USACE guidelines.

9.5.2.3 Constraints are restrictions that limit the DSM study process. Constraints are unique to each DSM study. Some general types of constraints that need to be considered are resource constraints and legal and policy constraints. It is also essential that the team focus on practical and realistic plans so that quick and efficient evaluation may occur. Resource constraints are those associated with limits on knowledge, expertise, experience, ability, data, information, money and time. Legal and policy constraints are those defined by law, USACE policy and guidance. Plans should be formulated to meet the DSM study risk reduction objectives and to avoid violating the constraints. Thus, a clear definition of risk reduction objectives and constraints is essential to the success of the DSM study process.

9.5.3 Estimate Baseline risk condition (Step 2). A quantitative and qualitative description is made, for both current and, in selected instances, future risk conditions that become the baseline conditions. A vital activity during this step is to identify all key assumptions and sources of uncertainty in defining this baseline risk condition. These activities would include the potential failure mode analysis (PFMA) and detailed risk assessment of current and where important, future, without modification, conditions. Existing conditions are those at the time the study is conducted and most often constitute the baseline risk condition. The baseline risk condition provides the basis from which alternative plans are formulated and their impacts are assessed. Since impact assessment is the basis for plan evaluation, comparison and selection, clear definition and full documentation of the baseline condition are essential. Consequence

analysis will consider existing and future population at risk and threatened population for fatality estimates. All dam safety issues (significant failure modes) will undergo a risk assessment to determine the baseline risk and for each subsequent risk reduction alternative. Each potential failure mode must be shown to lead to a plausible failure of the dam. These steps are accomplished with the risk assessment that establishes the baseline risk estimate on a without IRRM condition. Permanent structural IRRM and permanent changes to the water control manual are to be included in the baseline risk condition.

9.5.4 Formulating alternative risk management plans (Step 3). Alternative risk management plans shall be formulated to identify specific ways to achieve dam safety objectives within constraints, so as to resolve the dam safety issues and realize the opportunities that were identified in step 1. A risk management alternative plan consists of a system of structural and/or nonstructural measures, strategies, or programs formulated to meet, fully or partially, the identified DSM study risk reduction objectives subject to the constraints. At least one proposed risk management alternative must be shown to reduce the risk to the levels defined in the tolerable risk guidelines (Chapter 5). A risk management measure is a feature or an activity that can be implemented at a specific geographic site to address one or more objectives. Risk management measures are the building blocks of alternative plans and are categorized as structural and nonstructural. An alternative plan is a set of one or more risk management measures functioning together to address one or more objectives. A range of alternative plans shall be identified at the beginning of the study process and screened and refined in subsequent iterations throughout the study process. However, additional alternative plans may be identified at any time during the process. Plans should be in compliance with existing statutes, administrative regulations, and common law. Alternative plans shall not be limited to those USACE could implement directly under current authorities. Plans that could be implemented under the authorities of other Federal agencies, State and local entities and non-government interest should also be considered.

9.5.4.1 The first phase in the plan formulation process is the identification of dam safety risk management measures that could be implemented, giving consideration to structural and non-structural measures, for individual significant failure modes. The second phase is the formulation of alternative risk management plans by combining the risk management measures as appropriate for multiple significant failure modes. Alternative risk management plans should be significantly differentiated from each other. As a general rule alternatives must be formulated to contribute to achieving the tolerable risk and essential USACE engineering guidelines, and reflect the ALARP considerations.

9.5.4.1.1 Required alternatives are:

9.5.4.1.1.1 No action alternative (current condition baseline risk);

9.5.4.1.1.2 Meeting risk reduction objectives for the DSAC class of the dam (Refer to Section 9.4);

9.5.4.1.1.3 Achieving only tolerable risk limit for life safety;

9.5.4.1.1.4 Make IRRM permanent,

9.5.4.1.1.5 Remove structure, and

9.5.4.1.1.6 Replace structure.

9.5.4.1.2 Each alternative risk management plan shall be formulated in consideration of four criteria described in the Principles and Guidelines (P&G): completeness, efficiency, effectiveness, and acceptability.

9.5.4.1.2.1 Completeness is the extent to which an alternative risk management plan provides and accounts for all necessary investments or other actions to ensure the realization of the DSM study risk management objectives, including actions by other Federal and non-Federal entities.

9.5.4.1.2.2 Efficiency is the extent to which an alternative risk management plan is the most cost effective means of achieving the objectives.

9.5.4.1.2.3 Effectiveness is the extent to which an alternative risk management plan contributes to achieving the objectives.

9.5.4.1.2.4 Acceptability is the extent to which an alternative risk management plan is acceptable in terms of applicable laws, regulations and public policies.

9.5.4.1.2.5 Appropriate mitigation of adverse effects shall be an integral component of each alternative risk management plan.

9.5.4.2 Non-structural measures shall be considered as means for addressing dam safety issues and opportunities. Non-structural measures may be combined with structural measures to produce a risk management plan or considered as a stand-alone alternative. Non-structural measures shall receive equal consideration in the alternative development process to structural risk management measures.

9.5.5 Evaluating alternative risk management plans (Step 4). The evaluation of effects is a comparison of the with-risk reduction condition to the without IRRM condition (baseline condition) for each risk management alternative. This necessitates risk assessment be performed for all alternatives. Considering the IRRM as an alternative for permanent implementation should be considered in the formulation process.

9.5.5.1 Evaluation consists of four general tasks.

9.5.5.1.1 The first task is to determine the most likely condition expected under each alternative risk management plan. Each with-risk reduction condition will describe the same critical variables included in the baseline condition developed in step 2 (risk

evaluation factors of annual probability of failure, life safety and economic and environmental consequences, and costs and benefits). Criteria to evaluate the alternative plans include all significant resources, outputs and plan effects. They also include contributions to the dam safety risk management objectives, compliance with environmental protection requirements, the P&G's four evaluation criteria (completeness, effectiveness, efficiency and acceptability) and comparison with tolerable risk and essential engineering guidelines.

9.5.5.1.2 The second task is to compare each with-risk reduction condition to the baseline condition and document the differences between the two.

9.5.5.1.3 The third task is to characterize the beneficial and adverse effects by magnitude, location, timing and duration. Beneficial and adverse effects of each plan must be compared. Special care shall be taken to insure that the plan will not result in the risks being increased by the plan instead of lowered. These include monetary and non-monetary benefits and costs. Identification and documentation of tradeoffs will be required to support the final recommendation. The effects include those identified during the evaluation phase and any other significant effects identified in step 5. The comparison step can be defined as a reiteration of the evaluation step, with the exception that in this step each plan (including the no action plan) is compared against each other and not against the without-project condition. The output of the comparison step shall be a ranking of plans.

9.5.5.1.4 The fourth task identifies the plans that will be further considered, dropped or reformulated in the DSM study process. A plan will be further considered based on a comparison of the adverse and beneficial effects and the extent that the plan achieves the tolerable risk guidelines and essential USACE guidelines.

9.5.5.2 Steps in the procedures may be abbreviated by reducing the extent of the analysis and amount of data collected where greater accuracy or detail is clearly not justified by the cost of the plan components being analyzed. The steps abbreviated and the reason for abbreviation shall be documented in the study reports.

9.5.6 Comparing alternative risk management plans (Step 5). In this step, plans (including the no permanent risk reduction action plan) are compared against each other, with emphasis on the outputs and effects that will have the most influence in the decision making process, e.g. annual probability of failure, life safety tolerable risk guidelines, ALARP considerations, and essential USACE guidelines. A comparison of the outputs of the various plans must be made. The no action plan is to be based on a without IRRM condition. Beneficial and adverse effects of each plan must be compared. The comparison step can be defined as a reiteration of the evaluation step, with the exception that in this step each plan (including the no permanent risk reduction action plan) is compared against each other and not against the baseline condition. The output of the comparison step shall be a ranking of plans.

9.5.7 Selecting a risk management plan (Step 6). A single risk management plan will be selected for recommendation from among all alternative plans that have been considered, including the no action plan. The criteria for selecting the recommended risk management plan will generally be based on the ranking resulting from the comparisons of plans described in 9.5.5. The primary evaluation factors of tolerable risk guidelines, ALARP considerations, and essential USACE guidelines form the basis for plan selection. Beneficial and adverse effects of each plan must be compared. Other considerations, such as economic and environmental, might be used in selecting a risk management plan must be fully documented and justified. The DSM study risk assessment shall be updated after implementation of the risk reduction remedial measures and evaluated to determine if the risk reduction objectives were achieved.

9.6 Dam Safety Modification Study Project Management Plan and Tasks.

9.6.1 Project Manager, Lead Engineer, Project Delivery Team, and the Project Management Plan.

9.6.1.1 The first actions under the study shall be the assignment of a project manager, a lead engineer, creation of a vertical project delivery team, and the development and completion of a project management plan (PMP) for the study per ER 5-1-11, *U.S. Army Corps of Engineers Business Process* (reference A.35) and ER 1110-2-1150, *Engineering and Design of Civil Works Projects* (reference A.51). The PDT consists of personnel from engineering, planning, operations, public affairs office, and others necessary to develop the project.

9.6.1.2. A copy of the final DSM PMP reflecting all updates and revisions required from the review process shall be uploaded after PMP approval.

9.6.2 Establish Vertical Team. Establish the vertical project delivery team (PDT) to include the appropriate level of district, MSC, Risk Management Center, and HQUSACE members.

9.6.3 Vertical team meetings.

9.6.3.1 Kickoff Meeting. The district will hold a kickoff meeting with HQUSACE, Risk Management Center, MSC and all others involved to review and obtain concurrence of the PMP prior to approval by the district dam safety officer and the start of the DSM study (See Table 9.1). Any review comments are to be provided the district within 30 days of submission of the PMP for review or the district will proceed with the submitted plan. An electronic copy of the DSM study PMP (review copy) shall be uploaded to the Risk Management Center's centralized data repository at the time of review copy submittal.

9.6.3.2 Alternative Scoping Meeting. After step 2 (Estimate baseline risk condition) a vertical team meeting shall be held to brainstorm and identify the risk management measures to be used in the development of the risk management alternatives.

Table 9.1 Dam Safety Modification Study Project Management Plan - Review & Approval				
Activity/Document	District	MSC	HQ	
			RMC*	DSO
Dam Safety Modification Study PMP	Approval of PMP by DSO	Concurrent Review (NTE 30 days)	Concurrent Review (NTE 30 days)	Concurrent Review (NTE 30 days)
Review Plan	Prepare	Review and Approve	Concurrent Review and Certify (NTE 30 days)	N/A
*Review Management Organization				

9.6.3.3 Risk Management Plan Formulation Briefing. After step 3 (Formulate alternative risk management plans) there shall be a vertical team meeting where the various alternatives will be presented and discussed. The outcome of this meeting will be agreement on those alternatives that will be carried forward to steps 4, 5, and 6, and the level of design and cost estimate for each alternative.

9.6.3.4 In-Progress Reviews. Additional in-progress review meetings are to be scheduled with the vertical team on a regular basis not to exceed six month time intervals.

9.6.4 External Consultants. In consultation with the vertical team determine if an expert advisory panel to support the DSM study effort is recommended and outline the scope of services to be provided by the board of consultants. This is not the independent external peer review discussed later in this chapter.

9.6.5 Study Schedule and Cost Estimate. Based on the study scope, a study schedule and cost estimate shall be developed. Copies of the schedule and cost estimate shall be included in the PMP and provided to the MSC and HQUSACE DSO.

9.6.6 Investigations and Studies.

9.6.6.1 Detailed field investigations and office studies shall be scoped based on the need for a full baseline risk assessment of the dam.

9.6.6.2 The DSM study must include sufficient field investigations, model studies, and other studies to ensure that all dam safety issues have been adequately defined and the data will support the identified and recommended permanent risk management

alternatives and that a supportable cost estimate can be prepared for inclusion in the DSM Report.

9.6.7 Baseline Risk Estimate. One of the first major tasks of a DSM study is to perform a baseline risk assessment to ensure that all credible potential failure modes that contribute significant risk to the total risk of the dam are evaluated and their associated risk estimated for the baseline risk estimate. All risk assessments done up to this point are to be reviewed and considered for use in this full risk assessment of the dam.

9.6.8 Product Review.

9.6.8.1 Review Plan (RP). District will prepare a review plan per EC 1165-2-209 (reference A.5). The Risk Management Center is the RMO. This plan includes all levels of review: District Quality Control (DQC), Agency Technical Review (ATR), Quality Control and Consistency (QCC) review, quality assurance and policy compliance review, SOG review, and Independent External Peer Review (IEPR). DQC and ATR will occur during key stages in the development of the particular work product as outlined in the review plan. Figure 9.1 shows the sequence for the various levels of review. If a particular level of review is not anticipated, the RP will document the risk-informed decision not to perform that level of review. Note that DSM reports that recommend the 'no action' alternative are to be reviewed in the same manner as DSM reports that recommend an action alternative.

9.6.8.2 Quality Control and Consistency Review. Quality Control and Consistency (QCC) review will be conducted including the district, MSC, and RMC. The district and the risk assessment cadre present the baseline risk assessment, risk management alternatives considered, and the recommended risk management plan for review.

9.6.8.3 SOG Review. The district presents the baseline risk assessment, risk management alternatives considered, and the recommended risk management plan to the dam safety senior oversight group prior to the IEPR.

9.6.8.4 Independent External Peer Review (IEPR). Section 2034 of WRDA 2007 (P.L. 110-114) requires an IEPR for all new projects and for all project modifications that meet the criteria listed in EC 1165-2-209 (reference A.5). This review must be completed before the DSM report is approved. EC 1165-2-209, Water Resources Policies and Authorities, Civil Works Review Policy (reference A.5), contains the current guidance for the review for all civil works products. If a Type I IEPR is not required the Type II IEPR scope will contain a comprehensive review of the DSM report in addition to the Safety Assurance Review (Section 2035 of WRDA 2007, P.L. 110-114.) The intent is not to have two separate review panels for the same dam safety project. This review will be completed within a designated time frame for all DSAC I and II dams or the project will go forward without the review being completed due to life safety concerns.

9.6.9 IRRM Plan. After completion of the DSM baseline risk estimate review the IRRM plan and update as appropriate.

9.6.10 Post Implementation Risk Assessment. The PMP shall include the task of updating the DSM study risk assessment after implementation of the risk management remedial measures. The dam shall be evaluated to determine if the risk management objectives were achieved.

9.7 Dam Safety Modification Decision Document.

9.7.1 Name of Decision Document. The decision document for this phase of the dam safety portfolio risk management process shall be called a Dam Safety Modification Report (DSM Report) and shall be approved in accordance with paragraph 9.8, before initiation of detailed design leading to the preparation of the plans and specifications.

9.7.1.1 The DSM report will include a Dam Safety Action Decision Summary (DSADS) which is intended to be an extractable, stand alone component of the DSM report that meets the information needs of senior USACE officials in making dam safety decisions. It would be a public document with unrestricted distribution, but is not designed to be a public communications document per se.

9.7.1.2 The DSM report format, detailed description of the report requirements, and additional technical guidance is contained in Appendix Q. All technical sections shall be appended to the report. The reporting requirements are the same for all projects, regardless of the type of deficiency or mode of failure. Detailed guidance for preparation of the DSADS is in Appendix R.

9.7.2 Reports for DSAC I and II Dams. When a project is placed in DSAC Class I and II, an expedited process shall be followed in the preparation of the DSM Report. This expedited process can be accomplished by the maximum use of vertical teams, concurrent ATR, and early initiation of design documentation report and plans and specifications for the first contracts. This expedited process shall not short cut any necessary investigations and analysis. Field investigations should be started early and include concurrent analysis for findings as the investigations continue. The NEPA (Reference A.37) and real estate processes (Reference A.38) shall start as early as possible. While the report must be expedited, it should still follow the format outlined in Appendix Q. During preparation of the report, extensive and more frequent communication with approving authorities is required to assure a smooth and successful expedited approval process.

9.7.3 Cost Estimate, Economic Analysis, and Total Project Cost.

9.7.3.1 Recommended Risk Management Plan Cost Estimate. An M-CACES cost estimate is required for the recommended risk management plan. Cost estimates shall include a cost risk analysis showing the uncertainty per ER 1110-2-1302, Civil Works

Cost Engineering (reference A.53). The level of detail in the cost estimate is to be that of a feasibility report in order to more accurately identify the baseline cost estimate.

9.7.3.2 Present the results of the economic cost analysis and the total project cost for the recommended risk management plan.

9.8 Submittal, Policy Compliance Review, and Approval Process.

9.8.1 Submittal. The district DSO shall submit the DSM report package including a cover letter requesting policy compliance review in preparation for approval to the MSC DSO, Risk Management Center, and HQUSACE in the number listed in Table 9.2. Two complete copies and 6 copies of the main report without appendices shall be transmitted directly by the district to the USACE DSO at HQUSACE, ATTN: CECW-CE for concurrent review. The transmittals shall include the completed review checklists as given in Appendix S - Dam Safety Modification Report Issue Checklist and Appendix T - Post-Authorization Decision Document Checklist. Once the report is transmitted, further work on the project shall be accomplished only after consultation with the MSC and the USACE DSOs and their concurrence is obtained. An electronic copy of the DSM Report (review copy) shall be uploaded to the Risk Management Center's centralized data repository at the time of hard copy submittal. A copy of the final DSM Report reflecting all updates and revisions required from the review process shall be uploaded after report approval.

Table 9.2 DSM Report Submission

Office	Number of Complete Reports (Includes Appendices) Paper Copies	Number of Main Report (No appendices) Paper Copies	Number of CD-R Copies of Full Report
MSC DSO	6	-	10
HQ USACE RIT and DSPM	2	6	8
Dam Safety Risk Management Center	2	-	8

* The HQUSACE DSO will send two copies with CDs to the MSC RIT

9.8.1.1 Modification to the Water Control Plan. If one of the alternatives recommended is a change to the water control plan, the district is to follow the normal process of submitting a formal request to the USACE chain-of-command for approval of the changes in the official water control plan after the DSM report is approved. Guidance is provided in ER 1110-2-240, Water Control Management (reference A.49).

9.8.1.2 For DSAC I and II dams, during preparation of the report, extensive and higher frequency of communication with approving authorities is required to assure a

smooth and successful approval process. An appropriate level of communications is recommended for DSAC Class III and IV projects.

9.8.2 Policy Compliance Review. The MSC and HQ will conduct agency policy compliance review. The Risk Management Center will review the risk estimate and verify that risk estimate is in compliance with the current policy for dam safety risk estimates. The Risk Management Center will review the risk management recommendations and verify the estimated risk reductions.

9.8.3 Approval of Dam Safety Modification Reports (Table 9.3).

9.8.3.1 The USACE DSO has been delegated approving authority from the Assistant Secretary of the Army (ASA) (Civil Works) and is the responsible approval official for Dam Safety Modification Reports submitted in accordance with this regulation.

9.8.3.2 The district DSO, MSC DSO, and the Chairman, HQUSACE Dam Safety Senior Oversight Group will sign the memorandum recommending approval once the review process is completed. This memorandum will state that all agency requirements, certifications, and reviews have been completed and all NEPA and ESA documentation has been satisfactorily completed.

9.8.3.3 The report will then be sent to the USACE DSO for approval. The USACE DSO will then notify the USACE commander and the MSC commander that the DSM report has been approved.

9.8.3.4. Approval-Subject-To-Comments. If the report is approved subject to resolution of specific comments, the district shall provide the MSC and HQUSACE acceptable documentation during the design phase of the project to show compliance with the comments

9.9 ASA(CW) Notification and Concurrence with Construction. The USACE DSO shall notify ASA (CW) of report approvals and the start of the design phase of the project. Two copies of the approved and final reports shall be provided to ASA (CW) for concurrence with construction and consideration of budgeting as a continuing line item under the project name in the Construction program.

9.10 Supplemental DSM Decision Documents.

9.10.1 Past experience has shown that during the design or the construction phase large changes in the scope of the modifications or increases in construction effort occur increasing the cost of risk management measures. Whenever such changes occur, for whatever reason, a supplemental to the DSM report will be prepared and processed for approval in accordance with the guidance for the decision report. The supplement will be prepared and submitted for approval when new information increases the original cost estimate by 20 per cent.

<table>
<tr><th colspan="6">Table 9.3 Dam Safety Modification Study Report - Review & Approval Requirements</th></tr>
<tr><th rowspan="2">Phase</th><th rowspan="2">DSAC
I, II, III, & IV</th><th rowspan="2">District</th><th rowspan="2">MSC</th><th colspan="2">HQ</th></tr>
<tr><th>RMC</th><th>DSO</th></tr>
<tr><td rowspan="2">Dam Safety Modification Report</td><td rowspan="2">Includes:

Report, Appendices, & Risk Estimate.</td><td>ATR Cert*

IEPR

Joint recommen-dation for approval by District DSO</td><td>Quality Assurance and Policy Compliance Review

Joint recommen-dation for approval by MSC DSO</td><td>QCC Review

Concurrence with Report Recommendations</td><td>Policy Compliance Review

Joint recommen-dation for approval by SOG Chairman**

Approval by USACE DSO</td></tr>
<tr><td colspan="4">Coordination and collaboration of report findings, conclusions, and recommendations, and joint approval of the Dam Safety Modification Report, are required for the development of a unified path forward.</td></tr>
<tr><td colspan="6">*Risk Cadre must be included on ATR Team
** Dam Safety Senior Oversight Group Chairman is the HQUSACE, Special Assistant for Dam Safety</td></tr>
</table>

9.10.2 A supplement to the DSM study scope will be submitted for approval if additional significant failure modes are identified after the DSM report is approved or to address the failure modes that were not addressed in the original DSM report for DSAC I and II dams as per paragraph 9.4.1.

9.11 Funding of Dam Safety Modification Studies, Reports, and Construction Projects.

9.11.1 Initial Funding for the Study and Report Preparation. For dams operated and maintained by USACE, funds for preparation of DSM Reports will be made available from Dam Safety Assurance and Seepage/Stability Correction Program (WEDGE) line item in the Construction Account, except for projects on the Mississippi River and its tributaries funded by the Flood Control, Mississippi River and Tributaries (FC, MR&T) Account. Those projects will be funded from the Construction portion of the FC, MR&T Account. Districts should submit requests for Dam Safety WEDGE study funds in accordance with guidance from HQUSACE. Subject to overall budget constraints, funds should be sufficient in any one year for the study effort required for a

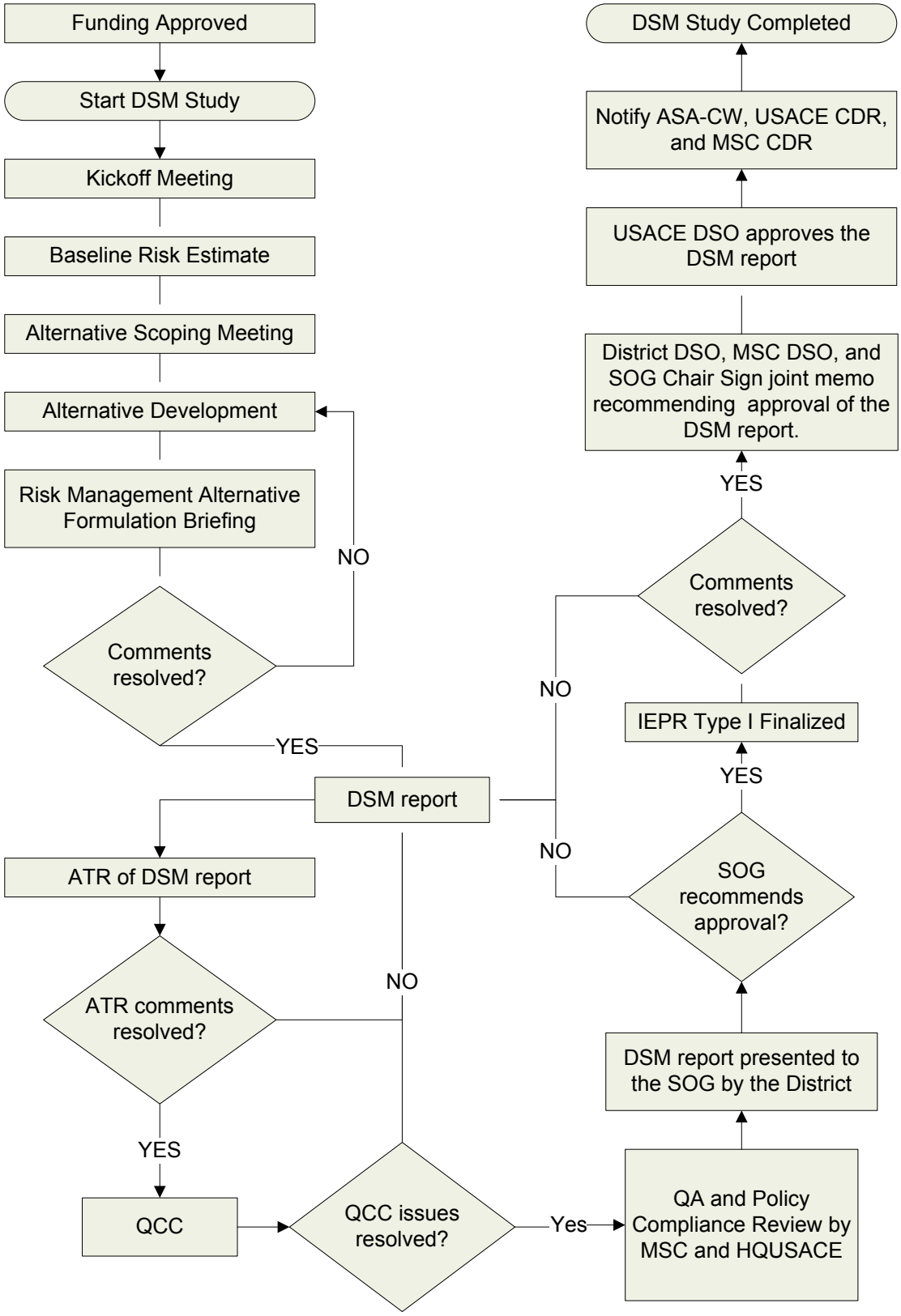


Figure 9.1 DSM Study, Review, Decision and Approval Process

newly identified problem, especially for expediting risk reduction to DSAC I dams. Additional Dam Safety WEDGE funds will be made available in future years until the report is completed or a no action required determination is made. For the definition of the Dam Safety WEDGE line item, refer to the current budget EC.

9.11.2 Funding for Engineering and Design Documents: Following DSM Report approval, the district shall request and use Dam Safety WEDGE funds to proceed with preconstruction engineering and design activities, and in some cases completion of plans and specifications and initiation of construction. The USACE DSO will consider the project's DSAC status, national priorities, and overall funding limitations when approving or disapproving the release of funds. Priority will be risk informed, based on the magnitude and relative importance of the life, economic and environmental consequences and the effectiveness of the proposed risk reduction measures for each dam in relationship to other dams of the same DSAC rating in the USACE portfolio of dams. The district shall recommend budgeting for follow on Construction funds for preconstruction engineering and design activities during the next budget cycle in accordance with guidance from HQUSACE. See chapter 6, Dam Safety Risk Management Prioritization, for further details on the prioritization guidance.

9.11.3 Funding Construction Activities: The ultimate decision to fund construction shall be based on the results of the DSM studies, the priorities of the USACE DSO considering all approved DSM reports, and overall budget priorities. The decision on construction priority will be risk informed based on the magnitude and relative importance of the life, economic and environmental consequences and the effectiveness of the proposed risk management measures. See chapter 6, Dam Safety Risk Management Prioritization, for further details on the prioritization guidance.

9.11.3.1 A district shall request funding for the construction of an approved dam safety project in accordance with current budget guidance from HQUSACE as a line item project.

9.11.3.2 When a project is ready for construction or land acquisition prior to receiving appropriations under the project name, the district DSO may request funds from the Dam Safety Assurance and Seepage/Stability Correction Program (WEDGE) line item to initiate construction; except for projects on the Mississippi River and its tributaries funded by the Mississippi River and Tributaries (MR&T) Account, in which case construction funds should be requested in the Construction portion of the MR&T Account.

9.11.3.3 Construction or land acquisition may not commence until construction funds have been specifically allocated for the required work, and a project partnership agreement (PPA) or amendment has been executed, if required. For DSAC I and some DSAC II projects, the USACE DSO may recommend to the ASA(CW) that construction commence without an approved PPA due to the risk to the public. Even if a PPA is not required, serious consideration should be given to developing one, especially for older projects, to make sure that they meet the provisions of modern day agreements.

9.11.4 Funding Minor Modifications: When the initial analysis of a dam safety deficiency indicates that the work will cost less than Major Rehabilitation funding cap (see guidance in the annual budget EC) and the work can be accomplished in one construction season, the district DSO should consider going directly to a major maintenance action. Such minor modifications for dam safety would be funded as major maintenance with Operation and Maintenance funds. If significant risk reduction can be made at high risk dams for amounts costing less than the Major Rehabilitation funding cap, districts should coordinate with the MSC and HQ dam safety program managers to determine if Operation and Maintenance funds are available.

9.12 Cost Sharing Requirements. Dam Safety Modifications shall be cost shared in accordance with the following policies.

9.12.1 Section 1203 of WRDA 1986: Section 1203, WRDA, 1986 (reference A-103) provides for special cost-sharing for modification of dams and related facilities constructed or operated by USACE. In accordance with long standing Army policy, Section 1203 cost sharing shall only apply to modifications needed to address new hydrologic or seismic data. While Section 1203 also addresses modifications related to changes in the state of the art design or construction criteria, this terminology makes it difficult to define the kinds of repairs that would be applicable, and so it is not used. Instead, any modifications that are required for safety that are not related to new hydrologic or seismic data (such as seepage and stability corrections) shall be addressed through the Major Rehabilitation program and cost shared in accordance with the provisions in effect at the time of initial project construction. The cost of dam safety modifications needed to address new hydrologic or seismic data shall be cost shared as described below. Section 1203 also may be used to modify dams built by the USACE where local interests are responsible for operation, maintainence, repair, rehabilitation, and replacement, but only if Congress directs the Secretary of the Army to do so, in law, for a specifically named project. Without specific congressional direction, in law, non-Federal sponsors remain responsible for operation, maintainence, repair, rehabilitation and replacement of these projects, as required by their authorizations and the terms of the agreements under which they were constructed by the Federal government.

9.12.1.1 In accordance with Section 1203 of WRDA 1986 (reference A-103) and the Army policy specified above, costs incurred for modifications for dam safety assurance (i.e., strictly limited to new hydrologic or seismic data) shall be recovered in accordance with provisions of the statute. Repayment of the local share of costs, except for irrigation, may be made, with interest, over a period not to exceed 30 years in accordance with provisions of subsection (a)(2) of the legislation. Costs assigned to irrigation shall be recovered by the Secretary of Interior in accordance with Public Law 98-404 (reference A-97).

9.12.1.2 Under Section 1203 and Army policy, for project modifications due to changes in hydrologic or seismic data, 15% of the cost of the modification is allocated to

the project purposes in the same percentages as the original project costs. General procedures for determining the amount of sponsor cost are outlined in the following subparagraphs. These are general procedures that will need to be tailored to fit the specifics of each individual project.

9.12.1.2.1 Projects with a Formal Cost Allocation. In this case, 15% of the cost of the modification for dam safety assurance shall be allocated among project purposes in the same percentage as the construction expenditures in joint-use facilities are allocated in the cost allocation currently in effect.

9.12.1.2.1.1 The cost allocated to each project purpose will then be shared in the same percentage as when the project was constructed, or when the purpose was added, whichever is appropriate.

9.12.1.2.1.1.1 For large reservoir projects, it is likely that the cost assigned to flood control is 100% Federal. The cost assigned to power generation is most likely 100% non-Federal (to be reimbursed by the sale of the power). Costs may have been allocated to water supply or to conservation. Costs allocated directly to water supply are 100% non-Federal costs. Where costs have been allocated to conservation, water supply users may have contracted for a portion or all of the conservation storage. In such cases, the contract will need to be modified if it does not include provisions of payment for the proposed work.

9.12.1.2.1.1.2 For illustrative purposes, assume a dam safety modification cost of $15 million, and a formal cost allocation that assigns 60% of the construction costs to hydropower, (with 45% as the hydropower joint-use construction costs); and 40% of the construction costs to flood control. Under this example, hydropower interests would have to repay $1,012,500 [($15,000,000 x 0.15) x 0.45].

9.12.1.2.1.1.3 If there was no sharing of· the initial construction costs (either cash or the value of real estate) allocated to flood risk management, all of the modification costs assigned to flood risk management would be Federal.

9.12.1.2.1.1.4 If a sponsor shared in the initial construction costs allocated to flood risk management (either cash or the value of real estate), the dam safety costs assigned to flood risk management would be shared on the same percentage basis.

9.12.1.2.1.2 In cases where storage is reallocated from flood risk management to another purpose, the sponsor for the added purpose is responsible for repaying a share of the dam safety modification costs. For example, if a contract is executed for water supply that assigned 1.5% of the joint-use cost of major replacements to a water supply sponsor, this sponsor would be required to repay $33,750 of the dam safety costs [($15,000,000 x 0.15) x 0.015].

9.12.1.2.2 Projects without a Formal Cost Allocation, but with a signed Project Partnership Agreement or Project Cooperation Agreement or Local Cooperation

Agreement: An agreement for the initial project construction may contain an allocation or assignment of costs among project purposes.

9.12.1.2.2.1 For projects with this type of agreement, 15% of the cost of the dam safety modification shall be assigned to project purposes in the same manner as costs were allocated for the agreement, and shared in the same percentage according to the terms of the agreement. The percent joint-use facilities cost should be used if available; otherwise, the assignment is based on the percent of total cost.

9.12.1.2.2.2 As before, assume a dam safety modification of $15,000,000; project agreement requiring a sponsor to provide a one-time payment of $3,000,000 (5%) toward the construction of a project with an actual initial construction cost of $60,000,000. The sponsor in this example would be required to repay $112,500 [($15,000,000 x 0.15) x 0.05].

9.12.1.2.3 Projects without a Formal Cost Allocation or a signed agreement: In most cases where there is no signed agreement, there was some sort of a letter of intent at the time of construction that indicated what items of local cooperation that non-Federal interests would provide, such as lands, easements, rights-of-way, relocations, or disposal areas (LRRED).

9.12.1.2.3.1 These projects will require a review of letters of intent or other documentation of arrangements for provision of LERRD, or of cash contributions by a sponsor at the time of project construction. If a sponsor accomplished some portion of the required work, such as relocations, or made cash contribution, the value of the work or the contribution should be converted to a percent of total initial project cost. Fifteen percent of the cost of the dam safety modification will be shared in the same percentage as the percentage of total initial project cost, computing the non-Federal share as the percent of contribution to total cost. The percentage should be computed based on actual rather than estimated cost of construction, if available.

9.12.1.2.3.2 For example, if the actual construction cost was $50,000,000, and non-Federal interests contributed LERRD's valued at $500,000, the non-Federal share of initial construction was 1%. In this case the non-Federal share of a $15 million dam safety assurance modification would be $22,500 [($15,000,000 x 0.15) x 0.01].

9.12.1.2.4 Contract for Storage. In some cases water supply storage may have been reallocated from conservation or from flood control storage. The agreement for the reallocation of storage is a contract. The terms of the contract will specify what storage capacity is provided in return for the payment amount. The contract usually defines how the amount paid by the contract holder was computed and shows the basis for the assignment of costs. The share of cost to be paid for the dam safety modification should be allocated in the same percent as the cost of joint use facilities was allocated. In such a case, the contract will need to be modified if it does not include a provision for payment of the proposed work.

9.12.2 Seepage/Stability Corrections do not qualify under Section 1203, WRDA 1986 (reference A-103). Therefore, 100% of the modifications shall be cost shared in accordance with current cost sharing policy as defined below.

9.12.2.1 Projects with a formal agreement with a non-Federal sponsor that identifies the cost sharing percentages for major rehabilitation or dam safety modifications shall be cost shared in accordance with the current agreement (contract).

9.12.2.2 Projects without a formal agreement will be cost shared at the same ratio as the original cost sharing for the project.

9.12.3 Special Cost Sharing for Navigation and Hydropower.

9.12.3.1 For navigation projects, dam safety modifications shall be cost shared by the Inland Waterways Trust fund or the Harbor Maintenance Trust Fund in accordance with WRDA 1986 as amended (reference A.99).

9.12.3.2 For hydropower dam safety modifications, costs are reimbursed, over time, by the affected Power Marketing Administration (PMA) in accordance with the joint use percentage for that particular dam.

9.12.3.3 Cost sharing for major maintenance work under the Operation and Maintenance account will be the same as cost sharing for ordinary annual operations and maintenance.

9.13 Sponsor Identification. Requirements for cost sharing sponsorship, and the identification of non-Federal sponsors shall occur very early in the study process to ensure that the non-Federal interests are willing cost share partners. Uncertainty about sponsorship and the lack of meaningful sponsor involvement in the scope and extent of dam safety repairs can cause delays to the dam safety modification work. Before initiating discussions with project sponsors on cost sharing, an interpretation on the need for sponsorship and the application of the generic guidance contained in this regulation shall be forwarded to HQUSACE, ATTN: Dam Safety Officer for information. This should occur within 60 days after the DSM is started and study funding is received.

9.13.1 Reports shall include documentation of substantive involvement and coordination with non-Federal sponsors, and expressions of their willingness to cost share in the dam safety assurance work when required

9.13.2 On projects classified as DSAC I or II, the lack of sponsor identification shall not delay completion of the report. When a sponsor cannot be identified, the district shall notify HQUSACE, ATTN: Dam Safety Officer, and request that project work continue without cost sharing due to the risk to public safety. Efforts shall continue to find the appropriate sponsor for the modification and recoup the non-Federal share of the modification cost. Extension of Interim Risk Reduction Measures, including permanent extension, shall be considered in lieu of the dam safety modification in those

cases where a non-Federal sponsor is unwilling or unable to participated as the cost share partner.

9.14 Cost Recovery. Recovery of the non-Federal share of the dam safety modification cost will be determined by the current arrangement for project cost recovery.

9.14.1 For costs that are reimbursable through the sale of power, the share of dam safety cost under Section 1203 will be reported to the power marketing administration for recovery in the same manner as major rehabilitation costs.

9.14.2 For cost sharing based on a project partnership agreement that does not have a provision for dam safety cost sharing, the agreement will need to be modified to include the dam safety costs, or a new agreement will be required.

9.14.3 Where the project cost sharing was based on a letter of intent, an agreement will be negotiated with the sponsor.

9.14.4 In the case of water supply, the existing contract may need to be modified, or a new contract signed to cover the dam safety cost sharing.

9.14.5 If no current agreement addresses repayment of this cost, the sponsor may elect to repay the cost, with interest, over a period up to 30 years in accordance with the provisions of Section 1203 (a) (2) of the Water Resources Development Act of 1986. If a sponsor is unwilling or unable to cost share the modification, the district/division will either seek authorization to terminate the project or perform the dam safety modification at 100% Federal cost and seek reimbursement from the sponsor through litigation, or extend the Interim Risk Reduction Measures until a non-Federal sponsor can be identified.

CHAPTER 10

Dam Safety Risk Communication

10.1 Purpose/Objective. This chapter provides guidance for the USACE to integrate risk communication into routine dam safety program activities, and develop communication strategies when conducting dam safety evaluations and risk reduction actions. Key points are use of the Dam Safety Action Classification System, the Dam Safety Portfolio Risk Management for the USACE portfolio of dams using the principles outlined in Chapters 2 and 3, and the importance of internal PDT communications on a "typical" dam safety project.

10.2 USACE Dam Safety Risk Communication Philosophy.

10.2.1 Risk communication is a management/leadership process and responsibility. It involves more than only the public affairs staff.

10.2.2 Risk communication is an open, honest, genuine, sincere exchange of information with affected stakeholders. It requires planning, practice and preparation. It helps USACE focus on its mission, build better relationships with stakeholders and drives better risk management decisions.

10.2.3 Communication about risk is equally important as the steps taken to determine the risks associated with a project. An informed public is safer because individuals are able to make risk-informed decisions about their personal safety. Communicating risk to the public is a shared responsibility among federal, state, local agencies and local stakeholders.

10.2.3.1 For example, USACE works closely with respective state and local emergency officials to ensure they have the information they need to fulfill their emergency management responsibilities to protect public health, safety and welfare.

10.2.3.2 Concerning the public affected by a high-risk project, information security must be balanced with information essential for individuals to make informed decisions about their safety. There are no simple solutions to communicating risk, but open and honest dialogue, along with diligent efforts at the local level, have proven successful when informing stakeholders about USACE highest risk projects.

10.2.4 USACE is responsible to protect public safety by effectively communicating risks associated with USACE-owned dams, while also protecting security interests.

10.2.5 A dam is adequately safe when it meets all essential USACE engineering guidelines and the residual risk is considered tolerable.

10.2.6 While risk communication is necessary when confirmed unsafe dam safety issues are identified, it is equally important when unconfirmed or potentially unsafe dam

safety issues are present that could have life safety, economic, or environmental consequences.

10.3 Understanding Tolerable Risks.

10.3.1 USACE operates more than 600 dams that range in age from less than 10 years old to more than 100 years old. These projects serve multiple purposes and span the range of construction methods and materials, and geographic settings, etc. USACE has a responsibility to educate internal and external stakeholders that the USACE dams are well constructed based on the state of practice and best science at that time, and have generally performed well. However, these structures do not have an indefinite life cycle and individual dams vary in their condition and risk potential. The public may falsely perceive that they are “safe” for a wide range of conditions, but the results of the USACE Screening for Portfolio Risk Analysis (SPRA) initiative conducted from 2005-2010 and risk assessments of specific dams have told us otherwise. These findings support the agency’s transition to a risk informed dam safety program and related decision making. More important to the longer term implementation of our dam safety program, however, are the lessons learned about how to continually adjust and refine the program. We are a learning organization and have recognized the need to build upon changes and improvements to the state of the practice in all aspects of flood risk management, which allows better assessment of risk and uncertainty, and therefore reduce public safety and economic risks.

10.3.2 The key to assessing safety is whether the residual risk for an individual dam is tolerable and that the dam meets essential USACE safety guidelines. An informed public better understands risk and can contribute to discussions of deciding how far to lower the risk and take on some degree of responsibility for their safety.

10.3.2.1 Tolerable Risk. ‘Tolerable’ does not mean ‘acceptable’. Tolerable refers to a willingness to live with a risk to secure certain benefits and with confidence that it is being properly managed. Tolerable risk is not regarded as negligible or something to ignore. It must, however be kept under review and reduced further if possible. For a risk to be ‘broadly acceptable’ on the other hand means that "for purposes of life or work, we are prepared to take it pretty well as it is." (HSE 1992) (Reference A.102) (See Chapter 5 of this regulation for more details).

10.3.2.2 Tolerable Risk Guidelines. Tolerable risk guidelines are used in risk management to guide the process of examining and judging the significance of estimated risks obtained using risk assessment. The outcomes of risk assessment are inputs to the risk management decision process along with other considerations. Meeting or achieving the tolerable risk guidelines is the goal for all risk reduction measures including permanent and interim measures. Reference is made to Chapters 2, 5, 6 and 8 for additional information.

10.3.3 Communication Shapes Risk-Informed Decisions. Risk communication is integral to decisions on interim and permanent risk reduction actions. Risk

communication ensures that decision makers, stakeholders, and affected publics understand potential short term and long term impacts and risks. Some may be willing to temporarily accept risks that exceed USACE tolerable risk guidelines and do not meet essential guidelines, if operating the dam serves a significant benefit or benefits. For example, the level of a reservoir operating restriction may be refined based on stakeholder and public feedback. Knowing their degree of risk allows people who feel they are not adequately protected to make individual decisions about their personal safety. This includes taking actions such as purchasing weather alert radios and developing evacuation plans.

10.4 Communication Planning. Dam safety issues must be coordinated within USACE and with the public and affected stakeholders. Examples of stakeholders requiring identification include but not limited to**,** neighboring dam owners, emergency managers, recreation partners, hydropower marketing agencies, irrigators, water supply contractors, and Dam Safety Regulating agencies.

10.4.1 Districts must clarify roles and responsibilities when organizing meetings and coordinating media events and will develop a detailed communication plan with a roles and responsibilities matrix to synchronize communication efforts.

10.4.2 Dam safety risk communication may also be required for routine project activities, such as dewatering, inspections and maintenance work, and for non-routine remediation work and responses to unusual or emergency events, such as floods or earthquakes. Because each project has different characteristics, the level of detail and methodology of communication effort should be commensurate with the overall risk posed by the project. Minimally, the communication planning team shall include the Operating Project Manager, the Dam Safety Program Manager, and the Public Affairs Officer.

10.5 Communication of the USACE Dam Safety Action Classifications.

10.5.1 In the past, the USACE dam safety program essentially recognized two categories of actions: those for dams considered safe, which comprised routine dam safety activities, normal operation and maintenance; and those for dams considered in need of remediation, for which investigations, remediation funding justification documents, and design and construction of remediation measures were additional activities. However, these two categories do not provide formal recognition of an adequate range of actions and degrees of urgency, especially for dams with significant issues or extremely high risk.

10.5.2 The USACE Dam Safety Action Classification is the framework by which USACE provides consistent and systematic guidelines for appropriate actions to address the dam safety issues and deficiencies of USACE dams. MSCs and districts may not reinterpret or redefine the Dam Safety Action Classification or project assignments. DSAC values should only be used in conducting internal communications with USACE staff. However, in coordinating with the public, the descriptions assigned

to each class (Urgent and Compelling, Urgent, High Priority, Priority and Normal), as well as the safety designations should be used, in lieu of the terms “DSAC I”, “DSAC II,” etc.

10.5.3 Appendix F provides information on the DSAC system. Appendix U includes examples of Frequently Asked Questions and Answers that may be useful in preparing for internal and external communication.

10.5.4 Risk-informed decision making, which drives action for IRRM and remediation, includes public communication about an unsafe project. Clearly communicating risks to the public is challenging, but necessary. In many cases the public perceives safety as being related only to probability of failure, regardless of consequences. We should not, however, miss the opportunity to discuss what is driving some of the risks and the very important responsibility and role the public and local governments have in managing their risks (consequence management).

10.5.5 DSAC ratings have the potential to cause concern among uninformed district staff and affected communities near the dam. Districts shall initiate notification planning shortly after receiving project specific DSAC rating. The Operating Project Manager should collaborate with the Dam Safety Program Manager, Dam Safety Officer, and the Public Affairs Officer to craft a strategy.

10.5.6 District leadership should brief district personnel prior to providing information to the public. The MSC and HQUSACE Dam Safety Officers must also be engaged for high risk, controversial, or locally sensitive issues. Leaders shall explain the situation and assure employees that appropriate details will be shared with the public. Any message to employees delivered prior to public communication should be delivered as FOUO.

10.6 DSAC I and II Communication Strategies.

10.6.1 Districts shall develop timely communication plans for DSAC I and II projects to inform key community leaders and affected stakeholders.

10.6.2 Engagement, awareness and understanding of the communication plan at all levels of district and MSC leadership are imperative to ensure adequate opportunity for full understanding of input and guidance. MSCs must also coordinate with HQUSACE to ensure consistency of key messages and strategies.

10.6.3 Districts shall not conduct external coordination prior to approval of the project specific Interim Risk Reduction Measures (IRRM) Plans, which shall include a Communication Plan unless, coordinated with the vertical team. Per Chapter 7, IRRM Plans for DSAC I and II projects are approved by the MSC Dam Safety Officer

10.7 Public Meetings and Stakeholder Involvement.

10.7.1 For security reasons, numerical risk results and aggregate lists of the Dam Safety Action classifications shall not be released to the public. Regional and project specific information may be shared with stakeholders, adjacent and potentially impacted dam owners, emergency responders and Congressional interests, designated as For Official Use Only. The HQUSACE Dam Safety Special Assistant and HQUSACE Homeland Security Office must approve release of aggregate information and FOUO reports, on a case by case basis. Release of inundation maps and information will be in accordance with Interim USACE Policy on Release of Inundation Maps, dated 10 May 2007 (reference A.77).

10.7.2 Prior to external coordination, fact sheets, press releases, and other informational products will be furnished to the MSC and HQ Public Affairs and Dam Safety Officers, applicable State Dam Safety Officials, and neighboring dam owners who may receive media inquiries.

10.7.3 It is extremely important that community leadership understands the issue when/if the public asks questions. Similarly, the district must ensure that USACE is the primary release of information to the public about its respective project dam safety risks. USACE has an obligation to educate and inform affected stakeholders about the risks associated with its projects. Withholding information because of potential embarrassment is not appropriate.

10.7.4 Dam safety is an extremely technical subject and it is important that information presented is understandable. Visual aids, such as physical models, drawings or cut-a-ways of the dam to help explain the technical issues during briefings may be particularly useful.

10.7.5 When scheduling external briefings, recommend using normal meetings/coordination opportunities, unless the project is a DSAC Class I or II dam where immediate risk reduction actions are required, such as operating restriction.

10.8 Emergency Risk Communications.

10.8.1 Local authorities, counties, and states may have plans for multiple disasters or for a specific disaster such as a dam failure. These plans provide detailed instructions for agencies and individuals for responding to emergencies and may include threat recognition, emergency action message formulation, message dissemination to authorities and the public, provisions for search and rescue, and early stages of recovery.

10.8.2 During a dam safety emergency, Reporting of Distress within USACE shall be conducted in accordance with Chapter 13. The district Dam Safety Officer shall take immediate actions to notify the USACE Dam Safety Officer, through the Chain of

Command, and mobilize a team to expediently develop a communication plan, including notifying key stakeholders and Congressional interests, and issuing press releases.

10.8.3 It is important that USACE field personnel establish relationships with downstream officials and stakeholders, and maintain accurate lists of contacts in preparation for emergency events.

10.8.4 Notification lists for emergency action plans shall be updated annually. Face-to-face interaction with the local emergency response entities is also strongly encouraged. Copies of the emergency action plans shall be furnished to appropriate emergency response agencies. Release shall be considered as FOUO. Emergency action plans and corresponding inundation mapping can be furnished to the public or media in accordance with Interim USACE Policy on Release of Inundation Maps, dated 10 May 2007 (reference A-80).

10.8.5 Preparation for real time emergency notifications can be greatly enhanced by including local officials and emergency response agencies at emergency exercises and project specific dam safety training sessions.

10.9 Internal PDT Communications. As outlined above, proper external communication of risk is a key component to ensure the success of a dam safety project. Equally important is the proper internal communication within the PDT as a project moves through its various phases (issue identification and analysis, planning, E&D, and construction). Communication within the PDT can be particularly challenging as it routinely involves internal district coordination as well as coordination with several vertical elements (MSC, HQ, RMC, stakeholders, etc…) throughout a project's life. For this reason it is vital that team members are selected who possess a solid combination of both technical and communication skills - particularly the lead engineer and project manager positions.

CHAPTER 11

Periodic Inspection, Periodic Assessment and Continuing Evaluation

11.1 Applicability and Policy. This chapter on Periodic Inspection, Periodic Assessment, and Continuing Evaluation is applicable to Civil Works structures including dams, navigation structures, and other water control facilities.

11.1.1 Periodic Inspections are recurrent engineering inspections conducted at dams and other civil works structures whose failure or partial failure could jeopardize the operational integrity of the project, endanger the lives and safety of the public or cause substantial property damage to ensure their structural stability, safety, and operational adequacy.

11.1.2 Periodic Assessments consist of a periodic inspection, a potential failure modes analysis, and a risk assessment based on existing data and a minimum development of limited consequence data.

11.2 Institutional Knowledge and Technical Expertise. It is essential that USACE maintain institutional knowledge and technical expertise in the disciplines related to dam design and dam safety, including risk assessment and forensic engineering. An important component of this knowledge is gained by conducting periodic inspections, periodic assessments and evaluations by district and MSC engineering, construction, and operations personnel. Lessons learned by multi-disciplinary assessment and inspection teams over a long period of observations and analyses can be applied to the design, construction, operation, and maintenance of existing and future projects.

11.2.1 Periodic inspections and assessments of significant and high hazard potential structures shall not be contracted. Where in-house manpower constraints exist, inspections and assessments may be augmented, in order of preference, by (1) use of trained and experienced USACE personnel from other districts, or other MSC's, on a fully reimbursable basis; or by (2) contracting for individual qualified personnel as inspection participants for highly specialized functions, such as underwater diving or camera work, or other tasks requiring special skills or equipment not readily available in the USACE.

11.2.2 It cannot be over emphasized that inspections should be done with licensed Professional Engineers present. Care must be taken to maintain in-house capability for the on-site conduct of the program and continue to keep the involved disciplines (design, construction, and operations personnel) fully integrated in project inspections and assessments. This does not imply the necessity for maintaining all technical disciplines in all districts. It may be in the best interests of the project and smaller districts to let other districts assist in the management their dam safety programs.

11.3 Inspection and Assessment Policy. Civil Works structures whose failure or partial failure could result in loss of life or major damage to permanent structures, utilities, or transportation facilities shall be periodically inspected and assessed to ensure structural stability, safety, and operational adequacy. This policy is to be accomplished using risk assessment and management tools provided by HQUSACE as follows:

11.3.1 Appropriate instrumentation programs that provide timely and accurate data for evaluations under all operating conditions shall support visual inspections and periodic assessments. During periods when a reservoir is, or is expected to be, above the maximum pool of record or above a potential "triggering" threshold level established from past performance, an appropriate team shall be dispatched to monitor and evaluate performance and verify the adequacy of flood and outlet control gates and other equipment, which facilitate downstream releases. A report of performance outlining the findings and evaluation shall be prepared and documented in a memorandum with copy furnished to the MSC for information within 14 days after the event. Evaluation reports shall provide a basis for initiating timely remedial or rehabilitation measures.

11.3.2 The operating entity of facilities constructed by USACE and turned over to others for operation and maintenance is responsible for periodic inspections after the first and second periodic inspections. USACE may conduct subsequent inspections and write a report on behalf of the Project Sponsor, provided appropriate procedural and financial reimbursement arrangements are made. Inspections shall be conducted in accordance with appropriate guidance contained in the operation and maintenance manual for the facility and in accordance with applicable portions of this regulation. In addition, any inspection responsibilities established by the Project Cooperation Agreement (PCA) shall be related to the operating entity at the time of their acceptance of the structure. Dams built by USACE and turned over to others for Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) shall include in the Operation and Maintenance (O&M) manual, a requirement that USACE conducts inspections/assessments in accordance with this regulation. These inspections are to ensure design/construction quality. USACE is responsible for the first and second periodic inspections. See Policy Guidance Letter No. 39, dated 13 November 1992 (reference A.77) for USACE and sponsor responsibilities.

11.3.3 Under the authority of ER 1130-2-530 (reference A.63), USACE shall participate in inspections/assessments of a sponsor-operated and maintained structure (e.g., local flood protection project) to ensure that the structure is conforming to the requirements of the PCA, the agreed upon inspection program, and the operation and maintenance program. USACE participation in these inspections shall be funded under Inspection of Completed Works (ICW) Program.

11.3.4 In cases where ownership, operation, maintenance, or other activities at a project or its major elements are divided between USACE and other organizations, private sector (e.g., power plants), government or municipal, USACE shall inspect and/or assess using risk and reliability tools, those features of non-USACE elements

that could adversely affect the stability, safety, or operational adequacy of any USACE owned, operated, maintained, or otherwise related portion of the project, including features not constructed by the USACE.

11.3.5 Non-Federal dams located upstream or downstream of a USACE project may potentially affect the safety of a USACE project. A list of significant dams upstream or downstream and their points of contact must be prepared and maintained in the project Emergency Action Plan (EAP). When inspecting/assessing a USACE structure or project it may be appropriate to evaluate the safety of the upstream or downstream non-Federal dam(s) and to ascertain operational procedures or emergency situations that could make excessive demands on a USACE project. When failure of a neighboring non-Federal structure would cause overtopping or other major damage to USACE project, USACE shall obtain and review the current comprehensive inspection report, such as a Federal Energy Regulatory Commission (FERC) or State Dam Safety Agency report, for the non-Federal structure. If the non-Federal project has not been inspected within the last five years, USACE shall coordinate with the owner and the regulatory authority to have the dam inspected. Every effort shall be made to encourage owners of such projects to comply with the inspection requirements in the Model State Dam Safety Program (FEMA Publication 316) (reference A.73).

11.3.6 Federally owned dams (non-USACE) on a military installation might have a substantial bearing on the safety of life and endanger downstream property. USACE, on request of the installation, may inspect, and/or assess these dams on a cost reimbursable basis. Requests are to be coordinated with HQUSACE DSPM. This policy extends to non-federally owned dams on a military installation where the safety of life and Federal property are in jeopardy from probability of a failure. These inspections and assessments shall be performed and documented in the same manner as the inspections of USACE dams, except that the reports should be forwarded to the Installation Management Agency and to the owner of the dam if not owned by the installation.

11.4 Program Implementation. A periodic and comprehensive inspection and assessment schedule shall be established based on the project size, importance, and hazard/risk potential. Other inspections, including intermediate, informal, and annual inspections, may be conducted between Periodic Inspections/Assessments. MSC Dam Safety Officers are responsible for management and oversight of the periodic inspection/assessment program. District Dam Safety Officers are responsible for implementing the inspection and periodic assessment program.

11.4.1 Frequency of Inspections/Assessments. Inspections/Assessments of all water control facilities shall be conducted as outlined below:

11.4.1.1 Dams and Appurtenant Structures. All dams are included in the Dam Safety Program without regard to the hazard potential classification of the dam. The guidance for developing the interval for initial inspections and subsequent periodic inspections /assessments of dams and appurtenant structures set forth in the following

subparagraphs does not preclude other intervals as the situation or structural integrity warrants. Nor does this guidance preclude the surveillance plan for the initial filling of USACE reservoirs as prescribed by ER 1110-2-1150 (reference A.51) and chapter 17 of this regulation.

11.4.1.1.1 Initial Periodic Inspection. The first periodic inspection and evaluation of a dam shall be carried out prior to impoundment of the pool; however, if involuntary impoundment occurs before the first inspection is accomplished; the inspection shall be performed at that time. This inspection will be funded using Construction funds. The initial periodic inspection of navigation locks shall be made immediately prior to flooding of cofferdams, culverts or chambers.

11.4.1.1.2 Subsequent Periodic Inspections. A second periodic inspection for new dams shall be performed no later than one year after impoundment is initiated. The 3rd and 4th periodic inspections shall also be performed at one-year intervals. The 5th and 6th periodic inspections shall be performed at two-year intervals. Subsequent periodic inspection intervals may then be extended to a maximum of five years with a periodic assessment, which includes the periodic inspection, held at intervals not to exceed ten years, i.e., at alternating periodic inspections. Inspection intervals more frequent than indicated above shall be scheduled, if conditions warrant, as approved by the district Dam Safety Officer. The second and all subsequent regular Periodic Inspections will be funded with Operations and Maintenance funds.

11.4.1.1.3 Special Inspections. Special inspections should be performed immediately after the dam has passed unusually large floods and after the occurrence of significant earthquakes, sabotage, or other unusual events reported by operating personnel.

11.4.1.1.4 Periodic Assessments. Periodic Assessment (PA) of projects shall be conducted as determined by risk factors, but they shall not exceed a ten-year interval. Initial periodic assessments involve a greater level of effort due to the data gathering and documentation requirements. Once completed, this information will be available for future assessments, and data collected in the interim and performance history will be added to the subsequent reports. The periodic assessment will generally be accomplished in conjunction with a periodic inspection. The district will coordinate schedule and resources for initial periodic assessments with the Risk Management Center.

11.4.1.1.5 Intermediate Inspections. For projects on five-year alternating cycle of periodic inspections and periodic assessments, an intermediate inspection of all or some of the features may be scheduled, if warranted. Selection shall be based on consequences of failure, age, degree of routine observation, performance record and history of remedial measures. Intermediate inspections shall also be made of any portion of a project exposed during dewatering that could not be accomplished during the scheduled periodic inspection. Completion of dam modifications, e.g., major rehabilitations, addition of appurtenance structures, addition of hydropower, etc.,

requires a series of intermediate inspections to determine effect and performance of new work. A summary of the findings from intermediate inspections is to be included in the next periodic inspection report. Annual inspections performed by Operations personnel, in accordance with ER 1130-2-530 (reference A.63), are mandatory for all high hazard potential dams, shall include district dam safety personnel, and are considered intermediate inspections for reporting purposes. As per Federal Guidelines for Dam Safety (reference A.71), annual inspections should include a thorough field inspection of the dam and appurtenant structures, and a review of the records of inspections made at and following the last periodic inspection. If unusual conditions are observed that are outside the expertise of these inspectors, arrangements should be made for inspections to be conducted by specialists.

11.4.1.1.6 Informal Inspections. Appropriate employees at the project shall make frequent observations of the dam and appurtenant structures. The purpose is to identify and report abnormal conditions and evidence of distress in accordance with training instructions and guidance. Any unusual conditions that seem critical or dangerous shall be reported immediately as Evidence of Distress, using proper procedures and channels to the DSO, as required by Chapter 13, paragraph 13.4, of this regulation, and the Emergency Action Plan Notification Plan for the project

11.4.1.2 Other Structures. The district is responsible for establishing periodic inspection and periodic assessments intervals, for other USACE-owned and -operated water control facilities. Inspection intervals must be defined in the project Operation and Maintenance (O&M) manual using a risk informed approach and methodologies. Projects designed and constructed by the USACE, but operated and maintained by the sponsor, shall also have inspection intervals defined in the O&M manual.

11.4.1.3 Hydraulic Steel Structures (HSS). ER 1110-2-8157 (reference A.60) requires fracture critical members to be inspected every five years and that all HSS be inspected not to exceed 25 years, even if dewatering is required. Based on the baseline and/or subsequent Periodic Assessment, a frequency shorter than every five, or 25 years may be necessary. When several of the same type of HSS exists at a project, at least one of each type of HSS must be inspected as part of each periodic inspection. A different HSS should be selected for each inspection. For HSS whose failure could result in loss of life, the critical components should be subjected to at least a thorough visual examination during each inspection. Hydraulic Steel Structures include lock gates, dam spillway gates, tainter valves, flood protection gates, stop logs, bulkheads, and lifting beams used for installing other Hydraulic Steel Structures. A summary of findings and deficiencies from the HSS inspection shall be included in the next subsequent periodic inspection report.

11.4.1.4 Stilling basins. When feasible, stilling basins shall be dewatered for inspection for each periodic inspection if there have been significant releases through the stilling basin or potential damage or wear is suspected. If no significant releases through the stilling basin have occurred, or there is no suspicion of damage or wear, the schedule for dewatering may be deferred until the next periodic inspection. The district

Dam Safety Officer may require a diver inspection or hydro-acoustic survey to verify that there is no significant debris in the basin or damage to the structure. When stilling basins cannot feasibly be dewatered, except for emergency repairs, diver inspections or hydro-acoustic surveys are recommended to be performed at five-year intervals. If there is a need, due to acceleration in erosion damage, then surveys may be necessary more frequently. Changes in the operational release patterns for environmental, fish and wildlife, or other purposes may warrant more frequent inspections of the stilling basin. After there have been significant releases through the stilling basin or potential damage or wear is suspected, the stilling basin shall be dewatered for a special inspection or an underwater inspection shall be performed immediately after the event.

11.4.2 Report. A formal technical report of periodic inspections and periodic assessments shall be prepared for permanent record and for reference for needed remedial work. These reports shall be based on a detailed, systematic technical inspection, and appropriate risk assessment methodology for each structure and its individual components regarding its safety, stability, structural integrity, operational adequacy, and risk of failure. A summary of findings from intermediate inspections shall be included in an appendix. See Appendices V and W for report content and format of PI reports and PA reports, respectively, and Appendix X for details on PFMA procedures and documentation.

11.4.2.1 Inspections or routine observations indicating that the safety of a structure is in jeopardy shall be reported in accordance with Chapter 13 of this regulation.

11.4.2.2 Inspections/assessments indicating necessity for project modifications, major repairs, rehabilitation, replacement or need for further study beyond the scope of normal maintenance shall be reported to the MSC Dam Safety Officer in the memorandum transmitting the report. Reports of conditions requiring modification shall contain a statement as to whether studies shall be pursued under Operations and Maintenance Program or Dam Safety Modification Program.

11.4.2.3 The Executive Summary of the reports shall be provided electronically to HQUSACE Dam Safety Program Manager (HQ-DamSafety@usace.army.mil) and the MSC Dam Safety Program Manager within 90 days of completion of the periodic inspection, or assessment. See Appendix V of this regulation for information on preparing and submitting the Executive Summary. The Executive Summary shall also be entered into the Dam Safety Program Management Tools (DSPMT) database within 90 days.

11.4.3 Report Completion and Submittal Schedule. Two printed copies of the reports shall be submitted by the district to the MSC Dam Safety Officer within 90 days after the inspection. The district shall establish completion and tracking standards for the review of periodic inspection and periodic assessment reports (District Quality Control Review for Periodic Inspection reports and Agency Technical Review for Periodic Assessment reports.) The submission shall include all review comments and the resolution of the comments. The district Dam Safety Officer shall certify the review

and the reports prior to submittal to the MSC Dam Safety Officer. At least two printed copies shall be retained at the district and one printed copy submitted to ERDC. Reports Control Symbol (RCS) is exempt based on AR 335-15 (reference A.3). Each printed copy of the report shall also contain an electronic version of the report in the appropriate media (CD or DVD).

11.4.4 Report Approval. The MSC Dam Safety Officer is responsible for approval of all the inspection and assessment reports on dams operated and maintained by the USACE.

11.4.5 Distribution of Approved Inspection Reports.

11.4.5.1 Library Copy. Upon approval of the inspection report, one printed copy together with a copy of all correspondence bound under the front cover will be sent by the originating district directly to:

Commander, U.S. Army Engineer Research & Development Center
ATTN: Research Center Library
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

11.4.5.2 District Copies. The districts shall determine the distribution of printed reports within their respective offices, to include the project site, local sponsor, military installation, and other Federal agency and/or state agency, as deemed appropriate.

11.4.6 Obligation to Others. In cases where ownership, operation, maintenance, and other activities at a project or its major elements is divided between USACE and others, information pertinent to the condition of project elements owned, operated, or maintained, or otherwise affected by others, as observed by USACE' inspection or periodic assessment teams, shall be furnished to the co-owner. The district Dam Safety Officer shall furnish this information to the FERC, when hydroelectric power projects are under the purview of the Federal Power Act (41 Stat. 1063, U.S.C. 791-823) 10 June 1920, as amended (FPA) (reference A-112). Owners and operators of such FERC licensed facilities shall be advised that the information made available by USACE shall not be presented as representing results of inspections/assessments performed for the licensee by USACE and is not a substitute for the FERC inspection under the FPA.

11.5 Instrumentation. Instrumentation shall be continually monitored and data analyzed in a timely manner by a qualified engineer between periodic inspections to detect changing conditions in the facility. Plots and written assessments and evaluations of the instrumentation data shall be included in pre-inspection/assessment packets, and in periodic inspection reports.

11.6 Responsibilities.

11.6.1 District Dam Safety Officer. The district Dam Safety Officer shall be responsible for:

11.6.1.1 Formulating the inspection/assessment plans, conducting the inspections /assessments, processing and analyzing the results of the instrument observations, evaluating the condition of the structures, recommending the schedule of the next inspection/assessment, and preparing and submitting the resulting reports.

11.6.1.2 Coordinating with the district Operations, and Programs & Project Management (PPMD) Divisions to ensure sufficient funding for inspections, assessments and remedial measures is budgeted in the Operations and Maintenance, General account**,** prioritizing recommended remedial measures as necessary using HQUSACE national risk-informed priorities for major remedial measures.

11.6.1.3 Notifying the district Commander, the MSC Dam Safety Officer, and the USACE Dam Safety Officer when allocated funding is insufficient for conducting inspections or other activities required by USACE criteria and standards and the Federal Guidelines for Dam Safety (reference A.71).

11.6.1.4 Coordinating with Operations Division personnel of scheduled inspections /assessments and requesting their assistance and participation. For projects or structures being inspected for the first time, personnel from the Construction Division shall be invited to participate. A representative(s) of the sponsor and the appropriate State Dam Safety official(s) shall also be invited to attend the inspection. If hydropower is a feature of the project, the regional FERC office and any licensee shall be invited to the inspection.

11.6.1.5 Forwarding the approved periodic reports to the district Operations Division for implementation of any routine recommendations. The Dam Safety Officer shall coordinate with PPPMD and Operations Divisions to develop schedules and any funding prioritization based on the PIs and PAs.

11.6.1.6 Ensuring the inspection team is comprised of the technical, and where appropriate professionally registered, expertise necessary to execute a thorough and technically sound inspections and assessments. Lacking district expertise, the Dam Safety Officer shall obtain assistance from HQUSACE, MSC, or other districts. HQUSACE personnel will not normally participate in inspections unless requested, or when project conditions dictate. See Appendix V for further details.

11.6.1.7 Ensuring all recommendations made in the reports are resolved. If the recommendation is related to confirmed and unconfirmed dam safety issues and interim risk reduction measures, the district DSPM will update the DSPMT.

11.6.1.8 Updating the deficiency spreadsheet module screen 4.5 of the Dam Safety Program Management Tool software and assigning the DSPMT priority code 1 through 6 to each recommendation so the assigned priority can be tracked over time. Only Confirmed and Unconfirmed Dam Safety Issues and Interim Risk Reduction Measures should be updated to the NID/DSPMT.

11.6.1.9 Performing annual program review, see paragraph 11.7.

11.6.2 District Operations Division. The district Operations Division shall be responsible for:

11.6.2.1 Performing needed maintenance, such as mowing and dewatering, to support a thorough and safe inspection, and allowing full access to critical project features.

11.6.2.2 Accompanying the inspection/assessment team and providing the field support required for the team. The project staff shall be prepared during the inspection/assessments to operate those project components whose failure to operate properly could impair the operational capability and/or usability of the structure. Where the operation of these components is vital to the safe operation of the project under emergency conditions, the components shall be operated using emergency power to ensure the inspection/assessment team that all critical project features will function under emergency conditions or in the absence of the normal source of power. Testing of the emergency power source shall require, if possible, the maximum power demand expected under emergency conditions. Additional details and requirements are described in Appendix V.

11.6.2.3 Performing required preliminary inspections, such as Gate Operability and Capability Inspections, and furnishing completed reports to the inspection team.

11.6.2.4 Acting on inspection recommendations for routine O&M in a timely manner in accordance with the deficiency classification table in Appendix V.

11.6.2.5 Completing an annual inspection of all water control projects and providing documentation of the findings and status of previous recommended actions to the district DSPM.

11.6.2.6 Annual budgeting and funding of sufficient funds for the district DSO to execute the district’s Dam Safety Program.

11.6.3 District Programs and Project Management Division. The Programs and Project Management Division shall be responsible for:

11.6.3.1 Supporting the program with proper funding and shall coordinate and cooperate with the project sponsor as needed.

11.6.3.2 Ensuring the sponsor fulfills all terms of the applicable Project Cooperative Agreement, Local Cooperative Agreement, or other agreements based on Section 221 of the Flood Control Act of 1970 (PL 91-611) (reference A.108).

11.6.3.3 Coordinating the timely correction of all noted deficiencies with the project sponsor.

11.6.4 MSC Dam Safety Officer. The MSC Dam Safety Officer shall provide quality assurance, oversight and management for this program. As a minimum, the MSC Dam Safety Officer shall:

11.6.4.1 Provide representation at the first and second post construction inspections, the inspection of high hazard potential structures, and the inspection of structures whose condition or performance has warranted more frequent attention.

11.6.4.2 Provide oversight for the monitoring of data collection, processing, and assessment using risk informed methodology.

11.6.4.3 Retain approval authority for the frequency and scope of periodic assessments, and review/approve the schedules for them. Intervals in excess of 10 years require written request and approval by USACE Dam Safety Officer.

11.6.4.4 Provide oversight and review of the regional database using DSPMT to include schedules and history of project remedial measures, unless this information is otherwise recorded in an official database.

11.7 Program Review. At the end of each fiscal year, the district Dam Safety Officer shall review and set priorities for the recommended remedial actions for the next budget submission.

11.8 Reporting Distress. Refer to Chapter 13, paragraph 13.4, of this regulation for procedures when reporting evidence of distress.

11.9 Funding. Funding for all Dam Safety activities and reports preparation shall be budgeted in the minimum funding level of the district's fiscal year budget request for project operation and maintenance. Periodic inspections are considered routine, recurring actions that are budgetable in the initial O&M increment for each project. Costs incurred by HQUSACE and MSC personnel shall not funded by the district.

11.9.1 Funding During Construction. Funding for inspections and other Dam Safety activities for a project during the period of construction shall be under Cost Code 51, Appropriation 96X3122, Construction. The term "period of construction" is defined as the period from the issuance of the solicitation for the first construction contract to the date the district Commander notifies the sponsor in writing of the government's determination that construction is complete; or, to the date the Government takes beneficial occupancy (for solely USACE-retained projects).

11.9.2 Funding During Operations. Funding for inspections and other Dam Safety activities after the project components are placed in operation shall be under Appropriation 96X3123, Operation and Maintenance, General. Funding for periodic assessments shall be included in the minimum program of the Operations and Maintenance budget submission.

This Page Left Blank

CHAPTER 12

Operations and Maintenance Activities

12.1 General. The transition from construction to operation may consist of overlapping activities. Therefore, it is very important that problems encountered during construction be adequately documented and resolved prior to the operational phase. Rigorous and continuous vigilance, checking, and inspection, for as long as the dam is operational, are necessary for dam safety, as problems may occur following many years of trouble-free operation. This is particularly true for untested flood control dams where a significant percentage of the maximum head has not occurred. Guidance on control of construction is available in EM 1110-2-1911 (reference A.16). Operations and maintenance policies for flood control operations are covered in ER 1130-2-530 (reference A.63).

12.2 Operations and Maintenance Manual. The Operations and Maintenance (O&M) manual provides guidance and instructions to project personnel for proper operation and maintenance of the facility. The O&M manual contains a narrative summary of the critical dam features including design features with safety limits, equipment operating and testing procedures, instrumentation requirements, probable failure modes, a history of problems, and how those problems could adversely affect the structure under stress. The O&M manual shall be prepared during the construction phase and shall be updated as features are added to the project, when equipment is replaced, or when changes in project operations are implemented.

12.3 Project Geotechnical and Concrete Materials Completion Report for Major USACE Projects. ER 1110-1-1901 (reference A.44) requires, as part of the permanent project record, documentation of the as-constructed geotechnical and concrete materials aspects of all major, complex and unique engineered projects constructed by USACE, including all subsequent modifications. This report, shall be identified, scheduled, and resourced in the Project Management Plan (PMP). The information and data in this document shall be presented and discussed with the sponsor/owner. The report provides, in a single document, the significant information needed by the sponsor, USACE technical staff, and other team members to become familiar with the project. The report shall facilitate accurate, timely inspections and performance evaluations, and serve as the basis for developing and implementing appropriate and effective modifications, “flood fighting” efforts, and emergency and/or remedial actions to prevent flood damage or required as a result of unanticipated conditions or unsatisfactory performance.

12.4 Instrumentation and Monitoring. All USACE dams and other water control facilities are required to have a level of instrumentation that enables proper monitoring and evaluation of the structure during the construction period and under all operating conditions. Instrumentation systems are also expected to furnish data on structural behavior for application to future designs. Each dam or other water control structure shall have instrumentation to measure hydrostatic pressure, embankment and abutment

seepage, foundation under seepage, and displacement of major elements of the structure. Strong motion accelerometers are to be installed in structures located in designated seismic regions in accordance with ER 1110-2-103 (reference A.46). After a project is operational for several years, scheduled maintenance, repair, and replacement of instrumentation shall be part of the normal plan of operation. Instrumentation shall be properly maintained or replaced, as necessary, in order to obtain accurate and timely data. Readings shall be made at scheduled frequency and shall be properly recorded and analyzed. Detailed information on instrumentation for earth and rock fill dams is given in EM 1110-2-2300 (reference A.25) and EM 1110-2-1908 (reference A.15). Information on instrumentation for concrete dams is given in EM 1110-2-2200 (reference A.23) and EM 1110-2-4300 (reference A.30). Full reliance shall not be placed on instrumentation alone to find problems or to forecast performance since it is impossible to install sufficient instrumentation to monitor every possible problem area. An extremely important part of the monitoring program is visual observation to determine evidence of distress and unsatisfactory performance (reference A.90). Project personnel shall receive training in basic engineering considerations pertaining to major structures, with procedures for surveillance, monitoring, and reporting of potential problems, and with procedures for emergency operations.

12.5 Reporting Distress.

12.5.1 General. Evidence of distress in dams, and other water control structures shall be immediately reported to the district Dam Safety Officer. If an engineering evaluation of the evidence of distress indicates the need for immediate remedial action, the Dam Safety Officer shall immediately report such conditions through command channels to the USACE Dam Safety Officer. The USACE Dam Safety Officer shall notify the Director of Civil Works and the USACE Commander, if necessary.

12.5.2 Procedures. When evidence of distress is reported to the district Dam Safety Officer, the DSO shall confirm the situation and determine if an engineering evaluation of the condition is needed or remedial measures are required. Initial notification shall be made by telephone (or e-mail for minor distress) to the MSC Dam Safety Officer and Dam Safety Program Manager. The MSC DSO shall notify USACE DSO. If the USACE Dam Safety Officer cannot be contacted, the reporting office shall follow the notification sequence shown in HQUSACE Dam Safety Notification Plan. A narrative summary, with appropriate photographs, endorsed by the MSC Dam Safety Officer shall follow the initial notification. After actions report shall be prepared and submitted to the MSC and HQUSACE. A post distress inspection shall be performed to evaluate damages or changes caused by any event listed in Chapter 13 of this regulation. If the distress is significant enough to require operational restrictions, the implementation of restrictions shall be reported as well.

12.5.3 HQUSACE Dam Safety Notification Plan. The Corps Dam Safety Program Manager shall maintain and periodically publish an official HQUSACE Dam Safety Notification Plan. This plan shall be distributed electronically to all DSO's and DSPM's.

It shall be updated each January, or as needed, to ensure that names and telephone numbers are current and accurate. If none of the individuals on the notification plan can be reached, the HQUSACE Operations Center should be notified at (202) 761-1001.

12.6 Operations and Maintenance Program.

12.6.1 Operations activities for Dam Safety includes instrumentation readings, daily monitoring of the structures, routine equipment testing, and other work items included in the Operations and Maintenance Manual as routine operations items.

12.6.2 Maintenance activities are divided into two categories. Normal repair and rehabilitation work that does not qualify for funding under either the Dam Safety Assurance Program or the Major Rehabilitation Program shall be funded under the regular O&M Program. Work recommended in the Periodic Inspection Report shall be prioritized and funded through this program unless qualifying under another program.

12.6.2.1 Recurring Maintenance for Dam Safety includes maintenance of instrumentation, cleaning and flushing toe drains and relief wells, and other work items included in the Operations and Maintenance Manual as recurring maintenance items.

12.6.2.2 Major Maintenance for Dam Safety includes non-routine major repairs that exceed $2,000,000. Some examples of major maintenance include concrete and riprap repairs and/or replacements.

12.6.3 The establishment, maintenance, and control of vegetation pose Engineering, as well as routine maintenance considerations. In accordance with ETL 1110-2-571 (reference A.67), this guidance establishes minimum requirements for maintenance/control of vegetation at USACE-owned dams, abutments, spillways, inlet/outlet channels, and other appurtenances. Details concerns vegetation maintenance is included in Appendix Y.

This Page Left Blank

CHAPTER 13

Reporting Evidence of Distress in Civil Works Structures

13.1 Purpose. This chapter prescribes the responsibilities and procedures for the immediate notification to higher authority of evidence of major distress or potential failure of civil works projects. These procedures apply to projects under construction or currently in operation.

13.2 General. Evidence of distress in dams, levees, and other water control structures shall be immediately reported to the district Dam Safety Officer. If an evaluation of the evidence of distress indicates the need for immediate remedial action, the Dam Safety Officer shall, as soon as practical, report such conditions through command channels to the USACE Dam Safety Officer. Actions that could impact life safety shall take precedence over notifications to command. The USACE Dam Safety Officer shall notify the Director of Civil Works, the Deputy Commander for Civil Works and Contingency Operations, and the USACE Commander, if necessary.

13.3 Discussion. The intent of these requirements is to keep the USACE chain of command situational aware of dam safety-related issues by ensuring the immediate reporting, inspection, and follow-up evaluation of conditions that demonstrate evidence of distress or conditions that could result in a potential hazard at civil works projects. In all cases the overriding concern must be to get the information in the hands of the technical staff as quickly as possible so that appropriate evaluation and response decisions can be made. This is even more critical in cases involving severe distress (sinkholes, significant seepage, large slides, gate failures, etc…) because the response time may be critical in limiting damage and saving lives. In these types of situations it would be better to have a “chain of command violation” rather than lose valuable time in the reporting process. It would also be better to raise the alarm of concern on something that ultimately turned out to be only a moderate issue as opposed to under-reacting on a problem that turned out to be severe. It is not the intent for reporting requirements to ever interfere with the local responsibility to react appropriately in the event of severe distress. The primary focus must always remain on taking all necessary emergency measures with the appropriate notification following thereafter as quickly as possible.

13.4 Procedures.

13.4.1 When evidence of distress is reported to the district Dam Safety Officer, the DSO shall confirm the situation and determine if an engineering evaluation of the condition is needed or remedial measures are required. Initial notification shall be made by telephone to the MSC Dam Safety Officer and Dam Safety Program Manager, with follow-up documentation and digital photos via email or express mail. The MSC DSO shall notify USACE DSO. If the USACE Dam Safety Officer cannot be contacted, the reporting office shall follow the notification sequence shown in HQUSACE Notification Plan. A narrative summary with an assessment of risks, and with appropriate

photographs, endorsed by the MSC DSO shall follow the initial notification to the HQUSACE DSO and be recorded in the Dam Safety Program Management Tools (DSPMT). The DSPMT software contains a built-in mechanism to enter details of the observed distress. The use of DSPMT is encouraged because it has the capability to generate a report that can be promptly and simply attached to an e-mail.

13.4.2 After action reports shall be prepared and submitted to the MSC and HQUSACE. A post-distress field inspection, and if necessary, a periodic assessment of risk shall be performed to assess damages or physical changes caused by any event listed in the following subparagraph. If the distress is significant enough to require operational restrictions, the implementation of restrictions shall immediately be coordinated with the Special Assistant for Dam Safety. See Chapter 7 for guidance on interim risk reduction measures.

13.4.3 HQUSACE Dam Safety Notification Plan. The USACE Dam Safety Program Manager shall maintain and periodically publish an official HQUSACE Dam Safety Notification Plan. This plan shall be distributed electronically to all DSOs and DSPMs. It shall be updated each January, or as needed, to ensure that names and telephone numbers are current and accurate. If none of the individuals on the notification plan can be reached, the HQUSACE Operations Center should be notified at (202) 761-1001.

13.5 Signs of Distress. Typical examples of distress are:

13.5.1 Sloughs, settlement, or slides in embankments such as earth or rock fill dams, and bridge abutments or slopes of spillway, channels, and lock and dam abutments.

13.5.2 Evidence of piping, muddy water boils in the areas of a structure such as embankments, abutments, dam monoliths, outlet works structures, lock walls, or cofferdams.

13.5.3 Abnormal increase or decrease of flow from foundation drains, structural joints, or face drains of concrete dams.

13.5.4 Any increase in seepage quantities through or under embankments or in abutments.

13.5.5 Any significant change in pore-water pressure in either embankments or their foundations or abutments.

13.5.6 Any significant change in uplift pressures under concrete structures.

13.5.7 Unusual vertical or horizontal movement, bulges, or cracking of embankments, abutments, or structures.

13.5.8 Significant cracking of mass concrete structures, either during construction or after completion.

13.5.9 Sinkholes or local subsidence in the foundation of or adjacent to embankments or other pertinent structures critical to the safe operation of the project.

13.5.10 Excessive deflection, displacement, or vibration of concrete structures (e.g. tilting or sliding of intake towers, bridge piers, lock walls, or floodwalls).

13.5.11 Erratic movement, binding, excessive deflection, or vibration of outlet and spillway gates and large flow control valves.

13.5.12 Significant damage to any structure (e.g. barge damage to bridge piers/lock walls or ice flow damage to intake towers and access bridge piers, spillway erosion damage (lined and unlined), stilling basin damage, cavitation damage to outlet works and spillways).

13.5.13 Significant damage to, or changes in, structures, foundations, reservoir levels, groundwater conditions, and adjacent terrain as a result of seismic events. Special inspections for damages should be made immediately following the events as described in ER 1110-2-1802 (reference A.55).

13.5.14 Any other indications of distress or potential failure that could inhibit the operation of a project or endanger life and property.

13.5.15 Excessive vibration, binding, unusual noises, movements, or deflections of gate hoist operating equipment.

13.5.16 Actual hydraulic equipment operating pressure in excess of 125% of the normal operating pressure. Electric motor operating equipment overheating or stalling.

13.5.17 Erratic movement or unusual sounds such as bumping, jumping, or popping miter gates.

13.5.18 Wire rope lifting cables or lifting chains having broken strands or deformed, worn, or severely corroded links.

13.5.19 Frequent power interruptions.

13.5.20 Excessive movement of penstock flexible couplings.

13.5.21 Penstocks or turbine spiral cases that show signs of distress such as deformation or cracking.

13.5.22 Failure of major mechanical or electrical equipment at locks and dams or local flood protection projects.

13.6 Inspections. Special inspections to evaluate damages or changes should be made immediately following any of the events outlined above. Results of these inspections and associated recommendations should be forwarded to the district Dam Safety Officer. The report should include what is believed to have lead to the situation, a description of the incident, damage occurred, distress seen, etc. Actions taken to remedy and future changes to surveillance and monitoring plans. The Risk Management Center will maintain a record of these reports to help in identifying trends and/or reoccurring problems. The DSO shall ensure that this information is promptly communicated through command channels (MSC and HQUSACE) so that appropriate decisions regarding the project's DSAC rating and national priority can be made. HQUSACE will ensure proper coordination and involvement of the Risk Management Center.

CHAPTER 14

Instrumentation for Safety Evaluations of Civil Works Structures

14.1 Policy. All Civil Works water control projects shall have an adequate level of instrumentation to enable design engineers to monitor and evaluate the safe performance of the structures during the construction period and under all operating conditions. The term "project" includes all dams, appurtenant structures, facilities, saddle dams, and any other feature whose failure or malfunction would cause loss of life, severe property damage, or inability to perform the authorized purpose.

14.1.1 The District Dam Safety Officer is responsible to ensure projects are adequately monitored and shall advise the District Commander, MSC, and Headquarters (HQ) if performance does not comply with safety thresholds or suggests distress of the structure. Concerns regarding the adequacy of instrumentation, funding, frequencies, procedures, and staffing shall be elevated to the Dam Safety Officer for resolution with District Senior leadership.

14.1.2 Appropriate instrumentation and monitoring frequency shall be based on that Dam's potential failure modes analysis. Seepage for example is a pervasive risk driver within the USACE inventory of dams. Districts must ensure that critical seepage areas are instrumented and equipment is in good working order. Monitoring programs shall be tailored to each individual dam.

14.2 Risk Informed Instrumentation Monitoring. Instrumentation data is an extremely valuable asset that supplies insight into the actual behavior of the structure relative to design intent for all operating conditions. Instrumentation data establishes performance that is uniquely characteristic to the structure and provides a basis for predicting future behavior.

14.2.1 The number of instruments, locations, types, and frequency of readings shall be commensurate with the risk classification and dominant failure modes identified for each project. Redundancy and use of automated data collection should be considered for high risk features or for locations that have limited on site staff or are difficult to access for monitoring and emergency response. Repair, replacement, and installation of new devices shall be evaluated throughout the life of the project subject to potential failure modes analysis (PFMA), flood performance, and other risk considerations. Increased data monitoring and analysis shall be performed in conjunction with unusual loading events, such as high reservoir levels or following earthquakes. Specific devices and frequency of readings shall be documented in project specific surveillance plans and be included as an appendix to the Emergency Action Plan.

14.2.2 The planning, design, and layout of an instrumentation program are integral parts of the project design and operation. A life cycle approach is needed; instruments that were critical for construction phase work may not be critical for the operations

phase. The number and locations of instruments shall be annually reviewed to assess if devices should be abandoned, added, or read at different time intervals. As structures age and new design criteria are developed, the historical data are relied upon to evaluate the safety of the structure with respect to current standards and criteria. Older structures may require additional instrumentation to gain a satisfactory level of confidence in assessing safe performance.

14.2.3 Instrumentation data can be of benefit only if the instruments consistently function reliably, the data values are compared to the documented design limits and historical behavior, and the data are received and evaluated in a timely manner.

14.2.4 Automation of dam safety instrumentation is a proven, reliable approach to obtaining instrumentation data and other related condition information, particularly when investigating and analyzing performance conditions that require frequent, and/or difficult access for obtaining measurements. Automated instrumentation must be periodically calibrated and verified manually. Further guidance for instrument automation is available through ER 1110-1-8158 (reference A.45). Automation should augment field visual inspection and not take the place of it. It is not recommended that automation be accomplished for all instrument requirements, but only to achieve those monitoring objectives that require automation.

14.2.5 Successful risk management requires a healthy routine monitoring program, including maintenance, repair, and staff who are trained in data collection and interpretation. Data assessment must consider the anticipated design performance of the project, and whether the actual performance meets design safety thresholds. Data anomalies in critical areas must be promptly evaluated by experienced technical staff and may include but not limited to verification readings, verification of calibration and collection methods, visual observation of area and instrument for damage or distress of structure, and comparison with redundant instrumentation if available.

14.2.6 In some cases, where data is complex and is relied upon for life safety risk reduction decisions, it may be appropriate to utilize independent expert consultants to review instrumentation data analyses and help validate conclusions.

14.3 Planning.

14.3.1 Instrumentation Systems. The design and construction of new projects as well as the rehabilitation, dam safety modifications, and normal maintenance of older projects present opportunities for planning instrumentation systems for the future engineering analyses of structural performance. Careful attention and detail shall be incorporated into the planning of instrumentation systems and programs to ensure that the concerns are adequately monitored. Once the parameters that are critical to satisfactory performance are determined by the design, appropriate instrument devices are selected to provide the engineering measurements to the magnitude and precision, and response time necessary to evaluate the parameters. Generally, the types of measurements are as follows;

14.3.1.1 Horizontal and vertical movement,

14.3.1.2 Alignment and plumb,

14.3.1.3 Stresses and strains in soil and rock-fill,

14.3.1.4 Pore pressure,

14.3.1.5 Uplift pressure,

14.3.1.6 Phreatic surfaces,

14.3.1.7 Seismic effects,

14.3.1.8 Seepage clarity and quantity.

14.3.2 References. ER 1110-2-103 (reference A.46) gives guidance on instrumentation for seismic effects, including instrumentation, automation, and determination of performance parameters. EM 1110-1-1005 (reference A.8) gives guidance on monitoring horizontal and vertical movements. EM 1110-2-2300 (reference A.25) provides information on design and construction of earth and rock-fill embankments. EM 1110-2-4300 (reference A.30) provides information on instrumentation requirements for concrete structures. EM 1110-2-1908 (reference A.15) provides detailed information on all aspects of instrumentation, including staffing qualifications, data management, analysis and long-term reassessments. EM 1110-2-1901 (reference A.12) provides information on analysis of seepage.

14.3.3 Instrumentation System Requirements. Baseline readings for all instrument data must be generated. Statistical and graphical methods are simple ways to establish this baseline. In all circumstances, background information that may affect the validity of the data or the analysis of the performance shall be documented, archived, and readily available for data reviewers. Other considerations include the potential for damage during construction and operations; the effects of a severe environment on the instruments; the personnel requirements for maintenance and data collection; and the evaluation of the instrument data. Automated systems have additional requirements as follows:

14.3.3.1 Each instrument should maintain the ability to be read manually or as appropriate have adjacent redundant manual system to verify automated data.

14.3.3.2 Each instrument shall have the capability to be read at the site in addition to upload to the network via satellite / radio / or other.

14.3.3.3 A backup communication link to the district shall be provided for the data transmission to allow redundancy for data acquisition.

14.3.3.4 Automated data acquisition system should include (1) desktop microcomputer and (2) laptop/portable microcomputer and / or (3) hand held rugged reader. Desktop microcomputer serves as the local monitor station to collect, process, display and produce a hard copy of the data at the project office or other designated point. This local monitoring station must also be capable of performing a quality control check of instrument readings, responding to a preset threshold level, interfacing with existing project hardware and software applications and should have the ability to be queried from the district or other remote location. The laptop/portable microcomputer is for infield trouble shooting and maintenance. This laptop/portable microcomputer will also serve as a backup capable of collecting data manually from the infield data loggers. Hand held reader may be used as a more rugged and portable alternative for many of the laptop/portable microcomputer purposes.

14.3.3.5 The automated system does not relieve or replace the normal visual inspection schedule of the project features to include the instrumentation. Rather, automation should supplement those critical activities.

14.3.3.6 In addition to these primary automation requirements, consideration shall also be given to backup power supply, lightning protection, maintenance, vandalism, system diagnosis, and software versatility.

14.4 Installation and Maintenance.

14.4.1 New Projects. Instrumentation for a project shall be included in the design phase, during construction, and throughout the life of the project as conditions warrant. After a project has been operational for several years, appropriate maintenance, repair, and replacement of instrumentation must be accomplished during the normal operation to ensure continuous data acquisition and analyses of critical performance parameters. Specialized expertise may be required to install and maintain instrumentation. Installation should be closely coordinated with construction activities to minimize instrument damage.

14.4.2 Existing Projects. Existing projects shall be evaluated to ensure that the original instrumentation is functioning as intended and is still appropriate. Threshold limits determined for original design condition or major modifications shall be examined and reviewed against current criteria. The instrumentation plan may require modification to delete some instruments and/or add other instruments in areas on the project where additional monitoring is required by performance concerns or advances in design practices. Changes to the instrumentation should be budgeted through normal operations and maintenance funding procedures.

14.5 Data Collection, Interpretation and Evaluation.

14.5.1 Collection Frequency. The frequency with which instrumentation data is obtained must be tailored to the instrument purpose, period of construction, investigation or other interest, and project operating conditions. In all cases, sufficient

calibration and background data shall be obtained to ensure that a reliable database is available to facilitate subsequent comparisons. The subsequent reading frequency of instruments during construction and operating conditions shall be based on an anticipated rate of loading or changes in reservoir levels to be determined by a dam safety engineer familiar with the design and performance parameters of the project.

14.5.2 Data Interpretation. The timely reduction and interpretation of instrumentation data is essential for a responsive safety evaluation of the project. For all USACE projects, this reduction and interpretation shall occur as soon as conditions warrant from the time that the data was obtained. The evaluation of the data shall follow immediately. As a minimum, all data shall be plotted as instrument response with respect to time, as well as to reservoir level or other range of loading. All instrumentation data shall be reviewed monthly and evaluated not less than annually. More frequent readings may be required when operating under Dam Safety Action Classification (DSAC) –based Interim Risk Reduction Measures (IRRM) or other critical Dam Safety events such as surcharge pool or near record pool. The district shall document instruments critical for monitoring during IRRM in an addendum to the project specific surveillance plan. High risk conditions will require more frequent and intensive scrutiny of instrumentation data in accordance with established plans.

14.5.3 Performance Prediction. During the initial project design, or reevaluation in the case of existing structures, the physical properties of the construction materials, design data, loading conditions, and the appropriate factors of safety shall be utilized to determine the desired threshold limits for each performance parameter. Quantitative values shall be established for these limits that can be accurately translated into measurements that are easily and readily obtained in the field, which will enable the designers and operators to evaluate the behavior and performance of the structure. A detailed discussion of the design assumptions shall be presented in the design documentation report (DDR) for new or modified features. The threshold limits along with the predicted performance levels shall be addressed in the project instrumentation DDR and in detailed instructions to project personnel and any other personnel involved with the instrumentation. The method of deriving the thresholds shall be documented to aid response to future exceeded thresholds. Exceeded thresholds shall trigger increased scrutiny and analysis of structural integrity and shall not be relied upon for sole basis of evacuation requests.

14.5.4 Monitoring Plans. Monitoring plans should remain adaptive to real time events and accelerate as appropriate to conditions. Data collection, reduction, and evaluation methods should be assessed routinely to try to shorten the process as appropriate to monitoring frequencies. If resources limit data collection / reduction / evaluation, priority shall be given to gather and assess data associated with high risk project features, based on a PFMA or detailed risk assessment. More detailed guidance for data acquisition, interpretation and presentation can be found in EM 1110-2-1908 (reference A.15) and EM 1100-2-4300 (reference A.30).

14.6 Reporting.

14.6.1 Upon completion of new projects or significant modifications to projects, the instrumentation data along with the written evaluation shall be consolidated and submitted to the MSC Dam Safety Officer in accordance with ER 1110-1-1901 (reference A.44). Written evaluation should also be incorporated in the subsequent periodic inspection reports.

14.6.2 The District Dam Safety Officer shall provide a written summary and evaluation of the district's instrumentation program annually to the MSC Dam Safety Officer. This annual program review shall include a specific write up on the performance of high risk (DSAC I and II) dams. The project information obtained annually shall be included in the periodic inspection report of the project. Instrumentation program records shall also be reported to and retained by the operations project staff.

14.7 Funding. The appropriate funding (General Investigation, Construction General, Operation and Maintenance, General appropriations, etc.) shall be utilized to accomplish the level of instrumentation outlined in this regulation. Funding for maintenance of instrumentation, data collection, data analysis, and reporting shall be included in the minimum routine program of the annual Operations and Maintenance budget submission. New or replacement instruments shall be programmed in the annual budget submissions as non-routine work items, and prioritized based on criticality. The DSAC rating and risk based failure modes shall be considered in budget prioritization, and coordinated with Operations and Programs staff.

CHAPTER 15

Dam Safety Training

15.1 Overview. The Corps of Engineers has an extensive program for training personnel in all matters related to its mission in water resources development. Much of the training is directly or indirectly related to dam safety. A comprehensive training program is conducted for dam operation and maintenance personnel. This program is designed to acquaint project personnel with basic engineering considerations pertaining to the major structures, with procedures for surveillance, monitoring and reporting of potential problems, and with emergency operations. In addition, the technical staff at the district office requires training to build expertise and ability to respond to emergencies. The Corps of Engineers has a training course on “Dam Safety in the Corps of Engineers” and has supported the development of the Training Aids for Dam Safety (TADS) Program. In 1991, the Federal Energy Regulatory Commission initiated a training course on “Emergency Action Plan”. ASDSO maintains a list of currently scheduled dam safety training courses on the web site at http://www.damsafety.org.

15.2 Corps of Engineers Training Course on Dam Safety. The Corps of Engineers Proponent Sponsored Engineer Corps Training (PROSPECT) program offers a course titled “Dam Safety in the Corps of Engineers”. Through lectures, case histories, and structured student discussions, the course covers all aspects of a dam safety program. The course outlines technical considerations (hydrologic, seismic, geotechnical, electrical/mechanical and structural) as well as the operational requirements (operation, maintenance, surveillance, preparedness, training, and notification). The scope and implementation details of the Dam Safety Assurance Program are covered in detail. Presentations, video modules, case histories, and a walk-through inspection are used to effectively present a multidiscipline approach to the successful monitoring and evaluation of Corps of Engineers dams.

15.3 National Dam Safety Conferences. National dam safety conferences, such as the Association of State Dam Safety Officials annual conference, the United States Society on Dams annual conference, the Corps of Engineers Infrastructure Conference, and conferences sponsored by other agencies, have speakers who are involved in state-of-the-art dam safety evaluations and remediation. These conferences are a great opportunity to share the technology and experiences of dam safety with people from other agencies, and within the Corps of Engineers. Participation in these conferences can be valuable training in dam safety activities.

15.4 Exchange Training – District to District. Participation in other district’s dam safety training, periodic inspections, and emergency exercises can be good training in dam safety and can spread the good things learned in one district to other districts. Other districts should be invited to attend periodic inspections, dam safety training, and emergency exercises, and whenever feasible, dam safety personnel should participate in those activities in other districts. There is a lot of information and experience available

that could be beneficially shared within districts and both districts could gain from the activities.

15.5 Training Program for Operations and Maintenance Personnel.

15.5.1 Dam Safety. Recognizing the important role that onsite operations and maintenance personnel have in dam safety, MSC commanders were directed in 1978 to develop a training program that addresses the following items:

15.5.1.1 Discussion of basic typical design considerations for various types of construction, including hydraulic considerations and foundation factors

15.5.1.2 Procedures for monitoring potential problem areas

15.5.1.3 Dam safety features in design and construction.

15.5.1.4 Normal operation, surveillance, monitoring, and reporting procedures

15.5.1.5 Emergency operations, surveillance, monitoring, and reporting procedures

15.5.1.6 Project specific features and history of problems and potential problems.

15.5.2 Training Frequency. All new field employees and field contractor personnel shall have a minimum of 6 hours training shortly after starting duty and at least 6 hours refresher training every five years.

15.5.3 Records. The Operations Project Manager shall document all formal training. These records shall be kept on file at the employee's project office and shall be available to the periodic inspection team and readily accessible for emergency response.

15.5.4 Exercises. Upon completion of the initial safety training at a new project, EAP exercises are developed based on the most probable emergency situations that might occur on each major dam feature.

15.6 Sample Dam Safety Training Course Outline for Project Personnel.

15.6.1 Purpose of Training Program. Basic objectives, history of dam failures, and films or slides depicting dam safety problems or failures.

15.6.2 Dam Safety Features in Design and Construction. Design philosophy for dams, design assumptions, construction history, salient features and regulating philosophy for the project, and past monitoring, experiences and performance for projects.

15.6.3 Normal Operation, Surveillance, Monitoring and Reporting Procedures. The value and use of instrumentation, effect of pool rises on monitoring requirements, reservoir regulation manuals, day-to-day surveillance, documentation of plans, records, reports, etc, generalizations on what is and what is not critical to safety of the structure, public relations with local communities, and coordination and notification to downstream water users and recreationists on controlled releases and flushing operations.

15.6.4 Emergency Operation, Surveillance, Monitoring and Reporting Procedures. Observations of evidence of distress, methods of treating obvious safety problems, knowledge of potential flood area downstream, alerting Corps of Engineer offices to emergency conditions, and alerting police and local civil defense groups to emergency conditions.

15.7 Dam Safety Training Courses.

15.7.1 Existing Available Courses.

15.7.1.1 *Bureau of Reclamation Safety Evaluation of Existing Dams (SEED)*. The Bureau of Reclamation has a dam safety training course for their personnel. In some cases it is more cost effective for Corps personnel in the western portion of the country to attend these courses than the PROSPECT courses. This training is another option that should be considered when selecting training for Corps personnel in dam safety.

15.7.1.2 *Training Aids for Dam Safety*.

15.7.1.2.1 Background. In 1986, the Corps of Engineers, along with 13 other Federal Agencies, all members of the Interagency Committee on Dam Safety, joined forces to develop a professionally prepared TADS Program. The TADS materials are arranged in three components that cover dam safety inspections, dam safety awareness and program development, and evaluations and remedial actions (references A.72 and A.78).

15.7.1.2.2 Structure. The entire package consists of 21 self-paced individual instruction modules that focus on performance of job tasks. Each module features a workbook text. The material is presented in a straightforward, easy-to-manage manner. Each workbook contains a glossary of terms and a list of references from which to obtain additional information. Some modules are supplemented with videotapes that illustrate certain concepts. Because the modules are self-contained, individuals may tailor a learning program to meet specific work requirements or personal needs.

15.7.1.2.3 Utilization of the Program. The TADS Program offers a standardized approach to dam safety training. The Corps of Engineers, as one of the primary sponsors of the TADS Program, distributes the TADS materials to each Corps of Engineers field office through the Engineering and Construction, Directorate of Civil Works, HQUSACE. All MSC's and districts shall maintain a complete set of modules including the videotape supplements.

15.8 Risk Assessment Training. The Risk Management Center will provide training on those activities and procedures that support risk assessments.

15.9 Consequence Training. Training on state-of-the-art USACE approaches for estimating consequences with initial emphasis on life loss and direct economic loss. As the tools evolve, training in additional consequences such as indirect economic losses, environmental and other non-monetary consequence will be offered. This training in support of dam safety risk assessments is provided by several means. For district staff committed to providing consequence assessment services to the Modeling, Mapping, and Consequence Center (MMC), annual courses are provided by the USACE Hydrologic Engineering Center (HEC). The focus is on bringing these staff up-to-speed so that they can fulfill the requirements of their agreement with the MMC. At present, there is an agreement between the MMC and the trainee's district that requires the district to allocate 50% of the trainees' time to support the MMC for a period of 2 years. Also, consequence assessment training can be provided by HEC on a reimbursable basis. A PROSPECT course presenting HEC-FIA (Flood Impact Analysis - the most common tool used for estimating consequences in support of dam safety risk assessments) will be available starting in FY 2012. Over the coming years, consequence estimates for risk assessments material will be worked into other regular PROSPECT courses to enable access by a broader audience.

CHAPTER 16

Emergency Action Plans

16.1 General. An Emergency Action Plan (EAP) is a formal document that identifies potential emergency conditions (either dam failure or large spillway releases) at a dam and specifies preplanned actions to be followed in order to minimize property damage and loss of life. The EAP specifies actions the dam owner[4] should take to moderate or alleviate the problems at the dam. It contains procedures and information to assist the dam owner in issuing early warning and notification messages to responsible downstream emergency management authorities in the event of an emergency. It also may contain inundation maps intended to highlight the critical areas for action for these emergency management authorities.

16.1.1 Historical references that provide the background for emergency action plans with the Corps of Engineers are as follows:

16.1.1.1 U.S. Army Corps of Engineers, Hydrologic Engineering Center, 1980 (Jun), “Flood Emergency Plans Guidelines for Corps Dams,” Research Document No. 13. Davis, CA (reference A.95).

16.1.1.2 U.S. Army Corps of Engineers, Hydrologic Engineering Center, 1982 (Jan), “Emergency Planning for Dams, Bibliography and Abstracts of Selected Publications,” Davis, CA (reference A.96).

16.1.1.3 U.S. Army Corps of Engineers, Hydrologic Engineering Center, 1983 (Aug), “Example Emergency Plan for Blue Marsh Dam and Lake,” Research Document No. 19, Davis, CA (reference A.97).

16.1.1.4 U.S. Army Corps of Engineers, Hydrologic Engineering Center, 1983b (Aug), “Example Plan for Evacuation of Reading, Pennsylvania, in the Event of Emergencies at Blue Marsh Dam and Lake,” Research Document No. 20, Davis, CA (reference A.98).

16.1.2 While the dam owner retains overall responsibility for the development of the EAP, this (and all subsequent revisions) must be done in close coordination with those having emergency management responsibilities at the state and local levels. Emergency management agencies will use the information in a dam owner's EAP to

[4] As used in this chapter, the term “dam owners” and their responsibilities are intended to have the same meaning as used in FEMA’s dam safety guidelines for emergency action planning, issued in 1998 by the Interagency Committee on Dam Safety to supplement the 1979 Federal Guidelines on Dam Safety. See Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners” (1998) (April 2004 reprint) at page 3, footnote 1 (“The term dam owner, as used in these guidelines, refers to the individual dam owner or the operating organization.”).

facilitate the implementation of their responsibilities. State and local emergency management authorities will generally have some type of plan in place, either a Local Emergency Operations Plan or a Warning and Evacuation Plan.

16.1.3 The effectiveness of an EAP is greatly enhanced by utilizing a consistent format which ensures that all aspects of emergency planning are covered in each plan. Having both a uniform EAP and advance coordination with local and state emergency management officials/organizations are critical in facilitating a timely response to a developing or actual emergency situation. Ownership and development of the floodplain downstream from dams varies, therefore the potential for loss of life as a result of failure or operation of a dam will also vary. For this reason every EAP must be tailored to site-specific risks/conditions and failure modes yet should remain simplistic enough to encourage its use. This should include the full range of failure scenarios (including upstream landslide failures, if appropriate) as well as different detection times for the incident.

16.1.4 Recognizing the importance of overall federal uniformity in the management and design of dams, an ad hoc interagency committee on dam safety (ICODS) was established and issued a report containing the first guidelines for federal agency dam owners. The Federal Guidelines for Dam Safety (reference A.71) generally encourage strict safety standards in the practices and procedures employed by federal agencies or required of dam owners regulated by the federal agencies. To supplement these published guidelines, ICODS also prepared and approved specific federal guidelines related to emergency action planning. The final document was published in 2004 and is entitled “Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners” (reference A.74). This document is intended to serve as the over-arching guidance which governs the content, structure, and implementation of EAPs for the U.S. Army Corps of Engineers.

16.2 Requirements. There are a few exceptions/elaborations to the Federal Guidelines related to EAPs that should be noted. These include:

16.2.1 EAPs are required for all Corps of Engineers Dams, including appurtenant structures having separate consequences from the main dam**.** This is more comprehensive than the Federal Guidelines, which specify EAPs only for high and significant hazard potential dams. EAP format/content for dams with high and significant hazard potential should follow the specifics outlined in this document and the Federal Guidelines. For Dams that are very similar and possibly on the same waterway such as navigation projects, you may want to have one EAP for the system with different call sheet for each project. For dams classified as low hazard, whether flood risk management or navigation, dam owners should scale back the complexity of the EAP to better fit the unique situation at the project. However, as a minimum the EAP should still include information on notification, emergency detection, responsibilities, and preparedness.

16.2.2 Inundation maps are required for any dam whose failure could result in loss of life or significant property damage as a direct result of the incremental flooding caused by failure of the dam. When required, inundation maps must be prepared for the following three scenarios: 1) Sunny day with dam failure, 2) Flood with dam failure, and 3) Flood without dam failure. Coordination with the Risk Management Center is required to obtain the most current and appropriate definitions of these scenarios for a particular project or study. Inundation maps are generally not required when the dam failure does not cause any incremental flooding, when dam failure discharges would not exceed downstream channel capacities or flood stages, or when consequences are limited to loss of service (e.g. navigation or hydropower disruption due to loss of pool).

16.3 Emergency Exercises.

16.3.1 Emergency Incidents. Emergency incidents at dams are not common events. Therefore, training and regular exercises are necessary to maintain proper operational readiness. In addition, annual meetings between a dam owner and emergency responders can facilitate a better understanding of roles and responsibilities and will enhance emergency readiness. The state of readiness should also be determined through periodic and regular simulations of emergency events. These emergency exercises should be initiated by the dam owner and should involve all of the key players who would normally be involved in an actual event. Consideration should be given to combining exercises for projects in the same watershed or multiple projects in the same geographical area. Periodic exercises will result in an improved EAP as lessons learned during the exercise can be incorporated into the updated document.

16.3.2 Participants in Exercises. Because nearly any dam safety incident has detection and reaction components, conduct of these exercises should be jointly led by a district's dam safety/technical elements (DSO, DSPM, and technical elements) and the Emergency Management Office. Exercises should ensure that both the technical aspects (i.e. internal district performance relating to detection and decision-making) as well as emergency management aspects of dealing with appropriate state/local officials are fully covered and evaluated. Focusing on only one aspect at the expense of the other can be dangerous as it could lead to a false sense of security regarding performance.

16.3.3 Exercise Frequency. The frequency of emergency exercises should correspond directly to the Dam Safety Action Classification (DSAC) rating and hazard potential of the project. The definition of the various hazard potential levels is given in Appendix Z. That is, the lower the DSAC rating the more frequently exercises should be conducted. As a minimum the EAP exercise schedule listed in table 16.1, Emergency Exercise Frequency, shall be followed for all projects having significant life/property loss implications. Note that actual emergency events may be substituted for the appropriate exercise provided they are properly documented and the lessons learned from that event are incorporated into the updated EAP.

16.3.4 Exercise Levels. The definitions of the exercise levels are included in Glossary. It is recommended that all exercises be based on a failure mode of concern for the particular dam. If an exercise has not been done in the last 5 years, it is recommended to start with a table top exercise and work up to the level appropriate for the DSAC. Low hazard potential projects, regardless of DSAC rating, require only an annual orientation seminar or drill. At their discretion and judgment, districts may choose to periodically conduct something more elaborate (i.e., tabletop, functional, or full-scale) if they deem the situation warrants.

Table 16.1 Emergency Exercise Frequency

Exercises* / Classifications	Drill	Tabletop	Functional Exercise	Full Scale Exercise
DSAC I and High Hazard Potential		Year 1, 3, 5, etc….	Year 2, 4, 6, etc….	At DSO discretion
DSAC II or III and High Hazard Potential	Year 1, 3, 5, etc…	Year 2, 4, 6, etc	At DSO discretion	At DSO discretion
DSAC IV or V Significant Hazard Potential	Year 1 – 4 and 6 - 9. etc….	Year 5, 10, etc…	At DSO discretion	At DSO discretion
Low Hazard Potential	At DSO discretion			

*Orientation Seminars shall be held for all new dams and whenever new information is developed.

16.3.5 Homeland Security Exercise and Evaluation Program (HSEEP). This is a national exercise program being developed by the Department of Homeland Security.

16.3.5.1 The Homeland Security Exercise and Evaluation Program (HSEEP) is a capabilities and performance-based exercise program which provides a standardized policy, methodology, and terminology for exercise design, development, conduct, evaluation, and improvement planning. HSEEP Policy and Guidance is presented in detail in HSEEP Volumes I-III. Adherence to the HSEEP policy and guidance ensures that exercise programs conform to established best practices and helps provide unity and consistency of effort for exercises at all levels of government.

16.3.5.2 HSEEP constitutes a national standard for all exercises. Through exercises, the National Exercise Program supports organizations to achieve objective assessments of their capabilities so that strengths and areas for improvement are identified, corrected, and shared as appropriate prior to a real incident.

16.3.5.3 Use of the policy and guidance presented in HSEEP is recommended to ensure that exercise programs conform to established best practices and aids

interaction with emergency service partners. Additional information about HSEEP is available from DHS at https://hseep.dhs.gov/pages/1001_About.aspx.

16.4 Modeling, Mapping, and Consequence Center. Inundation maps and data are one of the most useful tools to the emergency responders when dealing with an emergency event. They delineate the areas that would be flooded due to a dam failure or flooding resulting from large operational releases. Recognizing the need to have a more consistent, user friendly (i.e. easier to read/interpret), and accurate product the Mapping, Modeling, and Consequence Center has been established as a virtual asset under the Risk Management Center. The mission of this virtual center (comprised of H&H, GIS, and economist professionals from across the Corps) is to employ the latest technological tools to ensure consistency in how inundation maps and associated consequences are developed. While the actual production work may still be completed locally, coordination with this center is mandatory prior to work beginning so that the most current and appropriate guidance can be provided for a specific study or project.

16.5 Security Provisions. In recent years, man-made disasters (i.e. acts of terrorism) have been a cause of increasing concern. A comprehensive EAP should not only include security provisions surrounding a dam during an emergency event but must also consider actual failure modes (and associated consequences) initiated by such an event. These are particularly critical as they can potentially occur with no warning thereby resulting in very little response time

16.6 Communications. Good communication is a key element for successful execution of any EAP. This includes not only internal communications between Corps team members, but also between others who could potentially play a role in an emergency event. The dam owner should always strive to raise the level of public awareness (e.g. utilization of the media and internet) as it relates to dam operations and emergency response procedures. A detailed communications plan is recommended to be included as part of the official notification flowchart/chapter or as a stand-alone appendix to the EAP in order to reinforce its importance. Items recommended for inclusion are:

16.6.1 Notification Lists. Listing of persons to be notified about each emergency condition for which plans are made and procedures for notification. This should include a description of primary and secondary means of communication to be used, listing of telephone numbers and addresses, and other information needed for reliable and prompt contact for:

16.6.1.1 Notifications Internal to the Corps. This would include all communications within the district (e.g. notification to DSO, DSPM, EM, and/or appropriate technical element) as well as formal notification through command channels in accordance with this regulation.

16.6.1.2 Notifications from the Corps to Principal Local Officials.

16.6.1.3 Notifications from the Corps to Other Federal Officials.

16.6.1.4 Distribution of Warnings. Distribution of warnings from the Corps to officials responsible for dissemination to the general public (e.g. National Weather Service for use in public warning system).

16.6.1.5 Dissemination of warnings by the Corps directly to the general public in the immediate vicinity of the dam and reservoir.

16.6.1.6 As a minimum, full descriptions and separate actions required under each of three emergency classifications (failure imminent or has occurred, failure situation is developing, and non-failure emergency condition).

16.6.2 Example Press Releases. Example press releases for each emergency condition for which a plan is prepared and instructions for adaptation before their use to the specifics of an emergency situation including but not limited to:

16.6.2.1 Exact nature of emergency and degree of danger

16.6.2.2 Remedial action under way

16.6.2.3 Expected course of events and timing

16.6.2.4 Appropriate action for public to take

16.6.2.5 Description of the procedure and means for dissemination of warnings directly to the general public in the immediate vicinity of the dam and reservoir

16.7 Dam Owner's Responsibilities. Each EAP shall include information to help guide the dam owner in making immediate operational decisions in the event of various types of emergencies. Information shall be included to identify the need for equipment, material, labor, and other necessities for carrying out emergency repairs. Items to be considered include:

16.7.1 Identification of the appropriate response to the type and severity of existing or potential emergencies.

16.7.2 Emergency gate operation.

16.7.3 Reservoir dewatering plan.

16.7.4 Description of equipment and materials to be stockpiled for use in carrying out emergency operations and repairs.

16.7.5 Assignments of responsibilities for carrying out emergency operations and repairs.

16.7.6 Description of needs for equipment, material, and labor not available at the site which are needed to carry out each type of emergency operation or repair.

16.7.7 Listing of nearby contractors and other sources of needed equipment, material, and labor and description of procedures for securing their assistance on an emergency basis.

16.8 Responsibility for Evacuation (Non-Federal).

16.8.1 Non-Federal officials are to be encouraged to develop evacuation sub-plans as a complement to the EAP prepared by the Corps. Evacuation sub-plans should be considered for the following conditions:

16.8.1.1 Flood without dam failure

16.8.1.2 Flood with dam failure

16.8.1.3 Dam failure under sunny day or normal pool conditions.

16.8.2 Coordination with the Risk Management Center is required to obtain the most current and appropriate definitions of these scenarios for a particular project or study.

16.8.3 The objectives of the evacuation sub-plan are to provide for the timely and safe evacuation of threatened areas and the minimization of property damage. Items that might be covered in the sub-plan would include:

16.8.3.1 Description of traffic control arrangements to expedite evacuation and passage of emergency vehicles and prevent accidental travel into dangerous areas.

16.8.3.2 Provisions for any necessary assistance to evacuees such as transportation and aid to invalids.

16.8.3.3 Arrangements for sheltering, feeding, and other care of evacuees.

16.8.3.4 Description of actions to be taken to reduce damages and other losses.

16.8.3.5 Arrangements for security of evacuated areas.

16.8.3.6 Listing of vital services and facilities outside the area of inundation which will or may be disrupted by the level of inundation associated with each emergency condition for which plans are made.

16.8.3.7 Listing of major secondary problems resulting from the level of inundation associated with each emergency condition for which plans are made.

16.8.3.8 All areas which should be evacuated because of inundation, secondary problems, loss of services, isolation, or other reasons which are associated with each emergency condition for which plans are made.

16.8.3.9 Major evacuation routes.

16.8.3.10 Areas requiring priority in evacuation.

16.8.3.11 Potential obstacles to timely evacuation.

CHAPTER 17

Reservoir Filling Plans

17.1 Applicability. This regulation applies to all new and existing flood damage reduction dams and to all new navigation dams.

17.2 Introduction. Reservoir filling is defined as a deliberate impoundment to meet project purposes and is a continuing process as successively higher pools are attained. This may take place over only a few months but in many instances may be a process that takes several years. The initial reservoir filling is the first test of the dam to perform its design function. For this reason it is imperative that a comprehensive reservoir filling plan be developed well in advance of any actual impoundment event. It must also be recognized that existing reservoirs which have not yet experienced a design pool are actually undergoing a type of initial filling each time they achieve a new pool of record. Likewise, significant repairs or modifications to a dam might also necessitate the need to view the project as though it is once again undergoing an initial filling.

17.3 Reservoir Filling Plan.

17.3.1 A detailed reservoir filling plan shall be established on a dam-by-dam basis for all reservoirs which are new, significantly modified, or those which have yet to be filled to their design elevation. In general, the objective is to provide a planned program which allows adequate time for monitoring and evaluating the performance of the dam and its foundation as the reservoir is being filled (or as it achieves periodic record pool levels). This plan will utilize all pertinent hydrologic, hydraulic, structural, and geotechnical criteria that was developed during the design and construction of the project. If the plan is being developed for an existing dam, it must consider operational experiences. It must also consider all significant potential failure modes for monitoring and evaluation. Just because a dam is old in terms of years does not mean that it is old in terms of experience. Many factors must be considered when new or record impoundments are expected. These considerations might include:

17.3.1.1 Purposes of the new, modified or existing reservoir.

17.3.1.2 Risks associated with the filling - including potential failure modes.

17.3.1.3 Hazard potential both upstream and downstream.

17.3.1.4 Type of dam.

17.3.1.5 Dam Safety Action Class (DSAC) rating of the dam.

17.3.1.6 The geology and seismicity in the vicinity of the dam/reservoir.

17.3.1.7 Landslide potential along the banks.

17.3.1.8 Inflow characteristics (controlled or uncontrolled).

17.3.1.9 Hydrology of the river/basin as it relates to the time necessary to fill the reservoir.

17.3.1.10 Releases that must be made to meet project requirements.

17.3.1.11 Potential for flood releases.

17.3.1.12 Flood Emergency Plan and associated requirements.

17.3.1.13 Amount/type of instrumentation installed.

17.3.1.14 Provisions for monitoring/evaluating the instrumentation. Note: threshold readings should be established for instruments that change readings as a function of pool fluctuation.

17.3.1.15 Communicating the event.

17.3.2 Reservoir filling plans shall consider all of the items listed above and shall be organized to include (as a minimum):

17.3.2.1 Introduction and scope.

17.3.2.2 Project background and pertinent data (including history of pools experienced).

17.3.2.3 Preparations needed ahead of reservoir first filling.

17.3.2.4. Definition of reservoir filling which is specific to the reservoir (elevations, durations, etc…).

17.3.2.5 The preferred filling rate (for new projects), reasoning behind the recommended rate, and means to be used to control the rate of reservoir rise (if possible).

17.3.2.6 An inspection/surveillance plan designed to detect the most likely occurring problems. This shall be tied to the identified significant potential failure modes associated with the dam. A visual inspection checklist shall be developed to facilitate the effectiveness of the surveillance efforts and the reporting of results. Specific distress indicators for various failure modes shall be identified in the checklist.

17.3.2.7 A plan for reading the instruments and evaluating the data throughout the entire filling process. This shall also include the expected readings (i.e. what is normal for pools already experienced and what is expected for pools higher than yet experienced) and shall be tied to specific responses in the event of readings outside the

prescribed range. Reference EM 1110-2-2300 (Appendix E) (reference A.25) for detailed guidance relating to the establishment of performance/monitoring parameters and threshold limits.

17.3.2.8 Instructions for observers (inspectors and/or instrumentation evaluators) on conditions that require immediate attention of personnel authorized to make emergency decisions. Plan shall clearly define reporting requirements and specific actions to be taken for all observed problems. An appropriate level of response should be clearly identified and matched with the severity of the observation.

17.3.2.9 Discussions regarding public safety contingency plans. The Emergency Action Plan for the project should be complete, current and shall have been tested in accordance with the provisions of Chapter 16.

17.3.3 Initial reservoir filling plans for new reservoirs should be very comprehensive and exhibit an overall conservative approach due to the large number of unknowns. For existing reservoirs, the level of inspection, monitoring, etc… prescribed in the reservoir filling plan should be directly proportional to the perceived/identified risks as categorized by the project's Dam Safety Action Class (DSAC) rating. Because of their higher level of assigned risk, projects designated as DSAC I, II and III should strongly consider establishing elevations (or pool frequencies) somewhat lower than the pool of record where actions in the reservoir filling plan would be initiated. In any event, a thorough review and testing of the reservoir filling plan should routinely be included as part of any project's Interim Risk Reduction Measures Plan (IRRMP).

17.3.4 A completed and approved reservoir filling plan shall be furnished to design, inspection, monitoring and operations personnel prior to any applicable event. It is recommended that an on-site meeting be held prior to the initiation of any filling event. This would include both initial filling as well as forecasted record pools. This meeting would bring all of the interested parties together and would assure the plan, including all roles and responsibilities, is clearly understood. In addition, periodic emergency exercises (as outlined in Chapter 16) should introduce scenarios whereby record pools are forecast so that implementation of the reservoir filling plan can be tested and improved.

17.4 Plan Approval. Reservoir filling plans shall be prepared by the District, approved by the District Dam Safety Officer and furnished to the MSC Dam Safety Officer for informational purposes.

17.5 Performance Report. A performance report shall be prepared upon completion of a first filling (or new pool of record) event. This report will be transmitted through the appropriate district technical elements to the district Dam Safety Officer within 2 weeks of the event.

This Page Left Blank

CHAPTER 18

Risk Assessment Methodology

18.1 General.

18.1.1 The Risk Management Center (RMC) is responsible for the development, dissemination, and interpretation of methodology guidance for use in conducting dam safety risk assessments. As the state of the practice for risk assessment continuously evolves and improves, the RMC should be contacted for the most current risk assessment methodology guidance. Methodology guidance is developed and provided at two basic levels. A best practices manual has been developed jointly with the United States Bureau of Reclamation (USBR) as the top level for the purpose of summarizing the overall philosophy, methods, and approach to risk assessment for dam safety. In support of the best practices manual, a suite of toolboxes has been developed to provide specific methods and tools for performing analyses of loading, failure modes, and consequences needed to inform inputs to a risk assessment.

18.1.2. A goal is that models and software tools used for dam safety risk assessment will be certified following procedures outlined in EC 1105-2-410 as good practice. Occasionally, a dam safety study will involve significant environmental concerns and the study will necessarily need a certified environmental model. If an existing certified model does not exist, it may be necessary to fund certification of the model with dam safety modification study funds.

18.2 Philosophy and Approach.

18.2.1 The methodology contained in the best practices manual and supporting toolboxes provide a suite of scalable assessment approaches that provide information to promote critical thinking and guide a risk assessor’s judgment. These methods can be tailored and used with varying degrees of effort (time and cost) to provide the appropriate level of accuracy and rigor required to make credible risk informed decisions. It is important to understand that every decision does not require a high level of rigor, detail, and accuracy in the risk estimate in order to be credible.

18.2.2 Risk assessment cadres and others implementing the methodology are accountable for understanding what is happening inside the methodology, making and documenting credible and transparent decisions on key input parameters, explaining why the results either do or do not make sense, and adjusting the risk estimate accordingly. The cadre will always decide the final answer, not the methodology. This may require some judgment and expert elicitation to translate the results obtained from the toolboxes to the risk estimate. Analysts must use understanding of the failure mode, key factors, uncertainty, and sensitivity to obtain a risk estimate that they are willing and able to defend with a set of logical arguments.

18.2.3 The risk assessment results will be challenged and debated. The risk analyst must be prepared to explain and defend the logic behind the risk estimate. This process leads to better decisions in an environment of imperfect information. A group of experts will rarely agree on all of the details of a risk assessment but they will usually obtain agreement on the key decisions and the path forward. This agreement is achieved by working for consistency between the risk estimate, recommended actions, and understanding of the situation (i.e. does it make sense).

18.2.4 All risk estimates must give due consideration for intervention. An intervention is an action taken during the sequence of any failure mechanism either when failure has been initiated or later to prevent or delay completion of failure progression. This includes routine, non-routine, and heroic actions. Risk estimates are to be made and presented for both with and without intervention scenarios. It is important to understand the potential benefits of intervention while at the same time not masking the potential seriousness of a dam safety issue by using intervention to reduce the estimated risk. The risk estimates for with and without intervention scenarios will be plotted on the tolerable risk guidelines.

18.2.5 All risk estimates must give due consideration for uncertainty and sensitivity. Key areas of uncertainty and sensitivity are to be identified and their potential effect on the risk estimate and resulting decisions presented. It is important to understand that lack of information does not increase risk, but rather it increases uncertainty.

18.2.6 The event of interest in a dam safety risk assessment is failure which is defined as a set of events leading to sudden, rapid, and uncontrolled release of the reservoir impoundment. The probability of exceeding a limit state (i.e. factor of safety less than one) is not the same as probability of failure. Limit state exceedance is only one of several potential branches of a fully developed failure mode event tree. Similarly, the probability of a serious incident is not the same as probability of failure. An incident only addresses a portion of a fully developed failure mode event tree.

18.3 Best Practices. The Best Practices manual shall be maintained and updated on an as needed basis by the RMC. The current version of the Best Practices Manual may be obtained from the RMC. The risk assessment cadres shall use the Best Practices manual to guide their efforts in determining the loads, the conditional probability of failure associated with each failure mode, and the consequences associated with each failure mode.

18.4 Combining and Portraying Risks. After all potential failure modes have been identified, described, and evaluated relative to the risk they pose, the results need to be combined and portrayed so that the technical reviewers and decision makers can understand and act upon them. This requires some attention to detail, which if not undertaken properly, can result in an improper portrayal of the risk. During risk assessments, whether completed by a team or by an individual, estimates of risk are generated for individual failure modes. These estimates might include probability or risk values for different loading conditions, loading ranges, failure modes, spatial segments,

or other situations. Not only do the individual estimates result from an aggregation of their own constituents, but they themselves are often combined in some way to express their collective effect. In practice, the most common problems encountered during risk assessments are related to systems, correlations, common-cause loading, and combining risks. Although the methods to evaluate these issues can become complex, some simplifications can be applied to situations commonly seen when evaluating risks for dams. The Best Practices Manual guidance provided the details on how to properly combine and portray risks.

18.5 Risk Assessment Documentation.

18.5.1 The basis for the recommended actions should be documented in an objective, transparent manner, portraying the data, analysis, findings and any associated uncertainties in data or analysis on a factual basis. The findings and recommendations are presented in the formal risk assessment report in support of the IES or the DSM study. The objective of the risk assessment report is to present logical and rational documentation of analysis and results that accurately portray the risk assessment and recommended course of action in a manner and style that is to be read and understood by senior decision makers. The three basic risk components, (i.e. load probability, response probability, and consequences) should portray the dam's existing condition and ability to withstand future loading, the risk estimates, and provide the basis for the recommended actions. Since uncertainty is inherent in data, analysis, and conclusions/interpretations, the documentation should also address whether confidence is high enough for the recommendations to stand on the basis of existing evidence. The risk assessment report should present information regarding two main issues. First, data, analysis, and conclusions should support that risk falls within one or the other of the action-justification categories. Second, the risk assessment report must substantiate the confidence in the risk category, and whether additional exploration, investigation, or analysis has a reasonable likelihood of changing the perceived risk such that if falls in a different category. It is the factual information and associated interpretation presented in the risk assessment report that determines whether the risk numbers generated and the actions recommended make sense or 'feel right' in light of an understanding of the condition of the facility and its recent history of structural behavior.

18.5.2 A risk assessment report built upon sensitivity studies should investigate what would happen if more information was gathered, and whether the information is important. Plausible upper and lower bound values for variables in question can be chosen and processed through whatever assessment is being considered. When this test causes the perceived risk to move significantly, there may be justification to obtain additional information. A move is significant if it changes the risk tolerability category. Additional reasoning to show why the upper or lower bound values are plausible is necessary to support a recommendation for acquiring additional information and why the additional information being requested is likely to reduce the uncertainty.

18.6 Qualitative and Semi-Quantitative Risk Assessments. Qualitative or semi-quantitative risk assessments can be desirable in some cases such where it is desired to apply risk assessment principles to the decision making without the time, cost, and data/assessment requirements associated with a full blown quantitative risk assessment; for screening assessments of a portfolio where it is desired to get a quick evaluation of the risks so that risk reduction studies and actions can be prioritized; and for sensitive cases that involve the public to a high degree whereby those involved are more likely to understand qualitative assessments than full blown numerical analyses.

18.7 Facilitating Risk Assessments.

18.7.1 Facilitators are assigned to teams to assist them through a potential failure mode analysis (PFMA) and the risk assessment process. The facilitator contributes to the process by bringing experience with risk assessments, consistency in approach, knowledge of latest technology in risk assessments, and serves as a resource to the risk assessment team for technical input and questions. The facilitator must be experienced and generally familiar with most aspects of dam behavior. In addition, skills are needed to guide a team through the process. Facilitation is a critical part of the process to develop credible risk estimates during an assessment of risk. In general, the facilitator meets with the team prior to a risk assessment to ensure engineering analyses are completed to support the team assessment and ensure the team composition is appropriate to develop credible risk estimates, facilitates the team risk assessment, helping the team develop potential failure modes, event trees, strategies for estimating risks, and developing ranges of likelihood and consequence estimates; and reviews the final report.

18.7.2 The facilitators are primarily tasked to ensure appropriate methodologies are followed to develop risk estimates; the methods used during the assessment are consistent with current practice; alternative viewpoints are elicited, discussed, and recorded; the team contains the appropriate staff to arrive at a credible risk estimate; the final risk assessment report contains failure modes that are adequately described; the recommendations reflect the information developed during the risk assessment; and risk assessment report adheres to the principles described in this engineering regulation.

CHAPTER 19

Program Administration and Funding Process

19.1 Purpose. The Dam Safety Officer (DSO) and the Dam Safety Program Manager (DSPM) at the district and regional levels are responsible for the local and regional dam safety programs. To accomplish these duties the DSO and DSPM work closely with the Operations, Engineering, and Program elements in developing and administrating the dam safety program.

19.2 Program Documentation. Dam Safety is documented for each dam in the DSPMT. The DSPM manages input into DSPMT by the project operating personnel and various other personnel within the district. From the DSPMT, the status of each project is reviewed using the dam safety scorecard.

19.2.1 The DSPM should maintain a file copy of all appointment orders, the minutes of the dam safety committee meetings, and a copy of all Emergency Action Plans.

19.2.2 On a three year cycle (or as otherwise required by Army), the Dam Safety Officers should review the questions on the Management Control Checklist and complete DA Form 11-2-R (Management Control Evaluation Certification Statement). The Management Control Checklist for Dam Safety activities is in Appendix AA for this regulation.

19.3 Funding Process. The majority of the dam safety work in the district is funded through the Operations appropriation at the individual projects. This work includes the routine annual activities for inspections and instrumentation and any special interim risk reduction measures for the dam. When additional studies are required, funding for an Issue Evaluation Study should be requested from the Construction appropriation.

19.3.1 The annual budget cycle for a project is divided into three phases that run concurrently.

19.3.1.1 Prepare. This phase runs from January FY-2 until February FY-1. The district DSPM works with the Operations and Program elements to insure that the annual fiscal year dam safety requirements are included in the budget submission. The MSC DSPM and the Corps DSPM review the information from the districts and work with the business line managers to help prioritize the work. During this phase, the district DSPM should be reviewing the cycles for Periodic Assessments and Periodic Inspections to insure that approximately 10% of the district's required assessments and inspections are included in each year.

19.3.1.2 Defend. This phase runs from February FY-1 to the start of the fiscal year. The DSPM's at all levels work with Program elements to provide background information on the dam safety program as requested.

19.3.1.3 Execute. This phase runs from the start of the fiscal year on 1 October to the end of the fiscal year on 30 September. The district DSPM works with the Operations, Engineering, and Programs elements to insure that the program is fully executed. Work item changes between projects are coordinated with the district to make allowances for changed conditions since the start of the budget cycle 21 months earlier. Adjustments are subject to the annual reprogramming limits established by policy or enacted in legislation.

19.4 Funding Appropriations. Dam safety is funded from the following appropriations on a routine basis.

19.4.1 Routine Work is funded from the Operation and Maintenance appropriation (or MR&T Operations). This includes training, instrumentation readings and analysis, all levels of inspections, and other work items. Interim Risk Reduction Measures are also funded from the Operation and Maintenance appropriation. Minor dam safety repairs or modifications can be funded for the maintenance portion of this appropriation.

19.4.2 Evaluation Studies and Dam Safety Modification Studies are funded from the Construction appropriation. Districts submit requests for studies through the MSC and the RMC to HQUSACE for prioritization based on the project's DSAC level.

CHAPTER 20

Asset Management and Condition Assessments

20.1 Purpose. This chapter describes the direction of the Corps Asset Management (AM) Program and how it relates to the Corps Dam Safety Program. It includes information on the Asset Management Program vision and approach for the coordination of Dam Safety and Asset Management. The chapter is subject to modification as the Corps Asset Management program continues to mature.

20.2 General. USACE Asset Management vision is to incorporate a holistic and integrated approach that embraces a risk informed life-cycle watershed portfolio management perspective. This enhanced AM outlook will enable risk-informed, life-cycle investment decisions to include an assessment of sustainment, restoration, modernization, and disposition projects, as well as portfolio trade-offs. AM is the unifying catalyst to ensure integration of business lines, major programs, and initiatives to improve communication and collaboration. AM will leverage resources, eliminate duplication, evaluate economic and other consequential trade-offs, adapt to new and anticipated requirements, and benefit from synergy. This life-cycle watershed portfolio management approach is asset based and recognizes the multi-business line purpose, risk, and consequence in meeting the various mission requirements.

20.3 Policy. It is the policy of USACE Asset Management to corporately determine condition of the assets and components. Pursuant to this approach are the development (if required) and/or use of existing nationally consistent condition assessment and inspection processes and procedures to meet overall portfolio investment requirements.

20.3.1 Asset Management broadly uses the “feature codes” found in the Finance and Accounting regulations as the “primary constructed asset categories” that support the water resource mission portfolio. These codes are the two digit account numbers found in Appendix A, Chapter 14 of ER 37-1-30, “Financial Administration: Accounting and Reporting” (reference A.36) and as shown in Table 20.1 below.

20.3.2 Reference Memorandum for MSC Commanders dated 16 October 2009, subject “Interim Guidance – Operational Condition Assessments for Inland Navigation” co-signed by the Chiefs of Engineering and Construction and Operations and Regulatory (reference A.78). It is recognized that these baseline operational condition assessments require a similar skill set and experience utilized in the Dam Safety Periodic Inspections as discussed in Chapter 11, “Periodic Inspection, Periodic Assessment and Continuing Evaluation.” MSC’s should plan to transition the baseline operational condition assessments to coincide with the 5-year Periodic Inspection schedule. If the MSC determines that a more aggressive condition assessment schedule is required, they may supplement the 5-year schedule as necessary.

Table 20.1 – Applicable Feature Codes

Feature Code	Title
01	Land
02	N/A
03	Reservoirs
04	Dams
05	Locks
06	Fish and Wildlife
07	Power Plants
08	Roads, Railroads, and Bridges
09	Channels and Canals
10	Breakwaters and Seawalls
11	Levees and Floodwalls
12	Navigation Ports and Harbors
13	Pumping Plants
14	Recreation
15	Floodway Control and Diversion Structures
16	Bank Stabilization
17	Beach Replenishment
18	Cultural Resource Preservation
19	Buildings, Grounds, and Utilities
20	Permanent Operating Equipment

20.3.3. It is also the policy of Asset Management to eventually integrate and use the Facilities and Equipment Maintenance (FEM) day-to-day work maintenance records and other applicable data where applicable to inform and adjust the condition for critical components that may lead to mission interruption.

CHAPTER 21

Dam Safety Policy for Planning and Design

21.1 Purpose and Status. This chapter provides guidance on incorporating USACE dam safety policy into the planning and design of new dams and modification of existing dams through the Civil Works and Dam Safety Portfolio Risk Management processes. It applies to all structures that meet the definition of a dam in the National Dam Safety Program. It encompasses the dam safety requirements from WRDA '86 for new projects (reference A.99).

21.2 General. The civil works planning and design process for a new dam or for modification of an existing facility is continuous, although the level of technical detail varies with the progression through the different phases of project development and implementation. The phases of the process for a new dam or modification of an existing dam for non-dam safety reasons are reconnaissance, feasibility, pre-construction engineering and design (PED), construction, operation and maintenance[5], and finally decommissioning and removal. Detailed guidance on each phase is given in ER 1110-2-1150 (reference A.51). For modification of an existing dam due to dam safety issues the phases are issue evaluation study (Chapter 8), dam safety modification study (Chapter 9), PED (ER 1110-2-1150)(reference A.51), implementation of the risk reduction measures, and post implementation risk assessment (See Figure 3.1).

21.3 Project Delivery Team. A Project Delivery Team (PDT) is established for all projects in accordance with ER 5-1-11 (reference A-35). The PDT consists of a project manager and the technical personnel from engineering, planning, operations, public affairs office, and others necessary to develop the project. When more than one individual from the engineering organization is on the PDT, the technical chief shall designate a "lead engineer." While not necessarily appropriate for later phases of a project when the administrative requirements significantly increase, the lead engineer should be strongly considered for assignment as the project manager during the Issue Evaluation Study phase. The lead engineer may change as the project moves through the different phases of development, however continuity is very important and changes should only be made after careful consideration. At each phase of a project it is also vitally important that team members (in particular the PM and lead engineer) possess a solid combination of both technical and communication skills. External communication with the public and stakeholders is a certainty on dam safety projects and guidance on how to properly communicate risk is covered in Chapter 10. Equally important is the internal communications aspect as it frequently involves team members from within the district, the MSC, HQUSACE, and the Risk Management Center to name just a few. Selection of team members and their specific roles should not overlook this fact. The PDT may also include personnel from the local sponsor's staff and from other Federal agencies. Partnering with the local sponsor is a key element during the design of a

[5] Operation and maintenance is used in this regulation to include both "Operation and Maintenance (O&M)" and "Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)"

project and our partners are key members of the PDT. Partnering shall occur in all phases of project development (ER 1110-2-1150) (reference A-51).

21.4 Dam Safety Items for the Planning Phase.

21.4.1 Reconnaissance. During the reconnaissance phase, the Project Delivery Team (PDT) develops a Management Plan. At this phase the documentation requirements shall be identified, scheduled, and resourced in coordination between the PDT and the Dam Safety Officer or his representatives. Those documents generally include all Design Documentation Reports (DDR's), manuals, plans, and reports, including the Emergency Action Plan (EAP), Control of Water Plan (during construction), Initial Reservoir Filling Plan, Embankment Surveillance Plan, Project Security Plan, Instrumentation Plan, O&M (or OMRR&R) Plan, Turnover Plan, Water Control Plan (operational), Reservoir Control Report, and post-construction documentation of foundation, materials, and construction.

21.4.2 Feasibility. During the feasibility phase, the Project Delivery Team (PDT) develops a Management Plan. The feasibility study shall address the following items related to Dam Safety.

21.4.2.1 Project OMRR&R and dam safety requirements shall be identified and discussed with the sponsor and State. The local sponsor shall be informed that they shall be expected to comply with all State and Federal dam safety requirements. A turnover plan for non-Federally operated dams must be prepared to establish definite turnover criteria or date to the sponsor and to identify funding for the first and second periodic inspections. This information shall be documented in the Feasibility Report.

21.4.2.2 Project Cooperation Agreement. Guidance on policy and procedures for the turnover of completed dam projects to local sponsors is given in Policy Guidance Letter No. 39 (reference A.92). When the Project Cooperation Agreement is developed during the feasibility phase, the Dam Safety Officer or his representative shall ensure that all dam safety requirements are included in the agreement.

21.4.2.3 Consequence and Failure Mode Analysis and Preventative Measures. All reports to be submitted to Congress for authorization of water impoundment facilities shall include information on the consequences of failure and geologic or design factors which could contribute to the possible failure of such facilities (Water Resources Development Act of 1986 (Section 1202) (reference A.99) and ER 1105-2-100, *Planning Guidance Notebook, Appendix G* (reference A.42)). Consequences are defined as potential life loss, economic damages, and environmental damages. At the minimum estimate the consequences related to failure of the dam from a breach of the dam with the reservoir at the maximum pool – no spillway discharge, maximum pool with full spillway discharge, and overtopping of the dam. The geologic site conditions that could lead to failure are to identified, the associated failure mode described, and present the design steps taken to prevent the failure from occurring. Address the general potential

failure modes related to dams and present the how the design for this dam prevents these failure modes from occurring.

21.4.2.4 Downstream Lands. A real estate interest is required in downstream areas where a spillway discharge would create or significantly increase a potentially hazardous condition. Specific guidance on this issue is found in ER 1110-2-1451 (reference A.54).

21.4.2.5 Low-level Discharge Facilities. In 1975 a policy was established that all future lakes impounded by Civil Works projects would be provided with low-level discharge facilities capable of lowering the reservoir pool to a safe level within a reasonable time. This feature provides capability for safely responding to unanticipated needs such as repair or major rehabilitation for dam safety purposes. Specific guidance on this issue is found in Chapter 12 of this regulation.

21.5 Dam Safety Items for the PED Phase. During the PED phase the Dam Safety Officer, or his representative, shall ensure that the design criteria include the most current dam safety requirements and that the design is properly documented for the project records. Based on experience with the design, construction, and performance of existing dams, specific areas of dam safety concerns during the design phase include the following items.

21.5.1 Design Criteria. Current USACE criteria shall be used on all federally funded designs. When the design is being prepared for a sponsor on a cost-reimbursable basis, the district Dam Safety Officer may consider use of state criteria. Deviations from Corps criteria require written concurrence from the USACE Dam Safety Officer.

21.5.2 Public Safety Awareness. A policy of public safety awareness shall be adhered to in all phases of design and operation of dam and lake projects to ensure adequate protection for the general public.

21.5.3 Downstream Lands. See section 21.4.2.4 Downstream Lands.

21.5.4 Low-level Discharge Facilities. See section 21.4.2.5 Low-level Discharge Facilities.

21.5.5 Instrumentation and Monitoring. An adequate instrumentation and monitoring system is required by the “Federal Guidelines for Dam Safety” (reference A.71) as well as by good engineering practice.

21.5.5.1 Purpose. The purposes of the instrumentation are the following:

21.5.5.1.1 To provide data to validate design assumptions,

21.5.5.1.2 To provide information on the continuing behavior of the water control structure,

21.5.5.1.3 To observe the performance of critical features, and
21.5.5.1.4 To advance the state-of-the-art of dam engineering.

21.5.5.2 The rationale for the instrumentation shall be justified and thoroughly documented via the use of potential failure mode analysis. Use the potential failure mode analysis along with engineering analysis to identify the required type of instruments, general location, and expected range of performance.

21.5.5.3 The instrumentation plan shall be prepared and documented in the DDR. Although the monitoring system is expected to evolve commensurate with the observed performance of the dam, an initial system shall be designed and constructed to provide a background of data during initial reservoir filling, sufficient to identify problems and to verify design assumptions. Provide flexibility in the instrumentation plan to allow for changes from anticipated foundation conditions that are encountered during construction and/or operations. Specific guidance on design of instrumentation and monitoring systems is given in Chapter 14 of this regulation.

21.5.6 Operations during Construction. Safe operation of the dam during the construction of a new dam or modification of an existing dam needs to be considered during the development of the Water Control Plan (ER 1110-2-8156 (reference A.59)). A risk assessment should be used to inform the selection of the construction options and the results should influence the options selected.

21.5.7 Initial Reservoir Filling Plan. The Initial Reservoir Filling Plan (IFP) shall be prepared prior to construction, modified during construction to reflect the as built conditions, and documented in the DDR. As a minimum, the documentation on initial reservoir filling shall include:

21.5.7.1 The preferred filling rate and the available options to control the rate of reservoir rise.

21.5.7.2 The surveillance necessary to detect the most likely occurring failure modes.

21.5.7.3 A plan and schedule for reading the instruments and evaluating the data.

21.5.7.4 A plan and schedule for inspecting the dam and downstream areas.

21.5.7.5 Instructions for observers on observed conditions or instrumentation readings requiring immediate attention of personnel authorized to make emergency decisions.

21.5.7.6 An emergency plan listing responsibilities, name and/or positions, telephone numbers, and radio frequencies to be used (as appropriate).

21.5.8 Surveillance Plan. The Surveillance Plan shall be prepared during construction. The plan will address the routine and non-routine surveillance of the dam after the initial reservoir filling.

21.5.8.1 Define the level or intensity of the surveillance for given pool levels. For pool elevations above historical initial filling conditions exist and actions similar to the initial filling surveillance shall be addressed in this plan.

21.5.8.2 The surveillance necessary to detect most likely occurring failure modes.

21.5.8.3 A plan and schedule for reading the instruments and evaluating the data.

21.5.8.4 A plan and schedule for inspecting the dam and downstream areas.

21.5.8.5 Instructions for observers on observed conditions or instrumentation readings requiring immediate attention of personnel authorized to make emergency decisions.

21.5.9 O&M Manual. The O&M (or OMRR&R) Manual shall be prepared during construction. Specific guidance for preparation of the manual is given in ER 1110-2-401 (reference A.50) and ER 1130-2-500, (reference A.62).

21.5.10 Emergency Action Plan. The EAP shall be prepared during construction. Specific guidance for preparation of the EAP is given in ER 1130-2-530 (reference A.63), and in Chapter 16 of this regulation.

21.5.11. Water Control Plan. The Water Control Plan (Operational) shall be prepared during construction. Guidance on water control management is available in ER 1110-2-240 (reference A.49).

21.6 Consulting with State Dam Safety Officials. The district shall consult with state dam safety officials on the design, safety, and inspection of USACE dams when requested by state officials. This will be accomplished by making engineering design and construction criteria, studies, and reports available to the state officials, inviting state officials to attend design conferences and periodic inspections, and inviting state officials to participate in risk assessments.

This Page Left Blank

CHAPTER 22

Dam Safety During Construction (Remediation and New Dams)

22.1 Purpose. Construction (design implementation) is a crucial phase in achieving an adequately safe dam. The objective for construction management is always to deliver a quality project in a timely manner at a reasonable cost. This is considered commensurate with the importance of the project to the Corps and all stakeholders. During construction, the entire project team (particularly the on-site construction staff) is required to assure the design is compatible with actual conditions encountered. Inspection and quality assurance are required to prevent deficiencies in materials and construction practices. This is particularly important when working on dam safety projects as these projects often have significant life and economic loss implications. General processes to manage construction are already covered in detail in existing Corps regulations. The intent of this chapter is simply to supplement those regulations and provide a perspective of their application from a dam safety perspective.

22.2 Design/Pre-Construction Phase. Involvement of construction personnel in the design phase of a project is vital to assure the development of a technical product of the highest quality. This is particularly true on a dam safety project because of the uniqueness of the technical requirements. Experiences offered from a construction perspective regarding things such as the structuring of bid items, phasing, proper construction techniques, buildability, biddability, etc… are invaluable in assuring the project meets technical requirements while at the same time limiting government contractual risk (reference A.39)

22.2.1 In order to provide the best opportunity for project success, a district should always strive to build a cohesive team built upon the principles in ER 5-1-11 (reference A.35). This entire team shall be involved in the project from planning, design, and through completion of construction. This includes not only the technical elements within a district (planners, designers, constructors, PMs, etc…) but also the involvement of vertical elements such as the regional/HQ staff and the Risk Management Center (RMC). While the day-to-day execution of a project remains the responsibility of a district, the RMC is able to bring an agency-wide perspective to the project to ensure uniformity and adoption of best practices from across USACE. Their early and continual involvement as part of the PDT is essential. Involving all elements from the inception of a project will ensure the failure modes are identified, the correct alternatives are evaluated, and that the best project solution is chosen.

22.2.2 It is vital that the construction staff be part of the PDT throughout the life of a project, beginning with the earliest planning phases. This will ensure that each potential alternative is evaluated from an implementation perspective and that all construction-related risks are fully identified and mitigated to an acceptable level. For the preferred alternative, a construction risk assessment may be required if the perceived risks during construction are significant. While restoring a dam to a fully functional condition so that it can safely meet its intended purpose is the ultimate goal,

the more fundamental premise is that any modification undertaken must first do no additional harm to a structure (thereby increasing risks of failure). The PDT should never lose sight of the unique risks that might be present during the construction period and should remain diligent in monitoring and mitigating those risks. One way this can be assured is through frequent instrumentation reading/analysis and on-site inspections throughout construction – particularly during high water periods. This can be accomplished using a combination of design, construction and/or operations personnel. Particular care and oversight should always be given to activities such as dewatering, spillway/gate/outlet works modifications, excavating/blasting, drilling, and grouting to name just a few. Analysis of the instrumentation data and inspection results as it relates to the expected behavior of the dam must be done by the Lead Engineer or his designated PDT representative throughout the construction period.

22.2.3 It is paramount to the success of the dam safety modification project that the PDT clearly defines and communicates the design intent, including the risk reduction objectives, as early as possible so it is conveyed through the specifications and enforced by the staff reviewing/inspecting the work. Clear communication of this information has the potential to avoid costly modifications and claims. Construction personnel must pay particular attention to the “Engineering Considerations for Field Personnel” prepared by the PDT during the PED phase in accordance with Appendix G of ER 1110-2-1150 (reference A.51). The document will outline the proposed risk reduction measures, the potential failure modes to be mitigated, the logic that has gone into previous decisions, as well as the expected risk reduction to be achieved. This effort would then carry forth, in a risk-informed framework, through the critical phases of construction. The document should be reviewed and revised, as necessary, as the project progresses through design and construction. It is USACE’s policy to include key design intent descriptions within the construction specifications.

22.2.4 The PDT/construction personnel should develop a construction schedule with appropriate logic and work breakdown structure (WBS) of the preferred risk management alternative to assess potential constraints based upon the site conditions, construction season and production rates to aid/facilitate the design and estimating phases.

22.2.5 To ensure dam safety risks are adequately addressed by the designs, Districts shall form a Biddability, Constructability, Operability, and Environmental (BCOE) team in accordance ER 415-1-11 (reference A.39) with emphasis on reviewing the designs from the standpoint of constructability. Conducting a BCOE review in the latter stages of design development is an effective method to achieve a quality, cost effective and operations and maintenance (O&M) efficient design. The guiding principle for the BCOE team shall be to act much like a contractor preparing a bid or proposal and look for flaws or defects in the technical specifications. The Lead Engineer/PDT may need to brief the BCOE team on the potential failure modes mitigated by construction and on potential failure modes that may be present during construction activities. In addition to the list of items contained in ER 415-1-11

(reference A.39), the following constructability issues should also be reviewed and discussed if applicable:

22.2.5.1 Borrow area locations, ownership, and access

22.2.5.2 Borrow areas with respect to flooding

22.2.5.3 Borrow materials characteristics in relation to processing requirements

22.2.5.4 In situ moisture conditions

22.2.5.5 Unwatering and dewatering requirements

22.2.5.6 Waste and stockpile issues

22.2.5.7 Zoning

22.2.5.8 Protection of work from flooding

22.2.5.9 Reservoir operations and associated construction constraints

22.2.5.10 Availability of equipment and materials, delivery times, and their sources

22.2.5.11 User deliveries and special needs

22.2.5.12 Climatic effects on construction schedules

22.2.5.13 Available right of way

22.2.5.14 Expected acquisition times

22.2.5.15 Road relocations

22.2.5.16 Material utilization

22.2.6 Construction personnel shall assist the Lead Engineer/ PDT with development of assumptions to be submitted to the cost estimating team in support of cost estimates that are prepared for the various levels of estimates that are prepared throughout the PED phase.

22.2.7 During the construction period the emergency action plan (EAP) shall be updated to reflect the specific risks that have been identified. This update should include identification of visual signs or instrument readings that could indicate a problem is developing. The EAP is to be used by operations and construction

personnel to trigger decisions points which may require implementation of emergency actions at the project.

22.2.8 During the PED phase the Lead Engineer/PDT shall identify those submittals that require review and comment by a specific engineering discipline. Once a submittal is received, comments shall be provided to the construction staff (either the construction manager or RE depending on district processes) in a timely manner. The appropriate construction staff member shall review/resolve all comments prior to sending them to the contractor to ensure the comments are consistent from both a technical and contractual standpoint.

22.3 Construction Phase. Similar to the importance of having construction personnel involved in the planning and design phases of a project, it is equally vital that the design team remain integrally involved and integrated throughout the entire construction period. This is consistent with ER 5-1-11 (reference A- 35) and ER 1110-1-12 (reference A.43).

22.3.1 Quality Assurance Plan (QAP). The construction staff shall prepare a project-specific Quality Assurance Plan (QAP) that is consistent with the scope and complexity of the work. It shall be in accordance with the specific requirements in ER 1180-1-6 (reference A.66). The plan shall ensure that the quality of the construction meets the specifications requirements and design intent. This plan should be prepared during the design phase of the project as it is important to help establish the complete project picture. It should be updated as required as the project scope is modified. The QAP should be included in the DDR/Plans and Specification package and be subjected to ATR and RMC/HQ review and approval.

22.3.2 On dam safety construction/modification projects it is imperative that construction management personnel are aware of design philosophies, intent and assumptions as to the site conditions and functions of project structures. They must also understand the designer's basis for special technical provisions in the specifications in terms of the intended risk reduction objectives of the design. To this end, the Lead Engineer/PDT shall facilitate a coordination meeting prior to the start of construction to ensure the entire project team fully understands the project scope, design intent, limitations, risks, roles and responsibilities of the staff, and other issues which could have an effect on the project. Documents which will form the basis of the discussions at the coordination meeting may include (but are not limited to) Engineering Considerations for Field Personnel; Design Documentation Report (DDR); Results of Risk Assessment study and summary of risk reduction objectives; project EAP; construction plans and specifications, NEPA compliance documents and permits; and Real Estate agreements. For projects that include special features such as load tests, pile driving monitoring, grout monitoring, etc the Lead Engineer shall conduct technical workshops for the field inspection personnel and appropriate construction management staff to assure there is a good understanding of the monitoring requirements and their design implications.

22.3.3 Large and complex dam safety modification projects will require the establishment of an on-site USACE field office that is functioning prior to the beginning of construction activities. Development of the Quality Assurance Plan (QAP) outlining the responsibilities and duties of on-site personnel should be reviewed and clearly understood by all USACE employees working in the Field Office. The logistics of Resident Management System (RMS) computer systems and the pertinent administrative personnel to aid with the RMS set-up should be staffed at the site to troubleshoot USACE/contractor system problems and to ensure that information can be processed properly at contract start-up. All field office quality assurance (QA) staff, including the technical personnel, should have access to RMS and ensure that detailed daily QA reports are generated. The RMS daily QA reports are the official contract documents of all construction processes. If the field office is not the office of record, the method of routing contract documents needs to be developed. The field office, however, should be the contractor's direct point of contact (POC) to USACE, and all documents should pass through the field office. The field office should also maintain a file copy of all contract documents.

22.3.4 Performance of Quality Assurance

22.3.4.1 Dams with safety deficiencies usually have a high potential for loss of life, a risk of significant property damage, potential significant costs to the Government, and negative political impacts. Therefore, dam safety projects are considered of such critical nature that, to the extent practicable, quality assurance shall be performed directly by USACE forces. This includes, but is not limited to, performing inspection of all contract-related construction operations, materials testing, equipment factory inspection, survey control, and foundation testing. Inspection or testing by private consultants should be utilized only in situations where it is impractical for USACE to perform the inspection or testing, or the work is of such a specialized nature that USACE is not capable of performing it. Use of third parties to provide quality assurance should be limited to noncritical items/features. All quality assurance processes shall be in accordance with ER 1180-1-6 (reference A.66).

22.3.5 A communication/ information protocol flow chart for the dissemination of information between the Resident Engineer and the contractor shall be developed ahead of any work beginning. This protocol should address external and internal communications so that real-time information is released in a timely manner. The communication/information protocol should increase the efficiency of the field office by eliminating the burden on the field office of having to deal with numerous requests from different offices for the same information.

22.3.6 Contractor designed construction features such as cofferdams and dewatering plans must be properly designed, approved, and monitored during the construction or modification of a dam. In many cases, they serve as the dam or structure for periods of time while modifications are being implemented. Where failure of these features could potentially cause loss of life and property damage these features will be designed and constructed using USACE criteria for permanent dam

features. The design of these features must be reviewed and approved by the project Lead Engineer.

22.3.7 When a project includes the installation or modification of major electrical or mechanical equipment, special inspections shall be performed at the place of manufacture, upon delivery to the site, during installation, and during acceptance testing.

22.3.8 The Lead Engineer/PDT shall be actively involved in the confirmation of design assumptions during construction. Frequent and mandatory inspections shall be scheduled during construction to confirm that site conditions conform to those assumed for design or to determine if design changes may be required to ensure risk reduction objectives will be met. Critical changes in field conditions must be carefully reviewed and forwarded to the Lead Engineer and the command chain, including the Dam Safety Officer. In accordance with ER 1110-2-112 (reference A.43), key design members of the PDT (with appropriate support of management) shall visit the site regularly to evaluate changed conditions and to evaluate any impact they might have on the design. When necessary, work may need to be stopped until the conditions are reviewed. It is imperative that any changed condition be properly documented and entered into RMS. Temporary duty assignments to the project construction site during critical phases of foundation and embankment construction are desirable and can serve as a unique opportunity to develop key technical skills.

22.3.9 Many dam safety modification projects are related to poorly excavated, cleaned and/or treated foundations during the original construction. For this reason, many dam safety modifications will involve a solution which exposes the bedrock foundations and abutments. Current state of the dam engineering practice involves careful excavation, cleaning and surface treatment prior to placement of any fill material. EM 1110-2-1911 (reference A.16) shall be referenced for additional details relating to the construction or modification of rock fill dams. As previously mentioned, risks to a dam during the construction phase must be carefully identified, monitored and mitigated. This is especially true on items such as dewatering, spillway/gate/outlet works modifications, excavation/blasting, drilling, and grouting to name just a few. A detailed plan shall be required for any work related to these items (or ones posing similar risks). For example, if blasting is required on a project, a detailed blasting plan shall be developed. This plan shall clearly show blast hole spacing, depths, orientation, delays, powder factors and monitoring for peak particle acceleration. It is critical that construction personnel monitor the drilling and loading of blasts to ensure that it follows the blasting plan. Not following the approved blasting plans may result in additional excavation, treatment and support creating contractual issues and quantity overruns. Where specialized blast procedures are required, consideration should be given to retaining a blasting consultant. All similar plans shall be reviewed by experienced personnel in order to assure the desired results are achieved without causing excessive damage requiring additional excavation, support and/or treatment. As with all construction activities, requirements of EM 385-1-1, Section 29 (reference A.7) shall be enforced as applicable.

22.3.10 All cleanup, treatment, and support (bolts, mesh, shotcrete, etc.) of dam or structure foundations and excavated slopes (temporary or permanent) shall be directed by trained and experienced USACE construction personnel, engineers, and geologists. It is critically important that these surfaces are photographed, geologically mapped and as-built geometry surveyed for subsequent dam safety evaluations.

22.3.11 All foundation surfaces that are to be covered by fill and/or concrete shall be formally inspected and approved by the Lead Engineer or their designated representatives. No foundation surface shall be covered until this formal review is completed. The specifications should include the following:

22.3.11.1 A specific period of contract time for geologic mapping by USACE personnel.

22.3.11.2 A specific amount of contractor's staff and/or equipment time to assist in the cleanup of the foundation to allow for either or both the geologic mapping and/or foundation inspection.

22.3.11.3 A specific notification period and specific period of contract time for foundation inspection by USACE personnel.

22.3.12 In order to effectively accomplish this critical task, the Lead Engineer/PDT and Resident Engineer should work together to establish the foundation inspection procedures. This should be accomplished prior to, or shortly following, award of the construction contract. The foundation and acceptance procedures should include the following:

22.3.12.1 Describe an adequate and inadequate foundation.

22.3.12.2 Measures to be considered where an inadequate foundation is identified.

22.3.12.3 Measures to ensure the integrity of an adequate foundation once it has been prepared and prior to placing the structure on the foundation.

22.3.12.4 Procedures to be used when inspection and approval are made onsite.

22.3.12.5 Procedure to be used when inspection is made by field personnel and approval made via telephone.

22.3.12.6 Identify appropriate field testing to be conducted prior to, or during, foundation inspections.

22.3.12.7 Preparation of a foundation inspection checklist which should be used by field personnel.

22.3.13 Formal approval shall be documented in a “Foundation Approval Memorandum” including photographs and geologic maps. Multiple memorandums may be utilized depending on the construction schedule/sequence. These shall be included in the final project geotechnical report (reference paragraph 22.4.4).

22.3.14 Engineering representatives from RMC and MSC office are an integral part of the PDT and thus should be continually advised of construction progress in order to permit participation by personnel from those offices in field inspections at critical construction stages in accordance with the requirements of ER 1110-2-112 (reference A.48). This includes their participation in the latter stages of construction (prior to final acceptance). This shall be accomplished through a regular project update prepared by the Project Manager and distributed to the entire vertical/horizontal team. This update shall highlight current construction progress, issues (both funding and technical), and a 30 to 90 day look-ahead.

22.3.15 Construction operations at an existing facility result in unique problems associated with existing O&M activities. The construction activities will directly overlap into the active O&M program in place at the site. Therefore, it is very important that problems encountered during construction be adequately documented and resolved with the PDT members prior to the operational phase. Special emphasis must be placed on coordination activities between the Resident Engineer and O&M manager in charge of the facility.

22.4 Post Construction Phase.

22.4.1 Many important lessons, both positive and negative can be learned from dam safety projects. Near the end of construction (or as each phase of work is completed), the PDT (including all vertical and horizontal members) shall assemble and conduct a brainstorming session in order to capture lessons learned from both the design and construction phases of the project. The Lead Engineer and Resident Engineer shall ensure these lessons learned are officially entered into DrChecks, the Dam Safety CoP site on the Technical Excellence Network (TEN), or another accepted forum. These lessons should then be built into the official design/construction checklists (typically part of a Design Quality Management Plan) so that future projects can reap the benefits. The district shall organize and facilitate such brainstorming sessions. Typical subjects of discussion are:

22.4.1.1 Dam Safety Modification Studies (DSMS) problems/issues

22.4.1.2 Communications issues between design/construction/contracting and contractor as well as the public and other agencies/entities

22.4.1.3 Environmental issues

22.4.1.4 Procurement of the contract

22.4.1.5 Bid quantities

22.4.1.6 Key specification requirements

22.4.1.7 Problems encountered

22.4.1.8 Design issues

22.4.1.9 Contractor methods

22.4.1.10 Contract modifications

22.4.2 At the completion of the contract, all costs should be summarized and compared with the estimated costs. This will provide valuable information for future programmatic budgeting.

22.4.3 The Operation and Maintenance (O&M) Manual shall be revised/updated as a result of dam safety modifications. The O&M manual provides guidance and instructions to project personnel for proper operation and maintenance of the facility. It contains a narrative summary of the critical dam features including design features with safety limits, equipment operating and testing procedures, instrumentation requirements, potential failure modes, a history of problems, and how those problems could adversely affect the structure over the range of loading conditions. The O&M manual shall be prepared during the construction phase and shall be updated as features are added to the project, when equipment is replaced, or when changes in project operations are implemented.

22.4.4 ER 1110-1-1901 (reference A.44), Project Geotechnical and Concrete Materials Completion Report for Major USACE Projects, requires documentation of the as-constructed geologic, geotechnical and concrete materials aspects of all major, complex and unique engineered projects constructed by USACE, including all subsequent modifications. It is imperative that the report be all encompassing and records the geologic conditions encountered, solutions of problems, methods used, and experiences gained. It is imperative that data such as observations, notes, and photographs be collected and maintained during construction, describing procedures, conditions encountered, and the results of each major operation. This is particularly important for features representing departures from the anticipated conditions.

22.4.4.1 This report shall be identified, scheduled, and resourced in the Project Management Plan (PMP). The information and data in this document shall be presented and discussed with the sponsor/owner. The report provides significant information potentially needed by the sponsor, USACE technical staff, and other team members to become familiar with the project. The report shall facilitate accurate, timely inspections and performance assessments, and serve as the basis for developing and implementing appropriate and effective modifications, and emergency

and/or remedial actions to prevent flood damage, or required as a result of unanticipated conditions or unsatisfactory performance.

22.4.5 Post Implementation Risk Assessment. Review and update the DSM study risk assessment after implementation of the risk management remedial measures. The dam shall be evaluated to determine if the risk management objectives were achieved.

CHAPTER 23

Physical Security for Dams

23.1 Purpose and Status. The purpose of this chapter is to provide references and other information to guide dam safety personnel on physical security issues and facilitate in their coordination with security personnel and first responders.

23.2 Policy. All dams within USACE shall maintain an adequate security posture so as to allow the project to be operated in a safe and secure manner. The safety of employees, project visitors, and area residents is paramount. All project employees shall be familiar with all applicable security regulations, standard operating procedures, and regulatory guidance and be capable of discharging their duties on the project site relative to security matters. The operations chief is responsible for the implementation and oversight for project physical security. The engineering chief and the security chief provide technical support to the operations chief in execution of their responsibility. The District Engineer is ultimately responsible for the security of the project site and personnel within in the area of responsibility (AOR).

23.3 General. It shall be realized that the normal security posture will vary from project to project. The determination of the recommended steady-state security posture for USACE dams should be based on the completion of a security risk assessment. Enhanced security postures may be triggered by changes in the threat environment, new construction, changes of mission, change in condition of security systems, or changes in project operations. Normal and enhanced security postures should be described in the corresponding project specific physical security plan. Priority for completing security risk assessments and implementing enhanced security measures should be given to those USACE dams determined as most critical based on the Consequence-Based Top Screen methodology.

23.4 Physical Security Program. All USACE dams shall implement an appropriate physical security program designed to ensure effective and efficient uses of resources, meeting the needs of the command in protecting its assets against aggressors that are a threat to the project critical assets and hostile intelligence operations. The physical security program is required to include a project specific physical security plan, physical security inspections, and security systems designed and constructed in accordance with the appropriate chapters of AR 190-11 (reference A.1) and AR 190-13 (reference A.2).

23.5 Antiterrorism. All USACE dams shall have a viable, project specific Antiterrorism and Force Protection Plan in place and in accordance with Department of Defense (DoD) Directive Number 2000.12 “DoD Antiterrorism (AT) Program,” (18AUG03) (reference A.70), DoD Instruction Number 2000.16, “DoD Antiterrorism Standards,” (14JUN01) (reference A.69), and DoD O-2000.12-H, “Protection of DoD Personnel and Activities Against Acts of Terrorism and Political Turbulence,” (19FEB93) (reference A.68) that allows for the elevation and decrease of Force Protection Condition Measures as detailed in Chapter B, AR 525-13 (reference A.4).

23.6 Security Portfolio Prioritization. Consequence-based prioritization constitutes the first practical step towards implementation of a security risk management framework. The Consequence-Based Top Screen (CTS) methodology is used to identify the most critical facilities within a given portfolio from a critical infrastructure perspective. This methodology is based on characterizing impacts or effects associated with failure or disruption of a project, considering human impacts, economic impacts, and impacts on critical functions. The input data is developed by the USACE Modeling, Mapping, and Consequence (MMC) Production Center, which has overall responsibility for developing dam break failure modeling, flood inundation mapping, and consequence estimation studies for USACE dams.

23.7 Security Risk Assessment. At a minimum, a security risk assessment should be conducted every five years in conjunction with the project's periodic inspection or periodic assessment.

23.7.1 The results of the security risk assessment should be documented with the periodic inspection or periodic assessment report. Consideration should be given to conducting a revalidation of the security risk assessment between periodic inspections/ assessments. Additionally, in cases where there has been "change" at the project (threat, construction, mission, criticality of a project asset, condition of security systems, project operation, etc.), the revalidation should be implemented immediately by the District to document any change(s) and impact it would have on the initial, or subsequent analysis.

23.7.2 The security risk assessment methodology should be complete (assess consequence, vulnerability, and threat for every defined scenario), documented (clearly document which information is used and how it is synthesized to generate a risk estimate), reproducible (produce comparable, and repeatable results), defensible (technically sound, free from significant errors or omissions, and address the uncertainties associated with consequence, vulnerability, and threat variables). The risk assessment methodology should identify specific attack methods and scenarios. The threat should be estimated as the likelihood that the adversary would attempt a given attack method against the target. The vulnerability assessment component of the methodology should develop estimates of the likelihood of an adversary's success for each attack scenario, accounting for any protective measures in place and considering law enforcement response capabilities. For a given attack scenario, the vulnerability should be defined as the probability of attacker's success, given that an attack is attempted. The Common Risk Model for Dams (CRM-D) risk assessment methodology and the tools and templates for implementing CRM-D, are available through the HQUSACE Office of Homeland Security. CRM-D meet the assessment criteria.

23.8 Security Training and Resources. The following training courses and resources are available to project personnel with security responsibilities:

23.8.1 The web-based training module "IS-870 Dams Sector: Crisis Management" is available on FEMA's Emergency Management Institute website. This is part of a

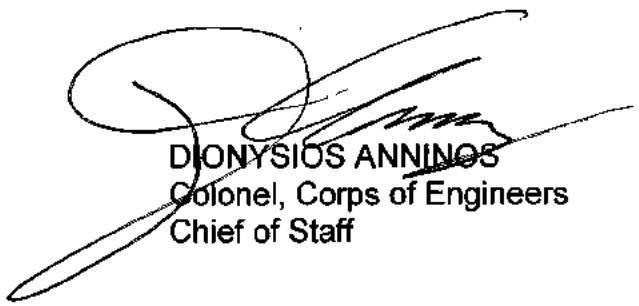
series of web-based training courses whose purpose is to provide general information pertaining to security awareness, protective measures, and crisis management of dams. This course explains how crisis management is an important component of an overall risk management program and provides guidelines to assist owners and operators in developing Emergency Action, Continuity of Operations, Pandemic Preparedness, and Exercise plans. The IS-870 module is available at the following link: http://training.fema.gov/EMIWeb/IS/IS870.asp.

23.8.2 The web-based training module "IS-871 Dams Sector: Security Awareness" is designated as 'For Official Use Only' and are thus only accessible through the Homeland Security Information Network – Critical Sectors (HSIN-CS) Dams Portal (https://cs.hsin.gov/C2/DS/default.aspx). This module provides information to enhance the ability to identify security concerns, coordinate proper response, and establish effective partnerships with local law enforcement and first responder communities. The training course describes common security vulnerabilities, potential indicators of threats, surveillance detection, and reporting of incidents and suspicious activities.

23.8.3 The web-based training module "IS-872 Dams Sector: Protective Measures" is designated as 'For Official Use Only' and are thus only accessible through the Homeland Security Information Network – Critical Sectors (HSIN-CS) Dams Portal. This module addresses protective measures related to physical, cyber, and human elements, and describes the importance of these measures as components of an overall risk management program. The training course describes the basic elements of the risk management model, and discusses the steps required to develop and implement an effective protective program.

23.8.4. Additional reference documents addressing security awareness, protective programs, and crisis management are available through the Homeland Security Information Network - Critical Sectors (HSIN-CS) Dams Portal. The District's Security Officer needs to understand the Homeland Security documents aforementioned and the applicable DoD requirements, and coordinate with the Division Security Officer and HQUSACE Office of Homeland Security as a security plan is developed for each dam.

FOR THE COMMANDER:



29 Appendices
(See Table of Contents)

DIONYSIOS ANNINOS
Colonel, Corps of Engineers
Chief of Staff

This Page Left Blank

APPENDIX A

References

A.1 AR 190-11, *Physical Security of Arms, Ammunition and Explosives*, 15 Nov 06
(Note: Available only through Army Knowledge-Online (AKO))

A.2 AR 190-13, *The Army Physical Security Program*, 30 Sep 93

A.3 AR 335-15, *Management Information Control System,* 28 Oct 86

A.4 AR 525-13, *Antiterrorism,* 11 Sep 08
(Note: Available only through Army Knowledge-Online (AKO))

A.5 EC 1165-2-209 *Civil Works Review Policy*, 31 Jan 10

A.6 EC 1165-2-210, *Water Supply Storage and Risk Reduction Measures for Dams*, 09 Apr 10

A.7 EM 385-1-1, *Safety and Health Requirements*, 15 Sep 08

A.8 EM 1110-1-1005, *Control and Topographic Surveying*, 01 Jan 07

A.9 EM 1110-1-1804, *Geotechnical Investigations*, 01 Jan 01

A.10 EM 1110-1-2907, *Rock Reinforcement*, 15 Feb 80

A.11 EM 1110-1-2908, *Rock Foundations*, 30 Nov 94

A.12 EM 1110-2-1901, *Engineering and Design: Seepage Analysis and Control of Dams*, 30 Sep 86 w/Ch 1 30 Apr 93

A.13 EM 1110-2-1902, *Slope Stability*, 31 Oct 03

A.14 EM 1110-2-1906, *Laboratory Soils Testing*, 30 Nov 70 w/Ch 1 20 Aug 86

A.15 EM 1110-2-1908, *Instrumentation of Embankment Dams and Levees*, 30 Jun 95

A.16 EM 1110-2-1911, *Engineering and Design: Construction Control for Earth & Rock-Fill Dams*, 01 Dec 70 w/Ch 1 10 Mar 86

A.17 EM 1110-2-1914, *Engineering and Design: Design, Construction and Maintenance of Relief Wells*, 29 May 92

A.18 EM 1110-2-2002, *Evaluation and Repair of Concrete Structures*, 30 Jun 95

A.19 EM 1110-2-2006, *Roller-Compacted Concrete*, 15 Jan 00

A.20 EM 1110-2-2100, *Stability Analysis of Concrete Structures*, 01 Dec 05

A.21 EM 1110-2-2104, *Strength Design for Reinforced - Concrete Hydraulic Structures*, 30 Jun 92 w/Ch 1 20 Aug 03

A.22 EM 1110-2-2105, *Design of Hydraulic Steel Structures*, 31 May 94

A.23 EM 1110-2-2200, *Gravity Dam Design*, 30 Jun 95

A.24 EM 1110-2-2201, *Arch Dam Design*, 31 May 94

A.25 EM 1110-2-2300, *Earth and Rock-Fill Dams: General Design and Construction Considerations for Earth and Rock-fill Dams*, 30 Jul 04

A.26 EM 1110-2-2400, *Structural Design and Evaluation of Outlet Works*, 02 Jun 03

A.27 EM 1110-2-2701, *Vertical Lift Gates*, 30 Nov 97

A.28 EM 1110-2-2702, *Design of Spillway Tainter Gates* 01 Jan 00

A.29 EM 1110-2-2703, *Lock Gates and Operating Equipment, 30 Jun 94*

A.30 EM 1110-2-4300, *Instrumentation for Concrete Structures*, 15 Sep 80 w/Ch 1 30 Nov 87

A.31 EM 1110-2-6053, *Earthquake Design and Evaluation of Concrete Hydraulic Structures*, 01 May 07

A.32 EM 1110-2-6054, *Inspection, Evaluation and Repair of Hydraulic Steel Structures*, 01 Dec 01

A.33 EP 1130-2-500, *Partners and Support (Work Management Guidance and Procedures)*, 27 Dec 96, w/Ch 1 01 Jun 06

A.34 EP 1165-2-1, *Digest of Water Resources Polices and Authorities*, 30 Jul 99

A.35 ER 5-1-11, *U.S. Army Corps of Engineers Business Process*, 01 Nov 06

A.36 ER 37-1-30, *Financial Administration – Accounting and Reporting*, 30 Sep 02, w/Ch 1 28 Nov 03; Ch 2 31 Dec 03; Ch 3 26 Jun 06; Ch 4 28 Feb 07; Ch 5 29 Jun 07; Ch 6 14 Jul 08; Ch 7 02 Sep 08; Ch 8 31 Mar 09; & Ch 9 15 Sep 10

A.37 ER 200-2-2, *Procedures for Implementing NEPA*, 04 Mar 88

A.38 ER 405-1-12, *Real Estate Handbook*, 20 Nov 85

A.39 ER 415-1-11, *Biddability, Constructability, Operability, and Environmental Review*, 01 Sep 94

A.40 ER 415-1-13, *Design and Construction Evaluation*, 29 Feb 96

A.41 ER 690-1-1212, *Professional Registration as a Selective Placement Factor,* 31 Mar 04

A.42 ER 1105-2-100, *Planning Guidance Notebook*, 22 Apr 00, w/App D 30 Jun 04; App F 31 Jan 07; App G 30 Jun 04; & App H 20 Nov 07

A.43 ER 1110-1-12, *Quality Management*, 21 Jun 06, w/Ch 1 30 Sep 06

A.44 ER 1110-1-1901, *Project Geotechnical and Concrete Materials Completion Report for Major USACE Projects*, 22 Feb 99

A.45 ER 1110-1-8158, *Corps-wide Centers of Expertise Program*, 16 Jan 98

A.46 ER 1110-2-103, *Strong Motion Instrument for Recording Earthquake Motions in Dams*, 10 Dec 81

A.47 ER 1110-2-111, *Periodic Safety Inspection and Continuing Evaluation of USACE Bridges*, 01 Aug 07

A.48 ER 1110-2-112, *Required Visits to Construction Sites by Design Personnel*, 15 Apr 92

A.49 ER 1110-2-240, *Water Control Management*, 08 Oct 82, w/Ch 1 30 Apr 87, & Ch 2 01 Mar 94

A.50 ER 1110-2-401, *Operation, Maintenance, Repair, Replacement, and Rehabilitation Manual for Projects and Separable Elements Managed by Project Sponsors*, 30 Sep 94

A.51 ER 1110-2-1150, *Engineering and Design of Civil Works Projects*, 31 Aug 99.

A.52 ER 1110-2-1155, *Dam Safety Assurance Program*, 12 Sep 97

A.53 ER 1110-2-1302, *Civil Works Cost Estimating*, 15 Sep 08

A.54 ER 1110-2-1451, *Acquisition of Lands Downstream From Spillways for Hydrologic Safety Purposes*, 10 Aug 78

A.55 ER 1110-2-1802, *Reporting Earthquake Effects*, 25 Jul 79

A.56 ER 1110-2-1806, *Earthquake Design and Evaluation for Civil Works Projects*, 31 Jul 95

A.57 ER 1110-2-1925, *Field Control Data for Earth and Rockfill Dams*, 03 Jul 69

A.58 ER 1110-2-1942, *Inspection, Monitoring and Maintenance of Relief Wells*, 29 Feb 88

A.59 ER 1110-2-8156, *Preparation of Water Control Manuals*, 31 Aug 95

A.60 ER 1110-2-8157, *Responsibility for Hydraulic Steel Structures*, 31 Jun 09

A.61 ER 1110-8-2 (FR), *Inflow Design Floods for Dams and Reservoirs*, 01 Mar 91

A.62 ER 1130-2-500, *Partners and Support (Work Management Policies),* 27 Dec 96, w/Ch 1 17 Oct 97; Ch 2 30 Sep 03; & Ch 3 01 Jun 06

A.63 ER 1130-2-530, *Flood Control Operations and Maintenance Policies*, 30 Oct 96

A.64 ER 1165-2-119, *Modifications to Completed Projects*, 20 Sep 82

A.65 ER 1165-2-131, *Local Cooperation Agreements for New Start Construction Projects*, 15 Apr 89

A.66 ER 1180-1-6, *Construction Quality Management*, 30 Sep 95

A.67 ETL 1110-2-571, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams and Appurtenant Structures*, 10 Apr 09

A.68 Department of Defense, 1993
Department of Defense (DoD), 1993 (Feb), “Protection of DoD Personnel and Activities Against Acts of Terrorism and Political Turbulence”, DoD O-2000.12-H

A.69 Department of Defense, 2001
Department of Defense (DoD), 2001 (Jun), “DoD Antiterrorism Standards”, DoD Instruction Number 2000.16

A.70 Department of Defense, 2003
Department of Defense (DoD), 2003 (Aug), “DoD Antiterrorism Program”, DoD Directive Number 2000.12

A.71 Federal Emergency Management Agency 1979
Federal Emergency Management Agency, 1979 (Jul). “Federal Guidelines for Dam Safety,” FEMA 93, (Prepared by the Ad Hoc Interagency Committee on

Dam Safety of the Federal Coordinating Council for Science, Engineering, and Technology), Washington, DC, (Last Preprinted 2007).

A.72 Federal Emergency Management Agency 1986b
Federal Emergency Management Agency, 1986 (Jan). "Training Courses Related to Dam Safety," FEMA 92, Washington, DC.

A.73 Federal Emergency Management Agency 1998a
Federal Emergency Management Agency, 1998. "Model State Dam Safety Program," FEMA 316, Washington, DC.

A.74 Federal Emergency Management Agency 2004
Federal Emergency Management Agency, 2004. "Emergency Action Planning for Dam Owners," FEMA 64, Washington, DC.

A.75 Federal Emergency Management Agency 2005
Federal Emergency Management Agency, 2005. "Technical Manual for Dam Owners: Impacts of Plants", FEMA Document 534, Washington, DC.

A.76 Federal Emergency Management Agency 2005
Federal Emergency Management Agency, 2005. "Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams", FEMA Document 333, Washington, DC.

A.77 U.S. Army Corps of Engineers, Headquarters, Washington 2007
U.S. Army Corps of Engineers, Headquarters, Memorandum, 10 May 2007, "Interim USACE Policy on Release of Inundation Maps"

A.78 U.S. Army Corps of Engineers, Headquarters, Washington 2009
U.S. Army Corps of Engineers, Headquarters, Joint Memorandum, 16 October 2009, "Interim Guidance – Operational Condition Assessments for Inland Navigation"

A.79 U.S. Army Engineer Division, Great Lakes and Ohio River, Cincinnati 2004
U.S. Army Engineer Division, Great Lakes and Ohio River, Cincinnati, 2004 (February). "Dam Safety Officer Roles, Responsibilities, Qualifications, and Professional Registration Requirements," Cincinnati, OH (Posted under the Dam Safety CoP on Technical Excellence Network (TEN)).

A.80 ANCOLD, Australian National Committee on Large Dams 2003 Guidelines on Risk Assessment, October 2003, http://www.ancold.org.au/publications.asp

A.81 Association of State Dam Safety Officials (ASDSO) 2001
ASDSO (2001). "Peer Review of the Dam Safety Program of the U.S. Army Corps of Engineers, September 30, 2001.

A.82 U.S. Office of Management and Budget (OMB) 1995
Memorandum for Regulatory Working Group, *Principles for Risk Analysis* (1995), http://georgewbush-whitehouse.archives.gov/omb/inforeg/regpol/jan1995_risk_analysis_principles.pdf

A.83 U.S. Office of Management and Budget (OMB) 2006
Proposed Risk Assessment Bulletin, January 2006, http://www.whitehouse.gov/sites/default/files/omb/assets/omb/inforeg/proposed_risk_assessment_bulletin_010906.pdf

A.84 U.S. Office of Management and Budget (OMB) 2007
Updated Principles for Risk Analysis, September 19, 2007, http://www.whitehouse.gov/sites/default/files/omb/assets/regulatory_matters_pdf/m07-24.pdf

A.85 D.S. Bowles, L.R. Anderson, T.F. Glover, and S.S. Chauhan 2003
Dam Safety Decision-Making: Combining Engineering Assessments with Risk Information. Proceedings of the *2003 USSD Annual Lecture,* Charleston, SC, April 2003.

A.86 Duscha 1982
Duscha, L.A. 1982 (Apr). "U.S. Army Corps of Engineers Programs for Safety of Dams in the United States," United States Committee on Large Dams, *Dam Safety Practices and Concerns in the United States,* Denver, CO pp 25-54.

A.87 Foster and Fell 1999
Foster, M., and Fell, R. 1999. "A Framework for Estimating the Probability of Failure of Embankment Dams by Piping Using Event Tree Methods", UNICIV Report (Draft), April 1999.

A.88 Jansen 1983
Jansen, R.B. 1983. *Dams and Public Safety,* U.S. Department of the Interior, Bureau of Reclamation, Denver, CO.

A.89 Jansen 1988b
Jansen, R.B. 1988 (Jun). "Dam Safety in America," *Hydro Review,* Vol 7, No 3, pp 10-20.

A.90 Mahoney 1990
Mahoney, D.J. 1990 (Jun). "FERC's Dam Safety Program: A New Focus on Monitoring," *Hydro Review,* Vol 9, No. 3, pp 38-45.

A.91 National Research Council 1983
National Research Council, 1983, *Risk Assessment in the Federal Government: Managing the Process*, National Academy Press, Washington, DC

A.92 U.S. Army Corps of Engineers 1992
Policy Guidance Letter No. 39, "*Responsibilities of the Corps of Engineers and Local Sponsor to Ensure Safe Operation, Maintenance, Repair, Replacement and Rehabilitation for Flood Control and Multipurpose Dams Constructed Under the Provisions of PL 99-662*," dated 13 November 1992.

A.93 Reclamation Safety of Dams Act Amendments of 1984 (P.L. 98-404).

A.94 Section 216, River and Harbor and Flood Control Act of 1970 (P.L. 91-611).

A.95 U.S. Army Corps of Engineers, Hydrologic Engineering Center 1980
U.S. Army Corps of Engineers, Hydrologic Engineering Center. 1980 (Jun). "Flood Emergency Plans Guidelines for Corps Dams," Research Document No. 13, Davis, CA.

A.96 U.S. Army Corps of Engineers, Hydrologic Engineering Center 1982
U.S. Army Corps of Engineers, Hydrologic Engineering Center. 1982 (Jan). "Emergency Planning for Dams, Bibliography and Abstracts of Selected Publications," Davis, CA.

A.97 U.S. Army Corps of Engineers, Hydrologic Engineering Center 1983a
U.S. Army Corps of Engineers, Hydrologic Engineering Center 1983a (Aug). "Example Emergency Plan for Blue Marsh Dam and Lake," Research Document No. 19, Davis, CA.

A.98 U.S. Army Corps of Engineers, Hydrologic Engineering Center 1983b
U.S. Army Corps of Engineers, Hydrologic Engineering Center 1983b (Aug). "Example Plan for Evacuation of Reading, Pennsylvania, in the Event of Emergencies at Blue Marsh Dam and Lake," Research Document No. 20, Davis, CA.

A.99 Water Resources Development Act of 1986, Title XII (P.L. 99-662).

A.100 U.S. Department of the Interior, Bureau of Reclamation 2003
"Guidelines for Achieving Public Protection in Dam Safety Decision Making," Bureau of Reclamation, Denver Colorado, June 15, 2003.

A.101 International Committee on Large Dams 2005
Risk Assessment in Dam Safety Management. A Reconnaissance of Benefits. Methods and Current Applications, 2005

A.102 Health Service Executive 1992
HSE (Health and Safety Executive, United Kingdom), The Tolerability of Risk from Nuclear Power Stations, 1992, Her Majesty's Stationary Office, London

A.103 Health Service Executive 1995
HSE (Health and Safety Executive, United Kingdom), Generic Terms and Concepts in the Assessment and Regulation of Industrial Risks, 1995, Her Majesty's Stationary Office, London

A.104 Health Service Executive 1999
HSE (Health and Safety Executive, United Kingdom), Reducing Risks, Protecting People, Discussion Paper, Risk Assessment Policy Unit,, 1999, Her Majesty's Stationary Office, London

A.105 Health Service Executive 2001
HSE (Health and Safety Executive, United Kingdom), Marine Risk Assessment prepared by Det Norske Veritis for HSE, 2001 page 9, Her Majesty's Stationary Office, London

A.106 New South Wales Dam Safety Committee 2006
New South Wales Dam Safety Committee, 2006 (Aug), Risk Management Policy Framework for Dam Safety, Endorsed by Parliament August 26, 2006.

A.107 Federal Power Act, 41 Stat, 1063, U.S.C. 791 – 823, 10 June 1920

A.108 Public Law 91-611, HR 10877 December 31, 1970, Sec. 221

A.109 National Environment Policy Act
40 CFR - Code of Federal Regulations - Title 40: Protection of Environment.

A.110 Memorandum US Department of Transportation, dated February 5, 2008, Subject: Treatment of the Economic Value of Statistical Life in Departmental Analyses.

A.111 Memorandum US Department of Transportation, dated March 18, 2009, Subject: Treatment of the Economic Value of Statistical Life in Departmental Analyses – 2009 Annual Revision.

APPENDIX B

Dam Safety in The Corps of Engineers

B.1 Background.

B.1.1 Corps Dam Safety. The safety of dams has been a major concern of the Corps of Engineers since it began building dams in the 1840s. As part of the flood control development of the Muskingum River in northeast Ohio in the 1930's, the Corps started a multiple level of review requirements for dam design. This is currently being performed by an Agency technical review at the district level. As dam designers and operators, USACE retains responsibility and accountability for the continued safe performance of our applicable dams and appurtenant structures, under the full range of anticipated loading conditions. For many years the Corps has made extensive use of experts to consult and advise on unusual and difficult designs. Advisory boards have been helpful in establishing design criteria and standards. Experience gained from the 1938 slide in the embankment of Fort Peck Dam led the Corps to adhere to the highest design standards and comprehensive inspection and testing for construction. The Corps was one of the first agencies to initiate a periodic inspection and evaluation program, and its program was used as input to the development of the "Federal Guidelines for Dam Safety" (reference A.71) due to its early, comprehensive and effective program.

B.1.2 Federal Dam Safety Action. As a result of several dam failures in the mid 1970's, none of which were Corps' owned or operated, a Presidential Memorandum was issued on 23 April 1977 that required each Federal agency having responsibility for dams to review their practices and activities related to dam safety. This memorandum also directed the Federal Coordinating Council for Science, Engineering and Technology to prepare guidelines for management practices and procedures to ensure dam safety. "Federal Guidelines for Dam Safety" (reference A.71) was published in June 1979, and with a memorandum dated 4 October 1979, President Carter asked each Federal agency having responsibility for dams to adopt and implement these guidelines and report their progress to the Federal Emergency Management Agency (FEMA) on a biennial basis. Executive Order 12148 gives FEMA the responsibility to coordinate dam safety in the nation. The purpose of these guidelines is to enhance national dam safety and to encourage high safety standards in the management procedures and technical activities of Federal agencies. The guidelines require the head of each Federal agency having responsibility for design, construction, operation and regulation of dams to establish a dam safety office (officer), which reports directly to the head of the agency. The Interagency Committee on Dam Safety (ICODS) was established in 1980 to promote and monitor Federal and State dam safety programs. The Corps of Engineers is the Department of Defense representative on ICODS.

B.1.3 Corps Dam Safety Officer. On 7 February 1980, the Chief of Engineers appointed the Chief of the Engineering Division, Directorate of Civil Works, as the HQUSACE Dam Safety Officer. This appointment also required that the Dam Safety Officer chair a standing committee composed of individuals having assigned

responsibilities for dam safety to include programming and policy functions. The purpose of this committee is to provide surveillance, evaluation, and guidance for the administrative, technical, and regulatory practices within the Corps of Engineers. The Dam Safety Officer is advisory to the Chief of Engineers, through the Director of Civil Works. The HQUSACE Dam Safety Officer is now Chief, Engineering and Construction.

B.2 Introduction. It is difficult to quantify the overall safety of a dam; however the way to achieve maximum dam safety is to apply the utmost care and competence to every aspect of design, construction, operation, and maintenance. The most important prerequisite for dam safety is the professional competence of persons associated with the dam over its life span. A dam with a record of safe performance may still experience failure from undetected deficiencies within the dam structure or in the foundation. Dam safety must take precedence over all other considerations (references A.86, A.88, A.89, and A.91).

B.3 History of Dam Safety.

B.3.1 Early Development of Dams. History indicates that dams have been vital to civilization for more than 5,000 years. The early United States settlers constructed dams in the 1600's for water supply and to power gristmills and sawmills. The oldest Corps of Engineers' dams are six locks and dams on the Green and Kentucky Rivers built between 1836 and 1844.

B.3.2 Dam Safety. Although construction of dams dates back many years, the history of dam safety covers a much shorter time span. Only a limited number of states had any laws regulating dam safety prior to 1900. The failure of the South Fork Dam in 1889 at Johnstown, Pennsylvania, resulting in 2,209 deaths, had limited influence on dam safety programs. California initiated a dam safety program following failure of the St. Francis Dam in 1928. Failure of the Buffalo Creek Dam in West Virginia and the Canyon Lake Dam in South Dakota in 1972 contributed to Congress passing "The National Dam Inspection Act" in 1972. "The Reclamation Safety of Dams Act" in 1977 followed failure of Teton Dam in Idaho in 1976. Failure of the Laurel Run Dam in Pennsylvania and the Kelly Barnes Dam in Georgia in 1977 set in motion the development of the "Federal Guidelines for Dam Safety" issued in 1979 by the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) (reference A.71).

B.3.3 Interagency Committee on Dam Safety. Although the Interagency Committee on Dam Safety (ICODS) was created in 1980, the Water Resources Development Act (WRDA) of 1996 codified it as a permanent forum for the various government agencies to advise FEMA on institutional, managerial, technical, legislative, and policy issues affecting national dam safety. The following Federal agencies serve on ICODS:

Department of Agriculture
Department of Defense
Department of Energy

Department of Interior
Department of Labor
Federal Emergency Management Agency
Federal Energy Regulatory Commission
International Boundary and Water Commission (U.S. Section)
Nuclear Regulatory Commission
Tennessee Valley Authority

B.3.3.1 ICODS encourages the establishment and maintenance of effective Federal programs, policies, and guidelines intended to enhance dam safety for the protection of human life and property. This is accomplished through (1) coordination and information exchange among Federal agencies and State dam safety agencies; (2) coordination and information exchange among Federal agencies concerning implementation of the "Federal Guidelines for Dam Safety" (reference A.59); (3) Federal activities that foster State efforts to develop and implement effective programs for the safety of dams; (4) improved techniques, historical experience, and equipment for rapid and effective dam construction, rehabilitation, and inspection; and (5) devices for the continued monitoring of the safety of dams. ICODS has an Operations Subcommittee, which focuses on activities essential to carrying out the operating activities of ICODS.

B.3.3.2 The Director of the Federal Emergency Management Agency was designated coordinator of the National Dam Safety Program in WRDA96, and is the Chair of the ICODS and the National Dam Safety Review Board.

B.3.4 National Dam Safety Review Board. The Water Resources Development Act of 1996 established the National Dam Safety Review Board (NDSRB). The NDSRB monitors state implementation of dam safety programs, and advise the Director of FEMA in national dam safety policy. The Director of FEMA based on their dam safety expertise selects nominees to the NDSRB. The USACE Dam Safety Officer recommends a qualified individual to serve on the NDSRB. Five subcommittees serve under NDSRB and focus on activities essential to carrying out the goals of the Program. These subcommittees are:

Dam Safety Research Work Group
Dam Safety Training Work Group
National Inventory of Dams Work Group
Guidelines Development Work Group
Dam Security Work Group

This Page Left Blank

APPENDIX C

Summary of the Federal Guidelines for Dam Safety

C.1 1977 Presidential Memorandum. In 1977, President Carter issued a memorandum directing three actions.

C.1.1 That all Federal agencies having responsibility for dams conduct a thorough review of their practices that could affect the safety of these structures and report their findings to the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET).

C.1.2 That FCCSET prepare the “Federal Guidelines for Dam Safety” for use by all Federal agencies.

C.1.3 That an Interagency Committee on Dam Safety (ICODS) be established to promote and monitor Federal and state dam safety programs.

C.2 Publication of Guidelines. In 1979, the “Federal Guidelines for Dam Safety” was published, and ICODS was given oversight responsibility for dam safety. The key management practices outlined in the guidelines (FEMA 93, (reference A.71)) are

C.2.1 Establish a Dam Safety Officer and appropriate staff,

C.2.2 Maintain an updated inventory of dams,

C.2.3 Document design criteria and construction activities,

C.2.4 Prepare initial reservoir filling plans and reservoir regulation criteria,

C.2.5 Prepare operation and maintenance instructions and document activities,

C.2.6 Maintain a training and awareness program,

C.2.7 Prepare and maintain Emergency Action Plans (EAP's) for each dam,

C.2.8 Establish a program of periodic inspections and evaluation of dams, and

C.2.9 Monitor and evaluate the performance of each dam and appurtenant structure and provide remedial construction as necessary.

C.3 Implementation of Guidelines. The “Federal Guidelines for Dam Safety” (reference A.71) requires each agency responsible for the design, construction, operation, or regulation of a dam project to be structured with a single identifiable, technically qualified head responsible for ensuring that all management and technical safety aspects of dam engineering are adequately considered throughout the development

and operation of the project. That position must have continuity of guidance and direction, and authority and resources to ensure these responsibilities can be carried out. To comply with this portion of the Guidelines, the Chief of Engineers has designated a USACE Dam Safety Officer by General Order. This regulation further defines the requirements and responsibilities of the Dam Safety Officers at each level of the command.

APPENDIX D

Levels of USACE Responsibility for Dams

D.1 Involvement Categories. USACE involvement and responsibility related to dams and dam safety can be categorized into six areas (categories) based on the USACE involvement in design, construction, modification, operations, permitting, and ownership.

D.2 Category 1.

D.2.1 Involvement. Dams USACE owns, operates, and maintains. This includes appurtenant structures such as navigation locks, powerhouses and USACE owned levees that retain permanent pools, whose failure could potentially yield loss of life, or environmental or economic damage.

D.2.2 Responsibilities. USACE is responsible for dam safety.

D.3 Category 2.

D.3.1 Involvement: Dams USACE has designed and constructed, but responsibility for operation and maintenance rests with others.

D.3.2 Responsibilities: The primary dam safety responsibility is with the agency or sponsor responsible for performing operation and maintenance. USACE responsibility is to fulfill the requirements of the Project Cooperation Agreement (PCA), including periodically inspecting the project to evaluate its performance and maintenance.

D.4 Category 3.

D.4.1 Involvement. Dams designed, constructed, operated, maintained, and owned by others where flood control storage is provided at Federal expense under the authority of the 1944 Flood Control Act (Section 7 Dams).

D.4.2 Responsibilities. USACE maintains pertinent data on the project and participates in inspections to ensure that the Federal flood control interest is properly maintained.

D.5 Category 4.

D.5.1 Involvement. Dams designed, constructed, operated, maintained, and owned by others and later modified by USACE for the entity responsible for operation and maintenance.

D.5.2 Responsibilities. USACE assumes a limited responsibility for dam safety when work is accomplished by USACE to modify the dam.

D.6 Category 5.

D.6.1 Involvement. Dams where USACE has issued permits under its regulatory authority.

D.6.2 Responsibilities. USACE has no responsibility for dam safety.

D.7 Category 6.

D.8.1 Involvement. Dams inspected and evaluated by USACE under the authority of the National Program for the Inspection of Non-Federal Dams, PL 92-367.

D.8.2 Responsibilities. USACE has no responsibility for dam safety.

APPENDIX E

Essential Agency Guidelines

E.1 Policy. Essential Agency Guidelines are the state-of-practice for design, construction, operation, and maintenance of USACE dams as documented in current USACE regulations. The requirements specified in these USACE regulations must be met for a dam to achieve DSAC V (Adequately Safe) classification status. These regulations include Engineer Circulars, Engineer Regulations, Engineer Manuals, Engineer Pamphlets and Engineer Technical Letters; and Engineering and Construction Bulletins, and other official HQUSACE dam safety-related Policy Letters and guidance. Current USACE guidance reflecting the state-of-practice guidance is summarized in following paragraphs.

E.2 Hydrology and Hydraulics Minimum Requirements.

E.2.1 Hydrologic Design. Engineering analysis defining hydrologic capacity of the dam must be provided in accordance with Engineer Regulation 1110-8-2 (FR) (reference A.61). In order to be classified as DSAC V, analysis must demonstrate with a high degree of assurance that the dam can pass the inflow design flood without the dam failing. Current guidance is that this requirement is achieved by providing a hydrologic analysis concluding that the dam can pass 100% of the inflow design flood with freeboard or have an adequacy study showing it is specifically designed or analyzed to safely pass the overtopping flow. If the identified threshold flood is less than the inflow design flood requirements, the classification must reflect the deficiency.

E.2.2 Spillway Capacity. The existing capacity of the spillway must be demonstrated to be able to pass with a high degree of assurance, the inflow design flood in such a manner that downstream flows will not exceed unimpaired (without-project) discharges and ensure integrity of the structure (non-failure) during the design event. Current guidance is that the spillway capacity requirement is achieved by providing an analysis that concludes that it will pass the design flood with freeboard. There may be damage to the infrastructure, but the damage should not result in failure or uncontrolled release through the spillway. Beyond the design capacity of the spillway there must be a spillway adequacy study performed to assess the integrity of the spillway in the event that spillway flows are necessary. Many of USACE spillways have never been utilized and the potential for damage/failure under significant flow conditions is highly probable. The intent of design is that the spillway should operate in such a manner that the dam is not failed. The damage may be repairable but the dam must retain pool and operational functionality. In order to be classified as a DSAC V, a spillway adequacy study must be provided that documents expected performance of spillway for design conditions. If materials in the spillway are susceptible to erosion or expected performance is suspect, the classification should reflect that deficiency.

E.2.3 Outlet Works Capacity. The existing capacity of the outlet works must be able to pass the inflow design flood as required by the water control manual without

exceeding the design capacity. In order to be classified as a DSAC V, an outlet works adequacy study must be provided that documents the expected performance of the outlet works for design conditions OR the water control manual revised to reflect the outlet works will not be used for these conditions. If the outlet works is not safely designed to pass the required water control releases the classification should reflect that deficiency.

E.2.4 Gate Reliability. One of the significant findings of the risk assessment portfolio of USACE dams relates to the dependency on reliable gate operations for satisfactory performance of our dams. In particular many of our spillway gates have never been tested under design loads. If a dam depends on gates to pass inflow design floods there must be a gate reliability study performed addressing risk of failure or potential operating issues (such as debris) to receive a DSAC V classification. If a gate reliability is a potential failure mechanism, the classification should reflect that deficiency.

E.2.5 Water Control. Many of USACE projects have been operating for decades and have not updated their water control operating plans. As a minimum, the authorized water control plan/manual should be updated on a periodic basis. This update could be a simple assessment resulting in “no-change” or a complete update that reflects approved operational changes. In order to receive a DSAC V classification the water control manual must have been updated within the last 5 years. If the water control manual is outdated, the classification should reflect that deficiency.

E.2.6 Water Management Data. Generally speaking appropriate levels of monitoring and data collection must be available to make dam safety operational decisions. This data is primarily water volume and timing but it may also include water quality parameters that impact operations. In order to receive a DSAC V classification an assessment of the gage availability and operational availability of critical gages must be provided. If there are gaging shortfalls and/or gages are not dependable during extreme flood events, the classification should reflect that deficiency.

E.2.7 Sustainability Issues. USACE does not have a specific regulatory requirement to assess sustainability but there has always been recognition that we must consider impacts on operational functionality over time due to potential changes in the environment. Recently Congressional guidance has mandated additional emphasis on addressing sustainability and adaptive management opportunities. These considerations should include lake sedimentation, changes in inflow design flood (updating HMR’s), climate/global change, etc. In order to receive a DSAC V classification, a qualitative assessment/report should be provided addressing at least the near term potential for continued operations. As a minimum an engineering report must be provided addressing the basis for the inflow design flood (Note: This report should include potential for change (HMR, etc) which can be based on regional assessments) and impacts of lake sedimentation. As a minimum, results of most recent sedimentation surveys should be provided and projections for remaining life before impacting flood control storage or other project purposes.

E.2.8 Real Estate Interests. The Project should contain documentation or engineering analysis to demonstrate an adequate real estate interest downstream of the project in accordance with the guidance of ER 1110-2-1451 (reference A.54). In order to receive a DSAC V classification, all real estate interests downstream of USACE projects must be adequate to assure project purposes can be accomplished within the criteria outlined in ER 1110-2-1451 (reference A.54). If any modifications have been made to the original project it is important to insure adequate real estate interests have been obtained. This should include, but is not limited to lands below spillways, fuseplugs, saddle dams, outlet works or any surface designed to be overtopped. If additional real estate interests are necessary to insure a project can operated as designed, the classification should reflect this deficiency in terms of the risks it introduces.

E.2.9 Modeling and Mapping. The dam failure model and inundation mapping used to support the Emergency Action Plan should be reviewed and updated on a periodic basis. This update could be a simple assessment resulting in "no-change" or a complete update that reflects changes in the dam or downstream consequences of potential failure**.** In order to receive a DSAC V classification, the dam failure model and inundation mapping must have been updated within the last 10 years. If the dam failure model and/or inundation mapping is outdated, the classification should reflect this deficiency. (Note: Dam failure modeling and inundation mapping is required only for those dams whose failure could result in life loss, economic damage, or environmental consequences as a direct result of the dam failure flood. Dams with only indirect consequences (e.g. navigation, hydropower, or water supply impacts due to loss of the pool) generally do not require modeling or mapping.)

E.3 Geotechnical and Materials Minimum Requirements.

E.3.1 Geotechnical & Materials Design. Geotechnical engineering considerations must be addressed for all types of water-retaining structures, whether they are earth or rock fill embankments, concrete gravity dams, or concrete arch structures, due to the dependence of their engineering performance on both the host geology and the materials employed in the built structure. In order to be classified as DSAC V, geotechnical analysis of the anticipated response to impoundment of the reservoir in accordance with hydraulic and hydrologic design requirements must indicate that the dam and its foundation will retain the pool without progressive degradation of seepage control features, internal erosion leading to void formation, sliding of the dam on its foundation or at the abutment contacts, excessive deformation of the embankment leading to unacceptable loss of freeboard or damage to seepage control features, differential displacements within a concrete dam that affect waterstops or appurtenant structural or mechanical elements, or bearing capacity of dam-foundation or dam-abutment contacts. Current USACE guidance reflecting the state-of-practice guidance for engineering analysis defining geotechnical and materials capacity of the dam is provided in Engineer Regulations 1110-2-1150 (reference A.51), 1110-2-1806 (reference A.56), and 1110-2-1925 (reference A.57), through procedures described in numerous Engineering Manuals, including, but not limited to Engineer Manuals 1110-1-

1804 (reference A.9), 1110-1-2907 (reference A.10), 1110-1-2908 (reference A.11), 1110-2-1902 (reference A.13), 1110-2-1906 (reference A.14), 1110-2-1908 (reference A.15), 1110-2-1911 (reference A.16), 1110-2-2006 (reference A.19), 1110-2-2200 (reference A.23), and 1110-2-2201 (reference A.24).

E.3.2 Reservoir Rim. In addition to assurance of the integrity of the dam itself, stability of the reservoir rim upstream of the structure must be assured for anticipated loadings, whether of hydrologic, earthquake, or other hazards, man-made or natural.

E.3.3 Conduits. Conduits passing through soil within or beneath the dam require additional investigation to assure that their embedment conditions preclude development of seepage paths that are conducive to piping of soil materials. Anti-seep collars or flanges were installed in many dams; it is difficult to compact soils around these features, and under-consolidation with time may lead to detrimental seepage along the conduit; presence of these collars may serve to justify changing the assignment of DSAC V to DSAC IV.

E.3.4 Drainage Features. Relief wells, drainage blankets, chimney drains and other design components intended to convey seepage downstream of waterstops or the earthen core of a dam must be free of contaminants or clogging that would impede their function. Clogged drainage features, whether by organic/bacterial attack, mechanical disturbance or constriction, or siltation, preclude assignment of DSAC V unless and until such contamination is cleared and surveillance reveals that contamination is not recurrent. This infers that a DSAC V dam will not have internal drainage elements that cannot be inspected and validated as to proper function, nor that may not be remediated in the event that such elements may be rendered ineffective at some time.

E.3.5 Filters. Piping of soil materials may result if transitions between fine-grained soils forming an impervious core and surrounding, supportive shell zones or drainage features are not designed and constructed with properly graded filter zones. Damage to the impounding capability of the dam would likely remain unseen until substantial and invasive remedial action is required; the absence of these filter zones precludes assignment as a DSAC V dam. Turbid or muddy seepage must be investigated to rule out internal erosion of dam or foundation soils as the source of the soil fines; a DSAC V dam must have no history of such unattributed sediments in downstream seepage. The presence of slumps, sinkholes or voids within the embankment or beneath or around any conduits or diaphragms such as facing or spillway armoring concrete or training/retaining structures is indicative of soil movement from some mechanism, whether seepage-related or from consolidation settlement, and precludes assignment as a DSAC V dam, unless the causative mechanism is fully determined and permanently resolved.

E.3.6 Earthquake Resistance. Earthquake response of site soils within and beneath the embankment to earthquake ground motions are unpredictable and may even cause damage to well-designed structures. Excess pore water pressures, above hydrostatic, may result during moderate to strong ground shaking in saturated soils;

these may reduce effective shear strength and lead to sliding or permanent deformations within or beneath any dam on a soil foundation. Well-compacted earth or rock fill embankments constructed on an intact rock foundation typically perform satisfactorily during earthquakes exhibiting peak ground accelerations less than about 0.2 g. If the design ground motion anticipated for a given dam is less severe than this, and if the dam otherwise meets all requirements from the engineering disciplines for which it is evaluated, it may be considered safe enough for the DSAC V designation. Hydraulic fill embankments, which are placed without engineering consideration other than expedience of constructability, should not be assigned as DSAC V unless dynamic seismic analysis indicates satisfactory performance.

E.3.7 Summary. If loads less than or equal to the design loads create critical distress (unsatisfactory performance that leads to loss of pool or loss of function that leads to loss of life or large economic consequences), the classification must reflect the deficiency.

E.4 Structural Minimum Requirements.

E.4.1 Structural Data. Historical structural design documents, including as-built drawings and material specifications must be available or adequate field surveys, sampling and testing performed to fully define critical geometric and physical properties of any structural component whose failure would adversely affect the performance of the project. If data on structure geometry and physical properties need to be assumed, or the accuracy of existing data is suspect, the classification should reflect that deficiency.

E.4.2 Structural Condition Assessment. All structures, whose failure would adversely affect the performance of the project, must be current with all required inspections, including underwater and/or dewatered inspections. All potentially significant deterioration must be located and quantified with a high level of confidence. This includes assessment of internal conditions such as presence of alkali-silica reaction in concrete or loss of post-tensioning in anchor rods. If inspections are not current or in accordance with guidance, or if there is not a high confidence level that all significant deterioration has been located, the classification should reflect that deficiency.

E.4.3 Structural Stability Evaluation. All structural units or monoliths, whose failure would adversely affect the performance of the project, must have a stability evaluation performed in accordance with EM 1110-2-2100 (reference A.20) and EM 1110-2-6053 (reference A.31) and meet all mandatory requirements stated in those documents. If evaluation methods or results are not in accordance with current guidance, the classification should reflect that deficiency.

E.4.4 Structural Strength and Serviceability Evaluation. All structures, whose failure would adversely affect the performance of the project, must have strength and serviceability evaluated in accordance with current guidance. Guidance for reinforced-

concrete hydraulic structures is contained in EM 1110-2-2104 (reference A.21). Guidance for hydraulic steel structures is contained in EM 1110-2-2105 (reference A.22). Additional guidance for specific structure types is included in EM 1110-2-2200 (reference A.23) for gravity dams, EM 1110-2-2201 (reference A.24) for arch dams, EM 1110-2-2400 (reference A.26) for outlet works, EM 1110-2-2701 (reference A.27) for vertical lift gates, EM 1110-2-2702 (reference A.28) for tainter gates, and EM 1110-2-2703 (reference A.29) for lock gates. If strength and serviceability have not been evaluated for all structures whose failure would adversely affect the performance of the project, or evaluation methods or results do not comply with current guidance, the classification should reflect that deficiency.

APPENDIX F

Background Information on the USACE Dam Safety Action Classification System

F.1 Policy.

F.1.1 The Dam Safety Action Classification process is intended to provide consistent and systematic guidelines for appropriate actions to address the Dam Safety issues and deficiencies of USACE dams. USACE dams are placed into Dam Safety Action Classes (DSAC) based on their individual Dam Safety risk considered as probability of failure and potential failure consequences. Consequences of the dam failure considered are lives lost, economic, environmental, and other impacts. All dams will be evaluated with a screening assessment and classified according to the DSAC. Dams will be reclassified as new dam safety related information about the dam is developed through monitoring or studies. The intent is that the classification of a dam is dynamic, changing as project characteristics change or as more refined information becomes available.

F.1.2 The structure and make-up of the DSAC table resulted from the need to formally recognize different levels and urgencies of actions that are commensurate with the different safety status of USACE dams. These actions range from immediate recognition of an urgent and compelling situation requiring extraordinary action through to normal operations and Dam Safety activities for safe dams.

F.1.3 In the past, the USACE Dam Safety program essentially recognized two categories of actions those for dams considered safe, which comprised routine Dam Safety activities, normal operation and maintenance; and those for dams that were considered in need of remediation, for which investigations, remediation funding justification documents, and design and construction of remediation measures were additional activities. However, these two categories do not provide formal recognition of an adequate range of actions and degrees of urgency, especially for dams with Dam Safety issues that are very high or extremely high risk, which warrant heightened actions that are not provided for in the current business-as-usual procedures. Three action classes are termed “unsafe” and two are termed “safe”. The choice of three “unsafe” action classes is to provide adequate separation in the range of levels of actions. These five action classes are now included in the USACE Dam Safety program and summarized in the DSAC table. At the top, DSAC I is for those dams considered to be critically near failure and for which urgent actions are needed to avoid catastrophe in the near-term. DSAC II is for dams with confirmed (unsafe) and unconfirmed (potentially unsafe) dam safety issues; failure could begin during normal operations or be initiated as the consequence of an event. The likelihood of failure from one of these occurrences, prior to remediation, is too high to assure public safety. DSAC III is for dams with confirmed and unconfirmed dam safety issues where the combination of life or economic consequences with probability of failure is moderate to high. DSAC IV is for dams that are not declared safe because they don’t meet current guidelines, but which are not considered unsafe enough to warrant heightened attention and for which

remediation is considered to be quite low priority, although investigations to confirm their DSAC classification should be given normal priority. At the bottom is DSAC V for dams that are determined to be safe. Examples of Dam Safety Action Classifications are given in following sections of this appendix.

F.2 Dam Safety Action Classes. Five classes of action were selected to portray the range of actions district Dam Safety officers are to take in executing their Dam Safety responsibilities. The USACE dams are to be placed into Dam Safety Action Classes (DSAC) based on their individual Dam Safety risk considered as probability of failure and potential failure consequences.

F.2.1 DSAC I – Urgent and Compelling (Unsafe).

F.2.1.1 Characteristics. Dams in this class are CRICTICALLY NEAR FAILURE OR EXTREMELY HIGH RISK under normal operations. These dams are ones where progression toward failure is confirmed to be taking place and are almost certain to fail under normal operations any time within a few years without intervention**;** or the dams have Extremely High Risk with a combination of life or economic consequences with high probability of failure.

F.2.1.2 Actions. A summary of the actions to be considered and pursued by the district for this class of dams are:

F.2.1.2.1 Take immediate action to avoid failure.

F.2.1.2.2 Validate classification through an external peer review.

F.2.1.2.3 Implement interim risk reduction measures, including operational restrictions, and ensure that emergency action plan is current and functionally tested for initiating event.

F.2.1.2.4 Conduct heightened monitoring and evaluation.

F.2.1.2.5 Expedite investigations to support justification for remediation using all resources and funding necessary.

F.2.1.2.6 Initiate intensive management and situation reports.

F.2.1.3 Examples of Critically Near Failure Dams.

F.2.1.3.1 Dam A. Dam A is experiencing foundation, abutment, and embankment piping or internal erosion due to seepage through these features under normal pool elevations. All of the seepage items may lead to the formation of piping, which can quickly progress to rapid breaching of the embankment. Loss of strength in the foundation or embankment may result in a slope stability failure which could result in dam overtopping though the lowered dam crest. Recent subsurface investigations have

revealed significant degradation of the foundation and embankment soils. Extremely soft zones were found in multiple borings. Piezometers within the embankment downstream of the existing cutoff wall show significantly higher than expected pressures in reaction to the pool. Movement monuments have indicated continual and increasing settlement of portions of the embankment crest. A temperature survey of the piezometers shows cooler zones in the rock foundations which indicate direct seepage from the pool. Numerous and excessive wet areas persist in areas just downstream of the embankment. These wet areas have progressively increased over the years.

F.2.1.3.2 Dam B. Dam B is experiencing foundation and abutment seepage and piping, and embankment piping along the conduit during all pool elevations. The conduit is founded on soil and constructed in soil materials. The periodic inspections indicated that a small amount of differential settlement has occurred at one of the conduit joints. It was constructed with seepage collars that likely prevented adequate compaction of the soil around the conduit and the seepage collars provide a seepage path along this interface that could lead to piping of the embankment. The left abutment is composed of granular glacial deposits and has experienced significant seepage during Normal pool events. The project has had several test fillings and subsequent seepage collection features were added after each test filling. The seepage is so severe that permanent operational restrictions have been imposed on the project to prevent high pools. The most likely mode of failure for this project is seepage and piping of foundation or abutment materials which may rapidly progress to breaching of the dam.

F.2.1.4 Example of Extremely High Risk Dam. Dam C. Items of concern include foundation and abutment seepage and piping under the embankment. The dam abuts highly karstic limestone formations. One documented cavity in the left rim is 77 feet deep and 15 feet wide. On the right rim, primary seepage pathways through the karst system have not been defined by previous subsurface investigations. In stream seepage measured downstream of the dam during zero releases have increased more than 40% from 90 cfs to 127 cfs in 15 years. Rim grouting has been performed twice previously with limited success. The seepage has potential to erode the earth embankment. There is a wet area downstream of the embankment that has appeared in the last 10 years. Initial foundation treatment, which consisted of minimal excavation and a single line grout curtain, is inadequate. The initial grout curtain and a curtain installed later encountered large clay-filled, solution features in the limestone. There is a potential for erosion of this clay-filled material, which would jeopardize the integrity of the embankment. Piezometer levels are higher than expected; however, some have steadily increased or decreased over the last 20 years indicating erosion of the foundation materials. There is a large metropolitan area (1,000,000 people) with high potential life loss and less than one hour of warning time for the flood wave. This project is considered to have extremely high risk.

F.2.2 DSAC II – Urgent (Unsafe or Potentially Unsafe).

F.2.2.1 Characteristics. Dams in this class are considered to have Failure Initiation Foreseen in that, for confirmed (unsafe) and unconfirmed (potentially unsafe) dam

safety issues, failure could be initiated during normal operations or from a hydrologic or seismic event. The likelihood of failure from one of these occurrences, prior to remediation, is too high to assure public safety. Or, dams in this class have Very High Risk in that the combination of life or economic consequences with probability of failure is very high.

F.2.2.2 Actions. A summary of the actions to be considered and pursued by the district for this class of dams are:

F.2.2.2.1 Implement interim risk reduction measures, including operational restrictions as justified, and ensure that emergency action plan is current and functionally tested for initiating event.

F.2.2.2.2 Conduct heightened monitoring and evaluation.

F.2.2.2.3 Expedite confirmation of classification.

F.2.2.2.4 Give very high priority for investigations to support justification for remediation.

F.2.2.3 Examples of Failure Initiation Foreseen Condition.

F.2.2.3.1 Dam D. The most likely mode of failure for this project is breaching of the dam by erosion or piping through cracks in the core caused by significant displacements of the upstream shell during an Operating Basis Earthquake (OBE) or greater earthquake. Foundation seepage may lead to the formation of piping, which can quickly progress to rapid breaching of the embankment. Detailed evaluation of the dam foundations indicates that a loose layer of alluvial materials will liquefy during an OBE earthquake or greater earthquake. The predicted large displacements during the earthquake will cause significant cracking or loss of the integrity of the dams' core section. The displacements are large enough to result in complete failure of the upstream shell of the dam. This will result in piping of the remaining dam embankment and will quickly progress to breach. The intake tower is located in the central part of the embankment just upstream of the core. Large displacement of the upstream shell will likely cause damage to the intake tower. The population at risk is located less than one hour travel time of the flood wave at the mouth of a narrow canyon. Loss of life is expected to be very high if the dam were to fail from an earthquake.

F.2.2.3.2 Dam E. The most likely failure mode is embankment, abutment, and foundation seepage and piping. Deficiencies in the design and construction techniques contribute to a condition of active piping at moderately high pools – 0.05 to 0.01 pool frequency. Most of the embankment is founded on alluvial and glacial soils without any seepage cutoff. Additionally, the rock below the foundation soils was not inspected or treated and has a history of solutioning. The grout curtain installed on the remainder of the foundation does not meet current standards. There is a history of seepage on the downstream embankment slope, the toe of the downstream embankment, zones

downstream of the toe, and along the abutment contacts with the higher pool levels. Piezometeric data show a 10 foot rise in the phreatic line over the last 20 years. There has been a continual and steady settlement of the dam crest to the left of the concrete section since at least 1978. It is likely that the settlement is the result of internal erosion caused by seepage. It is possible that seepage through the lift joints in the concrete section may be entering embankment materials.

F.2.2.4 Example of Very High Risk Condition. Dam G. Dam is overtopped by several feet at 80% of the probable maximum flood (PMF) and also has potential for foundation seepage creating a piping failure at pool levels for infrequent events. The very large population immediately downstream and a major downtown urban area within 10 miles of the dam has the potential for very high consequences and thus the risk for this project is considered to be very high even though the failure mode is driven by a near PMF event.

F.2.3 DSAC III – High Priority (Conditionally unsafe).

F.2.3.1 Characteristics. Dams in this class, for confirmed and unconfirmed Dam Safety issues, are considered to be Significantly Inadequate or have Moderate to High Risk in that the combination of life or economic consequences with probability of failure is moderate to high.

F.2.3.2 Actions. A summary of the actions to be considered and pursued by the district for this class of dams are:

F.2.3.2.1 Implement interim risk reduction measures, including operational restrictions as justified, and ensure that emergency action plan is current and functionally tested for initiating event.

F.2.3.2.2 Conduct heightened monitoring and evaluation.

F.2.3.2.3 Prioritize for investigations to support justification for remediation considering consequences and other factors.

F.2.3.3 Example of Significantly Inadequate Dam. Dam H. Two failure modes have been identified for this dam - overtopping and piping. The most probable is a piping failure of the foundation overburden materials, initiating at the left cut slope of the outlet channel. A pervious sand and gravel deposit overlying the bedrock is exposed in the outlet channel and does not have adequate seepage control filters. Dam is estimated to be overtopped by several feet by the probable maximum flood and the embankment is breached by erosion. During pools up to the record event, seepage has been observed downstream of the toe of the dam in the cut slopes on both sides of the outlet works stilling basin. Construction of remedial seepage control filters and relief wells were constructed several years after the dam was completed but appear to be insufficient to reduce the seepage to acceptable levels based on peizometer response. Seepage on the left cut slope is still occurring and is anticipated to increase in severity

under higher pool levels. The seepage being experienced along the outlet channel is occurring through a sand and gravel layer located immediately above the bedrock surface.

F.2.3.4 Example of a Moderate to High Risk Dam. Dam I. Dam has a long term history of downstream movement in the clay shale foundation. The piezometric data indicate high uplift in the foundation clays that are the result of the original loading by the embankment during construction. The available inclinometer data show distinct zones of movement at high pool levels as well as a very slow creep over time. The assessment shows the factors of safety for the more extreme pool elevations approach 1.0. The dam has been loaded to top of spillway gates for a pool of record, but there is still an additional 30 feet of storage above that elevation, thus the pool elevation of concern is a rare event. There is significant data to indicate a conditionally unsafe project (potential for failure only when the pool is very high) and the very large volume of water behind this dam at the higher pool elevations would create very high economic and environmental consequences with low to moderate loss of life consequences.

F.2.4 DSAC IV. Priority (Marginally Safe).

F.2.4.1 Characteristics. Dams in this class are considered to be inadequate with low risk. For confirmed and unconfirmed Dam Safety issues, the combination of life or economic consequences with probability of failure is low and may not meet all essential USACE guidelines.

F.2.4.2 Actions. A summary of the actions to be considered and pursued by the district for this class of dams are:

F.2.4.2.1 Conduct elevated monitoring and evaluation.

F.2.4.2.2 Give normal priority to investigations to validate classification, but no plan for interim risk reduction measures at this time.

F.2.4.3 Examples of Inadequate With Low Risk condition Dams.

F.2.4.3.1 Dam J. The embankment has a potentially preferential seepage path along the top of the outlet conduit and may result in piping of embankment materials during extreme hydrologic events. The dam does not have a foundation seepage cutoff system. Seepage has been apparent at the toe of the dam since the initial filling. High foundation seepage pressures are anticipated for the Extreme events. With the relief well system functional, it is estimated that the seepage pressure would be 2 feet above the ground surface at the toe during an Extreme event. It is likely that the high seepage pressures may cause some piping in the form of sand boils potentially causing embankment instability due to loss of foundation material. After the pool of record it was found that significant scouring occurred just below the outlet apron. There is currently a 140 foot long, 120 foot wide, and 13 foot (maximum) deep scour hole downstream of the outlet apron. There is potential for additional scouring and

undermining of the outlet apron and wing walls under Extreme conditions. The population centers downstream are all located on the elevated floodplain of a wide valley and the potential for economic consequences is low to moderate. The overall risk is considered low and some essential guidelines are met by this dam.

F.2.4.3.2 Dam K. An overtopping failure mode may result from inadequate freeboard based on existing routings. The resultant consequences are low because of a wide downstream valley, low population density, and ample warning time. Thus the risk is low.

F.2.5 DSAC V – Normal (Safe).

F.2.5.1 Characteristics. Dams in this class are considered to be adequately safe, meeting all essential USACE guidelines with no unconfirmed Dam Safety issues such that the residual risk is considered tolerable.

F.2.5.2 Actions. Continue routine Dam Safety activities, normal operation and maintenance.

F.2.5.3 Example of an Adequately Safe Dam. Dam L. Dam meets the requirements for hydrologic capacity to pass the most current inflow design flood (IDF), there is no known seepage and piping issue and seepage control features meet current standards, the seismic capacity and performance of all the features of the project are appropriate for the current seismic loads, and there are no operations and maintenance issues that impact the operations of the project for all pool and loading conditions. The project staff and water management staff are appropriately trained and qualified to deal with project operations under emergency and flood conditions. With this high level of readiness and low probability of unsatisfactory project performance a review of the project's residual risk indicates that the risk is tolerable for all design loads and the dam is "safe." Normal operations require due diligence by a district to perform the requisite monitoring, evaluation, maintenance, and training to actively manage the inherent residual risk associated with any dam with the goal to keep the residual risk at or below the that which is considered tolerable for the respective dam.

F.3 Actions. The actions listed are an executive summary of the actions that a district Dam Safety officer should pursue based on the action classification assigned to each dam. The basic concept is that dams in classes I, II, and III shall be treated as unsafe until confirmed safe.

F.4 Documentation**.** It is recommended that a district document their decision for assigning a class to a given dam using a short fact sheet that addresses the available information in summary form to include the failure modes of concern, the loading conditions of concern, the probability of failure, the consequences, and DSAC assignment.

This Page Left Blank

APPENDIX G

Dam Safety Program Management Tools

G.1 Purpose. The purpose for the Dam Safety Program Management Tools (DSPMT) is to facilitate agency wide data collection and monitoring of the USACE dam safety program and to track compliance against the "Federal Guidelines for Dam Safety" (reference A.71) and USACE criteria.

G.2 Introduction.

G.2.1 Since implementation of the USACE Dam Safety Program, it has become increasingly clear that there are broad information needs required to support dam safety. These data needs include:

G.2.1.1 Documenting the condition of the Agency's dams

G.2.1.2 Tracking the status and progress of the MSC's and District's dam safety programs

G.2.1.3 Reporting information regarding the Agency's inventory of dams periodically to the National Inventory of Dams (NID) and Congress.

G.2.2 Satisfying many of these data needs is the Dam Safety Program Management Tools (DSPMT). The DSPMT is an information collection and management system that is controlled locally by District dam safety program managers and which interacts with MSC's, Headquarters, and National external cooperative information resources for providing as-requested and periodic information on local dam safety information, program needs, and accomplishments within each organization's jurisdiction.

G.2.3 The purpose of the DSPMT is to provide dam safety program managers a tool to collect unbiased data about dams and dam safety programs, check selected data for accuracy, and then utilize the data to achieve an accurate local, regional, and National inventory of dams and to help address programmatic questions such as:

G.2.3.1 How well are our dam safety programs being implemented?

G.2.3.2 Are we doing too much in some areas and not enough in others?

G.2.3.3 Are we spending our scarce resources in the right places?

G.2.3.4 Are we improving?

G.2.4 The DSPMT consists of a set of interactive software programs which provide a resource to the dam safety data owners, managers, and data providers. The software

is under continual development and is evolving as needs are expressed by users. The DSPMT includes two distinct, complementary, and interoperable software programs:

G.2.4.1 The Dam Safety Program Performance Measures (DSPPM).

G.2.4.2 The National Inventory of Dams (NID) Electronic Submittal Workflow

G.2.5 Each of these programs is applicable to all levels of a dam safety organization. Output from the DSPPM at each level can be used individually and/or collectively as input at the next higher level to evaluate program performance on broader and broader scales (e.g., district, division, agency). By utilizing the tools provided by the DSPMT, data managers and providers can achieve the one-time-only data entry objective while maintaining an up-to-date, error-checked, consistent format database of dam inventory and program performance information.

G.3 Discussion. The overall objective of the DSPMT is to enable each user to have a computer program that interacts with the NID, local databases, and other external cooperative databases in a one-time-only data entry environment.

G.3.1 The vision is to eventually achieve:

G.3.1.1 One-time data entry for programs targeted at the different aspects of dam safety;

G.3.1.2 Efficient data extraction from local state and federal databases into a consistent user-friendly and user-managed inventory and performance measure database;

G.3.1.3 Automated error checking and identification of conflicting data;

G.3.1.4 Simple online exports of local inventory and performance measure (or indicator) data and import of national level data to/from a centralized server; and

G.3.1.5 Updating and reporting of inventory, performance measure, and incident information as frequently as desired.

G.3.2 The objectives of the DSPPM are also to provide simple, unbiased, quantitative data that are useful separately and/or collectively as metrics to help users:

G.3.2.1 Evaluate how well their dam safety programs are being implemented;

G.3.2.2 Determine whether they accomplished what they set out to accomplish;

G.3.2.3 Proactively “tell” their dam safety stories to others, both internal and external to their organizations; and

G.3.2.4 Encourage uniform and consistent application of laws, policies, and regulations.

G.4 DSPMT Overview.

G.4.1 DSPPM. The DSPPM is currently divided into seven subject areas:

G.4.1.1 Dam Safety Program Management Authorities and Practices,

G.4.1.2 Dam Safety Staff Size and Relevant Experience,

G.4.1.3 Inspections and Evaluations,

G.4.1.4 Identification and Remediation of Deficient Dams,

G.4.1.5 Project Response Preparedness,

G.4.1.6 Agency and Public Response Preparedness, and

G.4.1.7 Unscheduled Dam Safety Program Actions.

G.4.1.8 These broad performance measures are supported by detailed spreadsheets which are targeted at individual aspects of the performance measures. The following detailed additional spreadsheets are currently available within the DSPMT:

G.4.1.8.1 Staffing Spreadsheet

G.4.1.8.2 Deficiencies and Budgeting Prioritization Spreadsheet

G.4.1.8.3 Documentation Spreadsheet

G.4.1.9 These spreadsheets allow graphics of data to be generated that provide insight into the capabilities and challenges faced by the organization.

G.4.2 NID Submittal Workflow.

G.4.2.1 The NID electronic submittal software provides tools for State and Federal data owners to efficiently collect, access, and manage NID data. The workflow starts by importing a State or Federal agency's local inventory of dams, which can be in a variety of database formats. Interactive graphical tools provided by the DSPMT are then utilized to check for data errors in numeric values and spelling errors or inconsistencies in text values. The NID inclusion rules are then applied. The data submittal is checked for differences between the candidate and the current NID, and is then electronically sent to USACE for review and incorporation into the NID.

G.4.2.2 By performing data submittal workflows at the state and agency level, those most familiar with the data and most qualified to make any changes, specifically the data owners, managers, and data providers, are kept in the loop by the program as it highlights areas in the data that potentially need attention, modification, or double-checking. By performing these workflows at the state and agency level, and by using the original data from the day-to-day dam inventory management tools, the data quality and accuracy of the submittal is significantly enhanced.

G.5 USACE DSPMT Implementation Specifics. Since the Dam Safety Program Managers at the district level should be most familiar with the details of the individual projects in their inventory, they shall have the primary burden of maintaining up-to-date information on the dams in the database.

G.5.1 DSPMT databases shall be fully updated quarterly prior to HQ quarterly review. As inspections are completed, the DSPMT shall be updated to include any modifications to NID information on the dam, and to include the results of the inspection and any impacts on the performance measures such as inspection date, identified deficiencies, estimated costs of remediation, priority ratings, etc.

G.5.2 The MSC shall be responsible for providing quality assurance and review functions on district submittal information on a periodic basis. Instructions for accomplishing these updates are described in the DSPMT User's Manual. If questions, data conflicts, or errors are noticed in district inventory information, they shall not be corrected or modified at the division level or HQ level. It shall be the district responsibility to resolve the question or implement the correction in the district database.

G.6 Dam Safety Scorecard for Routine Dam Safety. For several years now, we have been collectively building an unbiased dam safety database within the Dam Safety Program Management Tools (DSPMT). Progress of the program is being tracked using Dam Safety Program Performance Measures (DSPPM). Selected performance measures which represent key routine activities are utilized to export in the form of the Dam Safety Scorecard. The Dam Safety Score Card provides a numerical and graphical report of the implementation of routine dam safety activities on a per dam basis. The score card is not used to be an indicator of the dam's condition or to determine the dam safety action class (DSAC). It does, however, provide a uniform and consistent way of evaluating routine program implementation in the form of numbers, verbal ratings (Excellent, Fair to Good and Poor), and colors (Green, Yellow, and Red). The scorecard is generated by the Dam Safety Program Management Tools as an output on a per dam basis, or it can be rolled up for dams in a district, a division, or HQUSACE. The Dam Safety Scorecard will be reviewed approximately quarterly in forums such as the HQ Dam Safety Committee meetings and Civil Works DMRs.

G.6.1 The six sections of the scorecard are Staffing and Funding; Inspections and Evaluations; Project Instrumentation; Project Response Preparedness; Agency and Public Response Preparedness; and Interim Risk Reduction Measures. The subjects

and the numerical values assigned to each of the six sections are based on a consensus of solicited expert opinions. The weighted values were evaluated during a beta testing period, adjusted accordingly, and as data is collected, in time the scorecard index value will be a reasonable, recognizable, and accepted index of a routine dam safety program implementation.

G.6.2 The data used to populate the scorecard is retrieved from information that the districts provide in their DSPMT databases. The scores, verbal ratings and graphical output are automatically generated by the DSPMT. The scorecard allows managers to evaluate the overall program on a per-dam basis, perform trend and gap analyses, and convey program accomplishments to others.

G.6.3 Districts should include discussions of their scorecards in their dam safety committee meetings and for briefing their DSAC I and II dams at PRBS. It is envisioned that the scorecards can be useful when defending budget requests to highlight the need for funding items or activities that are not being accomplished due to inadequate funding.

G.7 Summary. With continued reductions in budgets and staffing, both Federal and non-Federal dam safety programs are in need of continuous efficiency and effectiveness improvements. In addition, there is an ever-increasing need for performance-based reporting internally and to FEMA, Congress, and State Legislatures. The DSPMT provides the tools necessary for evaluating dam safety programs, for reporting accomplishments, and for expressing program needs to others. As a working tool, it implements true one-time-only data entry, provides assistance to program managers in achieving continuous program improvement, is a self-evaluation tool and an internal and external reporting tool, and encourages results-oriented management practices. By using the DSPMT, the agency will be assured of a more consistent, error-checked submittal of inventory and performance measure information provided on a periodic or as-needed basis.

This Page Left Blank

APPENDIX H

Dams Exempt from Portfolio Management Process

H.1 Purpose. To provide additional information and supplemental guidance on the identification and management of dams exempted from the portfolio management process as noted in paragraph 3.3.1 and Figure 3.1 of this regulation. These dams are referred to in paragraph 3.3.1 as *"dams found to have insignificant or no consequences should they fail."* The purpose in identifying and flagging such dams is to provide a mechanism to enable alternative, non-routine dam safety-related management of these structures.

H.2 References.

H.2.1 EP 1165-2-1, Digest of Water Resources Polices and Authorities, Chapter 7, Paragraph 7 (reference A.34).

H.2.2 ER 200-2-2, Procedures for Implementing NEPA (reference A.37).

H.2.3 ER 405-1-12, 27 Oct 80, Real Estate Handbook, Chapter 11, Disposal (reference A.38).

H.2.4 ER 1105-2-100, Planning Guidance Notebook, Appendix G, Section IV (reference A.42).

H.2.5 ER 1165-2-119, Modifications to Completed Projects (reference A.64).

H.3 Background. The portfolio of USACE dams managed in accordance with this regulation includes all structures that meet the definition of a dam and that would have unique and separate consequences should they fail. The portfolio thus includes as separate dams to be managed for safety, main dams, appurtenant saddle dams, ring dikes within reservoir pools initially intended to protect an area that would otherwise be flooded by the reservoir pool, debris dams both within the reservoir pool area or immediately upstream and other structures as yet identified. For the purposes of this document, all such structures are referred to as dams all of which have been assigned a DSAC class based on their risk. This policy is focused upon the subset of these dams found to have insignificant or no consequences should they fail. Thus, these dams do not warrant the same actions and attention as the larger set of remaining dams subject to routine application of the portfolio process.

H.4 Policy. Dams identified as meeting the requirements of paragraph H.4 below are exempt from the dam safety portfolio management process as described in Chapter 3 of this regulation. Subject to confirmation that exemption is justified, such dams are retained in the USACE inventory but will be managed in a non-routine manner tailored to their site-specific characteristics and circumstances. In essence, the posture taken by USACE with respect to these dams is that there is essentially no concern with their

possible failure, and thus, expenditure of scarce dam safety resources thereon is to be minimized. Non-routine management will generally take place as described in following paragraphs.

H.4.1 Dams that no longer serve an authorized purpose, nor any other Federal, state, local or tribe purpose and that pose a safety hazard to agency staff or the public if left to remain in their present state will be flagged for decommissioning. Decommissioning will be pursued in an expedited manner as authorities and funding permit – see paragraph H.6 below for further guidance. Routine operation, maintenance, and inspection will cease. Until decommissioned, the dams will undergo a 'routine inspection' at five year intervals to verify their status and justify continued non-routine management.

H.4.2 Dams as described in H.4.1 that pose insignificant hazard to agency staff and the public if left to remain in their present state will be flagged for decommissioning and routine operation, maintenance, and inspection will cease. Decommissioning will be pursued as authorities and funding permit – see paragraph H.6 below for further guidance. Until either the status of the dam changes (decommissioned, becomes a hazard to agency staff and the public if left in present state, fails, or deteriorates to a non-dam status), such dams will undergo 'routine inspection' at five-year intervals to verify their status and justify continued non-routine management.

H.4.3 Dams that have potential to serve a USACE or other Federal purpose, or state, local or tribe purpose will be flagged as such and routine operation, maintenance, and inspections will cease. Efforts to remove such dams from the dam safety inventory will be pursued as authorities and funding permit - see paragraph H.6 below for further guidance. If such dams pose a hazard to agency staff or the public if left to remain their present state, expedited efforts will be pursued to accomplish the appropriate action. Until such time as the purpose to be served by the dams is changed and the project modified, and/or title is transferred, the dams will undergo a 'routine inspection' at five year intervals to verify their status and justify continued non-routine management.

H.5 Criteria for 'Insignificant or No Consequences'. The consequences of interest for this guidance are those described in this regulation which are life safety, economic impact and environmental consequences, with life safety of primary concern. Of concern is the consequences should the dam fail, e.g. there would be an uncontrolled release of the reservoir pool.

H.5.1 Life safety criteria. Dam classified as 'low hazard potential' and failure would not result in fatalities exceeding the Corps 'Tolerable Risk Guidelines for Life Safety.'

H.5.2 Economic criteria. Reservoir pool area or downstream damage and/or disruption of business activities would be considered in the nuisance category, requiring but a few days to a week of typical maintenance activity to resolve.

H.5.3. Environmental criteria. Stated simply, the concept is that for 'insignificant or no consequences' should the dam fail, that no environmental laws or regulation would be violated, nor would there be negative impact on aquatic and terrestrial species, cultural resources, or local community environmental values. This concept is consistent with 'Findings of No Significant Impact' – Reference A.37. Thus, loss of reservoir pool would not permanently impact endangered species as listed by Federal or state agencies in the vicinity of the reservoir, including the reservoir pool, or downstream, nor permanently diminish what might be classified as critical habitat for threatened species. Potential erosion of sediment from the pool area may be of concern, e.g. sediment containing toxic material released or sediment movement impacting downstream in-stream habitat.

H.6 Confirmation of Meeting Exemption Criteria. A memorandum is to be prepared that documents the basis for a recommendation for exemption of the dam from 'routine' dam safety management. The memorandum is to be signed by the district Dam Safety Officer with concurrence by the MSC Dam Safety Officer. The copy of the memorandum is to be furnished to the Corps Dam Safety Officer and the Director, Dam Safety Risk Management Center. Scope and content of the memorandum is to include:

H.6.1 Brief dam/project/feature description,

H.6.2 DSAC classification and basis thereof,

H.6.3 Life safety, economic, and environmental consequences of dam failure, including summary of data, analysis, and confidence in estimates,

H.6.4 Hazard to agency staff and public if dam is left to remain in present state,

H.6.5 Recommended action (Decommission, change purpose, transfer Title, other), and

H.6.6 Approximate cost estimate/savings, schedule, potential funding source, priority to implement recommended action.

H.7 Authorities and Actions.

H.7.1 Authorization Research. The beginning point for any recommended exemption actions to decommission, modify, transfer, or dispose is thorough research of the original authorization and any other subsequent project/feature-related authorization changes or modifications. The project/feature authorization is the critical factual information.

H.7.2 Decommission. Decommissioning involves demolition of the structure, removal of the material, and restoration of the site in accordance with Federal, state, and local laws and regulations; e.g. the structure would cease to exist and any remaining authorization would be dropped or become moot and the structure removed

from the dam safety inventory. There are likely to be appropriate scales of decommissioning that range from just breaching/disabling the function of the dam through to complete removal of the structure. Regardless, the site would be prepared in such a manner that any remaining physical components do not present a hazard to agency staff or the public or violate applicable laws and regulations. Authority to study a dam for de-commissioning is 'Modification to Completed Projects' (reference A.64). The level-of-detail required and approval level, up to and including Congress, is case-specific. The Chief of Engineers has discretionary authority to approve actions in certain circumstances that may apply. The test governing the Chief's discretionary authority is the degree of impact on authorized project purposes. A dam meeting the criteria of this guidance might well fall into the Chiefs discretionary authority because its removal would not materially affect the authorized purpose of the project as a whole.

H.7.3 Transfer or Dispose. Should a civil works structure no longer serve an authorized Federal purpose but be of potential value to local interests, the project/structure title and all associated responsibilities may be transferred to other institutions. The hierarchy of preferred transfers documented in Chapter 11 of the Real Estate Handbook (ER 405-1-12 - Disposing Excess Property (reference A.38)), ranges from transfer to another DoD agency through to transfer to an authorized local agency. The end-point of the hierarchy is that of disposal of the property via competitive sale. Necessary investigation and decision processing is outlined in the Handbook and associated GSA regulations. Studies and documentation to justify such transfer/sale would be expected to be similar to that required for 'Modifications to Completed Projects' as discussed in ER 1165-2-119 (reference A.64).

H.7.4. Use of O&M Authority. On a case-specific basis, existing O&M authorities and policies may be applicable to actions outlined in this guidance. As an example, the continued maintenance of a dam meeting the criteria of paragraph H.4 may require continued operation and maintenance to ensure its presence does not present a potential safety hazard to agency staff or the public, or violate Federal or state laws and regulations, thus consuming resources while serving no useful Federal purpose. Savings in resources might be possible by disabling or removing the structure, thus accomplishing cost-effective management of the property. Coincidentally, if action is undertaken in this manner, for all practical purposes, the structure would no longer exist and could thus be removed from the dam safety inventory.

H.7.5. Convert Property to Another Purpose. On a case-specific basis, application of Section 1135 of the Water Resources Development Act of 1986 entitled 'Project Modifications to Improve the Environment' (reference A.99) might be applicable. This is a small project authority that permits modification of USACE projects for such purposes. Such a purpose might be accomplished by breaching and/or some other minor site preparation that enhances habitat or would serve some other environmental purpose. Thus, the project purpose could change; responsibility and management handed over to another USACE entity, and coincidentally remove the structure from the dam safety inventory.

H.8 Funding. There are several possible funding sources to pay for ‘exemption’ studies and for subsequently implementing the ‘exemption’ actions.

H.8.1 For studies to validate flagging dams for ‘exemption’ (e.g. justify ‘’non-routing management), the primary and logical source is regular O&M funds.

H.8.2. For studies to develop the actions and implementation plans, depending on the scale of the action, O&M funds are also a logical source. For substantial studies that would be undertaken under ‘Modification to Completed Projects’ (reference A.64) authorities, funding guidance provided therein would be appropriate and likely require cost sharing.

H.8.3. For implementation of actions formulated and approved under H.8.2 funding could be from a variety of sources and may or may not require cost sharing. The appropriate funding source would be case-specific.

This Page Left Blank

APPENDIX I

Screening Portfolio Risk Assessment Process

I.1 SPRA Process. The SPRA process includes having an independent regional cadre comprised of various disciplines including geotechnical, geology, structural, hydrologic, economic, and mechanical visit the district with dams to be screened. In one day, the cadre has a district presentation on the dam and reviews existing reports to estimate the consequences and engineering ratings to be entered in the SPRA spreadsheet. A SPRA report is prepared to document the range of the load cases considered, the engineering ratings, and consequences estimated from the existing data.

I.2 SPRA Spreadsheet. The SPRA spreadsheet provides information in the form of annualized risk in terms of potential loss of life and economic damages as well a probability of failure. These items are used to determine the appropriate DSAC for each dam. The methodology used for determining the appropriate DSAC (DSAC dam binning) has evolved over time. The current procedure plots the annualized potential loss of life (for Flood Damage Reduction (FDR) structures) or annualized economic damages (for Navigation (NAV) structures) after being divided by the resulting failure probability for the dam as rated. This operation results in an “average” potential loss of life or economic damage for a single dam failure. These values are plotted on the x-axis as shown in Figures I.1.a and I.1.b. The y-axis plots the probability of failure for the dam as rated by the regional cadre divided by the probability for a baseline dam. The baseline dam probability of failure is for a dam meeting all current guidelines. For example all features were rated “Adequate”. The y-axis then represents how many more times likely the dam (as rated) is to fail than a baseline dam or a dam meeting all current guidance. Navigation structures with potential for loss of life are plotted on both charts and the appropriate DSAC rating used.

I.3 SPRA Methodology. SPRA methodology does calculate a probability of failure, but the methodology in the SPRA calculations includes modifiers of 1, 10, 100, and 1000 for engineering ratings of Adequate, Probably Adequate, Probably Inadequate, and Inadequate respectively. These modifiers are multiplied times the baseline probability of failure for each feature and therefore result in a probability of failure that is comparable only to results of other dams using the SPRA spreadsheet. SPRA results represent more of a “relative comparison” system and the data is not compatible with the tolerable risk guidelines. DSAC V determinations cannot be made based on SPRA data since it is not compatible with tolerable risk guidelines.

I.4 DSAC Binning. The DSAC binning chart has “bounding” lines based on an interpretation of the DSAC descriptions for DSAC I, II, III and IV. These “bounding” lines are not finite lines and cannot be described by simple bounding limits. The basic limits for these bounding lines are shown in Table I.1.a, but should not be considered as absolute values as there is considerable uncertainty in the SPRA estimates. This requires the dam values to be plotted on the chart to determine the initial estimate of the DSAC for the dam. Once plotted, the initial estimate is the beginning point that is reviewed for other factors to determine if the rating should be adjusted higher or lower

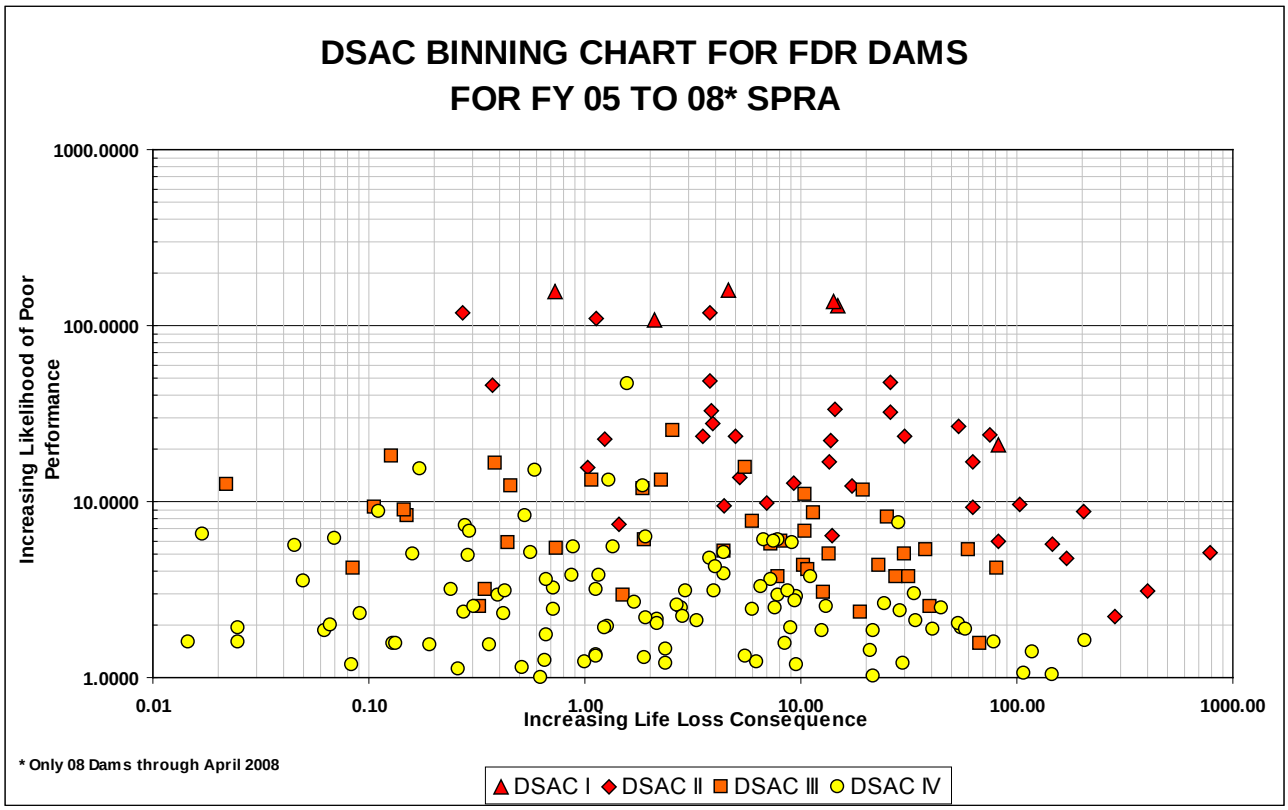


Figure I.1.a

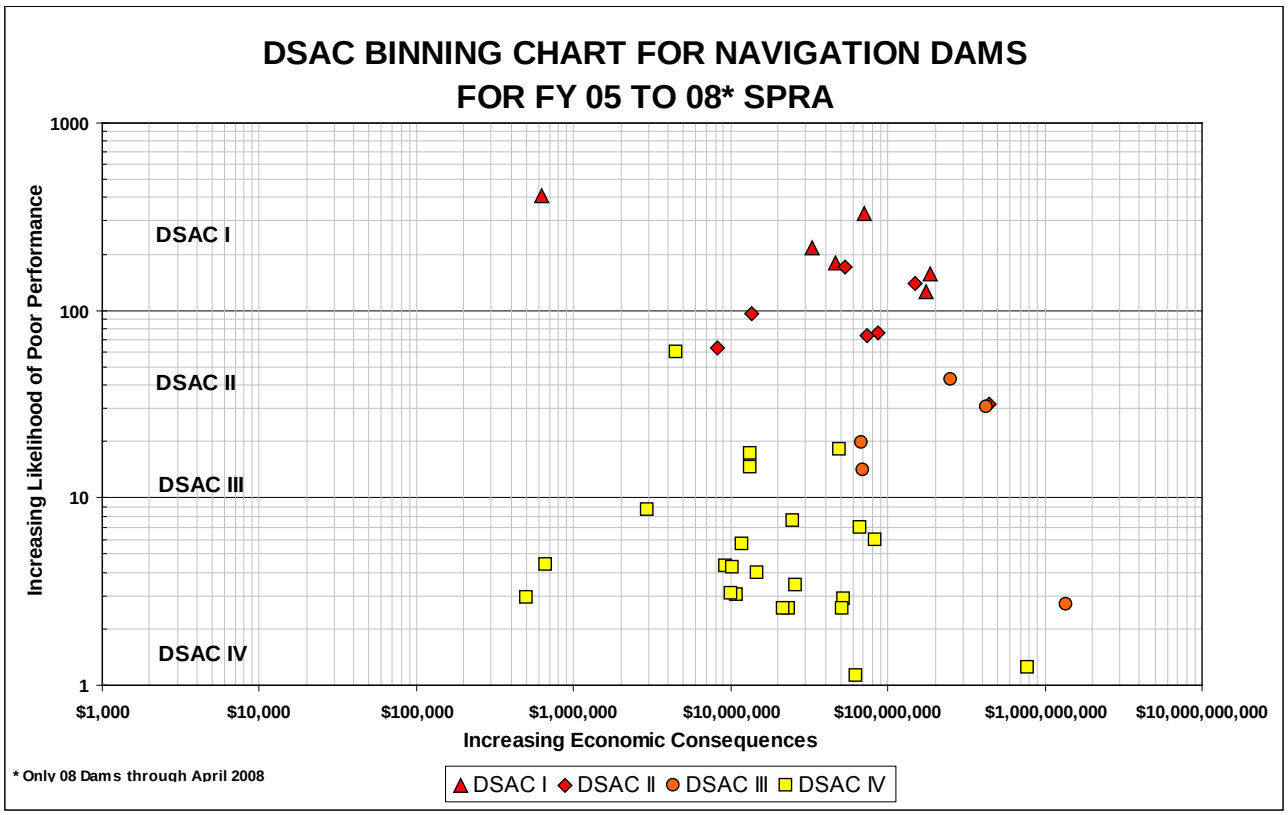


Figure I.1.b

Table I.1.a
Guidelines for determining
USACE Dam Safety Action Classification using SPRA

Dam Safety Action Class		SPRA Classification Criteria
I **URGENT AND COMPELLING** (Unsafe)		Life Risk Index > 40 and Performance Index > 100 or Economic Risk > $3B
II **URGENT** (Unsafe or Potentially Unsafe)		20 < Life Risk Index < 40 or $300M < Economic Risk < $3B or 20< Performance Index < 100
III **HIGH PRIORITY** (Conditionally Unsafe)		5 < Life Risk Index <20 or $50M < Economic Risk < $300M or 6 < Performance Index < 20
IV **PRIORITY** (Marginally Safe)		Life Risk Index < 5 or Economic Risk < $50M or Performance Index < 6
V **NORMAL** (Adequately Safe)		Cannot be determined using SPRA

as shown in Table I.1.b. The DSAC rating is then determined for dam with a brief justification for keeping or changing the initial DSAC for the dam.

I.5 Rating and Review of Rating. The initial DSAC rating is determined by the regional cadre following the district visit. The SPRA ratings, consequences, and DSAC determination go through two levels of review prior to being finalized.

I.5.1 The first level of review is completed by a group of quality control personnel including past regional cadre members and the Engineering Risk and Reliability Directorate (ERRDX) and the cadre lead responsible for the dam. The review consists of reviewing the district presentation, SPRA report, and SPRA spreadsheet. Based on the information presented, questions are asked about various SPRA items including engineering ratings, consequences, breach release severity parameters, justifications, and DSAC determination. These items are recorded and provided to the regional cadre to vet back with the entire cadre. The cadre considers the comments and either makes the recommended changes or documents why they are not changed. A follow-up discussion is held if the changes could potentially impact the agreed upon DSAC determination. From this effort a presentation summarizing the results of the screening are prepared for the next review.

Table I.1.b
Dam Safety Action Class Adjustment Guidelines

Dam Safety Action Class		Reasons to adjust Dam Safety Action Class	
I **URGENT AND COMPELLING** (Unsafe)		To Class II • External Peer Review does not support DSAC. • Studies and Investigations do not support suspected defect or failure mode. Extreme risk is not supported	
II **URGENT** (Unsafe or Potentially Unsafe)		To Class I • Progression toward failure is confirmed or supported by field observations (boils, excessive seepage, deformation, sink holes, etc)	Class III • Primary deficiency is in the extreme loading events. • History to indicate good performance at unusual loading range.
III **HIGH PRIORITY** (Conditionally Unsafe)		Class II • Field observations indicate signs of distress for unusual loading (Seepage & Piping) • Project has high component risk • Cadre belief that the dam has creditable failure modes that could initiate under unusual loading that is supported by a review of construction records and project documents. • Effectiveness of prior repairs are questionable • Site seismicity is believed to be significantly higher than original design basis.	Class IV • Deficiencies are at extreme loading events • Low component risk
IV **PRIORITY** (Marginally Safe)		To Class IV • Increasing piezometric pressure over time	
V **NORMAL** (Adequately Safe)		N/A	

I.5.2 The second level of review is completed by the Senior Oversight Group (SOG). The summary presentation is made by the cadre lead. SOG members have access to the district presentation, SPRA report, and the summary presentation prepared by the cadre lead. Based on the presentation questions, recommendations, and comments are made for the cadre lead to answer or address later. If the recommendations or comments may impact the proposed DSAC rating, the determination of the DSAC is withheld until addressed. If the recommendations would not change the DSAC rating, the SOG reviews the recommended rating and votes on the final DSAC determination.

I.5.3 Following the SOG meeting, any needed changes to SPRA reports and spreadsheets are made. The final DSAC recommendation is included in the SPRA report. Once finalized, the reports are finalized and distributed to the division DSPM.

This Page Left Blank

APPENDIX J

Corps of Engineers Dam Safety Community of Practice Steering Committee (DSSC)

J.1 Authority and Responsibilities. The Steering Committee is empowered to develop and implement a strategic plan and a long-range plan for the USACE Dam Safety Program, including a mission statement, goals, objectives, and performance measures. The Steering Committee shall establish USACE Dam Safety Standards and monitor district compliance with these standards. The Steering Committee shall function in accordance with requirements of the Project Management Business Process (PMBP).

J.2 Objectives and Goals. The objective of the Steering Committee is to provide a formal USACE structure to develop policies, practices, and relationships to effectively facilitate dam safety practices and accomplishments. The Steering Committee maintains a consistent and accountable nationwide dam safety program. The Steering Committee works with other agencies to improve the USACE Dam Safety Program. The Steering Committee affirms accountability for dam safety to all elements within the command chain, monitors performance, and inculcates dam safety as a fundamental USACE mission. The goals of the Steering Committee are:

J.2.1 Participating in development of USACE-wide guidance when requested by the HQUSACE Dam Safety Officer (DSO),

J.2.2 Making recommendations to HQUSACE Dam Safety Officer for studies, investigations, and research designed to improve the safety of dams,

J.2.3 Rendering consulting service and advice on specific safety of dams issues and problems as requested by various elements of USACE or other agencies,

J.2.4 Maintaining a continuing evaluation of the state-of-the-art for the safety of dams,

J.2.5 Serving as a liaison for the dam safety process between HQUSACE and MSC/districts and disseminate pertinent information throughout USACE, and

J.2.6 Promoting dam safety engineering career development.

J.3 Scope of Steering Committee Activities. The Steering Committee will provide recommendations to the HQUSACE DSO on all topics in the areas of safety of dams such as roles and responsibilities, training, career development, automated systems and software, guide specifications, uniformity of project specifications, uniformity of process, research and development, and interface with other elements within USACE, other agencies, and professional organizations.

J.4 Composition. The steering committee members are full-time civilian employees of USACE. The Steering Committee shall seek to maintain a diversity of civil works dam safety experience as well as a diversity of the engineering disciplines. A current list of

members will be posted on the Corps of Engineers Technical Excellence Network (TEN). The steering committee officers shall be steering committee leader, alternate steering committee leader, and recording secretary. The Special Assistant for Dam Safety shall serve as the steering committee leader. The HQUSACE Dam Safety Program Manager shall serve as recording secretary. The Steering Committee shall elect an alternate steering committee leader. The Steering Committee shall be composed of seventeen (17) members as listed below.

J.4.1 HQUSACE Members. Four (4) HQUSACE individuals, who will be the Special Assistant for Dam Safety (CECW-CE), the Dam Safety Program Manager (CECW-CE), one member from Operations (CECW-CO), and one member from Program Integration Division (CECW-IP).

J.4.2 Major Subordinate Command (MSC) Members. Eight (8) individuals comprised of the Dam Safety Program Manager from each MSC.

J.4.3 Engineering Research and Development Center (ERDC) Member. One (1) ERDC individual appointed by the ERDC Director.

J.4.4 District Members. Four (4) district representatives, with experience in the safety of dams, shall be nominated by the Steering Committee as at-large members with final selection by the Corps DSO. At least one of the district representatives shall be from an operating element, one should be a DSPM, and one should be a DSO.

J.4.5 Alternate Members. In the event that a member of the Steering Committee cannot attend a Steering Committee meeting, the member may designate an alternate to serve in his capacity. The member shall provide the name of the alternate to the steering committee leader prior to the meeting.

J.5 General. The Steering Committee will carry out its objective in accordance with the following:

J.5.1 Oversight. The Steering Committee functions under the general direction of the USACE DSO.

J.5.2 Meetings. The steering committee leader will call meetings as required to carry out the Steering Committee's objective; normally meetings will be held semi-annually. Advance notice, agenda, and minutes of each meeting will be furnished to steering committee members and pertinent USACE commands.

J.5.3 Funding. HQUSACE, MSC, and ERDC members will be funded by their respective organizations for steering committee activities. District members' salary, travel and per diem expenses may be funded by HQUSACE for steering committee activities based on the availability of funds.

APPENDIX K

Observations on How Reclamation Uses Their Guidelines

K.1 Basis for Decision Making.

K.1.1 Decisions regarding the safety of the facility are made using two perspectives; the numerical risk estimate and the case made to justify the risk estimate. Reclamation has many levels of detail for the risk estimates it generates relative to the significance of the corresponding decision. Some evaluations are simplified and scripted, some are determined after several team evaluations and consultant reviews.

K.1.2 For any level of risk estimate, a technical report of findings is developed to justify the numbers that are generated. It also includes the primary factors that led to the risk estimate, a description of the uncertainties, and the strengths and weaknesses behind the numbers. These pieces of information are used to "make the case" to the advisory panel and the decision makers. This is a critical component that is intended to give the decision makers enough information to make an informed decision.

K.2 Risk Estimates Related to Tolerable Risks. Reclamation uses the tolerable risk guidelines as goals for achieving public protection, as shown in Figure K.1 (reference A.100). They are also thresholds, shown below, used to justify expending funds to reduce risks. They are not the sole piece of information used to judge the absolute safety of a structure, but they are the primary means to judge the relative safety of a structure. When considering these guidelines, Reclamation generally averages over the distribution of uncertainty to obtain the mean estimate of risk for an individual failure mode in comparison to the threshold values. Graphical depiction of this is shown in the f-N diagram in Figure K.2. Each point on the plot represents the mean risk estimate for an individual failure mode. The lines near the two axes represent the uncertainty associated with each estimate. Uncertainty is also considered in the decision process, and will be discussed in a later section. The primary focus of the dam safety program is life safety. As such, the thresholds are listed below in order of importance.

K.2.1 Expedited Public Protection.

K.2.1.1 Reclamation considers that there is justification for taking expedited action to reduce risk when the mean estimate of the annualized life loss for an individual failure mode exceeds 0.01 lives per year or the total risk of all failure modes for the project exceeds 0.01 lives per year. While there is a full range of possible risk reduction actions that can be taken, Reclamation focuses on those that can quickly reduce risk or improve understanding of the uncertainties associated with the risk. As confidence increases that the risk is in this range, actions concentrate more on reducing the risk than reducing the uncertainties. Every effort is made to take actions to reduce risks and complete any reassessment within 90 days of determining the need for expedited risk reduction action.

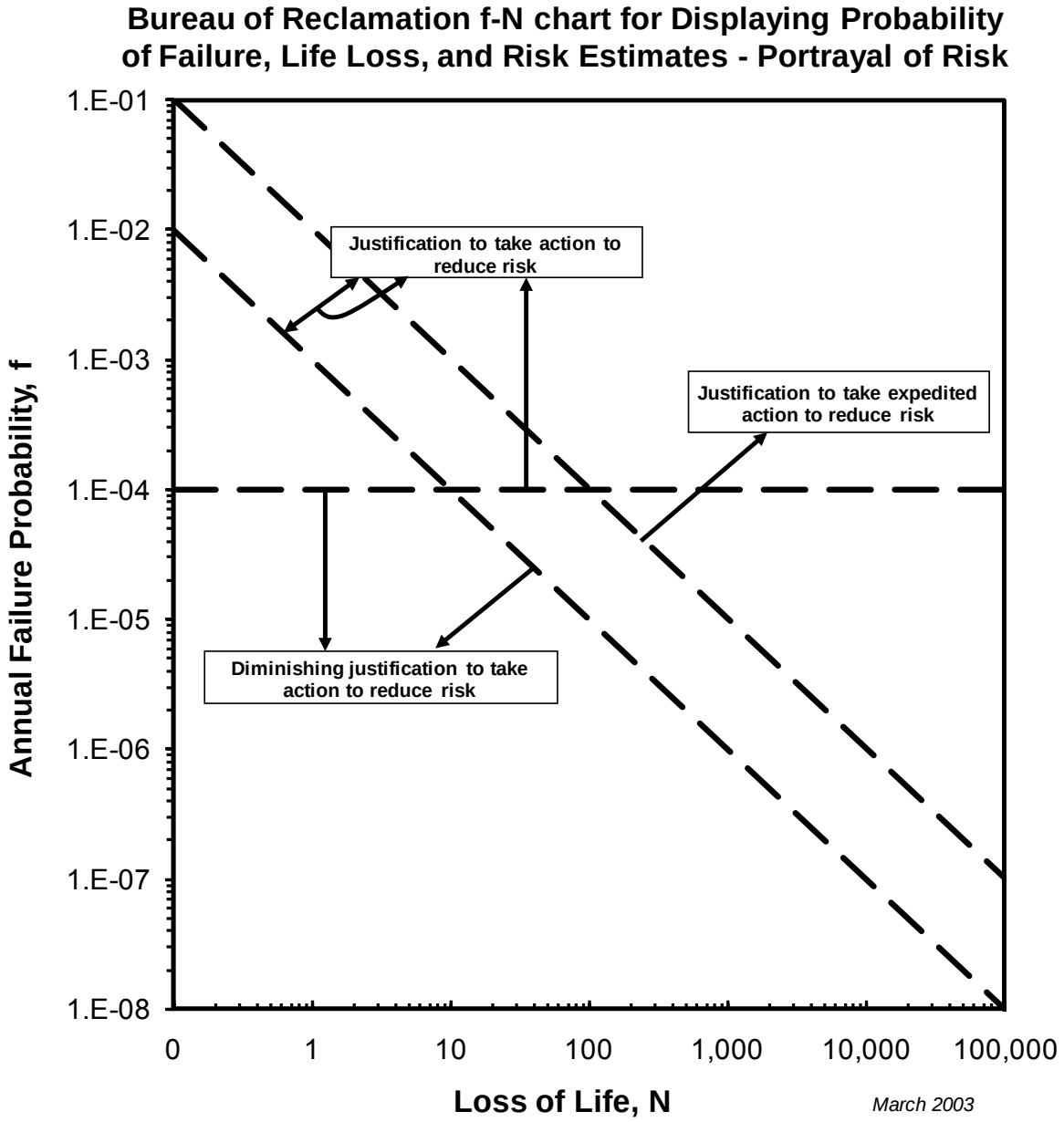


Figure K.1 - Reclamation's Public Protection Guidelines

K.2.1.2 The purpose of the "expedited guideline" is to reinforce the importance of reducing risks in an expedited fashion. In general, *identified risks* are addressed more rapidly the higher they plot in relation to the guidelines. In many occasions, risks that result in an expedited action are a result of an incident or observed change in structural behavior. In these cases, every effort is made to reduce risks on an interim basis while the magnitude of the problem is evaluated.

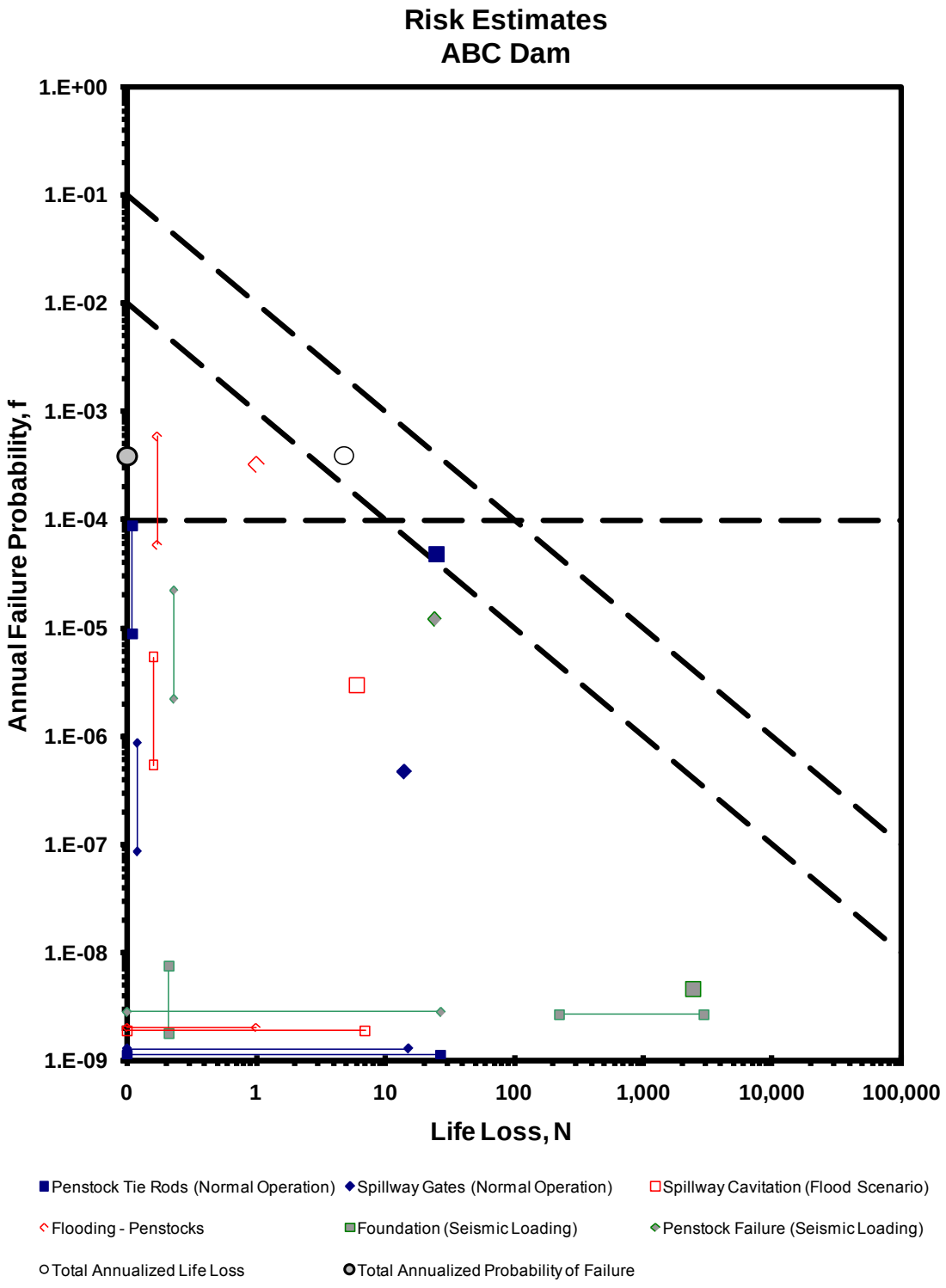


Figure K.2 - Example of an f-N Diagram for a Facility

K.2.2 Long-term Public Protection.

K.2.2.1 Reclamation considers that there is increasing justification for taking action to reduce risk when the mean estimate of the annualized life loss for an individual failure mode exceeds 0.001 lives per year or the total risk of all failure modes for the project exceeds 0.001 lives per year. When risk estimates exceed this value, there are a wide variety of possible actions which may be appropriate. The actions are scheduled into the dam safety program and coordinated with other needs at the facility and at other facilities. Actions to reduce risks are implemented on a schedule that is consistent with budgeting and appropriations processes. Typically, risk reduction should be accomplished within 7 years of a decision that identifies a need to reduce risk.

K.2.2.2 The purpose of the 'long-term' guidelines is to identify a threshold where actions are important, but not necessarily urgent. In this area, risks are managed in a more detailed and conscious manner while awaiting further evaluation or structural modifications. Interim actions are considered but not required. Decisions related to interim actions are constantly re-evaluated acknowledging that structures and conditions change over time and new information may influence the original decision.

K.2.3 Public Trust.

K.2.3.1 The justification to implement risk reduction actions increases as the mean estimate of the annual probability of failure for an individual failure mode exceeds 0.0001 per year or the total probability of failure for all failure modes for the project exceeds 0.0001 per year. Reasonable and prudent actions should be considered for implementation when the annual probability of failure estimate exceeds this value. A variety of possible actions may be appropriate.

K.2.3.2 The purpose of the public trust guidelines is to reinforce the idea that safety is important, even for facilities with low consequences.

K.2.4 Total Risk.

K.2.4.1 Figure K.3 illustrates the risk profile for one of Reclamation's five regions. Each point represents the total risk for an individual facility. In Reclamation, remediation decisions are made using the *mean estimate of risk for an individual failure mode*, whereas studies are prioritized based on the *sum of the mean risk estimates for an individual facility*.

K.2.4.2 Occasionally facilities with lower risk are worked on due to stakeholder requests or project requirements. Occasionally facilities with higher risk or probability of failure are delayed either intentionally or by circumstance. As Figure K.3 illustrates, most of the high-risk facilities in this particular region are currently being studied or modified.

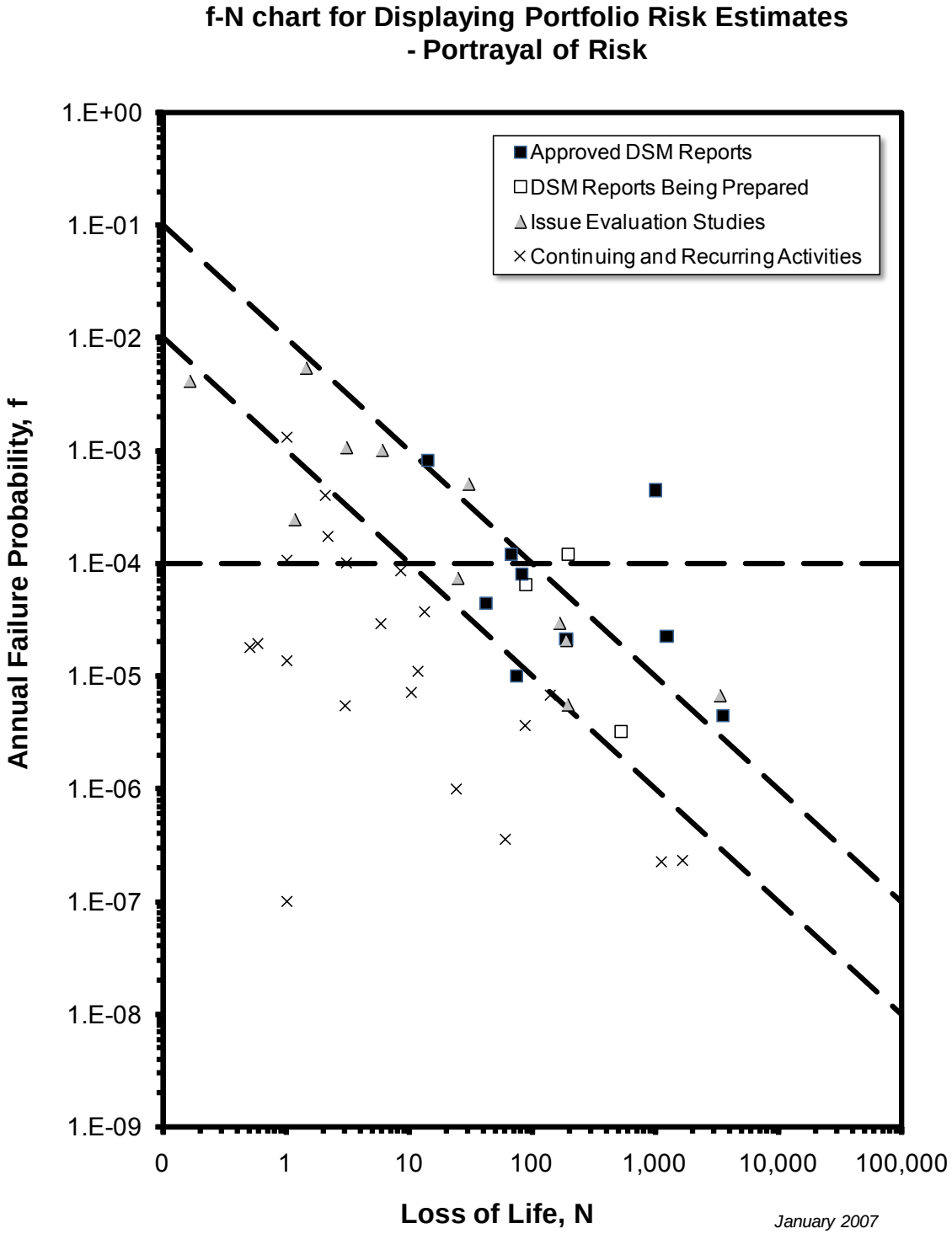


Figure K.3 - The Risk Profile for One Region in Reclamation

This Page Left Blank

APPENDIX L

Calculation of the Cost to Save a Statistical Life (CSSL)

Two variants of CSSL are calculated – unadjusted CSSL(U) and adjusted CSSL(A).

The adjusted CSSL(A) is calculated as follows:

$$CSSL(A) = \frac{C_A - (E[R:e] - E[E:pr]) - ([O:e] - [O:pr])}{E[L:e] - E[L:pr]}$$

Where CSSL(A) = adjusted cost-to-save-a-statistical-life, with the proviso that a negative value is taken as zero

C_A = ANNUALIZED cost of implementing risk reduction measure, dollars per annum

E[R:e] = existing expected value of risk cost (failure probability times monetary losses to the owner) for existing dam, dollar per annum

E[R:pr] = expected value of risk cost post-risk reduction, dollars per annum

E[L:e] = expected value of life loss for existing dam, lives per annum

E[L:pr] = expected value of life loss post-risk reduction, lives per annum

O:e = existing operating costs per annum

O:pr = post-risk reduction operating costs per annum

The "unadjusted" CSSL is calculated as follows:

$$CSSL(U) = \frac{C_A}{E[L:e] - E[L:pr]}$$

Reference: ANCOLD 2003 (reference A.80)

This Page Left Blank

APPENDIX M

Interim Risk Reduction Management Plan Development Sequence

M.1 General. IRRMP must be developed in an aggressive timeline to minimize the probability of failure once a potentially major dam safety deficiency is identified. IRRMPs are mandatory for DSAC I, II, and III Dams.

M.2 Development Sequence. The following table describes the sequence for IRRM development.

Table M.1 – Interim Risk Reduction Measures
Development Sequence

Item	Process	Notes
1	Designate dam as DSAC I, II, or III	One time screening or risk assessment
2	Alert MSC DSO, OPs Chief, EOC, and local PAO	
3	Use emergency contracting procedures to implement IRRM if necessary.	
4	District begins to pre-position contracts and materials and informs major stakeholders if appropriate.	
5	Obtain O&M funding from district to develop Interim Risk Reduction Measures Plan (IRRMP). Begin development of Communications Plan	District O&M funds are used for development & implementation of IRRMP.
6	District begins NEPA actions if necessary	
7	District completes IRRMP to include communications plan	
8	Public Coordination/Communication	Refine IRRM Communications Plan
9	DQC review of IRRMP done with Regional Technical Specialists	Includes Senior Oversight Group and concurrent RTS reviews throughout development
10	Seek approval of IRRMP from MSC DSO. Obtain O&M Funding for PED to implement the IRRMP	If requested include formal brief of IRRMP to MSC and HQ DSO

Item	Process	Notes
11	Approval of IRRMP by MSC DSO	Concurrence of approval by HQ DSO
12	Public Coordination/Communication	Begin coordination
13	NEPA actions completed for IRRM	
14	District implements non-structural IRRM and begins plans, specs, and detailed cost estimate for structural IRRM activities	Pool restrictions, exercises, etc.
15	District develops plans, specs and cost estimate for structural IRRMP activities	Completion
16	District issues contracts for structural IRRM	

M.3 Submission and Approval. IRRMPs for DSAC I dams shall be submitted to the MSC DSO within 60 days after being designated as a DSAC I, or within 90 days after being designated as a DSAC II, or within 120 days after being designated as a DSAC III. A formal IRRMP is not required for DSAC IV dams, and remedial actions may follow more routine processes.

APPENDIX N

Interim Risk Reduction Management Plan Review Checklist

N.1 Overall Project Description and Purposes. Make sure the description includes a brief summary of construction and operational history including remediation and past and current problems. A summary of instrumentation would be good as well (needs to be in appendix). This helps provide sufficient background for evaluating the validity of the potential failure modes and how they relate to the history of the dam.

N.2 Overview of Identified "Credible and Significant" Potential Failure Modes. Include an overview of all credible and significant potential failure modes. Identify if a quick PFMA based on SPRA results was completed or facilitated PFMA was completed. Both are acceptable for the initial IRRMP. If PFMA has not been done, have all identified potential failure modes from SPRA been included? If a facilitated PFMA has not been done, it should be identified as an IRRM and completed as soon as practical.

N.3 General Consequences Associated with Each Identified Potential Failure Mode. Estimates for each potential failure mode should be included. Consequences should include at least a qualitative estimate of consequence (SPRA results, etc.).

N.4 Structural and Nonstructural IRRM Alternatives. Alternatives considered to reduce the probability of failure and/or consequences associated with the failure modes (reservoir pool restrictions and modification of reservoir regulation plan must always be included as an option that is addressed).

N.4.1 Reservoir Restrictions. If a reservoir restriction or pool deviation has been ruled out, very specific reasons should be included as to why.

N.4.2 Non-Structural IRRM. Non-structural measures such as increased monitoring and surveillance, stockpiling materials, help to reduce probability of failure by early detection and ability to intervene should an incident occur. Non-structural measures can also be testing of EAP for better notification and evacuation, updated EAP inundation mapping, etc. that all reduce potential life loss.

N.4.3 Structural IRRM. These measures typically improve the system response which will reduce the probability of failure.

N.4.4 For each considered IRRM, a detailed explanation of how measure reduces system loading, uncertainty in the load, improves the system response, or reduces the estimated consequences.

N.5 Discussion of Probability of Failure and Consequences. A general discussion of how predicted reduction in risk (the probability of failure and associated consequences) impact on project purposes, environmental impacts, and economic impact to region associated with potential IRRM, both positive and negative is provided. This will help

reviewers discern if the cost of the IRRM is clearly justified based on its estimated risk reduction.

N.5.1 NOTE. Analysis does not reduce risk – just reduces the uncertainty associated with the risk estimate.

N.5.2 Has NEPA coordination been started and continued throughout the process?

N.6 Recommendations and Risk-Informed Justification for IRRM to be Implemented. Each justification should include an estimate of the risk reduction from the IRRM implementation. Address potential for reduction in probability of failure and consequences along with the estimated cost and impacts on other aspects of the project (possibly environmental, recreation, flood reduction, ability to execute). A table of this information by IRRM should be included as a summary.

N.7 Schedules and Costs for Implementation of IRRM Recommendations. Verify the IRRM's have been prioritized and consider the expediency of reducing overall risk. Prioritization shall consider the expediency of implementing the IRRM. Resources, funding, capability, execution time, and the time to complete the dam remediation shall all be considered when prioritizing IRRM's. For example, a warning system IRRM may take 2 years to design, coordinate, and construct while performing a table top exercise with the local emergency managers can be done in the next 2 months. Clearly one is more expedient than the other. IRRM's that can be implemented quickly should be given high priority particularly those that impact the ability to warn and help evacuate the public including increased monitoring and surveillance.

N.8 Estimate of Benefits and Costs for IRRM (DSAC I Dams). Include the proposed cost and schedules for conducting a risk-based assessment to estimate the benefits and costs for incremental evaluation of IRRM. This is primarily for DSAC I dams where significant and urgent risk reduction is necessary.

N.9 ATR Comments and Comment Resolutions. Review shall include multiple disciplines including water management, geotechnical, structural, hydraulics, and other disciplines as needed (environmental and counsel). Comments and resolution of comments need to be completed in a timely manner by all offices.

N.10 Updated EAP. The IRRMP should include updating the EAP to reflect site specific risks, and include emergency exercises for DSAC I, II, and III dams conducted in manners that are appropriate for the risk involved. Specifically it should include the local emergency managers for DSAC I, II, and III dams.

N.11 Communication Plan (Internal and External). Verify communication plan is in place and way of handling media, stockholders, and public is addressed. Check for schedule for media training based on DSAC rating, and discussion of how plan will be updated as the study progresses.

N.12 PFMA Report. Is an electronic link to the PFMA provided? Verify proper team skill sets were involved and that ALL credible and significant failure modes are addressed in the IRRMP.

N.13 MSC Internal Review Coordination. Coordination could include Environmental, Operations, Engineering, Water Management, Public Affairs, Programs, and Office of Counsel.

This Page Left Blank

APPENDIX O

Seepage Failure Mode Continuum

O.1 The Seepage Failure Mode Continuum. The Continuum (Figure O.1) was developed to illustrate the progressive nature for seepage\internal erosion failure of a dam. The failure continuum illustrates two relative and interdependent scales:

O.1.1 Stages of a seepage erosion/piping failure development, and

O.1.2 Corresponding risk reduction strategies that can be considered for implementation as the failure mode is progressing toward breach formation.

O.2 Stages. The stages of a seepage erosion/piping failure mode development as presented are generally consistent with the stages described by Foster and Fell (1999) (reference A.87), and the US Bureau of Reclamation (2000). The stages include initiation, continuation, progression, and breach formation. The literature describing these stages is somewhat ambiguous with regard to the transition between the continuation and progression phases. It is not uncommon for these terms to be used interchangeably depending on various nuances associated with a material transport (erosion and piping) failure of an embankment dam. However, the continuum developed in Figure O.1 illustrates these as two distinct and separate stages in the development of the failure mode as described further below.

O.2.1 Initiation. Initiation begins at the onset of a loading condition that leads to the development of a concentrated leak (e.g. raising the pool, development of a crack due to an earthquake, differential settlement, and hydraulic fracture). Initiation can also occur when seepage begins to exit a free (unfiltered) discharge face with sufficient gradient, quantity and velocity of flow so that soil particles begin to move. Initiation may occur in the embankment, in the foundation/abutment, or at the interface between the embankment and foundation materials.

O.2.2 Continuation. Following initiation is the continuation stage. During continuation, the pipe or erosion front moves up gradient toward the source of water and is not arrested due to the presence of a filter, cutoff, restriction or stoppage by material at the upstream end, caving because a roof does not form, or other intervention activity. The piping or erosion typically continues towards the source of water at an accelerating rate due to increasing gradients and flow quantities.

O.2.3 Progression. The progression phase occurs when the piping/erosion feature(s) widen and/or deepen as flows increase in the feature. Progression is enhanced when a roof continues to form and there are no other restraints to growth. The amount of flow continues to increase causing in most, if not all, cases the piping/erosion feature to grow rapidly. The progression phase follows the continuation phase and begins when there is a significant increase in the volume and velocity of flow in the erosion/pipe feature to cause it to enlarge. For example, the progression phase

would begin when a piping feature breaks through the upstream slope of the core (for a dam having highly permeable shells) or the upstream shell (for more homogeneous or low permeability shell materials) of an embankment, or through foundation materials and into the reservoir. The formation of the sinkhole through the upstream slope of the dam signifies the completion of the continuation phase and the start of the progression phase of failure mode development. In some instances where overlying foundation and/or embankment materials are very stiff or well compacted, the progression stage may not manifest itself in the form of sinkhole development until significant progression has occurred.

O.2.4 Breach Formation. As progression continues, flow through the erosion/piping feature and the corresponding erosion of material is not arrested. Typically, the dam crest will begin to settle due to sinkhole development, localized slope instability or unraveling of the downstream slope to the point where overtopping from the reservoir begins to occur. During breach formation, the materials in the dam are eroded, widening and deepening the opening in the dam until the full contents of the reservoir are lost.

O.3 Risk Reduction Strategies. The corresponding risk reduction strategies shown on the continuum diagram have been grouped into three overall categories that generally reflect the timeframe available for intervention: long-term, short-term, and heroic (i.e., crisis management).

O.3.1 Long-term. The timeframe for implementation of long-term risk reduction strategies would be in the range of 1 to 5 years. Corrective actions accomplished during this timeframe would not only stop a piping/erosion failure mode development, but in general would provide sufficient safeguards that would prevent any future failure mode initiation. Embankment dams on Karst foundations are a special consideration and long-term solutions that prevent future failure mode initiation may not be possible. In this case, long-term solutions such as cutoff walls that do not fully penetrate the formation with Karst may provide only a limited design life.

O.3.2 Short-term. The timeframe for the implementation of short-term risk reduction strategies would be in the range of 1 to 3 months. In some circumstances, depending on how far along are the continuation stage and the rate of failure mode development, short-term risk reduction strategies such as grouting or construction of filters/drains and cutoffs may occur over slightly longer periods of time. Corrective actions accomplished during this timeframe are generally aimed at preventing the failure mode from reaching the progression phase and failure of the dam. Short-term strategies usually involve some form of reservoir drawdown or modified reservoir operations under reduced storage levels.

O.3.3 Heroic. Heroic risk reduction (crisis management) strategies are typically those that must be implemented in the range of a few hours to a few days or weeks. Heroic actions are typically required when a piping/erosion failure mode has reached an

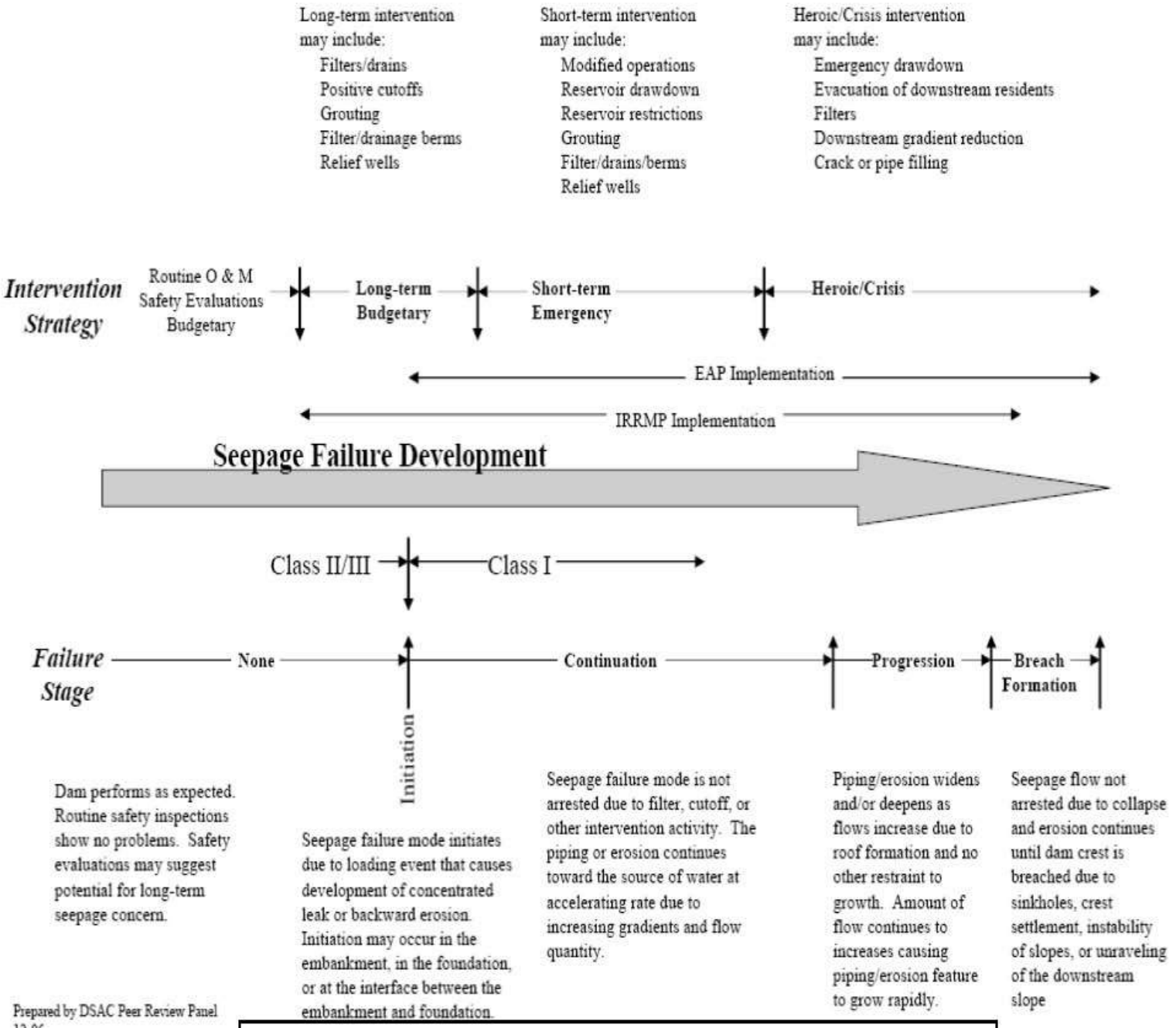


Figure O.1 – Seepage Failure Mode Development Continuum
DSAC Peer Review Panel. December 14. 2006

advanced continuation stage. The actions taken are aggressive and implementable in order to prevent entry to the progression stage or to arrest the progression stage in its earliest period of development and usually involves a rapid lowering of the reservoir level. Corrective actions accomplished during this timeframe would stop a piping/erosion failure mode development, and provide enough time for planning, design and construction of short- and long-term risk reduction measures leading to a permanent solution that will prevent any future failure mode initiation. It should be noted that each dam is unique and the actions taken at each site will need to be tailored to the attributes of the dam and the nature of the failure mode that is developing.

APPENDIX P

Format and Content for Issue Evaluation Study Documents

P.1 Issue Evaluation Study Summary of Findings (IESSF). This portion of the appendix describes the format and content of the IESSF.

P.1.1 Title Page. Include the following items on the title page:

P.1.1.1 Issue Evaluation Study Summary of Findings - Issue Evaluation Study

P.1.1.2 Dam Name

P.1.1.3 Location (river, city, state)

P.1.1.4 USACE District and USACE Division

P.1.1.5 Date

P.1.2 Approval Certification Sheet. Signature sheet in accordance with the approval requirements outlined in Table 8.2.

P.1.3 IESSF Section 1. Dam Safety Portfolio Risk Management Process. For Section 1 use the standard text (boiler plate) provided in Table P.1. Fill in the blanks at the end of the text.

P.1.4 IESSF Section 2. Summary History of Dam Safety-related Actions. Summarize, using text, diagrams, and photographs (as appropriate), the dam-safety-related issues and actions that might have arisen during design, construction, and operation continuing to the present. The information to be presented should include the following safety issues identified; remediation proposed and adopted; and a brief assessment of the degree of success of the remediation. A time-line diagram of major safety-related events and actions is a powerful way of presenting such history. Include the appropriate charts and diagrams.

P.1.5 IESSF Section 3. Guiding Principles and Key Concepts. For Section 3 use the standard text (boiler plate) provided in Table P.2.

P.1.6 IESSF Section 4. The following questions are to be answered in a narrative manner that succinctly communicates the essential dam safety issues, failure modes and risk assessment, and the recommended action(s). Tables, illustrations, and graphs are to be used as appropriate to summarize information and support the narrative.

P.1.6.1 Current Dam Safety Action Classification (DSAC). What is the existing DSAC classification, and what are the significant dam safety issues that have lead to this classification? (Include a summary listing of physical manifestations or PFM's.)

Table P.1 – Standard Text for IESSF Section 1
The overall Dam Safety Portfolio Risk Management Process is a series of hierarchical activities used to assess, classify, and manage the risks associated with the USACE inventory of dams. Dam Safety Action Classification (DSAC). The DSAC classification system provides consistent and systematic guidelines for appropriate dam safety actions, which are designed to address the dam safety issues and deficiencies of USACE dams and which are commensurate with the level of the dam failure risk. USACE dams are placed into a DSAC class based on their probability of failure or the individual dam safety risk estimate considered as a combination of probability of failure and potential life safety, economic, environmental, or other consequences. The intent is that the classification of a dam is dynamic over time, being revised as project characteristics are modified or more refined information becomes available affecting the loading, probability of failure, or consequences of failure. Portfolio Risk Management Process. The portfolio risk management process defines and documents the USACE risk assessment and risk management action decisions for each dam and facilitates risk communication. The actions and documents that reflect the process include normal operations and maintenance (O&M) activities and the documents generated through the portfolio risk management process to address dam safety issues. These documents are principally the Screening Portfolio Risk Assessment report, the Interim Risk Reduction Measures report, the Issue Evaluation Study report, and the Dam Safety Modification report. See ER 1110-2-1156 Chapter 3 for a detailed description of the process. Dam <*insert name*> is presently classified <*Insert dam's DSAC class*> and is poised at decision point <*Insert decision point ID*>. Prior dam safety actions for this dam are summarized in the following section.

P.1.6.2 Description of Potential Failure Mode(s) Judged to be Significant. List each significant PFM separately, (PFM-1, PFM-2, PFM-3, etc) and answer the following questions for each PFM:

P.1.6.2.1 Dam Safety Issue for PFM

P.1.6.2.1.1 What is the Dam Safety Issue?

P.1.6.2.1.2 What instigated the safety concern?

P.1.6.2.1.3 What physical evidence or project performance indicates that there is a problem or that a problem cannot be ruled out?

P.1.6.2.1.4 Why are these issues significant?

Table P.2 – Standard Text for IESSF Section 3
Assessments of the safety of USACE dams are conducted using a risk assessment approach which provides input to risk informed decision making. The approach combines the evaluation of dam safety against engineering guidelines, and evaluates the risk posed by USACE dams compared to tolerable risk guidelines. The former focuses on satisfying essential USACE guidelines for a wide range of engineering considerations (for an Issue Evaluation Study risk estimate this evaluation against engineering guidelines is very limited if done at all, and if done, is only done for those potential failure modes assessed in the IES). The latter involves identifying all credible and significant failure modes for a specific dam, quantifying their probabilities of occurrence and associated consequences, and evaluating their estimated risk of dam failure against the USACE tolerable risk guidelines. The tolerable risk guidelines address the probability of failure, risk to the public (life loss), economic risk and environmental risk. For a particular USACE dam, by combining the two evaluation approaches and the breadth of understanding gained from both, well-reasoned recommendations are made for reducing risks to tolerable levels and to meet essential USACE guidelines. Achieving and maintaining tolerably low risk levels for USACE dams requires structural measures in concert with an effective safety management regime, including staff training, operation and maintain, monitoring and surveillance, and emergency action planning. Since each USACE dam is part of a large portfolio of dams, risk management decisions viewed from a national perspective will be made centrally by HQUSACE. Therefore, the evaluation of dam safety for a particular dam must be made in a consistent manner such that the information obtained from these evaluations can be used to prioritize risk reduction actions across the portfolio of USACE dams. In addition, the Dam Safety Action Classification (DSAC) system is designed and used to maintain the appropriate degree of urgency for addressing safety issues at individual dams. It is recognized that both the engineering guidelines approach and the risk-informed approach are subject to limitations based on the available information, understanding about dam safety issues and failure modes, and limitations in the state-of-the-practice of dam safety engineering. Thus it is important that the degree of confidence in quantitative analyses be considered in both engineering analyses and risk assessments for each dam. Hence USACE does not consider tolerable risk guidelines as strict criteria, and it does not rely solely on these guidelines to demonstrate adequate dam safety, but rather USACE uses the entirety of the information available to support the recommendations made to take a particular risk management action. The IESSF presents a balanced and professional distillation of the risk assessment in support of the recommended risk informed decision.

P.1.6.2.2 Estimation of Risk Conditions for PFMA.

P.1.6.2.2.1 What is the estimated risk condition?

P.1.6.2.2.2 What are the major contributors of the risk condition? Provide a summary on the likelihood of the initiating event, the conditional probability of failure, and the exposure of people, property, and environment, given this failure, and the ultimate loses due to the failure. Discuss the nature of the flooding, the nature of the warning, the ease of evacuation, and size of the population at risk from a best case to a worst case evaluation.

P.1.6.2.2.3 What physical evidence or project performance metrics support that there is or could be a significant failure mode and what is the confidence in its existence?

P.1.6.2.2.4 What are the estimated probabilities of failure and consequences for the identified significant failure mode and the degree of confidence in these estimates?

P.1.6.2.2.5 Can the confidence in the risk estimates be increased and if so, how?

P.1.6.3 Evaluation of Risk Condition

P.1.6.3.1 Tolerable Risk Guidelines

P.1.6.3.1.1 What order of magnitude above or below the tolerable risk limit is the estimated risk, with respect to:

P.1.6.3.1.1.1 APF - total annual probability of failure and

P.1.6.3.1.1.2 ALL - annualized incremental societal risk.

P.1.6.3.1.2 What is the estimated individual risk (IR)?

P.1.6.3.1.3 Does the probability distribution of potential life loss exceed the societal (F-N) tolerable risk limit?

P.1.6.3.1.4 How does uncertainty impact the evaluation of the estimated risk in relation to the tolerable risk guidelines?

P.1.6.3.2 Recommended Dam Safety Action Classification (DSAC) – Do the results of the risk assessment justify a change in the DSAC classification? IESSF

P.1.6.3.3 Dam Safety Modification Study – Is a dam study modification study justified? If so, what is the rationale?

P.1.6.3.4 Interim Risk Reduction Measures.

P.1.6.3.4.1 Are changes in the interim risk reduction measures indicated by the risk assessment in support of the IES?

P.1.6.3.4.2 Are there minor dam safety issues or loss of service issues that should be addressed by operation and maintenance? If so, what is the rationale?

P.2 IES Report. This portion of the appendix describes the format and content of the IES Report.

P.2.1 Chapter 1 – Introduction. Overall project authority, purposes, location, and descriptions of pertinent project features.

P.2.2 Chapter 2 – Background. Discussion of past performance and key observations, Include summary of the dam features and components, foundation conditions, seepage control features, unique design considerations, and construction methods.

P.2.3 Chapter 3 – Current Assessment. Overview from the results of any past SPRA or PA findings and the reasons for the current DSAC rating. The current assessment shall include a summary of the objectives from the approved Issue Evaluation study plan. Include a description of the Phase 2 study efforts and investigations (if applicable).

P.2.4 Chapter 4 – Interim Risk Reduction Measures. Summary of the IRRMP implementation, and the benefits and impacts of the corresponding interim risk reduction measures.

P.2.5 Chapter 5 – Potential Failure Modes. Summary of the facilitated PFMA results with a listing of the significant and credible failure modes, the impacts if failure was to occur, and corresponding opportunities for risk reductions.

P.2.6 Chapter 6 – Hydrologic and Hydraulic Analysis. A discussion of the hydrologic loading events and frequency for the project as well as hydraulic modeling efforts.

P.2.7 Chapter 7 – Seismic Loading. A discussion of the seismic loading events and frequency for the project shall be included in this chapter. The overall seismic analysis process is provided in Appendices AB and AC.

P.2.8 Chapter 8 – Consequences. A detailed summary of the estimated life, economic, and environmental consequences. (e.g. impact on project purposes, loss of life, environmental and economic impact to region, etc.).

P.2.9 Chapter 9 – Risk Estimate.

P.2.9.1 Methodology. A description of the methodology and risk estimating tools, used to estimate the risk.

P.2.9.2 Sensitivity. Discussion of model and data uncertainty, and assumptions, including explicit presentation of how uncertainty influences the risk estimate using sensitivity analysis or other appropriate uncertainty analyses.

P.2.9.3 Summary of risk estimates. Discussion of the risk estimates based upon current tolerable risk guidelines. Plot the risk estimate results on the tolerable risk guideline charts. The summary shall provide a tabular summary of results that includes the Annual Probability of Failure, the estimated Life Loss (Mean Value), the Annualized Life Loss, and economic risk for each failure mode analyzed (see Chapter 5).

P.2.10 Chapter 10 – Conclusions and Recommendations. This section should include the findings and conclusions of the risk estimate, recommendations, and risk-informed justification for more detailed study. This section should also include a discussion on future data needs required to reduce unacceptable uncertainty at the next level of study.

P.2.11 Chapter 11 – Interim Risk Management Plan. A comprehensive discussion on the significant dam safety deficiencies identified by the risk analysis, the short and long term efficiency, effectiveness, and potential impacts of current and proposed IRRMs, the justification and urgency to take further action, the proposed scope of the efforts required to accomplish these actions, including the anticipated planning, design, and investigation tasks required to perform a DSM study.

P.2.12 Chapter 12 – Risk Communications Plan. A summary of efforts and actions the district intends or has implemented in accordance with chapters 7 and 10.

P.2.13 Supporting Documentation. Supporting documentation shall be included in the following Appendices:

P.2.13.1 Appendix A – References.

P.2.13.2 Appendix B – PFMA Documentation.

P.2.13.3 Appendix C – Initiating Events.

P.2.13.4 Appendix D – System Response.

P.2.13.5 Appendix E – Consequence Documentation.

P.2.13.6 Appendix F – Risk Engine Results.

P.2.13.7 Appendix G – Pertinent Project Data used in Risk Estimates.

P.2.13.8 Appendix H – Agency Technical Review.

P.2.13.9 Appendix I – IRRM Supporting Documentation.

This Page Left Blank

APPENDIX Q

Dam Safety Modification Investigations, Studies, and Reports

Q.1 Format of Dam Safety Modification Report. Each report shall include the requirements contained in the following paragraphs and the report format shall follow the order as presented below.

Q.2 Dam Safety Action Decision Summary (DSADS). The DSADS is intended to be an extractable, stand alone component of the DSM report. (Note: This is a different document from the Part 1, IES.) The DSADS is intended to meet the information needs of senior USACE officials in making dam safety decisions. It would be a public document with unrestricted distribution, but is not designed to be a public communications document per se. Detailed guidance for preparation of the DSADS is in Appendix R.

Q.3 Executive Summary. The Executive Summary will include project location, description, and DSAC; dam safety issues and significant potential failure modes; baseline risk estimate and relation to tolerable risk guidelines; alternatives considered; and recommendations with expected effects on risk. The Executive Summary should be brief, about 2 to 3 pages in length, summarizing the above items in such a way as to not include sensitive information so that the Executive Summary may be released publicly without being designated as “For Official Use Only.”

Q.4 Background.

Q.4.1 Project Authorization and Appropriate Funding Legislation. Provide pertinent information on the project authorization, including any modifications, and quote verbatim the requirements of local cooperation in the original authorization.

Q.4.2 Location and Description. Briefly describe the project, including type of dam or major structure and seismic zone and enclose a map to indicate its location.

Q.4.3 Project History. Provide a chronology of the expenditures for maintenance on the project since its completion, and a brief description of all previous major rehabilitations or dam safety modifications and their associated costs.

Q.4.4 Current Use of the Project and Projected Future Use. Provide a narrative description of the use currently being made of the project and the use projected during an appropriate period in the future (e.g., useful life without and, new useful life with, recommended modifications for dam safety). Indicate whether the project currently satisfies the authorized project purposes and what impact the proposed modifications for dam safety will have on the project’s capability to do so. Provide supporting data, as available from USACE or non-USACE sources.

Q.5 DSM Study Findings and Recommendations. This section presents a summary of the investigations, analysis, studies, and decision process for the recommended risk management plan.

Q.5.1 Identify Dam Safety Issues and Opportunities (Chapter 9, Section 9.5.2). Problems and opportunities statements will be framed in terms of the USACE dam safety program objectives, identified dam safety issues, and life safety tolerable risk and essential USACE engineering guidelines.

Q.5.2 Estimate Baseline Risk Condition (Chapter 9, Section 9.5.3). The baseline condition provides the basis from which alternative plans are formulated and impacts are assessed. All dam safety issues and credible potential failure modes will undergo a risk assessment to identify the significant potential failure modes and to estimate the baseline risk. All risk estimates must give due consideration for intervention. Risk estimates are to be made and presented for both with and without intervention scenarios. A risk assessment for each subsequent risk management alternative will be done to determine the estimated risk reduction.

Q.5.2.1 Provide a narrative description of the investigations and studies used to support the baseline risk estimate.

Q.5.2.2 Present any investigations and studies and explain how they improved the quality and reduce uncertainty of the baseline risk estimate and risk reduction estimates. This narrative should address the engineering assessment, related to each type of dam safety issue (failure mode); to characterize and quantify the existing conditions both deterministically and probabilistically. The narrative should address the uncertainty in all of the analyses performed. Present the loading and system response curves.

Q.5.2.3 Dam Break Analysis and Inundation Maps. Provide a narrative description of the dam break analysis used to estimate the flood characteristics and inundation area associated with a breach for each type of significant failure mode. This analysis is required to be done for a representative range of pool elevations. (Typically this done using selected reservoir elevations that represent break points that allow reasonable determination of consequences without extensive analysis.) The Modeling Mapping Consequence Production Center (MMC) has overall responsibility for developing dam failure, inundation mapping, and consequence models for USACE dams in support of the DSMS.

Q.5.2.4 Baseline Consequence Analysis. Provide a narrative description and tabular summary of the consequence analysis for the baseline condition developed to estimate the consequences associated with dam breach for the full range of loading and exposure conditions.

Q.5.2.4.1 Baseline Life Loss Consequences. This shall include the estimate of the population at risk; threatened population, and the potential loss of life.

Q.5.2.4.2 Baseline Economic Consequences. This shall include the estimated direct economic damages to property and infrastructure, cost of emergency response, loss in regional and national income and employment, and the discounted present value of project future economic benefits.

Q.5.2.4.3 Baseline Environmental and Other Consequences. This shall include the estimated environmental damages (i.e., acres of habitat destroyed, threatened or endangered species impacted.) and HTRW contamination from contaminates either within the reservoir or in the downstream inundation area. Other consequences that cannot be quantified shall be qualitatively described.

Q.5.3 Formulating alternative risk management plans (Chapter 9, Section 9-5.4.). A risk management alternative plan consists of a system of structural and/or nonstructural measures, strategies, or programs formulated to meet, fully or partially, the identified DSM study risk management objectives subject to the constraints. Provide a narrative description of the investigations and analysis included in the report supporting alternative formulation.

Q.5.3.1 At least one proposed risk management alternative must be shown to reduce the risk to the levels defined in the tolerable risk guidelines.

Q.5.3.2 Other alternatives to be considered include:

Q.5.3.2.1 Do nothing – continue project as is;

Q.5.3.2.2 Removal of dam;

Q.5.3.2.3 Replacement of dam;

Q.5.3.2.4 Plan formulated with full ALARP considerations;

Q.5.3.2.5 Only achieving tolerable risk limit for life safety; and

Q.5.3.2.6 Make Interim Risk Reduction Measures permanent.

Q.5.4 Evaluating Alternative Risk Management Plans (Chapter 9, Section 9.5.5). The evaluation of effects is a comparison of the with-risk reduction condition to the baseline condition for each risk management alternative.

Q.5.4.1 Present engineering analysis related to each dam safety issue (failure mode) addressed by each risk management alternative. Characterize and quantify the best estimate of the risk reduction for each alternative and the uncertainty around the best estimate of the risk reduction for each alternative. Develop and present system loading and system response curves for each alternative that relate the probability of failure to the full range of loading.

Q.5.4.1.1 Life Loss Consequences. Provide a narrative and tabulation of estimated Life Loss reduction for each of the alternatives. Characterize and quantify the best estimate of the life loss consequences, and the associated uncertainty, for each alternative.

Q.5.4.1.2 Economic Consequences. Provide a narrative and tabulation of economics consequences for each risk management alternatives. Characterize and quantify the best estimate of the economic consequences, and the associated uncertainty, for each alternative.

Q.5.4.1.3 Environmental Consequences. For each alternative provide a narrative and tabulation of estimated loss or impact on species and habitat for each of the alternatives. Characterize and quantify the best estimate of the environmental consequences, and the associated uncertainty, for each alternative.

Q.5.4.2 Alternative Cost Estimates. Provide a preliminary cost/economic analysis for each alternative included in the report.

Q.5.5 Comparing Alternative Risk Management Plans (Chapter 9, Section 9.5.5). In this step, plans (including the no permanent risk management action plan) are compared against each other, with emphasis on the outputs and effects that will have the most influence in the decision making process, e.g. annual probability of failure, life safety tolerable risk guidelines, ALARP considerations, and essential USACE guidelines.

Q.5.5.1 At a minimum for each alternative show the estimated probably of failure for the baseline condition and the with-risk reduction condition, show the estimated consequences - life loss, economic, present value of project future economic benefits that would be lost with a project failure, and environmental, present baseline condition and with-risk reduction condition estimated risk, show the reduction in total estimated risk and estimated risk for each failure mode, list the ALARP considerations to indicate the residual risk is tolerable, and the estimated cost for the alternative.

Q.5.5.2 Under the ALARP considerations present the disproportionality ratio, cost effectiveness of reducing statistical life loss, and the benefit cost ratio for each alternative. Present the evaluation to determine if each alternative meets essential USACE guidelines. See chapter 5 for details of the various risk guideline parameters to be used in evaluation of alternatives

Q.5.6 Selection of a Risk Management Plan (Chapter 9, Section 9.5.6). The primary evaluation factors of annual probability of failure, life safety tolerable risk guidelines, ALARP considerations, and essential USACE guidelines form the basis for plan selection.

Q.5.6.1 When available information is insufficient to justify the need for modification, recommendations will be made for additional special engineering

investigation(s), which would support a decision. In this case, the most probable plan shall be presented, pending the outcome of the proposed investigations.

Q.5.6.2 Present the justification for any aspect of the recommended plan that requires additional project authorization.

Q.5.6.3 Provide a narrative description of how the dam currently (no risk management measures implemented) deviates from current essential USACE guidelines.

Q.5.6.4 Provide a narrative on the cost to fully meet current standards based criteria. A discussion of the baseline risk, residual risk with the recommended plan, and residual risk for other alternatives that fully meet current standards based criteria (if different from the recommended plan) should be included in the report. Present the results of the economic cost analysis and the total project cost for the recommended plan. An M-CACES cost estimate is required for the recommended risk management plan. Cost estimates shall include a cost risk analysis showing the uncertainty per ER 1110-2-1302, (reference A.53).

Q.6 Cost Sharing Considerations.

Q.6.1 For risk assessment and decision document approval this dam safety regulation treats the dam safety assurance work (Section 1203 cost sharing) and major rehabilitation work for seepage and stability (regular cost sharing) the same way. Each dam safety issue shall be discussed and alternatives reviewed in light of all potential failure modes. For cost sharing purposes this section of the report shall tabularize the recommended risk management alternatives and discuss the proper cost sharing for each of the risk management alternatives in light of the section 1203 and regular cost sharing guidance – the cost sharing is failure mode dependent.

Q.6.2 Include a general explanation of the cost sharing requirements followed by a discussion of the circumstances of the particular project. Show the amount to be cost shared for each of the different cost sharing criteria. Explain the determination of cost allocation and cost sharing for the specific project. This will require documentation of pertinent agreements or contracts. The discussion shall include a tabulation of the costs to be paid by the Federal Government and the sponsor(s). Identify the sponsor(s) for the project and their contributions to initial project development, and sponsor(s) subsequently added to the project. Include the sponsor(s) views concerning cost sharing. Include copies of the existing contracts or agreements.

Q.7 Real Estate Plan(s). Present a summary of any real estate requirements. The Real Estate Plan shall be prepared at a level of detail commensurate with the scope of the project and included in the DSM report appendices. If no land acquisition or relocation requirements are identified, the appendix shall so document that finding.

Q.8. Environmental Compliance Documentation. Documentation of compliance with applicable environmental laws and regulations must be prepared. This may include items such as biological assessments required by the Endangered Species Act and the Fish and Wildlife Coordination Act Reports, in addition to NEPA documents. In accordance with ER 200-2-2, the NEPA document, either an EA or EIS, may either be a self-supporting document combined with and bound within the feasibility report or integrated into the text of the feasibility report. The EA/EIS should generally be integrated into the text of the report unless complex environmental impacts preclude this alternative. Additional information on environmental compliance documentation is in ER 1105-2-100, Appendix C. (reference A-42)

Q.9 Summary of Independent External Peer Review. When an Independent External Peer Review is completed on the project; a summary of the review report should be included in the report. (The detailed review report should be presented in an appendix.)

Q.10 Dam Safety Modification Report Appendices.

Q.10.1 Risk Assessment and Risk Management Alternative Formulation. Provide the detailed risk assessment for the dam and also of any reliability analysis conducted concerning the operating equipment on the structure. Provide the detailed analysis.

Q.10.2 Life Loss Consequences. Include all approaches, data sources, description of models, and model results for all life loss evaluations conducted to estimate the baseline condition life loss consequences of dam failure. This should also include the effect of each alternative on these consequences. Provide the results of the life loss analysis for the recommended plan with detailed backup data.

Q.10.3 Economic Evaluation and Economic Consequences. Include all approaches, data sources, description of models, and model results for all economic evaluations conducted to estimate the baseline condition economic consequences of dam failure. This should also include the effect of each alternative on these consequences. Provide the results of the economic cost analysis for the recommended plan with detailed backup data.

Q.10.4 M-CACES Estimate for Recommended Plan. A Micro Computer Aided Cost Engineering System (MCACES) baseline feasibility estimate (ER 1110-2-1302 (reference A.53)) in the Civil Works/HTRW Work Breakdown Structure will be prepared for the recommended plan. Cost estimates shall include a cost risk analysis showing the uncertainty following “Memorandum: Application of Cost Risk Analysis Methods to Develop Contingencies for Civil Works Total Project Costs, 3 July 2007.” The level of the cost detail will vary with the design information available to support the project scope, but shall be at least to the sub-feature level of detail. However, a higher level of detail approaching that of a feasibility report should be the goal in order to more accurately identify the baseline cost estimate. Although this baseline estimate is not subject to reauthorization if the Section 902 limit (WRDA 86) (reference A.99) is exceeded, the goal is to make every effort to adhere to the criteria of the 20% growth

limitation. Provide a Total Project Cost Summary (TPCS) and separate the costs to the sub-feature level. The TPCS shall be prepared following the current cost engineering policy. Include a summary and the full detail M-CACES estimate for the recommended plan.

Q.10.5 Environmental Documentation.

Q.10.5.1 NEPA and ESA. Include all NEPA and other environmental investigation and study results. Provide an assessment/description (for each alternative evaluated) of the impacts on the existing environment. Highlight any significant resources that are likely to be affected as well as any that are covered by a specific law (e.g., endangered species, clean air, clean water, cultural and historical, etc.). Compare the environment impacts of constructing the modification to those environmental impacts that would occur if we did nothing and let the dam fail.

Q.10.5.2 Pertinent Correspondence. For the recommended plan, provide the pertinent correspondence, a summarization of the studies conducted to evaluate the environmental effects of the plan, and the necessary National Environmental Protection Act (NEPA) documentation required in ER 200-2-2 (reference A.37) (e.g., EA, FONSI, EIS, or Supplement) and/or Section 404(1)(b) evaluation.

Q.10.5.3 Hazardous, Toxic, and Radioactive Waste. Include potential hazardous, toxic and radioactive waste concerns and conduct appropriate surveys. Identify the location of impacts and explain their significance, the likelihood of being able to mitigate such impacts, and associated cost. Indicate the concurrence or non-concurrence given by resource agencies that mitigation is possible and appropriate. Identify any environmental constraints that would render an alternative infeasible.

Q.10.6 PPA. When the project includes requirements of local cooperation, indicate the views or concurrence of local interests in the general plan of the proposed work, state whether these views were obtained by conference or public meeting, and provide a letter from local interests, which sets forth their views. Give the best available estimate of required local cooperation cost, a statement of the prospects for fulfillment of the required conditions, and the names, titles, and addresses of the principal officers and representatives responsible for fulfillment. Identify any differences in local cooperation requirements under existing agreements that should be changed and the basis therefore. Also indicate what will be done to obtain the desirable local cooperation. Include a copy of the draft PPA if required.

Q.10.7 PMP for Design Phase. Include the detailed Project Management Plan for the investigations in support of design, additional studies, design, and construction. Include a schedule of any additional engineering investigations and studies needed in the design phase and all DDR’s that will be prepared.

Q.10.8 Schedule of Fully Funded Project Costs by FY. Federal and non-Federal – Include a schedule for fully funding the project to achieve the intended risk reduction as

quickly and efficiently as possible. This is to include additional investigations and analysis, engineering and design (Pre-construction engineering and design), and construction cost. Provide a schedule of funding requirements by fiscal year to accomplish recommended modifications to the project based on current budgetary guidance. Indicate which requirements are recommended for funding under Construction, and which are recommended for funding under Operation and Maintenance, as part of continuing project operations; for example - routine instrument readings. If both authorized and unauthorized work are recommended and both items can stand on their own from an engineering and economic standpoint, a two-stage design and construction procedure may be required. The first stage would consist of work that is authorized. The second stage could involve those items of work that require additional congressional authorization.

Q.10.9 Authorizing Legislation. Present applicable legislation dealing with the initial construction and subsequent addition of project purposes. Specifically include documentation on cost sharing of added authorized purposes. Include a copy of the original and current authorizing legislation for the project.

Q.10.10 Existing Contracts with Sponsors, etc. Copies of existing contracts, agreements or letters of intent from project sponsor(s), cost sharing partners, and users. Provide a copy of any existing cost sharing and water supply contracts.

Q.10.11 Engineering Analyses and Determination of Compliance with Essential USACE Guidelines. Provide annexes with the engineering analysis of the geotechnical, structural, hydrologic and hydraulic investigations for site characterization, load determination, determination of probability of failure, etc. to determine the dam's ability to meet current design and performance criteria and develop component fragility and system response curves.

Q.10.11.1 Hydraulic or Hydrologic. Evaluate the ability to pass the spillway design flood in accordance with current policy.

Q.10.11.2 Seismic. Evaluate the ability to withstand seismic loads in accordance with current policy.

Q.10.11.3 Static stability. Evaluate the ability to withstand static pool loads in accordance with current policy. (e.g., seepage and piping, static stability)

Q.10.11.4 Erosion and Landslides. Evaluate the ability to withstand loads generated during operation of the dam in accordance with current policy. (e.g., spillway erosion, landslides)

Q.10.11.5 Spillway Gate Operations. Evaluate the ability to operate within the full range of design loads in accordance with current policy.

Q.10.11.6 Evaluate other conditions not meeting current design or construction criteria or seriously affecting project performance.

Q.10.11.7 Recommended Plan Drawings. Provide summary drawings for the recommended plan for use in review and presentation of the recommended plan.

Q.10.12 Real Estate Plan (including relocations). A Real Estate Plan shall be prepared at a level of detail commensurate with the scope of the project and the real estate requirements, if any, included in the modification report. If no land acquisition or relocation requirements are identified, the appendix shall so state. Provide the background details concerning the Real Estate requirements for the recommended plan.

Q.10.13 Independent External Peer Review. Section 2034 of WRDA 2007 (P.L. 110-114) requires an independent external peer review (IEPR) for all new projects and for all project modifications where an environmental impact statement (EIS) is required. The documentation of IEPR as required by EC 1165-2-209, Water Resources Policies and Authorities, Review of Decision Documents will be contained in this appendix.

Q.10.14 Agency Technical Review Documentation. When an agency technical review is completed on a study, the documentation of the review should be included in the report.

This Page Left Blank

APPENDIX R

Instructions for the "Dam Safety Action Decision Summary for a Dam Safety Modification Study"

R.1 Overview. The Dam Safety Action Decision Summary (DSADS) for a Dam Safety Modification Study is intended to be an extractable, stand-alone component of the DSM report that provides information to senior USACE officials to make dam safety decisions. The DSADS is a public document with unrestricted distribution but it is not designed as a public communications product. DSADS concisely summarizes the following the USACE dam safety program; the history and status of safety issues and actions for the subject dam; the risk management alternatives considered; the recommended actions and supporting facts; the outcomes from analysis and assessment; and the degree of confidence in the basis for the recommendations. The document will be ten to fifteen pages, well formed and will comprise text, tables, diagrams, and photos.

R.2 Document Content. The DSADS consists of:

R.2.1 Title page – Dam Safety Action Decision Summary. The title page shall include Dam Safety Modification Study, name of the dam, location, name of the USACE district and division, and date of the decision summary.

R.2.2 Section 1. Overview of USACE dam safety portfolio risk management process (*standardized text (boiler plate)*) (Table R.1), concluding with identifying the current stage of the dam in that process.

R.2.3 Section 2. Dam safety action summary for the dam.

R.2.4 Section 3. Principles and key concepts that guided the synthesis of the data, analyses and evaluations that provided the basis for action recommendations (*standardized text (boiler plate)*) (Table R.2).

R.2.5 Section 4. Succinct answers to the required standard set of questions posed in this guidance that encompass the scope of issues, investigations, alternatives, and consequences, and that substantiate the recommendations.

R.3 DSADS Instructions. The instructions for the DSADS content are presented in this attachment.

R.3.1 Title Page. Dam name, location (river, city, state), USACE district, USACE division.

R.3.2 Section 1 –"Dam Safety Portfolio Risk Management Process". For Section 1 use the standard text (boiler plate) provided in Table R.1. Fill in the blanks at the end of the text. Include a copy of Figure 3.1 and Table 3.1 in the DSADS at this point.

Table R.1 – Standard Text for DSADS Section 1
The overall Dam Safety Portfolio Risk Management Process is a series of hierarchical activities used to assess, classify, and manage the risks associated with the USACE inventory of dams. Dam Safety Action Classification (DSAC). The DSAC classification system provides consistent and systematic guidelines for appropriate dam safety actions, which are designed to address the dam safety issues and deficiencies of USACE dams and which are commensurate with the level of the dam failure risk. USACE dams are placed into a DSAC class based on their probability of failure or the individual dam safety risk estimate considered as a combination of probability of failure and potential life safety, economic, environmental, or other consequences. The intent is that the classification of a dam is dynamic over time, being revised as project characteristics are modified or more refined information becomes available affecting the loading, probability of failure, or consequences of failure. Portfolio Risk Management Process. The portfolio risk management process defines and documents the USACE risk assessment and risk management action decisions for each dam and facilitates risk communication. The actions and documents that reflect the process include normal operations and maintenance (O&M) activities and the documents generated through the portfolio risk management process to address dam safety issues. These documents are principally the Screening Portfolio Risk Assessment report, the Interim Risk Reduction Measures report, the Issue Evaluation Study report, and the Dam Safety Modification report. Portfolio Risk Management Process Graphic Depictions. Table 3.1 contains the definition of the USACE dam safety action classification system. Figure 3.1 is a flow chart of the USACE dam safety portfolio risk management process. Chapter 3 of the Safety of Dams regulation provides a detailed description of the process and discussion of the figures. Dam <*insert name*> is presently classified <*Insert dam's DSAC class*> and is poised at decision point <*Insert decision point ID*>. Prior dam safety actions for this dam are summarized in the following section.

R.3.3 Section 2 – Summary History of Dam Safety-Related Actions. Summarize, using text, diagrams, and photographs (as appropriate), the dam-safety-related issues and actions that might have arisen during design, construction, and operation continuing to the present. The information to be presented should include the following safety issues identified; remediation proposed and adopted; and a brief assessment of the degree of success of the remediation. A time-line diagram of major safety-related events and actions is a powerful way of presenting such history. Include the appropriate charts and diagrams.

R.3.4 Section 3 –"Guiding Principles and Key Concepts". For Section 3 use the standard text (boiler plate) provided in Table R.2.

Table R.2 – Standard Text for DSADS Section 3

Assessments of the safety of USACE dams are conducted using a risk assessment approach which provides input to risk informed decision making. The approach combines the evaluation of dam safety against engineering guidelines, and evaluates the risk posed by USACE dams compared to tolerable risk guidelines. The former focuses on satisfying essential USACE guidelines for a wide range of engineering considerations. The latter involves identifying all credible and significant failure modes for a specific dam, quantifying their probabilities of occurrence and associated consequences, and evaluating their estimated risk of dam failure against the USACE tolerable risk guidelines. The tolerable risk guidelines address the probability of failure, risk to the public, economic risk and environmental risk. For a particular USACE dam, by combining the two evaluation approaches and the breadth of understanding gained from both, well-reasoned recommendations are made for reducing risks to tolerable levels and to meet essential USACE guidelines. Achieving and maintaining tolerably low risk levels for USACE dams requires structural measures in concert with an effective safety management regime, including staff training, operation and maintain, monitoring and surveillance, and emergency action planning.

Since each USACE dam is part of a large portfolio of dams, risk management decisions viewed from a national perspective will be made centrally by HQUSACE. Therefore, the evaluation of dam safety for a particular dam must be made in a consistent manner such that the information obtained from these evaluations can be used to prioritize risk reduction actions across the portfolio of USACE dams. In addition, the Dam Safety Action Classification (DSAC) system is designed and used to maintain the appropriate degree of urgency for addressing safety issues at individual dams. To appropriately manage the prioritization and urgency of risk reduction for each individual dam across the entire portfolio, opportunities for staging risk reduction actions using logically separable construction packages are considered in the dam safety modification studies.

It is recognized that both the engineering guidelines approach and the risk-informed approach are subject to limitations based on the available information, understanding about dam safety issues and failure modes, and limitations in the state-of-the-practice of dam safety engineering. Thus it is important that the degree of confidence in quantitative analyses be considered in both engineering analyses and risk assessments for each dam. Hence USACE does not consider tolerable risk guidelines as strict criteria, and it does not rely solely on these guidelines to demonstrate adequate dam safety, but rather USACE uses the entirety of the information available to support the recommendations made to take a particular risk management action.

The DSADS presents a balanced and professional distillation of the risk assessment in support of the recommended risk informed decision.

R.3.5 Section 4. The following questions are to be answered in a narrative manner that succinctly communicates the essential dam safety issues, failure modes and risk assessment, alternatives formulated and analyzed, estimated risk reduction for each alternative, the recommended risk reduction action(s), and potential remaining dam safety issues. Tables, illustrations, and graphs are to be used as appropriate to summarize information and support the narrative. The questions are grouped consistent with the investigation structure presented in Chapter 9, paragraph 9.5.

R.3.5.1 Identification of the dam safety issues, risk reduction objectives, limitations and opportunities

R.3.5.1.1 What are the dam safety issues?

R.3.5.1.2 What instigated the safety concern?

R.3.5.1.3 What physical evidence or project performance indicates that there is a problem or that a problem cannot be ruled out?

R.3.5.1.4 Why are these issues significant?

R.3.5.1.5 What is the existing DSAC classification and what are the significant dam safety issues that have lead to this classification?

R.3.5.1.6 What are the dam safety risk reduction objectives?

R.3.5.1.7 What tolerable risk guidelines are being used for performance objectives – life safety, economic, and environmental?

R.3.5.1.8 What essential USACE guidelines are pertinent for this dam and why?

R.3.5.1.9 Is the ALARP principle to be applied and how?

R.3.5.1.10 What are the potential constraints on risk reduction actions that need to be addressed?

R.3.5.1.11 Are there physical site constraints and if so, what are they?

R.3.5.1.12 Are there resource constraints such as institutional, people, funding and if so, what are they?

R.3.5.1.13 Are there policy and legal constraints that must be considered, and if so, what are they?

R.3.5.2 Estimation of baseline risk conditions

R.3.5.2.1 What is the estimated baseline risk condition?

R.3.5.2.2 What are the major contributors of the baseline risk condition? And what is the likelihood of the initiating event; conditional probability of failure; exposure of people, property, and environment given this failure; and the ultimate losses due to the failure?

R.3.5.2.3 Was it necessary to consider future risk conditions (changes in consequences or deterioration in condition) and if so, what are they?

R.3.5.2.4 What physical evidence or project performance metrics support that there is or could be a significant failure mode and what is the confidence in its existence?

R.3.5.2.5 What are the estimated probabilities of failure and consequences for each significant failure mode and the degree of confidence in these estimates?

R.3.5.2.6 Can the confidence in the risk estimates be increased and if so, how?

R.3.5.2.7 Which essential USACE guidelines are not met?

R.3.5.2.8 Which tolerable risk guidelines are not met for baseline conditions, and what is the confidence in these assessments?

R.3.5.2.9 What is the risk estimates for with and without intervention scenarios? What are the interventions considered?

R.3.5.3 Formulation of alternative risk management plans

R.3.5.3.1 What risk reduction measures were considered in formulating the alternative plans?

R.3.5.3.2 How were the measures grouped to form the initial set of alternative plans?

R.3.5.3.3 What specifically are the alternative plans proposed for evaluation?

R.3.5.3.4 Does the set of alternatives formulated address all credible and significant dam safety issues?

R.3.5.3.5 How have staging of construction phases for remediation action been considered in the alternative plans?

R.3.5.3.6 Are there stakeholders or other interested parties promoting or objecting to one or more of the alternatives and why?

R.3.5.4 Evaluation of alternative risk management plans

R.3.5.4.1 What is the risk (hazard, probability of failure, and consequences) estimate for each failure mode for each alternative?

R.3.5.4.2 Which essential USACE guidelines remain unmet, if any, for each alternative risk reduction plan?

R.3.5.4.3 What are the costs, any changes in benefits, and tolerable risk evaluations, including benefit/cost, ALARP and disproportionality considerations, for each alternative plan and the degree of confidence in these?

R.3.5.4.4 How is the implementation of each alternative expected to affect the Interim Risk Reduction Measures that currently exist?

R.3.5.4.5 Are there any opportunities for increased project benefits (integrating remediation with enhancing other purposes) for each alternative plan and what are the incremental costs? Is additional congressional authorization required for these plans that increase benefits?

R.3.5.4.6 What would be the effect of staging implementation of selected components of the alternatives?

R.3.5.5 Comparison of alternative risk management plans

R.3.5.5.1 How much does each alternative plan reduce risk in comparison with the baseline risk, and what is the cost of the alternative?

R.3.5.5.2 How does each alterative plan compare in terms of meeting essential USACE guidelines?

R.3.5.5.3 What are the changes in relation to the tolerable risk evaluations, including ALARP (to include disproportionality) for each alternative plan?

R.3.5.5.4 What are the potential negative aspects of each alternative plan, such as reduction in benefits, increased cost to users, impact on the environment, and can they be mitigated?

R.3.5.6 Selection of the recommended risk management plan

R.3.5.6.1 What is the recommended risk management plan?

R.3.5.6.2 Are all dam safety issues (credible and significant failure modes) addressed by the recommended plan and if not, which are not addressed and what is the rationale?

R.3.5.6.3 Does the recommended risk management plan achieve the desired objectives including tolerable risk guidelines, ALARP, cost effectiveness, and essential USACE guidelines.

R.3.5.6.4 What is the expected DSAC class after implementation of the recommended risk management plan?

R.3.5.6.5 What would be the effect of delaying implementation of the recommended plan?

R.3.5.6.6 What are the consequences of not implementing, or delaying implementation of the recommended risk management plan?

R.3.5.6.7 Is there consensus on the recommended plan by principal stakeholders and other interested parties and who are they?

R.3.5.6.8 Are there opposing views and what are they and how were differences addressed?

R.3.5.7 Cost Sharing

R.3.5.7.1 What are the cost sharing requirements?

R.3.5.7.2 If there are no cost sharing requirements, what would the cost sharing requirements be under modern day legislation and policies?

This Page Left Blank

APPENDIX S

Dam Safety Modification Report Issue Checklist

S.1 Sensitive Policy Areas. Areas which require vertical team coordination with MSC/HQUSACE to Washington: _____

_____

_____

_____

S.2 General Project Information.

S.2.1 Project Name. (State, County, River Basin/Waterbody under Study)

S.2.2 Project Description. (Need project description with general details, such as a fact sheet attached--if project is the same as authorization attach a summary, if different provide a description of what differs from original authorization, the authorizing language, and dimensions to give perspective of the change in scope and scale. If there was an authorizing report, what level approved it—i.e., OMB, ASA(CW), HQUSACE (include date of approval). If no prior reports, give a more detailed description.)

S.2.3 Cost Sharing. (Describe the cost sharing for the project to be constructed. Describe whether the cost sharing follows general law or if there is other special cost sharing for the project)

S.3 General Questions.

S.3.1 Has a NEPA document been completed?

Response: YES _____ NO _____*

Remarks:

* A response where there is a "*", requires coordination through vertical team and complete description of issues under "Remarks", before decision to approve project/report can be delegated.

S.3.2 Will the NEPA Documentation be more than 5 years old at the time of PCA signing or construction initiation?

Response: YES _____* NO _____

Remarks:

S.3.3 Will the ESA Findings be more than 3 years old at the time of PCA signing or construction initiation? [Note: Findings refers to USACE documentation and/or US Fish and Wildlife Service's opinions and recommendations]

Response: YES _____* NO _____

Remarks:

S.3.4 Is ESA coordination complete?

Response: YES _____ NO _____*

Remarks:

S.3.5 If an EIS/EA was completed for the project, has the Record of Decision/Finding of No Significant Impact been signed?

Response: YES _____ NO _____*

Remarks:

S.3.6 Is the proposed project consistent with the ROD/FONSI?

Response: YES _____ NO _____*

Remarks:

S.3.7 Has there been any changes in Federal environmental laws or Administration or USACE policy since original project authorization that make updating necessary? [e.g., change to the Clean Air Act status for the project area…going from attainment to non-attainment]

Response: YES _____* NO _____

Remarks:

S.3.8 Is there a mitigation plan?

Response: a. Fish and Wildlife: YES _____* NO _____
b. Flood Damage: YES _____* NO _____
c. Cultural and Historic Preservation: YES _____* NO _____
d. Recreation: YES _____* NO _____

Remarks: [If yes, identify and describe what is being mitigated and cost shared. Describe the authority for the cost sharing.]

S.3.9 Are the mitigation plan(s) that are now being proposed the same as the authorized plan?

Response: a. Fish and Wildlife: YES _____ NO _____*
b. Flood Damage: YES _____ NO _____*
c. Cultural and Historic Preservation: YES _____ NO _____*
d. Recreation: YES _____ NO _____*

Remarks:

S.3.10 Is there an incremental analysis/cost effectiveness analysis of the fish and wildlife mitigation features based on an approved method and using an accepted model?

Response: YES _____ NO _____*

Remarks:

S.3.11 Does the project involve HTRW clean-up?

Response: YES _____* NO _____

Remarks:

S.3.12 Does the work involve CERCLA covered materials?

Response: YES _____* NO _____

Remarks:

S.3.13 Are the project purposes now being proposed different than the authorized project? [Note: different than specifically noted in authorization or noted in Chief's report and is it measured by project outputs]

Response: YES _____* NO _____

Remarks:

S.3.14 Are there any proposed scope changes to the authorized project? [Reference: ER 1105-2-100 (reference A.42)]

Response: YES _____* NO _____

Remarks: [Describe the authority that would enable the project to proceed without additional Congressional modification]

S.3.15 Is Non-Federal work-in-kind included in the project? [Note: Credit to a non-Federal sponsor for work-in-kind must be based upon having an existing authority. Need to identify the authority and if not a general authority such as Sec 215, provide a copy of the authority.]

Response: YES _____* NO _____

Remarks:

S.3.16 Does project have work-in-kind authority? [Note: If there is no existing authority, as determined in conjunction with District Counsel, the only other vehicle is to propose work-in-kind and rationale in the decision document and submit to HQUSACE for specific Congressional authorization.]

Response: YES _____ NO _____*

Remarks:

S.3.17 Are there multiple credit authorities (e.g., Sec. 104 & 215) including LERRDS, Work-In-Kind and Ability to Pay? [Note: See App. B of ER 1165-2-131 (reference A.65)]. Describe the authority for work-in-kind and if authority exists, the PM should submit a completed App. B through the vertical team.]

Response: YES _____* NO _____

Remarks:

S.3.18 Is an Ability to Pay cost sharing reduction included in the proposed project? [If yes, fully describe the proposal, citing how this authority is applicable. Include a table showing the cost sharing by project purpose and expected Ability to Pay reductions.]

Response: YES _____* NO _____

Remarks:

S.3.19 Is the recommended plan different from the NED plan? [Note: if this answer is yes, then a series of questions arise that will need to be addressed in the Remarks section…is plan less costly than NED plan, is the plan more costly with the same cost sharing the same as NED plan (exception), is plan more costly with all costs exceeding the cost of the NED plan at 100% non-Federal cost, or has ASA(CW) already grant exception]

Response: YES _____* NO _____

Remarks:

S.3.20 Was a standard accepted USACE methodology/model used to calculate NED benefits?

Response: YES _____ NO _____*

Remarks:

S.3.21 Are there non-standard benefit categories? [Reference ER 1105-2-100 (reference A.42)].

Response: YES _____ NO _____*

Remarks:

S.3.22 Is there a flood damage reduction component in the project?

Response: YES _____ NO _____
(If Yes, answer following question)

S.3.23 Are reallocation studies likely to change the existing allocated storage in lake projects?

Response: YES _____* NO _____

Remarks:

S.4 CONCURRENCE

_____ Date:_____
Project Manager

_____ Date:_____
District Counsel

_____ Date:_____
District Dam Safety Officer

_____ Date:_____
MSC Dam Safety Officer

_____ Date:_____
MSC Counsel

This Page Left Blank

APPENDIX T

Post-Authorization Decision Document Checklist

T.1 Basic Information.

T.1.1 Name of Authorized Project: _____

T.1.2 Name of Separable Element: _____

T.1.3 PWI Number: _____

T.1.4 Authorizing Document: _____

T.1.5 Law/Section/Date of Project Authorization: _____
(Note: attach copy to checklist)

T.1.6 Laws/Sections/Dates of Any Post-Authorization Modification: _____

T.1.7 Non-Federal Sponsor(s): _____

T.1.8 Project/Separable Element Purpose(s): _____

T.1.9 Congressional Interests (Senator(s), Representative(s) and District(s)): _____

_____

T.2 Project Documents.

T.2.1 Type of Decision Document: _____

T.2.2 Approval Authority of Decision Document: _____

T.2.3 Project Management Plan Approval Date: _____

T.2.4 Agency Technical Review (ATR) Approval Date: _____

T.2.5 Independent External Peer Review (IEPR) Completion Date: _____

T.2.6 Mitigation Authorized: ___ Yes ___ No Cost of Mitigation _____

Describe Type of Mitigation and Whether Included in Project Report: _____

_____
(Note: Project report is the one that supports the authorization for the mitigation. Need to make sure that mitigation is authorized as part of the project cost)

T.2.7 Current M-CACES Estimate: $ _____

Date Prepared and Price Level: _____

T.2.8 Date of Latest Economic Analysis: _____

T.3 Cost Sharing Summary.

Purposes	Non-Fed Cash	Non-Fed LERRD	Non-Fed Const. Credit	Non-Fed Total Share	Federal Share (%)	Total Project Cost
Totals						

T.3.1 Projected Credit for Section 215 Work and Date Section 215 Agreement Signed: _____

T.3.2 Projected Credit for Section 104 or Other Authorized Creditable Work and Date Work Approved by ASA(CW) or Agreement Addressing Work Signed: _____

_____

T.3.3 Annual Non-Fed OMRR&R Costs (1 Oct FY_____ Price Levels): _____

T.4 Funding History. Appropriations History for Project/Separable Element (include Wedge Funding)

Fiscal Year	Budget Amount	Appropriated Amount
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

T.5 Certification For Delegated Decision Documents. You must answer "Yes" to all of the following questions to approve the decision document under delegated authority.

T.5.1 Project Plan.

T.5.1.1 Has the project study issue checklist been completed and all issues resolved?

___Yes ___No

T.5.1.2 Does the non-Federal sponsor concur in the project plan as submitted?

___Yes ___No

T.5.1.3 Has project plan as submitted been reviewed and concurred with by the non-Federal sponsor's counsel?

___ Yes ___ No

T.5.2 Authority –

T.5.2.1 Has the Dam Safety Officer at each level approved the project report?

___Yes ___No

T.5.2.2 Is authority adequate to complete the project as proposed?

___ Yes ___ No

T.5.3 Policy/Legal/Technical Compliance

T.5.3.1 Has the District Counsel reviewed and approved the decision document for legal sufficiency?

____Yes (Certification included in decision document package submittal) _____ No

T.5.3.2 Have all aspects of ATR and IEPR have been completed with no unresolved issues remaining?

_____Yes _____No

T.5.3.3 Has the District Dam Safety Officer documented policy/legal/technical compliance of the decision document?

_____Yes _____No

T.5.3.4 Has the MSC Dam Safety Officer certified the policy/legal/technical compliance of the decision document?

_____Yes _____No

T.6 Authentication.

_____Date: _____
Project Manager

_____Date: _____
District Counsel

_____Date: _____
District Dam Safety Officer

_____Date: _____
District Support Team Leader

_____Date: _____
MSC Counsel

_____Date: _____
MSC Dam Safety Officer

APPENDIX U

Dam Safety Communication

U.1 Sample Frequently Asked Questions and Answers.

U.1.1 Question. Am I safe?

Answer. While we cannot completely eliminate risk, we can reduce risk. Our safety classification of this project does not mean the dam is in imminent danger of failing. It means we have identified dam safety issues that don't meet industry dam safety standards and the risk to public safety is unacceptable. The objective of our Dam Safety Program is to maintain public safety and to make sure our dams are safe and risks are minimized. Interim Risk Reduction Measures are in place to maintain public safety, until we complete engineering evaluations and develop a plan of action for permanent repairs. Routine inspections and operation of the lake and dam will continue and emergency action plans have been developed in coordination with local emergency management officials. Currently, there is no evidence to suggest an emergency situation exists, or is about to occur. USACE is responsible to take actions for suspected high risk conditions, until we have adequate information to confirm risks are acceptable.

U.1.2 Question. What is risk?

Answer. Risk is the measure of the likelihood, chance, or degree of belief that a particular outcome or consequence will occur along with the outcome of the failure including immediate, short and long-term direct and indirect losses and effects. Losses may include human casualties, water supply, recreation, and hydropower benefits. Effects may include downstream damages and/or adverse environmental impacts.

U.1.3 Question. What does failure mean?

Answer. In the context of dam safety, failure is generally confined to issues of structural integrity, and in some contexts to the special case of uncontrolled release of a reservoir through collapse of the dam or some part of it.

U.1.4 Question. Why do the DSAC categories emphasize the "unsafe" term? What does unsafe mean?

Answer. DSAC classifications are based upon confirmed and unconfirmed dam safety issues, the probability of failure and life or economic consequences. USACE will only designate a dam normal or safe when there are no unconfirmed dam safety issues.

U.1.5 Question. Is this (are these) dam(s) at risk of failing?

Answer. (For DSAC I projects) Our screening and classification of _____Dam identified this project as urgent and compelling. A dam with this classification is critically near failure or extremely high risk under normal operations. Critically near failure means we have confirmed failure is taking place and it is almost certain to fail under normal operations any time within a few years without intervention. Extremely high risk means that the dam poses a combination of life or economic consequences with a high probability of failure. Modification studies for DSAC I dams are funded immediately. We are taking the following interim risk reduction measures _____.

Answer. (For DSAC II projects) Our screening and classification of _____Dam identified this project as urgent. A dam with this classification is considered to have failure initiation foreseen or very high risk. Foreseen failure initiation means the dam has confirmed and/or unconfirmed safety issues and failure could begin during normal operations or from a hydrologic or seismic event. Very high risk means that the dam poses a combination of life or economic consequences with a high probability of failure. We are taking the following interim risk reduction measures _____.

Answer. (For DSAC III projects) Our screening and classification of _____Dam identified this project as a high priority. A dam with this classification is considered significantly inadequate or moderate to high risk. Significantly inadequate means the dam has confirmed and/or unconfirmed safety issues. Moderate to high risk means that the dam poses a combination of life or economic consequences with moderate to high probability of failure. We are taking the following interim risk reduction measures _____.

In all cases, interim risk reduction measures are taken to reduce the risk to public safety.

U.1.6 Question. May we have copies of your risk analysis and inspection reports?

Answer. You should contact the respective district headquarters for that information. Requests for inspection reports will be evaluated on a case-by-case basis because of information that may expose a vulnerability that could be an operational security concern. In many cases, the Corps has posted information on District websites that can be accessed by the public.

U.1.7 Question. If there are Classification I dams, are there other classifications? What are they and how are they defined?

Answer. The five Dam Safety Action Classes are:

DSAC I – URGENT AND COMPELLING (Unsafe)

DSAC II – URGENT (Unsafe or Potentially Unsafe)

DSAC III – HIGH PRIORITY (Conditionally Unsafe)

DSAC IV – PRIORITY (Marginally Safe)

DSAC V – NORMAL (Safe)

U.1.8 Question. What are interim risk reduction measures?

Answer. Interim risk reduction measures are a short-term approach to reduce dam safety risks while long-term solutions are pursued. They are an important step in returning the project to a stable and safe condition. In establishing IRRM, the prevention of loss of life is the first and foremost objective, followed by prevention of catastrophic economic or environmental losses.

U.1.9 Question. Is there funding available to complete the IRRM on these projects?

Answer. Development of IRRM Plans, and the accompanying actions should not be delayed, “contingent upon funding”. IRRM planning and implementation is a high USACE priority. In some cases, funds have been allocated from existing funding sources to initiate and implement IRRM. Some IRRM actions may require supplemental budgeting. We have been successful in obtaining critical IRRM funding via the American Recovery and Reinvestment Act and emergency authorities.

U.1.10 Question. What is the Corps doing to make sure the dam in my area gets fixed?

Answer. Funding for dam safety studies at DSAC I and II dams has been prioritized Corps wide, to allow us to advance work on the highest risk dams first. Studies are required to identify permanent repair options. The Corps of Engineers has updated our criteria on how to conduct dam safety evaluations. Projects that pose significant public safety risks are our top priority.

Routine Operations and Maintenance funds will be used for DSAC III projects, unless new information changes the risk classification.

The Corps has also set up a new organization, called our Risk Management Center, and has assigned our best engineering experts to work on dam and levee projects.

U.1.11 Question. Is there funding available to make permanent construction repairs?

Answer. Funding for DSAC I and II projects already in construction receive high budgeting DSAC ratings are being used to set national construction repair priorities. Projects classified as DSAC III and IV will not receive funding until the higher

risk DSAC I and II projects are addressed. Districts may elect to make partial repairs for DSAC III and IV projects with O&M funds.

USACE will continue to request funding for DSAC I and II projects, and transition to fund future studies and repairs for DSAC III projects as the repairs on the DSAC I and II dams are completed.

U.1.12 Question. Why is my dam now at high risk, when it has been here for many years?

Answer. In 2005 we began evaluating the risks at Corps operated dams. This was in response to recommendations a Peer Review of the USACE Dam Safety program conducted in 2001 by the Association of State Dam Safety Officials (ASDSO). ASDSO recommended that USACE develop risk reduction, risk assessment, and risk management procedures for implementing a nationwide evaluation process that prioritizes the funding and allocation of dam safety resources USACE-wide. USACE began an approach to consistently take appropriate actions to address our dam safety issues.

Following the first three years of risk-informed screening in 2005, 2006 and 2007, USACE categorized dams into Dam Safety Action Classes (DSAC) based on their individual dam safety risk considered as probability of failure and potential failure consequences.

As a result, our understanding of the conditions at our dams has changed. In some cases we have new observations at our dams that are symptoms of potentially serious problems. In other cases we have learned that the original design and construction methods do not meet our safety standards. External independent peer reviews have confirmed that we are doing the right things to help reduce risk and increase public safety. Lessons learned from our high risk dams, such as Wolf Creek, have heightened USACE's commitment to address risks attributed to our aging infrastructure, and take all actions necessary to prevent failure of a USACE dams.

U.1.13 Question. How long has the USACE known these dams were unsafe?

Answer. The dams validated as critically near failure is not new information. What is new is how we assess our dams and are incorporating risk concepts into dam safety management, routine activities and programming decisions.

U.1.14 Question. What will we do with the findings?

Answer. USACE will use DSAC information to set dam safety remediation priorities in its annual budget requests and to implement IRRM. The overall objective is to reduce the risks to public safety.

U.1.15 Question. How did USACE determine which dams are highest risk?

Answer. USACE developed a risk-informed screening tool to compare the condition of each dam with the risk associated with a new dam. Cadres of USACE professional personnel were trained in the use of the tool and evaluated each dam screened using information provided by the operating district. A group of senior engineers from across USACE reviewed the screening information and established the DSAC for each dam.

U.1.16 Question. What criteria did USACE use?

Answer. The criteria used in the screening are the current state-of-the art criteria for the design and construction of large dams. Tolerable risk guidelines from other agencies, including the Bureau of Reclamation, have been referenced to ensure consistency with public safety standards.

U.1.17 Question. What does “critically near failure” mean?

Answer. Critically near failure means a condition exists at the dam that if not properly addressed, the likelihood of the dam failing in the near future is high. While we can’t physically “see” this occurrence, we know it is happening through various scientific instruments embedded within the dam and foundation. While there are no cracks visible in the dam, instrumentation indicates settlement of the dam is occurring on a small scale. Instrumentation which monitors the water pressure in and beneath the embankment also indicates a rise in pressure over time above what would be expected or considered to be safe. These types of instrumentation readings along with increasing wet spots that have shown up on the downstream face of a dam are indications that the condition at this dam is worsening over time.

U.1.18 Question. If the dam fails, how do I find out if my home and business will be impacted?

Answer. The Corps has developed flood inundation maps as part of the emergency action plan (EAP) for each dam. Copies of these EAPs are provided to local Emergency Response agencies. The maps are not routinely posted for public use, because this information may expose a vulnerability that could be an operational security concern.

Information on high risk (DSAC I and II dams) will be shared with communities via public meetings. Property owners are encouraged to attend these meetings, to assess how their homes and businesses could be impacted.

Additionally, the local District office can provide site specific flood elevation information when contacted by individual home and business owners. In cases where public safety issues outweigh Security concerns, the local District may request a waiver from the Corps of Engineers HQ, and provide the maps to landowners.

U.1.19 Question. How do I prepare to make sure my family is safe?

Answer. Safety is a shared responsibility. The Corps has the responsibility to coordinate with local officials and communicate with the public on the condition of Corps operated dams. Private individuals are encouraged to become educated and aware of local conditions. Personal planning is encouraged, such as purchasing weather alert radios, keeping emergency supplies on hand, and determining personal evacuation routes.

U.1.20 Question. Should these dams be decommissioned?

Answer. Decommissioning of the dam is in the range of available options. However decommissioning a dam involves Congressional approval and to assure the safety of those living downstream of the high risk dam, immediate action is necessary.

U.1.21 Question. What is this classification system that we keep hearing about? How many more of these will you review?

Answer. There are two classification systems for dams:

1. The Potential Hazard Classification which is developed in accordance with FEMA Publication 333, Hazard Potential Classification System for Dams. This system ranks a dam as Low, Significant, or High Hazard Potential based on the damages that would occur if the dam failed. The hazard potential classification does not address the condition of the dam or its risk of failure.

2. The USACE Dam Safety Action Classification (DSAC) which is a classification of dams accomplished by a team of USACE dam safety professionals as a means to group dams that exhibited certain characteristics for potential safety concerns. From 2005-2007, USACE conducted an initial risk-informed screening of approximately 202 dams and the remaining dams operated by USACE will be screened in the next two years.

U.1.22 Question. Are External Peer Reviews Required?

Answer. HQUSACE is sponsoring External Peer Reviews by nationally known dam safety experts. These reviews are being conducted for the DSAC I Flood Damage Reduction dams. Additionally, USACE is complying with new requirements set by Congress in 2007 to conduct Independent External Peer Review (IEPR) on dam safety studies and designs.

U.1.23 Question. IRRM Plans are to include overview information on potential failure modes. What does this mean?

Answer. Potential Failure Mode Analyses (PFMA) is conducted as the first step in a risk analysis.

U.1.24 Question. Why does it take the Corps so long to fix a dam?

Answer. That is a good question. Given the multiple purposes of our dams and the long term benefits they provide we require through analysis of any modification to assure public safety and benefits are not comprised by modification to the dam.

Dam analysis and designs are complex technical efforts. Risk assessments must be performed to understand the extent of a problem and to evaluate options to fix the dams. In some cases a dam may have multiple deficiencies that require correction which increases the time required to start the fixes.

We also take great effort to comply with the National Environmental Protection Act and the Endangered Species Act which does require significant time to assure that all requirements are met.

Once construction starts most fixes will take two or more years to implement.

This Page Left Blank

APPENDIX V

Periodic Inspection Program – Inspection and Evaluation Procedures

V.1 Periodic Inspection Program.

V.1.1 Initial Pre-Inspection Brochure. A technical brochure shall be prepared in advance of the first project inspection to familiarize inspection team members with general project features. This brochure shall include a technical summary of the structural, material, and foundation conditions, instrumentation data, including settlement monuments, location of instrumentation and description of reservoir operations procedures, if pertinent. The brochure shall also include appropriate pertinent project data, project layout and typical section drawings, Federal and non-Federal responsibilities for OMRR&R, summaries of sub-surface soil profiles and boring logs, brief construction history and construction description, and the checklist developed for conducting the inspection. Pre-inspection brochures shall be completed and distributed to inspection team members at least 30 days prior to the inspection date.

V.1.2 Pre-Inspection Packets. A technical pre-inspection packet shall be prepared in advance of all subsequent project inspections to familiarize inspection team members with general project features and history. Pre-inspection packets shall be completed and distributed to inspection team members at least 15 days prior to the inspection date. Packets may be tailored to each discipline to avoid excessive reproduction. To be efficient and generate a 95% complete draft of the PI Report to leave at the project site (see paragraph W-3), many paragraphs and Appendices of the PI Report may be completed with the information that would be contained in the Pre-Inspection Packet. The partially completed PI Report may be distributed to the inspection team members instead of the packet. This packet shall include:

V.1.2.1 A project access map, history of project deficiencies and remedial measures, technical summaries of the structural, material, and foundation conditions, and description of reservoir operations procedures, if pertinent.

V.1.2.2 A written evaluation and plots of all instrumentation data, including settlement monuments shall be prepared along with the location of the instruments.

V.1.2.3 Project data, layout and typical section drawings, Federal and non-Federal responsibilities for OMRR&R, sub-surface soil profiles plots, examples of typical boring logs, list of project documents and engineering data that identifies the status and location of the project documents, and the checklist developed for conducting the inspection.

V.1.2.4 Findings of annual inspections since the last periodic inspection and the status of recommended action items shall be reviewed and included in the packet.

V.1.2.5 A section discussing the need for updating the project design parameters (hydraulic, seismic, HSS, etc.) shall be prepared, if applicable.

V.1.2.6 A brief summary of past performance and problems and concentrate on the continuing conditions that affect or may affect the overall safety and operational capability of the structure. Include narrative on intermediate inspections.

V.1.2.7 A summary of the project's bridge inspections that may impact project safety or access during emergency conditions shall be included.

V.1.2.8 Status of seismic re-evaluations, per ER 1110-2-1806 (reference A.56) shall be included in the packet.

V.1.2.9 Status of Hydrologic re-evaluations shall be included in the packet.

V.1.3 Inspection Procedures. A systematic inspection plan, based on the most recent risk informed methodology assessment from a Portfolio Risk Assessment (SPRA/PRA), will be established for the inspection and operation of those features related to the safety and stability of the structure and to the operational adequacy of the project. Operational adequacy means the inspecting, testing, operating, and evaluation of those components of the project whose failure or failure to operate properly could impair the operational capability and/or usability of the structure. Where the operation of these components is vital to the safe operation of the project under emergency conditions, these components will be operated by emergency power at least annually and these operations recorded in a project log. Emergency generators shall be tested under load on more frequent intervals to maintain their integrity. In addition, standby emergency generating systems shall be reviewed and tested during the scheduled inspection to assure the inspection team that all critical project features, including communication systems, can be operated under emergency conditions or in the absence of the normal source of power. The testing of emergency power shall include the maximum power demand that could be expected in emergency situations. As much as possible the operation and/or inspection of all the features outlined in the inspection plan shall be conducted during the scheduled inspection. The inspection of the remaining features may be conducted any time prior to completion of the inspection report but no earlier than occurrence of the last major flood event for the project. However, if possible, the inspection of certain features such as stilling basin dewatering, tainter gate inspections, operability inspections, etc., shall be completed before the periodic inspection so that the team can review the findings during the periodic inspection. If appropriate, a video of the event could document pertinent results of the pre-inspection for showing at the regularly scheduled inspection.

V.1.4. Inspection Plan. The risk-informed systematic inspection plan shall assure adequate coverage of the project in the most expedient manner. The plan will cover technical skills required by members of the inspection team, items of equipment to be operated, areas that will be inspected and support equipment that will be required, including equipment to generate a 95% complete draft of the PI report. The plan and

Site Specific Checklist shall complement each other. The plan shall provide, as appropriate, the examination and the operation of, but not be limited to, the following features and conditions:

V.1.4.1 Hydraulic Steel Structures (HSS), as defined and required in ER 1110-2-8157 (reference A.52), which include flood and outlet control gates (including flood gates in levees or flood walls), navigation lock gates and valves, emergency closure gates, spillway tainter gates, stoplogs and bulkheads, and associated lifting beams; hoists and operating machinery (including safety devices such as limit switches and fail-safe interlocks)**;** flood control pumps and related equipment**;** and cathodic protection systems. When several of the same type of HSS exists at a project, at least one of each type of HSS must be inspected as part of each periodic inspection. A different HSS should be selected for each inspection. For HSS whose failure could result in loss of life, the critical components should be subjected to at least a thorough visual examination during each inspection.

V.1.4.2 Structures including piers, overflow and non-overflow monoliths, roadways, parapets, training walls, spray walls, dam outlet conduits and tunnels, intake towers, bridges to gate towers, and steel sheet pile features.

V.1.4.2.1 Structural features.

V.1.4.2.2 Concrete surfaces.

V.1.4.2.3 Structural cracking and deterioration of material.

V.1.4.2.4 Joints and joint materials, including relative movement at joints between structures or portions of structures.

V.1.4.3 Water passages.

V.1.4.4 Embankments including foundation drains, joint drains, face drains.

V.1.4.4.1 Embankment cracks, bulging, and sliding; condition of abutment and embankment junctions; and vertical and horizontal alignment of the embankment or structure crest, slope, or toe area.

V.1.4.4.2 Unusual movement or cracking at or beyond the embankment or slope toe.

V.1.4.4.3 Seepage through or under embankment or abutment slopes.

V.1.4.4.4 Sloughing, sinkholes, or erosion of embankment or abutment slopes.

V.1.4.4.5 Condition of riprap, armor or other slope protection.

V.1.4.4.6 Scour protection stone and below water surface erosion control features.

V.1.4.4.7 Conditions of relief wells, collector pipes, inspection manholes, or other features of seepage control systems (EM 1110-2-1914 (reference A.14) and ER 1110-2-1942 (reference A.50)).

V.1.4.4.8 Condition and location of any known embedded utilities, including gas, water, and sewer lines in the embankment, abutments, or toe of the dam.

V.1.4.4.9 Seepage, depressions, sinkholes, and soft, marshy areas downstream of the dam.

V.1.4.4.10 Tailrace area, for muddy flows.

V.1.4.5 Spillways, spillway buckets and stilling basins and outlet channels including submerged features as necessary.

V.1.4.6 Conditions of instrumentation, and most recent measurements prior to the inspection

V.1.4.7 Reservoir rim conditions. (This can be limited to areas impacting the operation or stability of the dam).

V.1.5 Checklist. A detailed site specific checklist of elements relative to the structural stability and operational adequacy of the project shall be developed for each structural component of the project in order to ensure adequate examination coverage for each feature. The facility's instrumentation shall be included in the checklist to ensure that data are regularly collected and analyzed and to ascertain whether the instruments are in proper operating condition.

V.1.6 Photographs. In order to more accurately portray conditions and changes in conditions of surfaces and structural details, high resolution digital color photographs are highly recommended. In addition to photographs, video is encouraged for use in monitoring areas of concern. This is especially useful for comparing movement, water leakages, wave action, etc.

V.1.7 Examination of Deteriorated Concrete Structures. If the inspection reveals the need for any type of in-depth evaluation to determine the cause of deterioration or malfunction and to make sound recommendations for remediation, the need for the investigation shall be stated in the periodic inspection report. Guidance on repair of concrete is given in EM 1110-2-2002 (Reference A.15).

V.1.8 Structures. Steel structures shall be visually inspected for structural and operational adequacy. The inspection shall be sufficient to identify major defects such as visible cracks. Those structures involved directly in the safety of the project shall receive special consideration. Fracture critical members, where failure would result in

probable loss of life, shall initially be inspected by additional means, such as ultrasonic or other nondestructive testing. HSS inspection reports shall be prepared in accordance with ER 1110-2-8157 (reference A.52) and shall be included in the Periodic Inspection Report. Reference EM 1110-2-6054 (reference A.32) for additional information on these structures.

V.1.9 Riprap. The quantity, size, and location of riprap, sand, gravel, clay, sand bags, geotextiles, and other related materials and available equipment required to place these materials under any weather conditions shall be stated. Material sources that have unsatisfactory performance records shall be identified, reported, and eliminated from further use.

V.2 Composition and Qualifications of the Inspection and District Quality Control Review Teams.

V.2.1 Inspection team and District Quality Control Review team personnel shall consist of individuals qualified by experience and training in the design, construction, inspection, and operation of the project, and of individuals with appropriate specialized knowledge in structural, mechanical, electrical, hydraulic, geotechnical (embankment design), geology, concrete materials, and construction procedures, as required. Team leaders shall be registered professional engineers or geologists with dam safety experience. A representative(s) of the sponsor and the state dam safety agency shall be invited to be part of this team. Also, if the dam includes hydropower, representatives of the Federal Energy Regulatory Commission (FERC) shall be invited to be part of this team. The inspection team qualifications and composition may vary with the complexity of the facility and with the level of inspection, but at a minimum will include the disciplines of geotechnical, structural, and hydraulic engineering and Operations are required at all inspections. All team members shall receive training in the inspection procedures and personal safety during the inspection, including the use of personal protective equipment. Training Aids for Dam Safety (TADS) modules are recommended as a minimum for each team member, as well as a thorough understanding of this regulation. Where appropriate, inspection personnel shall be trained for confined space entry. The Dam Safety Officer of each district is responsible for scheduling this training.

V.2.2 In order to complete the Periodic Inspection report in a timely manner and be responsive to Operations Division, it is strongly recommended that the district institute an expedited report preparation method. To do so, the inspection team should be supplemented by at least one skilled technician and one clerical person with sufficient office equipment (computers, scanners, copiers, digital cameras, phones/radios) to be able to generate a 95% complete draft of the PI report to leave at the project site with the Operations personnel. The remaining 5% of the report can be accomplished in the office.

V.3 Executive Summary and Content. The district shall submit an electronic Executive Summary of each Periodic Inspection Report to HQ-DamSafety@usace.army.mil within 90 days of the completion of the formal inspection. The Executive Summary shall also

be entered into the Dam Safety Program Management Tools (DSPMT) database at the district level. The electronic executive summary should be limited in length to two to four pages and shall contain the following information.

V.3.1 Brief description of the project that was inspected.

V.3.2 Statement concerning the current inspection and major findings.

V.3.3 Statement regarding the project's safety status for continued operation.

V.3.4 General periodic inspection schedule including the dates of the previous, current, and next scheduled inspections of the project.

V.3.5 Statement concerning any major uncorrected deficiencies from the previous inspection.

V.3.6 List of major deficiencies found during the inspection and recommendations to correct the deficiencies.

V.3.7 Summary of conclusions from the periodic inspection report.

V.4 Inspection Report Content. The periodic inspection report shall present the results of each project inspection. The title of this report shall indicate the name of the project, watercourse, NID identifier, project features, and inspection number and date, in that order. An example of an appropriate title is "Beech Fork Lake Project; Twelvepole Creek, WV09903; Dam, Outlet Works and Spillway; Periodic Inspection Report No. 1, September 1992". Report No. 1 (report of initial inspection) shall provide a general project description and present the results of the initial inspection. Reports of subsequent inspections shall be supplementary to the initial report and will be numbered sequentially with the initial report; i.e., Report No. 2 would describe inspection number 2, etc.

V.4.1 Initial Periodic Inspection Report. To the extent possible, major elements of this report are:

V.4.1.1 An executive summary of the major items found in the inspection, including a statement regarding the project's ability to continue acceptable and safe operation.

V.4.1.2 A general project description including statement on hazard potential classification, layouts and typical section for the purpose of familiarization with general features of the project, and Federal and non-Federal responsibilities for OMRR&R.

V.4.1.3 List of project documents and engineering data that identifies the status and location of the project documents.

V.4.1.4 Discussion of dam safety training, emergency action plan and updates, and exercises.

V.4.1.5 Results of examination for each feature, including a statement as to its ability to function as designed.

V.4.1.6 Evaluation and summaries of the observations and inspection of instrumentation (Chapter 14 of this regulation) and relief wells with comparison to design predictions and actual conditions that signal changes in the structure's performance.

V.4.1.7 Where appropriate, statements, or exhibits summarizing the duration and frequency of spillway and control gate operations, including heads or velocities, and number of lock filling and emptying operations.

V.4.1.8 Technical assessment of the causes of distress, of abnormal conditions, and evaluation of the behavior, movement, deformation, and loading of the structure and its individual components. If such assessment cannot be accomplished within the time allotted to complete the inspection report, a preliminary assessment shall be discussed with a plan scheduled to complete the assessment.

V.4.1.9 High resolution digital color photographs with an appropriate caption, including the date taken.

V.4.1.10 A discussion of the deficiencies, the proposed remedial measures, with sketches if appropriate, related maintenance operations and both the cost estimates and a proposed completion schedule.

V.4.1.11 A discussion of the overall structural and individual project components stability, safety, and operational adequacy compared to its intended purpose(s) for the conditions with and without the recommended remedial measures. The DSMPT priority code 1 thru 6 assigned to each recommendation should be updated in the deficiency spreadsheet module screen 4.5 of the Dam Safety Program Management Tool software so the assigned priority can be tracked over time.

V.4.1.12 Recommendations, except for the routine maintenance type that can be performed by project personnel, should include the priority level for the recommended action in accordance with the following Table V.1.

V.4.1.12.1 Ensure prioritization of WORK CATEGORY CODES 61130, 61230, 61330, and 61630 as these are the primary work categories to be designated for correction of dam safety deficiencies using O&M funds. Other routine dam safety and maintenance requirements in the WCC 61XXX and 60XXX series may also be prioritized in DSMPT. Ensure coordination of all budgetary requirements with the Operations Manager, Business Line Manager(s) for your district and the Risk Assessment team in or visiting with your district.

Table V.1 – O&M Dam Safety Work Item Funding Priority Levels and Description		
Priority Funding Level	DSPMT Code	Descriptions
CFY	1	Serious dam safety deficiency exists that needs remediation immediately. If not corrected, item has an unacceptable dam safety risk. May require operational restrictions placed on the project. Reprogramming funds is appropriate.
CFY + 1	2	Remediation should be initiated within 12 months. May require operational restrictions placed on the project. Reprogramming funds is appropriate.
CFY+2	3	Study and remediation (as applicable) should be initiated within 24 months. The funds are currently being budgeted.
CFY+ 3	4	Study and remediation (as applicable) should be initiated within next budget cycle or 36 months. Used for tracking and monitoring.
CFY+ 4	5	Study and remediation (as applicable) should be initiated within next budget cycle or 48 months. Used for tracking and monitoring.
CFY+5	6	Needs to be resolved within 5 years. This work will probably not get funded unless the deficiency worsens. Monitoring is appropriate.

Notes: Priority codes are determined by setting the Current Fiscal Year from 1 Oct to 30 Sept with a priority code value = 1. For successive years add the number of fiscal years to 1 to get priority code.

V.4.1.12.2 See the current Budget EC for full definitions of all WORK CATEGORY CODES and specific requirements for Dam Safety Program activities.

V.4.1.13 Views of the non-Federal sponsor on any of the above shall be included (if applicable).

V.4.1.14 Exhibits (or Appendices) shall include, as appropriate trip reports; plots of instrumentation data; completed inspection checklist; summaries of crack surveys; correspondence that documents the performance of the project; the results of special investigations; a summary table/spreadsheet for documenting deficiencies, repair/evaluation recommendations, estimated costs, schedules, responsible office, and current status; district Quality Control Review Comments and Resolutions; and the

status and location of the project documents required by this document and ER 1130-2-530 (reference A.55). For the initial inspection report, the Pre-Inspection Brochure shall also be an Exhibit (or Appendix).

V.4.1.15 A discussion of the need for updating the project design parameters (hydraulic, seismic, HSS, etc.), if applicable.

V.4.1.16 Copies of selected drawings and boring logs.

V.4.2 Subsequent Reports. Subsequent reports shall generally include the items stated in paragraph V.4.1 above and shall follow the requirements of paragraph V.5 below, however they shall also include:

V.4.2.1 Brief summary of intermediate inspections and past performance and problems, and concentrate on the new and continuing conditions that affect or may affect the overall safety and operational capability of the structure. This summary shall not be merely a reference to a previous report. Include technical summaries of the structural, material, and foundation conditions, and description of reservoir operations procedures, if pertinent.

V.4.2.2 A discussion on maintenance and remedial activities to include materials used, application techniques, and performance.

V.4.2.3 A discussion on recommended remedial measures not completed since the previous inspection report, as well as a proposed schedule to accomplish the remedial measures.

V.4.2.4 Copies of selected drawings; however, extensive reproduction of previously published drawings shall be avoided. As a minimum, a location and vicinity map which also shows project access shall be included, as well as a general plan that shows each feature discussed in the report. The names and stationing shall be consistent on the drawings, narrative, and photograph captions.

V.4.2.5 A summary of the project's bridge inspections that may impact project safety or access during emergency conditions shall be included. ER 1110-2-111 (reference A.40) provides guidance on bridge inspections.

V.5 Inspection Report Format. The following paragraphs describe the requirements for hard-copy reports. Reports may be submitted electronically, as approved by the respective MSC, and shall be prepared in the same format as stated herein; however, at least two hard copies shall be retained at the district and at least two hard copies submitted to the MSC.

V.5.1 Organization. Reports shall generally be organized as follows:

V.5.1.1 Table of Contents

V.5.1.2 Executive Summary in accordance with Paragraph V.3, along with a Certification of district Quality Control Review.

V.5.1.3 General Statement of Inspection Program.

V.5.1.4 Description of the Project.

V.5.1.5 Brief Project Summary and History.

V.5.1.5.1 Construction history and construction description.

V.5.1.5.2 Project characteristics.

V.5.1.5.3 Description of past major remedial measures.

V.5.1.5.4 Deficiencies corrected since last inspection.

V.5.1.5.5 Past deficiencies not yet corrected, and explanation for not correcting.

V.5.1.5.6 Non-Federal sponsor OMRR&R responsibilities (if applicable).

V.5.1.5.7 Emergency Preparedness—Status of Dam Safety training (ER 1130-2-530 (reference A.55)) and status of Emergency Action Plans and their updates.

V.5.1.6 Inspection Results.

V.5.1.7 Recommendations, including date of next inspection.

V.5.1.8 Exhibits (or Appendices)

V.5.1.8.1 Figures (including Construction Plates, and other drawings that describe the project).

V.5.1.8.2 History of Remedial Measures.

V.5.1.8.3 Photographs (from current and previous inspections).

V.5.1.8.4 Inspection Checklist.

V.5.1.8.5 Summary of Inspection Notes.

V.5.1.8.6 Summary of Intermediate Inspection Reports

V.5.1.8.7 Instrumentation Data and/or Plots. Data shall contain all figures since the last inspection and have sufficient background data to support the report discussion, conclusions and recommendations. Reproduce the plan of instrument locations in each

report. Where appropriate, cross-sections showing piezometric data shall show design uplift assumptions along with the current pressure line. Plots of piezometric elevation versus pool elevation and plots of relief well or drain flow versus pool elevation shall be included. In each case, upper limit correlation lines should be drawn (to help eliminate time lag effects) and when possible, extrapolations should be made to maximum possible pool elevations. A summary of analyses of all instrumentation should be set forth. Where possible, threshold values for key instruments should be established. Threshold values should also be entered into the project emergency operations plans.

V.5.1.8.8 Summary of Crack Surveys.

V.5.1.8.9 Project Documentation.

V.5.1.8.10 District Quality Control Review Comments and Resolutions.

V.5.2 Text. All sections and paragraphs shall be numbered and shall be on 8 1/2 by 11-inch paper with sufficient margin on the left side for binding. Reproduction shall be any available process with printing done head-to-head, if possible.

V.5.3 Drawings. Drawings or plates shall normally be 8 1/2 by 11-inch with sufficient margin on the left for binding. Foldouts normally shall not exceed 11 inches by 17 inches. Drawings and photos may be included in the text or placed entirely in the Exhibit (or Appendix.) However, any figure or drawing in the text shall support the written material. All drawings and figures will be dated for ease of reference.

V.5.4 Binding and Cover. Reports shall have flexible paper or card stock, hidden hinge covers with fasteners that facilitate removal and insertion of pages and drawings. Information to be on the cover will be sufficient to identify the project report as unique from other reports name of the project; periodic inspection number; name of the preparing agency, and the date of inspection, and date of the report.

V.6 Project Documentation. All engineering data relating to project structures inspected shall be collected and permanently retained in appropriate files at the project site for availability to the inspection team and readily accessible for emergency response. Periodic Inspection Reports shall indicate which items are not available, and describe attempts to locate such records or documents. Project engineering data shall also be retained at the district office. In the absence of storage space at the district office, the data shall be retained at the nearest field office. These documents and drawings shall be considered as permanent engineering data, subject to retirement or disposal only upon termination of operation of the project. These data shall consist of, but not be limited to, the items listed below.

V.6.1 All previous Periodic Inspection and Periodic Assessment Reports.

V.6.2 Records of inspections by project personnel and interim/special event inspections by district personnel.

V.6.3 Design Memoranda, Design Documentation Reports, or Dam Safety Deficiency Reports to include principle design assumptions, stability and stress analyses, slope stability, seepage and settlement analyses, consolidation, shear, permeability, compaction, classification tests or summaries thereof, and contract plans and specifications.

V.6.4 As built plans, elevation, and sections.

V.6.5 As built drawings of important project features, to include details such as instrumentation, internal drainage, transition zones, or relief wells, and reports of any special investigations.

V.6.6 Foundation data and geological features, including boring profiles, foundation mapping, foundation reports, and final logs of subsurface exploration.

V.6.7 Location of borrow areas and identification of embankment, filter, riprap, large stone sources.

V.6.8 Laboratory Reports including:

V.6.8.1 As built properties of foundation and embankment materials, such as shear strength, unit weight, and water content and classification. The number of control tests and undisturbed record sample tests shall be included.

V.6.8.2 Physical, chemical, and thermal properties of concrete and concrete-making materials.

V.6.8.3 Summary of concrete mixture proportions and control procedures.

V.6.9 Project Geotechnical and Concrete Materials Completion Report.

V.6.10 Construction history records, construction photographs, construction videos, construction anomalies (piping, settlement, etc.) including diversion schemes and construction sequences shown on appropriate drawings.

V.6.11. Details of the overall instrumentation program to include predicted performance and record of actual observations, and annual updated evaluations.

V.6.12 Operations and Maintenance Manual.

V.6.13 Water Control Manual.

V.6.14 Copy of PCA.

V.6.15 Dam Safety Information:

V.6.15.1 Project copy of "Federal Guidelines for Dam Safety" (reference A.71).

V.6.15.2 Emergency Action Plan.

V.6.15.3 Records of dam safety training for project personnel.

V.6.15.4 Surveillance plan of the project that includes any special/significant events and threshold reservoir levels that initiate observations and/or inspections and reporting procedures.

V.6.15.5 List of local contractors and construction materials available for use in emergency situations.

V.6.15.6 Site-specific security and rapid recovery plans.

V.6.16 Manufacturers’ data for purchased items.

This Page Left Blank

APPENDIX W

Periodic Assessments

W.1 Periodic Assessment Purpose.

W.1.1 USACE risk management process resulted in assignment of a DSAC for each project. In many cases, the data used for initial classification may have been preliminary or incomplete or information used in the Screening Portfolio Risk Analysis (SPRA) process. The Periodic Assessment (PA) applies a higher level of rigor to further identify and refine project risks.

W.1.2 The PA is a Periodic Inspection (PI) with a facilitated Potential Failure Mode Analysis (PFMA), updated project consequences and evaluation of significant project risk drivers by a risk cadre working in tandem with district personnel. The normal field inspection activities for both the PI and PA will be maintained every five years. The PFMA and risk assessment will be completed prior to the traditional field inspection. The PA will be performed once every ten years.

W.1.3 The primary purposes of the PA are to:

W.1.3.1 Verify\re-evaluate the DSAC classification of a project;

W.1.3.2 Justify and revise interim risk reduction measures if needed;

W.1.3.3 Evaluate\revise the project risk assessment;

W.1.3.4 Identify operations and maintenance, monitoring, emergency action plan, training and other recurrent needs;

W.1.3.5 Confirm essential USACE dam safety guidelines are met and determine if the current risk is tolerable; and

W.1.3.6 Identify and prioritize any issue evaluation study needs.

W.1.4 Specific steps included in the PA that differ from a PI are:

W.1.4.1 Compilation of existing historic documents from design, analysis, and construction photos and records for the PFMA session.

W.1.4.2 Compilation and evaluation of project performance, instrumentation readings, and any recent remediation or improvements for the PFMA session.

W.1.4.3 Cursory site visit by the PFMA team. (Risk cadre and select district personnel)

W.1.4.4 District participation of a facilitated PFMA. (Documented by the risk cadre)

W.1.4.5 Update of project consequences by a regional cadre production pool.

W.1.4.6 District integration of a risk assessment report prepared by the risk cadre.

W.1.5 Completed PA reports will also serve as a “blue print” for districts to tailor and target on-going intermediate field site inspections and monitoring of dam features where significant PFM and/or high risk critical O&M features (i.e., relief wells, gallery drains) have been identified.

W.2 Periodic Assessment Report. The Periodic Assessment report ties existing information, field inspections, and the risk assessment together and provides engineering recommendations to decision makers. The report format is closely aligned to the Issue Evaluation Study (IES) and will have fifteen chapters and associated appendices as follows:

W.2.1 Executive Summary

W.2.2 Summary of All Dam Safety Recommendations (old\new compiled together)[1]

W.2.3 Introduction and Description of Dam and Operations

W.2.4 Current DSAC Assessment[1]

W.2.5 Evaluation of Foundation Materials and Construction Methods

W.2.6 Observed Project Past Performance Evaluation

W.2.7 Engineer’s Inspection Report (PI field inspection)

W.2.8 H&H Analysis - Hydrologic Loading and Duration[2]

W.2.9 Seismic Loadings[2]

W.2.10 Consequences of Failure[2]

W.2.11 Potential Failure Mode Analysis[2]

W.2.12 Risk Assessment[2]

W.2.13 Future Performance Monitoring\Risk Management Practice[1]

Notes: [1] = New district report sections from traditional PI.
[2] = Prepared by regional risk cadre.

W.2.14 Compliance with USACE Engineering Criteria[1]

W.2.15 Conclusions and Recommendations[1]

W.2.16 Report Appendices:

W.2.16.1 O&M History of Remedial Measures

W.2.16.2 Instrumentation Review

W.2.16.3 EIR Photos

W.2.16.4 EIR Field Notes

W.2.16.5 Intermediate Inspections (AI, Bulkheads, Conduit, Bridge Inspections)

W.2.16.6 Conduit Inspection

W.2.16.7 Supporting H&H Data[2]

W.2.16.8 Supporting Consequence Data[2]

W.2.16.9 Potential Failure Modes Analysis Report[2]

W.2.16.10 Support Risk Assessment Data[2]

W.2.16.11 Quality Control (ATR) Documentation

Notes: [1] = New district report sections from traditional PI.
[2] = Prepared by regional risk cadre.

W.3 Overall Workflow for PA. Proper scheduling and sequencing of the PA activities will be critical due to the need to engage the regional cadre, the engineering staff, the site operations staff, and MSC personnel. The general PA procedure is summarized in the following subsections.

W.3.1 The Risk Management Center will identify dams for Periodic Assessment and assign a PFMA Facilitator.

W.3.2 The district team shall compile all available design documentation reports including As-Built Drawings, construction records and photographs, foundation completion reports, Design Memoranda, Seismic Studies, Special Investigations, Periodic Inspection Reports, Water Control Manual, EAP, etc. for the PFMA and risk assessment. This activity should ideally be completed in the 1st and 2nd quarter of the fiscal year.

W.3.3 The Facilitator and Regional Cadre will be required to review the project design, construction, and performance records, prior to PFMA session.

W.3.4 A site visit shall be completed prior to the Potential Failure Modes Analysis session. All team members shall attend the cursory site visit and PFMA session.

W.3.5 The assigned regional cadre team will take the results from the PFMA and develop Event Trees for each plausible failure mode of concern using DAMRAE. System response curves will be estimated using available information and toolboxes and entered into the risk engine as well.

W.3.6 The district Team will perform the traditional field inspection and finalize a draft PA report.

W.3.7 An ATR will be performed by an independent regional cadre.

W.3.8 The Risk Management Center will review the final PA risk assessment and finalize any changes required to the DSAC ratings and prioritize funding of studies for the budget.

W.4 PA District Versus Risk Cadre Responsibilities. The initial PA will involve a greater level of effort due to the data gathering and documentation requirements. Once completed, this information will be available for future risk assessments as will additional data and performance history data collected following the initial PA. In addition, the PFMA and risk assessment within the PA will serve as a living document for ongoing district judgments required to manage normal O&M tasks within the program such as instrumentation replacement priorities, adjustments to surveillance and monitoring programs, etc.

W.4.1 For the PA, additional effort will be required by the district. These tasks will include:

W.4.1.1 The district will select a team leader (coordinator) to collect and organize a variety of documents and other information to support the PFMA, risk assessment, and compliance to USACE engineering criteria verification. The district will organize and summarize this information in preparation for the PFMA.

W.4.1.2 Appropriate in-house experts from engineering and operations including field personnel will participate in the PFMA process, which will include a cursory site visit and follow-on PFMA session.

W.4.1.3 Engineering and operations will collaborate in follow-up data for system loading events and system response for the risk assessment.

W.4.1.4 District personnel shall prepare the PA report including incorporating chapters supplied by the regional cadre.

W.4.2 The risk cadre will perform the following activities for the PA.

W.4.2.1 The regional cadre facilitator will verify proper district and regional cadre participants are assigned to the PA team.

W.4.2.2 Prepare updated consequences.

W.4.2.3 Conduct site visit and PFMA session and fully document findings.

W.4.2.4 Complete risk analysis system response curves using the latest methodologies.

W.4.2.5 Risk facilitator will assemble risk assessment portion of report and submit to district POC.

W.4.2.6 Risk cadre will help educate district personnel with the PFMA and risk assessment process. The district is encouraged to use this process to educate their technical staff on how to complete the PFMA and risk assessment portions of the PA.

W.4.2.7 Communicate the draft results from the baseline risk estimation process with district personnel.

W.4.3 The following subsections provide more detail on the risk cadre activities outlined above.

W.5 Updated Consequences.

W.5.1 For the PA, the regional cadre H&H engineer will work with regional consequence production pool members and district personnel to generate models and data needed to complete updated consequences.

W.5.2 The rapid consequence estimate requires a very limited detail unsteady model to reproduce various with and without dam failure scenarios including sunny day, PMF and several interim load cases in between all for with and without dam failure condition. Using GIS tools, the unsteady model results will be used to generate flood inundation mapping downstream as well as travel time and other values. This data will be used to interface with appropriate downstream data such as HAZUS to calculate population at risk, economic damages, potential for loss of life, and other consequence data. In addition, loss of function from a dam breach will need to be estimated such as hydropower, recreation, flood control, etc.

W.5.3 All of this data will be aggregated to allow consequences to be estimated for the risk assessment.

W.6 Potential Failure Modes Analysis (PFMA) Session. A PFMA chapter will be prepared by the regional cadre. The report records the thought process behind the derivation and justification of significant PFMs to be carried forward or excluded from the PA. More detailed information on the overall Potential Failure Modes Analysis process in Appendix X.

W.7 PA Risk Assessment. This risk assessment effort include identifying significant PFMs and critical O&M features from the PFMA session and develop system response curves for each PFM using the latest risk methodologies (toolboxes). Once these tasks are complete, the facilitator will generate the risk engine using DAMRAE to develop component and total project risk and compare of the overall and component risks with tolerable risk guidelines. Preparation of the related risk assessment chapters will incorporate the risk assessment findings.

W.8 Quality Control. The draft PA report will be prepared by the district and submitted to the facilitator for an ATR review. The ATR of the draft PA will be completed by another regional cadre not involved in the risk assessment process.

W.9 Periodic Assessment Schedule. The overall duration for the Periodic Assessment will depend on the level of complexity of the project. In some cases significant preparation may be needed for some sites while other project may have much of the data needed for the PA already on hand from the SPRA process. Regardless, 30 days before the scheduled PFMA site visit, the collected data should be transferred to the assign risk facilitator. The site visit and Potential Failure Modes Analysis will be completed in 1 week for most dams. The risk assessment will be completed by the regional cadre 45 days after completion of the PFMA session. PFMA and risk assessment activities should ideally be completed prior traditional field inspection such that findings can be used for targeted and more comprehensive engineering inspection of the project features. A draft of the PA report should be left “at the door” at the conclusion of the field inspection. The draft PA report should be submitted to the independent regional cadre for ATR 30 days after completion of field activities. The regional cadre shall complete review of the PA in 30 days. After which the final PA report shall be submitted to MSC 30 days after ATR is complete.

W.10 Periodic Assessment Funding. The district will budget for the expense of the Periodic Assessment through normal O&M processes. The cost of the regional cadre and facilitator will be funded by the Risk Management Center.

W.11 Approval Process of Periodic Assessment Report. The Periodic Assessment Report would be submitted to the district Dam Safety Officer for approval and sent to the MSC Dam Safety Officer for concurrence. A copy of the report will be sent to Risk Management Center.

APPENDIX X

Potential Failure Mode Analysis (PFMA) for Dams

X.1 Purpose/Applicability. Guidance for determination of potential failure modes for use in risk assessments of dams.

X.2 PFMA Overview.

X.2.1 PFMA is a method of analysis where particular faults and initiating conditions are postulated and the analysis reveals the full range of effects of the fault or the initiating condition on the system. The methods of failure are indentified, described, and evaluated on their credibility and significances. Failure Modes are a way that failure can occur, described by the means by which element or component failures must occur to cause loss of the sub-system or system function. The failure mode encompasses the full sequence of events from initiation (cause) through to the realization of ultimate failure effect of interest to include physical, operational, and managerial systems. PFMA is the first step in conducting a risk assessment for an existing dam or a risk reduction action. A significant increase in Dam Safety awareness can be learned from this step. Thorough failure mode identifications and complete descriptions will lead to a more efficient risk assessment process. Interim risk reduction measures and study plans can be effectively developed based on the results of the PFMA.

X.2.2 A PFMA is normally a facilitated identification and examination of potential failure modes (PFM) for a dam by a diverse team of persons who are qualified by experience and/or education to evaluate the dam. It is based on a review of available data and information, first hand input from field and operational personnel, site inspections, completed engineering analyses, discussion of known issues/problems, a general understanding of dam characteristics, and an understanding of the consequences of failure.

X.3 Outcomes. The PFMA outcomes will include the following:

X.3.1 List and detailed description of each PFM with a list of the factors that make the failure mode more likely to occur and a list of the factors that make the failure mode less likely to occur.

X.3.2 Classify PFM as not credible, credible and significant.

X.3.3 Major findings and understandings

X.3.4 Initial event tree development for each PFM to be carried forward in the next step of the risk assessment.

X.3.5 Review and update routine dam safety activities.

X.3.6 Identify needed additional investigations, analysis, testing, data, etc. for each PFM with unresolved issues.

X.3.7 PFMA documentation.

X.3.8 Plan for the risk assessment effort.

X.3.9 Review and update IRRM plan.

X.4 PFMA Process Description. The following is a brief overview of the steps required to perform a PFMA.

X.4.1 Step 1. Dam Safety Risk Management Center designates the PFMA facilitator and the facilitator coordinates with the district to assign PFMA participants.

X.4.2 Step 2. Collect and summarize background information, (requires assignment in the district).

X.4.3 Step 3. Perform a site visit/review (all members of the PFMA team should participate in the site visit).

X.4.4 Step 4. Review background information on the dam (by PFMA team)

X.4.5 Step 5. Conduct the PFMA.

X.4.6 Step 6. Generate final PFMA report.

X.5 Subject Matter Expert Facilitator Requirements /Corps Qualifications.

X.5.1 The facilitator is critical to the success of the PFMA, and should have a broad background and experience in dam engineering and experience in performing a PFMA. The Dam Safety Risk Management Center and USACE Dam Safety Program Manager shall approve PFMA facilitators.

X.5.2 Typical requirements to be an approved PFMA facilitator are:

X.5.2.1 Be a licensed engineer or a licensed engineering geologist/geologist with a minimum of ten years of experience in the design, construction, or operations of dams.

X.5.2.2 Be experienced in dam safety and related risk assessments.

X.5.2.3 Participate in a PFMA for at least one for embankment dam and one concrete structure PFMA for projects operated/regulated by USACE or USBR.

X.5.2.4 Complete the USACE facilitator training course.

X.5.2.5 Shall have consolidated data and written the report from at least one the PFMA session.

X.5.2.6 Successfully facilitated at least two PFMA sessions observed by an experienced facilitator with associated formal feedback and endorsement.

X.5.2.7 Possess good communication and group leadership skills.

X.6 Development of Supporting Data for PFMA. Gathering supporting data prior to the PFMA session is a critical step. The search for records should not be limited to the district files, but should include research in other locations (e.g. National Archives, university libraries, etc).

X.7 Identifying and Describing Potential Failure Modes. The potential failure modes must be described fully from initiation to breach and uncontrolled reservoir release and\or significant loss of operation control. Loss of operational control includes loss of projects purposes or services such as navigation capability. The reasons for completely describing the potential failure modes are shown below.

X.7.1 To ensure the PFMA team has a common understanding of the failure mode.

X.7.2 To document PFM for future reference and use.

X.7.3 To facilitate subsequent development of an event tree.

X.8 Evaluating a Potential Failure Mode. After the detailed PFM descriptions have been completed, the PFM are evaluated by listing the factors that make the failure mode more and less likely to occur. These are based on the team's understanding of the facility and background material.

X.9 Performance Monitoring Enhancements, Data Collection Needs, Analyses, and Risk Reduction Measures. Following development of a potential failure mode, the team will have a thorough understanding of the available information and circumstances leading to its development. This is the time to capture the team's thoughts on what additional information or analyses would be useful in understanding the potential failure mode, and additional opportunities for monitoring and risk reduction. Whether these will actually be implemented depends largely on the follow-on study plan and risk assessment.

X.10 Major Findings and Understandings. The knowledge gained from the PFMA and a determination whether or not USACE essential guidelines are met should be documented in the form of "Major Findings and Understandings" in the PFMA report. Below are examples of a major finding and understanding.

X.10.1 Galleries. There are four galleries that penetrate the base of the dam as described above: Duck Creek, utility galleries on either side of the spillway, and the

diversion gallery at the outlet works. The galleries have not been inspected during recent Periodic Inspections. Hence, the condition of the joints and any cracks and/or seepage is unknown. It is recommended that the district include inspection of the galleries as part of the Periodic Inspection program. The results of the inspection are needed to resolve the potential failure mode of internal erosion of the embankment materials into the galleries.

X.10.2 Seepage Control. Foundation reports were prepared for the outlet works and spillway structures only. However, there is little to no documentation of foundation preparation in the embankment areas. Only a 5-foot deep inspection trench was excavated during construction, and no cutoff was provided for the deep pervious foundation. The primary seepage control feature is a series of relief wells near the downstream toe. Material compatibility is essential to resolving several potential failure modes associated with internal erosion. Based on a review of embankment design gradations, it appears that filter criteria is not met at some locations. It is recommended that the district review the conclusions of the *Hydraulic Fracturing Evaluation Report* dated September 1997, for material compatibility for both internal erosion through the embankment and from the embankment into the soil foundation. Best available gradation data for the various materials as well as the original design gradations should be used in conjunction with the filtering criteria provided in EM 1110-2-1901 *Seepage Analysis and Control*, Change 2 dated February 2005 (reference A.9).

X.10.3. High Consequences. The area downstream of the dam is the highly developed urban area of Made-up County that extends for miles to the bay downstream. Even if the probability of failure is determined to be low for the credible and significant potential failure modes, the incremental loss of life and economic damages for dam failure will likely generate considerable risk because of the relatively flat flood plain and high population density. Furthermore, regardless of the level of modifications or improvements to the project, there will probably always be some appreciable residual risk due to high consequences that must be managed through emergency preparedness, communication, and/or education.

X.11 Documentation. The results of the PFMA will be documented using the following outline.

X.11.1 Introduction and Background including a summary of the last risk assessment completed (SPRA, Periodic Assessment, Issue Evaluation, etc.)

X.11.2 Current Assessment Effort (include a list of participants in this section)

X.11.3 Description of Project

X.11.4 Major Findings and Understandings

X.11.5 Potential Failure Modes Identified.

X.11.6 Credible Potential Failure Modes

X.11.7 Significant Potential Failure Modes

X.11.8 Potential Failure Modes with Unresolved Issues

X.11.9 Not credible Failure Modes

X.11.10 Summary and Conclusions

This Page Left Blank

APPENDIX Y

Dam Safety Vegetation Management

Y.1 Purpose. The establishment, maintenance, and control of vegetation pose Engineering, as well as routine maintenance considerations. In accordance with ETL 1110-2-571 (reference A.67), this guidance establishes minimum requirements for maintenance/control of vegetation at USACE-owned dams, abutments, spillways, inlet/outlet channels, and other appurtenances.

Y.2 References.

Y.2.1 ETL 1110-2-571, “Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures” (reference A.67).

Y.2.2 Federal Emergency Management Agency, (2005), “Technical Manual for Dam Owners: Impacts of Plants”, FEMA Document 534, Washington, DC (reference A.75).

Y.3 Background. Maintaining the integrity of our dams and appurtenant facilities is a critical USACE responsibility. Vegetation is much more than an aesthetic consideration. Proper vegetation management is necessary to preserve the design functionality of critical project features. Requirements for mowing and eradication are documented in the project specific Operations and Maintenance Manual. Changes in vegetation management practices to promote project benefits such as recreation and environmental enhancement must be carefully evaluated from a dam safety perspective and coordinated with dam safety experts. Vegetation that adversely impacts engineered structures or inhibits inspection, monitoring, and emergency response actions is not allowed.

Y.3.1 Beneficial Vegetation. Beneficial vegetation, such as grass cover, can assist in preventing erosion, controlling dust, defining zones of use, and creating a pleasant environment. Uniform grass cover enhances visual inspection, allowing the detection of seeps, settlement, displacements, and other evidence of distress. Robust grass coverage along embankments and discharge channels can help deter the natural establishment of trees and other deep rooted species.

Y.3.2 Undesirable Vegetation. Woody vegetation and aquatic plants (e.g. cattails) can obscure large portions of the dam, preventing adequate visual inspection, creating potential seepage pathways, reducing discharge capability, and can threaten the stability and integrity of a structure.

Y.3.2.1 Structural instability can occur due to falling/decaying tree/woody vegetation and root system growth. Large, seemingly stable and innocuous trees can easily be blown over or uprooted in a storm/flood and cause a large hole left by the root system. This in turn can shorten the seepage path and initiate piping, or a breach in the dam.

Y.3.2.2 Root systems may undermine concrete slabs, causing erosion of foundation materials and subsidence or heave. Additionally, root systems can interfere with interior drainage systems. Trees and aquatic vegetation in channels can restrict flow volumes, or become a source of debris which blocks releases. Trees in channels can also initiate uneven flow patterns and cause erosion that may divert discharges out of bank. All of these can ultimately threaten public safety.

Y.4 Policy.

Y.4.1 The following areas shall remain free of trees and other woody vegetation such as shrubs and vines:

Y.4.1.1 The dam and dam toe area

Y.4.1.2 In or around seepage monitoring systems or critical areas for seepage observation

Y.4.1.3 Abutments and groins

Y.4.1.4 Emergency spillways and regulating outlet channels, including channel floors, side slopes and approaches

Y.4.1.5 Outlet works discharge channels

Y.4.2 All areas of dam projects must be inspected according to Chapter 11 of this regulation and ER 1130-2-530 (reference A.63). Inspections conducted either by project personnel, or engineering personnel must always consider the potential dangers from excessive or inadequate vegetation growth. Changes in surfaces, such as cracks, depressions, and movements must also be readily observable via controlled grass cover. Any evidence of seepage or erosion must be quickly identified, monitored evaluated and controlled to prevent flows that could become detrimental to the safety of the structure. Inspection of vegetation shall be part of each annual and formal periodic inspection for each project and shall be discussed in the respective reports.

Y.4.3 The governing criteria for maintenance of vegetation on the dams, or areas adjacent to, or immediately downstream of dams is to provide ready and adequate visual observation.

Y.4.4 Design and construction of landscape plantings, including irrigation systems, must be carefully devaluated and reviewed from a Dam Safety perspective, comply with ETL 1110-2-571 (reference A.67), and approved by dam safety experts.

Y.4.5 Trees, brush, and weeds in spillways and inlet and outlet channels shall be maintained so as not to obstruct flows, or cause any threat or potential threat to areas downstream of the dam. Specified spillway and outlet works design discharge capacities must be maintained. Tree and vegetation removal from spillway discharge

areas downstream of the crest or sill is required to avoid “head cutting” or causing flow concentrations.

Y.5 Implementation.

Y.5.1 Mowing/ clearing limits for each dam shall be identified by dam safety personnel within Engineering Division and documented on aerial photographs or plan drawings, as part of the project Operations and Maintenance Manual. The limits shall be site-specific and shall take into consideration the topography, phreatic surfaces within the structure and abutments, foundation characteristics and any historical problems with the structure.

Y.5.2 The horizontal limits of clearing shall not be less than the entrance width of the spillway. In the vertical direction, no encroachment by woody vegetation of any kind can be tolerated up to the elevation of the inflow design flood profile. Dam safety personnel within Engineering Division shall establish specific clearing limits for spillways based on project hydrological characteristics, and they shall be permanently and clearly marked in the field.

Y.5.3 Riprap in all areas shall be maintained free of vegetation. This includes embankment slopes, discharge channel slopes, and emergency rock stockpiles.

Y.6 Remediation Procedures.

Y.6.1 Undesirable woody vegetation identified by Dam Safety personnel shall be removed. Removal of woody vegetation will require engineering judgment to determine if the root system has engaged water bearing regions of the dam and\or site specific geologic areas of special interests such as jointed rock formation which contain water at the toe or dam abutments.

Y.6.2 Tree and woody vegetation growth on the upstream slope should be undercut to remove all stumps, root balls, and root systems. The undercut area must be thoroughly inspected to confirm that all major root systems (greater than about one-half inch in diameter) have been removed during the undercutting operation to prohibit regrowth. Suitable backfill shall be placed in the excavation and properly compacted to the dam remediation design limits. Backfill shall be similar to the in-situ embankment fill material and shall be compacted. Installing a slope protection system is recommended to reduce the potential for wave and surface runoff erosion.

Y.6.3 Engineering judgment will be required to identify the depth and extent of stump and root ball removal, laying back the undercut slope and selection of backfill based on dam design.

Y.6.4 Alternative methods, such as herbicide spraying, burning, or cutting trees flush to the ground surface and leaving roots in place may be considered, in consultation with

dam safety experts. However, burning atop riprap is prohibited as this can weaken and degrade the rock.

Y.6.5 The suggested dam remediation design and construction procedure suggested for complete removal of trees, stumps, root balls, and root systems consists of the following activities:

Y.6.5.1 Cut the tree approximately two (2) feet above ground leaving a well-defined stump that can be used in the root ball removal process;

Y.6.5.2 Remove the stump and root ball by pulling the stump, or by using a track-mounted backhoe to first loosen the root ball by pulling on the stump and then extracting the stump and root ball together;

Y.6.5.3 Remove the remaining root system and loose soil from the root ball cavity by excavating the sides of the cavity to slopes no steeper than 1:1 (horizontal to vertical) and the bottom of the cavity approximately horizontal;

Y.6.5.4 Backfill the excavation with compacted soil placed in relatively loose lifts not greater than about eight (8) inches in thickness. Compaction of backfilled soils in these tree stump and root ball excavations typically requires the use of manually operated compaction equipment or compaction equipment attached to a backhoe.

Y.6.5.5 Procedure for total removal of trees near the toe is more complicated. Treatment of mature tree penetrations in a downstream slope may involve installation of a subdrain and/or filter system in the tree penetration excavation and backfill with compacted soil placed in maximum loose lifts of eight inches.

Y.7 Establishment of Vegetation. All disturbed areas must be protected by seeding and mulching. Timing must be considered to allow seed to germinate and develop roots prior to winter or heavy precipitation seasons.

Y.8 Waivers. Waivers to allow additional vegetation or alternate remediation techniques must be submitted in writing to the district Dam Safety Officer. A multi-discipline team shall review the proposed change, assess potential dam safety impacts, and provide a written recommendation to either approve or decline by the Dam Safety Officer.

APPENDIX Z

Hazard Potential Classification

Z.1 Discussion. The current classification system used to evaluate the hydrologic hazard potential of dams was established in response to several dam failures in the early 1970's which resulted in significant loss of life and property damage. This classification system, while useful for the evaluation of hazard to life and property, is deficient in that it does not consider the indirect losses of critical lifelines due to a dam failure. These losses, such as the loss of water supply, loss of key transportation or medical facilities, loss of power generation capability, or loss of navigation and environmental damage can have a significant impact on the public after a major hydrologic or seismic event. Some attempt has been made in the past to consider lifeline and environmental losses as economic losses; however, a standard classification system has not been established. An additional deficiency in the existing classification system is in the potential loss of life posed by the significant and high classifications. The terms "few" under the significant category, and "high potential" under the high category are too vague and subject to interpretation. The following is an attempt to quantify the loss of life associated with each level of hazard potential.

Z.2 Classification System. Table Z.1 establishes a classification system, which groups losses into four general categories: loss of life, property, lifeline and environmental losses. This hazard potential classification is related to the functional integrity of the project, not the structural integrity of project features or components. Direct loss of life is quantified as either none, certain (one or more) or uncertain. Economic indirect losses are classified as either direct property, environmental or lifelines losses. Hazard potential ratings are based entirely upon the proximity of the project to population, which would be at risk due to project failure or operation, and the impact upon life, and property of the loss of essential services. A more detailed discussion on each of the four categories follows:

Z.2.1 Loss of Life. “Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams” (reference A.76) states that the difference between the significant and high hazard potential classification levels is that a high hazard potential dam includes the probable loss of human life, regardless of the magnitude of other losses. If no loss of life is probable as the result of dam failure or mis-operation, the dam would be classified as Low or Significant Hazard Potential. The probable loss of human life is defined to signify one or more lives lost. The term "probable" indicates that the scenario used to predict the loss of human life must be reasonable and realistic, not contrived. In the definition for High Hazard Potential, the probable loss of human life is further clarified to exclude the casual user of the downstream or upstream area in determining the potential for loss of human life. Potential public response to the emergency should not be used to reduce the calculated probable loss of human life.

Z.2.2 Property Losses. Property losses are classified as either direct economic losses due to flood damaged homes, businesses, and infrastructure; or indirect

economic losses due to the interruption of services provided by either the failed facility or by damaged property or infrastructure downstream. Examples of indirect losses include:

Z.2.2.1 Loss of power generation capability at the failed dam (or at an inundated powerhouse downstream).

Z.2.2.2 Loss of navigation due to evacuation of the navigation pool at a failed reservoir (or due to direct damage to a lock).

Z.2.2.3 Loss of water supply due to a reservoir emptied by a failed dam.

Z.2.3 Lifelines Losses. Disruption of essential lifeline services or access to these services during or following a catastrophic event can result in indirect threats to life. The loss of key transportation links such as bridges or highways would prevent access to medical facilities at a time critically injured people need access the most. Another example would be the loss or damage to medical facilities.

Z.2.4 Environmental Losses. Damage to the environment caused by project failure or operation can result in the need for mitigative measures, or can cause irreparable damage to the environment. Environmental damage estimates shall consider the damage, which would normally be caused by the flood event under which the project failure occurs. Only the incremental damage caused by the project failure shall be attributed to project failure or operation. Some other examples of environmental impacts are:

Z.2.4.1 Environmental damage caused by the release of a reservoir contaminated by toxic or hazardous mine waste.

Z.2.4.2 Environmental damage caused by sediment released by a reservoir.

Z.3 Classification Table. See Table Z.1 for guidance in classifying Civil Works projects as low, significant, or high hazard potential.

Table Z.1 – Hazard Potential Classification for Civil Works Projects

CATEGORY[1]	LOW	SIGNIFICANT	HIGH
Direct Loss of Life[2]	None expected	None expected	Certain (one or more) (extensive downstream residential, commercial, or industrial development)
Lifeline Losses[3]	No disruption of services - repairs are cosmetic or rapidly repairable damage	Disruption of essential or critical facilities and access	Not considered for this classification
Property Losses[4]	Private agricultural lands, equipment and isolated buildings	Major or extensive public and private facilities	Not considered for this classification
Environmental Losses[5]	Minimal incremental damage	Major or extensive mitigation required or impossible to mitigate	Not considered for this classification

Notes:

[1] Categories are based upon project performance and do not apply to individual structures within a project.

[2] Loss of life potential based upon inundation mapping of area downstream of the project. Analyses of loss of life potential shall take into account the extent of development and associated population at risk, time of flood wave travel and warning time.

[3] Indirect threats to life caused by the interruption of lifeline services due to project failure, or operation, i.e., direct loss of (or access to) critical medical facilities or loss of water or power supply, communications, power supply, etc.

[4] Direct economic impact of value of property damages to project facilities and downstream property and indirect economic impact due to loss of project services, i.e., impact on navigation industry of the loss of a dam and navigation pool, or impact upon a community of the loss of water or power supply.

[5] Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond which would normally be expected for the magnitude flood event under a without project conditions.

This Page Left Blank

APPENDIX AA

Management Control

AA.1 Function. The function covered by this checklist is Civil Works Dam Safety Program.

AA.2 Purpose. The purpose of this checklist is to assist the District Safety Officer in evaluating the key management controls listed below. It is *not* intended to cover *all* controls.

AA.3 Instructions. Answers must be based on the actual *testing* of key management controls (e.g., document analysis, direct observation, sampling, simulation, etc.). Answers, which indicate deficiencies, must be explained and corrective action indicated in supporting documentation. These management controls *must* be evaluated at least once every five years and may be evaluated as often as very project. Certification that this evaluation has been conducted must be accomplished on DA Form 11-2-R (Management Control Evaluation Certification Statement).

AA.4 Test Questions.

AA.4.1 Does the office at each dam have a copy of the Federal Guidelines for Dam Safety – FEMA 93?

AA.4.2 Does the office at each dam have a set of the Training Aids for Dam Safety – FEMA 609DVD?

AA.4.3 Does the office at each dam have a copy of the Safety of Dams Regulation – ER 1110-2-1156?

AA.4.4 Does the office at each dam have a copy of the current Emergency Action Plan for the dam?

AA.4.5 Does the office at each dam have a copy of the latest Periodic Inspection Report and the latest Periodic Assessment Report?

AA.4.6 Does the office at each dam have a copy of the “as-built” plans for the dam?

AA.4.7 Is the Dam Safety Officer appointed on orders by the Commander in accordance with Chapter 4, ER 1110-2-1156?

AA.4.8 Does the Dam Safety Program Manager meet the qualifications requirements established in ER 1110-2-1156?

AA.4.9 Are both the Dam Safety Officer and the Dam Safety Program Manager registered Professional Engineers (or Geologists) with a current State registration?

AA.4.10 Is the Dam Safety Committee officially established with a list of members by names and does the committee meet on a regular basis?

AA.4.11 Is the data for the Dam Safety Program Management Tools up-to-date for all dams in the district or MSC?

AA.4.12 Are the Periodic Inspections and Periodic Assessments scheduled on a 10 year cycle and is the schedule current?

AA.4.13 Are inspection and assessment reports completed within 90 days of the field inspections and is a draft report left at the dam on the day of the inspections?

AA.4.14 Are instruments used to monitor the dams in working order and are they read in accordance with the established schedule? Is the data for instrumentation reading processed in 90 days or less for all projects?

AA.4.15 Are emergency exercises held at each dam in accordance with the schedule in ER 1110-2-1156?

AA.4.16 Do all new field employees receive 6 hours of dam safety training within 6 months of being assigned to the dam? Are new contractor employees also trained within 6 months?

AA.4.17 Does each dam (if required) have a current Interim Risk Reduction Plan?

AA.4.18 Does each PDT for a dam safety study have an assigned “Lead Engineer”?

This Page Left Blank

APPENDIX AB

Seismic Safety Evaluation Process for Embankment Dams and Foundations

AB.1 Introduction.

AB.1.1 This Annex provides detailed guidance for evaluating the seismic safety of existing USACE embankment dams and foundations. The process ensures:

AB.1.1.1 That seismic evaluations/re-evaluations for embankment dams and foundations are accurately identified and conducted with minimum expenditure of project funds, manpower or delay and

AB.1.1.2 That embankment dams and/or foundations not requiring modifications are accurately identified and removed from further study at the earliest possible point in the evaluation process.

AB.1.2 This guidance is to be used in evaluating the seismic safety of existing USACE Civil Works embankment dams in accordance with the provisions of the Dam Safety Program as defined in the main text of this regulation.

AB.1.3 The seismic safety of many existing embankment dams must be evaluated or re-evaluated in accordance with the requirements in ER 1110-2-1806. Seismic safety evaluation of major civil works projects, particularly embankment dams, is typically a complex, multi-stage process. It generally requires progressively more detailed definition of certain project characteristics and analysis of project response to the design earthquake ground motions at each subsequent stage. This process can be expensive and manpower intensive, and may take many months to several years to complete.

AB.2 Seismic Safety Evaluation Process.

AB.2.1 Evaluation Process. Stages of the seismic safety evaluation process are designated as:

AB.2.1.1 Seismic Safety Review,

AB.2.1.2 Phase I Special Studies, and

AB.2.1.3 Phase II Special Studies

AB.2.1.4 A flow chart illustrating the process is shown at Figure AB.1.

AB.2.2 The evaluation process is structured to validate technical conclusions and policy compliance as an integral part of each stage of the process. This is accomplished during appropriately timed Policy Compliance & Criteria Reviews (PCCR). These

reviews eliminate the need for several report submission and approval cycles preceding the development of an official decision document. The evaluation process leads either to negative findings (i.e., that critical project features are likely to perform in an acceptable manner during and following the design earthquake) resulting in removal of the dam from further evaluation, or to the conclusion that modifications are required to the embankment dam and/or its foundation to ensure acceptable performance when subjected to the design earthquake. Negative conclusions at any stage beyond the initial screening at the Seismic Safety Review stage require validation during a PCCR. Negative conclusions at any stage of evaluation require only minimal formal documentation. Conclusions which indicate additional studies are required or that the project requires some form of remediation or modification must be validated during a PCCR. Additionally, the evaluation process and resultant conclusions must be documented for record prior to proceeding into the next phase. If studies through the Phase II level lead to the conclusion that some form of remediation is required, the results of the evaluation process, recommended remediation or modifications and justification are presented in the Dam Safety Modification Report (DSMR).

AB.2.3 The Dam Safety Modification Studies and Documentation are described in Chapter 9 of this regulation.

AB.2.4 Phase III/Detailed Design. Following official approval of the DSMR, Phase III work should precede in accordance with the approved schedule. This includes detailed design for the seismic modifications approved in the DSMR as well as preparation of the plans and specifications for those measures.

AB.3 Funding. The Seismic Safety Review should be a recurring review has part of the Periodic Assessment of the dam and is funded with project O&M funds. The Phase I Special Studies are included in the Initial Evaluation Study (IES). The Phase II Special Studies are included in the Dam Safety Modification Study (DSMS). Both the IES and the DSMS are funded with Construction funds.

AB.4 Seismic Safety Review.

AB.4.1 A Seismic Safety Review (SSR) is required when certain conditions exist as described in ER 1110-2-1806. The SSR should be considered as a part of each Periodic Assessment (PA).

AB.4.2 The purpose of the SSR is to review and document conclusions about the seismic safety of embankment dams and foundations for civil works projects in accordance with ER 1110-2-1806. This review will conclude whether or not a Phase I Special Study is required. The SSR is normally limited to office examination and screening of available data and the results of the most recent PI and/or PA. In this review, available information, such as geologic maps, boring logs, seismic zone maps, acceleration contour maps, existing field investigation reports, as-built project records, and previous seismic evaluation reports, should be used. If the initial screening indicates that the embankment dam and/or its foundation may require

remediation/modification for seismic adequacy, then limited, simple preliminary analyses using existing available data should be performed as part of the SSR. If these analyses indicate that there is potential for sudden, uncontrolled loss of reservoir pool or other form of unacceptable performance which causes loss of life as a result of the project being subjected to the design earthquake, then a Phase I Special Study should be recommended. Where specialized expertise is needed, subject matter experts, either USACE or external, should participate in the examination and analysis as early as practical in the evaluation process.

AB.4.3 The level of effort to accomplish the SSR should be the minimum required to resolve whether or not seismic safety issues exist which require a Phase I Special Study. (The level of effort and associated cost are estimated to be on the order of a few man-weeks of office effort with costs in the range of $25-50K.)

AB.4.4 Seismic Safety Issues. Issues that are relevant to the determination of seismic safety and the need for further investigations may include some or all of the following:

AB.4.4.1 Project Hazard Potential Classification, which reflects the criticality of the project in terms of threat to public safety in the event of failure. It is USACE policy that seismic safety of USACE embankment dams, where failure would result in loss of life, must be assured. For embankment dams and other features for which the consequences of failure are economic and no loss of life is expected, the decisions about further investigations or other actions should be justified on an economic basis.

AB.4.4.2 Adequacy of past seismic evaluations, if any; including the adequacy of procedures used in selection of design ground motions and the appropriateness and adequacy of methods of analysis used, in light of the present state-of-the-practice.

AB.4.4.3 Proximity to seismic source zones

AB.4.4.4 Changes in the state of knowledge of regional or local seismicity since the last review.

AB.4.4.5 Existence of soils that are potentially unstable due to buildup of excess residual pore pressures or degradation of strength from cyclic loading in either the embankment or foundation.

AB.4.4.6 Existence of slopes that may be seismically unstable, including embankment slopes, the abutments or the reservoir rims.

AB.4.4.7 Existence of project features that may become critical to safety after small deformations of the embankment dam (i.e., outlet works becoming nonoperational or thin filter zones within the embankment being disrupted).

AB.4.4.8 A Policy Compliance & Criteria Review (PCCR) should be held after 95% completion of the technical examination and analysis for the SSR, but prior to forwarding a recommendation to the District Dam Officer. The PCCR should include geotechnical representatives from the RMC and the MSC as well as District representatives including representatives from Engineering and Operations. A PCCR is not needed if the results of the SSR indicate that the dam is seismically adequate. The PCCR should summarize the examination and screening and should provide a recommendation with justification for the initiation of Phase I studies. Supporting documentation should be presented. If a Phase I study is recommended, then a scope of work, cost estimate and schedule for the Phase I study should be presented. If the SSR is done in conjunction with a periodic assessment, the results of the SSR should be incorporated into the Periodic Assessment Report. As a minimum, the District should document the SSR as well as the results and conclusions of the PCCR in a memorandum for record to project files. No formal report or documentation is required to be submitted to the MSC or HQUSACE for review and approval; the PCCR replaces the MSC and HQUSACE review and approval process for the SSR. An information copy of the memorandum for record must be provided to both the MSC and HQUSACE (CECW-CE).

AB.5 Phase I Special Study.

AB.5.1 A Phase I Special Study is necessary when the PCCR for the SSR concludes that potential deficiencies exist in an embankment dam or foundation which could lead to sudden, uncontrolled loss of reservoir pool or other form of unacceptable performance likely to cause loss of life if the project were subjected to the Maximum Credible Earthquake (MCE), as defined in ER 1110-2-1806, or a lesser event.

AB.5.2 The purpose of Phase I study is as shown below. The Phase I study should be part of an overall risk-informed IES for the dam.

AB.5.2.1 Develop site specific ground motions appropriate for seismic evaluation of all project features to be evaluated,

AB.5.2.2 Perform limited field investigations and laboratory studies, and,

AB.5.2.3 Perform preliminary analyses, based on the ground motions, field data and laboratory testing results, to determine the response of the dam to seismic loading and to identify potential problem areas which may need more detailed analyses.

AB.5.3 The type and level of study required in the Phase I study will be project dependent; however, the content of a Phase I study normally includes the following:

AB.5.3.1 Project Description. Provide a brief description of the project, including type of dam, major structures or other critical feature. Provide tabulated pertinent project data. Describe design and current project operations. Identify key operational pool

levels such as conservation pool, power pool, seasonal pool levels, spillway crest, flood pool and maximum pool. Other relevant pool information should include reservoir pool history elevation versus time, average yearly maximum pool, and the reservoir pool elevation versus frequency relationship based on historical data supplemented with flood routing analyses for less frequent flood events as required.

AB.5.3.2 Purpose and Scope. Describe the purpose and scope of the study and the deficiency(s) identified in the SSR. (Estimating the level of effort and cost to perform a Phase I study is difficult to address on other than a project specific basis but are likely to range from many man-months to a few man-years of effort and involve expenditures in the range of $300-800K. Phase I duration should be limited to the shortest possible time period consistent with project complexity, manpower, funding and quality considerations.)

AB.5.3.3 Site Characterization. Perform limited field and laboratory investigations to define the soil and rock stratigraphy and to further clarify location and extent of potential problem areas. These investigations should be sufficient to develop preliminary soil and rock cross sections of the dam and foundation in areas which have potentially unstable soils. These investigations may include Standard Penetration Tests (SPT), Cone Penetration Tests (CPT), shear wave velocity, permeability, Becker Penetration Tests (BPT), conventional undisturbed sampling, and trenching in areas of much lateral heterogeneity or anisotropy.

AB.5.3.4 Seismotectonic Evaluation. Develop a detailed evaluation of the geology, tectonics and seismic history of the area, and the proximity of the dam to active seismic zones. Provide fault study and related field investigations and laboratory testing where necessary.

AB.5.3.5 Seismicity and Ground Motions. Select the final design earthquake ground motions and develop the ground motion parameters to which the project could be subjected. For all critical projects or features, these input ground motions will be obtained from a deterministic analysis of historic seismicity and active fault systems or seismic source zones and their activity. Develop several accelerograms for site response computations. The accelerograms should contain energy, frequency and duration components appropriate for the source, the region and the feature being evaluated. Caution is advised to avoid undue conservatism in selection of ground motions for use in analyses. Selection of specific accelerograms or the manipulation of accelerograms to generate records with specific time histories not representative of the characteristic ground motion records within the region of the project should be strongly justified and well documented. Of particular concern is that accelerograms be developed with energy content and occurrence of the peak energy representative of the seismological setting of the feature(s) being evaluated. For effective stress analyses, where site permeability profiles and boundaries are accurately known and seismic generated residual excess pore water pressures will be simultaneously dissipated, input motion time histories should not be manipulated to shift the energy content to the end of shaking to minimize pore pressure dissipation and thereby maximize excess residual

pore pressures during modeling of post earthquake response unless justified from seismological investigations and by expert seismologists. Selection of ground motions should be made with input from qualified seismologists, geologists and geotechnical engineers.

AB.5.3.6 Seismic Evaluations and Analyses.

AB.5.3.6.1 Liquefaction Potential. Evaluate the potential for liquefaction or development of excess pore pressure in soils of the embankment and foundation using standard methods. This should consist of using an appropriate empirical method linking documented field performance with site characteristics using field investigations. Use a 1-D analysis, such as SHAKE, to model propagation of earthquake induced rock motions through the foundation and the embankment.

AB.5.3.6.2 Post Earthquake Stability. Evaluate post earthquake limit equilibrium slope stability for the reach(es) of the embankment where liquefaction of the embankment and/or foundation is indicated. Post-earthquake shear strengths for zones not indicated to liquefy should be estimated taking into account residual excess pore pressures. Post-earthquake shear strengths for zones which are indicated to liquefy should be selected based on residual strengths back calculated for well documented liquefaction induced failures. The further reduction in shear resistance below the residual level is not justified.

AB.5.3.7 Post Earthquake Deformed Shape. Assess the shape and amount of deformation in the embankment after sliding or slumping for the cross section where inadequate factors of safety are indicated by limit equilibrium slope stability analyses. Similar cautions noted for selection of strength and pore pressure values in evaluating limit equilibrium stability are to be observed in evaluating the post earthquake deformed shape of an embankment or other slope.

AB.5.3.8 Conclusions and Recommendations. Develop conclusions and recommendations on the need for a Phase II seismic evaluation or departure from requirements of ER 1110-2- 1806.

AB.5.3.9 Cost Estimate and Schedule. If Phase II studies are recommended, develop a detailed scope, cost estimate and schedule for the proposed Phase II studies.

AB.5.3.10 Phase I PCCR. Conduct a PCCR for the Phase I study.

AB.6 Phase II Special Study.

AB.6.1 A Phase II Special Study is necessary when the PCCR for the Phase I concludes that potential deficiencies exist in an embankment dam or foundation which could lead to sudden, uncontrolled loss of reservoir pool or other form of unacceptable performance likely to cause loss of life if the project were subjected to the design earthquake. The Phase II study should be detailed and sufficiently comprehensive such

that conclusions reached concerning the seismic adequacy of the dam in question are definitive and constitute the basis for selection, detailed design and construction of modifications or other form of remediation required to ensure seismic safety of the project.

AB.6.2 The purpose and scope of Phase II study are as follows:

AB.6.2.1 Perform comprehensive detailed analyses to evaluate performance of the critical project features when subjected to the ground motions identified in Phase I.

AB.6.2.2 Determine if the dam is seismically adequate or if remediation/modifications are required to ensure acceptable seismic performance.

AB.6.2.3 Establish remediation requirements.

AB.6.2.4 Evaluate various alternative remedial techniques and select the most appropriate alternative.

AB.6.2.5 Prepare cost estimates, scope, and schedule for design documentation, plans and specifications, and construction.

AB.6.3 Methods of Analysis. The recommended engineering approach to analysis of an embankment dam and foundation for seismic stability generally consists of assessing both post earthquake static limit equilibrium slope stability and deformation response of the dam using, as appropriate, detailed 2D and 3D numerical analyses. The steps involved in a Phase II seismic analyses for earth dams normally include:

AB.6.3.1 Use the recommended design earthquake ground motions and accelerograms developed in the Phase I study for site response computations. For all critical projects or features, these input ground motions will be obtained from a deterministic analysis. The selected accelerograms should be used in the application of an appropriate, validated dynamic finite element program used for modeling the deformation process in response to an imposed earthquake ground motion time history.

AB.6.3.2 Perform detailed field investigations which may include SPT, BPT, CPT, field vane shear tests, field permeability, ground water observation wells, conventional undisturbed sampling, geophysical evaluations, and laboratory testing, to develop a detailed understanding of site conditions, including stratigraphy, geometry, hydrology, material properties and their variability, and the areal extent of potential problem zones.

AB.6.3.3 Determine the preearthquake vertical effective shear stresses, and the initial static shear stresses on horizontal planes throughout the dam and its foundation.

AB.6.3.4 Determine the dynamic shear moduli of the soils in the dam and foundation.

AB.6.3.5 Using an appropriate dynamic finite element analysis procedure, determine the stresses induced in the embankment and foundation when subjected to the accelerograms selected for the design earthquake. Pore water pressure dissipation should be properly accounted for in determining pore pressure behavior during shaking and residual excess pore pressure level after shaking stops. Consider relevant soil properties and stratigraphy including permeabilities in soil layers adjacent to the liquefiable soil layer, which restricts pore pressure dissipation.

AB.6.3.6 Determine the liquefaction resistance of the embankment and foundation soils and the maximum potential residual excess pore water pressure that can be generated by the earthquake using corrected penetration data from in-situ tests such as SPT, CPT, BPT, and laboratory index tests.

AB.6.3.7 Map the areal extent of all suspect materials. Determine post earthquake shear strength of relevant soils. Prepare several generalized cross sections of the dam and foundation for final analysis to determine seismic response.

AB.6.3.8 Perform static limit equilibrium slope stability analyses of the generalized cross sections to assess post earthquake stability and to identify potential zones of the dam and foundation which may require remediation.

AB.6.3.9 Estimate the deformation response of the embankment dam and the post earthquake shape of the embankment by using an appropriate 2D and/or 3D finite element or other appropriate deformation analysis program.

AB.6.3.10 Remediation should be recommended when the embankment dam is

AB.6.3.10.1 found to have inadequate limit equilibrium slope stability factors of safety and/or

AB.6.3.10.2 projected to experience unacceptable deformations when subjected to the design earthquake and it is concluded that either situation would result in sudden, uncontrolled loss of the reservoir pool and loss of life.

AB.6.3.10.3 If remedial measures are recommended, establish the remediation requirements, evaluate various remediation alternatives, and select the most appropriate alternative.

AB.6.3.11 Perform additional post earthquake limit equilibrium slope stability and finite element analysis to determine preliminary remediation needs such as extent and location of remediation required, strength/resistance required and to determine the level of protection to be obtained by remediation.

AB.6.3.12 Evaluate various preliminary remediation alternatives and select the most appropriate alternatives for cost estimating purposes.

AB.6.3.13 Perform additional finite element deformation analyses to determine expected deformations in both remediated and non-remediated sections of the dam. Determine overall dam response and differential deformation.

AB.6.3.14 Develop detailed scope, cost, and schedule for PED phase (Preconstruction Engineering and Design) which includes preparation of design documentation and plans and specifications (P&S).

AB.6.3.15 Conduct a PCCR for the Phase II study.

AB.6.3.16 Prepare the Phase II study summary. This is the basis for a technical appendix to the DSMR. The suggested format and content for the Phase II summary is described in Paragraph AB.6.4 below.

AB.6.4 Phase II Study Documentation. A detailed summary of the entire evaluation process including the Phase II study must be included as a Technical Appendix to the IES Report. To facilitate the Phase II PCCR, a summary should be developed and presented at the PCCR in the general format and scope indicated as follows:

AB.6.4.1 Introduction

AB.6.4.1.1 Authorization

AB.6.4.1.2 Purpose

AB.6.4.1.3 Project Description

AB.6.4.1.4 Method of Analysis

AB.6.4.2 Static Stress Analyses

AB.6.4.2.1 General

AB.6.4.2.2 Development of Static Properties of the Dam

AB.6.4.2.3 Results of Static Stress Analyses

AB.6.4.3 Design Earthquake Motions

AB.6.4.3.1 General

AB.6.4.3.2 Design Earthquake and Ground Motions

AB.6.4.3.2.1 Response Spectra

AB.6.4.3.2.2 Time Histories

AB.6.4.4 Dynamic Response Analyses

AB.6.4.4.1 General

AB.6.4.4.2 Field and Laboratory Tests and Results

AB.6.4.4.3 Development of Dynamic Properties

AB.6.4.4.4 Dynamic Analyses

AB.6.4.4.5 Dynamic Response

AB.6.4.5 Seismic Stability Assessment

AB.6.4.5.1 Evaluation of Dynamic Strengths

AB.6.4.5.1.1 Laboratory Data

AB.6.4.5.1.2 Field Data

AB.6.4.5.2 Dynamic Response and Stability

AB.6.4.5.3 Earthquake Induced Deformation Analyses

AB.6.4.6 Post Earthquake Stability Analyses

AB.6.4.6.1 General

AB.6.4.6.2 Post Earthquake Strength Properties

AB.6.4.6.3 Slope Stability

AB.6.4.6.4 Post Earthquake Deformed Condition

AB.6.4.7 Deformation Response Analyses

AB.6.4.7.1 General

AB.6.4.7.2 Deformation analyses of Remediated Sections

AB.6.4.7.3 Deformation Analyses of Unremediated Sections

AB.6.4.8 Remediation Alternatives

AB.6.4.8.1 General

AB.6.4.8.2 Potential Remediation Alternatives

AB.6.4.8.3 Cost Estimates for Potential Remediation Alternatives

AB.6.4.8.4 Estimated Construction Sequence, Schedule, Duration for Alternatives

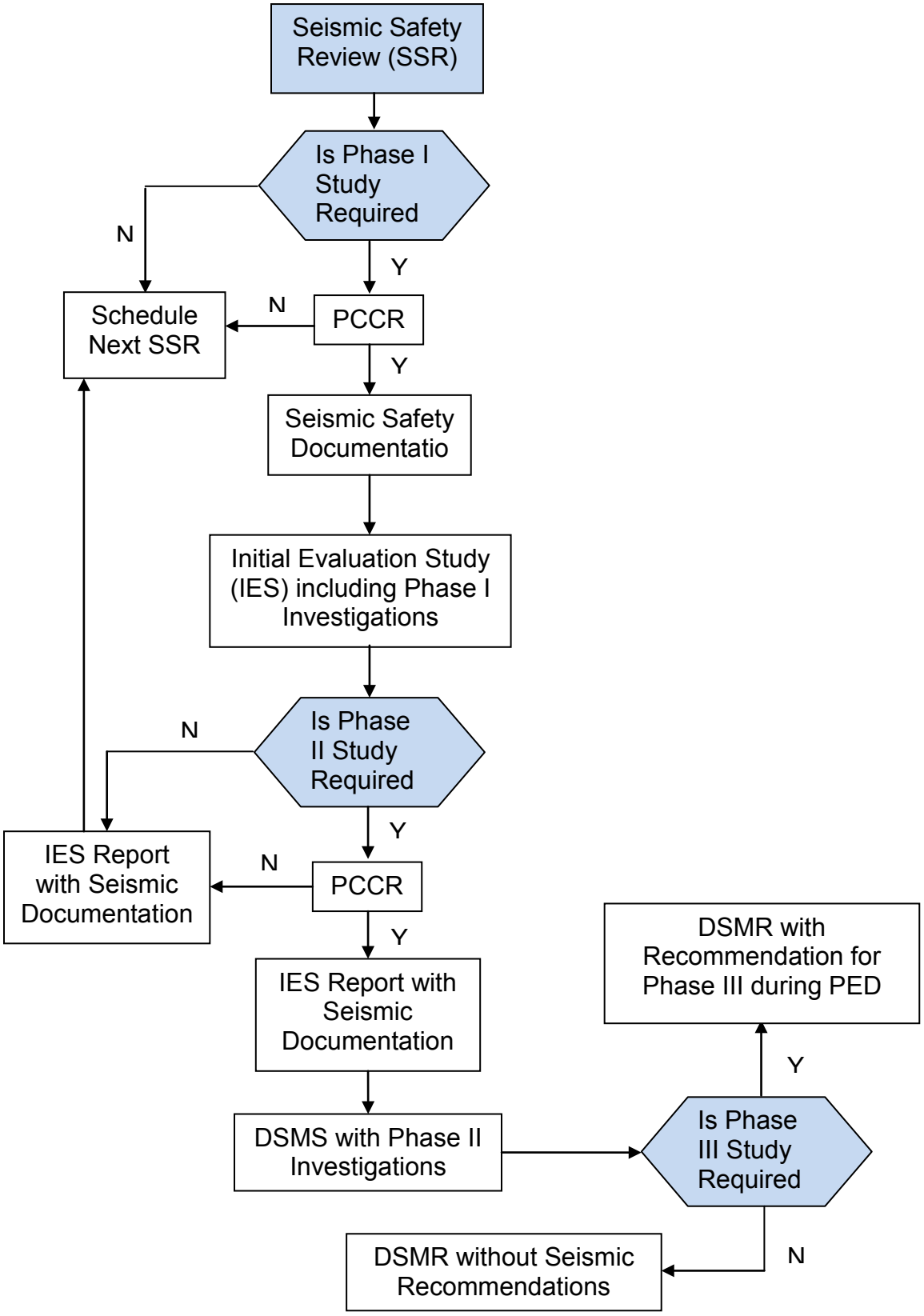
AB.6.4.9 Summary

AB.6.4.10 Conclusions and Recommendations

AB.6.4.11 References

AB.6.4.12 Attachments

Figure AB.1 – Seismic Analysis Process



APPENDIX AC

Seismic Safety Evaluation Process for Concrete Structures and Foundations

AC.1 Seismic Safety Review.

AC.1.1 General.

AC.1.1.1 Types and levels of programs for seismic evaluation of concrete dams needed at various times and for various purposes start with a Seismic Safety Review (SSR) and may be followed by special studies consisting of preliminary seismologic investigations coupled with simplified seismic evaluations (Phase I), full seismologic investigations and dynamic analysis of the project (Phase II), and preparation of design documents, plans and specifications (Phase III). Flexible guidelines, consistent with the policy in paragraph 5.b.of ER 1110-2-1806 are needed to permit experienced investigators to do the best practical and economical job for each specific situation.

AC.1.1.2 A review is required to identify specific problem areas and establish priorities for further study. Generally, Seismic Safety Reviews are based on evaluations of available pertinent data and surface inspections. Seldom do SSR level investigations include extensive exploratory or testing provisions.

AC.1.2 Project Description. Briefly describe the project, including type of dam or major structure and seismic zone. Enclose a location map and the tabulated pertinent project data. Describe design and current project operations.

AC.1.3 Geology/Seismicity. Describe site specific geology and provide current detailed seismicity of the site including faulting, seismic evaluation parameters used in the design and changes or experienced shaking at site based on a search of existing project files and current professional literature. Describe site specific ground motion data.

AC.1.4 Structural Investigations. Summarize structural design and results of recent analyses, if available. Describe those analyses used to conduct the evaluation.

AC.1.5 Evaluation. Provide diagnostic seismic evaluation of the structure and foundation based on the data presented. Evaluate post-seismic stability. Develop a basis for decision on the need for and justification of additional studies or departure from further studies of risk assessment based on probabilities of occurrence of earthquakes, operating pool elevations and structural failure.

AC.1.6 E&D Cost Estimate and Schedule. Provide scope of recommended studies and associated study costs and schedule.

AC.1.7 Conclusions and Recommendations. Provide conclusions and specific recommendations based on existing data evaluations. Schedule and conduct PCCR.

AC.2 Phase I – Special Study Content.

AC.2.1 Project Authorization. Reference the Project Guidance Memo (PGM) from the Policy Compliance & Criteria Review (PCCR) of the SSR for the project.

AC.2.2 Project Description. Briefly describe the project, including type of structures. Provide tabulated pertinent project data. Describe design and current project operations.

AC.2.3 Purpose and Scope. Describe the purpose of the study, scope, and deficiency identified in the SSR.

AC.2.4 Seismologic Investigations. Provide detailed seismologic study results, including fault study investigations, related field investigations, and laboratory studies.

AC.2.5 Seismicity. Develop design earthquakes in relation to active fault systems and their activity.

AC.2.6 Seismic Evaluation. Provide seismic evaluation of features subjected to design earthquakes. Provide basis for selection of parameters, method of analysis, and rationale for the decision on seismic assessment of the project.

AC.2.7 Conclusions and Recommendations. Develop conclusions and recommendations for terminating the study or proceeding to a Phase II seismic evaluation in accordance with the requirements of ER 1110-2-1806.

AC.2.8 Cost Estimate and Schedule. Provide scope, cost estimate, and schedule of recommended Phase II studies. Conduct the PCCR.

AC.3 Phase II – Special Study Guidelines for Dynamic Analysis of Concrete Structures.

AC.3.1 Design Earthquakes and Ground Motions. Design earthquakes and ground motions for the seismic evaluations of concrete dams and appurtenant structures shall be determined in accordance with ER 1110-2-1806, paragraphs 5.h., 6 and 8.f. The study scope shall be consistent with the PGM for the Phase I PCCR.

AC.3.2 Dynamic Analyses of Existing Structures and Proposed Remedial Alternatives.

AC.3.2.1 Review the candidate earthquake, location, and ground motions for most severe conditions to concrete structures.

AC.3.2.2 Select design response spectra.

AC.3.2.3 Select appropriate acceleration-time history records compatible with the design response spectra.

AC.3.2.4 Select dynamic properties for the concrete and foundation.

AC.3.2.5 Analyze and evaluate any cracking.

AC.3.2.6 Follow guidance in the current technical guidance and EM appropriate for that concrete structure.

AC.3.3 Conclusions and Recommendations. Discuss remedial alternatives in the DSMR and selection of remediation plan to be developed in Phase III Plans and Specifications. Provide a summary of the Phase II studies in the DSMR

AC.4 Phase II – Special Study Content.

AC.4.1 Introduction.

AC.4.1.1 Authorization

AC.4.1.2 Purpose

AC.4.1.3 Project Description

AC.4.1.4 Method of Analysis

AC.4.2 Static Finite Element Analysis.

AC.4.2.1 General

AC.4.2.2 Development of Static Properties

AC.4.2.3 Results of Static FEM Analyses

AC.4.3 Design Earthquake Motions

AC.4.3.1 General

AC.4.3.2 Design Earthquake and Ground Motions

AC.4.3.3 Response Spectra

AC.4.3.4 Time Histories

AC.4.4 Dynamic Finite Element Analyses

AC.4.4.1 General

AC.4.4.2 Field and Laboratory Tests & Results

AC.4.4.3 Development of Dynamic Properties

AC.4.4.4 Dynamic Analyses

AC.4.4.5 Dynamic Response

AC.4.4.6 Evaluate Cracking in Concrete Structures

AC.4.4.7 Fracture Mechanics Analysis

AC.4.4.8 Non-Linear Analyses of Concrete Structures

AC.4.5 Seismic Stability Assessment

AC.4.5.1 Evaluation of Dynamic Strengths

AC.4.5.1.1 Laboratory Data

AC.4.5.1.2 Field Data

AC.4.5.2 Dynamic Structural Response

AC.4.5.3 Soil Structure

AC.4.5.4 Interaction of backfill, structure and piles

AC.4.5.5 Earthquake Induced Cracking Analyses

AC.4.6 Post Earthquake Stability Analyses

AC.4.6.1 General

AC.4.6.2 Evaluate Cracking in Concrete structures

AC.4.6.3 Evaluate Structural Stability

AC.4.6.4 Post Earthquake Stability

AC.4.7 Remediation

AC.4.7.1 General

AC.4.7.2 Alternatives

AC.4.7.3 Cost

AC.4.8 Summary

AC.4.9 Conclusions and Recommendations

AC.4.10 References

AC.4.11 Attachments

This Page Left Blank

GLOSSARY

Abbreviations and Terms

Abbreviations.

ADAS ..... Automated Data Acquisition System

AIS ..... Automated Information System

ALARP ..... As Low as Reasonably Possible

ALL..... Annualized life loss

ANCOLD ..... Australian National Committee on Large Dams

APF ..... Annual Probability of Failure

ASA..... Assistant Secretary of the Army for Civil Works

ASDSO..... Association of State Dam Safety Officials

ATR..... Agency Technical Review

BCR..... Benefit Cost Ratio

BOR ..... Bureau of Reclamation

BPA..... Blanket Purchase Agreement

BSC..... Base Safety Condition

CCS..... Category Class Subclass

CG..... Construction General Funds

CIPR..... Critical Infrastructure Protection and Resilience

COE ..... Corps of Engineers

CoP ..... Community of Practice

CQC ..... Contractor Quality Control

CSSL..... Cost to save a statistical life

DA ..... Department of the Army

DDR ..... Design Documentation Report

DHS..... Department of Homeland Security

DQC ..... District Quality Control

DSAC ..... Dam Safety Action Classification

DSADS..... Dam Safety Action Decision Summary

DSAP ..... Dam Safety Assurance Program

DSDMR..... Dam Safety Deficiency Modification Report

DSM ..... Dam Safety Modification Study

DSO ..... Dam Safety Officer

DSPM..... Dam Safety Program Manager

DSPMT..... Dam Safety Program Management Tools

DSPPM ..... Dam Safety Program Performance Measures

DSSC ..... Dam Safety Steering Committee

DX ..... District Center of Expertise

EAP ..... Emergency Action Plan

EMA ..... Emergency management Agencies

ERDC ..... Engineer Research and Development Center

EIS ..... Environmental Impact Statement

EPRI..... Electric Power Research Institute

ERRDX..... Engineering Risk and Reliability Directory of Expertise

ESA..... Endangered Species Act

FCCSET..... Federal Coordinating Council for Science, Engineering, and Technology

FC, MR&T ..... Flood Control, Mississippi River and Tributaries

FCSA..... Feasibility Cost Sharing Agreement

FEMA ..... Federal Emergency Management Agency

FERC ..... Federal Energy Regulatory Commission

FOUO..... For Official Use Only

GIS ..... Geographical Information Systems

H H & C ..... Hydraulics Hydrology and Coastal

H & H..... Hydraulics and Hydrology

HQUSACE ..... Headquarters, U.S. Army Corps of Engineers

HSE..... Health Safety Executive, United Kingdom

HSS..... Hydraulic Steel Structures

HTRW ..... Hazardous, Toxic and Radioactive Waste

ICODS..... Interagency Committee on Dam Safety

ICOLD ..... International Commission on Large Dams

ICW ..... Inspection of Completed Works

IDF ..... Inflow Design Flood

IEPR..... Independent External Peer Review

IFP..... Initial Reservoir Filling Plan

IES ..... Issue Evaluation Study

IRRM..... Interim Risk Reduction Measure

IRRMP..... Interim Risk Reduction Measures Plan

IPMP ..... Initial Project Management Plan

IRC..... Issue Resolution Conference

ITR ..... Independent technical review

IWR ..... Institute for Water Resources

LCA ..... Local Cooperation Agreement

MCACES ..... Micro Computer Aided Cost Engineering System

MCE ..... Maximum Credible Earthquake

MDE ..... Maximum Design Earthquake

MMC ..... Mapping Modeling and Consequence Production Center

MSC ..... Major Subordinate Commands

NDSRB ..... National Dam Safety Review Board

NED ..... National Economic Development

NEPA ..... National Environmental Policy Act

NID ..... National Inventory of Dams

NSW DSC ..... New South Wales Dam Safety Committee

NWS ..... National Weather Service

O&M ..... Operation and Maintenance

OBE ..... Operating Basis Earthquake

OMB ..... Office of Management and Budget

OMRR&R ..... Operation, Maintenance, Repair, Replacement and Rehabilitation

PA ..... Periodic Assessment

PAO ..... Public Affairs Office

P&S ..... Plans and Specifications

P&G ..... Principles and Guidelines

PCA ..... Project Cooperation Agreement

PCCR ..... Policy Compliance & Criteria Review

PDT ..... Project Delivery Team

PED ..... Preconstruction Engineering and Design

PFM ..... Potential Failure Modes

PFMA ..... Potential Failure Modes Analysis

PGM ..... Project Guidance Memo

PI ..... Periodic Inspection

PMA ..... Power Marketing Agency

PMF ..... Probable Maximum Flood

PMP ..... Probable Maximum Precipitation

PMP ..... Project Management Plan

PPMD ..... Programs and Project Management Division

PROSPECT ..... Proponent-Sponsored Engineer Corps Training

QA ..... Quality Assurance

RA ..... Risk Assessment

RADS II ..... Risk Assessment For Dam Safety web site

REMR ..... Repair, Evaluation, Maintenance, and Rehabilitation

RMC ..... Risk Management Center

RMO ..... Review Management Organization

RP ..... Review Plan

RRDX ..... Risk and Reliability Center

SDF ..... Spillway Design Flood

SEE ..... Safety Evaluation Earthquake

SEF ..... Safety Evaluation Flood

SES ..... Senior Executive Service

SET ..... Standard Engineering Technology

SOG ..... Senior Oversight Group

SPRA ..... Screening Portfolio Risk Assessment

SSR..... Seismic Safety Review

TADS..... Training Aids for Dam Safety

TF..... Threshold Flood

TRC..... Technical Review Conference

USACE..... United States Army Corps of Engineers

USCOLD ..... U.S. Committee on Large Dams
(Renamed United States Society on Dams, USSD)

USDOT..... United States Department of Transportation

USSD ..... United States Society on Dams

VE ..... Value Engineering

WCC..... Work Cost Category

WPSF..... Willingness-to-pay-to-prevent-a-statistical-fatality

WRDA ..... Water Resources Development Act

WTP ..... Willingness-to-pay-to-prevent-a-statistical-fatality

Terms

Abutment – That part of the valley side against which the dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section to take the thrust of an arch dam where there is no suitable natural abutment. The left and right abutments of dams are defined with the observer viewing the dam looking in the downstream direction, unless otherwise indicated.

Acceptable Risk – A risk, for the purposes of life or work, everyone who might be impacted is prepared to accept assuming no changes in risk control mechanisms. Such risk is regarded as insignificant and adequately controlled. Action to further reduce such risk is usually not required.

Acre-foot – A unit of volumetric measure that would cover 1 acre to a depth of 1 foot. It is equal to 43,560 cubic feet. This is approximately 325,851.4 U.S. gallons.

Adequately Safe Dam – A dam is adequately safe when the dam meets all essential USACE engineering guidelines and the residual risk is considered tolerable.

Adit – A nearly horizontal underground excavation in an abutment having an opening in only one end, such as an opening in the face of a dam for access to galleries or operating chambers.

Adverse Consequences – The outcome of the failure of a dam or its appurtenances, including immediate, short and long-term, direct and indirect losses and effects. Loss may include human casualties, project benefits, monetary and economic damages, and environmental impact (Adapted from USACE).

Agency Technical Review (ATR) – An independent in-depth review designed to ensure the proper application of clearly established criteria, regulations, laws, codes, principles and professional practices. The ATR team reviews the various work products and assures that all the parts fit together in a coherent whole.

ATR Team – For dam safety studies, the ATR team shall include members from and be coordinated with the Dam Safety Risk Management Center (DSRMC) as well as recognized experts in the field of risk assessment outside of the DSRMC. The ATR team findings will be vetted with the MSC DSO, Dam Safety Risk Management Center, and HQUSACE.

Annual Inspections – Inspections conducted annually by the Operating Project staff with technical experts from Engineering or Operations (Reference ER 1130-2-500 (reference A.62)). The goal is to monitor the performance of the dam and note any evidence of changes in performance or needed dam safety related maintenance. Findings shall be documented and reviewed in support of Periodic Inspections (PI's) and Periodic Assessments (PA's).

Annual Probability of Failure (APF) – For dams the total estimated annual probability of failure from all failure modes associated with all loading or initiating event types that result in an unintentional release of the reservoir.

Annualized Life Lost (ALL) – As used in the f-N plot, the expected value (average) of potential life loss of the probability distribution of potential life loss from dam failure.

Appurtenant structure – Ancillary features of a dam such as inlet and outlet works, spillways, tunnels, or power plants.

As-Low-As-Reasonably-Practicable (ALARP) – That principle which states that risks, lower than the limit of tolerability, are tolerable only if risk reduction is impracticable or if its cost is grossly disproportional (depending on the level of risk) to the improvement gained.

Axis of dam – The vertical plane or curved surface, chosen by a designer, which appears as a line, in plan, or in cross-section, from which the horizontal dimensions of the dam are referenced.

Baffle block – A block, usually of concrete, constructed in a channel or stilling basin to dissipate the energy of water flowing at high velocity.

Baseline – The condition, data, or other representations of the topic of interest that will be used for comparison of 1) changes that may occur without intervention or as a result of a remediation alternative remediation and 2) changes and impacts estimated to result from intervention or remediation alternative. It is comprised of the existing conditions and such future projected conditions as chosen to be relevant for the comparison.

Baseline Component Risk Estimates – An Estimate of risk contributed by an individual credible failure mode that associated with the dam for given load combinations.

Baseline Consequence Analysis – Analysis of existing and future without remediation project consequences.

Baseline Risk Estimate – The baseline risk estimate is the risk estimate at a point in time.

Base thickness – Also referred to as base width. The maximum thickness or width of the dam measured horizontally between upstream and downstream faces and normal to the axis of the dam, but excluding projections for outlets, or other appurtenant structures.

Batter – Angle of inclination from the vertical.

Bedrock – The consolidated body of natural solid mineral matter which underlies the overburden soils.

Berm – A nearly horizontal step in the sloping profile of an embankment dam. Also a step in a rock or earth cut.

Borrow Area – The area from which natural materials, such as rock, gravel or soil, used for construction purposes is excavated.

Breach – An opening through a dam that allows the uncontrolled draining of a reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional opening caused by discharge from the reservoir. A breach is generally associated with the partial or total failure of the dam.

Broadly Acceptable Risk – "Risks falling into this region are generally regarded as insignificant and adequately controlled. The levels of risk characterizing this region are comparable to those that people regard as insignificant or trivial in their daily lives. They are typical of the risk from activities that are inherently not very hazardous or from hazardous activities that can be, and are, readily controlled to produce very low risks" (HSE, 2001) (reference A.105). By the nature of the hazard that dams pose it is inappropriate to attempt to manage them as a broadly acceptable risk and therefore the concept of the broadly acceptable risk level or limit does not apply to dams.

Catastrophe – A sudden and great disaster causing misfortune, destruction, or irreplaceable loss extensive enough to cripple activities in an area.

Channel – A general term for any natural or artificial facility for conveying water.

Cofferdam – A temporary structure enclosing all or part of the construction area so that construction can proceed in the dry. A diversion cofferdam diverts a river into a pipe, channel, or tunnel.

Compaction – Mechanical action, which increases the density by reducing the voids in a material.

Component Risks – Estimates of risk contributed by the physical components of a dam undergoing failure mode analysis for a remediation alternative.

Concept of Disproportionality – Entails the use of two measures associated with the 'statistical life' concept. The first is the cost effectiveness measure called, "cost-to-save-a-statistical-life" (CSSL). The second measure is the "willingness-to-pay-to-prevent-a-statistical fatality" (WPSF) or as sometimes used in the United States "the value to save a life" (VSL). The characterization of the sacrifice is based in part on the ratio of the CSSL estimate for a risk reduction measure to the WPSF value as an approximate efficiency measure.

Conditional Load Response Probabilities – Response probabilities (of failure) corresponding to the conditional load type and scenario under investigation.

Conditionally Unsafe – Assertion that the existence or occurrence of one thing or event (e.g., initiation of dam failure) depends on the existence or occurrence of another thing or event (e.g., extreme flood or extreme seismic event).

Conditional System Response Probability Estimates – System response probabilities that are conditional on the specific loading condition analyzed (over the range of loading conditions to be studied).

Conduit – A closed channel to convey water through, around, or under a dam.

Confirmed (Unconfirmed) – Through investigation or other means, Dam Safety issue is firmly established as of concern or not. Unconfirmed – not confirmed.

Confirmed Dam Safety Issues – Manifested or obvious issues are those impacting the safe operation of a dam. Examples of confirmed issues can be described as performance concerns - lack of spillway or seismic capacity, or deficiencies that are demonstrated by signs of seepage and boils, obvious flaws or defects, component distress or malfunction, unusual settlement, unsatisfactory instrument readings, etc. that can be specifically linked to one or more potential failure modes.

Conservation Pool – The permanent pool that lies just below the flood storage pool in a reservoir.

Construction Joint – The interface between two successive placings or pours of concrete where bond, and not permanent separation, is intended.

Contact Grouting – Filling, with cement grout, any voids existing at the contact of two zones of different materials, e.g., between a concrete tunnel lining and the surrounding rock.

Contractor Quality Control (CQC) – The construction contractor's system to manage, control, and document his own, his supplier's, and his subcontractor's activities to comply with contract requirements.

Core – A zone of low permeability material in an embankment dam. The core is sometimes referred to as central core, inclined core, puddle clay core, rolled clay core, or impervious zone.

Core Wall – A wall built of relatively impervious material, usually of concrete or asphaltic concrete, in the body of an embankment dam to prevent seepage.

Cost-to-Save-a-Statistical-Life (CSSL) – CSSL is the ratio of the cost of a proposed risk reduction measure divided by the consequent estimate of 'Statistical Lives Saved'.

Credible Baseline Risk Estimate – Occurs when the conditional load response probabilities and consequences used to estimate the total project risk are supported by sufficient data, analysis, and performance history. The need for additional information, studies, and investigations to determine or resolve uncertainty should be determined after parametric studies are completed and insight is gained as to improvement in the confidence of the risk estimate by more accurately predicting conditional load response

probabilities or life loss estimates. Typically, risk estimates for confirmed issues can be established with existing data and performance history because the physical manifestations are visual and measurable. Unconfirmed issues may require the collection of additional data if the concerns are less obvious or cannot be linked to a specific failure mode or observation.

Credible Failure Mode – A physically plausible failure mode.

Crest of dam – See top of dam.

Critically near failure – Failure sequence has been initiated and continues under normal loading. Without intervention (e.g., interim risk reduction measures or remediation), dam is expected to fail.

Cross section – An elevation view of a dam formed by passing a plane through the dam perpendicular to the axis.

Cutoff trench – A foundation excavation later to be filled with impervious material so as to limit seepage beneath a dam.

Cutoff wall – A wall of impervious material usually of concrete, asphaltic concrete, or steel sheet piling constructed in the foundation and abutments to reduce seepage beneath and adjacent to the dam.

Dam – An artificial barrier, including appurtenant works, constructed for the purpose of storage, control, or diversion of water, and which (1) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum water storage elevation or (2) has an impounding capacity at maximum water storage elevation of fifty acre-feet or more. Any such barrier which is under six feet in height regardless of storage capacity, or which has a storage capacity at maximum water storage elevation not in excess of fifteen acre-feet regardless of height is not considered a dam. This lower size limitation should be waived if there is a potentially significant downstream hazard.

This definition applies whether the dam has a permanent reservoir or is a detention dam for temporary storage of floodwaters. The impounding capacity at maximum water storage elevation includes storage of floodwaters above the normal full storage elevation. Various types of dams include the following:

a. *Afterbay dam.* See regulating dam.

b. *Ambursen dam*. A buttress dam in which the upstream part is a relatively thin flat slab usually made of reinforced concrete.

c. *Arch dam. A c*oncrete or masonry dam, which is curved upstream so as to transmit the major part of the water load to the abutments.

d. *Buttress dam.* A dam consisting of a watertight part supported at intervals on the downstream side by a series of buttresses. A buttress dam can take many forms, such as a flat slab or a massive head buttress.

e. *Cofferdam.* A temporary structure enclosing all or part of the construction area so that construction can proceed in the dry. A diversion cofferdam diverts a stream into a pipe, channel, tunnel, or other watercourse.

f. *Crib dam.* A gravity dam built up of boxes, crossed timbers, or gabions filled with earth or rock.

g. *Diversion dam.* A dam built to divert water from a waterway or stream into a different watercourse.

h. *Double curvature arch dam.* An arch dam, which is curved vertically as well as horizontally.

i. *Earth dam.* An embankment dam in which more than 50 percent of the total volume is formed of compacted earth material generally smaller than 3-inch size.

j. *Embankment dam.* Any dam constructed of excavated natural materials or of industrial waste materials.

k. *Gravity dam.* A dam constructed of concrete and/or masonry, which relies on its weight and internal strength for stability.

l. *Hollow gravity dam.* A dam constructed of concrete and/or masonry on the outside but having a hollow interior and relying on its weight for stability.

m. *Hydraulic fill dam.* An earth dam constructed of materials, often dredged, which are conveyed and placed by suspension in flowing water.

n. *Industrial waste dam.* An embankment dam, usually built in stages, to create storage for the disposal of waste products from an industrial process. The waste products are conveyed as fine material suspended in water to the reservoir impounded by the embankment. The embankment may be built of conventional materials but sometimes incorporates suitable waste products.

o. *Masonry dam.* Any dam constructed mainly of stone, brick, or concrete blocks jointed with mortar. A dam having only a masonry facing should not be referred to as a masonry dam.

p. *Mine tailings dam.* An industrial waste dam in which the waste materials come from mining operations or mineral processing.

q. *Multiple arch dam.* A buttress dam composed of a series of arches for the upstream face.

r. *Overflow dam.* A dam designed to be overtopped.

s. *Regulating dam.* A dam impounding a reservoir from which water is released to regulate the flow downstream.

t. *Rockfill dam.* An embankment dam in which more than 50 percent of the total volume is composed of compacted or dumped cobbles, boulders, rock fragments, or quarried rock generally larger than 3-inch size.

u. *Roller-compacted concrete dam.* A concrete gravity dam constructed by the use of a dry mix concrete transported by conventional construction equipment and compacted by rolling, usually with vibratory rollers.

v. *Rubble dam.* A stone masonry dam in which the stones are unshaped or uncoursed.

w. *Saddle dam (or dike).* A subsidiary dam of any type constructed across a saddle or low point on the perimeter of a reservoir.

x. *Tailings dam.* See mine tailings dam.

Dam failure – Failure characterized by the sudden, rapid, and uncontrolled release of impounded water. It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters that adversely affect a dam's primary function of impounding water is properly considered a failure. These lesser degrees of failure can lead to loss of services and progressively lead to or heighten the risk of a catastrophic failure.

Dam Safety – Dam safety is the art and science of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment. It requires the collective application of engineering principles and experience, and a philosophy of risk management that recognizes that a dam is a structure whose safe functioning is not explicitly determined by its original design and construction. It also includes all actions taken to identify or predict deficiencies and consequences related to failure, and to document, publicize, and reduce, eliminate, or remediate to the extent reasonably possible any unacceptable risks.

Dam Safety Action Classification (DSAC) System – The Dam Safety Action Classification system is intended to provide consistent and systematic guidelines for appropriate actions to address the dam safety issues and deficiencies of USACE dams.

USACE dams are placed into a Dam Safety Action Classification (DSAC) class based on their individual dam safety risk considered as a combination of probability of failure and potential life safety, economic, environmental, or other consequences. The DSAC table presents different levels and urgencies of actions that are commensurate with the different classes of the safety status of USACE dams. These actions range from immediate recognition of an urgent and compelling situation requiring extraordinary and immediate action for unsafe dams through normal operations and dam safety activities for safe dams.

Dam Safety Committee – The Dam Safety Committee includes the Dam Safety Officer (DSO) and the Dam Safety Program Manager (DSPM) plus additional members as required. The members should include various technical engineering disciplines from within the district. Other disciplines and areas of expertise may be represented, as required by the DSO or Commander. There is a standing Dam Safety Committee at each level of the decentralized USACE program (districts, divisions, and HQ), who convening regularly to discuss dam safety project and program matters, and advice the Commander on critical dam safety related decisions.

Dam Safety Community of Practice Steering Committee (DSSC) – A committee charged with facilitating and promoting dam safety as a fundamental USACE mission in all levels of the organization, promoting dam safety career development, disseminating pertinent information throughout USACE, and reviewing and evaluating policy, technical criteria and practices, administrative procedures, and regulatory functions to support the USACE dam safety program. The DSSC reviews experience and qualifications of dam safety staffing at all levels within the USACE to assess competency, serves as a resource for sharing information and project specific Lessons Learned, and makes recommendations for future research and development in areas related to dam safety. The team shall meet as required, and shall provide advice and information to the Special Assistant for Dam and Levee Safety.

Dam Safety Deficiency – A material defect or load capacity limit that threatens a dam failure.

Dam Safety Issue – Any confirmed or not yet confirmed condition at a dam that could result in intolerable life safety, economic, and environmental risks.

Dam Safety Modification Risk Assessment – The risk assessment addresses the life safety, economic, and environmental risks associated with the identified potential failure modes and the risk reduction that can be achieved with risk reduction measures, including potential staged implementation options.

Dam Safety Modification Study – The safety case that presents the investigation, documentation, and justification of modifications for dam safety at completed Corps of Engineers projects. The report presents the formulation and evaluation for a full range of risk reduction alternatives with preliminary level cost estimates. A detailed risk assessment is required to look at incremental risk reduction alternatives that together

meet the tolerable risk guidelines and cost effectiveness of additional risk reduction below the minimum safety criteria. However, the level of detail should only be what is needed to justify the modification decision. Related NEPA (reference A.109) and ESA studies will be conducted during the Modification Study, in support of the recommended risk reduction measures. The resultant Dam Safety Modification Decision Document will present a comparison of alternatives and the recommended risk management plan to include actions, components, risk reduction by increments, implementation plan, detailed cost estimate, NEPA, and ESA determinations.

Dam Safety Officer – A registered professional civil engineer with management abilities who is competent in the areas related to the design, construction, operation, inspection or evaluation of dams. They must understand adverse dam incidents and the potential causes and consequences of dam failure. The DSO is the highest-ranking Registered Professional Engineer in each level of the Corps of Engineers responsible for implementing the dam safety program of that organization. The Commander shall ensure the DSO meets the technical qualifications and experience. The DSO is the Chair of the Dam Safety Committee.

Dam safety preparedness – The quality or state of being prepared to deal with emergency conditions which endanger the structural integrity of the dam and/or downstream property and human life.

Dam Safety Portfolio Risk Management – The management process shown generally on Figure 2.3 and for USACE in detail on Figure 3.1. It is a risk-informed USACE-wide portfolio perspective process applied to all features of all dams on a continuing basis.

Dam Safety Program – The purposes of a dam safety program are to protect life, property, and the environment by ensuring that all dams are designed, constructed, operated, and maintained as safely and effectively as is reasonably possible. Accomplishing these purposes require commitments to continually inspect, evaluate, and document the design, construction, operations, maintenance, rehabilitation, and emergency preparedness of each dam and the associated public. It also requires the archiving of documents on the inspections and history of dams and the training of personnel who inspect, evaluate, operate, and maintain them. Programs must instill an awareness of dams and the potential hazard that they may present in the owners, the users, the public, and the local and national decision-makers. On both local and national scales, program purposes also include periodic reporting on the degree of program implementation. Key to accomplishing these purposes is to attract, train, and retain a staff proficient in the art and science of dam design.

Dam Safety Program Management Tools – A shared software database, developed and maintained by USACE on behalf of FEMA, used for managing and monitoring Dam Safety Programs. It is used by multiple Federal and State agencies, to track program accomplishments, including entering data for the National Inventory of Dams and preparing the Federal Dam Safety Biennial Report to Congress.

Dam Safety Program Manager (DSPM) – The DSPM is a Dam Safety official at the HQUSACE, MSC, and district level responsible for the overall daily management of the Dam Safety program. These managers normally support and report to the Dam Safety Officer at their respective level.

Dam Safety Senior Oversight Group (SOG) – Designated USACE Dam Safety senior headquarters and field staff team that performs an oversight function for the Dam Safety program. The SOG meets periodically to advise the Dam Safety Officer on key issues related to the program, such as determining Dam Safety Action Classifications. The SOG generally consists of the following members: Special Assistant for Dam and Levee Safety (Chair); USACE CoP leaders (for Geotechnical, Structural and H&H technical disciplines); Regional representatives determined by Special Assistant for Dam and Levee Safety; USACE Business Line & Program Representatives to include USACE DSPM, Flood Damage Reduction, Navigation, Programs, and Dam Safety Risk Management Center Director; and any other Representatives determined by the Special Assistant for Dam and Levee Safety. The Senior Oversight Group is established to vet the findings of the Regional Risk Cadres and confirm dam safety work priorities based on portfolio risk findings.

Design Structural Capacity – The maximum loading condition that the project was planned to withstand, although the project may fail at a lesser loading condition

Design water level – The maximum water elevation including the flood surcharge that a dam is designed to withstand.

Design wind – The most severe wind that is reasonably possible at a particular reservoir for generating wind setup and run-up. The determination will generally include the results of meteorological studies, which combine wind velocity, duration, direction, and seasonal distribution characteristics in a realistic manner.

Diaphragm wall (membrane) – A sheet, thin zone, or facing made of an impervious material such as concrete, steel, wood, or plastic. Also see core wall.

Dike – See Dam, w. *saddle dam.*

Direct Economic Losses – Direct economic losses are the damage to property located downstream from the dam due to the failure. Items in this category include those commonly computed for the National Economic Development (NED) account in any USACE flood risk management study. These include damage to private and public buildings, contents of buildings, vehicles, public infrastructure such as roads and bridges, public utility infrastructure, agricultural crops, agricultural capital, and erosion losses to land.

Disproportionality Ratio – See definition for 'Concept of Disproportionality'.

Diversion channel, canal, or tunnel – A waterway used to divert water from its natural course. The term is generally applied to a temporary arrangement, e.g., to by-pass

water around a dam site during construction. “Channel” is normally used instead of “canal” when the waterway is short.

Drain, blanket – A layer of pervious material placed to facilitate drainage of the foundation and/or embankment.

Drain, chimney – A vertical or inclined layer of pervious material in an embankment to facilitate and control drainage of the embankment fill.

Drain, toe – A system of pipe and/or pervious material along the downstream toe of a dam used to collect seepage from the foundation and embankment and convey it to a free outlet.

Drainage area – The area, which drains to a particular point on a river or stream.
Drainage curtain – Also called drainage wells or relief wells. A line of vertical wells or boreholes placed to facilitate drainage of the foundation and abutments and to reduce water pressure.

Drawdown – The difference between a water level and a lower water level in a reservoir within a particular time. Used as a verb, it is the lowering of the water surface.
DSAC Class I (Urgent and Compelling) – Dams where progression toward failure is confirmed to be taking place under normal operations and the dam is almost certain to fail under normal operations within a time frame from immediately to within a few years without intervention; or, the combination of life or economic consequences with probability of failure is extremely high.

DSAC Class II (Urgent) – Dams where failure could begin during normal operations or be initiated as the consequence of an event. The likelihood of failure from one of these occurrences, prior to remediation, is too high to assure public safety; or, the combination of life or economic consequences with probability of failure is very high.

DSAC Class III (High Priority) – Dams that have issues where the dam is significantly inadequate or the combination of life, economic, or environmental consequences with probability of failure is moderate to high.

DSAC Class IV (Priority) – Dams are inadequate with low risk such that the combination of life, economic, or environmental consequences with a probability of failure is low and the dam may not meet all essential USACE engineering guidelines.

DSAC Class V (Normal) – Dams considered adequately safe, meeting all essential agency guidelines and the residual risk is considered tolerable.

Earthquake – A sudden motion or trembling in the earth caused by the abrupt release of accumulated stress along a fault.

Earthquake, Maximum Credible (MCE) – The most severe earthquake that can be expected to occur at a given site on the basis of geologic and seismological evidence.

Earthquake, Maximum Design (MDE) – A postulated seismic event, specified in terms of specific bedrock motion parameters at a given site, which is used to evaluate the seismic resistance of man-made structures or other features at the site.

Earthquake, Operating Basis (OBE) – The earthquake(s) for which the structure is designed to resist and remain operational. It reflects the level of earthquake protection desired for operational or economic reasons and may be determined on a probabilistic basis considering the regional and local geology and seismology.

Earthquake, Safety Evaluation (SEE) – The earthquake, expressed in terms of magnitude and closest distance from the dam site or in terms of the characteristics of the time history of free-field ground motions, for which the safety of the dam and critical structures associated with the dam are to be evaluated. In many cases, this earthquake will be the maximum credible earthquake to which the dam will be exposed. However, in other cases where the possible sources of ground motion are not easily apparent, it may be a motion with prescribed characteristics selected on the basis of a probabilistic assessment of the ground motions that may occur in the vicinity of the dam. To be considered safe, it should be demonstrated that the dam can withstand this level of earthquake shaking without release of water from the reservoir.

Earthquake, synthetic – Earthquake time history records developed from mathematical models that use white noise, filtered white noise, and stationary and non-stationary filtered white noise, or theoretical seismic source models of failure in the fault zone. (White noise is random energy containing all frequency components in equal proportions. Stationary white noise is random energy with statistical characteristics that do not vary with time).

Economic Consequences – Direct and indirect losses of the failure of a dam and other economic impacts on the regional or national economy. Part of the direct losses is the damage to property located downstream from the dam due to the failure. Items in this category include those commonly computed for the National Economic Development (NED) account in any USACE flood risk management study.

Economic Damages – These include damage to private and public buildings, contents of buildings, vehicles, public infrastructure such as roads and bridges, public utility infrastructure, agricultural crops, agricultural capital, and erosion losses to land.

Economic Regret – Condition when the costs of making a “wrong” decision are deemed to be high. The basic concept of regret is the difference between the outcome of the "best alternative for a future, uncertain state" and outcome of each alternative evaluated

for that state. So it is really the potential costs, if you choose an alternative as the best given some future scenario, and a different future actually happens. All regret values are determined by comparing each alternative to the best (e.g. maximum net benefits) for a scenario. So you end up with a regret matrix with scenarios as column headings and alternatives as row headings. There is nothing in the notion about regret about it being "too high." The minimax principle is usually applied to regret to identify the plan or plans that are robust across multiple future scenarios.

Efficiency – Efficiency is the need for society to distribute and use available resources so as to achieve the greatest benefit. For dam safety investments, this means ensuring that resources and expenditure directed to safety improvements are cost-effective and that an appropriate balance between the monetary and non-monetary benefits and the monetary and non-monetary costs is achieved.

Embankment – A raised structure of earth, rocks, or gravel, usually intended to retain water or carry a roadway.

Emergency – An emergency, in terms of dam operation, is a condition, which develops unexpectedly, endangers the structural integrity of the dam and/or downstream property and human life, and requires immediate action.

Emergency Action Plan (EAP) – An action plan that provides detailed instructions for agencies and individuals for responding to emergencies such as a potential dam failure. Plans typically include threat recognition, emergency action message formulation, message dissemination to authorities and the public, provisions for search and rescue, and early stages of recovery.

Emergency Exercise – Drill – A drill is the lowest level exercise that involves an actual exercise. It tests, develops, or maintains skills in a single emergency response procedure. An example of a drill is an in-house exercise performed to verify the validity of telephone numbers and other means of communication along with the response of the entity responsible for the dam. A drill is considered a necessary part of ongoing training.

Emergency Exercise – Full Scale – The full scale exercise is the most complex level of exercise. It evaluates the operational capability of all facets of the emergency management system (both dam operator and state and local emergency management agencies) interactively in a stressful environment with the actual mobilization of personnel and resources. It includes deployment to and movement in the field of personnel and equipment to demonstrate coordination and response capability. The participants actively "play out" their roles in a dynamic environment that provides the highest degree of realism possible for the simulated event. Actual evacuation of critical residents may be exercised if previously announced to the public.

Emergency Exercise – Functional – The functional exercise is the highest level exercise that does not involve the full activation of the entity responsible for dam operation and

state and local emergency management agency field personnel and facilities or test evacuation of residents downstream of the dam. It involves the various levels of the entity responsible for dam operation and state and local emergency management personnel that would be involved in an actual emergency. The functional exercise takes place in a stress-induced environment with time constraints and involves the simulation of a dam failure and other specified events. The participants "act out" their actual roles. The exercise is designed to evaluate both the internal capabilities and responses of the entity responsible for dam operation and the workability of the information in the EAP used by the emergency management officials to carry out their responsibilities. The functional exercise also is designed to evaluate the coordination activities between the entity responsible for dam operation and emergency management personnel.

Emergency Exercise – Orientation Seminar – This exercise is a seminar that involves bringing together those with a role or interest in an EAP, *i.e*., entity responsible for dam operation and state and local emergency management agencies, to discuss the EAP and initial plans for an annual drill or more in-depth comprehensive exercise. The seminar does not involve an actual exercise of the EAP. Instead, it is a meeting that enables each participant to become familiar with the EAP and the roles, responsibilities, and procedures of those involved. An orientation seminar can also be used to discuss and describe technical matters with involved, non-technical personnel.

Emergency Exercise – Tabletop – The tabletop exercise involves a meeting of the entity responsible for dam operation and the state and local emergency management officials in a conference room environment. The format is usually informal with minimum stress involved. The exercise begins with the description of a simulated event and proceeds with discussions by the participants to evaluate the EAP and response procedures and to resolve concerns regarding coordination and responsibilities.

Endangered Species Act (ESA) – The Endangered Species Act of 1973 (7 U.S.C. § 136, 16 U.S.C. § 1531 et seq.) or ESA is the most wide-ranging of the dozens of United States environmental laws passed in the 1970s. As stated in section 2 of the act, it was designed to protect critically imperiled species from extinction as a "consequence of economic growth and development untendered by adequate concern and conservation." See ER 1105-2-100 Appendix C (reference A.42) for detailed discussion.

Energy dissipater – A device constructed in a waterway to reduce the kinetic energy of fast flowing water.

Environmental and other Non-monetary Consequences – Direct and indirect consequences that cannot be measured in monetary terms. These stem from the impacts of the dam failure flood and loss of pool on environmental, cultural, and historic resources. In most cases, the assessment of the impacts of dam failure will be the reporting of area and type of habitat impacted, habitat of threatened and endangered species impacted, number and type of h

Environmental Impact Statement (EIS) – An environmental impact statement, in the United States, is a document that must be filed when the federal government takes a "major Federal action significantly affecting the quality of the human environment." The law requiring this is the National Environmental Policy Act. See ER 200-2-2 (reference A.37) and ER 1105-2-100, Appendix C (reference A.42), for details on preparation of EIS.

Epicenter – The point on the earth's surface located vertically above the point of origin of an earthquake.

Equity in Risk Management – Equity, in the risk management context, is the right of individuals and society to be protected, and the right that the interests of all are treated with fairness, placing all members of society on a (more) equal footing in terms of levels of risk faced. The equity objective is addressed by requiring that all risks higher than a limit value be brought down to below the limit, except in exceptional circumstances.
Essential Agency Guidelines – The state-of-practice for design, construction, operation, and maintenance of USACE dams as documented in current USACE regulations. The requirements specified in these USACE regulations must be met for a dam to achieve DSAC V (Adequately Safe) classification status. These regulations include: Engineer Circulars, Engineer Regulations, Engineer Manuals, Engineer Pamphlets and Engineer Technical Letters; and Engineering and Construction Bulletins, and other official HQUSACE dam safety-related Policy Letters and guidance. Current state-of-practice guidance is summarized in Appendix E.

Event Tree(s) – An event tree serves as a model of the physical dam system in which each node represents an identifiable behavior of the dam or its physical components and each event should be something that happens in space or time (Hartford and Baecher, 2004). An event tree begins with a single initiating branch on the left hand side and progress toward more detailed events to the right hand side. Starting with an initiating event branch (e.g. a severe flood, an earthquake or other natural or human caused hazards), each node is divided at various nodes to generate all possible subsequent events. Each node is an origin of possible subsequent events and each branch is a possible event that is a logical consequence of the one before it, and a necessary precursor of the one that follows. As the number of events increases, structure fans outs like the branches of a tree until each event tree chain comes to a terminal branch. Terminal branches are the system outcome or system effect of an initiating event which leads to adverse consequences or failure of the system completely or partially. The tree may be extended to represent the economic damages and life loss consequences associated with the terminal branches.

Exposure Assessment – Exposure occurs when a susceptible asset comes in contact with a hazard. An exposure assessment, then, is the determination or estimation (which may be qualitative or quantitative) of the magnitude, frequency, or duration, and route of exposure.

Failure Mode – A way that failure can occur, described by the means by which element or component failures must occur to cause loss of the sub-system or system function of a dam that could result in failure.

Fault – A fracture or fracture zone in the earth crust along which there has been displacement of the two sides relative to one another.

Fault, active – A fault which, because of its present tectonic setting, can undergo movement from time to time in the immediate geologic future.

Fault, capable – An active fault that is judged capable of producing macro earthquakes and exhibits one or more of the following characteristics:

a. Movement at or near the ground surface at least once within the past 35,000 years.

b. Macroseismicity (3.5 magnitude Richter or greater) instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault.

c. A structural relationship to a capable fault such that movement on one fault could be reasonably expected to cause movement on the other.

d. Established patterns of microseismicity, which define a fault, with historic macroseismicity that can reasonably, be associated with the fault.

Fetch – The straight-line distance across a body of water subject to wind forces. The fetch is one of the factors used in calculating wave heights in a reservoir.

Filter (filter zone) – One or more layers of granular material graded (either naturally or by selection) so as to allow seepage through or within the layers while preventing the migration of material from adjacent zones.

Flashboards – Structural members of timber, concrete, or steel placed in channels or on the crest of a spillway to raise the reservoir water level but that may be quickly removed in the event of a flood.

Flip bucket – An energy dissipater located at the downstream end of a spillway and shaped so that water flowing at a high velocity is deflected upwards in a trajectory away from the foundation of the spillway.

Flood – A general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties from: (1) overflow of inland or tidal waters; (2) unusual and rapid accumulation or runoff of surface waters from any source; (3) mudflow; or (4) collapse or subsidence of land along the shore of a lake or similar body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels that result in a flood as defined

above. The four terms below are used to further define flooding and efforts to prevent flooding.

a. *Flood Level.* The size of a flood may be expressed in terms of probability, of exceedance per year such as one percent chance flood or expressed as a fraction of the probable maximum flood or other reference flood.

b. *Flood Control.* The Flood Control Act of 1936 declared that flood control was a national priority since floods constituted a menace to the national welfare. This act authorized the construction of levees, floodwalls, channel improvements, and reservoirs to control flooding.

c. *Flood Damage Reduction.* The term flood damage reduction was adopted in recognition that the structures built for flood control only reduced the level of flooding and did not totally control all floods. Projects developed for flood damage reduction also include non-structural elements.

d. *Flood Risk Management.* This term recognizes that there are different levels of risks in flood control works and in flood damage reduction activities. Since all flood management structures and other features have a risk of failure, the current practice is to seek to reduce the risk to a tolerable level that the public is willing to accept.

Flood routing – A process of determining progressively over time the amplitude of a floodwave as it moves past a dam or downstream to successive points along a river or stream.

Flood, antecedent – A flood or series of floods assumed to occur prior to the occurrence of an inflow design flood.

Flood, base safety standard (BSS) – The inflow design flood where there is no significant increase in adverse consequences from dam failure compared to non-failure adverse consequences.

Flood, Safety Evaluation (SEF) – The largest flood for which the safety of a dam and appurtenant structure is to be evaluated.

Flood, Inflow Design (IDF) – The flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.
Flood, Probable Maximum (PMF) – The most severe flood that is considered reasonably possible at a site as a result of meteorological and hydrologic conditions.

Floodplain – An area adjoining a body of water or natural stream that has been or may be covered by floodwater.

F-N chart (plot) – This chart is a plot of the annual probability of exceedance (greater than or equal to) of potential life loss (F) vs. incremental potential loss of life (N) due to failure compared to the no failure condition. Thus, the F-N chart displays the entire estimated probability distribution of life loss for a reservoir encompassing all failure modes and all population exposure scenarios for a particular reservoir. See figure 5.4.b.

Freeboard – Vertical distance between the design water level and the top of dam.

Full pool – The reservoir level that would be attained when the reservoir is fully utilized for all project purposes, including flood control.

Gallery – A passageway in the body of a dam used for inspection, foundation grouting, and/or drainage.

Gantry crane – A fixed or traveling bent-supported crane for handling heavy equipment.

Gate – A movable, watertight barrier for the control of water in a waterway. Types of gate include the following:

a. *Bascule gate.* See flap gate.

b. *Bulkhead gate.* A gate used either for temporary closure of a channel or conduit before dewatering it for inspection or maintenance or for closure against flowing water when the head difference is small, e.g., for diversion tunnel closure.

c. *Crest gate (spillway gate).* A gate on the crest of a spillway to control the discharge or reservoir water level.

d. *Drum gate.* A type of spillway gate consisting of a long hollow drum. The drum may be held in its raised position by the water pressure in a flotation chamber beneath the dam.

e. *Emergency gate.* A standby or auxiliary gate used when the normal means of water control is not available. Sometimes referred to as guard gate.

f. *Fixed wheel gate (fixed roller gate or fixed axle gate).* A gate having wheels or rollers mounted on the end posts of the gate. The wheels bear against rails fixed in side grooves or gate guides.

g. *Flap gate.* A gate hinged along one edge, usually either the top or bottom edge. Examples of bottom-hinged flap gates are tilting gates and fish belly gates so called from their shape in cross section.

h. *Flood gate.* A gate to control flood release from a reservoir.

i. *Outlet gate.* A gate controlling the flow of water through a reservoir outlet.

j. *Radial gate (tainter gate).* A gate with a curved upstream plate and radial arms hinged to piers or other supporting structure.

k. *Regulating gate (regulating valve).* A gate or valve that operates under full pressure flow conditions to regulate the rate of discharge.

l. *Roller drum gate.* See drum gate.

m. *Roller gate (stoney gate).* A gate for large openings that bears on a train of rollers in each gate guide.

n. *Skimmer gate.* A gate at the spillway crest whose prime purpose is to control the release of debris and logs with a limited amount of water. It is usually a bottom hinged flap or Bascule gate.

o. *Slide gate (sluice gate).* A gate that can be opened or closed by sliding in supporting guides.

Gate chamber – Also called valve chamber. A room from which a gate or valve can be operated, or sometimes in which the gate is located.

Geotextiles – Any fabric or textile (natural or synthetic) when used as an engineering material in conjunction with soil, foundations, or rock. Geotextiles have the following uses: drainage, filtration, separation of materials, reinforcement, moisture barriers, and erosion protection.

Groin – The area along the contact (or intersection) of the face of a dam with the abutments.

Grout – A fluidized material that is injected into soil, rock, concrete, or other construction material to seal openings and to lower the permeability and/or provide additional structural strength. There are four major types of grouting materials: chemical, cement, clay, and bitumen.

Grout curtain – One or more zones, usually thin, in the foundation into which grout is injected to reduce seepage under or around a dam.

Grout blanket – An area of the foundation systematically grouted to a uniform shallow depth.

Grout cap – A concrete pad constructed to facilitate subsequent pressure grouting of the grout curtain.

Hazard – Hazard is anything that is a potential source of harm to a valued asset (human, animal, natural, economic, social).

Hazard Characterization – Hazard Characterization is the qualitative and/or quantitative evaluation of the nature of the adverse effects associated with the identified hazard(s), which may be present in the situation of interest.

Hazard Identification – Hazard Identification identifies all biological, chemical, social, economic, and physical agents or natural/anthropogenic events capable of causing adverse effects on people, property, economy, culture, social structure, or environment.

Hazard potential classification – The rating for a dam based on the potential consequences of failure. The rating is based on potential for loss of life and damage to property that failure of that dam could cause. Such classification is related to the amount of development downstream of a dam.

HAZUS – A database and software system sponsored by the Federal Emergency Management Agency (FEMA) for performing a range of hazard analysis, including flood loss and impacts, for a variety of levels of detail regional wherein analysis supported by national databases; and site specific wherein local data be substituted for data that would come from national databases.

Head, static – The vertical distance between two points in a fluid.

Head, velocity – The vertical distance that would statically result from the velocity of a moving fluid.

Headrace – A free-flow tunnel or open channel that conveys water to the upper end of a penstock; hence, the terms “headrace tunnel” and ‘headrace Canal.”

Heel – The junction of the upstream face of a gravity or arch dam with the ground surface. For an embankment dam the junction is referred to as the upstream toe of the dam.

Height, above ground – The maximum height from natural ground surface to the top of a dam.

Height, dam – The dam height is the vertical distance between the lowest point on the crest of the dam and the lowest point in the original streambed.

Height, hydraulic – The vertical difference between the maximum design water level and the lowest point in the original streambed.

Height, structural – The vertical distance between the lowest point of the excavated foundation to the top of the dam.

Incident – An event occurrence at a dam that could potentially result in a dam safety issue, such as a spillway flood, seismic event, gate operation failure, etc. that should be documented and trigger an investigation.

Inclinometer – An instrument, usually consisting of a metal or plastic tube inserted in a drill hole and a sensitized monitor either lowered into the tube or fixed within the tube. This measures at different points the tube's inclination to the vertical. By integration, the lateral position at different Levels of the tube may be found relative to a point, usually the top or bottom of the tube, assumed to be fixed. The system may be used to measure settlement during embankment construction (Bartholomew, Murray, and Goins 1987). A reference benchmark is used to establish the top of the inclinometer casing. The instrument probe is lowered to each slip joint in the casing, and the depth to each joint is read directly off the tape. Settlement measurements are made as each section of casing is added during embankment construction.

Incremental consequences – Incremental consequences are associated with a failure of the project to provide the planned level of public protection plus any additional risk created by the project due to dam failure. Incremental consequences = (Consequences associated with the estimated performance of the project including failure) - (Consequence associated with the estimated performance of the project hypothetically without failure).

Independent External Peer Review Team – A team of experts selected in accordance with Section 2034 and/ Section 2035 of the Water Resources Development Act of 2007 (Public Law 110-114) to review proposed Civil Works projects and projects under construction.

Independent Technical Review (ITR) – A comprehensive independent review of a technical product (design and construction documents). .The ITR was replaced by an ATR level of review in 2009.

Indirect Economic Impacts – Impacts associated with the destruction of property and the displacement of people due to the failure. The destruction due to the failure flood can have significant impacts on the local and regional economy as businesses at least temporarily close resulting in loss of employment and income. Similarly, economic activity linked to the services provided by the dam will also have consequences. All these indirect losses then have ripple or multiplier effects in the rest of the regional and national economy due to the resulting reduction in spending on goods and services in the region. These losses are the increment to flood losses above those that would have would have occurred had the dam not failed.

Individual incremental life safety tolerable risk guideline (ANCOLD) – For existing dams, the individual risk to the person or group, which is most at risk, should be less than a limit value of 1 in 10,000 per year, except in exceptional circumstances, following the ANCOLD (2003) (reference A.80) individual life safety risk guideline. For new dams or major augmentations , the individual risk to the person or group, which is most at risk,

should be less than a limit value of 1 in 100,000 per year, except in exceptional circumstances, following the ANCOLD (2003) (reference A.80) individual life safety risk guideline. In the case of existing dams and new dams or major augmentations, individual risks are to be lower than the limit values to an extent determined in accordance with the ALARP principle.

Individual Risk – The increment of risk imposed on a particular individual by the existence of a hazardous facility. This increment of risk is an addition to the background risk to life, which the person would live with on a daily basis if the facility did not exist. (ANCOLD October 2003) (Reference A.80).

Initial reservoir filling – A deliberate impoundment to meet project purposes (a continuing process as successively higher pools are attained for flood control projects).

Institute for Water Resources – The U.S. Army Engineer Institute for Water Resources (IWR) was formed to provide forward-looking analysis and research in developing planning methodologies to aid the Civil Works program. Since its beginnings in 1969, the Institute was envisioned to provide the Corps with long-range planning capabilities to assist in improving the civil works planning process. Today the Institute continues to provide the Civil Works program with a variety of products to enhance the U.S. Army Engineer Institute for Water Resources development planning. IWR is comprised of several semi-independent Centers, and a senior staff of planning and policy experts. See http://www.iwr.usace.army.mil.

Instrumentation – An arrangement of devices installed into or near dams (i.e., piezometers, inclinometers, strain gages, measurement points, etc.), which provide for measurements that can be used to evaluate the structural behavior and performance parameters of the structure.

Intake – Any structure in a reservoir, dam, or river through which water can be discharged. Placed at the beginning of an outlet-works waterway (power conduit, water supply conduit), the intake establishes the ultimate drawdown level of the reservoir by the position and size of its opening(s) to the outlet works. The intake may be vertical or inclined towers, drop inlets, or submerged, box-shaped structures.

Intangible Consequences – These are consequences that have no directly observable physical dimensions but exist in the minds, individually and collectively, of those affected. Such consequences are real and can support decisions. Intangible consequences identified in ANCOLD (2003) (reference A.80) include such things as: the grief and loss suffered by relatives and friends of those who die; the impact of multiple deaths on the psyche of the community in which they lived; the stress involved in arranging alternative accommodations and income; the sense of loss by those who enjoyed the natural landscape destroyed; and the fear of lost status and reputation of the dam owning organization and its technical staff (see discussion at paragraph 5.3.10.3 and ANCOLD (2003) (reference A-83). The affect of these intangible

consequences can be observed more tangibly in terms of increased mental health expenditures and increased suicides.

Interagency Committee on Dam Safety – The Interagency Committee on Dam Safety (ICODS) is comprised of a representative of each of the Department of Agriculture, the Department of Defense, the Department of Energy, the Department of the Interior, the Department of Labor, the Federal Emergency Management Agency, the Federal Energy Regulatory Commission, the Nuclear Regulatory Commission, the Tennessee Valley Authority, and the United States Section of the International Boundary Commission. ICODS encourages the establishment and maintenance of effective Federal programs, policies, and guidelines intended to enhance dam safety for the protection of human life and property through coordination and information exchange among Federal agencies concerning implementation of the Federal Guidelines for Dam Safety (reference A.71).

Interim Risk Reduction Measure (IRRM) – Dam Safety Risk Reduction Measures that are to be formulated and undertaken for dams that are not considered to be tolerably safe and are intended as interim until more permanent remediation measures are implemented. Increased monitoring and reservoir restrictions are examples of interim measures that can be taken at a project.

Interim Risk Reduction Measures Plans (IRRMP) – Plans prepared by the districts for all DSAC Class I, II, and III dams. The urgency of submittal corresponds to the DSAC Class. In general, the plans will describe the project and area, dam safety issues, failure modes and analysis, interim risk reduction plans, consequences with and without the plan, schedule, cost, coordination and review documentation, updated emergency action plan, and communications plan.

Intervention – An action taken during the sequence of any failure mechanism either when failure has been initiated or later to prevent or delay completion of failure progression.

Inundation map – A map showing areas that would be affected by flooding from releases from a dam's reservoir. The flooding may be from either controlled or uncontrolled releases or as a result of a dam failure.

Issue Evaluation Studies – Issue Evaluation studies for dams classified in DSAC Classes II, III, and IV are studies to better determine the nature of the dam safety issue and the degree of urgency for action within the context of the full USACE inventory of dams. The intent of an Issue Evaluation Study is to perform a more robust and detailed level of risk assessment, than used in the SPRA that will enable informed decisions about the need for further investigations, the DSAC classification, and interim risk reduction measures implementation. However the level of detail should only be what is needed to justify the decision to pursue or not to pursue a dam safety modification study.

Lead Engineer – A professional engineer, engineering geologist, or geologist, qualified through appropriate technical training and experience, assigned the responsibility to lead the technical team members of a product delivery team. The lead engineer is responsible for working closely with the Project Manager and insuring that all technical requirements are addressed in the Project Management Plan (PMP). The lead engineer insure that the necessary field investigations are completed during the study and design phases; that plans and specifications are reviewed; that the technical comments on the design are properly addressed; and that engineers on the PDT visit the project during the construction phase. When possible the same individual should function as the lead engineer from the start of the dam safety studies until the completion of the modifications to the dam. (This definition is specifically for the dam safety program.)

Length of dam – The length along the top of the dam. This also includes the spillway, power plant, navigation lock, fish pass, etc., where these form part of the length of the dam. If detached from the dam these structures should not be included.

Levee – An embankment whose primary purpose is to furnish flood protection from seasonal high water. Embankments that are subject to water loading for prolonged periods or permanently should be designed in accordance with earth dam criteria.

Life Loss Consequences – This shall include the determination of the population at risk, threaten population, and the estimated potential loss of life.

Life Loss Estimates – Estimate of potential life loss using approved life loss estimating methodology. May be for individual failure modes, or total for specified loading scenario.

Life Safety Tolerable Risk Guidelines – Three types of life safety tolerable risk guidelines will be used under the USACE tolerable risk guidelines. Individual incremental life safety risk using probability of life loss and Societal incremental life safety risk express in two different ways - Probability distribution of potential life loss (F-N chart); Annualized Life Loss (ALL).

Likelihood – Used as a qualitative description of probability and frequency. (ICOLD) A description of the occurrence chance of a particular event.

Limit Line for Life Safety – Tolerable Risk Limit is depicted in Figures 5.4 and 5.5 of Chapter 5, Tolerable Risk Guidelines. It defines the limit line separating unacceptable risk from tolerable risk on F-N diagram.

Limit of Tolerability – Limit of Tolerability as depicted on Figure 5.1 of Chapter 5. It defines the limit line separating Intolerable Residual Risk from Tolerable Residual Risk within the range of tolerability conceptually depicting the ALARP principle.

Liquefaction – A condition whereby soil undergoes continued deformation at a constant

low residual stress or with low residual resistance, due to the buildup and maintenance of high pore water pressures, which reduces the effective confining pressure to a very low value. Pore pressure buildup leading to liquefaction may be due either to static or cyclic stress applications and the possibility of its occurrence will depend on the void ratio or relative density of a cohesionless or slightly cohesive soil and the confining pressure.

Logboom – A chain of logs, drums, or pontoons secured end-to-end and floating on the surface of a reservoir so as to divert floating debris, trash, and logs.

Marginally safe – Safe with reservations, barely within the lowest standards or limits of safety.

Maximum flood control level – The highest elevation of the flood control storage.

Maximum pool – The highest pool elevation resulting from the inflow design flood.

Maximum wave – The highest wave in a wave group.

Minimum operating level – The lowest level to which the reservoir is drawn down under normal operating conditions.

National Dam Safety Review Board – The National Dam Safety Review Board provides the Director of FEMA with advice in setting national dam safety priorities and considers the effects of national policy issues affecting dam safety. Review Board members include FEMA, the Chair of the Board; representatives from four federal agencies that serve on the Interagency Committee on Dam Safety (ICODS); five state dam safety officials; and one member from the private sector.

National Environmental Policy Act (NEPA) – The National Environmental Policy Act (NEPA) (reference A.109) requires federal agencies to integrate environmental values into their decision making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. To meet NEPA requirements federal agencies prepare a detailed statement known as an Environmental Impact Statement (EIS). EPA reviews and comments on EIS's prepared by other federal agencies, maintains a national filing system for all EIS's, and assures that its own actions comply with NEPA.

National Inventory of Dams – The National Inventory of Dams (NID) contains information on approximately 79,000 dams throughout the U.S. that are more than 25 feet high, hold more than 50 acre-feet of water, or are considered a significant hazard if they fail. The NID is maintained and published by the U.S. Army Corps of Engineers with information from all 50 states, Puerto Rico, and 16 Federal agencies. The NID is available on the web at https://rsgis.crrel.usace.army.mil/apex/f?p=397:12:854569765989113.

Non-Structural Risk Reduction – Risk reduction by measures that do not require structural modification or construction related to the dam and its appurtenant works.

Normal Operations – Loading on the dam resulting from day-to-day pool operations to achieve authorized purposes. (For the purposes of a screening analysis for dry dams, or where pool elevations fluctuate widely and no historical normal pool elevation has been established, the normal loading is usually correlated to a 1 to 10 year return period.)

Observation well – A hole used to observe the groundwater surface at atmospheric pressure within soil or rock.

Operation restrictions – Changes to operating pool levels and durations, or reduced lockages, power generation, water supply, or conservation operations.

Outlet – An opening through which water can be freely discharged from a reservoir to the river for a particular purpose.

Outlet works – A dam appurtenance that provides release of water (generally controlled) from a reservoir.

Parametric Studies – Parametric studies execute one application many times with different sets of input parameters. Such studies are in-effect, systematic, carefully controlled sensitivity studies.

Parapet wall – A solid wall built along the top of a dam (upstream or downstream edge) used for ornamentation, for safety of vehicles and pedestrians, or to prevent overtopping caused by wave run-up.

Peer Review – Peer review is a form of deliberation involving an exchange of judgments about the appropriateness of methods and the strength of the author's inferences. Peer review involves the review of a draft product for quality by specialists in the field who were not involved in producing the draft.

Peer Review Panel – A panel of peer experts, usually formed by a district, to review and to advise on particular difficult or controversial technical issues related to a dam safety study. The peer group may be from inside or outside USACE, or whatever combination of experts is judged to best fit the need.

Penstock – A pressurized pipeline or shaft between the reservoir and hydraulic machinery.

Performance Evaluation – Description of how the dam and appurtenant structures have performed over the years since construction.

Performance Uncertainty – Performance uncertainty refers to the situation in which more rigorous and detailed studies are needed to more accurately predict the system response probabilities within each applicable failure mode.

Periodic Assessments (PA) – The periodic assessment will consist of a periodic inspection, a potential failure modes analysis, and a risk assessment based on existing data and a minimum development of limited consequence data. The primary purposes of the Periodic Assessment are to: Confirm the DSAC classification of a project; Justify interim risk reduction measures; Provide initial input for quantitative risk reporting; Identify needed issue evaluation studies; Prioritize issue evaluation studies; Identify operations and maintenance, monitoring, emergency action plan, training and other recurrent needs; and Confirm essential USACE dam safety guidelines are met and determine if the current baseline risk is tolerable to confirm a DSAC class V.

Periodic Inspections (PI) – The recurrent engineering inspections conducted at dams and other civil works structures whose failure or partial failure could jeopardize the operational integrity of the project, endanger the lives and safety of the public or cause substantial property damage shall be periodically inspected and evaluated to ensure their structural stability, safety, and operational adequacy.

Phreatic surface – The free surface of water seeping at atmospheric pressure through soil or rock.

Piezometer – An instrument used for measuring fluid pressure (air or water) within soil, rock, or concrete.

Piping – The progressive development of internal erosion by seepage.

Plunge pool – A natural or artificially created pool that dissipates the energy of free falling water.

Population at Risk – The population downstream of a dam that would be subject to risk from flooding in the instance of a potential dam failure; usually documented in numbers of persons at risk.

Pore water pressure – The interstitial water pressure within a mass of soil, rock, or concrete.

Portfolio Risk Management Process – The management process shown generally on Figure 2.3 and in detail for USACE Figure 3.1. It is a risk-informed USACE-wide portfolio perspective process applied to all features of all dams on a continuing basis. Same definition as 'Dam Safety Portfolio Risk Management Process" above.

Potential Failure Mode (PFM) – The chain of events leading to dam failure or a portion there of that could lead to dam failure. The dam does not have to completely fail in the sense of a complete release of the impounded water.

Potential Failure Mode Analysis (PFMA) – A PFMA is an examination of "potential" failure modes for an existing dam by a team of persons who are qualified either by experience and\or education to evaluate dams. It is based on a review of existing data and information, first hand input from field and operational personnel, site inspection, completed engineering analyses, discussion of dam characteristics, failure causes and an understanding of the consequences of failure. The PFMA is intended to provide enhanced understanding and insight on the risk exposure associated with the dam or levee.

Probability – A measure, of the likelihood, chance, or degree of belief that a particular outcome or consequence will occur. A probability provides a quantitative description of the likelihood of occurrence of a particular event. This is expressed as a value between 0 and 1. (USACE)

Probability of Failure – The probability that a component of a dam or the dam will fail, given a specified load, leading to sudden, rapid, and uncontrolled release of impounded water.

Probability of Individual Life Loss – The probability of individual life loss, which is used in the evaluation of Individual incremental life safety risk, is not necessarily the same as the probability of failure that is used in the evaluation of Reclamation's APF guideline. The probability of life loss is based on the probability of failure and a consideration of exposure factors such as day-night differences in PAR and evaluation and the seasonal presence of people in campgrounds. The level of detail that is appropriate for characterizing exposure factors should be "decision driven", although it is noted that FEMA's HAZUS data base provides opportunity for some level of automation in capturing information on exposure factors. The distinction between probability of failure and probability of life loss is particularly important for navigation dams, but can also have a significant effect on the evaluation of life safety for other types of dams. It applies to societal risk as well as to individual risk.

Probable Maximum Precipitation (PMP) – Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location.

Pumped storage reservoir – A reservoir filled entirely or mainly with water pumped from outside its natural drainage area.

Quality (as related to construction) – Conformance to properly developed requirements.

Quality Assurance (QA) – The procedure by which the Government fulfills its responsibility to be certain the contractors' quality control is functioning and the specified end product is realized.

Quality Management – All control and assurance activities instituted to achieve the product quality established by the contract requirements

Rapid Consequence Analysis/Estimate – The rapid consequence estimate requires a very limited detail, unsteady-flow hydraulic model to reproduce various, with and without, dam failure scenarios. These failure scenarios would include sunny day, Probably Maximum Flood (PMF) and several intermediate load cases between these extremes for both the with and without dam failure condition.

Redundancy – The duplication of critical components of a system with the intention of increasing reliability of the system, usually in the case of a backup or fail-safe.

Regional Cadres – Teams of technical specialists and analysts (cadre) assembled to conduct project specific risk evaluations, such as PFMAs, based on expert knowledge of the geology, hydrology, structural integrity, soils, consequences, and other relevant factors.

Regulation Design Capacity – The maximum hydrologic loading condition (flood hydrograph) above which the project no longer has storage capacity to reduce flow that would provide flood damage reduction benefits. The regulation design capacity is typically the reservoir storage capacity (and attendant operation rules and policies) that are authorized for a flood damage reduction reservoir project. This will always be a hydrologic loading level less than the loading levels used as the structural design capacity.

Reliability – For gate and mechanical systems reliability is defined as the likelihood of successful performance of a given project element. It may be measured on an annualized basis or for some specified time period of interest or, for example, in the case of spillway gates, on a per demand basis. Mathematically, Reliability = 1 - Probability of unsatisfactory operation.

Remediation – Implementation of long-term structural and non-structural risk reduction measures to resolve Dam Safety issues.

Reservoir – A body of water impounded by a dam and in which water can be stored.

Reservoir regulation (or operating) procedure – Operating procedures that govern reservoir storage and releases.

Reservoir surface area – The area covered by a reservoir when filled to a specified level.

Residual Risk – The remaining level of risk at any time before, during and after a program of risk mitigation measures has been taken.

Resilience – The ability to avoid, minimize, withstand, and recover from the effects of adversity, whether natural or manmade, under all circumstances of use.

Riprap – A layer of large uncoursed stone, precast blocks, bags of cement, or other suitable material, generally placed on the upstream slopes of an embankment or along a watercourse as protection against wave action, erosion, or scour. Riprap is usually placed by dumping or other mechanical methods and in some cases is hand placed. It consists of pieces of relatively large size as distinguished from a gravel blanket. Also known as stone slope protection.

Risk – A measure of the probability and severity of undesirable consequences or outcome.

Risk Analysis – Risk analysis is a decision-making framework that comprises three tasks: risk assessment, risk management, and risk communication

Risk Analysis Framework – In 1995 and again in September 2007 the US Office of Management and Budget (OMB) published a memorandum (references A.82 and A.84) setting forth a set of principles (framework) to guide policymakers in assessing, managing, and communicating risk policies.

Risk assessment – Risk assessment is a broad term that encompasses a variety of analytic techniques that are used in different situations, depending upon the nature of the risk, the available data, and needs of decision makers. A risk assessment is a systematic, evidence based approach for quantifying and describing the nature, likelihood, and magnitude of risk associated with the current condition and the same values resulting from a changed condition due to some action. Risk assessment includes explicit acknowledgment of the uncertainties in the risk. As applied to dam safety, the process of identifying the likelihood and consequences of dam failure to provide the basis for informed decisions on a course of action.

Risk Characterization – Risk characterization is the qualitative or quantitative description of the nature, magnitude and likelihood of the adverse effects associated with a hazard with and without a risk management action. A risk characterization often includes: one or more estimates of risk; risk descriptions; evaluations of risk management options; economic and other evaluations; estimates of changes in risk attributable to the management options.

Risk Communication – Risk communication is the open, two-way exchange of information and opinion about hazards and risks leading to a better understanding of the risks and better risk management decisions.

Risk Engine – Software and computational algorithms either commercially available or under development by USACE that is used to construct an event tree for a plausible failure mode and automatically calculate the estimated risk.

Risk Estimate – The end result risk evaluation generated by application of a risk engine to the credible failure mode under study.

Risk Exposure – The population, infrastructure, and other assets and valued resources that would be adversely impact from a dam failure.

Risk-informed – Risk information will play a key role in decisions related to dam safety but will not be the only information to influence the final decisions.

Risk management – Risk management is the process of problem finding and initiating action to identify, evaluate, select, implement, monitor and modify actions taken to alter levels of risk, as compared to taking no action. The purpose of risk management is to choose and prioritize work required to reduce risk.

Risk Management Center (RMC) – An independent USACE Center assigned to the Institute for Water Resources, which is responsible for development and implementation of dam and levee safety policy, prioritization of national dam and levee safety projects and technical consistency of dam and levee safety products. The Center utilizes a combination of in-situ and virtual resources (district, contract, and Risk and Reliability Directory of Expertise, the Modeling, Mapping, and Consequence Production Center, and Policy and Procedures workgroups) to manage the program.

Risk Reduction Measure – Actions formulated and undertaken to reduce risk.

Risk to Tolerable Levels – In context, this refers to implementing dam safety risk reduction measures such that the resulting risk is 'tolerable' as shown graphically in figure 5.1. Generally is the outcome of application of the ALARP (As Low As Reasonably Possible) considerations.

Robustness – Robustness is the ability of a system to continue to operate correctly across a wide range of operational conditions, with minimal damage, alteration or loss of functionality, and to fail gracefully outside of that range. The wider the range of conditions included, the more robust the system.

Rock anchor – A steel rod or cable placed in a hole drilled in rock, held in position by grout, mechanical means, or both. In principle, the same as a rock bolt, but usually the rock anchor is more than 4 meters long.

Rock bolt – A steel rod placed in a hole drilled in rock, held in position by grout, mechanical means, or both. A rock bolt can be tensioned.

Run-up – The vertical distance above the setup that the rush of water reaches when a wave breaks on the dam embankment.

Safe (Unsafe) – Involving little or no chance of dam failure. Meets all required USACE guidelines and criteria.

Safety – Safety is thought of as the condition of being free from danger, risk, or injury. However, safety is not something that can be absolutely achieved or guaranteed. Instead safety is the condition to which risks are managed to acceptable levels. Therefore, safety is a subjective concept based on individual perceptions of risks and their tolerability

Safety Assurance Review Team – Section 2035, Safety assurance review team, Public Law 110-114, the Water Resource Development Act of 2007, requires a safety assurance review of the design and construction of work effecting public safety. This review team is formed at the time pre-construction engineering and design starts and stays with the project until the completion of construction.

Screening Portfolio Risk Analysis (SPRA) – This analysis screens projects based on available information, to expeditiously identify the highest risk dams requiring urgent and compelling action (Dam Safety Action Classification Classes I and II Dams) with low chance of missing any such dams Also, the SPRA is to provide information for preliminary classification of the remainder of the USACE dams into Dam Safety Action Classes III – IV. SPRA does not provide sufficient information to confirm whether a dam can be placed in Dam Safety Action Classification Class V. SPRA will be performed only once for every dam in the USACE inventory. Risk estimates that are computed from SPRA are a relative measure only to compare dams across the USACE portfolio. Decisions and actions relative to tolerable risk cannot be made solely from SPRA results.

Section 1203 – Dam Safety Assurance Cost Sharing – Section 1203, WRDA, 1986 (reference A.99) provides for special cost-sharing for modification of completed Corps of Engineers dam projects that are potential safety hazards in light of current engineering standards and criteria. The problems that meet the criteria of Section 1203 fall into three main categories: hydrologic, seismic, and change in state-of-the-art. (Modifications required on a project due to state-of-the-art changes, but not related to hydrologic or seismic deficiencies, shall be decided on a case-by-case basis by the ASA(CW). Costs incurred in modifications for dam safety assurance shall be recovered in accordance with provisions of the statute.

Seepage – The interstitial movement of water that may take place through a dam, its foundation, or its abutments.

Senior Oversight Group (SOG) – See Dam Safety Senior Oversight Group

Significant Failure Mode – Significant failure modes are a subset of credible failure modes (*i.e. physically possible*). The term “significant” should be judged in the context of the purpose of the risk assessment and the decisions that it will inform. Factors to consider include Dam Safety Action Classification, comparisons with tolerable risk guidelines, scoping the next level of study, portfolio roll-up of the risk estimates, the level of confidence in risk estimates, representation of uncertainty in estimates, and

prioritization for next phase of work. For example credible failure mode should be considered significant if the probability of failure and associated consequences approach closely or exceed a tolerable risk limit guideline.

Significant wave height – The average height of the one-third highest waves of a given wave group.

Sill – A submerged structure across a river to control the water level upstream. The crest of a spillway. A horizontal gate seating, made of wood, stone, concrete, or metal at the invert of any opening or gap in a structure; hence, the expressions “gate sill” and “stoplog sill.”

Slope – Inclination from the horizontal. Sometimes referred to as batter when measured from vertical.

Sluice – An opening for releasing water from below the static head elevation.

Societal incremental life safety tolerable risk guideline – For existing dams, the societal risk should be less than the limit line shown in the chart of societal risk guideline for existing dams, except in exceptional circumstances, following an adaptation of the ANCOLD (2003) (reference A.80) and NSW(2006) (Reference A.106) societal life safety risk guideline. For new dams or Section 216 major modifications (reference A.93), the societal risk should be less than the limit line shown in the chart for societal risk guideline for new dams and Section 216 major modifications (reference A-97), except in exceptional circumstances, following an adaptation of the ANCOLD (2003) (reference A.80) and NSW (2006) (Reference A.106) societal life safety risk guideline. Societal risks are to be lower than the limit lines to an extent determined in accordance with the ALARP principle.

Societal Risk – The risk of widespread or large scale detriment from the realization of a defined risk, the implication being that the consequence would be on such a scale as to provoke a socio/political response, and/or that the risk (that is, the likelihood combined with the consequence) provokes public discussion and is effectively regulated by society as a whole through its political processes and regulatory mechanisms. Such large risks are typically unevenly distributed, as are their attendant benefits. Thus the construction of a dam represents a risk to those close by and a benefit to those further off, or a process may harm some future generation more than the present one. The distribution and balancing of such major costs and benefits is a classic function of Government, subject to public discussion and discussion (HSE, 1995) (Reference A.103) and (ANCOLD October 2003) (Reference A.80).

Special Assistant for Dam and Levee Safety – Acts for the USACE DSO in the execution of daily program activities and serves as Chairman of the HQUSACE DSSC and the SOG. The Special Assistant shall be a registered professional civil engineer with management abilities, be competent in the areas related to the design, construction, or evaluation of dams and understand adverse dam incidents and the

potential causes and consequences of dam failure. The Special Assistant works for and reports directly to the USACE DSO and represents the USACE DSO in the development of the budget submission, working with the appropriate Business Line Managers and the DSRMC to ensure that dam safety priorities are addressed. The Special Assistant serves as the Department of Defense and/or USACE representative on various national teams as directed by the USACE DSO.
Spillway – A structure over or through which flow is discharged from a reservoir. If the rate of flow is controlled by mechanical means such as gates, it is considered a controlled spillway. If the geometry of the spillway is the only control, it is considered an uncontrolled spillway.

Spillway, auxiliary – Any secondary spillway, which is designed to be operated very infrequently and possibly in anticipation of some degree of structural damage or erosion to the spillway during operation.

Spillway, primary (or service) – A spillway designed to provide continuous or frequent releases from a reservoir without significant damage to either the dam or its appurtenant structures.

Spillway Design Flood (SDF) – See Flood, Inflow Design.

Spillway channel – An open channel or closed conduit conveying water from the spillway inlet downstream.

Spillway chute – A steeply sloping spillway channel that conveys discharges at supercritical velocities.

Spillway crest – The lowest level at which water can flow over or through the spillway.

Spillway, fuse plug – A form of auxiliary spillway consisting of a low embankment designed to be overtopped and washed away during an exceptionally large flood.

Spillway, shaft – A vertical or inclined shaft into which water spills and then is conveyed through, under, or around a dam by means of a conduit or tunnel. If the upper part of the shaft is splayed cut and terminates in a circular horizontal weir, it is termed a bellmouth or morning glory spillway.

Stakeholders – Elected, and agency officials, public and private individuals and groups that have a direct stake in the subject matter under consideration.

Stilling basin – A basin constructed to dissipate the energy of rapidly flowing water, e.g., from a spillway or outlet, and to protect the riverbed from erosion.

Stoplogs – Large logs, timbers, metal beams, or metal frames placed on top of each other with their ends held in guides on each side of a channel or conduit so as to

provide a cheaper or more easily handled means of temporary closure than a bulkhead gate.

Storage – The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel. Definitions of specific types of storage in reservoirs are:

a. *Dead storage.* The storage that lies below the invert of the lowest outlet and that, therefore, cannot readily be withdrawn from the reservoir.

b. *Inactive storage.* The storage volume of a reservoir between the crest of the invert of the lowest outlet and the minimum operating level.

c. *Active storage.* The volume of the reservoir that is available for some use such as power generation, irrigation, flood control, or water supply. The bottom elevation is the minimum operating level.

d. *Live storage.* The sum of the active and the inactive storage.

e. *Reservoir capacity.* The sum of the dead and live storage of the reservoir.

f. *Flood surcharge.* The storage volume between the top of the active storage and the design water level.

Surcharge – Any storage above the full pool.

Tailrace – The tunnel, channel, or conduit that conveys the discharge from the turbine to the river; hence, the terms “tailrace tunnel” and “tailrace canal.”

Tailwater level – The level of water in the tailrace at the nearest free surface to the turbine or in the discharge channel immediately downstream of the dam.

Threshold Flood – The flood that fully utilizes the existing dam, i.e., the flood that just exceeds the design maximum water surface elevation at the dam.

Thrust block – A massive block of concrete built to withstand a thrust or pull.

Toe of dam – The junction of the face of a dam with the ground surface. For concrete dams, see heel.

Tolerable Risk – A risk within a range that society can live with so as to secure the benefits provided by the dam. It is a range of risk that we do not regard as negligible or as something we might ignore, but rather as something we need to keep under review and reduce it still further if and as we can (HSE, 1999) (Reference A.104). In addition to the tolerable risk limit the ALARP considerations will be applied to determine tolerable risk.

Tolerable Risk Guidelines – Tolerable risk guidelines are used in risk management to guide the process of examining and judging the significance of estimated risks obtained using risk assessment. The outcomes of risk assessment are inputs to the risk management decision process along with other considerations. Meeting or achieving the tolerable risk guidelines is the goal for all risk reduction measures including permanent and interim measures.

Tolerable Risk Limit – Tolerable risk limit, as depicted on Figure 5.1, defines the limit separating the unacceptable risk region from the range of tolerability.

Top of dam – The elevation of the uppermost surface of a dam, usually a road or walkway excluding any parapet wall, railing, etc.

Total Annual Probability of all Failure Modes – Total estimated annual probability of failure from all failure modes associated with all loading or initiating event types.

Trashrack – A device located at an intake to prevent floating or submerged debris from entering the intake.

Tunnel – A long underground excavation with two or more openings to the surface, usually having a uniform cross section used for access, conveying flows, etc.

Type I IEPR – An Independent External Peer Review conducted for feasibility, reevaluation, modification, and assessment reports with an EIS and managed by an outside eligible organization (OEO) that is described in Internal Revenue Code Section 501(c) (3); as exempt from Federal tax under section 501(a), of the Internal Revenue Code of 1986; as independent; as free from conflicts of interest; does not carry out or advocate for or against Federal water resources projects; and has experience in establishing and administering IEPR panels. These reviews are exempt from the Federal Advisory Committees Act (FACA). The scope of review will address all the underlying planning, engineering, including safety assurance, economics, and environmental analyses performed, not just one aspect of the project.

Type II IEPR – A Safety Assurance Review (SAR) of design and construction activities for flood damage reduction or coastal storm damage reduction projects or for other activities that affect public safety, and will also be conducted for reviewing the relevancy and effectiveness of the Corps inspection of completed works and safety programs in promoting safety and competent performance. They are not required to be managed by OEO's and may be managed by the Corps MSC or by an outside organization. While all aspects of the project may be included in the review, it will focus on the public safety aspects.

Unacceptable Level of Risk – The risk cannot be justified except under extraordinary circumstances.

Unacceptable Risk Region – The region within the risk range shown in figure 5.1 that is above the zone referred to as the 'Range of Tolerability'. In the 'Unacceptable Region' the risk is considered unacceptable and cannot be justified except in extraordinary circumstance HSE (2001) (reference A.105)

Uncertainty – Uncertainty is the result of imperfect knowledge concerning the present or future state of a system, event, situation, or (sub) population under consideration. The level of uncertainty governs the confidence in predictions, inferences, or conclusions.

Unsafe – Unacceptable chance of a dam failure.

Uplift – The uplift pressure in the pores of a material (interstitial pressure) or on the base of a structure.

Upstream blanket – An impervious blanket placed on the reservoir floor and abutments upstream of a dam. For an embankment dam, the blanket may be connected to the core.

Valve – A device fitted to a pipeline or orifice in which the closure member is either rotated or moved transversely or longitudinally in the waterway so as to control or stop the flow.

a. *Hollow jet valve.* A device for regulating high-pressure outlets. Essentially, it is half a needle valve in which the needle closure member moves upstream toward the inlet end of the valve to shut off flow. As there is no convergence at the outlet end, the flow emerges in the form of an annular cylinder, segmented by several splitter ribs for admitting air into the jet interior to prevent jet instability.

b. *Regulating sleeve valve.* A valve for regulating high-pressure outlets and ensuring energy dissipation. Inside the valve there is a fixed-cone, pointed upstream, which ensures dispersion of the jet. Outside the valve a cylindrical sleeve moves downstream to shut off flow by sealing on the periphery of the cone.

Variability – One of two components often thought of as comprising ‘uncertainty’. Epistemic or 'knowledge uncertainty' that is possible to reduce with additional data and study; and aleatory or 'natural variability' that reflects a process that is random but uncertainty in its magnitude and values may not be; reduced with additional data and study. Annual stream flow is an example of 'natural variability.'

Volume of dam – The total space occupied by the materials forming the dam structure computed between abutments and from top to bottom of dam. No deduction is made for small openings such as galleries, adits, tunnels, and operating chambers within the dam structure. Portions of powerplants, locks, spillway, etc., should be included only if they are necessary for the structural stability of the dam.

Watershed divide – The divide or boundary between catchment areas (or drainage areas).

Waterstop – A strip of metal, rubber, or other material used to prevent leakage through joints between adjacent sections of concrete.

Wave run-up – Vertical height above the stillwater level to which water from a specific wave will run up the face of a structure or embankment.

WEDGE Fund – A special line item in the Construction Remaining items entitled Dam Safety Assurance and Seepage Stability Correction Program. Funding is provided to a project for investigation (study and report) and the start of construction for a dam safety modification while waiting for the current budget cycle project funding to become available.

Weir – A notch of regular form through which water flows.

a. *Weir, broad-crested.* An overflow structure on which the nape is supported for an appreciable length in the direction of flow.

b. *Weir, measuring.* A device for measuring the rate of flow of water. It generally consists of a rectangular, trapezoidal, triangular, or other shaped notch, located in a

vertical, thin plate over which water flows. The height of water above the weir crest is used to determine the rate of flow.

c. *Weir, ogee.* A reverse curve, shaped like an elongated letter “S.” The downstream faces of overflow spillways are often made to this shape.

Willingness-to-Pay-to-Prevent-a-Statistical-Fatality – This is defined as the economic principle that attempts to place a value on a potential life lost by determining the willingness of society to pay to prevent a statistical fatality. Such values are determined from studies of court cases involving involuntary death, from Federal and other agency studies of establishing regulatory standards for public safety. See also definition for 'Concept of Disproportionality' for further insight.

Wind setup – The vertical rise in the stillwater level at the face of a structure or embankment caused by wind stresses on the surface of the water.

D.9. U.S. Bureau of Reclamation



conditions between borings requiring additional treatment and/or design modification.

9. It is time that the civil engineering profession in the area of dam design respond with action programs rather than reacting to disasters and analyzing why the situation occurred. This can only be achieved with adequate funding to provide for the proposed Phase I and following Phase II dam inspection and remedial works as outlined by the speakers from the Corps of Engineers. These funds must be generated so that the public safety can be adequately protected.

REFERENCES

American Society Civil Engineers. 1973. Reevaluating spillway adequacy of existing dams: Am. Soc. Civil Engs. Proc., Hydraulics Div. Jour., p. 337-372

Bureau of Reclamation. 1973. Design of small dams, 2nd ed: U. S. Dept. Interior, Bur. Rec., Water Resources Tech. Pub. 816 p.

Corps of Engineers. 1968. Hydraulic design criteria: U. S. Army Corps of Engineers

Carlier, M. 1974. French laws and regulations regarding dam supervision and inspection: Proc. Eng. Found. Conf. on Inspection, Maintenance and Rehabilitation of Old Dams, Asilomar, Calif. Sept. 1973, Published by Am. Soc. Civil Engineers

Davis, W. E. 1973. Buffalo Creek Dam disaster - why it happened: Civil Eng. July 1973 p. 69-72.

U. S. Department Agriculture. 1972. National engineering handbook, Section 4, Hydrology: U. S. Dept. Agri., Soil Cons. Service. Aug. 1972.

BUREAU OF RECLAMATION'S CRITERIA FOR THE DESIGN OF SPILLWAYS

By Erwin Thomas Scherich[1/]

Of the Bureau of Reclamation's 340 plus storage dams about 30 meet our definition of small dams - up to 50 feet in height above streambed and up to 1,000,000 cubic yards embankment volume. We also have designed over 136 diversion dams - nearly all meeting our definition of small dams. Of the small storage dams, storage capacities range from 100 acre-feet to 527,000 acre-feet. The dam impounding a 527,000 acre-foot reservoir is only 37 feet high. From a safety standpoint volume of storage, in most cases, should be of more concern than height of dam or volume of embankment, and we have no quarrel with the limitation of 1,000 acre-foot storage for the small dam category used by other agencies.

Our earliest storage dam, Minidoka, was completed in 1906. It is 48 feet high, has an embankment volume of 257,300 cubic yards, and creates a reservoir of 210,000 acre-foot capacity. I mention this early dam to focus attention on the fact that when design criteria are evaluated we must keep in mind that dams are not designed for a certain number of years of useful life. After a service of two, three, or many times the repayment period, dams are expected to continue to function in a safe manner. Dams and their appurtenant

1/ Civil Engineer, Spillways, Outlets, and Experimental Analysis Section, Hydraulic Structures Branch, Division of Design, Engineering and Research Center, Bureau of Reclamation, Denver, Colorado.

structures should be designed to give satisfactory and safe service for an indefinite period. Federal agencies continue to have responsibility for dams they design, or are placed under their supervision, after operation and maintenance have been transferred to the owners, perhaps an irrigation district. This accounts, at least in part, for a tendency toward conservatism in design.

Even with this tendency to be conservative in our design assumptions, we have 86 dams under study primarily to determine if they can safely handle newly prepared inflow design floods. Inadequate spillway capacity has proved to be a major cause for concern. I am convinced that the greatest single deficiency in dams throughout the world is inadequate spillway capacity.

In small as well as large dams the first and most important concern of the designer should be the capability, by temporary surcharge storage in conjunction with releases through spillways and outlet works, to safely handle the inflow design flood. The inflow design flood may be the maximum probable flood, a less than maximum probable flood, or even a definite frequency flood, for example, 100-year frequency.

The flood selected for the spillway design is obviously the key to the dam safety, and to a great extent, the structural cost, and in many cases, the project cost. The selection of the inflow design flood involves consideration of dam height, storage capacity of the reservoir behind the dam, type of development - present and projected - in the floodplain downstream from the dam, potential hazard to life

in case of failure, and importance of the value of water stored behind the dam. The following criteria are used by the Bureau of Reclamation for selection of the inflow design flood:

1. Where failure of the dam would endanger human life and/or would cause excessive property damage, a maximum probable flood is used to size surcharge space and spillway capacity.

2. Where failure of the dam would not endanger human life, and would not cause heavy property damage to present or to projected future development below the dam but would impair the usefulness of the project, a less than maximum probable flood may be used to size surcharge space and spillway capacity provided a minimum freeboard will result (depending on type and construction of dam) when the maximum probable flood is routed through the reservoir.

3. Where failure of the dam would not endanger human life, would not cause significant property damage, or seriously impair the usefulness of the project such as the supply of water to a municipality or other critical use or where repair or replacement would not involve major costs or delays in the supply of water, such as a diversion dam, a specific frequency flood (50- or 100-year frequency) may be used to size the surcharge space and the spillway.

Criterion No. 2 is currently (1974) being used for the design of

Palmetto Bend Dam in Texas, a dam of intermediate height - 64 feet above streambed - but large capacity and embankment volume - 170,500 acre-feet and 5,436,000 cubic yards. The less than maximum probable flood was used to establish the dam crest with a normal 8 feet of freeboard allowance for a gated spillway. The maximum probable flood results in a 3-foot encroachment on the freeboard - a 5-foot encroachment would have been considered the maximum for the existing conditions.

After having decided on the appropriate inflow design flood to use in establishing surcharge space and spillway capacity, the second step is to determine a freeboard allowance that will satisfy conditions that exist for the proposed dam. These conditions include computed wave heights based on fetch and wind velocity assumptions, provisions for settlement where poor foundation conditions exist, an arbitrary allowance for improper gate operation where applicable, and perhaps an arbitrary allowance for contingencies to provide an increased factor of safety.

The third step is to determine the combination of surcharge storage and spillway capacity which will result in the least total project cost. This is the least total cost for the level of safety established for conditions that exist for a particular dam and involves comparative cost estimates for various sizes and types of spillways and combinations with outlet works of various sizes and types. Ungated spillways should be favored because of greater reliability over gated spillways where the economic choice is not clearly indicated by the cost difference. It is acceptable Bureau of

Reclamation practice to use auxiliary spillways and flood outlets in combination with service spillways where site and operating conditions are favorable. It is also acceptable practice to store the volume of the inflow design flood provided flood outlet capacity is adequate to evacuate the volume of a 100-year frequency flood antecedent to or subsequent to the inflow design flood, and provided further that the flood outlet is considered to be highly reliable. Where no spillway is provided evacuation of surcharge space must be accomplished at the maximum rate possible for the outlet works. In some cases an emergency spillway may be added to increase the safety against overtopping. Outlet works reliability and requirements for use of auxiliary and emergency spillways are discussed further in later paragraphs.

The three steps that have been discussed establish the level of safety for the dam, assuming the spillways and outlet works function in a manner that will not endanger the integrity of the dam. The design criteria for these structures will now be considered.

The service spillway control structure must have the capacity assumed in the flood routings and must safely convey the flood releases to the stream beyond the toe of the dam. These criteria involve careful crest design and gating provisions where applicable; adequate chute capacity with allowance for freeboard; and adequate energy dissipation for the conditions that exist in the stream and at the downstream toe of the dam.

Where an auxiliary spillway is used in combination with the service spillway it is current practice in the Bureau to set the free overflow control level, or the reservoir level where auxiliary spillway gates are to be put into operation, at the maximum water surface elevation for a 100-year frequency flood or some other specific frequency flood routed through the service spillway. The auxiliary spillway thus will only have infrequent use and should be designed to minimum standards provided the following requirements are met:

1. The auxiliary spillway will discharge into a water course sufficiently separated from the dam abutment and discharging into the main stream a sufficient distance downstream from the toe of the dam that maximum releases will not endanger the dam integrity.

2. The control weir and spillway channel are separated from the dam and service spillway a sufficient distance or by adequate rock formation to insure that maximum releases will be contained in the auxiliary spillway channel and not endanger the service spillway.

3. The auxiliary channel is in adequate rock or is adequately protected by grass lining or other protective surfacing to withstand maximum flows to the degree that the reservoir control does not degrade to a level below the top of conservation storage and further to the extent that restoration of the channel to original grade and condition is feasible.

4. A permanent grade sill or overflow crest is provided to maintain a positive control level.

Where the volume of the inflow design flood is temporarily stored in the surcharge space of the reservoir, the outlet works must be highly reliable and of adequate capacity to evacuate a 100-year frequency flood antecedent to or subsequent to the inflow design flood. The time interval between peaks is established by hydrometeorological determination. The outlet works must also be operated at full capacity to evacuate the surcharge capacity as rapidly as possible.

Where an emergency spillway is used for additional safety, the control is usually set at the maximum water surface for the inflow design flood routed through the reservoir. The emergency type spillway is rarely used in Bureau designs. It would be appropriate where storage is provided for the entire flood volume and marginal evacuation facilities are provided or where a small service spillway can become clogged. We consider the auxiliary type, which by our definition is intended to function on a specific frequency basis, more desirable and may be more economic where flood volumes are relatively large with respect to reservoir storage capability.

Normally our policy is to locate spillways on the rock formation where such exists at reasonable depths. In some instances we have decided that the dam embankment may provide better foundation conditions than the natural ground at the site. In recent years we have located free overflow spillways for small and intermediate dam

heights on the embankment. These spillways have rather small capacity and are combined with high capacity flood outlet works. Two examples are Meeks Cabin Dam which is in operation, and Currant Creek Dam on which construction will begin this year. Meeks Cabin Dam is 74 feet high above streambed and has a storage capacity of 33,090 acre-feet. The flood release capacities are 1,070 cfs for the outlet works and 6,250 cfs for the spillway. Currant Creek Dam will be 132 feet high above streambed and has a storage capacity of 15,670 acre-feet. The flood release capacities are 5,540 cfs for the outlet works and 850 cfs for the spillway.

Of somewhat less importance than the foregoing considerations are the design details of the control structure; conveyance chute, conduit or tunnel; energy dissipator; and upstream and downstream channels. These features become of greater significance with increases in dam height. Individual spillway features should be designed to give the level of performance and safety that can be justified by the conditions that exist for a particular dam. Factors that should be considered include frequency of operation and type of flood used in establishing the dam crest elevation.

This means that the inflow design flood - maximum probable, less than maximum probable, or definite frequency - used in sizing surcharge space and spillway capacity should also be the design flood for the individual features. As in our practice for establishing dam freeboard, however, the maximum probable flood must be accounted for. For example, if the less than maximum probable flood is used for

sizing surcharge storage capacity and spillway capacity, and normal freeboard is provided to establish the crest of the dam, encroachment on freeboard is permitted up to a minimum established value for the maximum probable flood routed through the reservoir. All of the features of the spillway should be designed to normal standards for the less than maximum probable flood and to reduced but safe standards for the maximum probable flood. Likewise, performance standards should be higher for a spillway where reservoir operation studies indicate there will be frequent spills, than if the studies indicate the spillway will be rarely used.

The control structure may be a simple weir or may be of more complex design with automatic gates and precisely designed flow surfaces. Ordinarily, large discharge capacities and high heads will require much more refinement in the hydraulic design than small discharge and low heads. The designer has many types of spillway control structures to choose from.

Spillways are frequently classified according to the type of control (free overflow or gated) and according to type of conveyance (chute, tunnel, or conduit). In addition to these general classifications, the control structure may be one of the following:

1. Ogee crest - straight or curved
2. Broad crest or flat crest
3. Side channel or double side channel
4. Drop inlet, often called shaft or morninglory
5. Siphon

6. Straight drop inlet

Types of energy dissipators are as numerous and include the following:

1. Hydraulic jump stilling basin
2. Impact type dissipator
3. Deflector bucket
4. Submerged deflector bucket
5. Plunge pool
6. Baffled chute

The most appropriate combination depends upon topographic features of the site, the relationship of storage capacity to flood volume, geologic conditions, degree of protection desired, type of dam, height of dam, and many other factors peculiar to a particular site. The experienced designer has many highly developed options to choose from in providing a desired level of protection for a dam. In the Bureau of Reclamation we prefer to select protective measures which can be designed to reasonably assure a degree of risk which can be evaluated in terms of progressive structural damage without endangering human life or causing excessive property loss.

My discussion of spillway designs has intentionally included spillways for large dams and large reservoirs in order to avoid limitations as to applicability. For small dams of 40-foot hydraulic height and less than 1,000 acre-feet of normal storage capacity, the chances of a catastrophic failure will ordinarily be much less than for a large dam. However, I have observed some very questionable residential zoning immediately downstream from dams of this size.

Small dams can be designed to withstand a small amount of overtopping without rapid loss of water in storage. For example, compacted cohesive embankments provide considerable resistance to erosion. Where accurate predictions of release rates can be made, use of specific frequency floods (50 to 100 years) may frequently be justified for establishing surcharge storage space and spillway capacity. We would use a maximum probable flood for evaluation of overtopping risks.

Spillways for small dams usually are of simple design but should have adequate provisions for safe release of the routed inflow design flood to the stream below the dam. Two feet of freeboard for the dam may be adequate if the reservoir storage capacity is small. We consider an uncontrolled overflow crest superior to a gated flood outlet, but where a gated flood outlet is used, provisions can ordinarily be made for free overflow in the gate shaft at very little added expense. This overflow weir is usually located at the top of a divider wall in the gate shaft and at the top of active storage to prevent storage in the surcharge space when the gates are closed. The need for energy dissipation should always be investigated in order that the downstream toe of the dam or the end of the spillway is not subjected to damaging erosion conditions.

The design criteria that I have discussed apply to new construction. It is desirable that existing dams meet these criteria but a different set of economic factors may exist for an old dam than for a dam that is being planned. For example, the ability of the dam owner to finance expensive modifications may be severely limited or the

ratio of benefits to costs may not justify continued operation of the project. Faced with such conditions, the reasonable approach is to evaluate the probable results of continued unsafe operation.

The Bureau of Reclamation has established systematic evaluation procedures that are used for dams that do not meet acceptable standards for safe operation. Deficiencies are usually discovered by routing an updated inflow design flood through the reservoir. In areas of high seismic risk a seismic study is made in addition to the flood routing study.

Before corrective measures are recommended, freeboard allowances are reviewed taking into account the known condition of the dam and other factors that have become known during the operating life of the dam. Operating procedures are examined to determine if an acceptable level of safety can be produced by a limited reservation of storage space during periods of high flood risk. If it is finally determined that overtopping will occur for the inflow design flood, the failure mode and rate are estimated and time-stage relationship is computed for the flow through the breached dam. Downstream loss of life and property damage is then estimated. Finally a decision on the best course of action may be made on the basis of the following alternatives:

1. Modification of dam and spillway to a satisfactory level of safety and performance. (This alternative includes replacement of the dam and construction of additional upstream storage.)

2. Continue to operate the project with reduced storage or other operational adjustments which will assure safety.

3. Continue to operate the project without modification but with knowledge of effects of overtopping. Where human life is endangered or excessive property loss would result from overtopping the dam, this alternative is not considered to be acceptable.

4. Dewater reservoir, demolish dam, and restore site to acceptable environmental standards.

My discussion of spillway design criteria has been focused on those elements that are critical with respect to dam safety. Of greatest importance is the selection of the appropriate inflow design flood for the level of safety indicated by such factors as value of stored water and risks to property and human life in the flood plain below the dam. This desired level of safety can only be assured by adequate provisions for temporarily storing and/or releasing flood water. Flood releases must be conveyed over, under, or around the dam to the stream below in such a manner that the dam will not be damaged. To economically accomplish this the designer has at his disposal many highly developed types of spillways and flood outlets that can be used separately or in combination. For large and small dams alike the spillway should be considered equal in importance to the dam. No dam should be built without adequate provisions for safely handling a major flood.

RECLAMATION

Managing Water in the West

Design Standards No. 14

Appurtenant Structures for Dams (Spillway and Outlet Works) Design Standards

Chapter 1: Introduction
Draft: Phase 3 (Public and Stakeholders Review)

U.S. Department of Interior
Bureau of Reclamation

March 2010

MISSION STATEMENTS

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Design Standards Signature Sheet

Design Standards No. 14

Appurtenant Structures for Dams (Spillways and Outlet Works) Design Standards

DS-14(1)-2: Draft: Phase 3 (Public and Stakeholders Review) March 2010

Chapter 1: Introduction

Approved:

_____ _____

Deputy Commissioner, Operations **Date**

Chapter Signature Sheet
Bureau of Reclamation
Technical Service Center

Design Standards No. 14

Appurtenant Structures for Dams (Spillways and Outlet Works) Design Standards

Chapter 1: Introduction

DS-14(1)-2:[1] Draft: Phase 3 (Public and Stakeholders Review)
March 2010

Design Standard 14 is a new document. Chapter 1 of this Design Standard was developed to provide:

- An overview of how the Bureau of Reclamation analyzes/designs spillways and outlet works appurtenant for dams and/or dikes.
- An outline of the following chapters for this design standard that provides details for spillway and outlet works analyses/designs.
- A list of key technical references used for each major task involved with spillway and outlet works analyses/designs.

[1] DS-14(1)-2 refers to Design Standard No. 14, chapter 1, revision 2.

Prepared by:

John LaBoon, P.E.
Design Standard Team Leader

3/12/2010
Date

Technical Approval:

Bill Fiedler, P.E.
Technical Specialist

3/18/2010
Date

Peer Review:

Tom Hepler, P.E.
Civil Engineer

3/18/2010
Date

Don Read, P.E.
Technical Specialist

3-19-2010
Date

Security Review:

Larry Nuss, P.E
Technical Specialist

3/18/2010
Date

Submitted:

Richard LaFond, P.E.
Chief, Civil Engineering Division

3/29/10
Date

Approved:

Lowell Pimley, P.E.
Director, Technical Service Center

Date

Contents

Page

Chapter 1: Introduction 1-1
1.1 Purpose 1-1
1.2 Application of Design Standards 1-1
1.3 Deviations and Proposed Revisions 1-1
1.4 Scope 1-2
1.5 Definitions 1-2
1.5.1 Spillway 1-2
1.5.1.1 Service Spillway 1-3
1.5.1.2 Auxiliary Spillway 1-3
1.5.1.3 Emergency Spillway 1-3
1.5.2 Outlet Works 1-3
1.6 Configurations 1-4
1.6.1 Spillway 1-4
1.6.2 Outlet Works 1-5
1.7 Design Procedures/Considerations 1-7
1.7.1 Spillway Design/Analysis 1-7
1.7.1.1 Location, Type and Size. 1-7
1.7.1.2 Hydraulic Analysis/Design 1-8
1.7.1.3 Foundation Analysis/Design 1-10
1.7.1.4 Structural Analysis/Design 1-11
1.7.1.5 Mechanical/Electrical Design 1-13
1.7.1.6 Risk Analysis (only for significant and high hazard dams/dikes) 1-15
1.7.2 Outlet Works Design/Analysis 1-17
1.7.2.1 Location, Type and Size. 1-17
1.7.2.2 Hydraulic Analysis/Design 1-19
1.7.2.3 Foundation Analysis/Design 1-21
1.7.2.4 Structural Analysis/Design 1-22
1.7.2.5 Mechanical/Electrical Design. 1-23
1.7.2.6 Risk Analysis (only for significant and high hazard dams/dikes) 1-25

References 1-39

Figures

		Page
1.5.1.1-1	Example: Service spillway (gated) – Jackson Lake Dam, Wyoming	1-28
1.5.1.1-2	Example: Service spillway (ogee crest) – Crystal Dam, Colorado	1-28
1.5.1.2-3	Example: Auxiliary spillway (gated) in foreground, service spillway (gated) in background – Stewart Mountain Dam, Arizona	1-29
1.5.1.2-4	Example: Auxiliary spillway (grade control sill) – Heart Butte Dam, North Dakota	1-29
1.5.1.3-5	Example: Emergency spillway (fuseplug) in foreground, auxiliary spillway (ogee crest) in background – New Waddell Dam, Arizona	1-30
1.5.1.3-6	Example: Emergency spillway – San Justo Dam, California	1-30
1.5.2-7	Example: Combination tunnel outlet work and power penstock, highlighting a number of features such as the upstream intake structure and the downstream control structures. Theodore Roosevelt Dam, Arizona	1-31
1.6.1-8	Common features of spillway	1-32
1.6.1-9	Ogee crest (uncontrolled) spillway – Bumping Lake Dam, Washington	1-33
1.6.1-10	Double side-channel (bathtub) crest (uncontrolled) spillway – Fontenelle Dam, Wyoming	1-33
1.6.1.-11	Side-channel crest (uncontrolled) spillway – Big Sandy Dam, Wyoming	1-34
1.6.1-12	Morning glory (glory hole) crest (uncontrolled) spillway – Whiskeytown Dam, California	1-34
1.6.1-13	Labyrinth crest (uncontrolled) spillway – Ute Dam, New Mexico	1-35
1.6.1-14	Radial gated (controlled) spillway – Stewart Mountain Dam, Arizona	1-35
1.6.1-15	Crest (Obermeyer type) gated (controlled) spillway – Friant Dam, California	1-35
1.6.1-16	Drum gated (controlled) spillway – Hoover Dam, Arizona-Nevada	1-35
1.6.1-17	Fuseplug crest (controlled) spillway (reservoir rim) – Horseshoe Dam, Arizona	1-36
1.6.1-18	Fusegate (controlled) spillway – Terminus Dam, California	1-36
1.6.2-19	Common features of outlet works	1-37
1.6.2-20	Preferred outlet works configuration: hydraulic control at upstream intake with free flow conditions downstream of the regulating gate/valve	1-38

Figures

Page

1.6.2-21 Preferred outlet works configuration: hydraulic control at downstream control structure, with guard/emergency gate/valve at/near centerline of dam/dike, and downstream pressurized pipe (between dam/dike centerline and control structure inside larger access conduit) 1-38

1.6.2-22 Acceptable outlet works configuration: hydraulic control at/near centerline of dam/dike with free flow conditions downstream of the regulating gate/valve 1-38

1.6.2-23 Least acceptable outlet works configuration: hydraulic control at downstream control structure (i.e., pressurized flow conditions upstream of the regulating gate/valve along most of the outlet works) 1-38

Chapter 1

Introduction

1.1 Purpose

The design standards present clear and concise technical requirements and processes to enable design professionals to prepare design documents and reports necessary to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. Compliance with these design standards assists in the development and improvement of Bureau of Reclamation (Reclamation) facilities in a way that protects the public's health, safety, and welfare; recognizes all stakeholder needs; and achieves the lasting value and functionality necessary for Reclamation facilities. The responsible designer(s) accomplishes this through processes that enable compliance with these design standards and all other applicable technical codes, as well as incorporation of the stakeholder's vision and values, that are then reflected in the construction project.

1.2 Application of Design Standards

All Reclamation design work, whether performed by the Technical Service Center (TSC), the regional offices, or an architectural/engineering (A&E) firm, will conform to the design standards.

Reclamation's use of its design standards requires designers to also integrate sound engineering judgment with applicable national standards, site-specific technical considerations, and project-specific considerations to ensure suitable designs and protect public safety.

The design standards are not intended to provide cookbook solutions to complex engineering problems. Strict adherence to a handbook procedure is not a substitute for sound engineering judgment. The designer should be aware of and use state-of-the-art procedures. Designers are responsible for using the most current edition of referenced codes and standards and to be aware that Reclamation design standards may include exceptions to requirements of these codes and standards.

1.3 Deviations and Proposed Revisions

Design activities must be performed in accordance with established Reclamation design criteria, Reclamation engineering, architectural, or technical standards, and approved national design standards. Exceptions to this requirement will be

pursued in accordance with provisions of Reclamation Manual Policy, *Performing Designs and Construction Activities*, FAC P03.

Reclamation designers should inform the TSC, via the Web site notification procedure, of any recommended updates or changes for the design standards to meet current design practices.

1.4 Scope

Design Standard No. 14 provides technical guidance concerning Reclamation's procedures/considerations for analyzing/designing two key appurtenant structures associated with dams and/or dikes. These appurtenant structures are spillways and outlet works. Chapter 1 provides an overview for the analysis/design of spillways and outlet works, while the following chapters provide detailed procedures/considerations that should be followed by Reclamation staff and others involved with analyzing/designing modifications to and/or new spillways and outlet works. It should be stressed that this design standard will not duplicate other existing technical references but, wherever possible, it will reference existing procedures/considerations that should be used for the analysis/design of spillways and outlet works.

1.5 Definitions

The following definitions are provided to clarify the terminology used in Design Standard No. 14. These definitions are consistent with other technical references used by Reclamation.

1.5.1 Spillway

A spillway is a hydraulic structure that passes normal (operational) and/or flood flows in a manner that protects the structural integrity of the dam and/or dikes (reservoir impoundment structures). Spillways are hydraulically sized to safely pass the Inflow Design Flood (IDF).[2] The IDF will be equal to, or less than, the Probable Maximum Flood (PMF).[3] For more details and guidance about floods, refer to Chapter 2, "Hydrologic Considerations."

---

[2] For significant and high hazard dams and/or dikes and their appurtenant structures, selection of the IDF will be based on a quantitative risk analysis. The IDF will be less than, or equal to, the PMF.

[3] The largest flood that may reasonably be expected to occur at a given maximum runoff condition resulting from the most severe combination of meteorological and hydrologic conditions that are considered reasonably possible for the drainage basin under study.

There are three types or classifications of spillways typically employed by Reclamation, which are based on frequency of use. They are explained in more detail below.

1.5.1.1 Service Spillway

A service spillway provides continuous or frequent regulated (controlled) or unregulated (uncontrolled) releases from a reservoir without significant damage to the dam, dike, or appurtenant structures due to releases up to and including the design discharge. Service spillways are illustrated in figures 1.5.1.1-1 and 1.5.1.1-2.

1.5.1.2 Auxiliary Spillway

An auxiliary spillway is infrequently used and may be a secondary spillway which is operated sparingly. During operation there could be some degree of structural damage or erosion to the auxiliary spillway due to releases up to and including the design discharge. Auxiliary spillways are illustrated in figures 1.5.1.2-3 and 1.5.1.2-4.

1.5.1.3 Emergency Spillway

An emergency spillway is designed to provide additional protection against overtopping of a dam and/or dike and is intended for use under extreme conditions such as misoperation or malfunction of the service spillway or other emergency conditions or during very large, remote floods (such as the PMF). As with auxiliary spillways, some degree of structural damage and/or erosion would be expected due to releases up to and including the design discharge. Emergency spillways are illustrated in figures 1.5.1.3-5 and 1.5.1.3-6.

1.5.2 Outlet Works

Outlet works consist of a combination of features (i.e., intake structure, conveyance features such as conduits, control structure, etc.) and operating equipment (electrical and mechanical) required for the safe operation and control of water released from a reservoir to meet downstream needs. The outlet works serves various purposes such as regulating streamflow and water quality; releasing floodwater; power generation; emergency evacuation; and providing irrigation, municipal, and/or industrial water. Features of outlet works are illustrated in figure 1.5.2-7.

1.6 Configurations

There are some common/typical and unique configurations (features) associated with spillways and outlet works. These features are further discussed in the following sections.

1.6.1 Spillway

Generally speaking, features common to most spillways are illustrated in figure 1.6.1-8 and include:

- Approach channel and safety/debris/log boom.
- Control structure, such as crest structure or grade sill, and gates, bulkheads, stoplogs, along with associated operating equipment.
- Conveyance features, such as chute floor and walls and/or conduit(s)/tunnel(s).
- Terminal structure, such as hydraulic jump stilling basin, flip bucket, plunge pool, etc.
- Downstream channel.

Another consideration of the spillway configuration relates to the type of hydraulic control. With some exceptions,[4] the two types are uncontrolled or free-flow spillways and controlled or gated spillways. The hydraulic control is usually based on whether the spillway crest structure has gates or not. Finally, with some exceptions, the spillway is typically referred to by the type of crest structure, such as:

- For uncontrolled spillways:
    - Ogee crest (figure 1.6.1-9) and grade control sill spillway (figures 1.5.1.2-4 and 1.5.1.3-6).
    - Bathtub (or double side-channel) (figure 1.6.1-10) and side-channel ogee crest spillway (figure 1.6.1-11).
    - Morning glory (or glory hole) spillway (figure1.6.1-12).
    - Labyrinth weir spillway (figure 1.6.1-13).

[4] There are exceptions, such as the morning glory spillway, that could experience hydraulic control shifts with increasing hydraulic head: crest or free flow control to throat or orifice control to pipe or pressure control.

- For controlled spillways:

    - Gated spillway (figures 1.6.1-14 through 1.6.1-16).
    - Fuseplug spillway (figure 1.6.1-17).
    - Fusegate spillway (figure 1.6.1-18).

Consideration should also be given to the location of the spillway, which should not be on or through an embankment dam/dike unless there is justification to deviate. The preferred locations would be on the dam abutments or through the reservoir rim.

For more detailed guidance, refer to Chapter 3, "General Spillway Design Considerations."

1.6.2 Outlet Works

Features common to most outlet works are illustrated in figure 1.6.2-19 and include:

- Intake structures, trashracks, gates/valves, and bulkheads (if appropriate).

- Conveyance features, such as conduit(s)/tunnel(s).

- Control structure, such as gate chamber, gates/valves, access shaft/adit/conduit, along with operating equipment.

- Terminal structure, such as hydraulic jump stilling basin, impact structure, plunge pool, etc.

- Downstream channel.

Considerations that should be used, unless there is justification to deviate, include:

- Two gates or valves in series should be installed and operated in Reclamation outlet works. The downstream gate or valve provides regulating capabilities, while the upstream gate or valve provides emergency closure capabilities under unbalanced head (flow) conditions, or routine closure capabilities under balanced head (nonflow) conditions.

- Although common throughout the water resource engineering industry, constructing an outlet works through/beneath an embankment dam and/or dike should be viewed as a second choice (i.e., avoid/limit contact/interface between the conduit and embankment). A preferred

alternative to minimize internal erosion potential is to construct a tunnel outlet works through the dam and/or dike abutment or through the reservoir rim.

Another aspect of outlet works configuration relates to the location of hydraulic control (i.e., the location of the regulating gate or valve). The four configurations [1][5] typically used by Reclamation are illustrated in figures 1.6.2-20 through 1.6.2-23 and include the following:[6,7]

- **Preferred configuration.** Hydraulic control at intake with free flow conditions downstream of the regulating gate or valve. Most often used for low head applications in embankment dams where pressurized flow is not required at the downstream end of the outlet works. When the outlet works is not being operated, there is access for inspection and maintenance through the entire length of the conduit (figure 1.6.2-20).

- **Preferred configuration.** Hydraulic control at downstream control structure, with guard/emergency gate/valve at/near centerline of dam/dike, and downstream pressurized pipe (between dam/dike centerline and control structure) inside larger access conduit. Applicable for power generation or pressurized downstream flow. During both operation and nonoperation of the outlet works, there is excellent access for inspection and maintenance through downstream conduit (figure 1.6.2-21).

- **Acceptable configuration.** Hydraulic control at/near the dam/dike centerline with free flow conditions downstream of the regulating gate or valve. When the outlet works is not being operated, there is access for inspection and maintenance through the downstream conduit (figure 1.6.2-22).

- **Least acceptable configuration.** Hydraulic control at the downstream end of the outlet works, which may be near the downstream toe or face of the dam/dike (i.e., pressure flow conditions upstream of the regulating gate or valve along most of the outlet works). Commonly used in concrete

---

[5] Numbers in brackets indicate a reference listed at the end of this chapter.

[6] Outlet works configurations are listed in order of increasing potential of pressurizing surrounding dam, dike, and/or foundation materials, which could lead to an incident or failure.

[7] Although the figures associated with following outlet works configurations illustrate an outlet works through/beneath an embankment dam/dike (which should be a second choice to a tunnel through the dam/dike abutment or reservoir rim), the focus is on the hydraulic control configuration, which would be applicable regardless of the location of the outlet works.

dams. Accessibility for inspection and maintenance is limited (underwater inspection) without bulkheading upstream intake structure or draining the reservoir (figure 1.6.2-23).

For more detailed guidance, refer to Chapter 4, "General Outlet Works and Diversion Design Considerations."

1.7 Design Procedures/Considerations

Details of analysis/design procedures/considerations will be provided in the following chapters of Design Standard No. 14. An overview is provided in the following text of this chapter. Analysis and/or design (including both new and modification) for a spillway and/or outlet works will typically follow a number of key procedural guidelines including:

- Design data collection guidelines [2].
- Feasibility design guidelines [3].
- Final design process [4].
- Cost estimating [5].
- Safety of Dams project management guidelines [6].

1.7.1 Spillway Design/Analysis

Tasks for analyzing/designing spillways are summarized in the following sections.

1.7.1.1 Location, Type, and Size

Selection of the location, type, and size of a spillway will be dependent on the evaluation of a number of factors including:

- Site conditions (geology/topography).
- Dam and/or dike type.
- Hydrologic considerations.
- Hydraulic considerations.
- Seismic considerations.

- Construction/constructability considerations.
- Project objectives.
- Robustness of design.
- Risks associated with Plausible Potential Failure Modes (PFMs), which must be tolerably below Reclamation's public protection guidelines [7].
- Operation and maintenance considerations.
- Economics.

These factors are further discussed in the following chapters of this design standard and some of the following sections. Two factors that should be highlighted, which are somewhat unique to Reclamation facilities, are the robustness of design and the risks associated with PFMs. Because many of the spillways are associated with significant and high hazard dams/dikes, it is important that any new or modified appurtenant structure designs protect the public to levels consistent with Reclamation's public protection guidelines [7] (i.e., maintain and/or reduce risks to acceptable levels). This could mean some redundant features/equipment and designing to stricter requirements than commonly called for by professional codes, standards, and/or guidelines.

For more detailed guidance associated with locating, along with selecting, a type and size of a spillway, refer to Chapter 3, "General Spillway Design Considerations."

1.7.1.2 Hydraulic Analysis/Design

The hydraulic analysis/design will be concurrent with the previous task of locating and selecting a type and size of spillway. The following chapters of this design standard explain the steps of hydraulic analysis/design, including:

- Develop/verify discharge curves.
- Prepare initial flood routings of frequency floods up to the PMF to verify the appropriateness of the spillway type and size, and to select the IDF.
- Refine spillway control (crest) structure layout and associated discharge curves based on results from previous steps.

- Prepare final flood routings to estimate maximum reservoir water surfaces (RWS) and discharge ranges for various floods and operational conditions (part of the final flood routings will include a freeboard assessment, which is sometimes referred to as a robustness study).

- Prepare initial water surface profiles to lay out the spillway conveyance features and terminal structure size and type.

- Refine spillway conveyance features and terminal structure based on results from previous step.

- Prepare final water surface profiles to finalize size and type of the spillway conveyance features and terminal structure.

For more detailed guidance associated with hydrologic and hydraulic analysis/design for a spillway, refer to Chapter 2, "Hydrologic Considerations," and Chapter 5, "Hydraulic Considerations."

Technical references associated with the hydraulic analysis/design of spillways include:

- *Design of Small Dams*, third edition [8].

- Engineering Monograph (EM) No. 9 – *Discharge Coefficients for Irregular Overfall Spillways* [9].

- EM No. 25 – *Hydraulic Design of Stilling Basins and Energy Dissipators* [10].

- EM No. 42 – *Cavitation in Chutes and Spillways* [11].

- Reclamation – Engineering and Research Center (REC-ERC)-73-5 – *Hydraulic Model Studies of Chute Offsets, Air Slots, and Deflectors for High-Velocity Jets* [12].

- REC-ERC-78-8 – *Low Froude Number Stilling Basin Design* [13].

- REC-ERC-85-7 – *Hydraulic Model Studies of Fuseplug Embankments* [14].

- REC-ERC-88-3 – *Overtopping Flow on Low Embankment Dams – Summary Report of Model Test* [15].

- Dam Safety Office (DSO)-07-07 – *Uplift and Crack Flow Resulting from High Velocity Discharges Over Offset Joints* [16].

- Assistant Commissioner – Engineering and Research (ACER) Technical Memorandum (TM) No. 10 – *Guidelines for Using Fuseplug Embankments in Auxiliary Spillways* [17].

- *Hydraulic and Excavation Tables,* 11th edition [18].

- *Computing Degradation and Local Scour* [19].

- *Guide for Computing Water Surface Profiles* [20].

- *Design of Labyrinth Spillways* [50].

- *Research State-of-the-Art and Needs for Hydraulic Design of Stepped Spillways* [51].

- *Plastic Pipe Used In Embankment Dams: Best Practices for Design, Construction, Identification and Evaluation, Inspection, Maintenance, Renovation, and Repair* [52].

- *Outlet Works Energy Dissipators: Best Practices for Design, Construction, Identification and Evaluation, Inspection, Maintenance, Renovation, and Repair* [53].

1.7.1.3 Foundation Analysis/Design

The foundation analysis/design will start when a tentative type and size of spillway is located and selected, and it parallels the structural analysis/design efforts. The following chapters of this design standard explain the steps of foundation analysis/design, including:

- Define site-specific foundation material and strength properties.

- Assist in identifying suitable sites based on site-specific foundation needs for a spillway.

- Define and analyze ground water conditions.

- Develop appropriate foundation designs which include:

    - Drainage features such as underdrains, slope drainage, and filters (NOTE: Identify and evaluate drainage features/systems that will be accessible for inspection using closed circuit television (CCTV) equipment).
    - Adequate support for the spillway, which could range from excavating to competent rock to driving piles or placing piers in a soil foundation.

- Accommodating loading conditions on the spillway that could include static (hydrostatic, rock/soil, ice and frost heave), hydrologic (floods), and seismic (hydrodynamic, dynamic soil/rock) loads.

For more detailed guidance associated with foundation analysis/design for a spillway, refer to Chapter 6, "Foundation Considerations."

Technical references associated with the foundation analysis/design of spillways include:

- *Design of Small Dams*, third edition [8].
- EM No. 13 – *Estimating Foundation Settlement by One-Dimensional Consolidation Tests* [21].
- REC-ERC-74-10 – *Rock Mechanics Properties of Typical Foundation Rock Types* [22].
- REC-ERC-82-17 – *Frost Action in Soil Foundations and Control of Surface Structure Heaving* [23].
- ACER TM No. 9 – *Guidelines for Controlling Seepage Along Conduits Through Embankments* [24].
- *Drainage for Dams and Associated Structures* [25].
- *Guidelines, Foundation and Geotechnical Studies for Existing Concrete Dams* [41].

1.7.1.4 Structural Analysis/Design

The structural analysis/design of the spillway typically follows the hydraulic analysis/design. The following chapters of this design standard explain the steps of structural analysis/design, including:

- Identify which features are considered "critical"[8] and "noncritical."[9] [26]

[8] A critical feature is one in which its failure or damage could lead to failure and/or damage of the dam/dike or other appurtenant structures, which, in turn, may lead to the uncontrolled release of part or the entire reservoir or leave the appurtenant structure inoperable, preventing releases needed to protect the dam/dike.

[9] A noncritical structure is one in which failure or damage would not lead to failure of and/or damage to the dam/dike, nor would it inhibit operations of the structure to protect the dam/dike.

- Identify and define loading conditions for both critical and noncritical features, which will typically fall into four categories, including:

  - Construction.
  - Operational (normal or static).
  - Flood (hydrologic).
  - Earthquake (seismic).[10]

- Identify, evaluate, and select material types and associated properties. Materials could include concrete (reinforced, conventional mass, roller compacted, and precast), steel, and plastic such as high-density polyethylene (HDPE).

- Apply appropriate structural analysis/design methods, which are based on the crawl, walk, and run philosophy (i.e., using the simplest approach that is technically adequate to prepare the analysis/design). These include:

  - **For analyses.** Pseudo-static, linear elastic finite element modeling (FEM), using response spectra, and nonlinear elastic FEM, using time histories, are employed to analyze a structure.
  - **For designs.** Design methods are typically based on Reclamation technical references, such as *Design of Small Dams* [8], and industry codes are used, such as the American Concrete Institute (ACI) manuals.

For more detailed guidance associated with structural analysis/design for a spillway, refer to Chapter 7, "Structural Considerations."

Technical references associated with the structural analysis/design of spillways include:

- *Design of Small Dams*, third edition [8].

- EM No. 14 – *Beggs Deformeter-Stress Analysis of Single-Barrel Conduits* [27].

- EM No. 14 Supplement – *Beggs Deformeter-Analysis of Additional Shapes* [28].

---

[10] For significant and high hazard dams and/or dikes and their appurtenant structures which have been identified as "critical," selection of the seismic design load will be based on a quantitative risk analysis. For noncritical structures, a minimum earthquake loading will be used which approximates a design basis earthquake (DBE) or about a 500-year event.

- EM No. 27 – *Moments and Reactions for Rectangular Plates* [29].
- EM No. 34 – *Control of Cracking in Mass Concrete Structures* [30].
- *Concrete Manual*, eighth edition [31].
- Current ACI 318 and ACI 350 building codes.
- EM 1110-2-2104 – *Strength Design for Reinforced Concrete Hydraulic Structures, U.S. Army Corps of Engineers* [32].
- ACI SP-3 – *Reinforced Concrete Design Handbook* (Working Stress Method), third edition [33].
- *Design Criteria for Retaining Walls* [34].
- *Roller-Compacted Concrete: Design and Construction Considerations for Hydraulic Structures* [35].

1.7.1.5 Mechanical/Electrical Design

The mechanical/electrical design takes place concurrently with the structural analysis/design. The following chapters of this design standard explain the steps of mechanical/electrical design, including:

- Select, size, and design gates/valves, if applicable.
- Select, size, and design trashracks, stoplogs, and/or bulkhead gates, if applicable.
- Select, size, and design gate/valve operators and generators, if applicable.
- Select, size, and design heating, ventilation, and cooling (HVAC) systems, if applicable.
- Select, size, and design hoists and/or cranes, if applicable.
- Design lighting and electrical control systems for gate/valve operations, HVAC systems, and supervisory control and data acquisition (SCADA) systems.
- Address life safety considerations as note in the National Fire Protection Association (NFPA) 100, *Life Safety Code Handbook*, 2009 edition.

For more detailed guidance associated with mechanical/electrical design for a spillway, refer to Chapter 7, “Mechanical/Electrical Considerations.”

Selection of type and size of a spillway gate and operating system will be dependent on the evaluation of a number of factors including:

- Site conditions.
- Spillway configuration.
- Access.
- Available power.
- Hydraulic considerations.
- Seismic considerations.
- Construction/constructability considerations.
- Ice loading.
- Navigation needs.
- Sediment and debris loading.
- Operation and maintenance considerations.
- Economics.

These factors are further discussed in the following chapters of this design standard and some of the following sections. Because many of the spillways are associated with significant and high hazard dams/dikes, and failure of gates/valves may result in uncontrolled release of large flows, some redundant features/equipment might be required. Therefore, it may be advisable to design to stricter requirements than commonly called for by professional codes, standards, and/or guidelines.

Technical references associated with the mechanical/electrical design of spillways include:

- American Institute of Steel Construction (AISC) *Manual of Steel Construction*, thirteenth edition - refer to American National Standards Institute (ANSI)/AISC 360-05, Specifications for Structural Steel Buildings).

- American Welding Society (AWS) AWS D1.1/D1.1M Structural Welding Code – Steel; AWS D1.6 Structural Welding Code - Stainless Steel.

1.7.1.6 Risk Analysis (Only for Significant and High Hazard Dams/Dikes)

Probabilistic (in the form of a quantitative risk analysis), rather than deterministic, considerations will be part of any analysis/design for significant and high hazard dams and/or dikes, along with associated appurtenant structures (such as spillways) or critical components of associated appurtenant structures. The steps will be integrated with the previous design/analysis and include:

- Identify and define credible PFMs for the existing, modified, and/or new spillway. Although each spillway may have some unique PFMs, common PFMs include:

  - Flood-induced overtopping of dam and/or dike.
  - Flood-induced spillway operations which exceed the original/maximum design discharge, leading to overtopping of the chute wall and/or terminal structure walls, pressurizing the conduit and/or tunnel, or sweepout of the terminal structure, and leading to erosional headcutting of the spillway foundation or erosion of the dam and/or dam foundation.
  - Flood-induced spillway operations which result in cavitation damage of the chute and/or conduit, leading to erosion of the foundation.

  - Flood-induced operations which result in stagnation pressure (hydraulic jacking) and/or structural collapse of the chute and/or terminal structure, leading to erosion of the foundation.
  - Seismic-induced structural collapse of the spillway crest structure or features (such as piers, walls, and/or gates).

- Based on Reclamation's public protection guidelines [7], estimate the sum of the baseline (existing) annual probability of failure (APF) for all credible PFMs, and annualized loss of life (ALL) for all credible PFMs for a given loading condition, associated with existing and/or new dams, dikes, and all appurtenant structures such as spillways and outlet works.

- If an existing spillway is to be modified, estimate the sum of the modified APF for all credible PMFs and the sum of ALL for all credible PMFs associated with a given loading condition.

- For the modified or new spillway, if estimated sum of APF for all credible PFMs, and the sum of ALL for all credible PFMs associated with a given loading condition are "tolerably"[11] below Reclamation guidelines (1E-4 or a 1 in 10,000 chance during a given year for APF; and 1E-3 or a 1 in 1,000 chance during a given year for ALL), designs may be acceptable; however, if not tolerably below Reclamation guidelines, additional design considerations/features will be necessary to lower the estimated APF and ALL for the modified or new spillway.

- To address the uncertainties associated with using quantitative risk analysis to select an IDF, a robustness study is done to evaluate plausible operational and hydrologic/hydraulic scenarios that could increase the maximum RWS above the IDF-induced RWS. Typical scenarios that are evaluated include:

    - Misoperation.
    - Change in hydrology.
    - Debris blockage.
    - Change in downstream consequences.
    - Wind-generated waves.

For more detailed guidance associated with risk analysis/design for a spillway, refer to Chapter 2, "Hydrologic Considerations" and Chapter 3, "General Spillway Design Considerations".

Technical references associated with the risk analysis/design of spillways include:

- *Guidelines for Achieving Public Protection in Dam Safety Decisionmaking* [7].

- REC-ERC-88-3 – *Overtopping Flow on Low Embankment Dams – Summary Report of Model Test* [15].

- DSO-07-07 – *Uplift and Crack Flow Resulting from High Velocity Discharges Over Offset Joints* [16].

- DSO-99-06 – *A Procedure for Estimating Loss of Life Caused by Dam Failure* [36].

---

[11] Tolerably below Reclamation guidelines will be unique to each condition/situation and will be mutually agreed to by the designer of record and Reclamation's Dam Safety Office, along with concurrence by Reclamation management. Consideration will include the level of uncertainty associated with estimates, and future conditions that could increase the estimates (such as changes in downstream consequences).

- Final Technical Report No. 99DG81029 – *Considerations for Estimating Structural Response Probabilities in Dam Safety Risk Analysis* [37].

- Appendix D – *Toolbox for Handling Loads by Upstream Dams and Incorporating Consequences for Failure of Downstream Dams* [38].

- DSO-98-004 – *Prediction of Embankment Dam Breach Parameters: A Literature Review and Needs Assessment* [39].

- *Interim Guidelines for Addressing the Risk of Extreme Hydrologic Events* [40].

- *Risk Analysis Facilitator's Notebook* [42].

- *Dam Safety Risk Analysis Best Practices Training Manual* [43].

1.7.2 Outlet Works Design/Analysis

Tasks for analyzing/designing outlet works are summarized in the following sections.

1.7.2.1 Location, Type and Size

Similar to the spillway, selection of the location, type, and size of an outlet works will be dependent on the evaluation of a number of factors including:

- Site conditions (geology/topography).

- Dam and/or dike type.

- Hydrologic considerations.

- Hydraulic considerations.

- Seismic considerations.

- Construction/constructability considerations.

- Project objectives.

- Robustness of design.

- Risks associated with credible PFMs, which must be tolerably below Reclamation's public protection guidelines [7].

- Operation and maintenance considerations.

- Economics.

These factors are further discussed in the following chapters of this design standard and some of the following sections. Also, the two factors that were highlighted for the spillway are also highlighted for the outlet works, which are the robustness of design and the risks associated with PFMs. It is worth restating that because many of the outlet works are associated with significant and high hazard dams/dikes, it is important that any new or modified appurtenant structure designs protect the public to levels consistent with Reclamation's public protection guidelines [7]. This could mean some redundant features/equipment and designing to stricter requirements than commonly called for by professional codes, standards, and/or guidelines. Additionally, it should be restated that, as a starting point, an outlet works should include:

- Two gates or valves in series (one guard or emergency valve and one regulating gate/valve) that can be operated under unbalanced head conditions.

- Hydraulic control at or upstream of the projected centerline of the dam/dike with either a pressurized pipe inside a larger access conduit and/or tunnel or a free flow conduit and/or tunnel downstream of hydraulic control, particularly when associated with embankment dams/dikes.

- Stoplogs or bulkhead and slots provided near the intake structure.

- For embankment and/or rockfill dams/dikes, isolate the outlet works from the dam/dike (i.e., consider tunnel through the dam/dike abutments or reservoir rim, rather than a cut-and-cover outlet works through or beneath the dam/dike).

There will be cases where deviation from the above considerations will occur. However, there should be strong justification to not incorporate these considerations.

For more detailed guidance associated with locating, along with selecting, a type and size of an outlet works, refer to Chapter 4, "General Outlet Works and Diversion Design Considerations."

1.7.2.2 Hydraulic Analysis/Design

Similar to the spillway, the hydraulic analysis/design will be concurrent with the previous task of locating and selecting a type and size of outlet works. The following chapters of the design standard explain the following steps of hydraulic analysis/design:

- Develop/verify discharge curves.
- Evaluate intake structure and conveyance features (such as conduit) sizes, along with gate/valve types/sizes based on:
    - **Diversion.** If outlet works will be used for diversion during construction, initial flood routings of diversion floods (sometimes referred to as construction floods) should be done to size conveyance features and temporary cofferdams.
    - **Normal operations.** Evaluate conveyance features size and gate/valve type/size for passing operational flows.
    - **Emergency evacuation.** Evaluate ability of outlet works to lower the reservoir in a timely fashion pursuant to guidelines noted in *Criteria and Guidelines for Evacuating Storage Reservoirs and Sizing Low-Level Outlet Works* [45].
    - **Floods.** Although not typical, some outlet works are used in passing floods. If this is the case, flood routing steps similar to those noted for the spillway should be employed.
- Refine discharge curves based on results from previous steps and finalize intake structure and conveyance features sizes, along with gate/valve types/sizes.
- Depending on type/configuration of the outlet works, initial water surface profiles to layout conveyance features (such as chute/conduit) and terminal structure size and type.
- Final water surface profiles to finalize size and type of outlet works conveyance features and terminal structure.

For more detailed guidance associated with hydraulic analysis/design for an outlet works, refer to Chapter 2, “Hydrologic Considerations,” and Chapter 5, “Hydraulic Considerations.”

Technical references associated with the hydraulic analysis/design of outlet works include:

- *Conduits through Embankment Dams: Best Practices for Design, Construction, Problems Identification and Evaluation, Inspection, Maintenance, Renovation, and Repair* [1].
- *Design of Small Dams*, third edition [8].
- EM No. 25 – *Hydraulic Design of Stilling Basins and Energy Dissipators* [10].
- REC-ERC-73-5 – *Hydraulic Model Studies of Chute Offsets, Air Slots, and Deflectors for High-Velocity Jets* [12].
- REC-ERC-78-8 – *Low Froude Number Stilling Basin Design* [13].
- DSO-07-07 – *Uplift and Crack Flow Resulting from High Velocity Discharges Over Offset Joints* [16].
- *Hydraulic and Excavation Tables*, 11th edition [18].
- *Computing Degradation and Local Scour* [19].
- *Guide for Computing Water Surface Profiles* [20].
- ACER TM No. 3 – *Criteria and Guidelines for Evacuating Storage Reservoirs and Sizing Low-Level Outlet Works* [44].
- EM No. 7 – *Friction Factors for Large Conduits Flowing Full* [45].
- REC-ERC-78-24 – *Hydraulic Design of Stilling Basin for Pipe or Channel Outlets* [46].
- EM No. 41 – *Air-Water Flow in Hydraulic Structures* [47].
- ACER TM No. 4 – *Criteria for Bulkheading Outlet Works Intakes for Storage Dams* [48].
- *Plastic Pipe Used In Embankment Dams: Best Practices for Design, Construction, Identification and Evaluation, Inspection, Maintenance, Renovation, and Repair* [52].

- *Outlet Works Energy Dissipators: Best Practices for Design, Construction, Identification and Evaluation, Inspection, Maintenance, Renovation, and Repair* [53].

1.7.2.3 Foundation Analysis/Design

The foundation analysis/design will start when locating and selecting a type and size of outlet works and parallels the structural analysis/design efforts. The following chapters of this design standard explain the steps of foundation analysis/design, including:

- Define site-specific foundation material and strength of properties.
- Assist in identifying suitable sites based on site-specific foundation needs for an outlet works.
- Define and analyze ground water conditions.
- Develop appropriate foundation designs which include:
    - Drainage features, which in many cases are the key foundation design feature. (NOTE: Identify and evaluate drainage features/systems that will be accessible for inspection using CCTV equipment).
    - Adequate support for the outlet, which could range from excavating to competent rock to driving piles, placing piers in a soil foundation, or supporting excavated tunnels with rock bolts, shotcrete, etc.
- Accommodating loading conditions loads on the outlet works that could include static (hydrostatic, rock/soil, ice, and frost heave), hydrologic (floods), and seismic (hydrodynamic, dynamic soil/rock) loads, etc.

For more detailed guidance associated with foundation analysis/design for an outlet works, refer to Chapter 6, “Foundation Considerations.”

Technical references associated with the foundation analysis/design of outlet works include:

- *Conduits through Embankment Dams: Best Practices for Design, Construction, Problems Identification and Evaluation, Inspection, Maintenance, Renovation, and Repair* [1].
- *Design of Small Dams*, third edition [8].
- EM No. 13 – *Estimating Foundation Settlement by One-Dimensional Consolidation Tests* [21].

- REC-ERC-74-10 – *Rock Mechanics Properties of Typical Foundation Rock Types* [22].

- REC-ERC-82-17 – *Frost Action in Soil Foundations and Control of Surface Structure Heaving* [23].

- ACER TM No. 9 – *Guidelines for Controlling Seepage Along Conduits Through Embankments* [24].

- *Drainage for Dams and Associated Structures* [25].

1.7.2.4 Structural Analysis/Design

Similar to the spillway, the structural analysis/design of the outlet works typically follows the hydraulic analysis/design. The following chapters of this design standard explain the steps of structural analysis/design, including:

- Identify which features are considered "critical"[7] and "noncritical"[8] [26].

- Identify and define loading conditions for both critical and noncritical features, which will typically fall into four categories, including:

  - Construction.
  - Operational (normal or static).
  - Flood (hydrologic).
  - Earthquake (seismic).

- Identify, evaluate, and select material types and associated properties. Materials could include concrete (reinforced, conventional mass, roller compacted, and precast), steel, and plastic such as HDPE.

- Apply appropriate structural analysis/design methods which are based on the crawl, walk, and run philosophy (i.e., using the simplest approach that is technically adequate to prepare the analysis/design). These include:

  - **For analyses.** Pseudo-static, linear elastic FEM using response spectra and nonlinear elastic FEM using time histories.

  - **For designs.** Design methods are typically based on Reclamation technical references such as *Design of Small Dams* [8], and industry codes are used such as the ACI manuals.

For more detailed guidance associated with structural analysis/design for an outlet works, refer to Chapter 7, "Structural Considerations."

Technical references associated with the structural analysis/design of outlet works include:

- *Conduits through Embankment Dams: Best Practices for Design, Construction, Problems Identification and Evaluation, Inspection, Maintenance, Renovation, and Repair* [1].
- *Design of Small Dams*, third edition [8].
- EM No. 14 – *Beggs Deformeter-Stress Analysis of Single-Barrel Conduits* [27].
- EM No. 14 Supplement – *Beggs Deformeter-Analysis of Additional Shapes* [28].
- EM No. 27 – *Moments and Reactions for Rectangular Plates* [29].
- EM No. 34 – *Control of Cracking in Mass Concrete Structures* [30].
- *Concrete Manual*, eighth edition [31].
- Current ACI 318 and ACI 350 building codes.
- EM 1110-2-2104 – *Strength Design for Reinforced-Concrete Design of Hydraulic Structures* [32].
- ACI SP-3 – *Reinforced Concrete Design Handbook (Working Stress Method),* third edition [33].
- *Design Criteria for Retaining Walls* [34].
- *Roller-Compacted Concrete: Design and Construction Considerations for Hydraulic Structures* [35].

1.7.2.5 Mechanical/Electrical Design.

The mechanical/electrical design takes place concurrently with the structural analysis/design. The following chapters of this design standard explain the steps of mechanical/electrical design, including:

- Select, size, and design gates/valves.
- Select, size, and design bulkhead gates, if applicable.
- Select, size, and design trashracks.

- Select, size, and design steel pipe.
- Select, size, and design gate/valve operators and generators.
- Select, size and design HVAC systems.
- Select, size, and design hoists and/or cranes, if applicable.
- Design lighting and electrical control systems for gate/valve operations, HVAC systems, and SCADA systems.
- Address life safety considerations as noted in NFPA 100, *Life Safety Code Handbook*, 2009 edition.

For more detailed guidance associated with mechanical/electrical design for an outlet works, refer to Chapter 7, "Mechanical/Electrical Considerations."

Selection of type and size of an outlet gate or valve and operating system will be dependent on the evaluation of a number of factors including:

- Site conditions.
- Outlet works configuration.
- Access.
- Available power.
- Hydraulic considerations.
- Seismic considerations.
- Construction/constructability considerations.
- Ice loading.
- Sedimentation and debris loading.
- Operation and maintenance considerations.
- Economics.

These factors are further discussed in the following chapters of this design standard and in some of the following sections. Because reliable operation of outlet works may be critical in maintaining the safety of dams, some redundant

features/equipment might be required, and it may be advisable to design to stricter requirements than commonly called for by professional codes, standards, and/or guidelines. Of special note, gate and/or valve controls should be located outside of flooded area, should a failure occur, to ensure that emergency/guard gates and/or valves can be operated.

Technical references associated with the mechanical/electrical design of outlet works include:

- AISC *Manual of Steel Construction*, thirteenth edition (refer to ANSC/AISC 360-05, Specifications for Structural Steel Buildings).

- AWS D1.1/D1.1M Structural Welding Code – Steel; AWS D1.6 Structural Welding Code - Stainless Steel.

- *Hydraulic Downpull Forces on Large Gates*, Research Report No. 4 [49].

1.7.2.6 Risk Analysis (Only for Significant and High Hazard Dams/Dikes)

Similar to the spillway, probabilistic (in the form of a quantitative risk analysis), rather than deterministic, considerations will be part of any analysis/design for significant and high hazard dams and/or dikes, along with appurtenant structures such as outlet works. The steps will be integrated with the previous design/analysis and include:

- Identify and define credible PFMs for the existing, modified, and/or new outlet works. Although each outlet works may have some unique credible PFMs, common PFMs have included:

    - Flood-induced overtopping of dam and/or dike (if outlet works are used to help pass floods).

    - Flood-induced outlet works operations which exceed the original/maximum design discharge, leading to overtopping of the chute wall and/or terminal structure walls, or sweepout of the terminal structure, and leading to erosional headcutting of the outlet works foundation or erosion of the dam and/or dam foundation, overstressing the conduits and/or tunnels, introducing pressurized seepage through cracks/joints in the conduit and/or tunnels into surrounding embankment or foundation materials.

    - Operational- and/or flood-induced cavitation damage typically downstream of gates/valves in the chute and/or conduit, leading to erosion of the foundation.

  - Stagnation pressure (hydraulic jacking) and/or structural collapse of the chute and/or terminal structure, leading to erosion of the foundation.

- Based on Reclamation's public protection guidelines [7], estimate the sum of the baseline (existing) APF for all credible PFMs and ALL for all credible PFM for a given loading condition, associated with existing and/or new dams, dikes, and appurtenant structures such as spillways and outlet works.

- If an existing spillway is to be modified, estimate the sum of the modified APF for all credible PMFs and the sum of ALL for all credible PMF associated with a given loading condition.

- For the modified or new spillway, if estimated sum of APF for all credible PFMs, and the sum of ALL for all credible PFMs associated with a given loading condition are "tolerably" below Reclamation guidelines (1E-4 or a 1 in 10,000 chance during a given year for APF; and 1E-3 or a 1 in 1,000 chance during a given year for ALL), designs may be acceptable; however, if not tolerably below Reclamation guidelines, additional design considerations/features will be necessary to lower the estimated APF and ALL for the modified or new outlet works.

For more detailed guidance associated with risk analysis/design for an outlet works, refer to Chapter 2, "Hydrologic Considerations" and Chapter 4, "General Outlet Works and Diversion Design Considerations."

Technical references associated with the risk analysis/design of spillways include:

- *Guidelines for Achieving Public Protection in Dam Safety Decisionmaking* [7].

- REC-ERC-88-3 – *Overtopping Flow on Low Embankment Dams – Summary Report of Model Test* [15].

- DSO-07-07 – *Uplift and Crack Flow Resulting from High Velocity Discharges Over Offset Joints* [16].

- DSO-99-06 – *A Procedure for Estimating Loss of Life Caused by Dam Failure* [36].

- Final Technical Report No. 99DG81029 – *Considerations for Estimating Structural Response Probabilities in Dam Safety Risk Analysis* [37].

- Appendix D – *Toolbox for Handling Loads by Upstream Dams and Incorporating Consequences for Failure of Downstream Dams* [38].

- DSO-98-004 – *Prediction of Embankment Dam Breach Parameters: A Literature Review and Needs Assessment* [39].

- *Interim Guidelines for Addressing the Risk of Extreme Hydrologic Events* [40].

- *Risk Analysis Facilitator's Notebook* [42].

- *Dam Safety Risk Analysis Best Practices Training Manual* [43].

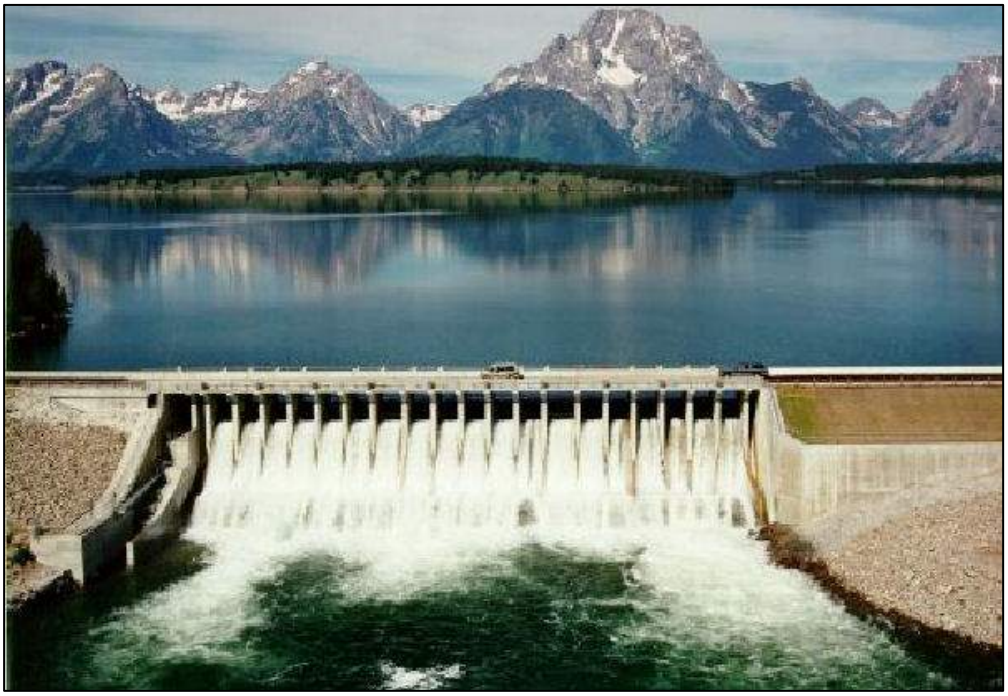


Figure 1.5.1.1-1. Example: Service spillway (gated), Jackson Lake Dam, Wyoming.

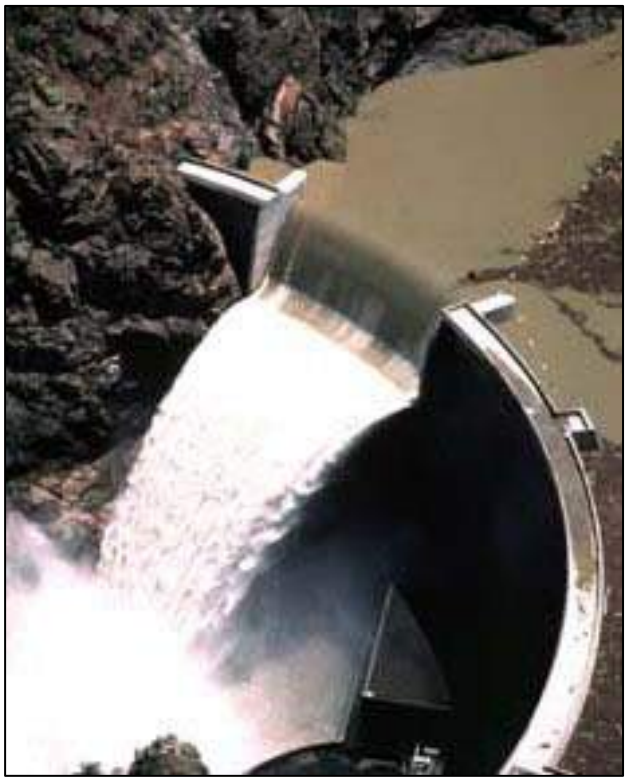


Figure 1.5.1.1-2. Example: Service spillway (ogee crest), Crystal Dam, Colorado.



Figure 1.5.1.2-3. Example: Auxiliary spillway (gated) in foreground and service spillway (gated) in background, Stewart Mountain Dam, Arizona.

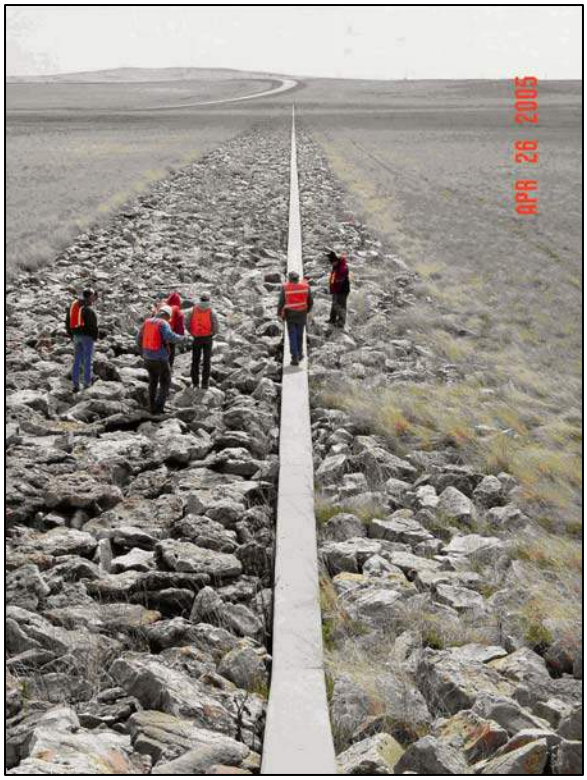


Figure 1.5.1.2-4. Example: Auxiliary spillway (grade control sill), Heart Butte Dam, North Dakota.



Figures 1.5.1.3-5. Example: Emergency spillway (fuseplug) in foreground and auxiliary spillway (ogee crest) in background, New Waddell Dam, Arizona.

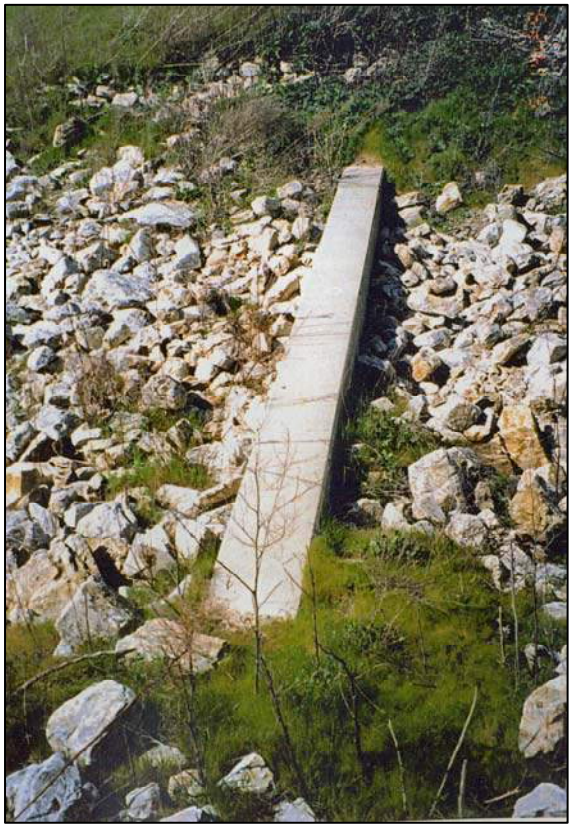


Figure 1.5.1.3-6. Example: Emergency spillway (grade control sill), San Justo Dam, California.

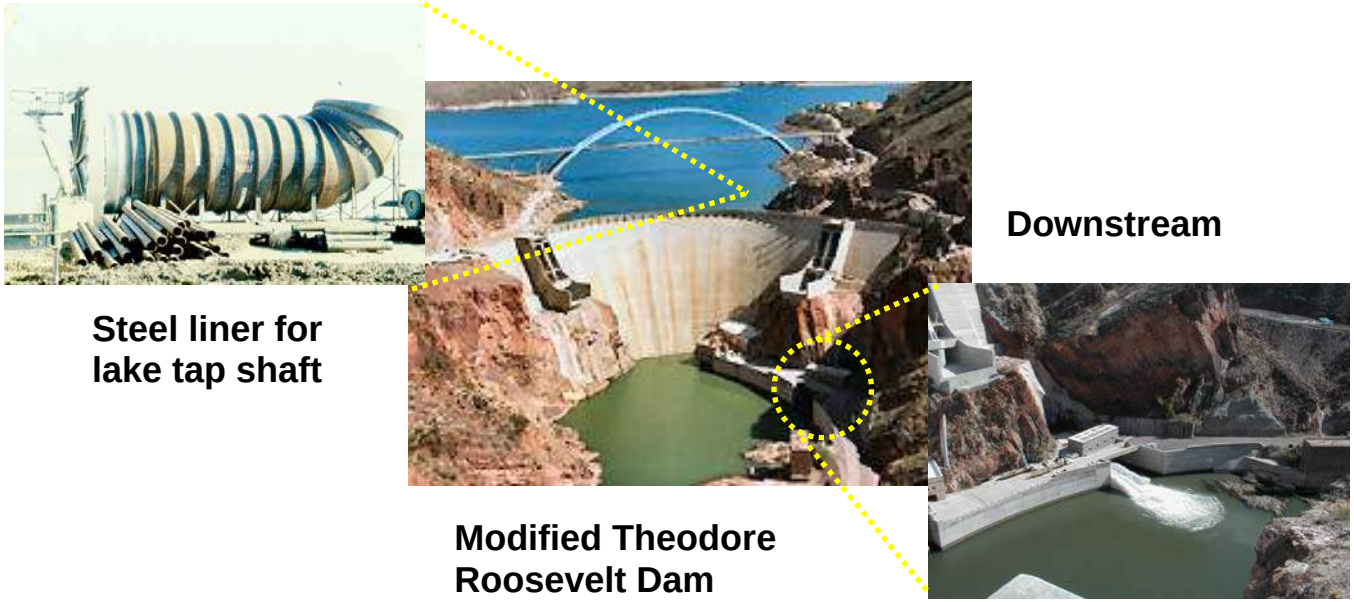


Figure 1.5.2-7. Example: Combination Tunnel outlet work and power penstock, highlighting a number of features such as the upstream intake structure and the downstream structures. Theodore Roosevelt Dam, Arizona.

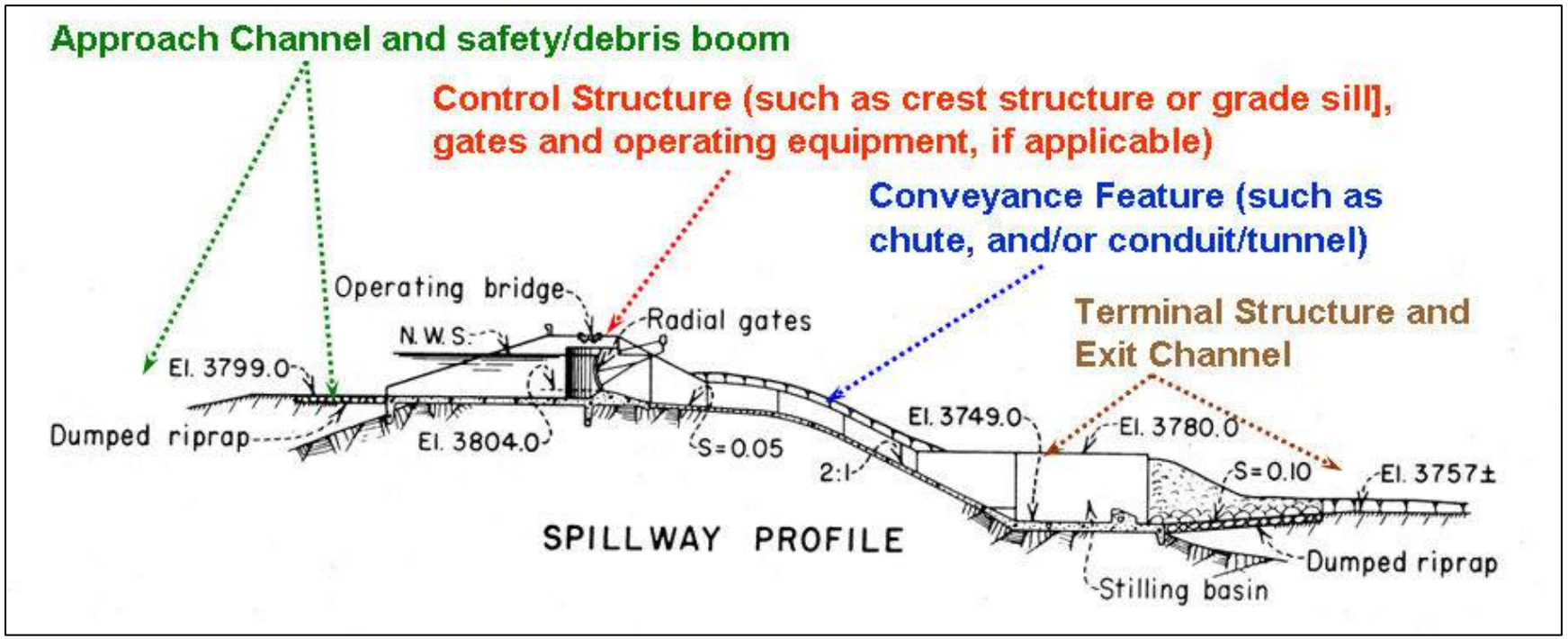


Figure 1.5.2-8. Common features of spillways.



Figure 1.6.1-9. Ogee crest (uncontrolled) spillway, Bumping Lake Dam, Washington.



Figure 1.6.1-10. Double side-channel (bathtub) crest (uncontrolled) spillway, Fontenelle Dam, Wyoming.



Figure 1.6.1-11. Side-channel crest (uncontrolled) spillway, Big Sandy Dam, Wyoming.



Figure 1.6.1-12. Morning glory (glory hole) crest (uncontrolled) spillway, Whiskeytown Dam, California.



Figure 1.6.2-13. Labyrinth crest (uncontrolled) spillway, Ute Dam, New Mexico.



Figure 1.6.1-14. Radial gated (controlled) spillway, Bradbury Dam, California.



Figure 1.6.1-15. Crest (Obermeyer type) gated (controlled) spillway, Friant Dam, California.

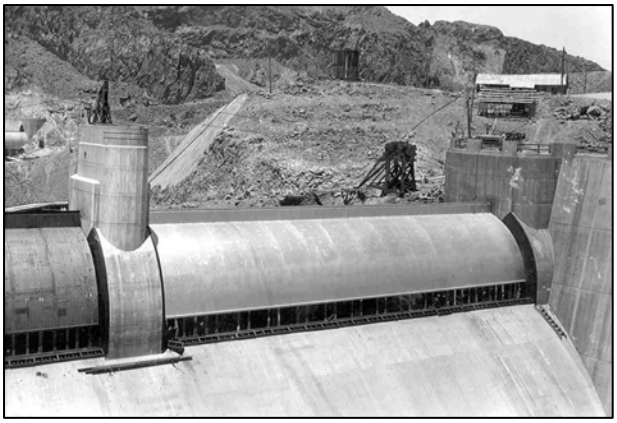
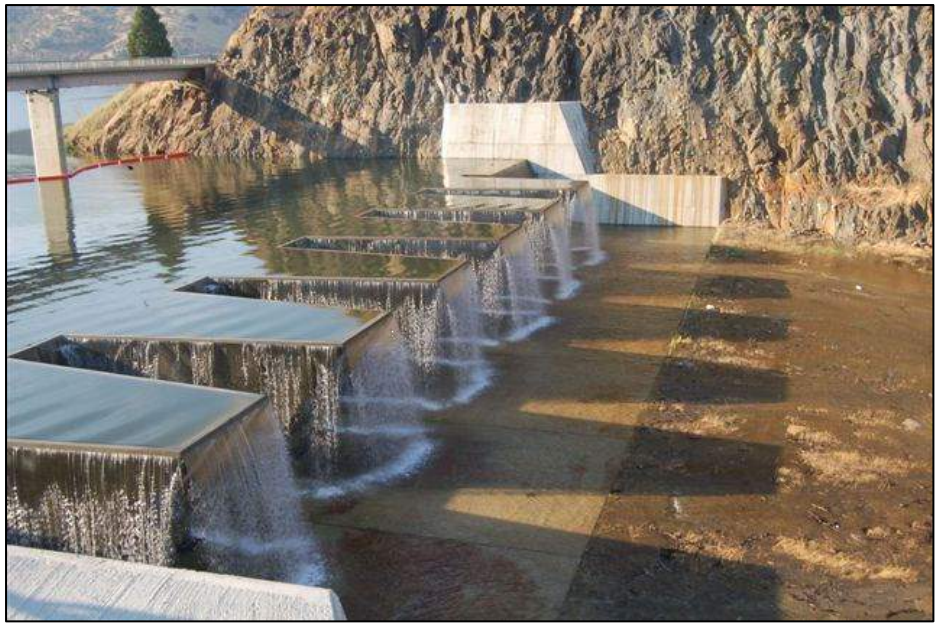


Figure 1.6.1-16. Drum gated (controlled) spillway, Hoover Dam, Arizona-Nevada.



Figure 1.6.1-17. Fuseplug crest (controlled) spillway (reservoir rim), Horseshoe Dam, Arizona.



Figures 1.6.1-18. Fusegate crest (controlled) spillway, Terminus Dam, California (courtesy of the U.S. Army Corps of Engineers, Sacramento District, Rick Poeppelman).

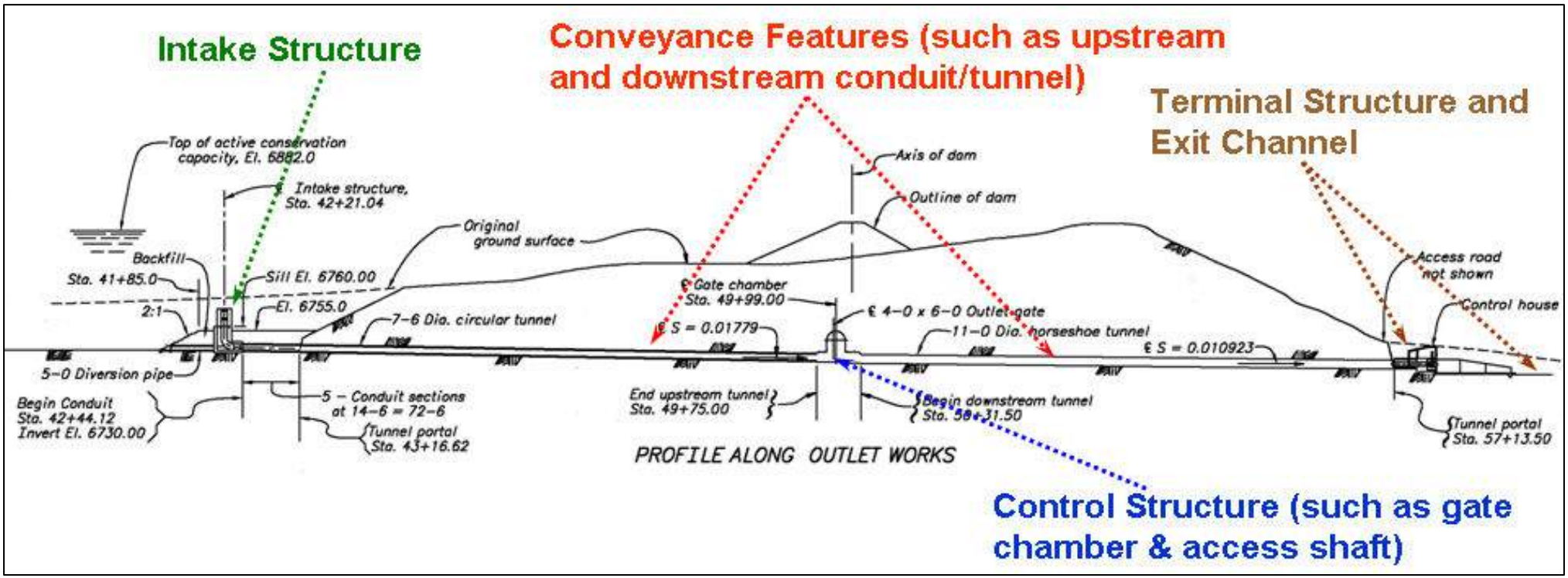


Figure 1.6.2-19. Common features of outlet works.

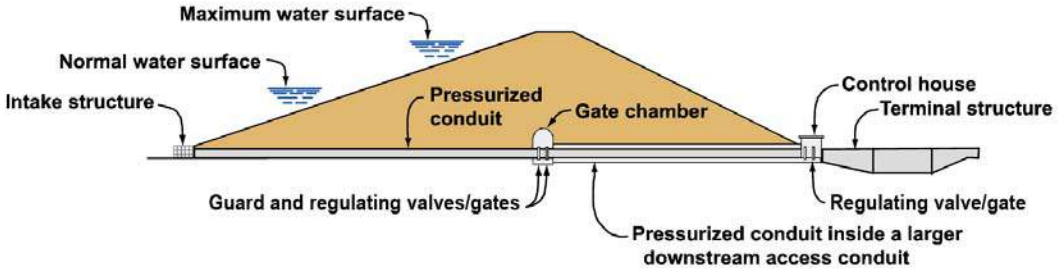


Figure 1.6.2-20. Preferred outlet works configuration for low-head embankment dams: hydraulic control at upstream intake with free flow conditions downstream of the regulating gate/valve [1].

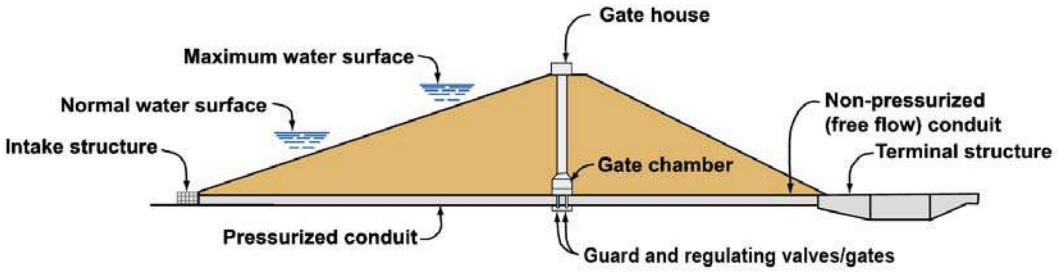


Figure 1.6.2-21. Preferred outlet works configuration for high-head embankment dams: hydraulic control at downstream control structure, with guard/emergency gate/valve at/near centerline of dam/dike, and downstream pressurized pipe (between dam/dike centerline and control structure inside larger access conduit) [1].

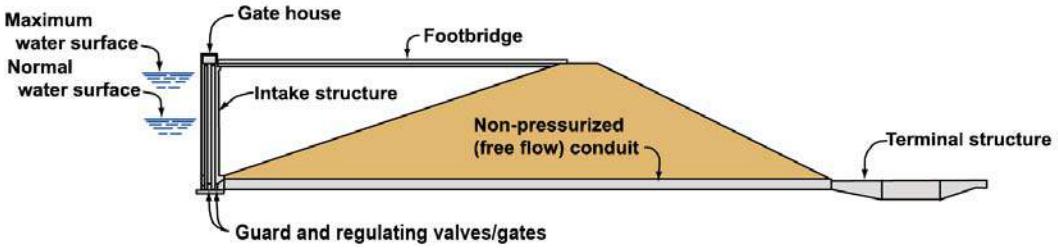


Figure 1.6.2-22. Acceptable outlet works configuration for embankment dams: hydraulic control at/near centerline of dam/dike, with free flow conditions downstream of the regulating gate/valve [1].

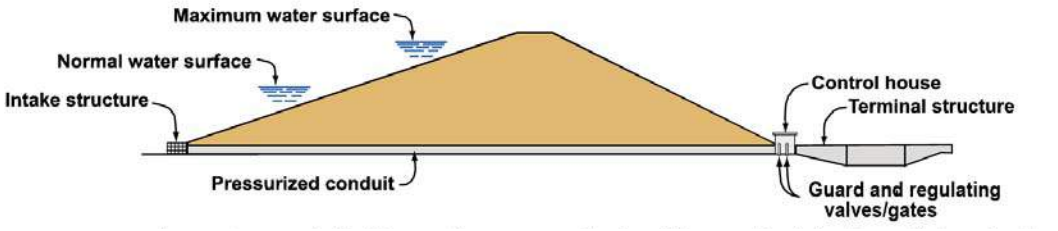


Figure 1.6.2-23. Least acceptable outlet works configuration for embankment dams: hydraulic control at downstream control structure (i.e., pressurized flow conditions upstream of the regulating gate/valve along most of the outlet works) [1].

References

[1] *Conduits through Embankment Dams – Best Practices for Design, Construction, Problem Identification and Evaluation, Inspection, Maintenance, Renovation, and Repair,* technical manual, Federal Emergency Management Agency, September 2005.

[2] *Reclamation Manual – Design Data Collection Guidelines,* Bureau of Reclamation, September 2007.

[3] *Feasibility Design Guidelines,* Bureau of Reclamation, July 2008.

[4] *Final Design Process,* Bureau of Reclamation, April 2008.

[5] *Reclamation Manual – Cost Estimating,* Bureau of Reclamation, October 2007.

[6] *Safety of Dams Project Management Guidelines,* Bureau of Reclamation, March 2003.

[7] *Guidelines for Achieving Public Protection in Dam Safety Decisionmaking,* Bureau of Reclamation, June 2003.

[8] *Design of Small Dams,* third edition, Bureau of Reclamation, 1987.

[9] EM No. 9 – *Discharge Coefficient for Irregular Overfall Spillways,* Bureau of Reclamation, March 1952.

[10] EM No. 25 – *Hydraulic Design of Stilling Basins and Energy Dissipators,* Bureau of Reclamation, March 1984.

[11] EM No. 42 – *Cavitation in Chutes and Spillways,* Bureau of Reclamation, April 1990.

[12] REC-ERC-73-5 – *Hydraulic Model Studies of Chute Offsets, Air Slots, and Deflectors for High-Velocity Jets,* Bureau of Reclamation, March 1973.

[13] REC-ERC-78-8 – *Low Froude Number Stilling Basin Design,* Bureau of Reclamation, August 1978.

[14] REC-ERC-85-7 – *Hydraulic Model Studies of Fuseplug Embankments,* Bureau of Reclamation, December 1985.

[15] REC-ERC-88-3 – *Overtopping Flow on Low Embankment Dams,* Bureau of Reclamation, August 1988.

[16] DSO-07-07 – *Uplift and Crack Flow Resulting from High Velocity Discharge Over Offset Joints*, Bureau of Reclamation, December 2007.

[17] ACER TM No. 10 – *Guidelines for Using Fuseplug Embankments in Auxiliary Spillways*, Bureau of Reclamation, July 1987.

[18] *Hydraulic and Excavation Tables*, 11th edition, Bureau of Reclamation, 1957.

[19] *Computing Degradation and Local Scour*, Bureau of Reclamation, January 1984.

[20] *Guide for Computing Water Surface Profiles*, Bureau of Reclamation, undated.

[21] EM No. 13 – *Estimating Foundation Settlement by One-Dimensional Consolidation Tests*, Bureau of Reclamation, March 1953.

[22] REC-ERC-74-10 – *Rock Mechanics Properties of Typical Foundation Rock Types*, Bureau of Reclamation, July 1974.

[23] REC-ERC-82-17 – *Frost Action in Soil Foundations and Control of Surface Structure Heaving*, Bureau of Reclamation, June 1982.

[24] ACER TM No. 9 – *Guidelines for Controlling Seepage Along Conduits Through Embankments*, Bureau of Reclamation, April 1987.

[25] *Drainage for Dams and Associated Structures*, technical manual, Bureau of Reclamation, 2004.

[26] *Guidelines for Earthquake Design and Evaluation of Structures Appurtenant to Dams*, United States Committee on Large Dams, May 1995.

[27] EM No. 14 – *Beggs Deformeter-Stress Analysis of Single-Barrel Conduits*, Bureau of Reclamation, 1968.

[28] EM No. 14 Supplement – *Beggs Deformeter-Stress Analysis of Single-Barrel Conduits*, Bureau of Reclamation, 1971.

[29] EM No. 27 – *Moments and Reactions for Rectangular Plates*, Bureau of Reclamation, 1963.

[30] EM No. 34 – *Control of Cracking in Mass Concrete Structures*, Bureau of Reclamation, May 1981.

[31] *Concrete Manual*, eighth edition, Bureau of Reclamation, 1981.

[32] EM No. 1110-2-2104, *Strength Design for Reinforced-Concrete Hydraulic Structures*, U.S. Army Corps of Engineers, June 30, 1992.

[33] ACI SP-3 – *Reinforced Concrete Design Handbook (Working Stress Method),* third edition, ACI Committee 317, 1977**.**

[34] *Design Criteria of Retaining Walls*, Report of the Task Committee of Design Criteria of Retaining Walls, Bureau of Reclamation, August 1971.

[35] *Roller-Compacted Concrete: Design and Construction Considerations for Hydraulic Structures*, technical manual, Bureau of Reclamation, 2005.

[36] DSO-99-06 – *A Procedure for Estimating Loss of Life Caused by Dam Failure*, Bureau of Reclamation, September 1999.

[37] Final Technical Report No. 99DG81029 – *Considerations for Estimating Structural Response Probabilities in Dam Safety Risk Analysis*, Bureau of Reclamation, September 1999.

[38] Appendix D – *Toolbox for Handling Loads by Upstream Dams and Incorporating Consequences for Failure of Downstream Dams*, Bureau of Reclamation, March 2000.

[39] DSO-98-004 – *Prediction of Embankment Dam Breach Parameters: A Literature Review and Needs Assessment*, Bureau of Reclamation, July 1998.

[40] *Interim Guidelines for Addressing the Risk of Extreme Hydrologic Events*, Bureau of Reclamation, August 2002.

[41] *Guidelines, Foundation and Geotechnical Studies for Existing Concrete Dams*, Bureau of Reclamation, September 1999.

[42] *Risk Analysis Facilitator's Notebook*, Bureau of Reclamation, 2008.

[43] *Dam Safety Risk Analysis Best Practices Training Manual*, Version 1.1, Bureau of Reclamation, May 2009.

[44] ACER TM No. 3 – *Criteria and Guidelines for Evacuating Storage Reservoirs and Sizing Low-Level Outlet Works*, Bureau of Reclamation, 1990.

[45] EM No. 7 – *Friction Factors for Large Conduits Flowing Full*, Bureau of Reclamation, 1977.

[46] Research Report No. 24 – *Hydraulic Design of Stilling Basin for Pipe or Channel Outlets*, Bureau of Reclamation, 1978.

[47] EM No. 41 – *Air-Water Flow in Hydraulic Structures,* Bureau of Reclamation, December 1980.

[48] ACER TM No. 4 – *Criteria for Bulkheading Outlet Works Intakes for Storage Dams*, Bureau of Reclamation, February 1982.

[49] Research Report No. 4 – *Hydraulic Downpull Forces on Large Gates*, Bureau of Reclamation, 1966.

[50] American Society of Civil Engineers Journal of Hydraulic Engineering – *Design of Labyrinth Spillways*, by J. Paul Tullis, Nasratollah Amanian, and David Waldron, March 1995.

[51] Hydraulic Laboratory Report HL-2005-06 – *Research State-of-the-Art and Needs for Hydraulic Design of Stepped Spillways*, Bureau of Reclamation, June 2006.

[52] *Plastic Pipe Used in Embankment Dams: Best Practices for Design, Construction, Problem Identification and Evaluation, Inspection, Maintenance, Renovation, and Repair,* technical manual, Federal Emergency Management Agency, November 2007.

[53] "Outlet Works Energy Dissipators: Best Practices for Design, Construction, Problem Identification and Evaluation, Inspection, Maintenance, Renovation, and Repair," technical manual, Federal Emergency Management Agency (to be published in 2010).

TSC Security Review of Proposed Public Disclosure of Technical Information

Type: Design Standard

Design Standard: Design Standards No. 14 – Appurtenant Structures for Dams (Spillway and Outlet Works) Design Standards

Chapters: 1. Introduction

Brief Description of Information: An overview of how the Bureau of Reclamation analyzes/designs spillways and outlet works appurtenant for dams and/or dikes. An outline of the following chapters for this design standard that provides details for spillway and outlet works analyses/designs. A list of key technical references used for each major task involved with spillway and outlet works analyses/designs.

Requesting/Sponsoring Organization: Director, Technical Service Center

Program Office: Deputy Commissioner, Operations

Is Information Official Use Only / SENSITIVE? (Y(N))
(to be completed by reviewer)

Is Information Official Use Only / RESTRICTED? (Y(N))
(to be completed by reviewer)

(Sensitive or Restricted information shall not be included in a design standard.)

Design Standard Team Leader:

Name(s)/Mail Code(s): John LaBoon / 86-68130
Signature(s)/Date(s): [signature] / 3/12/2010

Group Manager(s) Approving Release:

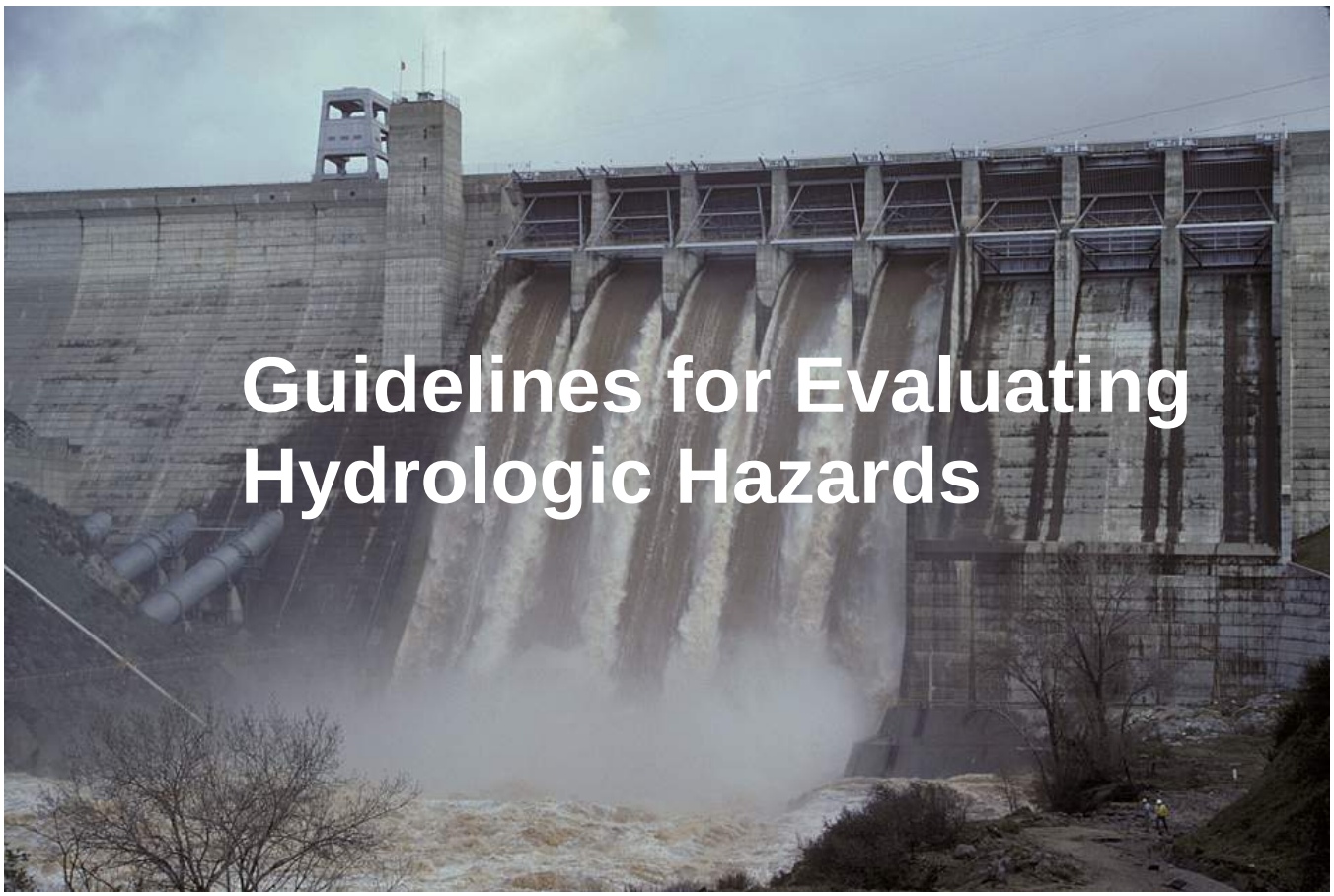
Name(s)/Mail Code(s): John LaBoon / 86-68130
Signature(s)/Date(s): [signature] / 3/12/2010

Division Security Reviewer(s) Peer Reviewing Approval:

Name(s)/Mail Code(s): Larry K. Nuss 86-68110
Signature(s)/Date(s): [signature] 3/12/2010

RECLAMATION

Managing Water in the West



Guidelines for Evaluating Hydrologic Hazards

U.S. Department of the Interior
Bureau of Reclamation

June 2006

MISSION STATEMENTS

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Guidelines for Evaluating Hydrologic Hazards

By
Robert E. Swain
John F. England, Jr.
Kenneth L. Bullard
David A. Raff

U.S. Department of the Interior
Bureau of Reclamation

June 2006

Contents

Page

Executive Summary **S-1**

1. Introduction **1**

2. Background **1**

2.1 General 1

2.2 Public Protection Guidelines 2

Dam Safety Program Processes 2

3. Process **3**

3.1 Data Sources 4

3.2 Flood Frequency Extrapolation 4

3.3 Flood Peak and Volume Relationships 7

4. Analysis Techniques **8**

4.1 Flood Frequency Analysis with Historical/Paleoflood Data 9

4.1.1 Historical and Paleoflood Data 9

4.1.2 Mixed-Population Graphical Approach 11

4.1.3 Expected Moments Algorithm 12

4.1.4 FLDFRQ3 13

4.2 Hydrograph Scaling and Volumes 15

4.3 GRADEX Method 17

4.4 Australian Rainfall-Runoff Method 25

4.4.1 Approach 26

4.4.2 Calibration 28

4.4.3 Strengths and Limitations 29

4.5 Stochastic Event-Based Precipitation Runoff Modeling with the SEFM 29

4.6 Stochastic Rainfall-Runoff Modeling With CASC2D 35

4.7 PMF Analysis Technique 36

5. Characterization of Hydrologic Hazards **45**

5.1 Integration of the PMF into Hydrologic Hazard Evaluations 46

5.2 Characterization of Hydrologic Risk for the CFR 46

5.3 Detailed Hydrologic Studies 50

6. Case Studies **52**

6.1 Los Banos Dam 52

6.1.1 Los Banos Hydrologic Hazard Curves Using Flood Frequency Analysis and Hydrograph Scaling 53

6.2 A.R. Bowman Dam 54

6.2.1 A.R. Bowman Hydrologic Hazard Curves Using Flood Frequency Analysis and Hydrograph Scaling 56

6.2.2 A.R. Bowman Hydrologic Hazard Estimates Based on a Stochastic Event Flood Model 57

6.2.3 A.R. Bowman Hydrologic Hazard Estimates Using Bayesian Statistical Estimation 60

6.2.4 Combined Hydrologic Hazard Estimates for Risk Analysis and Dam Safety Implications 62

6.3 Fresno Dam 64

6.3.1 Fresno Dam Hydrologic Hazard Curves Using Flood Frequency Analysis and Hydrograph Scaling 64

6.3.2 Fresno Dam Hydrologic Hazard Analysis Using the GRADEX Method 66

7. Summary **72**

8. Bibliography **74**

Executive Summary

The purpose of this document is to establish guidelines for generating hydrologic hazard information for use in evaluating hydrologic risk at dams. This information is intended to be used for risk analysis and prioritization of further work at Bureau of Reclamation (Reclamation) dams and other U.S. Department of the Interior facilities. Hydrologic hazard information consists of a flood frequency analysis and frequency flood hydrographs for a full range of Annual Exceedance Probabilities (AEP) necessary for decision making.

Reclamation has developed an approach toward developing hydrologic hazard curves for use in evaluating dam safety issues. The procedure relies on extracting information from existing studies to the fullest extent possible. The procedures and analysis techniques defined in these guidelines allow for the possibility, and even plausibility, that peak discharge and volume estimates may exceed the probable maximum flood (PMF). This is a function of the uncertainty and inconsistency among and between analysis techniques. Therefore, in these cases, the PMF is believed to represent the upper limit to hydrologic risk.

The procedure for developing hydrologic hazard curves considers the dam safety decision criteria, potential dam failure mode and dam characteristics, available hydrologic data, possible analysis techniques, resources available for analysis, and tolerable level of uncertainty. Dam safety decision criteria determine the probabilistic range of floods needed to address hydrologic issues. The potential dam failure mode and dam characteristics impact the type of hydrologic information needed to assess the problem. The specific elements selected to be incorporated in an analysis of hydrologic hazards should consider the tolerable level of uncertainty. To reduce the uncertainty in the estimates, additional data collection and use of more sophisticated solution techniques may be required.

Reclamation currently uses a combination of seven hydrologic methods to develop hydrologic hazard curves. These general techniques include:

- Flood frequency analysis with historical/paleoflood data
- Hydrograph scaling and volumes
- The GRADEX Method
- The Australian Rainfall-Runoff Method
- Stochastic event-based precipitation runoff modeling with stochastic event flood model
- Stochastic rainfall-runoff modeling with CASC2D
- The PMF

It is believed that increasing the level of effort and sophistication of analysis technique increases the level of confidence associated with the results.

The amount of effort expended on analyzing a hydrologic hazard depends on the nature of the problem and the potential cost of the solution. A staged approach toward evaluating a hydrologic safety issue is recommended. Initially, very little effort is expended to determine the

magnitude of the hydrologic hazard. Reclamation attempts to make use of all the available studies for the site of interest. Often, the PMF and initial flood frequency studies are the only hydrologic studies available before the start of a probabilistic investigation. When other hydrologic studies have been performed, available data will be used to decrease uncertainty in results as well as provide an overall assessment of hydrologic risk.

Dam safety evaluations usually begin by characterizing hydrologic risk for the Comprehensive Facility Review (CFR) process. If detailed studies have been conducted for the site of interest, they are summarized, consolidated, and presented to the risk assessment team. About two-thirds of Reclamation's dams can safely accommodate the PMF; when the PMF is selected as the inflow design flood, no additional work may be required unless other hydraulic issues need evaluation. Additional hydrologic work begins with a flood frequency analysis developed for peak flows and volumes and hydrograph scaling. It is believed that this type of information is sufficient to address hydrologic issues and make dam safety decisions at about 80 percent of the remaining dams. For the sites that still have potential safety problems, more sophisticated solution techniques than the initial flood frequency analysis and hydrograph scaling may be required.

When planning more detailed studies, the goal is to achieve a balance between the amount of hydrologic analysis needed to address the issues and the level of effort required to conduct the study. As the studies get more detailed, the results should become more precise and contain less uncertainty.

When multiple methods are used, alternative hazard curves are developed by weighting results from the individual analyses. A team of hydrologists evaluates the alternatives and selects the one most representative for the site for use in the risk assessment. Selection of the final hydrologic hazard curve depends on the experience of the hydrologists and the assumptions that went into each analysis.

Three case studies, Los Banos, Fresno, and A.R. Bowman Dams, are presented in these guidelines to illustrate the variety of methods available. These sites were chosen to demonstrate the use of flood frequency analysis and hydrograph scaling to characterize the flood hazard and more detailed followup studies, where available. The A.R. Bowman example shows how multiple studies were combined into a single flood hazard curve for use in risk assessment.

1. Introduction

The purpose of these guidelines is to develop hydrologic hazard curves and flood hydrographs for use in evaluating and prioritizing the need for dam safety modifications at Reclamation and other U.S. Department of the Interior (Interior) facilities. Hydrologic hazard curves are defined as graphs of peak flow and volume (for specified durations) versus Annual Exceedance Probability (AEP). The range of AEPs that is displayed on these graphs is to be sufficient to support the decision making needs of the organization. The intent of these guidelines is to provide a procedure for developing hydrologic hazard information that will allow decision makers to determine appropriate courses of action to assure the safety of the dam while minimizing study costs. Hydrologic hazard information is intended to support Reclamation's risk-based Dam Safety Program.

These guidelines are based on the Dam Safety Research Report DSO-04-08, *Hydrologic Hazard Curve Estimating Procedures* (Swain et al., 2004). The research project used information developed at the Logan, Utah Workshop held in 1999 to provide a framework for Reclamation to assess flood hazards. The workshop produced the report, *A Framework for Characterizing Extreme Floods for Dam Safety Risk Assessment* (Bureau of Reclamation, 1999). Hydrologic research has led to advances in flood estimation procedures that allow improvements to the framework. These guidelines describe current approaches used by Reclamation to determine flood loadings for its dams. New techniques for developing hydrologic hazard information can be added to these guidelines as they are developed by the hydrology community.

2. Background

2.1 General

Reclamation's Dam Safety Program mission is "To ensure that Reclamation dams do not present unacceptable risks to people, property, and the environment" (Bureau of Reclamation, 1993). As the owner of over 350 high- or significant-hazard storage dams in the western U.S., Reclamation is committed to providing the public and the environment with adequate protection from the risks that are inherent in collecting and storing large volumes of water. Traditional design and analysis methods have focused on selecting a level of protection based on spillway evaluation flood loadings, which were usually based on the probable maximum flood (PMF) (Bureau of Reclamation, 1999).

Since 1995, Reclamation has used a risk assessment process to determine an appropriate level of public protection by evaluating a full range of loading conditions and possible dam failure consequences. This is in contrast to the traditional approach of using upper bound events without regard to their likelihood of occurrence and without assessment of their incremental consequences. As a water resources management agency, Reclamation strives to provide decisionmakers with risk-based information founded upon current or emerging water resources management and public safety practices (Bureau of Reclamation, 1999).

Risk assessment methods provide techniques to organize and plan the data collection and technical studies necessary to evaluate dam safety issues at a site. The risk assessment process allows the risk assessment team to consider the possible adverse outcomes to a given loading condition and compute the risk associated with each possible outcome. The process involves identifying all of the possible loading conditions, dam responses, exposure conditions, and consequences. The overall risk from the dam is the accumulation of the risks associated with each of these factors (Bureau of Reclamation, 1999).

When evaluating hydrologic hazards, a systematic means of developing flood hazard relationships is needed for risk-based assessments to determine hydrologic adequacy for Reclamation dams. The nature of the potential failure mode and characteristics of the dam and reservoir dictate the type of hydrologic information needed. For some sites, only a peak-discharge frequency analysis may be required, while at other sites, flood volumes and hydrographs may be required. The goal of any hydrologic analysis is to provide the hydrologic information needed to make dam safety decisions at the least possible cost.

2.2 Public Protection Guidelines

Guidance for providing adequate and consistent levels of public protection in the evaluation and modification of existing dams and the design of new structures are described in the *Guidelines for Achieving Public Protection in Dam Safety Decisionmaking*, (Bureau of Reclamation, 2003a). The reader may refer to the guidelines for a complete description of the assessment measures used by Reclamation in making dam safety decisions.

Determining an appropriate level of public protection involves assessing the existing risks, determining the need for risk reduction, and, where needed, evaluating specific alternatives to reduce risk. Because the total needs for the agency's financial and human resources generally exceed the available resources, the Public Protection Guidelines were prepared to assist Reclamation staff in presenting public safety information to decisionmakers for prioritizing among projects and allocating limited resources.

Reclamation's Public Protection Guidelines consist of two assessment measures of risk that are considered in the decision process for a dam: (1) the probability of dam failure and (2) the life loss consequences resulting from unintentional reservoir release. The annual probability of failure guideline considers the accumulation of risks from Reclamation's total inventory of dams. The life loss guideline deals with agency public trust responsibilities.

Dam Safety Program Processes

Hydrologic hazard information is generally required during four stages of the dam safety program process. These four stages include the Comprehensive Facility Review (CFR), Issue Evaluation (IE), Corrective Action Study (CAS), and Final Design (FD). Most projects do not progress through each stage of the process because the process is intended to address dam safety deficiencies, and many projects either have no deficiencies or the safety issues can be resolved without a need for structural modifications. The remainder of this section of the guidelines will

briefly describe the four stages of the dam safety program process that require hydrologic hazard information. For more detailed information about the dam safety process, the reader should review the references cited.

The CFR provides a mechanism for early detection of developing and/or existing dam safety issues. The CFR is performed every 6 years and consists of a state-of-the-art review of the dam and its performance, previous studies/analyses (including hydrology), construction practices, downstream consequences, risk, and dam safety decisions (Bureau of Reclamation, 1998). The CFR is used to identify risks at individual dams and to prioritize further work. Once hydrologic hazard information is developed for the CFR, the Dam Safety Office determines whether or not additional hydrologic studies are required to make decisions during subsequent stages of the process.

The IE stage is used to confirm problems identified previously. Data collection and/or analysis activities are focused on addressing specific dam safety issues and updating risk estimates. At the conclusion of the IE, the decision makers determine whether or not actions are required to reduce risk at the dam (Bureau of Reclamation, 2003b).

A CAS formulates and evaluates risk reduction alternatives. Data is collected and analyzed to the extent necessary to develop the details of identified alternatives, to estimate project costs, and to provide sufficient information to allow decision makers to select and justify the proper course of action. The baseline risk analysis is updated to show the risk reduction potential of each of the developed alternatives (Bureau of Reclamation, 2003b).

During the FD stage, the conceptual design is transformed into the final design. Additional data collection and analysis are used to improve the design, reduce and refine project costs, and finalize design drawings and specifications (Bureau of Reclamation, 2003b).

3. Process

The elements selected for incorporation in an analysis of hydrologic hazards must consider the potential dam failure mode and dam characteristics, available hydrologic data, possible analysis techniques, resources available for analysis, and tolerable level of uncertainty. The potential dam failure mode and dam characteristics impact the type of hydrologic information needed to assess the problem. Some problems may require only a peak-discharge frequency curve, while others may need complete hydrographs. The available data, possible analysis techniques, resources available, and needs of the decision makers influence the selection of elements to be included in developing hydrologic hazard curves.

The process that follows provides a systematic approach for estimating hydrologic hazard curves that can be used for dam safety decisionmaking. It recognizes that additional studies do not always lead to better decisions. Therefore, the process relies on using existing data and previous analyses as much as possible to produce hydrologic information suitable for dam safety decisionmaking at the least possible cost.

3.1 Data Sources

Developing hydrologic hazard curves for risk assessment uses the length of record and type of data to determine the extrapolation limits for flood frequency analysis. Extrapolation beyond the data is often necessary to provide information needed for dam safety risk assessments. The sources of information used for flood hazard analyses include streamflow and precipitation records and paleoflood data.

Streamflow records consist of data collected at established gaging stations and indirect measurements of streamflow at other sites. Streamflow data can include estimates of peak discharge as well as average or mean discharge for various time periods. Most streamflow measurements on U.S. streams began after 1900, with only a few records dating back that far. Most often, streamflow records at a single site range in length from about 20 to 60 years. In some cases these records can be extended to about 150 years using historical information, which include human observations and recordings prior to the development of systematic streamflow measurement.

Precipitation and weather data used in hydrologic models can include rainfall, snowfall, snow water equivalent, temperature, solar radiation, and wind speed and direction. These data are available from various sources and vary greatly in record length and quality throughout the United States. Some of these types of data (i.e., snowfall, snow water equivalent, solar radiation, and wind) are limited to record lengths of less than about 30 years; rainfall and temperature data are available for some stations for up to 150 years, but in most cases are limited to less than 100 years.

Paleoflood hydrology is the study of past or ancient flood events which occurred before the time of human observation or direct measurement by modern hydrological procedures (Baker, 1987). Unlike historical data, paleoflood data do not involve direct human observation of the flood events. Instead, the paleoflood investigator studies geomorphic and stratigraphic records (various indicators) of past floods, as well as the evidence of past floods and streamflow derived from historical, archeological, dendrochronologic, or other sources. The advantage of paleoflood data is that it is often possible to develop records that are 10 to 100 times longer than conventional or historical records from other data sources in the western United States. Paleoflood data generally include records of the largest floods, or commonly, the limits on the stages of the largest floods over long time periods.

3.2 Flood Frequency Extrapolation

The type of data and the record length used in the analysis form the primary basis for establishing a range on credible extrapolation of flood estimates. The objective of flood frequency analysis and extrapolation is to provide reliable flood estimates for a full range of AEPs necessary for dam safety decisionmaking. In order to develop reliable flood estimates, flood frequency relationships should include an estimate of the uncertainty around the median values. The data used in the analysis provide the only basis for verification of the analysis or modeling results, and as such, extensions beyond the data cannot be verified. The greatest gains to be made in providing credible estimates of extreme floods can be achieved by combining regional data from multiple sources. Thus, analysis approaches that pool data and information

from regional precipitation, regional streamflow, and regional paleoflood sources should provide the highest assurance of credible characterization of low AEP floods. The information that follows was developed in a workshop sponsored by Reclamation and documented in Bureau of Reclamation, 1999.

For Reclamation dam safety risk assessments, flood estimates are needed for AEPs of 1 in 10,000 and possibly ranging down to as low as 1 in 100,000,000. Developing credible estimates at these low AEPs generally requires combining data from multiple sources and a regional approach. Table 3-1 lists the different types of data that can be used as a basis for flood frequency estimates and the typical and optimal ranges of credible extrapolation for AEP (Bureau of Reclamation, 1999). In general, the optimal ranges are based on the best combination(s) of data envisioned in the western U.S. in the foreseeable future. Typical ranges are based on the combination(s) of data that are commonly available and analyzed for most sites.

Table 3-1.—Data types and extrapolation ranges for flood frequency analysis (Bureau of Reclamation, 1999)

Type of data used for flood frequency analysis	Range of credible extrapolation for annual exceedance probability	
	Typical	Optimal
At-site streamflow data	1 in 100	1 in 200
Regional streamflow data	1 in 500	1 in 1,000
At-site streamflow and at-site paleoflood data	1 in 4,000	1 in 10,000
Regional precipitation data	1 in 2,000	1 in 10,000
Regional streamflow and regional paleoflood data	1 in 15,000	1 in 40,000
Combinations of regional data sets and extrapolation	1 in 40,000	1 in 100,000

Many factors can affect the equivalent independent record length for the optimal case. For example, gaged streamflow records in the western United States only rarely exceed 100 years, and extrapolation beyond twice the length of record, or to about 1 in 200 AEP, is generally not recommended (Interagency Advisory Committee on Water Data [IACWD], 1982). Likewise, for regional streamflow data the optimal range of credible extrapolation is established at up to 1 in 1,000 AEP by considering the number of stations in the region, lengths of record, and degree of independence of these data (Hosking and Wallis, 1997). For paleoflood data, only in the Holocene epoch (or the past 10,000 years) is climate judged to be sufficiently like that of the present climate for these types of records to have meaning in estimating extreme floods for dam safety risk assessment. This climatic constraint indicates that an optimal range for extrapolation from paleoflood data, when combined with at-site gaged data, for a single stream should be up to about 1 in 10,000 AEP. For regional precipitation data, a similar range is imposed because of the difficulty in collecting sufficient station-years of clearly independent precipitation records in the orographically complex regions of the western United States. Combined data sets of regional gaged and regional paleoflood data can be extended to smaller AEPs, perhaps to about 1 in

40,000, in regions with abundant paleoflood data. Analysis approaches that combine all types of data are judged to be capable of providing credible estimates for an AEP range up to about 1 in 100,000 under optimal conditions.

In many situations, credible extrapolation ranges may be less than optimal. Typical ranges would need to reflect the practical constraints on the equivalent independent record length that apply for a particular location. For example, many at-site streamflow record lengths are shorter than 100 years. If in a typical situation the record length is only 50 years, then the range of credible extrapolation might be up to an AEP of about 1 in 100. Similarly, many paleoflood records do not extend to 10,000 years, and extensive regional paleoflood data sets do not currently exist. Using a record length of about 4,000 years, a typical range of credible extrapolation might be up to an AEP of 1 in 15,000 based on regional streamflow and regional paleoflood data.

The information presented in table 3-1 is intended as a guide; each situation is different and should be assessed individually. The ranges of extrapolation should be determined by evaluating the lengths of records, number of stations in a hydrologically homogeneous region, degree of correlation between stations, and other data characteristics that may affect the accuracy of the data.

Ideally, one would like to construct the flood frequency distribution for all floods that could conceivably occur. However, the amount of data and flood experience for any site or region constrain the range of the floods to which AEPs can be assigned based solely on data. In general, the scientific range to which the flood frequency relationship can be credibly extended, based upon any characteristics of the data and the record length, will fall short of the PMF for a site. However, there is a need in dam safety risk assessment to determine the probability of occurrence of very large floods with very small AEPs. The lack of an ideal data set does not absolve the hydrologist from extending the flood frequency relationship to cover the full range of AEPs needed for risk assessment. Therefore, a systematic approach is provided for estimating hydrologic hazard curves that can be used for dam safety decisionmaking.

Floods can be categorized, according to the Australian Rainfall and Runoff: A Guide to Flood Estimation (Nathan and Weinmann, 2001), as large, rare, and extreme. These flood categories are shown in figure 3-1. Large floods generally encompass events for which direct observations and measurements are available. Rare floods represent events located in the region between direct observations and the credible range of extrapolation from the data. Extreme floods generally have very small AEPs, which are beyond the credible range of extrapolation but are still needed for dam safety risk assessments. Occasionally, Reclamation has an interest in floods with an AEP as low as 1 in 10^8.

Extreme floods border on the unknowable. Uncertainty is very large and unquantifiable. Since data cannot support flood estimates in this AEP range, hydrologists and engineers must rely on our knowledge and understanding of hydrologic processes to estimate extreme floods. Oftentimes, these floods may result from unforeseen and unusual combinations of hydrologic parameters generally not represented in the flood history at a particular location. One potential upper bound to the largest flood at a particular site of interest is the PMF.

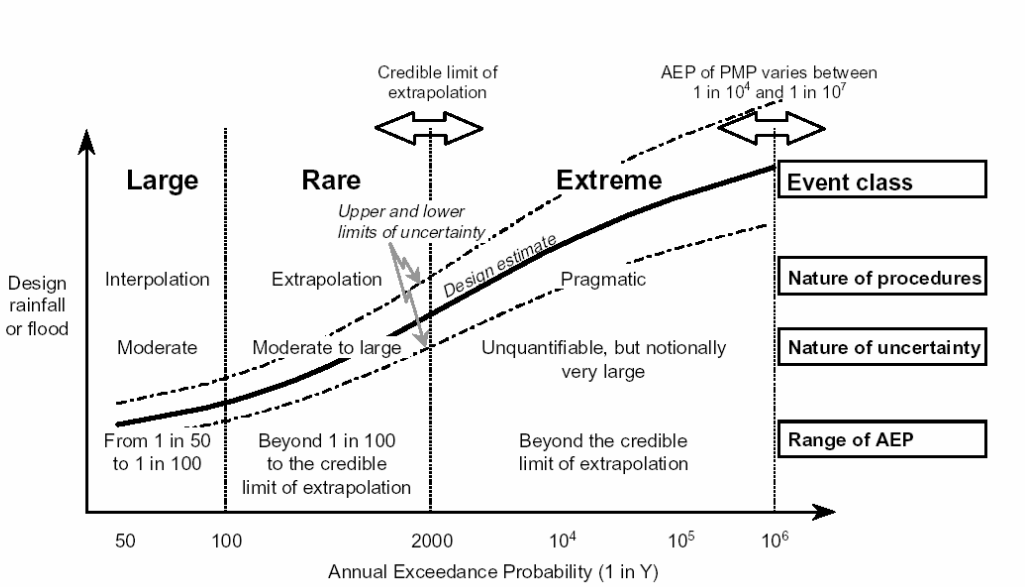


Figure 3-1.—Characteristics of notional floods (Nathan and Weinmann, 2001).

Reclamation uses the PMF as the upper limit of flood potential at a site for storm durations defined by the probable maximum precipitation (PMP). If peak flows or volumes calculated using probability or statistically based hydrology methods exceed those of the PMF, then the PMF is used in evaluating the hydrologic risk and as a theoretical and practical upper limit to statistical extrapolations. The PMF is defined as "the maximum runoff condition resulting from the most severe combination of hydrologic and meteorological conditions that are considered reasonably possible for the drainage basin under study" (Cudworth, 1989). If the PMF has been properly developed, it represents the upper limit to runoff that can physically occur at a particular site. Various storm types, sequences, and durations are taken together with the most severe hydrologic parameters in its development. Extrapolation of statistical analyses can become unbounded for flood distributions that exhibit positive skewness; therefore, Reclamation uses the PMF to limit extrapolation to flood discharges that are physically possible.

Oftentimes, reliable flood frequency estimates are needed for very low AEPs for use in dam safety decisionmaking. Considerable judgment may be required to extrapolate out to the low AEPs required for risk assessment. Even though the flood frequency estimates become less reliable as they are extended beyond the optimal ranges, a systematic way of doing this provides a useful decision making tool.

3.3 Flood Peak and Volume Relationships

Hydrologic hazard relationships display peak flow and flood volumes for various durations versus AEP. Figure 3-2 is a hypothetical example of the type of relationship needed to address hydrologic dam safety issues. Floods with AEPs as low as 1 in 10^8 are desired to encompass the full range of events needed for dam safety risk assessment. The next section of this report describes the available approaches for developing the flood peak and volume relationship. Some of the approaches will also produce flood hydrographs, which can be routed through the reservoir.

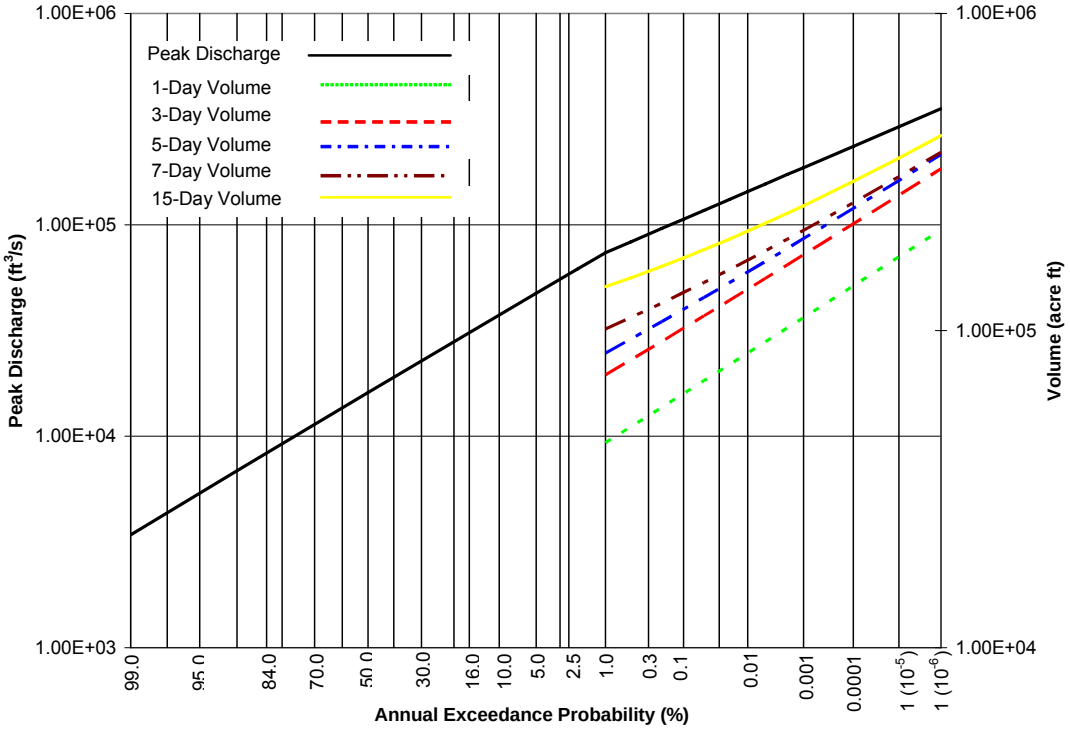


Figure 3-2.—Example hydrologic hazard curve.

4. Analysis Techniques

The main probabilistic and engineering hydrology methods that are currently being used, applied, and under investigation by the Flood Hydrology Group are summarized in this section of the report. There are seven general techniques:

- Flood frequency analysis with historical/paleoflood data
- Hydrograph scaling and volumes
- The GRADEX Method
- The Australian Rainfall-Runoff Method
- Stochastic event-based precipitation runoff modeling with the stochastic event flood model (SEFM)
- Stochastic rainfall-runoff modeling with CASC2D

- The PMF

Other models and approaches are briefly noted by reference in each section. General sources of models and approaches for estimating extreme floods are listed in Maidment (1993), Singh (1995), and Bureau of Reclamation (1999). Methods to calculate extreme floods and associated probabilities have recently been revised and published in the United Kingdom (Institute of Hydrology, 1999) and Australia (Nathan and Weinmann, 2001).

4.1 Flood Frequency Analysis with Historical/Paleoflood Data

There are three main techniques that Reclamation currently uses to develop a peak-flow frequency curve and integrate streamflow (gage) data, historical data, and paleoflood data. The first is a mixed-population graphical approach (England et al., 2001). The two other techniques are statistical models that use gage, historical, and paleoflood data. The Expected Moments Algorithm (EMA) (England, 1999) uses moments to estimate the parameters of a log-Pearson Type III (LP-III) distribution and is consistent with Bulletin 17B (IACWD, 1982). A Bayesian maximum likelihood approach is used by FLDFRQ3 (O'Connell, 1999) to estimate a peak-flow frequency curve with historical and paleoflood data and uncertainties. All three techniques have been used for estimating flood peaks at various Reclamation dams.

4.1.1 Historical and Paleoflood Data

Many different kinds of historical and paleoflood data can be used for flood frequency analysis. Historical flood data are typically extreme floods that have occurred and were described in some qualitative or quantitative fashion before establishing a stream gaging station. The typical information that is available for historical floods is the date of occurrence and the height of the water surface (Thomson et al., 1964). In many cases, people physically mark, on a relatively permanent surface, the approximate high-water mark of a flood (Thomson et al., 1964; Leese, 1973; Natural Environment Research Council, 1975; Sutcliffe, 1987; Fanok and Wohl, 1997).

Paleoflood hydrology is the study of past or ancient floods that occurred before the time of human observation or direct measurement by modern hydrologic procedures (Baker, 1987). The basic types of paleoflood indicators that are useful for flood frequency analysis are paleostage indicators and botanical evidence (Wohl and Enzel, 1995; Baker, 2000). Recent investigations, techniques, and analyses for collecting and using paleoflood data are discussed in House et al. (2002). Fluvial geomorphic evidence includes erosional and/or depositional features that are used to infer paleostages or non-inundation levels. The fluvial geomorphic evidence used in paleoflood and flood frequency studies that represents paleostage indicators includes: silt lines, scour lines, slackwater deposits, boulder and gravel bars, and modified geomorphic surfaces (Costa, 1978; Baker, 1987; Kochel and Ritter, 1987; Jarrett and Costa, 1988; Salas et al., 1994; Jarrett and England, 2002; Levish, 2002). Botanical evidence consists of vegetation that records evidence of a flood (or several floods) or indicates stability of a geomorphic surface for some time period. Botanical evidence of floods includes: corrosion scars, adventitious sprouts, tree age, and tree-ring anomalies (Hupp, 1987).

The historical and paleoflood data can generally be represented with four major data classes (Stedinger et al., 1988): floods of known magnitude, floods of unknown magnitude that are less than some level, floods of unknown magnitude that exceed some level, and floods with magnitudes described by a range. Historical and paleoflood data generally are described in terms of exceedance or non-exceedance of a discharge threshold (Q_o). To correctly interpret the data, one needs to understand the mechanisms by which historical and paleoflood records document the magnitudes of floods that either did, or did not, occur (Stedinger et al., 1993). In many situations, one knows the magnitude of each flood. Annual (gage) peak discharge estimates, historical floods, and paleofloods whose magnitudes are known are described by "floods of known magnitude" class. For example, the solid bars depicted in figure 4-1 describe known floods in the gage and historical period.

The most common situation for using historical and paleoflood data in flood frequency analysis is that a peak discharge Q is known to be smaller than some threshold Q_o, but the magnitude of Q is unknown. The shaded region in figure 4-1 represents these unknown floods that are below a threshold Q_o. The total record length (n) is the sum of the systematic (s) and historical/ paleoflood (h) record lengths (n=s+h). We define the number of observations that exceed the threshold in the systematic record (s) as e, which is equal to 1 in figure 4-1. The number of known observations in the historical period (h) is designated e' (equal to 3 in figure 4-1); it is also known that the values are greater than Q_o. We define k as a random variable equal to the number of observations greater than Q_o in the entire record n, where k = e + e'. The number of observed floods is denoted g, where g = s + k - e.

In some cases, one may know that no floods exceeded the discharge threshold, or k=0. Data in this case have been termed a "non-exceedance bound" (Levish et al., 1994; Levish, 2002), where one has knowledge that no flood has exceeded a designated threshold or geomorphic surface in some time period. An example of a non-exceedance bound is knowledge that a river has not inundated "Main Street," a bridge deck spanning a river, or a geomorphic surface in some time period. Knowledge that k = 0 is valuable information that can be used in flood frequency analysis.

Historical and paleoflood information may be described in terms of a flood that exceeded a threshold, with no upper bound. In some cases, one knows only that a flood was larger than some level and does not know the magnitude of the flood. One knows the number of floods that exceeded the discharge threshold. Stedinger and Cohn (1986) have termed this category as "binomial censoring," in which the exact magnitude of a value is unknown except that it exceeded a lower threshold (see also Russell, 1982). This situation is common for some types of botanical investigations where one can, at present, determine only the minimum stage for plant damage (Hupp, 1988).

There are many situations in which one does not know the exact magnitude of a flood, but that it lies within a range or interval. Interval censoring is used when the exact magnitude of a flood is unknown, but is known to be between some upper and lower amount (Stedinger et al., 1988; Cohn et al., 1997). This class can be used to describe floods with measurement uncertainty. In some cases, the upper threshold, Q_u, can vary for each observation, depending on the data source.

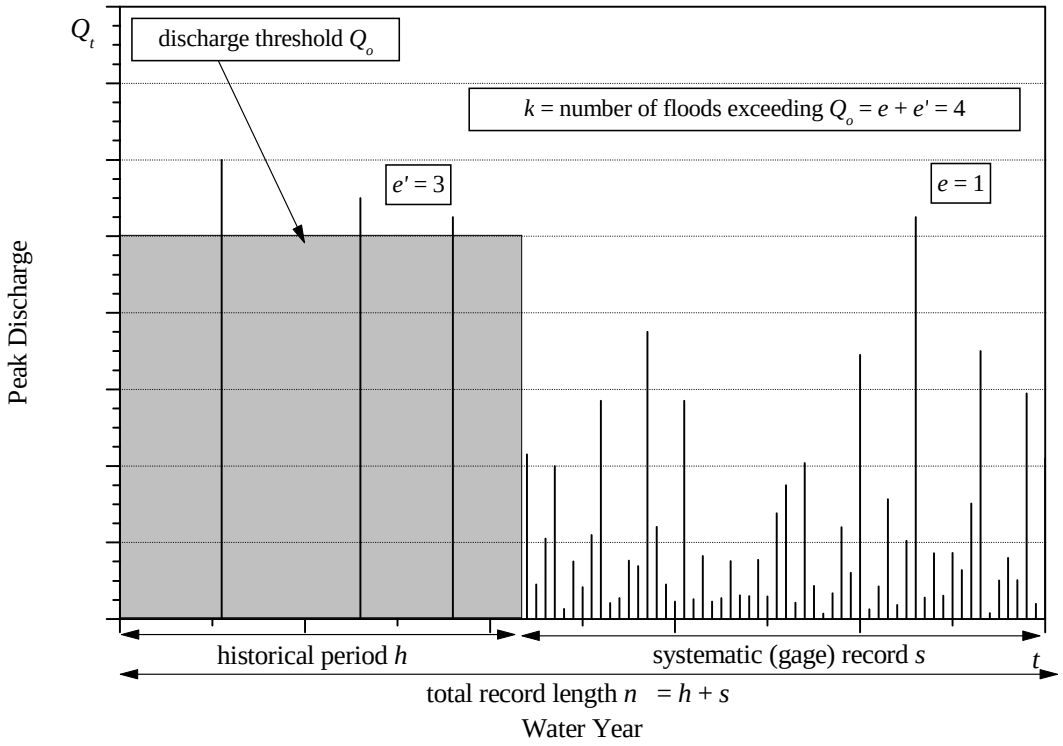


Figure 4-1.—Example of peak discharge time series with historical period and discharge threshold Q_o. The shaded area represents floods of unknown magnitude less than Q_o.

4.1.2 Mixed-Population Graphical Approach

A mixed-population graphical peak-discharge frequency approach has been developed by Reclamation (England et al., 2001). The graphical approach is an at-site frequency method and the frequency curve is constructed in two distinct parts: (1) standard hydrologic statistical methods are used to define a frequency curve for return periods less than and including the 100-year return period (e.g., IACWD, 1982; Ries and Crouse, 2002) and (2) graphical methods are used for estimates greater than the 100-year return period. Peak discharge estimates from gaging stations are used to define the first part of the curve and at-site paleoflood data are used to define the second part of the curve. The first part is estimated assuming an LP-III distribution. One of three at-site techniques and associated computer programs is typically used to estimate the parameters of the LP-III distribution, calculate quantiles, and estimate confidence intervals: (1) the Bulletin 17B Method (IACWD, 1982) and FREQY (Carson, 1989); (2) expected moments methods (Cohn et al., 1997) and EMA (England, 1999); or (3) Bayesian maximum likelihood and FLDFRQ3 (O'Connell, 1999). Historical information is included in the at-site frequency analysis when it is available. Historical data can be used to adjust a so-called "high outlier" using FREQY, EMA, or FLDFRQ3. Low outliers can be adjusted using IACWD (1982) methods. The second portion of the frequency curve is estimated assuming a 2-parameter log-Normal (LN-2) distribution. It is defined between the 100-year and the available paleoflood data return periods, and extrapolated beyond the paleoflood data using this LN-2 distribution. Two points are typically used to estimate this portion of the flood-frequency curve: (1) the LP-III

model 100-year peak discharge estimate and (2) the midpoint in time and discharge of the paleoflood data. Logarithms (base 10) of the peak flows and standard Normal variates of return periods are used to estimate the LN-2 parameters using least squares (England, 2000). The LN-2 distribution was found to reasonably represent daily standardized precipitation in the western United States (Lane, 1997).

The mixed-population graphical approach is used to estimate flood hazard curves. The approach has been developed so that one can estimate an extreme flood frequency curve at any location in the western United States with a minimal amount of effort using existing streamflow data and some site-specific paleoflood data. There are two main assumptions of this graphical approach for estimating extreme flood probabilities: the upper portion of the frequency curve is appropriately defined by the 100-year peak discharge and paleoflood data and the extrapolation of this portion of the curve using a LN-2 model is appropriate. An example peak-flow frequency curve using the graphical approach is shown in figure 4-2. The approach has been reviewed by Kuczera (2000). Kuczera pointed out the major weaknesses were the use of an envelope curve, lack of confidence intervals, and extrapolation. Kuczera recommended that regional growth curves be used to compliment the use of envelope curves.

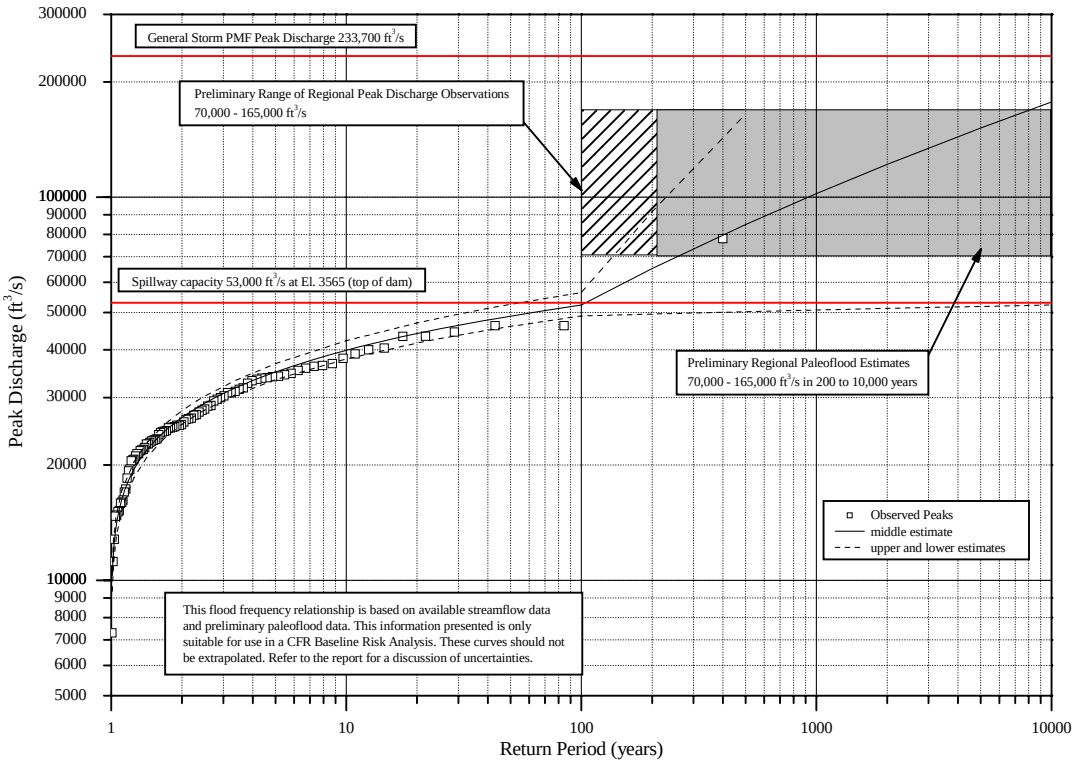


Figure 4-2.—Example application of mixed-population graphical flood frequency curve using peak discharges on the South Fork Flathead River near Hungry Horse, Montana.

4.1.3 Expected Moments Algorithm

The EMA (Lane, 1995; Lane and Cohn, 1996; Cohn et al., 1997, 2001) is a new moments-based parameter estimation procedure that was designed to incorporate many different types of systematic, historical, and paleoflood data into flood frequency analysis. EMA assumes the

LP-III distribution is the true distribution for floods. EMA was designed to handle the four different classes of historical and paleoflood data beyond the applicability of the Bulletin 17B historical weighting procedure (IAWCD, 1982). As noted by Cohn et al. (1997, 2001) and England (1998), EMA is philosophically consistent with, and is an improvement to, the Bulletin 17B method of moments procedure when one has historical or paleoflood information. EMA is specifically designed to use historical and paleoflood data, in addition to annual peak flows from gaging stations, in a manner similar to Maximum Likelihood Estimators (Lane and Cohn, 1996). It is a more logical and efficient way to use historical and paleoflood data than the current Bulletin 17B historical method, and it is a natural extension to the moments-based framework of Bulletin 17B.

The five basic steps of EMA are:

(1) Estimate an initial set of the three sample statistics $\left(\hat{\mu}, \hat{\sigma}^2, \hat{\gamma}\right)$, from the floods with known magnitudes. These floods are typically observations from the gaging station record and possibly some historical or paleofloods. At this step, floods with unknown magnitudes and magnitudes described by a range are not included.

(2) Based on the initial sample statistics from step (1), estimate a set of the LP-III distribution parameters $\left(\hat{\tau}, \hat{\alpha}, \hat{\beta}\right)$.

(3) From the set of LP-III parameters from step (2), estimate a new set of sample moments based on the complete data set: known-magnitude floods, floods less than some threshold(s), unknown magnitude floods that exceed some threshold(s), and floods described by a range.

(4) From this new set of moments, estimate a new set of LP-III parameters.

(5) Compare the parameters from step (4) to those computed from step (2). Repeat steps (3) and (4) until the parameter estimates converge. The main equations used by EMA are listed in Cohn et al. (1997), England (1999), and England et al. (2003).

EMA has been rigorously peer reviewed in the literature (Cohn et al., 1997, 2001; England et al., 2003a, 2003b) and provides a suitable flood frequency model. EMA has been applied at many sites for peak-flow frequency (England et al., 2003b). The National Research Council applied EMA for 3-day annual maximum mean floodflows on the American River (NRC, 1999). An example peak-flow frequency curve with EMA is shown in figure 4-3. There are several limitations with the current version of EMA: (1) the program assumes that the distribution is LP-III, (2) software has not been fully developed to implement the confidence interval technique of Cohn et al. (2001), and (3) low outlier and regional skew methods with EMA have been recently developed (Griffis et al., 2003), but not tested with actual data.

4.1.4 FLDFRQ3

FLDFRQ3 (O'Connell, 1999; O'Connell et al. 2002) uses a Bayesian maximum likelihood procedure to estimate parameters of various distributions. The Bayesian approach includes

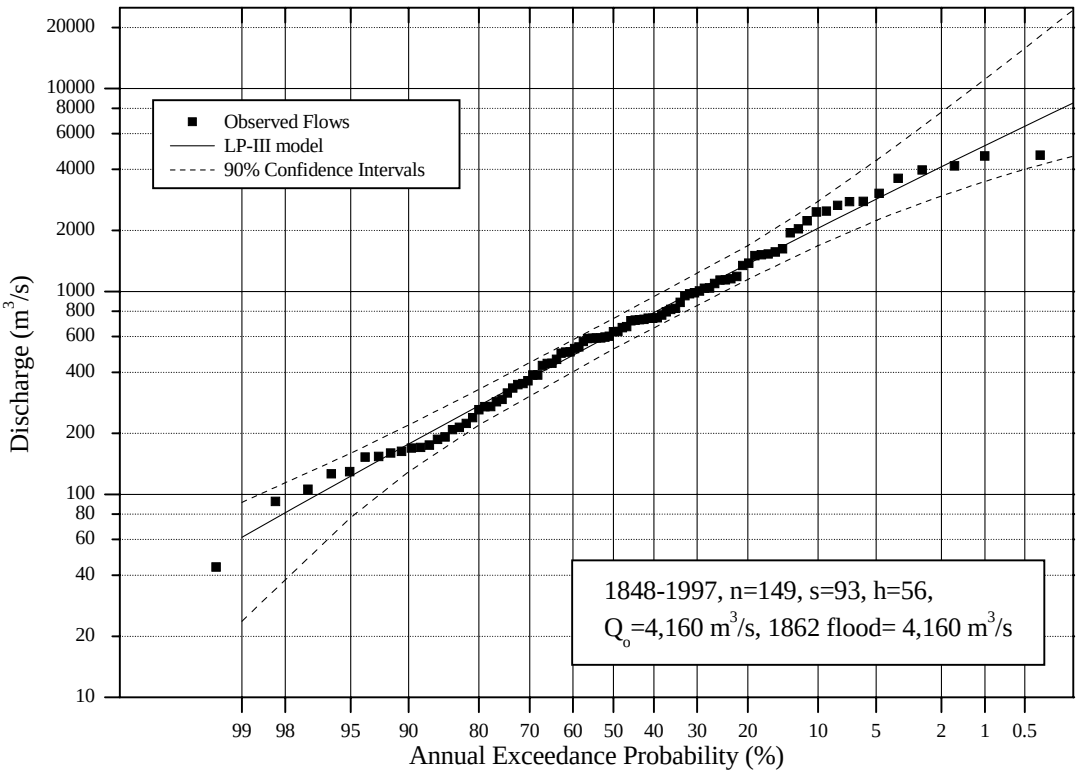


Figure 4-3.—Example application of EMA for American River annual maximum 3-day mean discharge frequency analysis.

measurement uncertainty in the parameter estimation procedure. This approach uses a "global" parameter integration grid in order to identify ranges of probability distributions that are consistent with the data (O'Connell, 1999). Two measurement error sources are included: peak discharge measurement errors and errors in paleohydrologic bound ages. Bayesian methods (Tarantola, 1987) and likelihood functions modified from Stedinger and Cohn (1986) are used to incorporate data and parameter uncertainties. Two options can be used to find the "global" maximum likelihood estimate in FLDFRQ3 (O'Connell, 1999): simulated annealing and the downhill simplex method. In FLDFRQ3, one is able to choose among five main three-parameter probability distributions to assume a peak discharge parent distribution. These distributions are the Generalized Extreme Value, Generalized Logistic, Generalized Normal, Generalized Pareto, and Pearson Type III (P-III) (Hosking and Wallis, 1997). These distributions include two logarithmic transform options for P-III models to include the LP-III. O'Connell (1999) provides details of the numerical approach used for estimating distribution parameters and uncertainty using grid integration.

There are generally three main steps in running FLDFRQ3 (O'Connell, 1999): input and data check, parameter estimation for a particular distribution, and generating parameter uncertainties for a particular model (e.g., LP-III) using grid integration. The data are grouped into two broad classes: data with normal uncertainties, such as peak discharge, and values in a range with potentially variable probability density and skew within the range, such as paleohydrologic bound discharges and ages and discrete paleofloods. After entering and checking data, the parameter estimates are obtained from the data and assumed model. The user then checks the appropriateness of the model and estimated parameters. There can be several steps here to

determine the "best models" (there can be more than one) that fit the data and the model parameters. Finally, the user estimates the parameter uncertainty given the chosen model and parameter combination. O'Connell et al. (2002) demonstrate how to combine results of several models and their parameter uncertainties using a likelihood criterion.

FLDFRQ3 has been rigorously peer reviewed in the literature (O'Connell et al., 2002) and contains suitable flood frequency models for all levels of analysis. It has been used at many sites for peak-flow frequency, such as Folsom Dam (Bureau of Reclamation, 2002), Seminoe and Glendo Dams (Levish et al., 2003), and Pathfinder Dam (England, 2003). An example peak-discharge frequency curve using FLDFRQ3 is shown in figure 4-4.

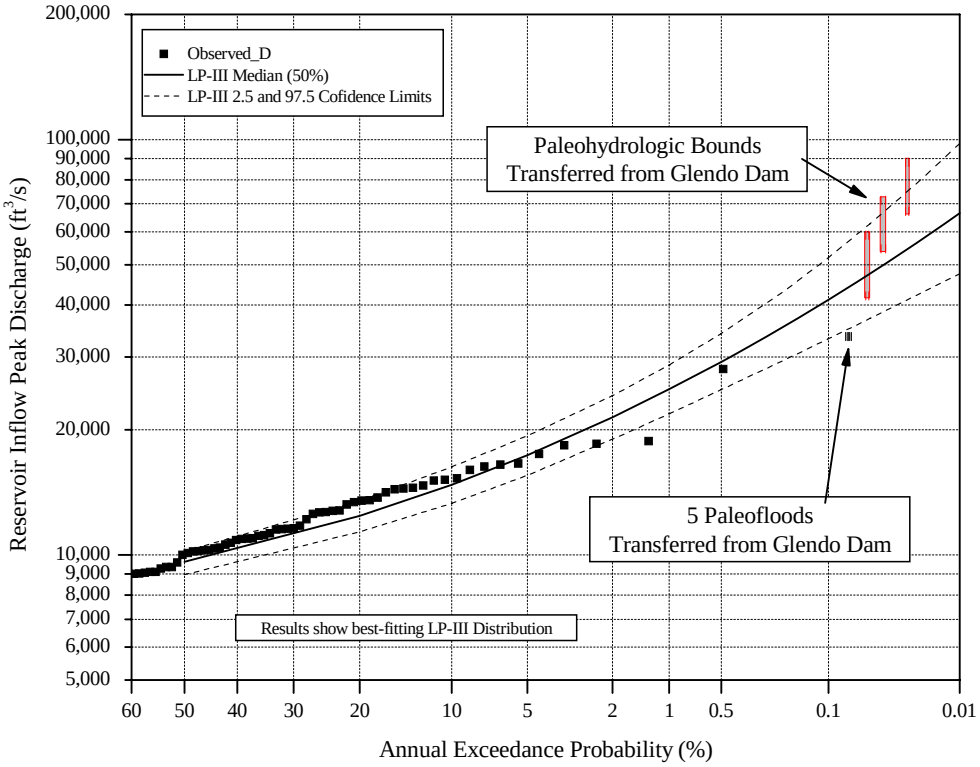


Figure 4-4—Annual peak-discharge frequency inflows to Pathfinder Dam, Wyoming, from best-fitting LP-III distribution using FLDFRQ3 (England, April 2003).

4.2 Hydrograph Scaling and Volumes

Practical tools have been developed for estimating probabilistic hydrographs that can be used in risk analyses for dam safety. These tools are presented in England (2003a) and are summarized below. The key feature of the approach is to use peak-discharge frequency curves that include paleoflood data as a basis to develop hydrographs and volume frequency curves. The methods are relatively flexible and can be tailored to different types of investigations. The methods need to be adjusted depending on the available data at the site and region of interest. For example, if a peak-discharge frequency curve developed using the graphical approach is available, one could use less detailed methods to develop hydrographs because the data might not warrant sophisticated techniques. In contrast, if detailed, high-quality peak discharge and paleoflood

data are available, one could use more refined methods such as the SEFM (MGS Engineering Consultants, Inc. [MGS], 2001) discussed below.

Probabilistic hydrographs can be constructed based on streamflow estimates from gaging stations, historical data, and paleoflood data. Four components are used: (1) a peak discharge-probability relationship, (2) an extreme storm duration probability relationship, (3) relationships between peak discharge and maximum mean daily flow volumes, and (4) observed hourly flow hydrographs that have regulation effects removed. The key idea is calibration or scaling of hydrographs to match peak discharge for a given probability. The approach relies completely on the specification of a peak-flow frequency curve that describes the probabilities of interest, based on paleoflood data.

There are four major assumptions for developing the hydrographs: (1) the probability of peak discharge represents a probability of the composite hydrograph, (2) unit hydrograph assumptions apply to the basin, (3) direct runoff volumes can be estimated from daily flow hydrographs, and (4) the recorded streamflow observations, historical information, and paleoflood data in the river basin of interest provide an adequate sample so one can extrapolate peak discharge probabilities, peak-volume relationships, and hydrographs for extreme floods. Maximum mean discharge ($\overline{Q}_d$) for n-day periods is related to peak discharge (Q_p) by a power function:

$$\log \overline{Q}_d = a + b \log Q_p \qquad (1)$$

The assumed known variable is peak discharge (Q_p), with an associated exceedance probability estimate from the frequency curve. The quality of the regression relationship expressed in equation (1) depends principally on the data from the site of interest and the flow duration (n). Mixed-population flood data (e.g., from thunderstorms, snowmelt, or rain-on-snow) can lead to difficulties in obtaining statistically significant relationships. Good regression fits are typically found for shorter duration (1- to 7-day) flow volumes; the relationships become progressively worse for longer durations. The maximum n-day hydrograph ordinates are linearly scaled, based on the selected n-day volume.

An alternate approach to using streamflow data is to use hydrographs from rainfall-runoff models as a basis for scaling. In these cases, there are typically no flood hydrograph data at the site of interest. A design flood hydrograph, a PMF hydrograph, or other suitable hydrograph for the basin is obtained. The hydrograph can then be scaled in some linear fashion to match peak flows from a peak-flow frequency curve. The analyst needs to be careful to ensure that flood volumes do not exceed physical limits when applying this scaling procedure.

Probabilistic hydrographs, developed from scaling streamflow observations or from rainfall-runoff models, are combined with recommendations for initial reservoir levels for hydrograph routing. Reservoir routing issues and selection of varying initial levels are discussed in England (2003a). One can then determine a maximum reservoir level by routing the given hydrograph and initial reservoir level. Initial reservoir levels can sometimes have a large effect on maximum reservoir level estimates for extreme floods. Maximum reservoir elevation probability estimates depend on the inflow hydrograph peak, volume, shape, and probability estimate. The initial reservoir level can also be a major factor. The selection of an appropriate initial reservoir level is of considerable importance in determination of spillway adequacy (Nathan and Weinmann,

1999, p. 57). For estimating maximum reservoir levels for design floods such as the PMF, Reclamation uses a fixed initial reservoir level. This initial reservoir level is usually set at the top of active conservation or bottom of the flood control pool. This assumption has been criticized as being unduly conservative. Newton (1983, p. 914) notes that current practice for most agencies is to assume conservatively high initial pool levels for routing PMFs. Instead of using a fixed initial reservoir level for routing hydrographs, variable initial reservoir levels are needed for risk analysis. Initial reservoir levels and associated exceedance probabilities should be estimated from daily reservoir elevation estimates for the period of record at the site of interest.

4.3 GRADEX Method

Much of this description of the GRADEX Method is paraphrased from the Ph.D. dissertation, "Methodology for Estimating the Upper Tail of Flood-Peak Frequency Distributions Using Hydrometeorological Information," by Mauro Da Chunha Naghettini, completed in partial fulfillment of the requirements for the Ph.D. degree at the University of Colorado, Department of Civil, Environmental, and Architectural Engineering, 1994. Naghettini, Potter, and Illangasekare later described the same method in the Water Resources Research publication in 1996. Some additional comments related to Reclamation dam safety needs are inserted when appropriate.

In its 1988 report, the National Research Council Committee on Estimating the Probabilities of Extreme Floods identified principles for improving the estimation of floods with AEPs on the order of 10^{-3} or smaller. These principles are: "(1) 'substitution of space for time'; (2) introduction of more 'structure' into the models; and (3) focus on extremes or 'tails' as opposed to or even to the exclusion of central characteristics" (NRC, 1988). The methodology proposed in Naghettini's Ph.D. dissertation (1994) presents techniques for the estimation of extreme flood peaks and volumes that make strong use of these principles. The main objective is to develop a peak-flow frequency curve for the extremely rare probabilities. To do so, the method involves a peak to volume relationship and the derivation of a frequency curve of extreme flood volumes based on extreme regional rainfall statistics. The method is useful to current Reclamation dam safety needs in that it provides a means to produce frequency curves for rare flood volumes and also some apparatus to define peak flows for the extreme flood volumes. It can also be used to create hydrographs based on the flood volumes and peaks, if needed.

The method relies on extrapolating a conventionally estimated probability distribution of flood volumes. To strengthen this step, the GRADEX Method, originally developed by Guillot and Duband (1967), is incorporated. The GRADEX Method has been used extensively in France since about 1967 for various improvements and hydrologic safety investigations and spillway renovations at numerous hydroelectric dams and facilities. The French Committee on Large Dams has prepared the publication, *Small Dams* (undated), which outlines the very basic steps that can be used to perform such calculations in France. The main GRADEX Method is based on two assumptions:

(1) That, asymptotically, the upper tail of the flood volume distribution is exponential with the same scale parameter as that which describes the upper tail of the

distribution of rainfall volumes for the basin. Figure 4-5 graphically displays this assumption.

(2) That any increase in total precipitation during a severe rain event, falling on already saturated ground, will produce a corresponding increase in volume of the resulting flood.

The estimation of the rainfall scale parameter has been enhanced in this application from the original French methodology by incorporating the work of Smith (1989), who developed a regional model for estimating the upper tail of a frequency distribution based on extreme order statistics. Figure 4-5 depicts the GRADEX Method.

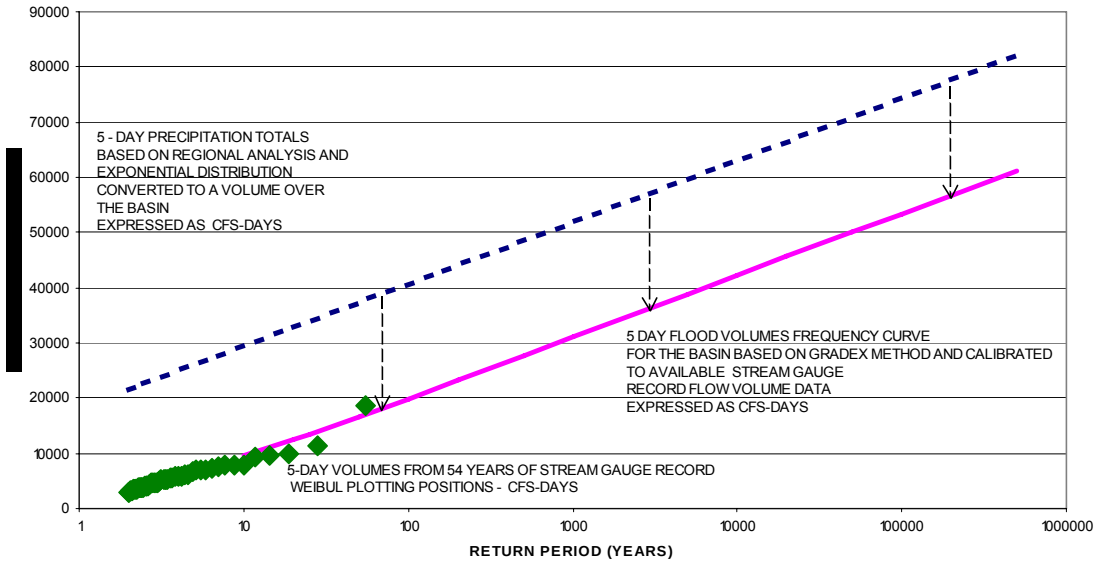


Figure 4-5.—GRADEX Method of volume frequency curve calculation.

The location where the extrapolated flood volume curve takes over from a more conventional analysis of stream gage volume data, such as using LP-III, is not fixed, but must be assumed. In the literature from France, this return period ranges from about 10 years, for very impermeable basins, to 50 years for very permeable basins.

The first assumption of the GRADEX Method given above refers to the upper tail of the rainfall volume distribution, which is assumed to be a generalized Pareto density function of the form:

$$g_p(p|s,K) = 1/a\ [1- ((Kp)/a)]^{1/K - 1} \quad \text{if } K \neq 0 \qquad (2)$$

This will reduce to a simple exponential density function of the form:

$$g_p(p|s,K) = (1/a)\exp(-p/a) \quad \text{if } K = 0 \qquad (3)$$

Where the positive constants K and *a* are the location and scale parameters, respectively. The scale parameter a is a function of various physical components of the available rain gage data

sets such as elevation and mean annual precipitation (MAP). If K > 0 then the distribution of rainfall for all sites has an upper bound; if K < 0 it is unbounded. If K = 0 the upper tail of the distribution is exponential with a scale parameter *a*. The parameter estimates are found by fitting a distribution that asymptotically exhibits an exponential upper tail (e.g., Exponential, Gumbel, Gamma, or log-Normal) to rainfall maxima. Combining the two GRADEX assumptions causes the upper tail of the flood volume distribution to also be exponential with the same scale parameter *a* (the GRADEX parameter) as the one estimated for the upper tail of the distribution of rainfall volumes, except for a necessary conversion to units of volume instead of precipitation depth.

The first step in the GRADEX Method involves selecting a critical duration. This begins with an examination of the time series of unregulated daily flows for a stream gage record deemed to be hydrologically similar to the basin being studied or a record of reservoir daily inflows. What is required is a series of independent flood events (hydrographs) that have occurred over the entire length of the unregulated streamflow record. These flood events should be rain-generated, as opposed to floods derived from snowmelt. Also, the rain-generated flood events should all be of the same storm type. For these reasons, the stream gage record analysis should be limited to a "season" when the rain floods of the same type are most likely to occur based on historic experience. Once the season is selected, the daily streamflows for each year within that season are examined. A threshold discharge, Q threshold, is set. The number of daily flows above this threshold value is observed. Multi-day events with several days of flow above the threshold are observed. The number of and the duration of each of these multi-day events are then calculated. It is desired to obtain a set of independent flood events with nearly the same number of events as the number of years in the length of record. If the number of events calculated is too large or small, then the threshold Q value is raised or lowered until approximately the number of events equals the number of years in the stream gage record. The average duration for the entire set of events is then calculated. This average duration, generally raised to the next highest number of days, will become the critical duration d used for the rest of the study. Once the critical duration *d* is determined, the average flow discharge of all of these events can be calculated. A second flow value, termed the reference discharge, is also determined such that 90 percent of the selected flood events will have average *d*-day flow values less than this discharge value. An approximate return period is also placed on this reference discharge value by the inverse of the Gringorten plotting position formula.

$$\text{Reference return period} = 1/\left((i - 0.44)/(N + 0.12)\right) \tag{4}$$

Where N is the total number of years of record and *i* is the rank of the selected reference discharge. This part of the analysis can require much hydrologic judgment. Often, a set of daily flows will show a pattern that is above the selected threshold Q for 1, 2, or 3 or more days, then drop just below the threshold for 1, 2, or 3 days, and then continue for a few more days above the threshold. Decisions have to be made as to whether this should all be considered one flood event or separated into two or more events. Rainfall records from the area may help with this decision, but, generally, it is left to the analyst to make the decision. Independence of the events is generally assumed if the time from the end of the first event to the beginning of the next event is longer than the critical duration that is calculated for this set of events.

In hydrology, this process is often referred to as a marked point process. Much literature is available dealing with statistical assumptions related to events derived by the marked point process. By its nature, the set of floods derived by this process may include several events in any one year, and no events for several years. This is what is desired because the data will be used to help calibrate the GRADEX-derived flood volume information from rainfall totals for the critical duration. It is often the case that several large rainfall events can occur in any one year. Cautions that are given for the selection of the critical duration are: (1) that selection of too short a duration might result in non-exponential, probably heavier-than-exponential, upper tails for the rainfall volumes and (2) adoption of too long a duration might result in poor peak-volume relationships. Since the goal of the application of the GRADEX Method to Reclamation dam safety investigations is to create a good volume relationship, it is advised to raise the computed critical duration value to the next higher full day.

In conventional applications of the GRADEX Method, the parameter *a* can be estimated by fitting an exponentially tailed distribution to seasonal or annual rainfall maxima. The simplest estimation procedure of the GRADEX parameter is to fit a Gumbel distribution to a series of annual maximum rainfall events for a duration *d* that is equal to the watershed critical duration, or some other measure based on time of concentration calculations. However, the most frequently used estimation procedure is to fit an exponentially tailed distribution to seasonal (sometimes monthly) rainfall maxima and then combine the seasonal (monthly) distributions to obtain the annual distribution. What can be shown is that the annual frequency curve, which would no longer be a strictly exponential curve, will tend to have the same shape or slope (GRADEX) as that of the month that produces the largest rainfall amounts, especially at the extreme upper end. A slightly more conservative approach is to use smaller durations of seasonal maxima rainfall totals for even smaller durations, even 24 or 48 hours.

Estimation of the GRADEX parameter of flood volumes requires that different units for expressing the rainfall be used. If the drainage area and critical duration *d* are expressed as mi^2 and days, respectively, and the GRADEX parameters are to be expressed in English units, then:

$$\text{Flood Volume GRADEX} = [(26.89 * DA)/d] * \text{Rainfall GRADEX} \quad (5)$$

Similar expressions exist for computations done in metric units.

Usually, following the French examples, the extrapolation of the flood volume distribution according to the GRADEX parameter starts at the 10-year flood for small and relatively impervious basins, or at the 20-year flood for larger basins, or possibly the 50-year flood for watersheds showing very little topographical relief or high infiltration capacity.

The current application of the GRADEX Method applies a new methodology to estimate the slope of the rainfall durations for a critical duration d within a specified season. This new approach combines deterministic constraints with contemporary statistical techniques, extracting the maximum information from the available data. The regional rainfall frequency model described in this section is based on the premise that meteorological processes affecting large rainfall events may be different from those affecting smaller rainfall events. The model is an adaptation of a regional flood frequency model developed by Smith (1989) and is based on results from extreme value theory. In this model, the parameters *a* and *K* in the Pareto or

exponential distribution functions (equations 2 or 3) are determined based on a regional analysis of the largest *d*-day rainfall totals for several daily rainfall stations that are shown to be or believed to be homogeneous and to represent the meteorological conditions of the basin under study. The parameter *a* is further allowed to be a function of the basin mean annual precipitation and the basin mean elevation.

$$a = S_i = \exp(c + b_1 W_{i1} + b2 W_{i2}) \quad (6)$$

Where W_{i1} and W_{i2} are the natural logarithms of the set of rain gage elevations and mean annual precipitation values for each gage site i, respectively. The constants b_1, b_2, and c are determined as part of the parameter estimation process. This is an improvement over the French general cases where only one rain gage or set of regional information reduced to one point for any basin may be used. Further, no consideration of elevation or mean annual precipitation is given in the standard GRADEX analysis.

The mathematical process to estimate the parameters K, c, b_1, and b_2 from the data set of rainfall totals proceeds as a maximum likelihood parameter estimation process. A log-likelihood function is then formed.

$$L_n(K, b_1, b_2, c) = \sum \sum \ln[g_p(Zg / K, b_1, b_2, c)] + C \quad (7)$$

Zg is the set of random variables of *d*-day rainfall totals above the threshold precipitation value at each gage site. The double sum is for all of precipitation values above the threshold value at each site and then summed over all sites.

Partial derivatives of the log-likelihood function with respect to the four parameters to be estimated (K, b_1, b_2, and c) are derived. In taking the partial derivatives, the additional constant C in the log-likelihood function is eliminated. These partial derivative functions are then set equal to zero, and a series of four non-linear equations with four unknowns (if $K \neq 0$) or three non-linear equations with three unknowns (if K = 0 is assumed) are formed. As part of the parameter estimation process, statistical tests are performed to see if the three-parameter exponential distribution form is equally valid for the data set as is the four-parameter Pareto distribution. In almost all cases, this is true. The assumption that the extreme rainfall totals can follow an exponential distribution is validated, and the rest of the GRADEX Method follows. The three parameters are then used to form the single scale parameter a (equation 5) for a single parameter exponential distribution form. In cases where the statistical test does not prove the validity of the three-parameter exponential distribution form, the rainfall total data sets need to be further investigated as to homogeneity.

Software to solve the complex sets of non-linear equations was adopted from the MINPACK software package originally developed in 1980 at the Argonne National Laboratory. This software is now free and in the public domain. Only the most extreme rainfall totals for the critical durations *d* at each daily rainfall stations are used as data. Once the equations are solved, the scale parameter *a* is estimated. Readers who are interested in the complete theoretical and mathematical background are referred to Naghettini (1994, chapter 4). The remainder of this discussion deals with the hydrological and meteorological details of this method.

The method requires that all stations selected have a common period of record that is as long as possible. Daily rainfall totals for all official rainfall gage stations in the United States are available on compact disks from Hydrosphere Corp. (2002). Several stations near the basin being studied need to be selected and their periods of record noted. These rain gage records should represent climate and meteorological conditions similar to conditions in the basin being studied. Stations too far from the study area or too high or low in elevation should not be used. The same continuous period of record should be available for each rain gage selected. It is also advisable to avoid selecting too many stations in any one area, which would then overly weight the climate and rainfall records in that localized area compared to the rest of the surrounding areas for the basin being studied.

The method relies on data from the rainfall gage records that cover the same continuous period of time for each gage. If large gaps in the gage record are found (even though the beginning and ending dates may cover the continuous period needed), the record should be discarded. Recorded rainfall data is subject to many errors, omissions, and other anomalies. Within each rain gage record, missing days, days with accumulated rainfall from several previous days, and days with only a trace of precipitation or other notations are noted. Analyzing the daily rainfall totals involves summing the total rainfalls for the number of days previously defined as the critical duration d for this basin based on analysis of the appropriate stream gage records. The process is complicated by the need to eliminate all the days with missing data or with special notes, such as when the recorded value was already an accumulated value. Any multi-day total rainfall that includes such data is then set to zero and eliminated from further consideration. Trace values are set to zero for the day that they were reported and then they are allowed in the summation process. Any extremely large daily rainfall totals need to be further checked against official hardcopy records, and the correct daily values for these dates are inserted in the analysis if changes are needed. In the process, independence of the rainfall total events also needs to be ensured. The start dates of any two multi-day events must be more than the critical duration *d* apart.

The method requires selection of a number of multi-day total rain events at each gage equal to the number of common years of record for all selected gages. A threshold *d*-day total rainfall for each gage is selected such that exactly the same number of independent *d*-day rain totals is above this value as are in the continuous period of record covered by all the rain gages in the analysis. Further, a reference total precipitation value for each rain gage is also selected such that 90 percent of the previously selected events are below this reference precipitation value. The threshold and reference precipitation values are used later in the statistical analysis. Only the top 10 percent of the *d*-day rainfall totals are used in the regional analysis. This amounts to a form of top-end fitting for the precipitation totals.

To further facilitate the computations, the rainfall multi-day totals are reduced by subtraction of the reference precipitation amount for each rain gage. This step is necessary to eliminate very large numbers in the calculations that follow. This is a form of “indexing” and is common in many regional flood methodologies.

The upper order statistical method calculates the slope (or GRADEX parameter) of the best-fit decaying exponential distribution of the top 10 percent of the *d*-day total indexed precipitation amounts for each selected rain gage site. The selected station elevations and mean annual

precipitations help weight the slope parameter. Knowing the basin's mean elevation and MAP, a GRADEX parameter fit specifically to the drainage basin being studied can be calculated. The result is the slope of the decaying exponential distribution of the most extreme precipitation amounts that the selected precipitation data suggest can occur over the drainage basin. The distribution of *d*-day total index precipitation values can then be used with knowledge of the contributing drainage area for the basin to create associated *d*-day volumes as shown in equation 5, above. This distribution of *d*-day volumes now has a slope, but it must also be fit to the actual reservoir *d*-day inflow volumes at the lower return periods. This is done through a statistical procedure. The fitted curve will match the experienced stream gage *d*-day volumes near the computed reference Q value previously computed. The resulting curve can be extended to very high return periods based on the second basic assumption of the method, that all large flood volumes will occur from rain falling on already thoroughly saturated conditions in the contributing areas of the basin, and any increase in a *d*-day rainfall will result in a corresponding increase in *d*-day inflow volume to the reservoir.

Since the GRADEX parameter *a* is calculated using a maximum likelihood estimate, it is further possible to place a confidence bound on this parameter. Note that for one-parameter distributions such as the exponential, the natural logarithm ratio between the estimated likelihood function and a true likelihood function for the one parameter can be proportional to a chi-square distribution with one degree of freedom. This process is displayed on the Web page, <http://www.weibull.com.LifeDataWeb/likelihood_ratio_confidence *bounds*exp.htm>. By a trial and error process, the upper and lower confidence bounds associated with the *a* parameter estimate can be determined for some set confidence level.

Once the slope and location of the flood volume curve for the *d*-day durations have been established, the question of what is the probability that a particular volume of flooding will be equaled or exceeded in any year can be answered. The more common question is what is the volume of flooding that will be exceeded on average only once in a stated return period, T_c = number of years. To answer that question, the calculated exponential distribution and associated confidence bounds, need to be inversed. The inverse of the distribution has the form:

$$\hat{x}(T_c) = \hat{\beta}_1 + \hat{a}\ln\left(T_c + \hat{\beta}_2\right) \tag{8}$$

Where:

$\hat{x}(T_c)$ is the *d*-day flow value for any required return period, in ft^3/s-days, T_c is the return period (in years) for which a *d*-day flow estimate is required, $\hat{a}$ is the previously estimated GRADEX slope factors converted to volume units, and $\hat{\beta}_1$ and $\hat{\beta}_2$ are constants that can be estimated from a system of simultaneous equations that are formed knowing the mean of the sample of *d*-day flood discharges and the reference *d*-day discharge with an approximate return period. Both of these discharge values and the reference discharge return periods are previously computed from the daily inflow record for the location of the study. The $\hat{x}(T_c)$ value can then be further converted to more common volume units such as acre-feet for a specified number of days.

The original goal of the method, as presented in Naghettini (1994), was to produce a peak-flow frequency curve. In this procedure, a known set of peak flows associated with *d*-day volumes can be determined from the stream or reservoir inflows, assuming peak flows have been recorded. This set of paired data for the period of the streamflow record can be further extended by the use of various rainfall-runoff models. Calibrated rainfall-runoff models can be created for some of the largest events in the stream gage record if appropriate rainfall data are also available.

In the original presentation of the method, it is suggested that several large storms, all of the same type and from meteorologically similar areas, could be transposed into the basin. For each of these large storms, the calibrated rainfall-runoff models can then be rerun with the transposed storm precipitation data and a new peak flow and hydrograph can be generated. Additional sensitivity analysis runs can be made by varying certain parameters in the rainfall-runoff model that affect the peak, such as the lag time or other parameters related to unit hydrograph development. The peaks and *d*-day volumes from all of the additional transposed storms can then be added to the original set of peak and volume data. Regressions on this extended set of peaks and volumes can provide the necessary information to help determine a peak flow for a selected volume at some rare return period that has been calculated by the GRADEX Method. In both the French and American literature for the GRADEX Method, it is suggested that the regression between volume and peak data should not be linear. The French literature states that the ratio of peaks to a *d*-day volume will increase with increasing return periods. A regression procedure known as LOWESS (Locally Weighted Regression and Smoothing of Scatter Plots) (Cleveland, 1979) can be used to perform the non-linear curve fitting required for this procedure.

Reclamation's practice with the method has not involved multiple storm transpositions. For each application, some attempt has been made to create a calibrated rainfall-runoff model using HEC-HMS (U.S. Army Corps of Engineers, 2002). The largest one or two floods from the stream gage record and the best available rainfall data are used to create the calibrated runoff model. The model is calibrated to match as nearly as possible the peak and the entire volume of flooding, which may be longer than the *d*-day critical duration determined earlier. Once the calibrated rainfall-runoff model is completed, the historic rainfall information, with both temporal and spatial distribution, is increased by a constant ratio at each time period. The resulting peak and *d*-day volume of the hydrograph is recorded. Additional runs are made and the lag times are reduced by 10 or 20 percent to account for the fact that the historic flood may not have resulted from such intense rainfall as the desired higher return period floods might produce. With more intense rainfalls, it may be that the basin lag times should be reduced to allow for quicker formation of the flood peaks. The extended peak and *d*-day volume set is then fit with the LOWESS procedure. Using this non-linear regression, peak flows associated with the various volumes for different return periods by the GRADEX Method can be estimated. This method will also allow for production of the entire hydrograph with exactly the required *d*-day volume estimated by the GRADEX Method. Examples of the results of this computation can be seen in the Fresno Dam example at the end of this report.

In the publication, *Small Dams*, (French Committee on Large Dams, undated), an empirical equation is given that will produce an entire hydrograph with a specified peak, time to peak, and the desired time step. One of the parameters in that equation can be varied by trial and error until the desired volume of the hydrograph over any period of time, such as *d*-days, is achieved. This

represents another strictly empirical method to derive a hydrograph once a peak and volume for the desired return period are known.

Some other concerns have become apparent in the application of the GRADEX Method to some dams in the Reclamation inventory. The first concern is with the possible additional volume of flooding that may result from snowmelt that may not be explicitly considered in the GRADEX Method. The available literature indicates that a separate snowmelt volume analysis should be undertaken. For each year of stream gage record, the maximum snowmelt volume for some time period larger than *d*-days should be estimated. A separate LP-III (or any other distribution) analysis of the snowmelt volumes can be constructed and extrapolated to rare return periods. This frequency curve of snowmelt flood volumes can be used with a combined probability analysis of the rain flood GRADEX *d*-day volumes. The resulting frequency curve will display the probability of getting a flood volume composed of both snowmelt and rain flood volumes. What becomes apparent for the large return periods is that the GRADEX rain flood curve will dominate the combined probability volumes. The combined probability curve is almost identical to the GRADEX curve at the large return periods. For a large return period, the probability of getting a flood with X acre-feet composed of Y acre-feet of snowmelt, plus Z acre-feet of rain generated flood volume (X = Y + Z), is nearly identical to getting the rain flood alone with X acre-feet of volume. An example of this type of combined probability analysis is given in the Fresno Dam example later in this report. It is recommended that in all future applications of the GRADEX Method to Reclamation dams some attempt be made to create a separate snowmelt flood volume frequency curve and a combined probability analysis with the GRADEX rain-flood curve be made to ensure that the rain floods dominate at the rare return periods.

A second concern is with drainage area size. The GRADEX Method is based on assumed basin average rainfall. Because of this, there is a clear question as to its applicability to large basins. The original French literature limits the size of the drainage basins where the GRADEX Method can be applied to about 10^4 square kilometers, or about 3,800 square miles. It is noted that few storms with greater aerial coverage exist in the rain gage data. The application of the method to such larger drainage sizes would not produce defendable results. To approach this problem, the suggestion is that the larger basin be broken into smaller parts along logical lines, such as at major tributary confluences, such that each part is no larger than 3,000 square miles. The GRADEX Method could be applied to each separate part, and a combined probability analysis could then be performed with the resulting curves for each part. The resulting frequency curve would show the volume of flooding that could occur resulting from contributions from each separate part of the basin. This approach has not yet been tried for any Reclamation dams.

For the full application of the method for a detailed hydrologic study, additional effort should be made to determine a homogeneous set of rain gages for use in the GRADEX Method. Naghettini (1994) provides some useful suggestions and examples along these lines. Due to time and money constraints, this has not been done in any Reclamation studies to date.

4.4 Australian Rainfall-Runoff Method

The Australian Institution of Engineers developed and published an approach for estimating large to extreme floods in 1999 and revised the method in 2001 (Nathan and Weinmann, 2001). The focus of this work is on estimating floods with very low probabilities of occurrence. The

floods developed using this technique usually have AEPs ranging between 1 in 50 and 1 in 10 million. Uncertainties involved in estimating floods increase with increasing sizes of floods. The following discussion describes Reclamation's experience with estimating rare and extreme floods using the Australian approach.

Three categories of floods are considered – large, rare, and extreme. Large floods typically have probabilities of occurrence ranging from 1 in 50 to 1 in 100. Rare floods include floods with AEPs extending from 1 in 100 to the credible limit of extrapolation, generally around 1 in 2,000. Extreme floods involve estimating floods for the AEPs beyond the limit of credible extrapolation. For risk analysis purposes, rare and extreme floods are of most interest.

Rare floods include events between the largest observed flood and the credible limit of extrapolation. The creditable limit of extrapolation depends on the type and amount of data used for flood frequency analysis. Generally, regional flood and precipitation data, and the inclusion of paleoflood data, allow extrapolation out to around 1 in 2,000 or 1 in 5,000. It is important to note that floods in this category contain considerable uncertainty because estimates are outside the range of observations.

Extreme floods extend beyond the credible limit of extrapolation from the data to AEPs out to 1 in 10 million. Estimating these floods requires prescriptive measures, which do not allow the hydrologist to quantify the uncertainty of the estimates even though it is known to be very large. Extreme floods determined by these methods are intended to be consistent and as reasonable as possible given the state of current knowledge.

4.4.1 Approach

The procedures involved in the Australian Rainfall-Runoff Method are based on flood frequency analysis and rainfall-runoff modeling. Any of the flood frequency analysis techniques previously discussed in previous sections of this report are applicable to the Australian Rainfall-Runoff Method. The unique concept in this approach is the use of "AEP-neutral" parameters in the rainfall-runoff modeling process. This involves selecting model parameters such that the AEP of the 1 in Y rainfall amount produces a flood with a 1 in Y AEP.

Reclamation has used an event-based deterministic rainfall-runoff model to convert a 1 in Y AEP design rainfall into a 1 in Y AEP flood. A single set of hydrometeorological parameters and watershed characteristics are used to produce a flood event. No soil moisture or surface storage recovery is provided. Therefore, the deterministic model always produces the same output.

The major inputs to the deterministic rainfall-runoff model are: (1) precipitation (rainfall and snowfall), (2) losses (infiltration/interception), (3) physical watershed characteristics for runoff and routing simulations (drainage areas, watershed and channel slopes, lag times, antecedent moisture, etc.), (4) precipitation-runoff transformation function, and (5) runoff conveyance and routing mechanisms. Model output includes runoff hydrographs at user-specified locations, maximum peak discharges, and total runoff volumes.

Deterministic event-based precipitation-runoff modeling applies design rainfall distributions and volumes to watersheds for which runoff response is characterized by unit hydrographs and

generalized loss-rate functions. Calculations proceed from upstream to downstream in the watershed. Subbasin hydrographs are routed and combined at the points of interest.
A design storm (rainfall and basin snow cover) is the primary model input. Typically, a time series of basin-average rainfall for a preselected duration and frequency is input to the model. A 1-hour to 72-hour duration storm event is typically simulated. Appropriate duration storm events should be derived from local and regional rainfall records. In the process of developing extreme floods, the Australian Rainfall-Runoff Method assigns an AEP to the PMP, and is solely a function of drainage area size. Reclamation assigns an AEP to the PMP on an as-needed basis and does not endorse the drainage area relationship used by the Australians. Reclamation considers the proximity to moisture sources, areal coverage of the storm, and other factors in assigning an AEP to the PMP.

Excess precipitation is estimated by subtracting losses typically due to infiltration and interception. A variety of infiltration models are available and range from constant uniform loss rates to approximate theory-based functions (Green and Ampt, Philips equation). Antecedent storm assumptions can have a severe impact on basin infiltration estimates. Since the deterministic rainfall-runoff model is based on a single event, soil moisture storage and recovery during and between storms is not considered.

The amount of watershed information required is a function of the type of precipitation-runoff model used. Two classes of models are currently used—lumped and distributed parameter models. Lumped parameter models consider the system as being spatially averaged. In contrast, a distributed system considers hydrologic processes at various points in space and defines model variables as functions of the space dimensions. Some lumped parameter models that are widely in use are HEC-1 (HEC, 1990), FHAR (Bureau of Reclamation, 1990), and RORB (Laurenson and Mein, 1995). Some distributed models that can handle single events include DR3M (Dawdy et. al, 1978), PRMS (Leavesley et. al, 1983), HEC-HMS, and WMS. Additional surface water models are discussed in DeVries and Hromadka (1993).

Transformation of rainfall excess to a direct runoff hydrograph is completed via a convolution integral using (1) unit hydrograph techniques or (2) kinematic wave routing for overland flow. The unit hydrograph has been used extensively for flood runoff estimation. Kinematic wave and distributed modeling approaches may be more appropriate for modeling non-linear systems. A good discussion about rainfall-runoff processes and floods, including practical issues comparing design floods and actual storms, is presented in Pilgrim and Cordery (1993). Beard (1990) presents a methodology for simulating floods of a given probability from hypothetical design storms derived from point rainfall.

Streamflow routing may be classified as either lumped/hydrologic (linear reservoirs, level-pool, Muskingum, etc.) or distributed/hydraulic (diffusive wave, kinematic wave, etc.). In lumped flow routing, streamflows are computed as a function of time at one location; however, in distributed flow routing, streamflows are computed as a function of time at several locations along the stream. Most precipitation-runoff models have adequate routing mechanisms. A detailed discussion of routing options is presented in Chow et al. (1988).

For risk-based dam safety studies, it is necessary to adopt an AEP-neutral approach, where the objective is to derive a 1 in Y AEP flood with an AEP equivalent to its 1 in Y rainfall. The

factors that influence the transfer between rainfall and runoff can be characterized by probability distributions. Thus, ideally, the design hydrograph should be determined by considering the joint probabilities of all the input factors. Stochastic methods are ideally suited to the AEP-neutral objective because they accommodate the observed variability of the inputs while still preserving the interdependencies between parameters. However, for the least important parameters, it may be appropriate to adopt a single representative value instead of the full distribution. Since the relationship between rainfall and runoff is non-linear, it is important to note that adoption of a single representative value for the major inputs will introduce bias into the rainfall-runoff transformation. Therefore, more important model inputs may require use of a joint probability approach.

The simplest approach to deriving AEP-neutral inputs is to use the correlation relationship between the two variables. For example, if it is necessary to derive a temporal relationship to use with the design rainfall magnitude, an appropriate relationship may be derived from the correlation between the largest observed storms and their temporal characteristics during the largest storms on record. When applying relationships based on a limited historical sample to large flood events, the inputs should be conditioned by physical reasoning. For instance, large snowmelt events may require large snowpacks and high temperatures, but the meteorological conditions required to sustain an extreme rainfall event may preclude the joint occurrence of extreme wind speeds. The concurrent wind speeds used in the transformation of snow into runoff must be bounded by a reasonable upper limit.

The selection loss parameters are required inputs common to all event-based rainfall-runoff models. With loss rates, there is evidence to suggest that loss rates are independent of flood magnitude for design floods up to 1 in 100 AEP, though, for more extreme events, it is possible that the loss rates depend on both the AEP and the duration of the design rainfall. When considering snowmelt design floods, it may be necessary to vary loss rates with snowpack extent (Nathan and Bowles, 1997).

The most appropriate approach required to achieve AEP-neutrality depends on the complexity of the system being modelled, the nature of the available data, and the requirements of the flood model. In many cases, it may be expedient to adopt model input parameters derived using regional data, and it will be necessary to supplement empirical evidence by physical reasoning. Calibration of the design flood estimates to flood frequency quantiles will help reduce the uncertainty in extreme flood estimates.

4.4.2 Calibration

Calibration of a flood event model for application to design flood estimation is traditionally restricted to the selection of model parameters to achieve a fit between observed and estimated hydrographs. Attention is focused on collecting streamflow and rainfall data corresponding to the largest events on record. Considerable effort is required to ensure that the temporal and spatial distribution of the rainfall data is representative of the actual event. The ability of a model to reproduce historic events certainly gives some confidence to the validity of subsequent flood estimates. However, the available historic information for floods is usually much smaller than the extreme floods of interest. In most watersheds, the AEPs of the calibration floods are likely to range between 1 in 10 and 1 in 25. While it would be expected that floods of this

magnitude would activate some floodplain storage, the non-linear nature of the out-of-bank flood response is such that the streamflow routing characteristics of larger events may be considerably different. Therefore, while calibration of the model provides valuable information on the flood routing parameters for small floods, caution is needed when using the model to estimate extreme floods of much larger magnitude.

Calibration of rainfall-runoff model results to flood frequency quantiles can provide important information on flood response characteristics for extreme flood events. With this approach, rainfall data are prepared for a specified AEP and then used with a given set of model parameters and input assumptions to derive a flood hydrograph. The peak (or volume) of the flood hydrograph can then be compared to the corresponding quantile obtained from flood frequency analyses. The model inputs associated with the greatest uncertainty can be varied within appropriate limits to ensure agreement between the selected flood quantile. It is recommended that model calibration be undertaken for a range of exceedance probabilities to ensure a consistent variation of parameters with flood magnitude. The approach is suited to ungaged watersheds using regional flood frequency methods as well as sites with limited information. The approach is considered to be particularly useful when combined with flood frequency information that uses paleoflood data.

4.4.3 Strengths and Limitations

Event-based deterministic rainfall-runoff modeling has a long track record in the engineering and hydrologic community and is a proven technique for generating design hydrographs. Reclamation uses deterministic precipitation-runoff modeling. From a technical standpoint, the approach is flexible and requires less effort than most of the more complex approaches. Model choice should be a function of the hydrometeorological and physical data available. For example, a distributed model could be applied in cases where detailed information was available; however, a simplified lumped-parameter model would be appropriate in less data-rich locations. Output from either model would be similar.

Limitations to this method arise from the need to calibrate model results to known historical flood events or to flood frequency analyses so that the AEP of the storm is the same as the resulting flood. Calibration can be difficult if the model is sensitive to many input parameters. A lack of good meteorological data can prove troublesome in developing design storms with appropriate temporal and special characteristics. Rainfall-runoff modeling in data-sparse locations may require a high level of regional data gathering and analyses to obtain the necessary hydrometeorological inputs.

4.5 Stochastic Event-Based Precipitation Runoff Modeling with the SEFM

The SEFM has been developed by MGS Engineering Consultants, Inc., in conjunction with Reclamation personnel. The SEFM was developed for analysis of extreme floods resulting from 72-hour general storms and to provide magnitude-frequency estimates for flood peak discharge, runoff volume, and maximum reservoir levels for use in hydrologic risk assessments at dams

(Schaefer and Barker, 2002). The SEFM is fully described in MGS Engineering Consultants, Inc. (March 2001) and summarized in Schaefer and Barker (2002).

The basic concept of the SEFM is to employ a deterministic flood computation model and treat the input parameters as variables instead of fixed values. Monte Carlo sampling procedures are used to allow the hydrometeorological input parameters to vary in accordance with those observed in nature, while preserving the natural dependencies that exist between some climatic and hydrologic parameters. Example outputs from the SEFM are shown in figures 4-6, 4-7, and 4-8 (MGS, March 2001).

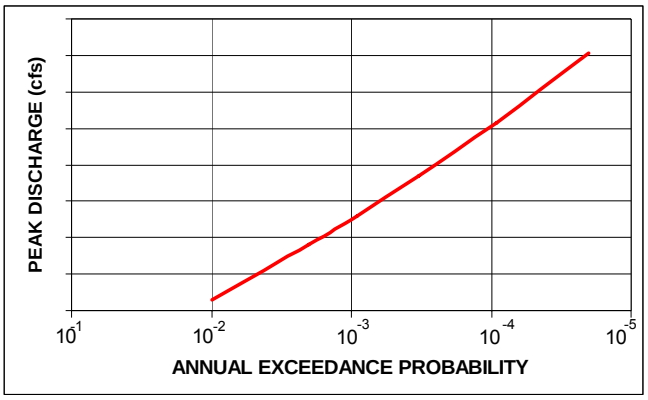


Figure 4-6.—Example of magnitude-frequency curve for peak discharge.

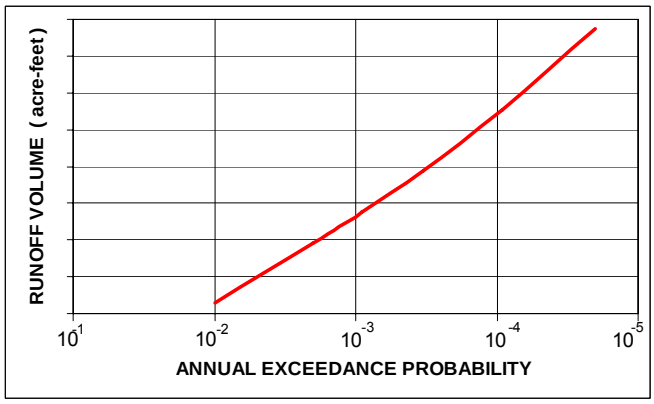


Figure 4-7.—Example of magnitude-frequency curve for runoff volume.

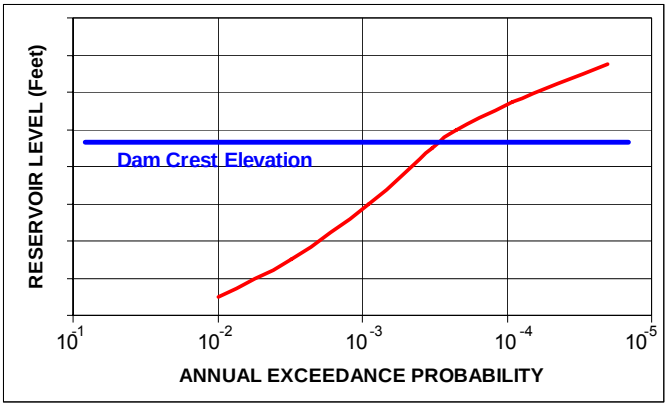


Figure 4-8.—Example of magnitude-frequency curve for maximum reservoir level.

A general flowchart for stochastic modeling with the SEFM is shown in figure 4-9. Thousands of computer simulations are conducted where each simulation contains a set of input parameters that were selected based on the historical record and, collectively, the simulations preserve the dependencies between parameters. The simulated floods constitute elements of an annual maxima flood series that can be analyzed by standard flood-frequency methods. The resultant flood magnitude-frequency estimates reflect the likelihood of occurrence of the various combinations of hydrometeorological factors that affect flood magnitude. The use of the stochastic approach allows the development of separate magnitude-frequency curves for flood peak discharge, flood runoff volume, and maximum reservoir level. Frequency information about maximum reservoir levels is particularly important for use in hydrologic risk assessments because it accounts for flood peak discharge, runoff volume, hydrograph shape, initial reservoir level, and reservoir operations. The precipitation estimates used in the SEFM are typically developed using regional precipitation frequency analysis with L-Moments (Hosking and Wallis, 1997). This approach uses a space-time substitution principle and assumes that there is sufficient precipitation data in a region to combine for subsequent model extrapolation to the probabilities of interest.

The general storm SEFM is composed of seven software components: data entry, input data pre-processor, multiple sample parameter test workbook, HEC-1 template file, stochastic inputs generator, HEC-1 rainfall-runoff flood computation model, and an output data post-processor. The flowchart shown below (figure 4-10) depicts the sequence of actions required for conducting the computer simulations using the software components. Each of these components is described in the SEFM Technical Support Manual (MGS, March 2001). The software (MGS, April 2001) helps the user input data, run the model, and visualize results.

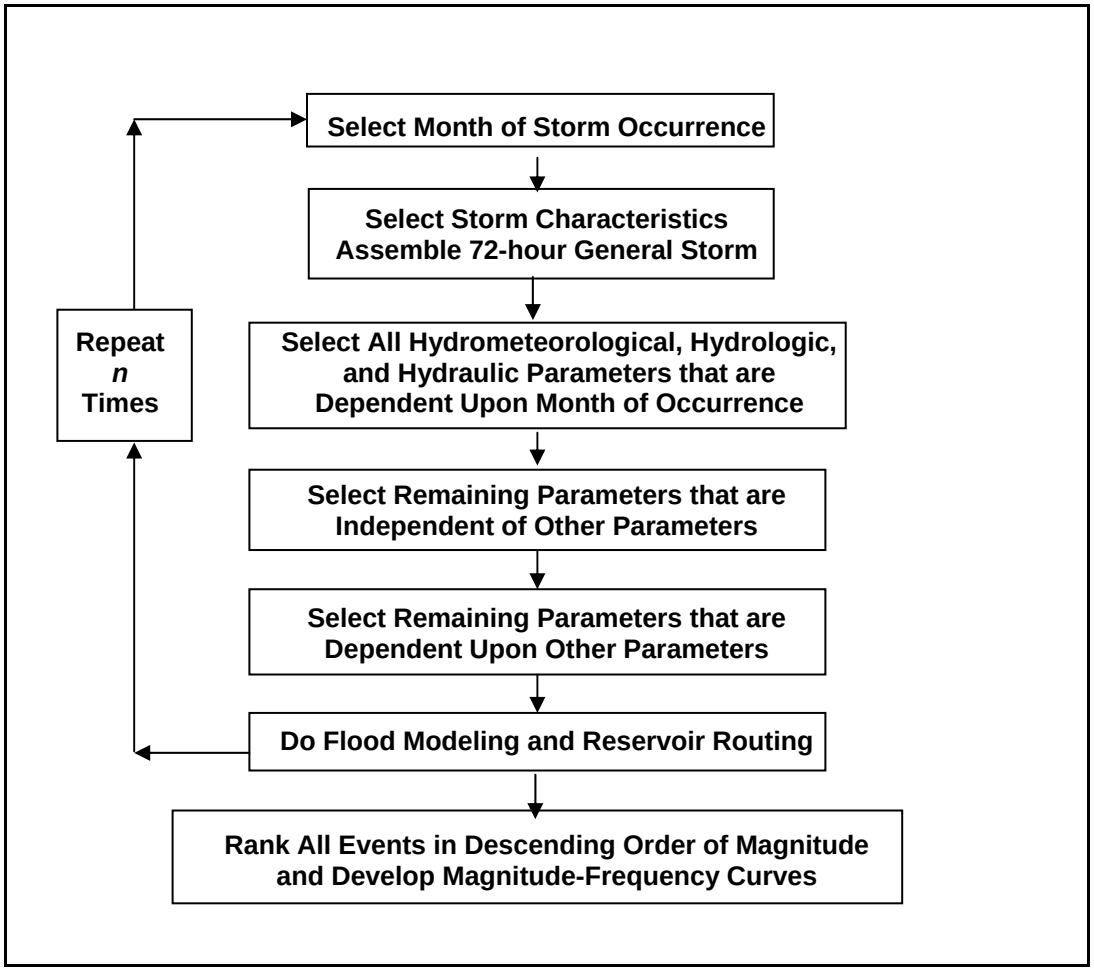


Figure 4-9.—General flowchart for the SEFM simulations (after MGS, 2001).

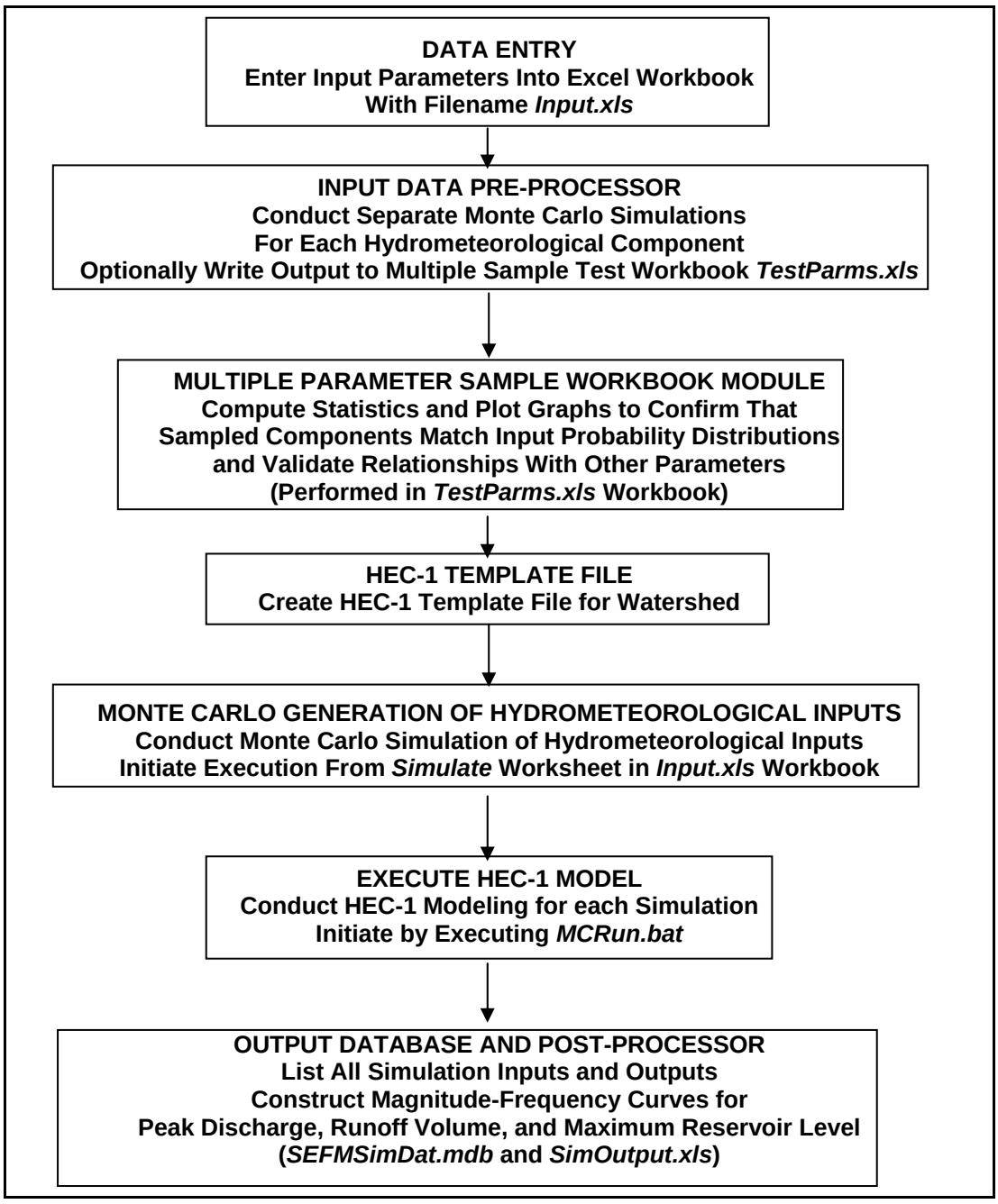


Figure 4-10.—General flowchart for the sequence of actions required for conducting the computer simulations using the SEFM.

The input processor to the SEFM is an Excel workbook. The workbook includes different spreadsheet screens for input (figure 4-11), for model execution, and for output (figure 4-12). The improvements are contained in software version 1.8 of the SEFM.

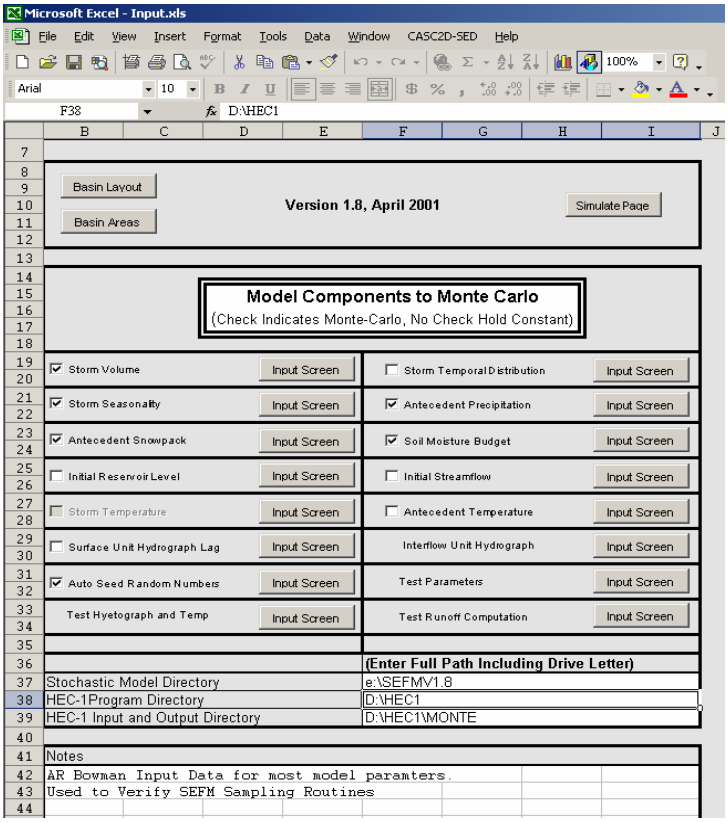


Figure 4-11.—The SEFM input screen.

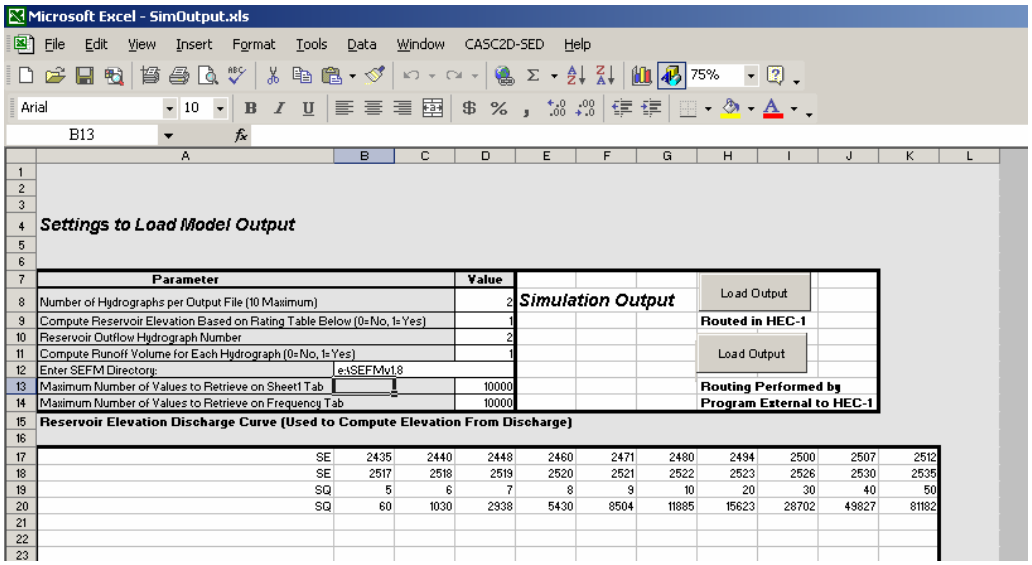


Figure 4-12.—The SEFM output simulation options.

The basic concept behind the SEFM was first used to explore PMF variability and extreme flood probability issues at Bumping Lake Dam for Reclamation (Barker et al., 1996; 1997). The prototype of the SEFM was developed for application to the A.R. Bowman watershed (Schaefer and Barker, 1997; 1998). The SEFM was subsequently generalized for use by Reclamation on other projects and applied at Keechelus and Cle Elum Dams (Bullard and Schaefer, 1999). A sensitivity analysis has been performed for A.R. Bowman Dam (MGS, January 2001) to determine the dominant features that affect model results. A brief review of the model (Singh, 1999) indicated that the model is a sound package for extreme flood modeling, and there could be some eventual improvements.

There are some current limitations to the SEFM and the applicability to certain Reclamation sites. The SEFM is currently configured for simulation of 72-hour general storms. There is no computational limit to the size of the watershed to which it can be applied. However, implicit in the development of the model is the condition that some hydrometeorological parameters are highly correlated spatially. As the watershed size increases, the requirement for high spatial correlation of multi-month precipitation and snowpack becomes more difficult to satisfy. This consideration suggests that the stochastic model is applicable to watersheds up to a nominal size of about 500 mi^2. For larger watersheds, the spatial variability of some hydrometeorological parameters may warrant that site-specific modules be developed to address the site-specific characteristics of the watershed under study (Schaefer and Barker, 2002, p. 732). Currently, the model does not handle thunderstorm events. Additional routines would need to be added to simulate any storms with durations that differ from 72 hours. These limitations may be relaxed as improvements are made to the model.

4.6 Stochastic Rainfall-Runoff Modeling With CASC2D

CASC2D is a fully unsteady, physically based, distributed-parameter, raster (square-grid), two-dimensional, infiltration-excess (Hortonian) hydrologic model for simulating the runoff response of a watershed subject to an input rainfall field for a particular storm event (Julien and Saghafian, 1991; Julien et al., 1995; Ogden and Julien, 2002). Major components of the model include rainfall interception, infiltration, surface and channel runoff routing using the diffusive wave method, soil erosion, and sediment transport. CASC2D is appropriate for simulating extreme floods and physically based extrapolations of frequency relationships combined with a derived distribution approach. The main differences between CASC2D and the SEFM are that CASC2D is a fully distributed model and uses hydraulic principles for runoff generation and routing precipitation excess. The SEFM is essentially a lumped model and uses the unit hydrograph as the basis for runoff and routing precipitation excess. Other differences are the infiltration models and routing mechanisms for river channels. CASC2D is also a somewhat experimental model that has not been used in extreme flood applications for dam safety, or for many applications outside academic research.

The idea and basis to use CASC2D for extreme flood modeling and prediction is centered on two concepts: (1) a derived distribution approach (e.g., Eagleson, 1972) can be used to estimate the extreme flood peak and volume probability distributions and (2) physically-based methods for flood runoff and routing provide a suitable and improved physical basis for the extrapolations of derived flood probability distributions. Ramirez (2000) summarizes the theory behind the

derived distribution approach. In the disciplines of science and engineering, relationships that predict the value of a dependent variable in terms of one or many basic (independent) variables are commonly developed. Physical systems are naturally complex. The functional form of the relationship between independent and dependent quantities or the values of the independent variables (or both) is not usually known with certainty. Techniques based on probabilistic assumptions can be used to account for this uncertainty. When the uncertainty derives from uncertainty in the independent variables, but not from uncertainty in the functional dependence, a derived distribution approach leads to the probability density function of the dependent variable. In this case, the functional form relating independent and dependent variables is assumed known with certainty. In such instances, it is possible to derive the probability density function of the dependent variable(s) from that of the independent variable(s) (Ang and Tang, 1975).

Several research applications use the derived distribution approach to estimate flood frequency curves; these show much promise. The pioneering study for flood frequency is Eagleson (1972). Bras (1990) discusses some of the potential applications of derived distributions in hydrology.

4.7 PMF Analysis Technique

The PMF is defined by Reclamation as "the maximum runoff condition resulting from the most severe combination of hydrologic and meteorologic conditions that are considered reasonably possible for the drainage basin under study" (Cudworth, 1989). Other agencies have developed somewhat different definitions, but all consider the PMF to be a "maximum runoff condition" that is "reasonably possible."

In Reclamation practice, the basic model to convert PMP to runoff is the unit hydrograph. It is recognized that many other techniques, including sophisticated computerized models, are available for making this conversion. The unit hydrograph concept represents the modeling of the rainfall-runoff process as a linear system. The fact that the rainfall-runoff process is actually non-linear is one of the acknowledged shortcomings of the concept. However, if properly applied, the concept provides entirely satisfactory results for developing flood hydrographs resulting from extreme rainfall events.

During the period from the mid-1940s to the late 1990s Reclamation engineers designed and built most of the large storage dams currently in Reclamation's inventory. During this period, Reclamation published three editions of the *Design of Small Dams*. That publication has served as a textbook and as a technical guide for numerous States and many foreign countries. Many States, consultants, and other agencies still use the methods and PMF philosophies expressed in the recent editions of those publications. The basic PMF methodologies described in those publications have served as the basis for thousands of dams in the U.S. and other countries designed by both Reclamation and non-Reclamation engineers. These publications are still in widespread use. Reclamation engineers often employed somewhat different techniques and nomenclature for deriving design floods, but the intent was nearly always to design for the PMF determined by the then current techniques. Some exceptions were made for small dams and diversion structures where it was believed that failure of the structure caused by overtopping would not produce any loss of life or major economic damages.

The steps involved in deriving the PMF hydrograph for a single basin have been described in many sources. The following steps are modified from the list given by the National Research Council (NRC, 1988). This list briefly summarizes the PMF calculation process currently followed by Reclamation and many other dam building agencies:

1. Divide the drainage area into subbasins, if necessary, and determine the appropriate drainage areas.

2. Derive a runoff model (unit hydrographs for Reclamation studies).

3. Determine the PMP using criteria contained in NOAA Hydrometeorological Report (HMR) series.

4. Arrange the PMP increments into a logical storm rainfall pattern.

5. Estimate for each time interval the losses from rainfall, due to such actions as surface detention and infiltration within the watershed.

6. Deduct the losses from rainfall to estimate rainfall excess values for each time interval.

7. Apply rainfall excess values to the runoff model for each subbasin.

8. Add to the storm runoff hydrograph allowances for stream base flow, runoff from prior storms, etc., to obtain the synthesized flood hydrograph for each subbasin.

9. Route the flood from each subbasin to a point of interest.

10. Compare the computed PMF peak and volume to the applicable envelope curve of peak and volume flows, if available.

11. Route the resulting inflow hydrograph through the reservoir storage, outlets, and spillways to obtain estimates of maximum storage, elevations and discharges, and durations at the dam.

Many factors influence the ultimate magnitude of the PMF hydrograph, but the intensity and duration of the rainfall are the most important. Considerable analysis and discussion of the derivation and application of PMP estimates has taken place in the past. The original definition of PMP dates back to the late 1930s. In 1981, Reclamation, the National Weather Service, and the U.S. Corps of Engineers adopted a mutually acceptable, uniform definition of the widely used term PMP. The PMP, as defined by these three agencies at that time, is “theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of the year.” PMP must always be termed as an estimate because there is no direct means of computing and evaluating the accuracy of the results. Since the mid-1980s, Reclamation has considered that the series of

HMRs prepared and updated by the National Weather Service provide the best estimates of PMP potential within the limits of each report. Figure 4-13 displays the current coverage of the continental United States by this series of reports.

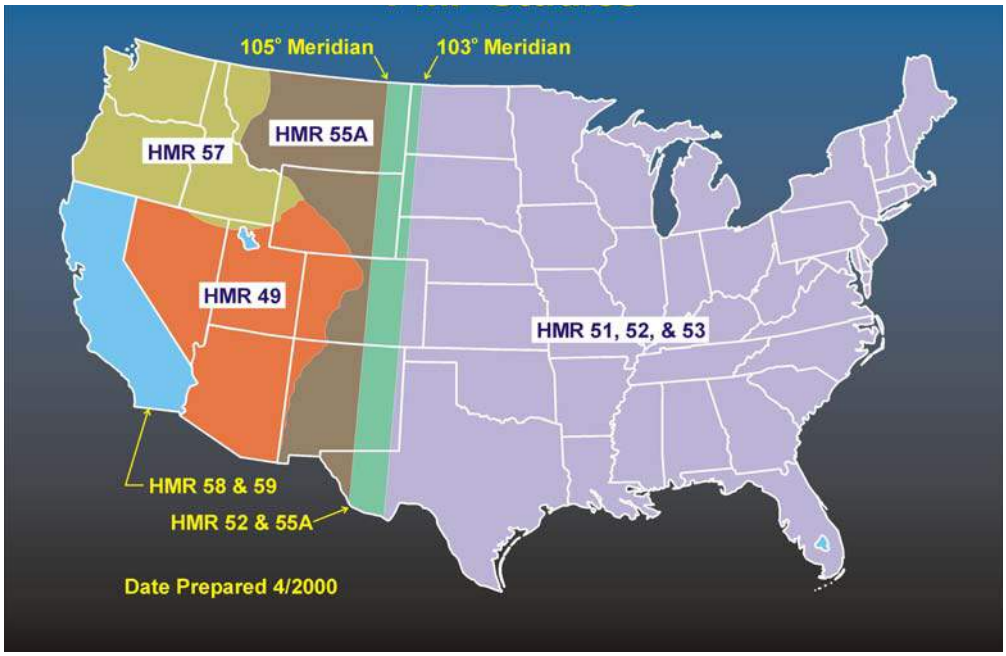


Figure 4-13.—Regions covered by generalized PMP studies.

Other aspects of the PMP to PMF conversion that are unique to Reclamation are discussed in the following paragraphs.

After determining the total PMP depths for specific time intervals from the appropriate HMR, a smooth depth-duration curve is created. This curve is then read at time intervals equal to the desired computation interval for the PMF hydrograph. Each individual precipitation total for each time increment is subtracted from the preceding time increment total PMP. The result is the incremental values of PMP to be used in the computation of the PMF hydrograph. Figure 4-14 displays a typical depth-duration curve from which incremental PMP can be determined.

The temporal rainfall pattern most commonly used with Reclamation PMF studies places the maximum increment of rainfall at the 2/3 point of the storm and arranges the remaining increments of precipitation in descending order about this point. This distribution is applied throughout the United States and results from an examination of individual drainage area regionalized storm criteria combined with various hydrological tests. This arrangement, when combined with the unit hydrograph procedures, will produce a maximum runoff condition for the basin being studied that is still reasonable based on meteorological experience. Figure 4-15 displays this temporal distribution.

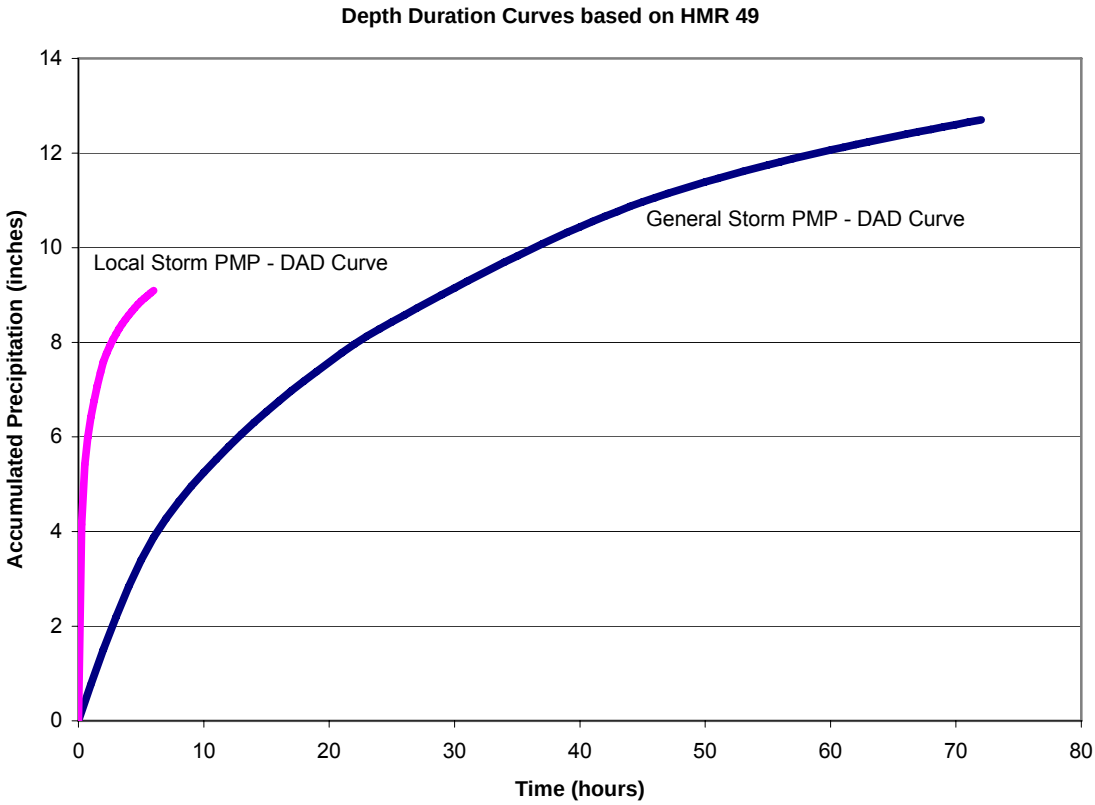


Figure 4-14.—Typical PMP depth duration curves.

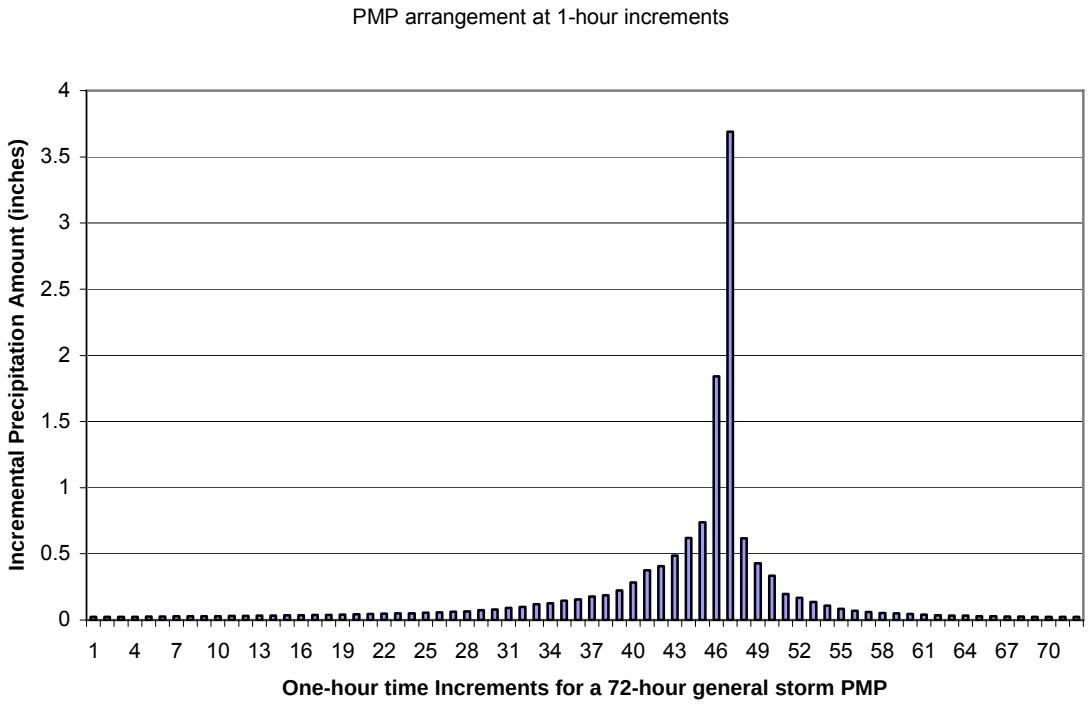


Figure 4-15.—Typical PMP temporal arrangement for a 72-hour storm.

In Reclamation PMF studies for large basins with many subbasins, consideration is given to "centering of the PMF" by allowing the spatial distribution of the PMP to vary across the entire basin. The storm is centered over a single subbasin, and the PMP for that subbasin is calculated along with the PMP for the total basin. PMP amounts over the other subbasins are calculated in a manner that preserves the total basin volume of the PMP but allows for heavier amounts over the subbasins nearest the assumed center of the storm. This calculation is termed "successive subtraction."

Another unique feature of some PMF studies is the use of an elliptical storm pattern as specified in the appropriate HMR. The use of this pattern allows the PMP to vary within a large area in a manner that does not depend on subbasin sizes or shapes but, rather, on historic observations of large storms. This type of PMP calculation is most common for large general storms in the HMR 51-52 area. Local storm PMPs can also use a theoretical elliptical shape in the HMR 49 and HMR 59 areas. For these types of studies, the PMP storm is usually centered over the basin. Volume centerings will center the entire PMP storm over the subbasin nearest to the center of the entire basin. Peak centerings will allow the PMP to be centered over the subbasin nearest to the dam. Volume centerings will typically produce a PMF hydrograph with the largest total volume. Peak centerings will typically produce a PMF with a higher peak but a lower volume. Both PMF hydrographs need to be routed through the dam.

Another good feature of the PMF calculations is that a series of dams all on the same river can be studied. By allowing the PMP to be centered over subbasins above each individual dam, the most severe cause of flooding at that dam can be obtained. Concurrent floods above the other dams on the same river basin can then be calculated for the same PMP event. Once the PMF hydrographs from the upstream dams are formed and routed through those structures, the complete PMF series of hydrographs for the downstream dam can be obtained. This is not always the case with methods based solely on statistical methods.

Local storm hydrographs are also computed for most Reclamation Dams if the HMR series provides specific data for deriving a separate local storm. Such storms are generally considered the thunderstorm type events and are limited in durational and areal coverage. Local storms will generally produce more intense precipitation and are usually most critical for smaller drainage basins. Local storms are considered spring or summer events and may become critical for dams and reservoirs where higher water surfaces are allowed in the spring and summer.

Lag time computations and unit hydrographs for Reclamation PMF studies have come from many past investigations of large floods. Basic unit hydrographs for sites where sufficient data were recorded were derived by standard means after subtracting out any base flows or snowmelt flows. With some knowledge of the basin average rainfall total and duration, the resulting hydrograph could be reduced to a unit hydrograph. The unit hydrographs were then put into a dimensionless form unique to Reclamation, with the flow ordinate being expressed as a dimensionless volume of flooding divided by the amount of flooding that could be expected from 1 inch of excess runoff in 24 hours (expressed as $ft^3/s\text{-}day/ft^3$ or often abbreviated as q). The time ordinate was expressed as a percent of the basin lag time plus 1/2 of the unit duration for that basin. Figure 4-16 is a sample of such a dimensionless graph. Over 60 dimensionless graphs are available to Reclamation engineers, but this number has been reduced to only 6 for publication in the *Flood Hydrology Manual* and in the latest edition of *Design of Small Dams*.

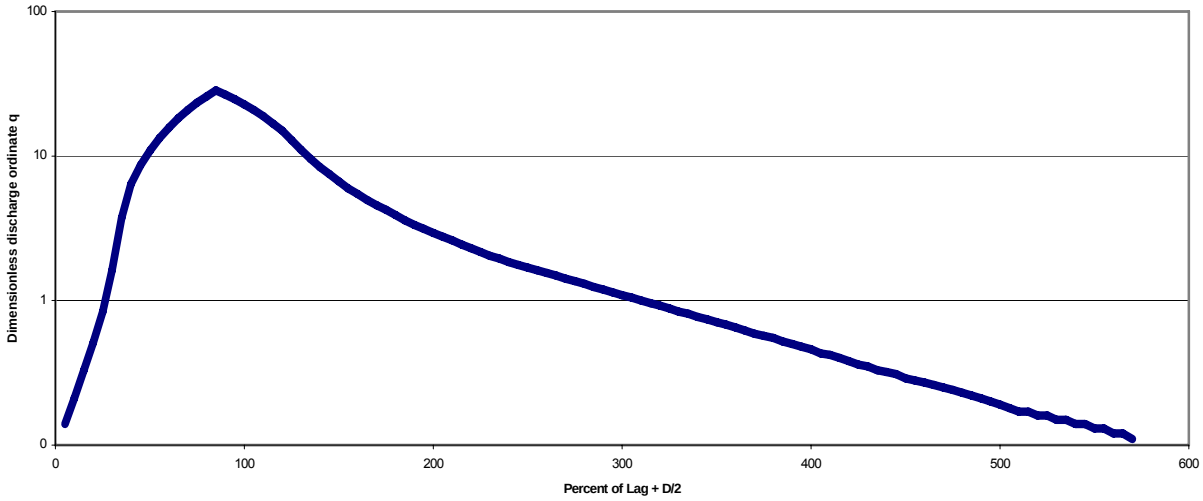


Figure 4-16.—Reclamation dimensionless graph.

The physical definition of the lag time used by Reclamation in PMF studies is the time from the mid-point of a unit of excess rainfall to the mid-point of the total volume of the resulting runoff hydrograph from that single unit of excess rainfall. With this definition in mind, much of the historic flood data collected by Reclamation engineers in the 1940 to 1970 time period was used to define relationships between the physical measurement of the length of the main channel, L (mi); the length to a point on the main channel opposite of the basin centroid, Lca (mi); and the basin slope S (ft/mi). Such data were plotted on log-log graphs, and straight lines on these plots were drawn based on different basin vegetation and soil conditions. Figure 4-17 is a sample of such a plot from the Reclamation *Flood Hydrology Manual*.

The locations of the straight lines on these plots reflect the basin vegetation, soils, overall slope and, to some degree, the basin area and type of PMF being calculated. Such graphs also represent floods from much smaller events than the PMF, and some judgment must be applied to the lag numbers. PMF conditions will usually require somewhat shorter lag times than computed for more common flood events. Lag times for Reclamation PMF studies are based on this type of historical knowledge, reviews of other PMF studies prepared in the area, and reviews of pertinent basin topography, soils, and land use maps. For final design-level PMF studies, field trips to the basin in question by a qualified hydrologist are required to ensure that the information from the maps and other calculated basin parameters is valid. Generalized equations based on the lag curves such as displayed above are available to provide a computational procedure for calculating a lag time for each subbasin and storm type in the basin being studied.

With a computed lag time, drainage area, and dimensionless graph selected, the final unit hydrograph for each subbasin can be calculated. Procedures for this calculation are given in Reclamation's *Flood Hydrology Manual* and in *Design of Small Dams*.

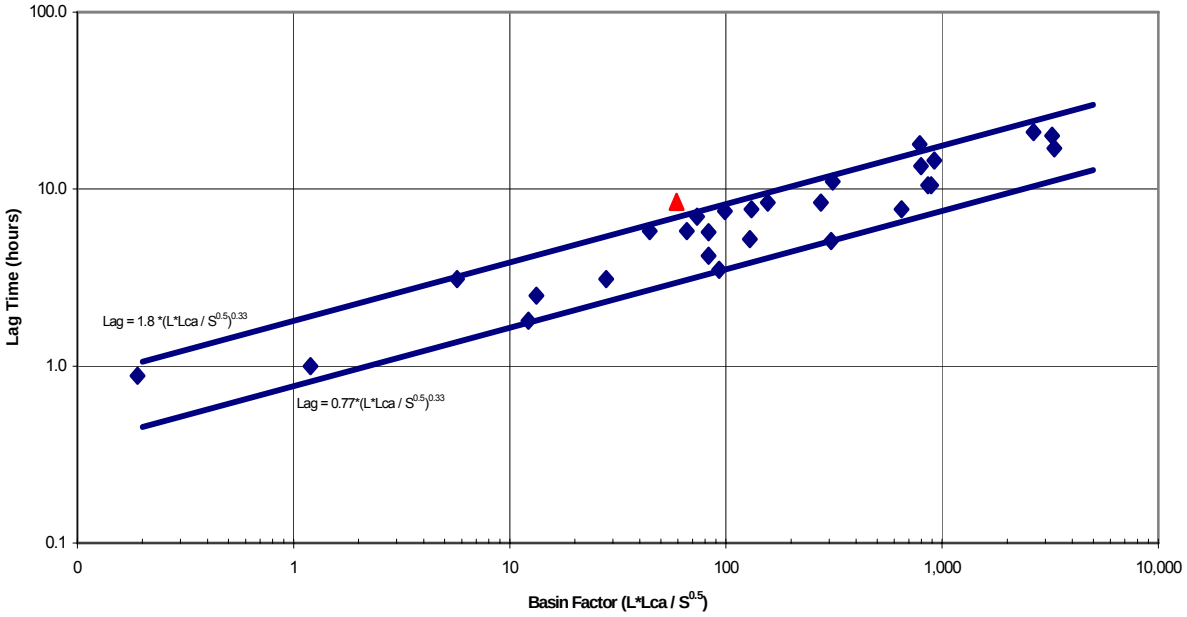


Figure 4-17.—Lag time versus basin factor data for Great Plains Region
(from Reclamation *Flood Hydrology Manual*, 1989).

Loss rates for Reclamation studies always assume saturated basin conditions caused by antecedent flooding. Most often, the loss rates are derived by studying basin soils maps available from previous Soil Conservation Service (SCS) soils mapping reports or, more recently, by using the NRCS STATSGO computerized soils database. The SCS divided the soils into four basic hydrologic groups for rainfall-runoff studies. These groups range from very porous sandy or gravely soils with high infiltration rates to very tight clay soils with very low porosity and low loss rates for rainfall-runoff studies. The four soil categories have been assigned ranges of minimum loss rates. By determining the percentage or amount of the different soils in each subbasin, an average minimum loss rate can then be selected or computed from the published minimum loss rate ranges. Initial loss rates are seldom used in Reclamation PMF studies. The definition of the PMF requires the assumption of saturated soil conditions before the onset of the PMP. Under such an assumption, the initial loss rates will be completely satisfied, leaving only a minimum constant loss rate to be considered. It is recognized that more sophisticated loss rate algorithms exist, but for the PMF computation and assumptions, the use of a constant loss rate based on minimum losses for the upper soil layers in the basin is considered adequate.

Antecedent flooding is also considered for general storm PMF hydrograph computations in Reclamation studies. The general storm most often occurs at a time of the year when flooding is most likely to occur in the basin. It is likely that previous storms or a melting snow pack will provide some antecedent streamflow before the onset of the PMP. For basins without significant snowmelt contributions, the antecedent flood comes from a study of applicable streamflow records or, if needed, rainfall-runoff analysis. The desire is to derive a 100-year event by statistical means or by rainfall-runoff modeling if limited stream gage data are available. This derived flood hydrograph is then placed a number of days in front of the onset of the PMP. In

most parts of the central United States, there is a 3-day separation between the peak of the antecedent flood and the start of the PMP. This length of time between the antecedent rain flood hydrograph peak and the start of the PMP will vary near coastal areas. Figure 4-18 displays this type of application.

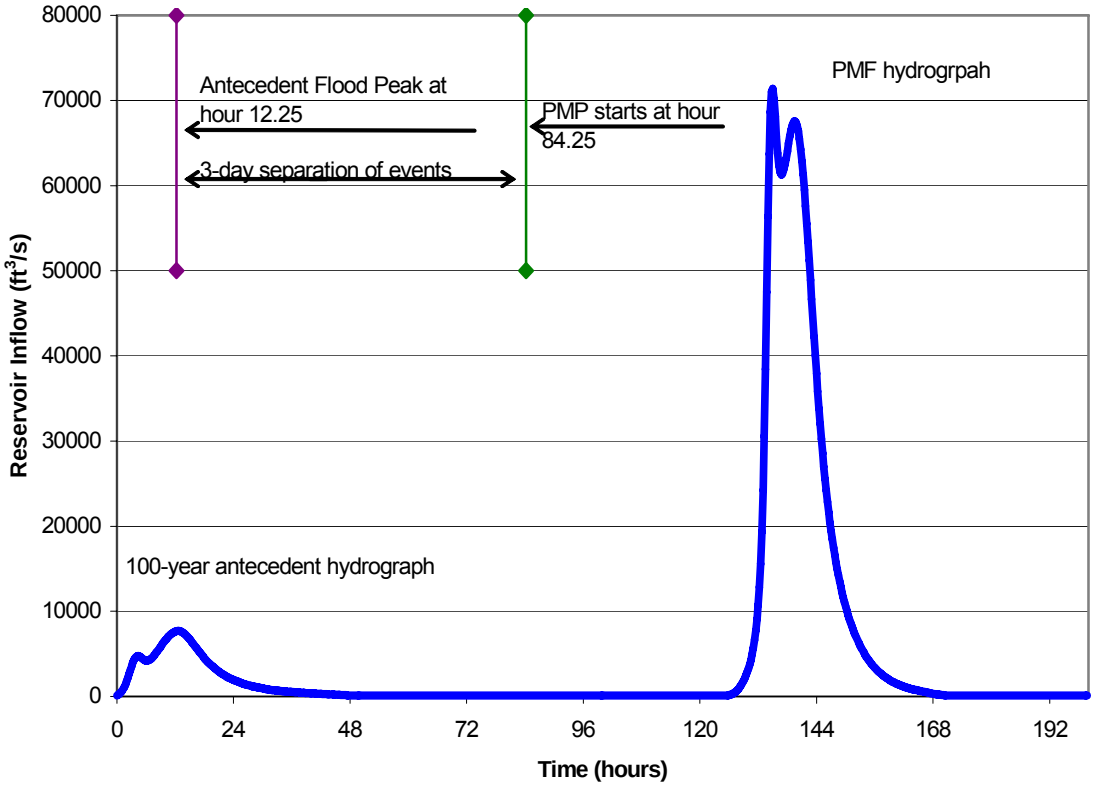


Figure 4-18.—PMF with antecedent 100-year floods.

In areas where snowmelt adds to the volume of the flooding, the antecedent flood in Reclamation PMF studies is often derived from an analysis of stream gage data. The data are limited to the season when snowmelt adds to the flooding. A large historic snowmelt flood may be selected or a statistical analysis of the volume of flooding for several different durations may be undertaken. The result is a 100-year flood volume for a duration longer than the base length of the calculated PMF rain flood hydrograph. If a historic flood event is selected, the daily flows for the hydrograph will be adjusted by a ratio such that the resulting volume for the selected duration is a 100-year volume that can be determined by a statistical analysis of appropriate gage records. The historic flood hydrograph may also be rearranged in time to provide a more normal hydrograph shape. If no historic flood hydrograph is appropriate, then the antecedent snowmelt hydrograph may be derived as a balanced hydrograph. If a snowmelt hydrograph is used as an antecedent flood, Reclamation places that hydrograph under the rain-generated portion of the PMF such that the peaks will exactly coincide. Figure 4-19 displays such a derived historic flood hydrograph for a 15-day antecedent event. Figure 4-20 displays the placement of the derived balanced hydrograph to coincide with the peak of the rain-generated PMF hydrograph for a basin.

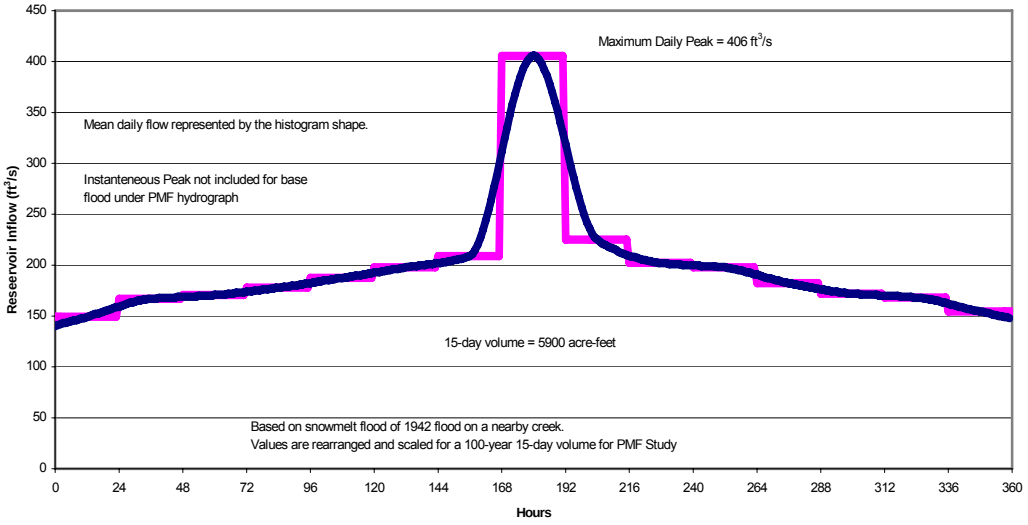


Figure 4-19.—100-year 15-day derived snowmelt flood from an historic snowmelt flood event.

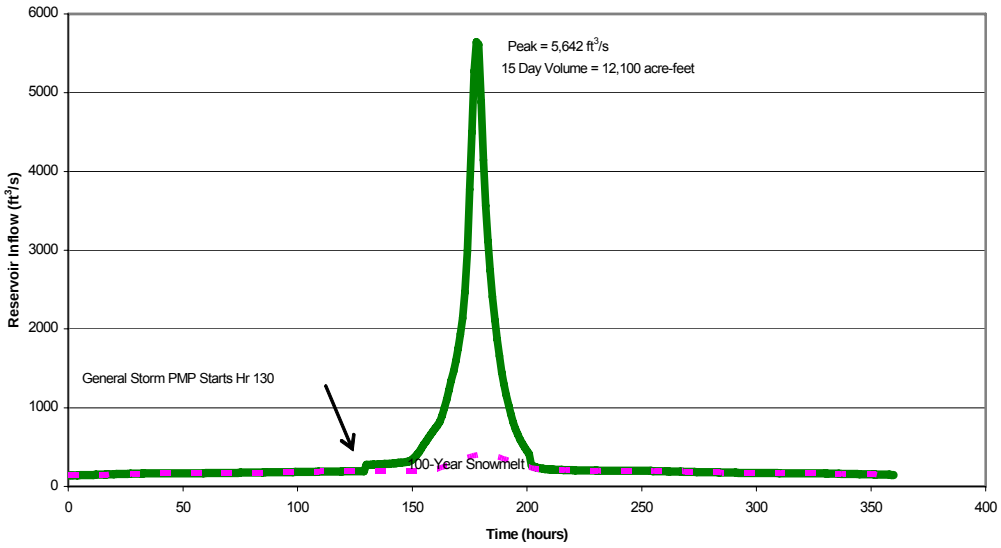


Figure 4-20.—General storm PMF with 100-year snowmelt antecedent flood.

When a snowmelt flood is required, the loss rate for the measured or estimated snow-covered areas in the basin is reduced to a constant 0.05 inch per hour. This is assumed to account for the fact that the 100-year snowmelt is already in progress at the start of the PMP and most of the available constant loss rate will have already been taken up by the melting snow.

In areas where deep snow packs are known to occur, such as the high Sierra Mountains in California, Reclamation will use a snowmelt computation program. This program will account for the effect of rain falling on a snow pack that may not be fully ripened and ready to melt at the start of the PMP. The snowmelt program requires additional meteorology data such as wind and temperature sequences compatible with the PMP derivation. The HMR series will provide good

information in this regard. Additional study of the historic snow gage records in or near the basin being studied is also required. The depth and initial density of the snow pack at various elevations in the basin are used in the computations. Such snowmelt computations provide additional depths of water to be added to the arranged PMP sequence. The combined snowmelt and PMP depths are then used with the unit hydrograph procedures to derive the desired PMF hydrographs.

Routing of floods between subbasins is also required. If sufficient data for several large flood events are available, routing coefficients for the Muskingum Method can be derived. Usually, little information is available for large floods at more than one gage in the basin being studied. In lieu of Muskingum routing, the most common procedure is an analytical procedure referred to as the Tatum Method. This method requires only an assumed travel time between the various subbasins and will attenuate the routed hydrographs by a simple arithmetical computation. This procedure does not affect the volume of the flooding, but it does have some impact on the PMF peak.

Envelope curve comparisons of the PMF peak and sometimes a volume comparison are also made. The comparison is only to ensure the hydrologist that the PMF peak or volume is not below experienced flood levels in the region of concern. If the PMF peak falls below an envelope curve of peak flows for a nearby region, some additional thought must be given to the derivation of the PMF or the derivation of the envelope curve values. There are no rules about how far above the envelope curve a PMF peak should be. This would depend on the derivation of the envelope curve. Envelope curves covering large regions might have additional high-peak flows and the PMF comparison would be closer. Smaller regions would most likely have PMF peaks much higher than the envelope curve.

5. Characterization of Hydrologic Hazards

Since no single approach is capable of providing the needed characterization of extreme floods over the full range of AEPs required for risk assessment, results from several methods and sources of data should be combined to yield a hydrologic hazard curve. The application of several independent methods applicable to the same range of AEPs will increase the credibility and resulting confidence of the results. The previous section of this report describes the available approaches for estimating the hydrologic hazard.

To compute a hydrologic hazard curve for risk assessment, Reclamation makes use of all available studies for the site of interest. Often, the PMF and initial flood frequency studies are the only hydrologic studies available before the start of a probabilistic investigation. If a dam passes the PMF or a flood with an AEP low enough to meet dam safety risk criteria, no further studies may be needed. The intent of the hydrologic hazard analysis is to provide information that will allow decision makers to make appropriate dam safety decisions while minimizing study costs.

The remainder of this section of the report describes Reclamation's approach toward characterizing the hydrologic hazard for a particular site of interest. The process begins with

Flood frequency analysis and hydrograph scaling for the CFR and may progress through more detailed studies if the need arises. If detailed studies are already available for a particular site, these studies would be summarized and would form the basis of the hydrologic hazard characterization.

5.1 Integration of the PMF into Hydrologic Hazard Evaluations

The PMF is recognized as the upper limit of flood potential at a site, for storm durations defined by the Probable Maximum Precipitation (Bureau of Reclamation, 2002b). This means that Reclamation uses the PMF as the upper limit to extreme floods for risk assessment, corrective action decisions, and dam safety modifications. If a dam does not have a hydrologic safety deficiency using the PMF as the hydrologic loading condition, no further hydrologic studies are warranted for evaluation of spillway capacity. If a flood frequency analysis produces peak flows or volumes that exceed the PMF, then the PMF should be used in evaluating the hydrologic risk and as a theoretical and practical upper limit to statistical extrapolations. Before applying the PMF as the upper limit, the hydrologist should ensure that it has been developed using current procedures with up-to-date data and for a PMP duration suitable for the site of interest.

5.2 Characterization of Hydrologic Risk for the CFR

Hydrologic hazard curves and flood hydrographs are developed for use in evaluating and prioritizing the need for dam safety modifications at Reclamation and other U.S. Department of the Interior facilities. These guidelines provide an approach for developing hydrologic hazard information that will allow decision makers to determine appropriate courses of action to assure the safety of the dam while minimizing study costs. If detailed hydrologic studies are available for the site of interest, they should be reviewed for adequacy, then summarized and used for the CFR. If no study is available, a hydrologic hazard curve and flood hydrographs should be constructed using flood frequency analysis and hydrograph scaling procedures. The remainder of this section explains the procedure for developing hydrologic hazard information for the CFR using these procedures.

The characterization of hydrologic risk is first provided in terms of estimated peak discharges, which are then used to estimate flood volumes. Peak discharges are estimated using a mixed-population model, and the results are subsequently input to a linear scaling algorithm of volume critical hydrographs. The hydrologic hazard characterization for the CFR is usually accomplished with minimal effort, about 15 staff days or less.

The mixed-population model used to estimate peak discharges is described by an LP-III distribution for return periods from 1 to 100 years and an LN-2 distribution for return periods greater than 100 years. Historical data are used to calibrate the LP-III model, and an informed hydrologic estimate of a single flood potential point (SFPP) with a return period of greater than 100 years must be made. The fitting of the LP-III model to the historical data is carried out using the Method of Moments (MOM) with which a regional skew may be used to fix or weight the distribution. The fitting of the LN-2 distribution is carried out analytically between the 100-year flood estimate and the SFPP. The value of the SFPP may take the form of a paleoflood non-exceedance bound, a paleoflood estimate, a historical data point with an estimated return period

greater than 100 years, or any other estimate of a flood with a return period greater than 100 years believed to characterize the extreme values of the flood potential. Once the initial data requirements are met, a list of peak-discharge estimates is calculated and the results are provided in tabular as well as graphical format (table 5-1, figure 5-1). The analysis is extended beyond the SFPP to floods with AEPs as small as 10^{-8}, but peaks are not allowed to exceed the PMF for the site of interest.

Table 5-1.—Example peak-discharge estimates in tabular form

Annual exceedance probability	Return period	Peak discharge estimate (ft^3/s)
0.01	100	26,500
0.005	200	31,100
0.002	500	37,700
0.001	1,000	43,200
0.0005	2,000	49,200
0.0002	5,000	57,700
0.0001	10,000	64,800
0.00005	20,000	72,300
0.00002	50,000	83,200
0.00001	100,000	92,000
0.000001	1,000,000	126,000
1E-07	10,000,000	167,800
1E-08	100,000,000	218,800

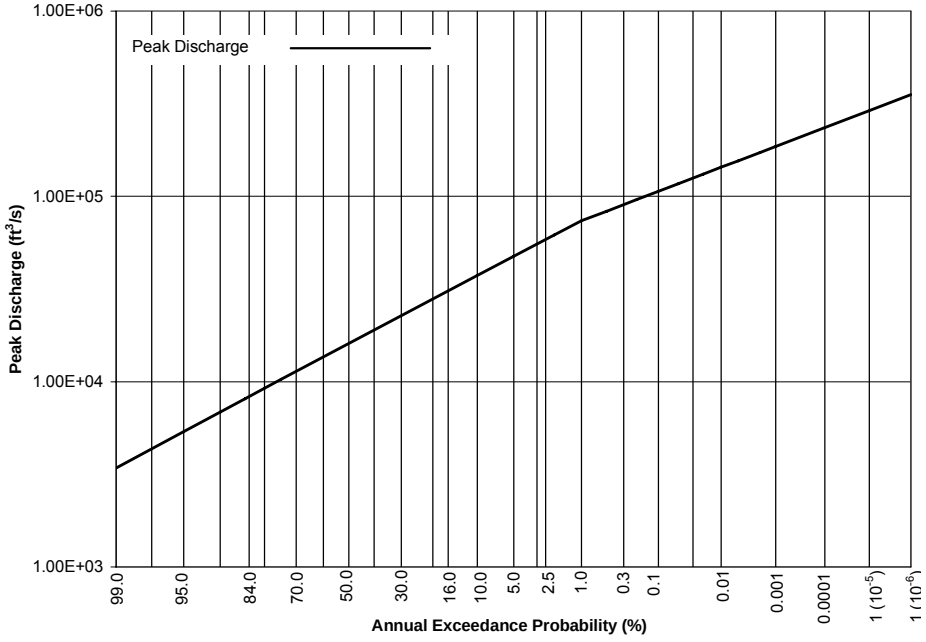


Figure 5-1.—Example of peak-discharge estimates in graphical form.

To make a volume estimate, a time series flood hydrograph estimate is required. The time series flood estimate may be a historical flood hydrograph or a PMF hydrograph; either must be believed to describe the rainfall-runoff response of the basin of interest at a wide range of return periods. Flood hydrographs are linearly scaled so that the peaks match the estimates from the peak-discharge analysis described above. When the hydrograph duration permits, 1-, 3-, 5-, 7-, and 15-day volumes are calculated as the maximum volume of water transported during the desired continuous time period.

When a rain-on-snow PMF hydrograph or rain-on-snow historical hydrograph is used as an input, the analysis technique requires two hydrograph ordinates for each time period – one for the snowmelt portion and one for the rainfall portion. Only the rainfall portion of the hydrograph is scaled to achieve the desired peak. The snowmelt portion of the hydrograph remains intact. For all other input hydrographs, the entire hydrograph is scaled linearly to match peak estimates. When volume estimates are calculated, the results are provided in tabular as well as graphical format (table 5-2, figure 5-2). Graphical results (peak and volume flows) can be provided within a combined chart (figure 5-2) or as two separate charts, as desired by the client (figure 5-1 and figure 5-3).

The major assumption involved with scaling PMF hydrographs to various return periods is that the dimensionless hydrograph used to develop the PMF is appropriate to describe the rainfall-runoff response of the basin at all return periods. Because the generation of a hydrograph from a dimensionless hydrograph involves only the convolution with time distributed rainfall rates, assumptions are further made that the rainfall spatiotemporal distribution does not change with flood magnitude, and soil characteristic response is linear in nature. The latter assumption may be appropriate when floods of interest begin with saturated ground conditions. When these assumptions are violated, predictions may be inaccurate by orders of magnitude. Similar assumptions can be made when scaling a historical hydrograph. These assumptions are mainly that the storm that caused the flood is similar in temporal and spatial characteristics to the storm that would cause a flood of a different return period and that the initial soil conditions are also similar. Soil infiltration responses are known to be highly non-linear in the unsaturated condition; therefore, as with the PMF scaling, it is the initial condition for which the soils are saturated that this type of scaling is most appropriate.

Reclamation uses the PMF as the upper limit of flood potential at a site for storm durations defined by the PMP. If peak flows or volumes calculated using probability or statistical-based hydrology methods exceed those of the PMF, the PMF is used in evaluating the hydrologic risk and as a theoretical and practical upper limit to statistical extrapolations. If the PMF has been properly developed, it represents the upper limit to runoff that can physically occur at a particular site.

Hydrograph ordinates for the peak-scaled hydrographs, produced during the volume analysis, are also provided for the CFR hydrologic hazard evaluation. Ordinates for the scaled hydrographs have the same duration and number of ordinates as hydrograph data provided for input to scaling analysis, thus requiring no interpolation. The scaled hydrographs have an AEP associated with them, so they are suitable for use in reservoir routing studies and for dam safety risk assessment.

Table 5-2.—Example of combined peak-discharge and volume estimates in tabular form

RETURN PERIOD (yrs)	PEAK DISCHARGE (cfs)		1-Day Volume (acre ft)	3-Day Volume (acre ft)	5-Day Volume (acre ft)	7-Day Volume (acre ft)	15-Day Volume (acre ft)
100	73,890		44,300	72,530	84,940	101,130	137,590
200	83,220		49,740	80,900	94,070	109,920	146,730
500	96,140		57,260	92,470	106,690	122,070	159,360
1,000	106,370		63,220	101,640	116,700	131,710	169,380
2,000	117,040		69,440	111,200	127,120	141,740	179,810
5,000	131,840		78,060	124,450	141,590	155,670	194,290
10,000	143,590		84,910	134,980	153,070	166,730	205,790
20,000	155,840		92,040	145,950	165,050	178,260	217,770
50,000	172,830		101,940	161,180	181,650	194,250	234,400
100,000	186,310		109,800	173,250	194,830	206,940	247,590
1,000,000	235,220		138,290	217,070	242,630	252,970	295,450
10,000,000	291,000		170,790	267,040	297,150	305,460	350,020
100,000,000	354,340		207,690	323,780	359,050	365,060	411,990

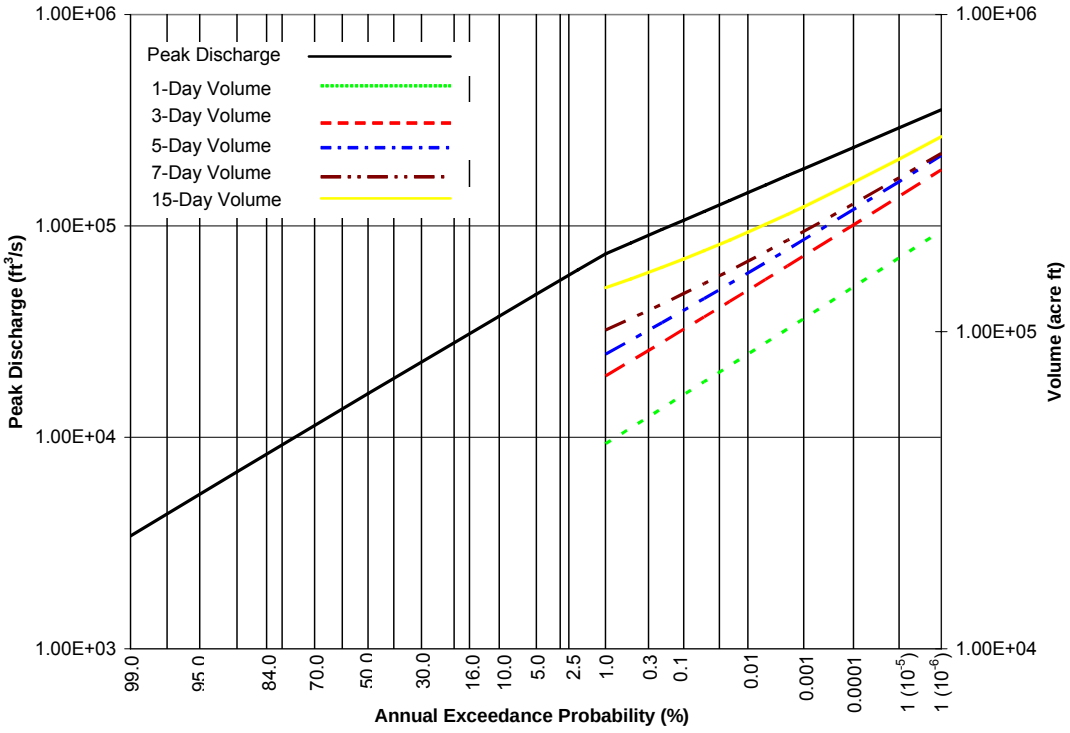


Figure 5-2.—Example of combined peak-discharge and volume estimates in graphical form.

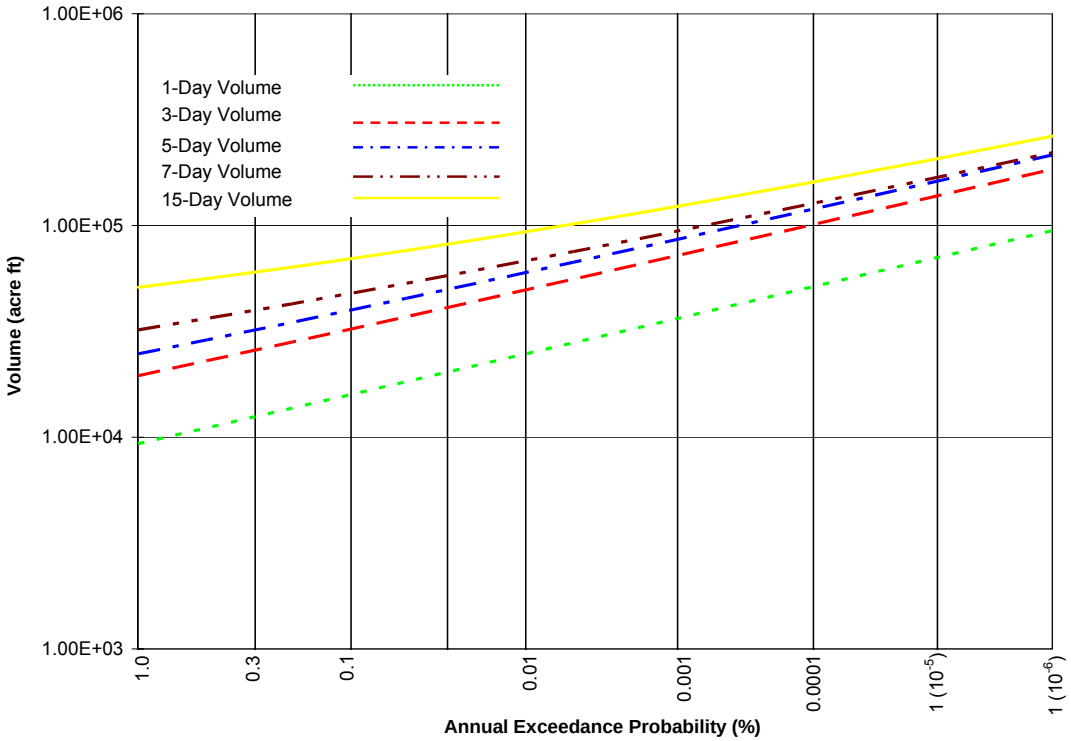


Figure 5-3.—Example of volume only chart.

5.3 Detailed Hydrologic Studies

After developing the hydrologic hazard information for the CFR, more detailed hydrologic studies may be necessary to better define the hydrologic problem, reduce uncertainty, develop solutions, or make decisions. The amount of effort expended on analyzing a hydrologic hazard is dependent on the nature of the problem and potential cost of the solution. Reclamation uses a staged approach toward solving this problem. Initially, very little effort is expended to determine the magnitude of the hydrologic hazard. If additional hydrologic studies are needed, a project plan is developed that tailors the study to the particular needs of the project. The scope of work attempts to address the specific dam safety issue at the least possible cost while providing sufficient information to the dam safety decision makers to make informed safety decisions.

Flood characterization for risk assessments uses the length of the data record and other characteristics of the data to determine the range of credible extrapolation used in the flood frequency analysis. Because Reclamation risk assessments may require estimation of floods with AEPs as small as 1 in 100,000,000, extrapolation of flood frequency relationships is required well beyond the limits warranted by the data. These guidelines provide a reasonable and reliable approach for characterizing the hydrologic hazard beyond the range of extrapolation suggested by the data for use in dam safety risk assessments. Reliable flood frequency estimates are needed for very small AEPs for dam safety decisionmaking, and these estimates should convey an estimate of the uncertainty in the analysis for the consideration of the decision maker.

The uncertainties associated with flood estimates are likely to be substantial and an important attribute to convey into the risk assessment. Flood characterization should include a "best estimate" of the AEP of floods of different magnitudes and a description of the uncertainty in such results. Such uncertainties need to be honestly represented and considered throughout the risk assessment process.

Further analyses might be necessary if the hydrologic hazard information provided during the CFR is insufficient to define and quantify hydrologic dam safety issues and make decisions. Additional studies may become necessary to address reservoir routing effects of upstream dams, reduce uncertainty in the flood estimates, verify statistical results before committing large capital expenditures to dam safety modifications, etc. When planning the next study, the goal is to achieve a balance between the amount of hydrologic analysis needed to address the issues and make decisions, and the level of effort required to conduct the study. Generally, studies progress from those requiring a low level of effort to those requiring a higher level of effort. As the studies get more detailed, the results should become more precise and contain less uncertainty.

Since each study site is different, no single approach can be identified to address all hydrologic issues. The method chosen should consider climatic and hydrologic parameters, drainage area size, amount of upstream regulation, data availability, and level of confidence needed in the results. The previous chapter of this report described the methods available in Reclamation to develop hydrologic hazard curves.

Table 5.3 lists various methodologies that were considered for characterizing extreme floods to support dam safety risk assessment. A flood frequency analysis must be combined with each of these methodologies to assign annual exceedance probabilities to the floods.

Table 5-3.—Alternative methods to develop hydrologic hazard information

Method of Analysis and Modeling	**Risk Analysis/Design Level[1]**	**Level of Effort[2]**
Flood frequency analysis with historical/paleoflood data - Graphical method; - EMA; - FLDFRQ3	CFR, IE, CAS, FD	Low
Hydrograph Scaling and Volumes	CFR, IE, CAS, FD	Low
GRADEX Method	IE, CAS, FD	Moderate
Australian Rainfall-Runoff Method	IE, CAS, FD	Moderate
Stochastic Event-Based Precipitation Runoff Modeling with SEFM	CAS, FD	High
Stochastic Rainfall-Runoff Modeling with CASC2D	CAS, FD	High
Probable Maximum Flood	CFR, IE, CAS, FD	Moderate

Notes:

1. Risk analysis/design level: CFR - Comprehensive Facility Review, IE - Issue Evaluation, CAS - Corrective Action Study, and FD - Final Design.

2. Level of effort: Low requires 10-20 staff-days to complete the analysis; moderate requires 21-75 staff-days; and high requires more than 75 staff-days.

Hydrologic studies usually will proceed from flood frequency and hydrograph scaling to an analysis using either the GRADEX or Australian Rainfall-Runoff Method. The advantages of these approaches are that they use regional rainfall data in developing flood estimates and yield flood hydrographs. Both approaches work best on small drainages (less than 2,000 mi^2), and the Australian Rainfall-Runoff Method works better if snowmelt floods are important.

The SEFM and CASC2D are more sophisticated hydrologic modeling techniques used to address hydrologic issues driven by large potential dam failure consequences. These approaches are more suitable for CAS and final designs. They also allow for better quantification of hydrologic uncertainty. These approaches require a lot of data and are generally more costly than the others.

When multiple methods have been used to determine the hydrologic hazard, sound physical and scientific reasoning for weighting or combining results is needed. Clearly, a measure of judgment is required to ensure that appropriate information is included in the dam safety decisionmaking process. Reclamation develops various weighting schemes to evaluate the results of multiple analyses and uses a team of hydrologists to select the weighting scheme that best characterizes the hydrologic conditions for the site of interest. The selection is based on the experiences of the team members and the assumptions used in each of the analyses. The A.R. Bowman case study that follows illustrates this approach.

6. Case Studies

Three case studies are presented to illustrate the use of several methods. The study sites are Los Banos, Fresno, and A.R. Bowman Dams. Each study begins with a flood frequency analysis and hydrograph scaling. Different solution techniques were used to answer follow-up questions for each of the following case studies.

6.1 Los Banos Dam

Los Banos Dam is an earthfill structure with an uncontrolled spillway. It was completed between 1964 and 1965. This dam is located 7 miles southwest of the town of Los Banos, California, on Los Banos Creek. The drainage basin upstream from the dam has a total area of approximately 156 mi^2. The spillway crest elevation is 353.5 feet and the dam crest elevation is 384.0 feet. The spillway discharge capacity at the dam crest elevation is 11,800 ft^3/s. The total capacity of the dam at water surface elevation 353.5 feet is 34,600 acre-feet. The active capacity between elevations 296 and 353.5 feet is 26,300 acre-feet. The current PMFs for Los Banos Dam were computed in 1996 (Bureau of Reclamation, 1996a). The results of these PMF studies are summarized in table 6-1.

The PMFs were computed using a standard storm arrangement. Routing results indicate that Los Banos Dam would be overtopped by a flood with a magnitude about 37.6 percent of the general

storm PMF (Bureau of Reclamation, 1996b). The general storm PMF would overtop the dam by 6.2 feet for 30 hours. The thunderstorm PMF does not overtop the dam.

Table 6-1.—Probable maximum flood summary for Los Banos Dam, California

Flood Type	HMR	Peak Inflow (ft^3/s)	Volume (acre-feet)	
			With 100-year antecedent storm event	Without 100-year antecedent storm event
General storm	58	75,800	146,700 (7 day)	138,000 (4.3 days)
Thunderstorm	58	75,200	27,400 (24 hr)	—

Because Los Banos Dam is overtopped by the general storm PMF, flood probabilities are needed to understand and quantify the risk of overtopping and hydrologic hazard for dam safety. A flood frequency and volume frequency analysis was completed using the procedures recommended for a CFR.

6.1.1 Los Banos Hydrologic Hazard Curves Using Flood Frequency Analysis and Hydrograph Scaling

A recent flood study, including paleoflood data, peak-flow frequency, and hydrographs, was completed for a risk analysis (Weghorst and Klinger, 2002). The streamflow and paleoflood data from that study are summarized below and then used to compute a hydrologic hazard curve. Because streamflow gage records for Los Banos Creek at Los Banos Dam were limited, the records from the gaging station on Orestimba Creek, near Newman, California (U.S. Geological Survey [USGS] station No. 11274500), were used in this example. This gage is located just north of Los Banos Dam, has a drainage area of about 134 mi^2, and provides 71 years (1932 to 2002) of unregulated peak discharge records. The peak discharge data were adjusted by the square root of the drainage area ratio (Cudworth, 1989); this factor was $(156/134)^{0.5} = 1.078$.

There are several sources of regional and reconnaissance-level paleoflood data that may be applied to estimates of flood frequency at Los Banos Dam including reconnaissance-level data on Los Banos Creek and supporting data from site-specific soil stratigraphic information on the Cantua Stream Group, located about 55 miles south of Los Banos Creek (Weghorst and Klinger, 2002). The hydrometeorologic setting for the Cantua Stream Group and Los Banos Creek, in general, appears to be very similar to each other; however, no field verification was performed to confirm this. Each of the basins is located on the eastern flank of the central Coast Ranges, and the drainage basin areas are close enough in size that differences in their runoff characteristics would be negligible given similarities in rock types, basin aspect and slope, average elevation, and vegetation and land use. Therefore, the paleoflood peak discharge bounds and age estimates from the Cantua Stream Group are believed to be applicable to Los Banos Creek (Weghorst and Klinger, 2002). Paleoflood bounds were established by scaling (Cudworth, 1989) the peak discharges for paleoflood data on the Cantua Stream Group to the Los Banos basin. It appears that peak discharges in the range of 42,000 to 60,000 ft^3/s on Los Banos Creek have not been exceeded in the last 1,800 – 2,800 years.

A hydrologic hazard curve for Los Banos Dam was constructed using the flood frequency analysis and hydrograph scaling procedures recommended for a CFR. Peak flow and paleoflood data and a PMF general storm hydrograph were used to estimate the hazard curve (figure 6-1). Estimated peak flows and volumes can exceed the PMF peak and volume at this site (table 6-1 and table 6-2). Therefore, the PMF was considered as an upper limit for design and risk analysis (Bureau of Reclamation, 2002).

Hydrographs for these floods were then routed through Los Banos Reservoir and spillway. The results from this characterization of the hydrologic hazard and flood hydrograph routing indicate that Los Banos Dam may potentially be overtopped by a flood with a return period of about 2,800 years (based on peak flow). Using these results, Los Banos Dam does not meet Reclamation hydrologic hazard criteria for overtopping because it does not pass a 10,000-year flood (at a minimum). Because this dam does not meet Reclamation criteria, additional studies for Los Banos are required to further assess the flood risk, estimate the need for any structural modifications, and determine suitable probability-based design hydrographs for any potential modification or design alternatives.

6.2 A.R. Bowman Dam

The case study for A.R. Bowman Dam is an example of a project where several hydrologic studies have been completed. The dam is an earthfill structure with an uncontrolled spillway. It was completed in 1961. This dam is located about 20 miles upstream from Prineville, Oregon, on the Crooked River. The drainage basin upstream of the dam has a total area of approximately 2,635 mi^2. The spillway crest elevation is 3234.8 feet, and the dam crest elevation is 3264.0 feet. The spillway capacity at the dam crest elevation is 11,500 ft^3/s. The total capacity of the dam at water surface elevation 3257.9 feet is 233,100 acre-feet. The current PMFs for A.R. Bowman Dam were computed in 1994. The results of these studies are summarized in table 6-3.

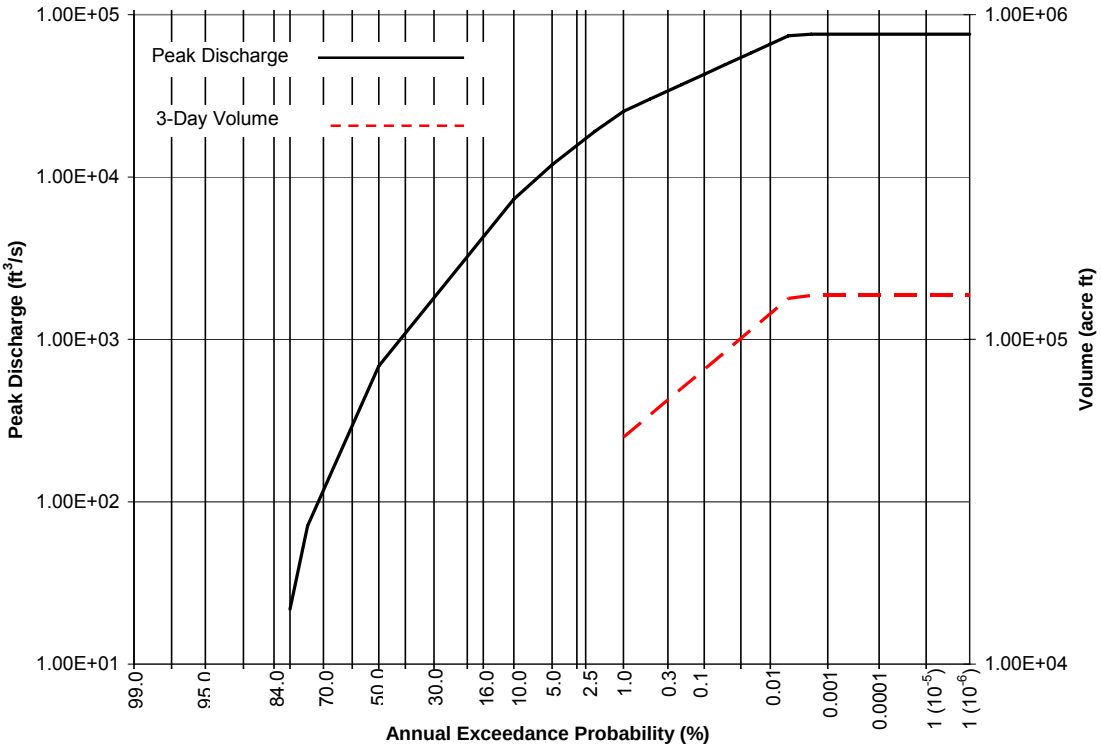


Figure 6-1.—Example of hydrologic hazard curve for Los Banos Dam, California.

Table 6-2.—Peak and volume (3-day) estimates at Los Banos Dam, California, for specified probabilities

Annual exceedance probability	Return period	Peak discharge estimate (ft^3/s)	3-day volume estimate (acre-feet)
0.01	100	25,400	50,100
0.005	200	30,100	58,500
0.002	500	37,000	70,800
0.001	1,000	42,800	80,800
0.0005	2,000	49,100	91,700
0.0002	5,000	58,300	107,200
0.0001	10,000	65,900	120,000
0.00005	20,000	74,100	133,700
0.00002	50,000	75,800	136,500

Table 6-3.—Probable maximum flood summary A.R. Bowman Dam, Oregon

Flood type	HMR	Peak inflow (ft^3/s)	Volume (acre-feet)	
			With 100-year antecedent conditions	Without 100-year antecedent conditions
February General storm	57	255,000	770,000 (15 day)	138,000 (4.3 days)
June General storm	57	83,300	185,600 (15 day)	185,600 (15 day)
August General storm	57	75,000	—	112,600 (15 day)

Routings of the PMF hydrographs indicated that the February general storm event, with a starting water surface elevation of 3211.17 feet, would overtop the dam by 18.6 feet. A.R. Bowman Dam would only pass approximately 10 to 25 percent of the February general storm PMF without overtopping. The June and August PMFs did not overtop the dam.

Because A.R. Bowman Dam is overtopped by the February general storm PMF, flood probabilities are needed to understand and quantify the risk of overtopping and hydrologic hazard for dam safety. Several investigations have been undertaken since about 1991 to determine PMF design modification alternatives, including overtopping protection and parapet walls. In addition, detailed probabilistic flood studies using alternative approaches (stochastic event flood modeling and paleoflood studies) were completed at A.R. Bowman Dam to better estimate the flood risk.

Three methods for estimating the hydrologic hazard are discussed in this section: flood frequency analysis and hydrograph scaling, SEFM, and peak-flow frequency analysis with detailed paleoflood data. Flood risk results from the three methods and implications for potential modifications at A.R. Bowman Dam are then discussed.

6.2.1 A.R. Bowman Hydrologic Hazard Curves Using Flood Frequency Analysis and Hydrograph Scaling

Peak flow data at A.R. Bowman Dam were obtained from three USGS gaging stations:

- Crooked River at Post, Oregon (USGS station No. 14079500)
- Crooked River above Prineville Reservoir near Post, Oregon (USGS station No. 14079800)
- Crooked River near Prineville, Oregon (USGS station No. 14078050)

These gages are the closest to A.R. Bowman Dam; the first two are located upstream from the reservoir, and the gage near Prineville is located downstream from the dam. The combined gages provide 38 years (1909 to 1972, with many missing years) of unregulated peak discharge records. The peak discharge data for the upstream gages were adjusted by the square root of the drainage area ratio (Cudworth, 1989). The December 1964 flood was treated as a historic peak with a return period of approximately 140 years (largest since about 1860).

The reconnaissance-level paleoflood data that may be applied to estimate flood frequency at A.R. Bowman Dam are based on the detailed paleoflood data presented below. Information from the paleohydrologic bound with the largest discharge was used and was dated based on the Mount Mazama volcanic eruption 7,600 years ago. Based on this information, it appears that a peak discharge between 27,000 and 36,000 ft^3/s on the Crooked River has not been exceeded in the last 7,600 to 10,000 years.

A hydrologic hazard curve for A.R. Bowman Dam was constructed using the techniques outlined in section 5. This example calculation was completed after the results of the SEFM and paleoflood study were completed. This example represents the first step that might be performed in future flood studies for Reclamation dam safety. Peak flow and paleoflood data and a general storm PMF hydrograph were used to estimate the hazard curve (figure 6-2 and table 6-4).

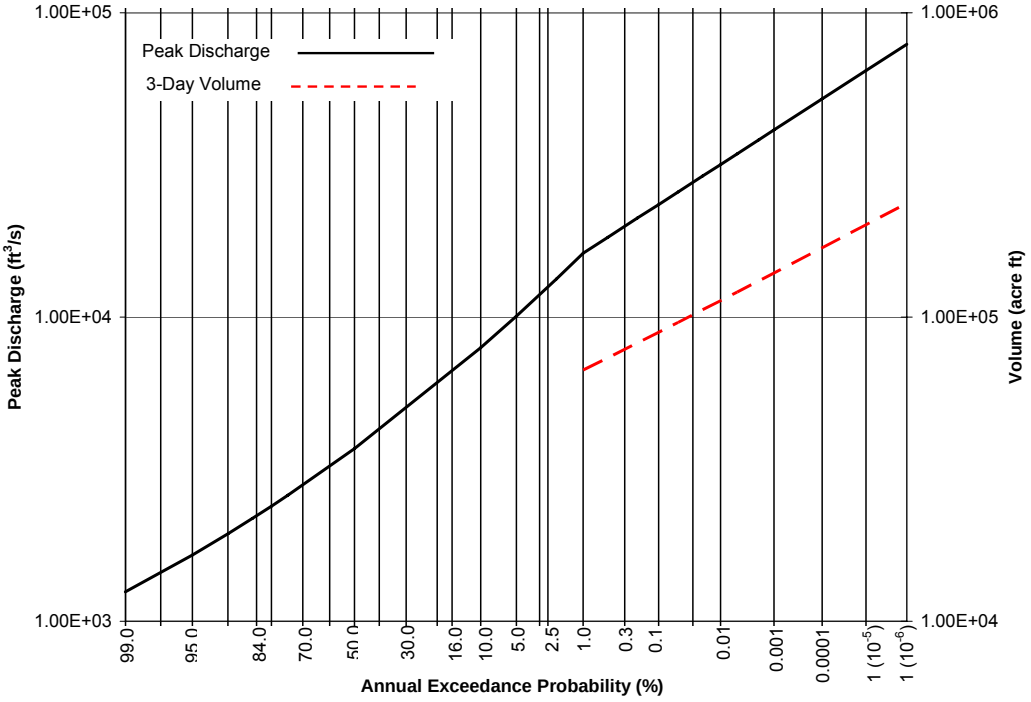


Figure 6-2.—Example of a hydrologic hazard curve for A.R. Bowman Dam, Oregon.

6.2.2 A.R. Bowman Hydrologic Hazard Estimates Based on a Stochastic Event Flood Model

MGS Engineering Consultants, Inc., was contracted in November 1997 (Schaefer and Barker, 1997) to perform a hydrologic stochastic analysis to develop magnitude frequency curves for flood peak discharge, runoff volume, and maximum reservoir elevation. The SEFM was developed using a deterministic rainfall-runoff model (HEC-1) and treated input parameters that were selected by Monte Carlo sampling procedures as a probabilistic distribution of values rather than fixed values. The SEFM is described in section 4.5. After the initial modeling runs and results at A.R. Bowman Dam were made, the precipitation depth-area relationships were refined (Schaefer and Barker, 1998) and new flood frequency relationships were developed.

The results from the SEFM include peak flow, volume, and reservoir elevation frequency curves. These graphs are shown below and include polynomial equations fitted to model output that are applicable in the range of AEP from 10^{-2} to 10^{-5} (Schaefer and Barker, 1998). From these results, the dam may be potentially overtopped with a maximum reservoir elevation probability equal to 0.0005 (2,000-year return period) (figure 6-4).

Peak discharge estimate:

$$Q_p = 2322\,Log^2(AEP) - 2241\,Log(AEP) + 950$$

Flood Runoff Volume Estimate:

$$Q_v = 8385\,Log^2(AEP) - 59700\,Log(AEP) - 39490$$

Maximum reservoir elevation estimate:

$$ELEV_{\max} = -0.3993\,Log^4(AEP) - 6.193\,Log^3(AEP) - 33.67\,Log^2(AEP) - 89.81\,Log(AEP) + 3159.2$$

Table 6-4.—Peak and volume (3-day) estimates at A.R. Bowman Dam, Oregon, for specified probabilities

Annual exceedance probability	Return period	Peak discharge estimate (ft^3/s)	3-day volume estimate (acre-feet)
0.01	100	16,000	65,100
0.005	200	18,100	71,300
0.002	500	21,000	79,700
0.001	1,000	23,300	86,300
0.0005	2,000	25,700	93,000
0.0002	5,000	29,100	102,100
0.0001	10,000	31,700	109,200
0.00005	20,000	34,500	116,600
0.00002	50,000	38,400	126,600
0.00001	100,000	41,500	134,500
0.000001	1,000,000	52,700	162,400
1E-07	10,000,000	65,500	193,200
1E-08	100,000,000	80,300	227,300

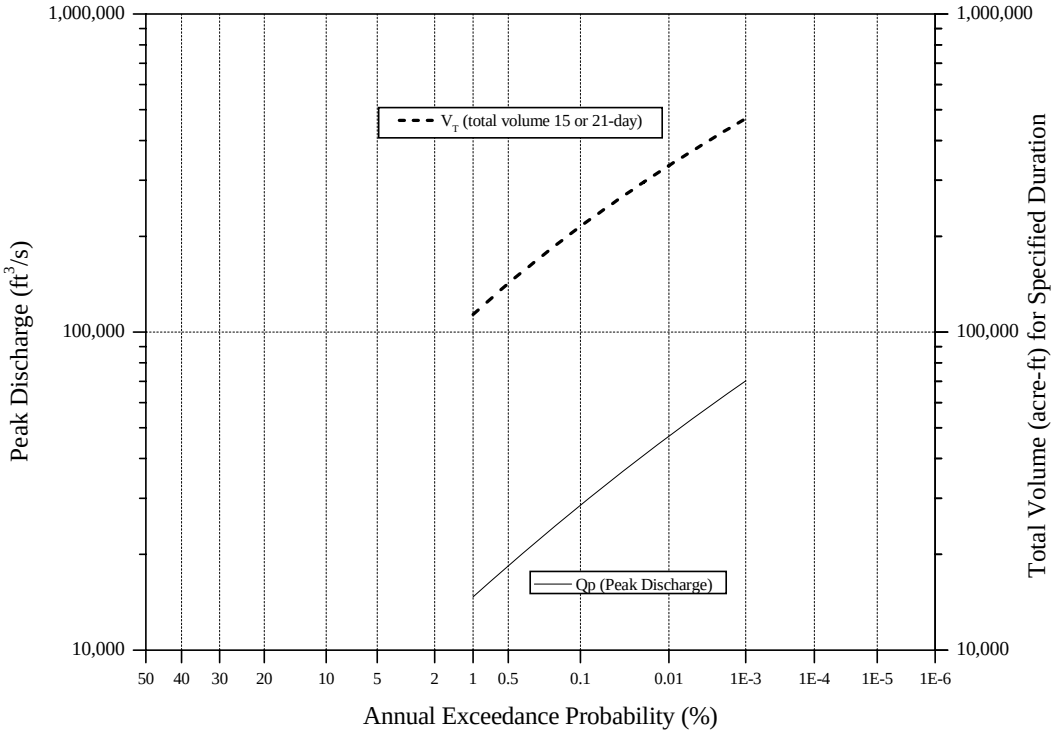


Figure 6-3.—Peak discharge and total volume frequency curves from the SEFM for A.R. Bowman Dam, Oregon.

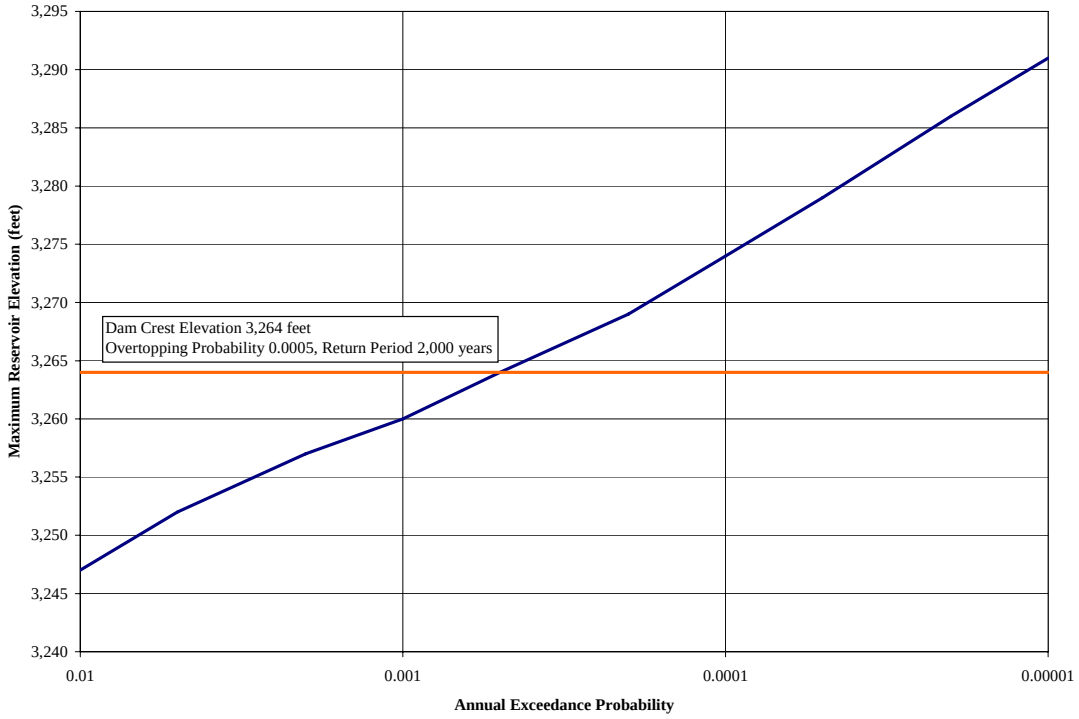


Figure 6-4.—Maximum reservoir elevation frequency curve from the SEFM for A.R. Bowman Dam, Oregon.

6.2.3 A.R. Bowman Hydrologic Hazard Estimates Using Bayesian Statistical Estimation

To gain information on the magnitude of low probability floods for risk analysis, the Dam Safety Office, in 1995, requested a paleoflood study on the Crooked River at A.R. Bowman Dam. The paleoflood study was an alternative approach to the SEFM. The paleoflood report has not been published because of changing priorities in the Dam Safety Office.

For the Crooked River paleoflood study, two reaches downstream from A.R. Bowman Dam were selected for detailed hydraulic modeling. These reaches are about 2 and 35 miles downstream from the dam. At these study reaches, there is geomorphic, stratigraphic, and botanic evidence to limit the paleostage of floods throughout the Holocene epoch (the past 10,000 years). In one of the downstream reaches, it is possible to reconstruct the magnitude of the December 1861 flood based on the presence of driftwood piles. In addition to these downstream study reaches, a third study reach was identified just upstream from Prineville Reservoir, where the stage of paleofloods during the late Holocene epoch can be related to the peak discharge estimates from the December 1964 flood.

Stratigraphy and soils were described at eight sites along the Crooked River, including the three study reaches. At these sites, the soils were described in detail and material was collected for radiocarbon dating. In total, there are 54 radiocarbon ages for the Crooked River paleoflood study. In addition to these radiocarbon ages, the Mazama ash forms an important stratigraphic datum along the river downstream from A.R. Bowman Dam. The calibrated ages of radiocarbon samples associated with the Mazama ash throughout the western U.S. yield an age of about 7,650 years. The hydraulic geometry of the Crooked River channel is remarkably consistent at all the study sites. This implies long-term stability of the Crooked River channel and of the mechanisms that produce large floods on the Crooked River.

The paleoflood data that have been collected and analyzed to date are summarized in table 6-5.

Table 6-5.—Detailed paleoflood estimates at A.R. Bowman Dam, Oregon

Type	Preferred age (years before present)	Age range (years)	Preferred discharge (ft^3/s)	Discharge range	
				Low (ft^3/s)	High (ft^3/s)
1862 historical bound	140	—	15,000	13,000	18,000
Paleohydrologic bound	1,100	980 – 1,210	20,700	18,000	25,000
Paleohydrologic bound	3,150	2,650 – 3,650	25,000	22,000	30,000
Paleohydrologic bound	3,500	3,350 – 5,050	27,000	25,000	32,500
Paleohydrologic bound	9,000	7,600 – 10,000	30,000	27,000	36,000
Historical flood	140	—	20,700	18,000	25,000
Paleoflood	1,100	980 – 1,210	20,700	18,000	25,000

The paleoflood data were combined with peak flows from three gaging stations. A frequency analysis was performed using FLDFRQ3 (O'Connell, 1999; O'Connell et al., 2002). The peak-flow frequency results for a particular distribution (log-Pearson) are shown in figure 6-5 and summarized in table 6-6. Based on this peak-discharge frequency curve and scaling model hydrographs, the dam might be overtopped at exceedance probabilities greater than 0.0001 (more frequently than the 10,000-year return period).

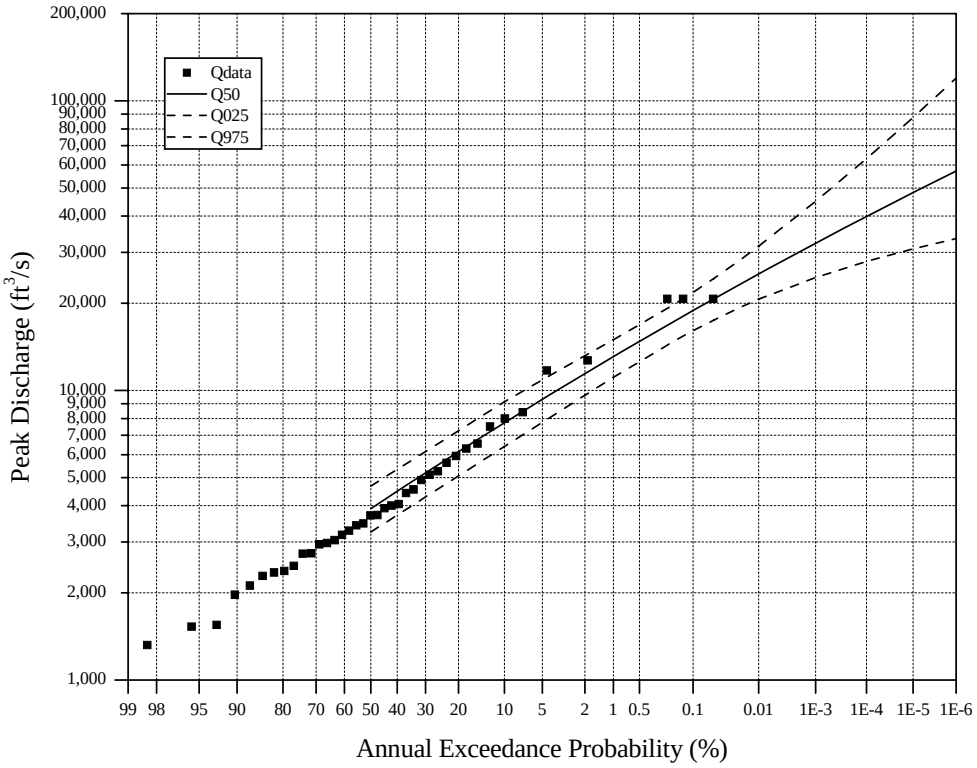


Figure 6-5.—Peak-discharge frequency curve based on paleoflood data for A.R. Bowman Dam, Oregon.

Table 6-6.—Peak discharge estimates based on paleoflood data at A.R. Bowman Dam, Oregon, for specified probabilities

Annual Exceedance Probability	Return Period	Median (50%) LP3 Model Peak Discharge Estimate (ft^3/s)	2.5% LP3 Model Peak Discharge Estimate (ft^3/s)	97.5% LP3 Model Peak Discharge Estimate (ft^3/s)
0.01	100	13,100	11,100	15,000
0.002	500	17,100	14,600	19,500
0.001	1,000	18,900	16,100	21,800
0.0005	2,000	20,700	17,500	24,400
0.0002	5,000	23,300	19,300	28,200
0.0001	10,000	25,200	20,700	31,500
0.00001	100,000	32,200	24,500	44,900
0.000001	1,000,000	39,800	27,900	63,200
0.0000001	10,000,000	48,200	30,800	87,500
0.00000001	100,000,000	57,100	33,400	119,700

6.2.4 Combined Hydrologic Hazard Estimates for Risk Analysis and Dam Safety Implications

Both the SEFM and paleoflood study indicate that A.R. Bowman Dam potentially might not meet Reclamation hydrologic hazard criteria for overtopping because it does not pass the 10,000-year flood (at a minimum). The results from the three approaches (flood frequency analysis and hydrograph scaling, SEFM, and paleoflood study) were combined to provide a single estimate of the hydrologic hazard curve for risk analysis. The weighting schemes are simple numerical weights given to each model result. Three weighting schemes were analyzed for A.R. Bowman: (1) enveloping all results (figure 6-6), (2) weighting the SEFM and paleoflood peak flow curves equally (50 percent each) (figure 6-7), and (3) choosing a "best estimate" between the SEFM and paleoflood peak flow curves equal to the upper 97.5 percent confidence limit from the Bayesian analysis (figure 6-8). The third option was selected to represent the peak discharge flood frequency based on results and decisions made in 1999 for a risk analysis. A "combined" hydrologic hazard curve is shown in figure 6-9, which also includes a volume frequency analysis based on results of the SEFM.

Because A.R. Bowman Dam might not meet Reclamation criteria, additional engineering studies are ongoing to estimate the need for any potential structural modifications at this site. Probability-based design hydrographs for any potential modification or design alternatives were selected based on a combination of the weighting results shown above. Corrective action studies are ongoing.

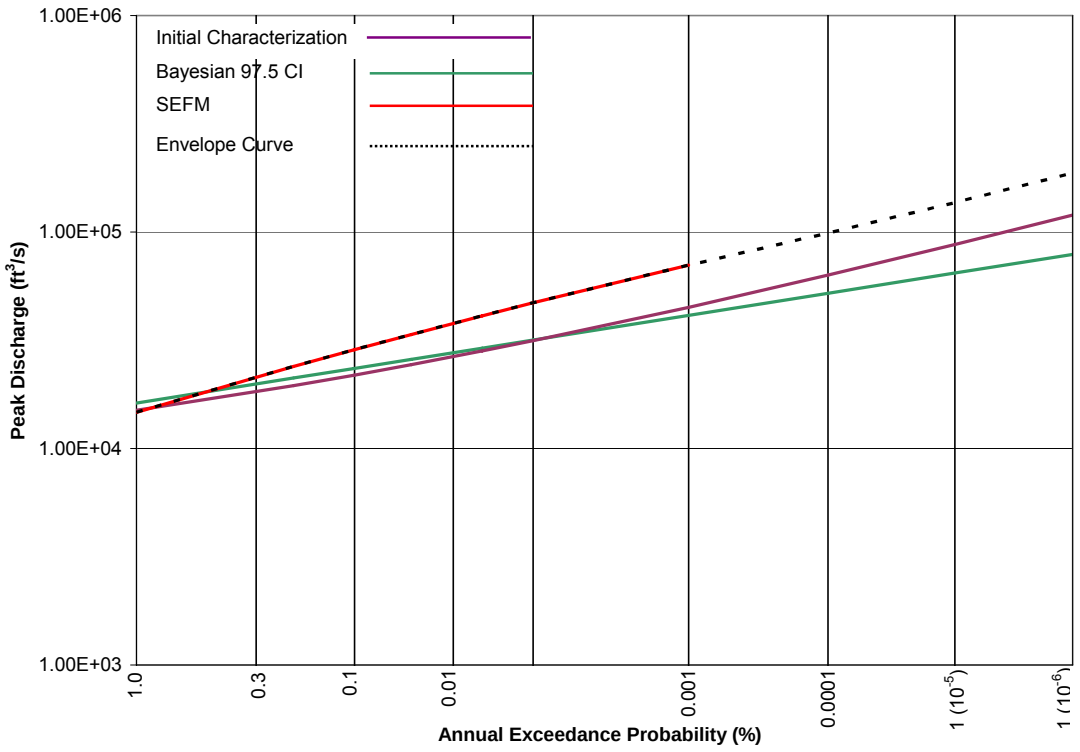


Figure 6-6.—Weighted peak-discharge frequency curve based on enveloping results for A.R. Bowman Dam, Oregon.

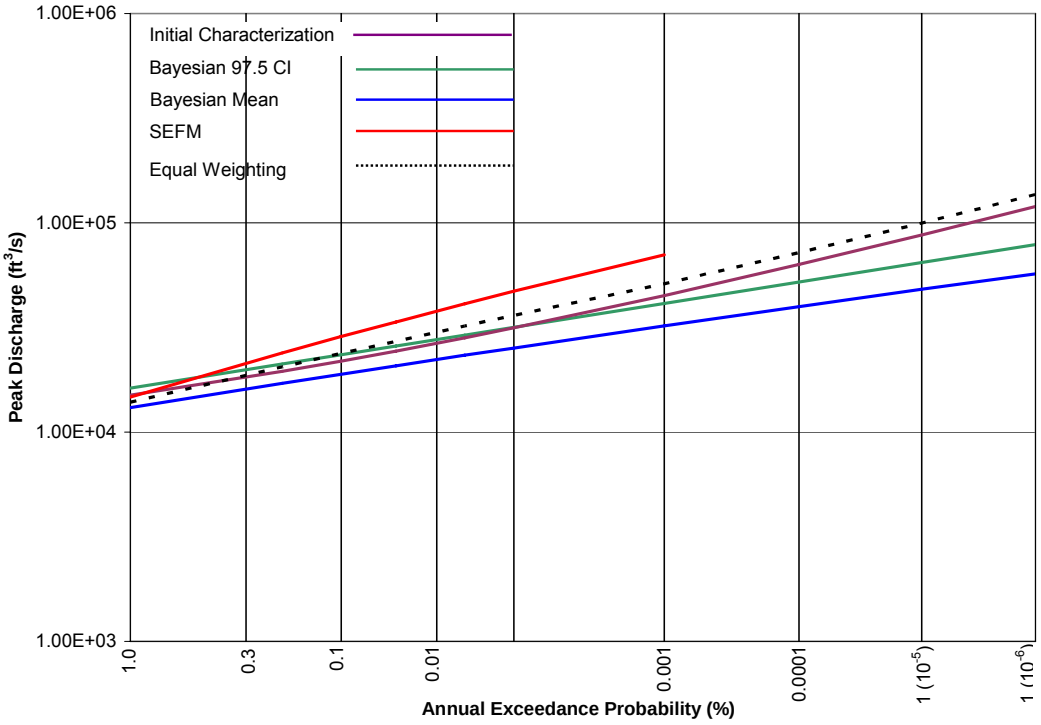


Figure 6-7.—Equal (50 percent) weighted peak-discharge frequency curve for A.R. Bowman Dam, Oregon.

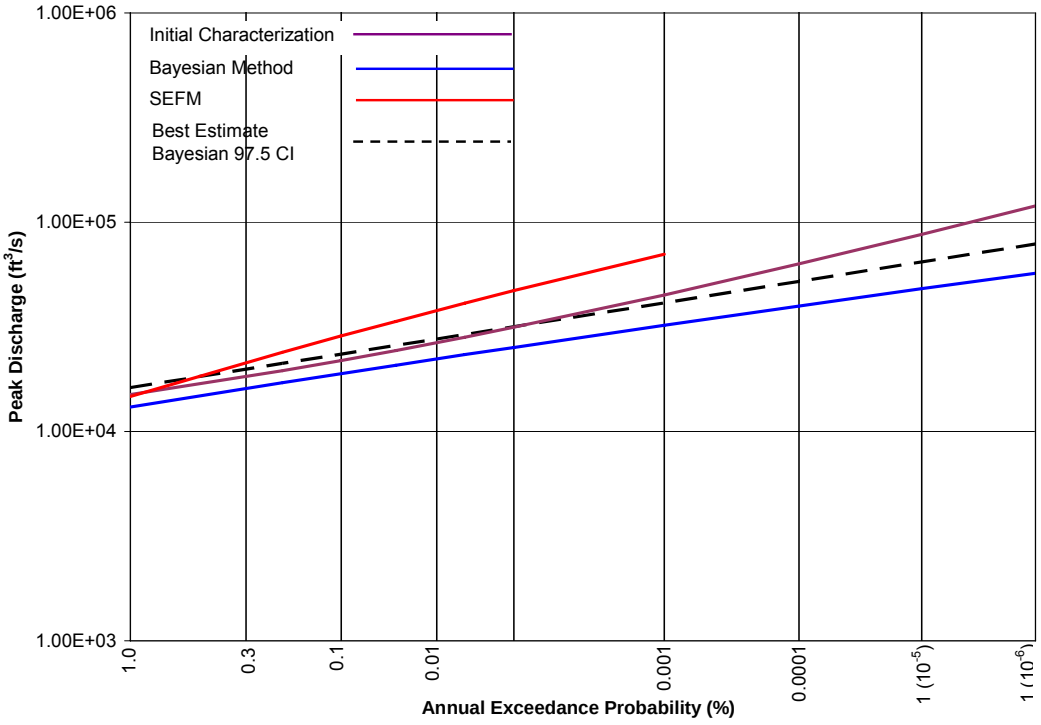


Figure 6-8.—Best estimate (Bayesian 97.5 percent) weighted peak-discharge frequency curve for A.R. Bowman Dam, Oregon.

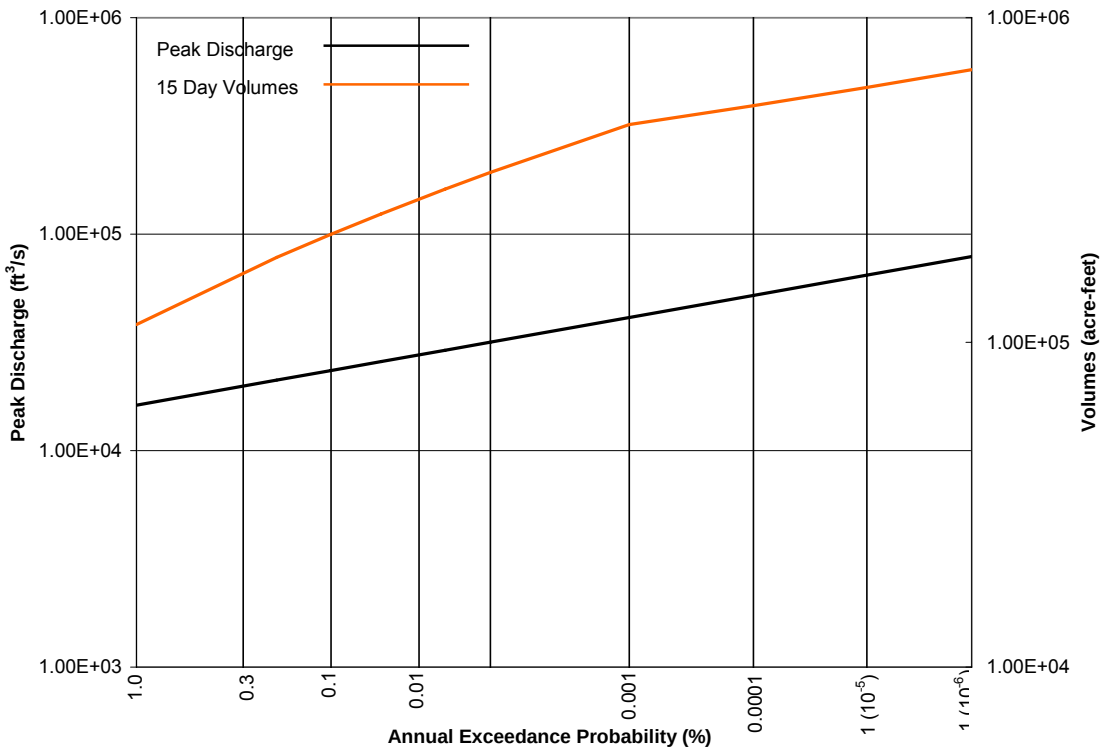


Figure 6-9.—Final combined hydrologic hazard curve for A.R. Bowman Dam, Oregon.

6.3 Fresno Dam

Fresno Dam is located on the Milk River in north-central Montana, approximately 14 miles west of the town of Havre (figure 6-10). The compacted earthfill dam was constructed from 1937 to 1939. It is approximately 110 feet high. Previous studies have indicated that the dam could safely pass Reclamation's 1985 PMF hydrograph. Normally, Reclamation would not have conducted additional hydrologic studies for this dam; however, project beneficiaries wanted to examine the possibility of enlarging the dam.

6.3.1 Fresno Dam Hydrologic Hazard Curves Using Flood Frequency Analysis and Hydrograph Scaling

A hydrologic hazard curve for Fresno Dam was constructed using flood frequency analysis techniques. Peak flow and paleoflood data and a general storm PMF hydrograph were used to estimate the hazard curve (figure 6-11 and table 6-7).

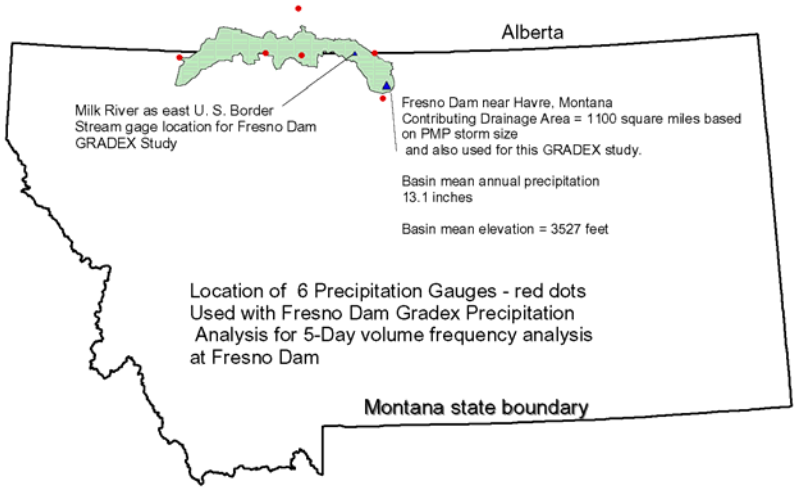


Figure 6-10.—Site and watershed depiction of Fresno Dam, Montana.

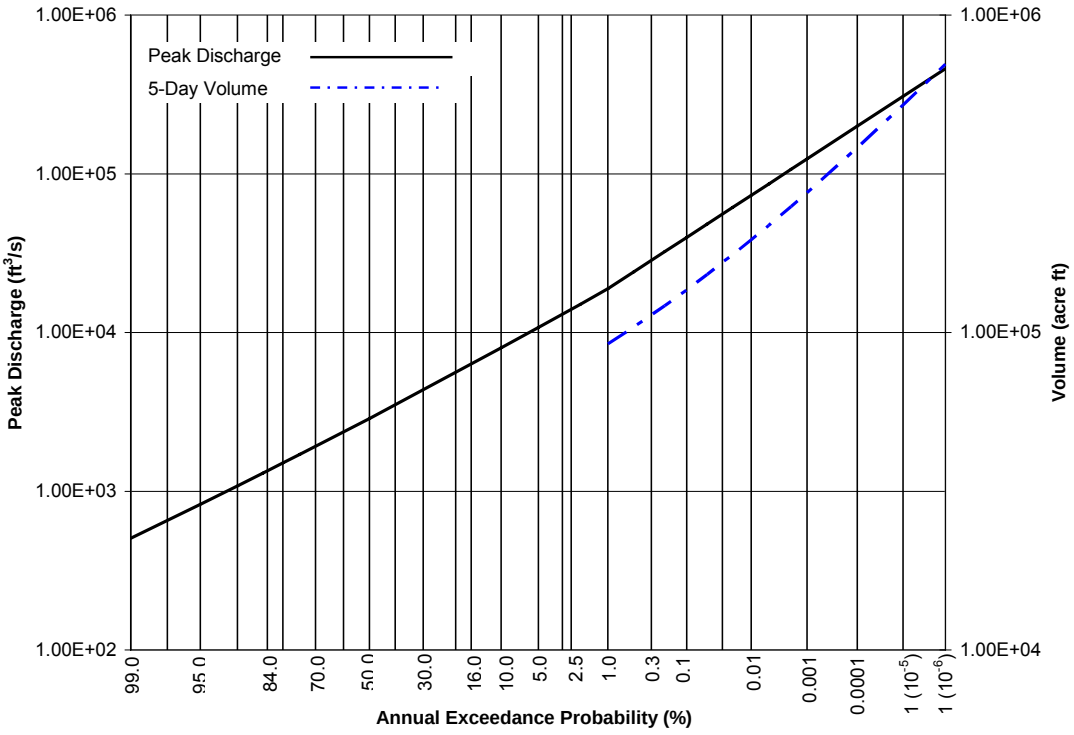


Figure 6-11.—Example of hydrologic hazard curve for Fresno Dam, Montana.

Table 6-7.—Peak and volume (5-day) estimates at Fresno Dam, Montana, for specified probabilities

Annual Exceedance Probability	Return Period	Discharge Estimate	5-Day Volume Estimate (acre ft)
0.01	100	18,900	92,000
0.005	200	24,100	103,900
0.002	500	32,300	121,400
0.001	1000	39,700	136,100
0.0005	2000	48,200	152,300
0.0002	5000	61,500	176,000
0.0001	10000	73,100	195,900
0.00005	20000	86,400	217,600
0.00002	50000	106,600	249,500
0.00001	100000	124,200	276,000
0.000001	1000000	199,600	382,100
0.0000001	10000000	307,800	520,800
0.00000001	100000000	459,400	700,300

Peak flow data at Fresno Dam were obtained from the USGS gaging station, Milk River at Eastern U.S. Border Crossing (USGS station No. 06135000). The gage provides peak flow records from 1910 through 2002. No adjustments were performed on these data, as the associated drainage area and streamflow records were believed to accurately represent the conditions at Fresno Dam.

The reconnaissance-level paleoflood data that may be applied to estimate flood frequency at Fresno Dam are based on detailed chronology developed at archaeological sites on the Milk River. Based on this information, it appears that a peak discharge between 40,000 and 70,000 ft^3/s on the Milk River has not been exceeded in the last 2,000 to 4,000 years.

Fresno Dam has a spillway discharge capacity of 51,360 ft^3/s at the maximum water surface elevation of 2591 feet. Comparing this value with the peak-discharge flood frequency curve indicates that the spillway is capable of passing a flood with a return period of only slightly longer than 2,000 years. At the time of this study, the methods for determining the volume frequency relationship had not been developed, so hydrographs were not available for reservoir routing. Therefore, we decided to develop hydrographs using the GRADEX Method.

6.3.2 Fresno Dam Hydrologic Hazard Analysis Using the GRADEX Method

Daily flow records that approximate the daily inflows to Fresno Dam come from the stream gage on the Milk River at the Eastern U.S. Border Crossing (USGS station No. 06135000). This gage record has daily flow data from August 1909 through September 2001. A total of 86 years of daily flow data is available, with a few missing years. The contributing drainage area at the gage site is considered to be 2,525 mi^2, and the gage is located about 54 river miles upstream from Fresno Dam. The total possible contributing drainage area at Fresno Dam is considered to be 2,911 mi^2 for the rainfall-runoff modeling calculations in this study. These daily flow records were checked with available reservoir inflow records for concurrent years.

The information needed from the stream gage record is a set of independent flood volumes, representing the volume of flooding caused by rainfall for independent storms in the basin. The process starts by setting a threshold flow value and then counting the number of events that have continuous days of flow above that value. A threshold flow value was set and adjusted until about 86 independent flood events above this value were determined. The average duration of all of the independent flood events was then calculated. This average duration of independent flood events for the Milk River above Fresno Dam was found to be between 4 and 5 days, with a threshold value of 1,307 ft^3/s. The value of 5 days was selected for further use in the study as the critical duration for both rainfall and flood events.

The GRADEX Method required that the number of multi-day rain events at each gage be equal to the number of common years of record for the selected gages. The number of multi-day rain events was made equal by selecting a threshold 5-day total rainfall for each gage such that exactly fifty 5-day rain totals were above the threshold value for each gage. Figure 6-10 displays the locations of the six precipitation gage stations selected for the GRADEX analysis at Fresno Dam. Table 6-8 lists the six stations used for the remainder of this analysis along with some pertinent information including the MAP.

Table 6-8.—Rainfall data description

Selected Rainfall Stations with a Period of Record Including 1950-2000 Used with Fresno Dam GRADEX Study for high return period volumes Fresno basin mean basin elevation = 3527 feet Fresno basin mean annual precip. = 13.1 inches					
Station	**State/Prov.**	**Latitude**	**Longitude**	**Elevation (feet)**	**M.A.P. (inches)**
Babb	MT	48.93	113.36	4300	18.27
Gold Butte	MT	48.98	111.4	3498	13.38
Kremlin	MT	48.52	110.1	2860	11.56
Simpson	MT	49	110.22	2815	10.24
Sweetgrass	MT	49	111.97	3466	13.98
Foremost	ALB	49.48	111.45	2899	14.68

Using the 5-day precipitation totals, 5-day flow volumes, drainage area, and other data described above, the GRADEX Method computations were made as outlined in Naghettini (1994) and Naghettini et al. (1996). For this study, a special situation arises with respect to selection of the contributing drainage area above Fresno Dam.

Based on all previous Reclamation IDF and PMF studies for Fresno Dam, the authors of this study believe that a single-storm precipitation pattern will not cover the entire basin. For this GRADEX study, a total contributing drainage area of 1,100 mi^2 was selected, based primarily on the use of the hypothetical elliptical patterns used with the PMP studies.

Table 6-9 and figure 6-12 display the summary results from the calculations for Fresno Dam. The volume of the PMF volume centered hydrograph from the 1985 Reclamation PMF study is plotted as a straight line on the frequency curve for comparison. It should be noted that the PMF is based on a 3-day rainfall, and the Fresno Dam frequency curve is based on 5-day total rainfall amounts. The GRADEX Method is intended to give flood volume data for very large return periods, in excess of 200 years. More common methods, such as a LP-III distribution fit to available streamflow data, should be used for the lower return periods, 100 years and less in this study.

Table 6-9.—Five-day volume frequency curve for Fresno Dam, Montana, based on GRADEX Method

Return Period (years)	Five-day Volume (acre-ft)	Upper Bound (acre-ft)	Lower Bound (acre-ft)
500	188,700	320,100	112,400
1,000	214,700	358,700	131,100
5,000	275,100	448,200	174,700
10,000	301,100	486,800	193,500
20,000	327,100	525,400	212,300
50,000	361,600	576,400	237,200
100,000	387,600	615,000	256,000
500,000	448,000	704,600	299,600
1,000,000	474,100	743,100	318,500

In most normal years, snowmelt may contribute a large amount to the total volume of inflows to Fresno Reservoir. Another assumption in the GRADEX Method is that the precipitation that is measured at the gages is in liquid form and ready for runoff, or if it is snow, the snow will melt during the critical storm-time period and add to the runoff volume. A simple scheme to separate purely snowmelt runoff from rain or rain-on-snow runoff was used with the 86 years of daily flows at the Milk River at Eastern U.S. Border Crossing gage. The 7-day maximum of purely snowmelt flow was then determined for each year and expressed as a constant flow for 7 days. The 86-year-long series of 7-day maximum snowmelt flows at the gage site was then analyzed using a standard LP-III analysis. The lower curve in figure 6-13 displays the frequency curve of maximum 7-day purely snowmelt flows. The curve is quite flat. This is expected for purely snowmelt driven volumes. There is a physical limit to how much snow can be melted with normal ranges of climate variables. The snowmelt volume frequency curves will become quite flat for larger return periods. The 7-day flows were then converted to volumes in acre-feet and a similar frequency curve was also plotted in figure 6-13.

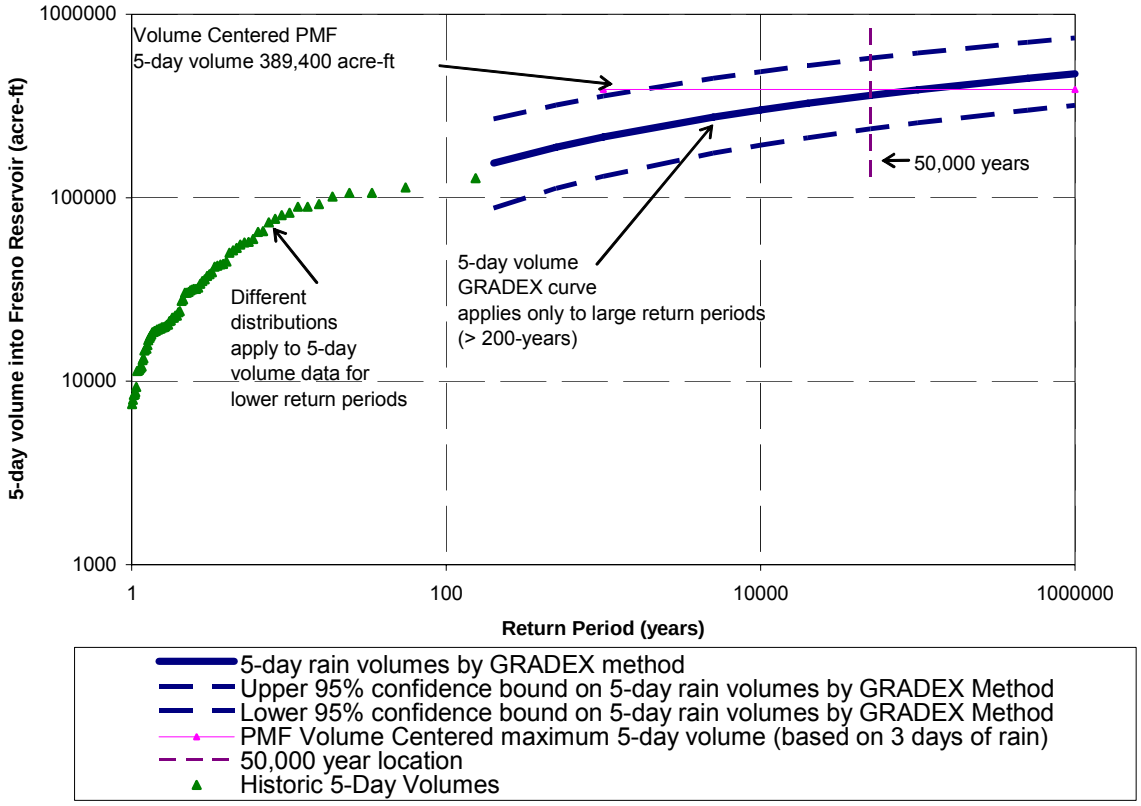


Figure 6-12.—Fresno Dam, Montana, 5-day rain-generated volumes by GRADEX Method.

The 5-day volumes of the GRADEX rain flood volumes from this study were then added to the plot. This is the blue curve near the top of figure 6-13. A combined probability curve was then computed and is shown as the red curve on the top of figure 6-13. The combined probability curve expresses the probability (or return period) of getting a particular total flood volume by combining a 7-day snowmelt with a 5-day rain flood volume. The combined probability curve very closely follows the 5-day rain flood volume curve for the large return periods.

Hourly inflow hydrographs were developed for Fresno Dam for the desired return periods by applying indexed rainfall amounts to the HEC-HMS models calibrated to the 1906 and 1964 rainfall flood events. The rainfall amounts for the 1964 and 1906 storm hyetographs were uniformly increased in each subbasin until the 5-day volume of the respective return periods, determined by the GRADEX Method, was achieved. Figure 6-14 displays the results for the 1964 flood computations. Figure 6-15 displays the results of increasing the 1964 precipitation amount to calculate hydrographs with the GRADEX volumes for specified return periods.

The peak versus volume relationship was developed using a LOWESS technique (Cleveland, 1979). The 86 years of peak and 5-day volume data from the USGS gage at the Milk River at Eastern Border were plotted. In addition, the 30 peak-flow and 5-day volumes generated from

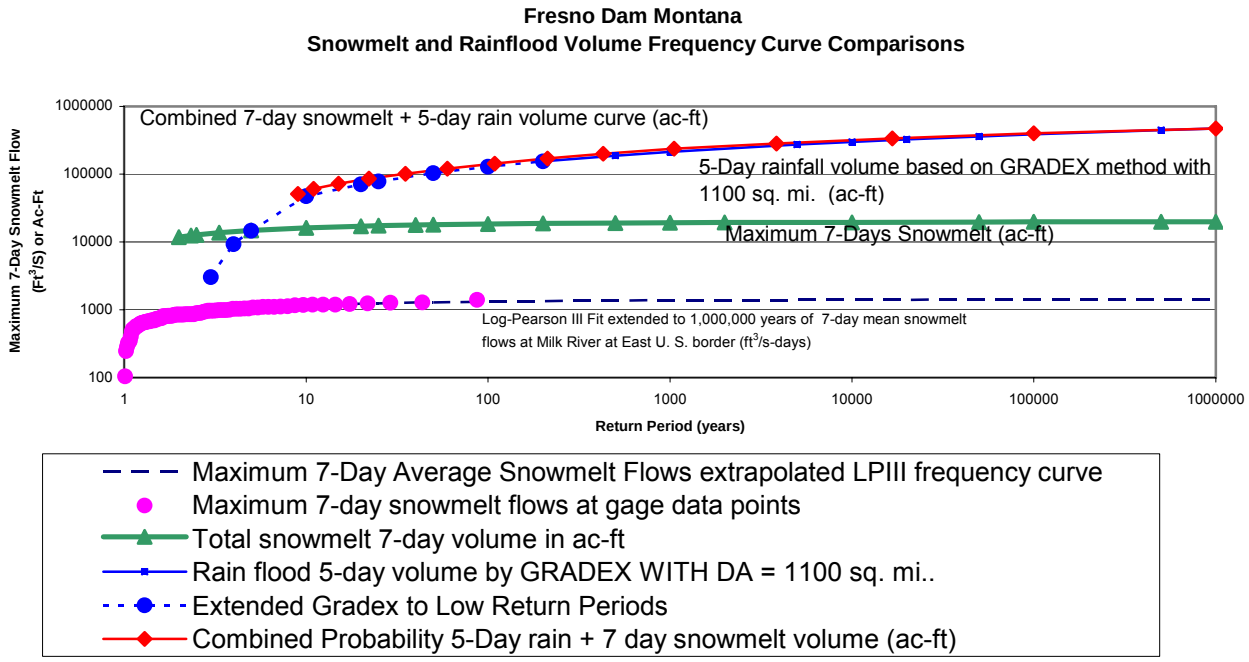


Figure 6-13.—Fresno Dam, Montana, snowmelt and rainflood volume frequency curve comparisons.

the HEC-HMS models originally calibrated to both the 1906 and 1964 flood events were run. In each run, the lag time was varied or the rainfall was increased in a systematic manner to cover a range of possible values for greater storm events. A LOWESS fit was done using the entire set of peak versus volume points and is shown in figure 6-16. This relationship was used to determine the peak discharge estimates that correspond to the selected 5-day return period volumes computed using the GRADEX Method.

The results of this calculation can be used to derive a peak-flow flood frequency curve. The information for the peak flow and volumes for the return periods of interest in this study is summarized in table 6-10. In this study, the reported paleohydrology information indicated a non-exceedance peak flood bound with an age between 2,000 and 4,000 years and a magnitude between 40,000 and 70,000 ft^3/s. The paleohydrology information was in agreement with the GRADEX results.

For Fresno Dam, the results of the GRADEX Method were used for the risk assessment because flood volumes were needed to evaluate the safety of the dam. Since only peak flow data were available at the time of the first analysis, the GRADEX study was conducted. Hydrographs could then be routed through the reservoir to take advantage of the flood attenuation effects of the large surcharge storage in the reservoir.

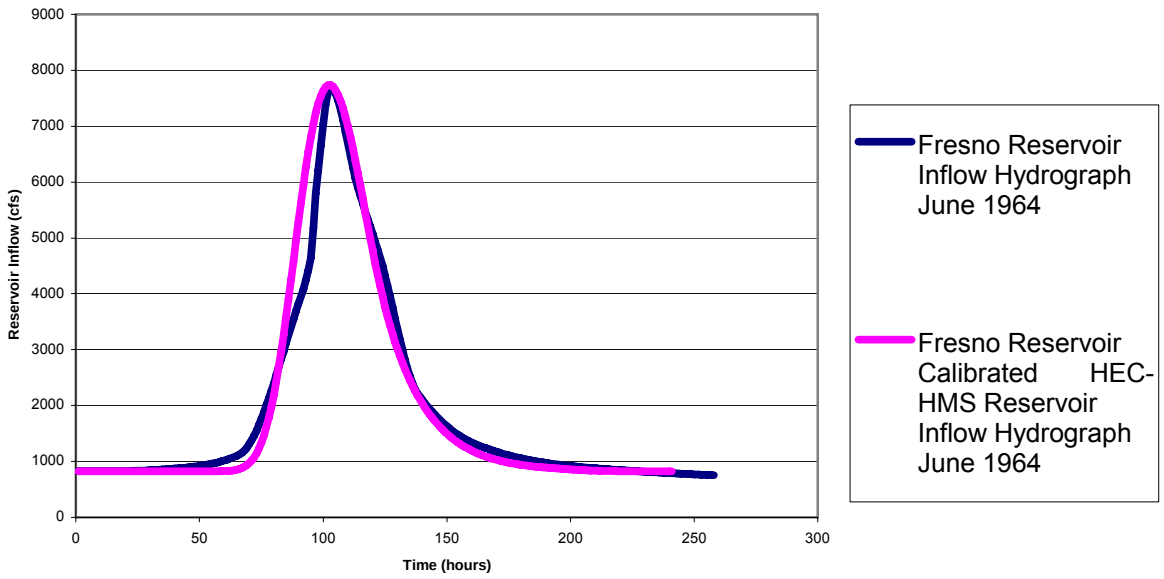


Figure 6-14.—Comparison of gage record and HEC-HMS calibration run.

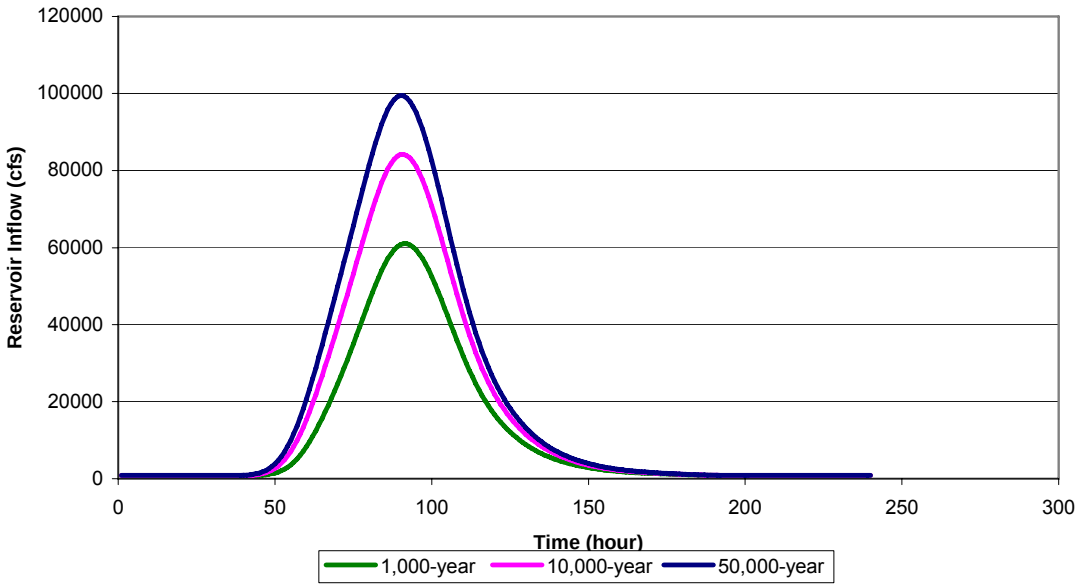


Figure 6-15.—Fresno Dam, Montana, 1,000-, 10,000-, and 50,000-year hydrographs. Hydrographs from 1964 precipitation pattern with volume from GRADEX Method.

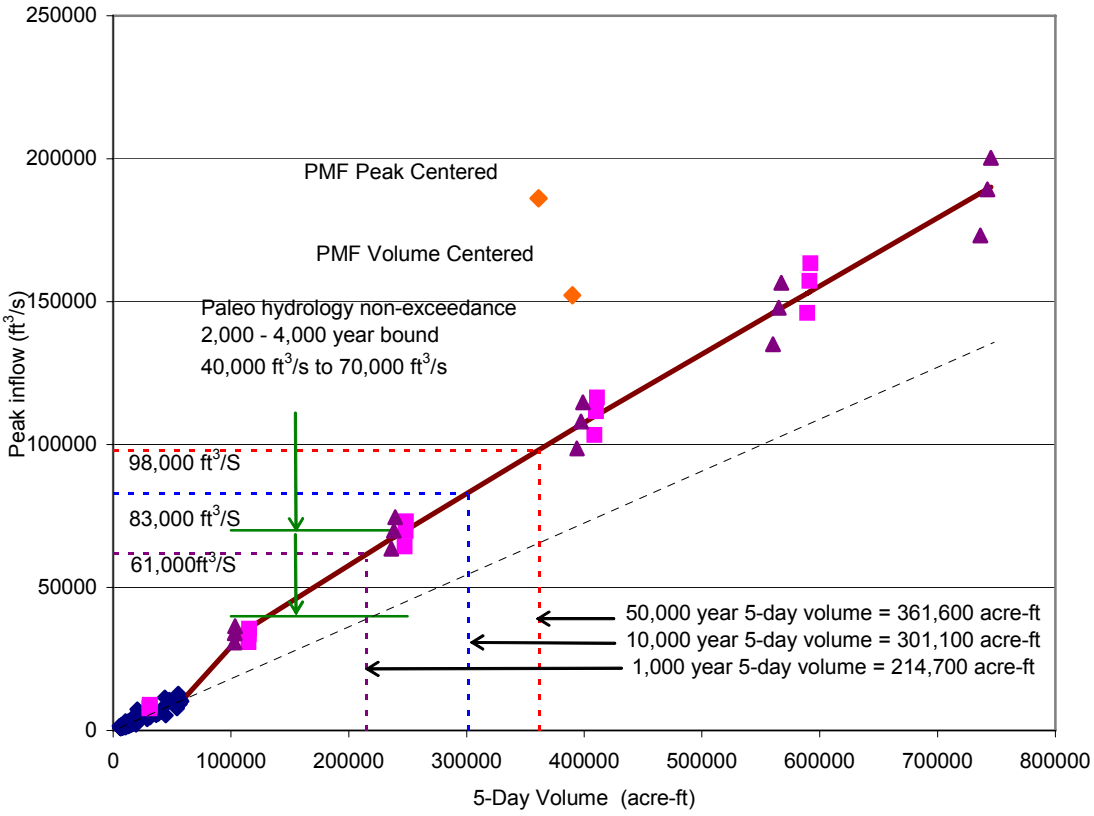


Figure 6-16.—Fresno Dam, Montana, 5-day volumes versus peaks.

Table 6-10.—Fresno Dam, Montana, GRADEX Method results

Return Period (year)	Peak Inflow (cfs)	5-Day Volume (acre-ft)
1,000	61,000	214,700
10,000	83,000	301,100
50,000	98,000	361,600

7. Summary

This report summarizes Reclamation's approach toward developing hydrologic hazard curves for use in evaluating dam safety issues. The procedure relies on extracting information from existing studies to the fullest extent possible. The characterization of hydrologic risk for a CFR can usually be accomplished with minimal effort. CFR hydrologic hazard curves display peak

flow and volume relationships for a full range of Annual Exceedance Probabilities necessary for decision making. The procedures and analysis techniques defined in this report allow for the possibility, and even plausibility, that peak discharge and volume estimates may exceed the PMF. This is a function of the uncertainty and inconsistency among and between analysis techniques. Therefore, in these cases, the PMF is believed to represent the upper limit to hydrologic risk.

The procedure for developing hydrologic hazard curves considers the dam safety decision criteria, potential dam failure mode, and dam characteristics, available hydrologic data, possible analysis techniques, resources available for analysis, and tolerable level of uncertainty. Dam safety decision criteria determine the probabilistic range of floods needed to address hydrologic issues (Bureau of Reclamation, 2003a). The potential dam failure mode and dam characteristics impact the type of hydrologic information needed to assess the problem. The specific elements selected to be incorporated in an analysis of hydrologic hazards should consider the tolerable level of uncertainty. Reducing the uncertainty in the estimates may require additional data collection and use of more sophisticated solution techniques. It is believed that increasing the level of effort and the sophistication of analysis techniques increases the reliability and level of confidence associated with the results.

Reclamation currently uses a combination of seven hydrologic methods to develop hydrologic hazard curves. These general techniques include: flood frequency analysis with historical and paleoflood data, hydrograph scaling and volumes, the GRADEX Method, the Australian Rainfall-Runoff Method, stochastic event-based precipitation runoff modeling with the SEFM, stochastic rainfall-runoff modeling with CASC2D, and the PMF. Each method is described within these guidelines.

The hydrologic methods described in these guidelines are not all inclusive. New techniques for developing hydrologic hazard information can be added to these guidelines as they are developed by the hydrology community.

The amount of effort expended on analyzing a hydrologic hazard depends on the nature of the problem and the potential cost of the solution. A staged approach toward evaluating a hydrologic safety issue is recommended. Initially, very little effort is expended to determine the magnitude of the hydrologic hazard. Reclamation attempts to make use of all available studies for the site of interest. Often, the PMF and initial flood frequency studies are the only hydrologic studies available before the start of a probabilistic investigation. When other hydrologic studies have been performed, available data will be used to decrease uncertainty in results as well as to provide an overall assessment of hydrologic risk.

Dam safety evaluations usually begin with a characterization of hydrologic risk. If detailed studies have been conducted for the site of interest, they are summarized and presented to the risk assessment team. About two-thirds of Reclamation’s dams can safely accommodate the PMF; when the PMF is selected as the IDF, no additional work may be required unless other hydraulic issues need evaluation. Additional hydrologic work begins with a flood frequency analysis and hydrograph scaling to develop a peak-discharge relationship and frequency flood hydrographs. It is believed that this type of information is sufficient to address hydrologic issues and make dam safety decisions at about 80 percent of the remaining dams. For the sites that still

have potential safety problems, project plans can be developed for studies to address the specific hydrologic issues. These studies require more work and more sophisticated solution techniques than flood frequency analysis and hydrograph scaling.

When planning more detailed studies, it is recommended that the goal be to achieve a balance between the amount of hydrologic analysis needed to address the issues and the level of effort required to conduct the study. As the studies get more detailed, the results should become more precise and contain less uncertainty. An example is a hydrologic study that proceeds from flood frequency analysis and hydrograph scaling to an analysis using the GRADEX Method, the Australian Rainfall-Runoff Method, a stochastic rainfall-runoff model, or any other statistical estimation technique available.

When multiple methods are used, alternative hazard curves are developed by weighting results from the individual analyses. A team of hydrologists evaluates the alternatives and selects a weighting scheme that is most representative of the site for use in the risk assessment. Selection of the final hydrologic hazard curve depends on the experience of the hydrologists and the assumptions that went into each analysis.

Three case studies, Los Banos, Fresno, and A.R. Bowman Dams, have been presented to illustrate the variety of methods available. These sites were chosen to demonstrate the use of the various techniques for characterization of the flood hazard. The A.R. Bowman example shows how multiple studies were combined into a single-flood hazard curve for use in risk assessment.

8. Bibliography

Ang, A.H.S. and W.H. Tang. 1975. *Probability concepts in engineering planning and design*, vol. 1. Basic Principles, John Wiley, New York, 409 p.

Argonne National Laboratory. August 1980. *User guide for Minpack-1*.

Australian Rainfall and Runoff (ARR). 2001. *A guide to flood estimation* (in eight books), vol. 1. The Institution of Engineers, Australia.

Baker, V.R. 1987. Paleoflood hydrology and extraordinary flood events, *J. Hydrol*., 96, 79-99.

_____. 2000. Paleoflood hydrology and the estimation of extreme floods, in *Inland flood hazards - human, riparian and aquatic communities*, edited by E.E. Wohl, Cambridge University Press, Cambridge, U.K., pp. 359-377.

Baker, V.R., R.C. Kochel, and P.C. Patton (Eds.). 1988. *Flood geomorphology*, John Wiley, New York, 503 pp.

Barker, B., M.G. Schaefer, J. Mumford, and R. Swain. 1996. A Monte Carlo approach to determine the variability of PMF estimates, in *Proceedings of the 13th Annual Association*

of State Dam Safety Officials Conference, September 8-11, 1996, Seattle, Washington, pp. 107-122.

_____. 1997. Part I: *A Monte Carlo approach to determine the variability of PMF estimates*; Part II: *Monte-Carlo simulation using variable precipitation volume and temporal distribution, Bumping Lake Basin flood frequency estimate*, Bureau of Reclamation, 24 p.

Beard, L.R. 1990. Practical determination of hypothetical floods. *ASCE J. Water Resources Planning and Management* 116(3). pp. 389-401.

Bras, R.L. 1990. An Introduction to Hydrologic Science. *Hydrology*. Addison-Wesley, Reading, Massachusetts, 643 p.

Bullard, K.L., and M.G. Schaefer. June 1999. Stochastic modeling of extreme floods, Cle Elum Dam, Washington. Draft Report, Flood Hydrology Group, Bureau of Reclamation, 54 p.

Bureau of Reclamation. 1960. *Design of small dams*, 1st ed.

_____. 1977. *Design of small dams*, 2nd ed.

_____. 1987. *Design of small dams*, 3rd ed.

_____. 1990. *Flood hydrograph and routing system (FHAR) computer model version 4.14*, Technical Service Center, Denver, Colorado.

_____. 1993. Bureau of Reclamation Dam Safety Program Training.

_____. 1996a. Memo to Regional Director, Sacramento, California, from Thomas A. Pick, Hydraulic Engineer, Technical Service Center, Flood Hydrology Group, Subject: Probable Maximum Flood Study for Los Banos Dam, California.

_____. 1996b. Technical Memorandum No. LOB-D8110-CAS-TM-96-1. Subject: Flood Routings for 1996 Los Banos Dam, California.

_____. 1998. *Reclamation Manual*. Directives and Standards FAC 01-07, Bureau of Reclamation, Denver, Colorado.

_____. 1999. *A framework for characterizing extreme floods for dam safety risk assessment*. Prepared by Utah State University and Bureau of Reclamation, Denver, Colorado, 67 p.

_____. 2002a. *Flood hazard analysis* - Folsom Dam, Central Valley Project, California. Bureau of Reclamation, Denver, Colorado, 128 p. and 4 appendices.

_____. 2002b. *Interim guidance for addressing the risk of extreme hydrologic events*. Dam Safety Office and Technical Service Center, Bureau of Reclamation, Denver, Colorado, 3 p.

_____. 2003a. *Guidelines for achieving public protection in dam safety decisionmaking*. U.S. Department of Interior, Denver, Colorado. 19 p.

_____. 2003b. *Safety of Dams Project Management Guidelines.* Bureau of Reclamation, Denver, Colorado.

Carson, Rod. January 1989. *PC computer program No. 1, flood flow frequency analysis (FREQY), users manual*. Flood Section, Bureau of Reclamation, Denver Office, 9 p. and 1 appendix.

Chow, V.T., D.R. Maidment, and L.W. Mays. 1988. *Applied Hydrology*. McGraw-Hill, New York, 572 p.

Cleveland, W.S.. 1979. Robust locally weighted regression and smoothing scatterplots, *Journal of American Statistical Association,* 74(368), 829-836.

Cohn, T.A., W.L Lane, and W.G. Baier. 1997. An algorithm for computing moments-based flood quantile estimates when historical information is available, *Water Resources Research*, 33(9), 2089-2096.

Cohn, T.A., W.L. Lane, and J.R. Stedinger. 2001. Confidence intervals for expected moments algorithm flood quantile estimates, *Water Resources Research*, 37(6), 1695-1706.

Costa, J.E. 1978. Holocene stratigraphy in flood frequency analysis, *Water Resources Research*, 14(4), 626-632.

Cudworth, A.G. 1989. *Flood hydrology manual*. A water resources technical publication. Bureau of Reclamation, Denver, Colorado, 243 p.

Dawdy, D.R., J.C. Schaake, and W.M. Alley. 1978. *Distributed routing rainfall-runoff model*. U.S. Geological Survey Water Resource-Investigations Report 78-90.

DeVries, J.J. and T.V. Hromadka. 1993. Computer models for surface water, chapter 21 in *Handbook of Hydrology*, Maidment, D.R. (ed.), McGraw-Hill, New York, pp. 21.1-21.39.

Eagleson, P.S. 1972. Dynamics of Flood Frequency. *Water Resources Research* 8(4), 878-898.

England, J.F. Jr. 1998. Assessment of historical and paleohydrologic information in flood frequency analysis, 292 p., M.S. Thesis, Colorado State University, Fort Collins, Colorado.

_____. 1999. Draft user's manual for program EMA, at-site flood frequency analysis with historical/paleohydrologic data. Bureau of Reclamation, Denver, Colorado, 52 p.

_____. February 2000. *Instructions for using the LNFFA computer program to compute preliminary flood frequency curves for comprehensive facility reviews*. Flood Hydrology Group, Bureau of Reclamation, 5 p.

_____. August 2000. *Preliminary hydrologic loadings for risk assessment*, Rifle Gap Dam, Colorado, Bureau of Reclamation, Denver, Colorado, 9 p. and appendices.

_____. January 2003a. *Probabilistic extreme flood hydrographs that use paleoflood data for dam safety applications*. Bureau of Reclamation, Denver, Colorado, 29 p.

_____. January 2003b. *Dam safety research final report, stochastic modeling methods, a summary of research completed in fiscal years 2000 through 2002*. Bureau of Reclamation, Denver, Colorado, 31 p. and appendices.

_____. April 2003. *Peak discharge frequency analysis for spillway risk analysis*, Pathfinder Dam, North Platte Project, Wyoming. Bureau of Reclamation, Denver, Colorado, 16 p. and appendices.

England, J.F. Jr., R.E. Klinger, M. Camrud, and J.E. Klawon. September 2001. *Guidelines for preparing preliminary flood frequency analysis reports for comprehensive facility reviews*. Version 1.0. Bureau of Reclamation, Denver, Colorado, 16 p. and appendices.

England, J.F. Jr., J.D. Salas, and R.D. Jarrett. 2003. Comparisons of two moments-based estimators that utilize historical and paleoflood data for the log-Pearson Type III distribution, *Water Resources Research*, 39(9), p. 1243, doi:10.1029/2002WR001791.

_____. 2003b. Data-based comparisons of moments estimators that use historical and paleoflood data. *J. Hydrology*, 278 (1-4), pp. 170-194.

Environment Canada. 2002. *Canadian Daily Climate Data, Temperature, and Precipitation – Western Canada*, CD data disk.

Fanok, S.F., and E.E. Wohl. 1997. Assessing the accuracy of paleohydrologic indicators, Harpers Ferry, West Virginia, *J. Amer. Water Resour. Assoc*., 33(5), 1091-1102.

French Committee on Large Dams. No date. *Small dams – Guidelines for design, construction and monitoring*, (Internet version).

Griffis, V.W., J.R. Stedinger, and T.A. Cohn. 2003. *Extension of EMA to address regional skew and low outliers*. Paper presented at American Society of Civil Engineers EWRI Conference, Philadelphia, Pennsylvania, 10 p.

Gulliot, P. 1993. The arguments of the GRADEX method: a logical support to assess extreme floods. In *Extreme hydrological events: Precipitation, floods, and droughts proceedings of Yokohama symposium*, I.A.S.H. Publication 213, 287-298.

Gulliot, P., and D. Duband. 1967. La methode du GRADEX pour le calcul de la probabilite des crues a partir des pluies. In *Floods and their computation – Proceedings of the Leningrad symposium*, IASH Publication, 84, 560-569.

Hosking, J.R.M. and J.R. Wallis. 1997. *Regional frequency analysis - An approach based on L-moments*. Cambridge University Press, 224 p.

House, P.K., R.H. Webb, V.R. Baker, and D.R. Levish, eds. 2002. *Ancient floods, modern hazards: Principles and applications of paleoflood hydrology*, Water Sci. and Appl. Ser., vol. 5, 386 p., AGU, Washington, D.C.

Hupp, C.R. 1987. Botanical evidence of floods and paleoflood history. In *Regional flood frequency analysis*, edited by V.P. Singh, pp. 355-369, D. Reidel.

_____. 1988. Plant ecological aspects of flood geomorphology and paleoflood history. In *Flood geomorphology*, edited by V.R. Baker, R.C. Kochel, and P.C. Patton, pp. 335-356, John Wiley, New York.

Hydrologic Engineering Center. 1990. *HEC-1 flood hydrograph package, user's manual*. U.S. Army Corps of Engineers, Davis, California, 283 p.

Hydrosphere Corporation. 2002. *CLIMATEDATA*, vol. 13-3, NCDC Summary of the Day.

Institute of Hydrology. 1999. *Flood estimation handbook (FEH) - Procedures for flood frequency estimation.* (In five volumes.) Institute of Hydrology, Wallingford, Oxfordshire, United Kingdom.

Interagency Advisory Committee on Water Data (IACWD). March 1982. *Guidelines for determining flood flow frequency*. U.S. Interagency Advisory Committee on Water Data, Hydrology Subcommittee, Bulletin 17-B (revised and corrected), with editorial corrections, 28 p. and appendices.

Jarrett, R.D. 1991. *Paleohydrology and its value in analyzing floods and droughts*. U.S. Geological Survey Water-Supply Pap. 2375, pp. 105-116.

Jarrett, R.D., and J.E. Costa. 1988. *Evaluation of the flood hydrology in the Colorado Front Range using precipitation, streamflow, and paleoflood data for the Big Thompson River Basin*. U.S. Geological Survey Water-Resources Invest. Rep. 87-4117, 37 p.

Jarrett, R.D., and J.F. England, Jr. 2002. Reliability of paleostage indicators for paleoflood studies. In *Ancient floods, modern hazards: Principles and applications of paleoflood hydrology*. Water Sci. and Appl. Ser., vol. 5, edited by P.K. House et al., pp. 91-109, AGU, Washington, D.C.

Julien, P.Y. and B. Saghafian. 1991. *CASC2D users manual - A two dimensional watershed rainfall-runoff model*. Civil Eng. Report CER90-91PYJ-BS-12, Colorado State University, Fort Collins, Colorado.

Julien, P.Y., B. Saghafian, and F.L. Ogden. 1995. *Raster-Based hydrologic modeling of spatially-varied surface runoff*. Water Resources Bulletin, AWRA, 31(3), 523-536.

Kochel, R.C., and D.F. Ritter. 1987. *Implications of flume experiments for the interpretation of slackwater paleoflood deposits, in regional flood frequency Analysis*, edited by V.P. Singh, pp. 371-390. D. Reidel.

Kuczera, G. December 2000. *Review of Extreme Flood Risk.* Department of Civil, Surveying and Environmental Engineering, University of Newcastle, on behalf of TUNRA, University of Newcastle, Callaghan, NSW, 2308, Australia, for Probabilistic Flood Hazard Cadre, Bureau of Reclamation, 45 p.

Lane, W.L. 1995. Method of moments approach to historical data, informal handout, Bulletin 17B Working Group, Hydrology Subcommittee, Interagency Advisory Committee on Water Data, 2 p.

_____. September 1997. *Extreme precipitation in the 17 Western States: A space for time statistical study - frequency analysis of daily extreme precipitation*; Bureau of Reclamation, 21 p. and 3 appendices.

Lane, W.L., and T.A. Cohn. 1996. Expected moments algorithm for flood frequency analysis. In *N. Am. Water and Environ. Cong*., edited by C.T. Bathala, Amer. Soc. Civ. Eng., Anaheim, California.

Laurenson, E.M. and R.G. Mein. 1995. RORB: Hydrograph Synthesis by Runoff Routing. In *Computer Models of Watershed Hydrology*, edited by V.P. Singh, Water Resources Publications, Highlands Ranch, Colorado, pp. 151-164.

Leavesley, G.H., R.W. Lichty, B.M. Troutman, and L.G. Saindon. 1983. *Precipitation-runoff modeling system—User's manual*. U.S. Geological Survey Water Resource-Investigations Report 83-4238.

Leese, M.N. 1973. Use of censored data in the estimation of gumbel distribution parameters for annual maximum flood series, *Water Resources Research*, 9(6), 1534-1542.

Levish, D.R. 2002. Paleohydrologic Bounds—Non-exceedance information for flood hazard assessment. In *Ancient floods, modern hazards: Principles and applications of paleoflood hydrology*, Water Sci. and Appl. Ser., vol. 5, edited by P.K. House et al., pp. 175-190, AGU, Washington, D.C.

Levish, D.R., J.F. England, Jr., J.E. Klawon, and D.R.H. O'Connell. November 2003. *Flood hazard analysis for Seminoe and Glendo Dams, Kendrick Project and Pick-Sloan Missouri Basin Program, Wyoming*, Final Report, Bureau of Reclamation, Denver, Colorado, 126 p. and appendices.

Levish, D.R. and D.A. Ostenaa. 1996. Applied paleoflood hydrology in north-central Oregon. *Guidebook for Field Trip 2, April 19-21, 1996, Cordilleran Section 92nd Annual Meeting.* Geological Society of America, Portland, Oregon, Seismotectonics Report 96-7, Bureau of Reclamation Denver, Colorado, 182 p.

Levish, D.R., D.A. Ostenaa, and D.R.H. O'Connell. 1994. A non-inundation approach to paleoflood hydrology for the event-based assessment of extreme flood hazards. In *Proc. of the Assoc. of State Dam Safety Off. Annual Conf.*, pp. 69-82, Boston, Massachusetts.

Maidment, D.R. 1993. *Handbook of hydrology*, edited by D.R. Maidment, McGraw-Hill, New York.

MGS Engineering Consultants, Inc. (MGS). March 2001. *General storm stochastic event flood model (SEFM) - technical support manual*, prepared for the Bureau of Reclamation, Flood Hydrology Group.

_____. April 2001. *General storm stochastic event flood model (SEFM) – computer program*, prepared for the Bureau of Reclamation, Flood Hydrology Group, libraries and spreadsheets on CDs.

_____. January 2001. *Sensitivity analysis of input parameters for stochastic flood modeling at A.R. Bowman Dam*, Appendix C. Prepared for Bureau of Reclamation, Flood Hydrology Group, 41 p.

Naghettini, M.D.C. 1994. Methodology for Estimating the Upper Tail of Flood-Peak Frequency Distributions using Hydrometeorolocial Information. Ph.D. Dissertation at the University of Colorado, Department of Civil, Environmental, and Architectural Engineering.

Naghettini, M.D.C., K.W. Potter, and Tissa Illangasekare. June 1996. *Estimating the upper tail of flood-peak frequency distributions using hydrometeorological information*, Water Resources Research, vol. 32, No. 6., pp. 1729-1740.

Nathan R.J., and D.S. Bowles. November 1997. A probability-neutral approach to the estimation of design snowmelt floods. *Conference proceedings, 24th hydrology and water resources symposium*, Auckland, New Zealand.

Nathan, R.J. and P.E. Weinmann. 2001. Estimation of Large to Extreme Floods: Book VI. In *Australian rainfall and runoff, a guide to flood estimation*, the Institution of Engineers, Australia.

National Oceanic and Atmospheric Administration. 1982. *Application of probable maximum precipitation estimates – United States east of the 105th meridian*, NOAA Hydrometeorological Report No. 52. U.S. Army Corps of Engineers.

National Research Council (NRC). 1988. *Estimating probabilities of extreme floods*, National Academy Press, Washington, D.C.

National Research Council. 1988. *Safety of dams flood and earthquake criteria*, National Academy Press.

_____. 1999. *Improving american river flood frequency analysis*, National Academy Press, Washington, D.C., 120 p.

Natural Environment Research Council (NERC). 1975. *Flood Studies report*, vol. 4, hydrological data, Whitefriars Press, London, 541 p.

Norval, M., and R.E. Klinger. 1999. *Fresno Dam, Montana, preliminary hydrologic loading for performance parameter*; Technical Memorandum, Bureau of Reclamation, 12 p.

O'Connell, D.R.H. February 24, 1999. *FLDFRQ3: Three-parameter maximum likelihood flood-frequency estimation with optional probability regions using parameter grid integration*. User's Guide (Release 1.1), Bureau of Reclamation, Denver, Colorado, 19 p.

O'Connell, D.R.H., D.A. Ostenaa, D.R. Levish, and R.E. Klinger. 2002. *Bayesian flood frequency analysis with paleohydrologic bound data*. Water Resources Research, 38(5), DOI 10.1029/2000WR000028, 14 p.

Ogden, F.L., and P.Y. Julien. 2002. CASC2D: A two-dimensional, physically based, hortonian hydrologic model,chapter 4. In *Mathematical models of small watershed hydrology and applications*, edited by V.P. Singh and D. Frevert. Water Resources Publications, Littleton, Colorado, pp. 69-112.

Pilgrim, D.H., and I. Cordery. 1993. *Flood runoff*, chapter 9. In *Handbook of hydrology*, edited by D.R. Maidment, McGraw-Hill, New York, pp. 9.1-9.42.

Ramirez, J.A. 2000. *Derived distribution approach – summary notes, CE522 engineering hydrology*. Department of Civil Engineering, Colorado State University, Fort Collins, Colorado.

Ries, K.G., III, and M.Y. Crouse. 2002. *The national flood frequency program, version 3: A computer program for estimating magnitude and frequency of floods for ungaged sites*, U.S. Geological Survey Water-Resources Investigations Report 02-4168, 42p.

Russell, S.O. 1982. Flood probability estimation, *J. Hydraul. Div.*, ASCE, 108(HY1), 63-73.

Salas, J.D., E.E. Wohl, and R.D. Jarrett. 1994. Determination of flood characteristics using systematic, historical and paleoflood data. In *Coping with floods*, edited by G. Rossi, N. Harmancioglu, and V. Yevjevich, Kluwer Acad. Publ., Netherlands, pp. 111-134.

Schaefer, M.G., and B.L. Barker. November 1997. *Stochastic Modeling of extreme floods for A.R. Bowman Dam*. MGS Engineering Consultants, Inc., Lacey, Washington, 79 p.

_____. October 1998. *Assessment of risk reduction measures at A.R. Bowman Dam using a stochastic model of extreme floods*. MGS Engineering Consultants, Inc., Lacey, Washington, 21 p.

_____. September 1999. *Stochastic modeling of extreme floods for Keechelus Dam*. MGS Engineering Consultants, Inc., Olympia, Washington, 29 p.

_____. 2002. Stochastic Event Flood Model. In *Mathematical models of small watershed hydrology and applications*, chapter 20, edited by V.P. Singh and D. Frevert, Water Resources Publications, Littleton, Colorado, pp. 707-748.

Schamach, S. ,and J. Simpson. 1966. *Revised design storm for Fresno Dam, Montana*, Bureau of Reclamation, Denver Office.

Sigafoos, R.S. 1964. *Botanical evidence of floods and flood-plain deposition*, U.S. Geological Survey Prof. Paper 485-A, 35 p.

Singh, V.P. 1995. *Computer models of watershed hydrology*. Water Resources Publications, Littleton, Colorado, 1130 p.

_____. July 2, 1999. *SEFM and its application to Cle Elum Dam and A.R. Bowman Dam*. Review by V.P. Singh, Arthur K. Barton Endowed Professor, Louisiana State University, 7 p.

Smith, J.A. 1989. Regional flood frequency analysis using extreme order statistics of the annual peak record, *Water Resources Research*, 25(2), 311-317.

Stedinger, J.R., and V.R. Baker. 1987. Surface water hydrology: historical and paleoflood information, *Rev. Geophys*., 25(2), 119-124.

Stedinger, J.R., and T.A. Cohn. 1986. Flood frequency analysis with historical and paleoflood information, *Water Resources Research*, 22(5), 273-286.

Stedinger, J.R., R. Surani, and R. Therivel. 1988. Max user's guide: A program for flood frequency analysis using systematic-record, historical, botanical, physical paleohydrologic and regional hydrologic information using maximum-likelihood techniques, Dept. Environ. Eng., Cornell Univ., Ithaca, New York, 51 p.

Stedinger, J.R., R.M. Vogel, and E. Foufoula-Georgiou. 1993. Frequency analysis of extreme events. In *Handbook of hydrology*, edited by D.R. Maidment, McGraw-Hill, New York, pp. 18.1-18.66.

Sutcliffe, J.V. 1987. The use of historical records in flood frequency analysis, *J. Hydrol*., 96, 159-171.

Swain, R.E., J.F. England, K.L. Bullard, and D.A. Raff. 2004. *Hydrologic Hazard Curve Estimating Procedures*, DSO-04-08, Bureau of Reclamation, Denver, Colorado, 79 p.

Tarantola, A. 1987. *Inverse problems theory: Methods for data fitting and model parameter estimation*, Elsevier, NewYork, 613 p.

Thomson, M.T., W.B. Gannon, M.P. Thomas, and G.S. Hayes. 1964. *Historical floods in New England*. U.S. Geological Survey Water-Supply Paper 1779-M, 105 p.

U.S. Army Corps of Engineers. 2002. HEC-HMS version 2.2.1, Rainfall-runoff modeling package, Davis California.

U.S. Geological Survey Water-Supply Paper 1779-M. No date. New England, 105 p.

U.S. National Weather Service (1943-1997). National Oceanic and Atmospheric Administration Hydrometeorological Reports 1-59. (A series of PMP studies for various drainages and regions. Many were not published, and many are now out of print.)

Weghorst, K.M. and R.E. Klinger. January 2002. *Preliminary Hydrologic Loadings for Los Banos and Little Panoche Dams, California*. Flood Hydrology Group, Bureau of Reclamation, Denver, Colorado, 17 p. and appendices.

Wickenberg, D.F. 1985. *Fresno Dam Probable Maximum Flood*; Bureau of Reclamation, Great Plains Regional Office.

Wohl, E.E. and Y. Enzel. 1995. *Data for palaeohydrology, in Global Continental Palaeohydrology*, edited by K.J. Gregory, L. Starkel, and V.R. Baker, John Wiley, New York, pp. 23-59.

Yanosky, T.M. 1983. *Evidence of floods on the Potomac River from anatomical abnormalities in the wood of flood-plain trees*, U.S. Geological Survey Prof. Paper 196, 42 p.

Yanosky, T.M., and R.D. Jarrett. 2002. Dendrochronologic evidence for the frequency and magnitude of paleofloods. In *Ancient Floods, Modern Hazards: Principles and Applications of Paleoflood Hydrology*. Water Sci. and Appl. Ser., vol. 5, edited by P.K. House et al., AGU, Washington, D.C., pp. 77-89.

A FRAMEWORK FOR CHARACTERIZATION OF EXTREME FLOODS FOR DAM SAFETY RISK ASSESSMENTS

Robert E. Swain[5], David Bowles[6], and Dean Ostenaa[7]

Abstract

Risk-based decisions require different types of information than standards-based decisions. Traditional sources of information used for estimating probabilities of extreme floods include gaged streamflow records, indirect discharge measurements, and precipitation records. Generally these data sources have records that are less than 100 years in length. This framework for flood characterization for risk assessments uses the length of the data record and other characteristics of the data to determine the credible extrapolation limits used in the flood frequency analysis. Because risk assessments require estimation of floods with annual exceedance probabilities of 1 in 10,000, or less, emphasis is placed on developing probabilistic estimates using regional hydrometeorological data and paleoflood information. The uncertainties associated with descriptions of flood flow exceedance probabilities are likely to be substantial and an important attribute to convey into the risk assessment.

No single approach is capable of providing estimates of extreme floods over the full range of annual exceedance probabilities required for risk assessment. Therefore, results from a number of approaches need to be combined to yield a composite flood characterization; this means several methods and sources of data are needed. The application of several independent methods applicable to the same range of annual exceedance probabilities will increase the credibility and resulting confidence in the results.

Introduction

The U.S. Bureau of Reclamation is now making extensive use of quantitative risk assessment in support of dam safety decision making (Von Thun and Smart, 1996). An important input to Dam Safety Risk Assessment is the development of probabilistic extreme flood estimates. This shifts the focus for dam safety flood evaluation from routing a single "maximum" event (i.e. the probable maximum flood, PMF) to consideration of the entire range of plausible inflow flood events, and ultimately to the magnitude-frequency relationship of maximum reservoir stages.

[5]Technical Specialist - Flood Hydrology, Bureau of Reclamation, P.O. Box 25007, Denver CO ; 80225-0007; E-mail-rswain@do.usbr.gov
[6]Professor of Civil and Environmental Engineering, Utah Water Research Laboratory, Utah State University, Logan UT 84322-8200; E-mail-dbowl@pub.uwrl.usu.edu
[7]Lead Geologist, Geophysics, Paleohydrology and Seismotectonics Group, D-8330, Bureau of Reclamation, P.O. Box 25007, Denver CO 80225-0007; E-mail-dostenaa@do.usbr.gov

For floods, the risk assessment process involves selecting a spillway evaluation flood (SEF) based on the probability of dam failure and the severity of the incremental consequences of dam failure. Past practice also examined consequences, but without formal consideration of probability of failure; if consequences were judged to be large, the SEF was chosen as the PMF.

Reclamation has identified the need for a review of its present procedures for developing probabilistic extreme flood estimates and their associated uncertainties for use in dam safety risk assessment. Where practical, Reclamation would like to develop improved procedures. The overall objective is to develop a practical, robust, consistent, and credible framework for developing probabilistic extreme flood estimates for Dam Safety Risk Assessment. The desired outcome is a robust framework in which components can be improved in the future as the state-of-the-art develops.

The framework was developed by inviting a group of approximately 20 professionals with extensive experience in the theoretical and practical aspects of physical, paleo-, and statistical flood hydrology and hydrometeorology to participate in a one-week workshop held at Utah State University in June 1997. Participants from North America, Australia, and the United Kingdom reviewed current Reclamation practice, and evaluated various advances in developing probabilistic extreme flood estimates for their potential role in the needed framework. A smaller group met in Denver to develop the details of the framework. This paper summarizes the findings of these groups.

Risk Assessment Stages

Present Reclamation risk assessment practice uses a staged approach for conducting risk assessments (USBR, 1997a). Project schedule and budget constraints are considered in determining the type of flood assessment prepared at each stage. While each risk assessment is unique, the following stages are generally used in Reclamation risk assessments:

a) **Screening Level Risk Assessment**: An evaluation of risk that includes definition of load probabilities and consequences for all load classes (flood, earthquake, and static). Structure failure probabilities and associated uncertainties are also considered in a global sense, but detailed event trees are not usually prepared. An emphasis at this stage is to maximize the use of available information, without conducting new analyses or collecting additional data. The intent is to identify areas where risks are potentially high and to determine the need for further evaluations and data collection. Results of these evaluations are used to determine Reclamation's risk profile and to "screen" out dam safety issues where additional funding and effort appears to have little potential for reducing dam safety risks.

b) **Scoping Level Risk Assessment**: A more detailed evaluation of risks is performed for the dam safety issues identified in a screening level risk assessment. This level of risk assessment typically involves more detailed treatment of event trees, load probabilities, structural response, and consequences. The intent is to invest sufficient effort so that the risk assessment team understands the major contributors to risk to enable formulation of risk reduction strategies and to determine the need for additional analyses and investigations.

c) **Decision Level Risk Assessment**: At this level, more detailed evaluation of risks is performed to provide decision makers with the information necessary to reach a dam safety decision for a structure. The decision may be related to continuing project operations, correcting dam safety deficiencies, selecting among risk reduction alternatives, or determining the need for interim actions to reduce risk while long term plans are developed. The intent is to provide decision makers with sufficient pertinent risk information such that the risk reduction objective can be effectively considered along with other Reclamation objectives. At this level of risk assessment, detailed loading information, structural response analyses, and consequence evaluations are developed for all significant issues. This type of risk assessment focuses on reducing uncertainties in the risk estimates and evaluating risk reduction actions.

Data Sources

The proposed framework for developing probabilistic extreme flood estimates for risk assessment uses the length of record and other characteristics of the data to determine the extrapolation limits for flood frequency analysis. Traditional sources of information used for flood hazard analyses include streamflow and precipitation records. Generally, these data sources have records that are less than 100 years in length, although in some cases these records can be extended to about 150 years using historical information. Regional precipitation and streamflow data can create pooled data sets from short periods of observation, and paleoflood data can extend records of floods to periods of up to several thousand years.

Streamflow Data

Many different types of streamflow information are used in developing probabilistic extreme flood estimates for risk assessment. Streamflow data are used in flood hazard assessment as input for frequency studies or as the basis for developing flood hydrographs. The usual source of these data is the streamflow records collected and maintained by the U.S. Geological Survey. However, similar data are collected and archived by many other Federal and State government agencies and some non-government organizations. Streamflow records consist of data collected at established gaging stations and indirect measurements of streamflow at other sites. Streamflow data can include estimates of peak discharge, as well as average or mean discharge for various time periods. Most streamflow measurements on U.S. streams began after 1900 with only a few records dating back that far. Most often, streamflow records at a single site range in length from about 20 to 60 years. Completeness of the data set may vary from station to station.

Climate Data

Precipitation and weather data used in hydrologic models can include rainfall, snowfall, snow water equivalent, temperature, solar radiation, and wind speed and direction from individual weather stations, as well as remote sensing information and radar information for broader regions. Data types available from various sources vary greatly in record length and quality throughout the United States. Some of these types of data (i.e., snowfall, snow water equivalent, solar radiation, and wind)

are limited to record lengths of less than about 30 years; basic rainfall and temperature data are available for some stations for up to 150 years, but in most cases are limited to less than 100 years.

Historical Data

Historical data can provide a means for extending the length of record for many types of data, in particular for observations of the most extreme events. These data are most commonly used to extend streamflow records of peak discharge prior to organized stream gaging. Historical observations can provide information for other types of data such as weather patterns and the frequency of extreme storm events, or changes in land use or vegetation that may be significant to runoff modeling calculations. However, as with any type of historical data, the accuracy and validity of the observations must be carefully assessed and compared to the other types of data used in the analysis.

Paleoflood Data

Paleoflood hydrology is the study of past or ancient flood events which occurred prior to the time of human observation or direct measurement by modern hydrological procedures (Baker, 1987). Unlike historical data, paleoflood data do not involve direct human observation of the flood events. Instead, the paleoflood investigator studies geomorphic and stratigraphic records (various indicators) of past floods, as well as the evidence of past floods and streamflow derived from historical, archeological, dendrochronologic, or other sources. The advantage of paleoflood data is that it is often possible to develop records that are 10 to 100 times longer than conventional or historical records from other data sources in the western United States. In addition, the paleoflood record is a long-term measure of the tendency of a river to produce large floods. In many cases, paleoflood studies can provide a long-term perspective, which can put exceptional annual peak discharge estimates in context and assist in reconciliation of conflicting historical records.

Paleoflood data generally include records of the largest floods, or commonly the limits on the stages of the largest floods over long time periods. This information can be converted to peak discharges using a hydraulic flow model. Generally, paleoflood data consist of two independent components. One component is a peak discharge estimate; the second is a time period or age over which the peak discharge estimate applies. Paleoflood studies can provide estimates of peak discharge for specific floods in the past, or they can provide exceedance and non-exceedance bounds for extended time periods. Each of these differing types of paleoflood data must be appropriately treated in flood frequency analyses.

Extrapolation Limits for Different Data Types

The primary basis for a limit on credible extrapolation of extreme flood estimates derives from the characteristics of the data and the record length used in the analysis. The data used in the analysis provide the only basis for verification of the analysis or modeling results, and as such, extensions beyond the data cannot be verified. Different risk assessments require flood estimates for different ranges of annual exceedance probability (AEP), and therefore analysis procedures and data sources should be selected to meet project requirements. The greatest gains to be made in providing

credible estimates of extreme floods can be achieved by combining regional data from multiple sources. Thus, analysis approaches that pool data and information from regional precipitation, regional streamflow, and regional paleoflood sources should provide the highest assurance of credible characterization of low AEP floods.

For many Reclamation dam safety risk assessments, flood estimates are needed for AEPs of 1 in 10,000 and ranging down to 1 in 100,000, or even lower. Developing credible estimates at these low AEPs generally require combining data from multiple sources and a regional approach. Table 1 lists the different types of data which can be used as a basis for flood frequency estimates, and the typical and optimal limits of credible extrapolation for AEP, based on workshop discussions or subsequent communications. The limits presented in the table represent a general group consensus; however, opinions differed amongst workshop participants. In general, the optimal limits are based on the best combination(s) of data envisioned in the western U.S. in the foreseeable future. Typical limits are based on the combination(s) of data which would be commonly available and analyzed for most sites.

Many factors can affect the equivalent independent record length for the optimal case. For example, gaged streamflow records in the western United States only rarely exceed 100 years in length, and extrapolation beyond twice the length of record, or to about 1 in 200 AEP, is generally not recommended (IACWD, 1982). Likewise, for regional streamflow data the optimal limit of credible extrapolation is established at 1 in 1,000 AEP by considering the number of stations in the region, lengths of record, and degree of independence of these data (Hosking and Wallis, 1997). For paleoflood data, only in the Holocene epoch, or the past 10,000 years, is climate judged to be sufficiently like that of the present climate, for these types of records to have meaning in estimates of extreme floods for dam safety risk assessment. This climatic constraint indicates that an optimal limit for extrapolation from paleoflood data, when combined with at-site gaged data, for a single stream should be about 1 in 10,000 AEP. For regional precipitation data, a similar limit is imposed because of the difficulty in collecting sufficient station-years of clearly independent precipitation records in the orographically complex regions of the western United States. Combined data sets of regional gaged and regional paleoflood data can be extended to smaller AEPs, perhaps to about 1 in 40,000, in regions with abundant paleoflood data. Analysis approaches that combine all types of data are judged to be capable of providing credible estimates to an AEP limit of about 1 in 100,000 under optimal conditions.

In many situations, credible extrapolation limits may be less than optimal. Typical limits would need to reflect the practical constraints on the equivalent independent record length that apply for a particular location. For example, many at-site streamflow record lengths are shorter than 100 years. If in a typical situation the record length is only 50 years, then the limit of credible extrapolation might be an AEP of about 1 in 100. Similarly, many paleoflood records do not extend to 10,000 years, and extensive regional paleoflood data sets do not currently exist. Using a record length of about 4,000 years, a typical limit of credible extrapolation might be an AEP of 1 in 15,000 based on regional streamflow and regional paleoflood data.

The information presented in Table 1 is intended as a guide; each situation is different and should be assessed individually. The limits of extrapolation should be determined by evaluating the length of record, number of stations in a hydrologically homogeneous region, degree of correlation between stations, and other data characteristics which may affect the accuracy of the data.

Ideally, one would like to construct the flood frequency distribution for all floods that could conceivably occur. However, the limits of data and flood experience for any site or region place practical limits on the range of the floods to which AEPs can be assigned. There does not appear to be sufficient data to justify computation of AEPs less than 1 in 100,000. In general, the scientific limit to which the flood frequency relationship can be credibly extended, based upon any characteristics of the data and the record length, will fall short of the probable maximum flood (PMF) for a site. PMF estimates provide a useful reference to past practice and can be compared with extreme floods characterized for risk assessment. However, the workshop participants concluded that there is limited scientific basis for assigning an AEP to the PMF. For precipitation data, similar limitations apply to extrapolations that approach values described by probable maximum precipitation.

Table 1. Hydrometeorological Data Types and Extrapolation Limits for Flood Frequency Analysis

Type of Data Used for Flood Frequency Analysis	Limit of Credible Extrapolation for Annual Exceedance Probability	
	Typical	Optimal
At-site streamflow data	1 in 100	1 in 200
Regional streamflow data	1 in 750	1 in 1,000
At-site streamflow and at-site paleoflood data	1 in 4,000	1 in 10,000
Regional precipitation data	1 in 2,000	1 in 10,000
Regional streamflow and regional paleoflood data	1 in 15,000	1 in 40,000
Combinations of regional data sets and extrapolation	1 in 40,000	1 in 100,000

Methods of Analysis

At Site Flood Frequency Analysis

Frequency analysis is an information problem: if one had a sufficiently long record of flood flows, or perhaps rainfall for a basin, then a frequency distribution for a site could be determined with good precision, so long as change over time due to anthropogenic or natural processes did not alter the distribution of floods. In most situations available data are insufficient to precisely define the annual exceedance probability of large floods. This forces hydrologists to use practical knowledge of the physical processes involved, and efficient and robust statistical techniques, to develop their estimates (Stedinger et al., 1993).

Fitting a distribution to data sets allows both a compact and smoothed representation of the frequency distribution revealed by the available data, and a systematic procedure for extrapolation to frequencies beyond the range of the data set. Given a family of distributions, one can estimate the parameters of that distribution so that required quantiles and expectations can be calculated with the "fitted" model. Appropriate choices for distribution functions can be based upon examination of the data using probability plots, the physical origins of the data, previous experience, or prescriptive guidelines.

Several general approaches are available for estimating the parameters of a distribution. A simple approach is the *method of moments,* which uses the available sample to compute estimators of the distribution's parameters. The Federal guidelines published in Bulletin 17B (IACWD, 1982) recommend fitting a Pearson type 3 distribution to the common base 10 logarithms of the peak discharges. It uses at-site data to estimate the sample mean and variance of the logarithms of the flood flows, and a combination of at-site and regional information to estimate skewness.

Another method that may be used to estimate the parameters of a distribution for at-site frequency analysis is the Expected Moments Algorithm (EMA). EMA (Cohn et al., 1997) is a moments-based estimation procedure and is identical to the existing Bulletin 17B (IAWCD, 1982) approach when no high or low outliers are present. The EMA method was developed to utilize historical and paleoflood information in a censored data framework. This approach explicitly acknowledges the number of known and unknown values above and below a threshold, similar to a maximum-likelihood approach. Three types of at-site flood information are used: systematic stream gage records; information about the magnitudes of historical floods; and knowledge of the number of years in the historical period when no large flood occurred.

Still another method, which has strong statistical motivation, is the *method of maximum likelihood*. Maximum likelihood estimators (MLEs) have very good statistical properties in large samples, and experience has shown that they generally do well with records available in hydrology. In many cases MLEs cannot be reduced to simple formulas, so estimates must be calculated using numerical methods (Stedinger et al., 1988; O'Connell, 1997).

L-moments are another way to summarize the statistical properties of hydrologic data. Sample estimators of L-moments are linear combinations (and hence the name L-moments) of the ranked observations, and thus do not involve squaring or cubing the observed values as do the product-moment estimators. As a result L-moment estimators of the dimensionless coefficients of variation and skewness are almost unbiased and have very nearly a normal distribution (Hosking and Wallis, 1997).

Regional Flood Frequency Analysis

In hydrology, sufficient information is seldom available at a site to adequately determine the frequency of rare events using frequency analysis. This is certainly the case for the extremely rare events which are of interest in dam safety risk assessment. The National Research Council (1988) has proposed several general strategies, including substituting space for time for estimating extreme floods. One substitutes space for time by using hydrologic information at different locations in a region to compensate for short records at a single site.

Three approaches (Cudworth, 1989) have been considered for regional flood frequency analysis: (1) average parameter approach; (2) index flood approach; and (3) specific frequency

approach. With the average parameter approach, some parameters are assigned average values based upon regional analyses, such as the log-space skew or standard deviation. Other parameters are estimated using at-site data, or regression on physiographic basin characteristics**,** perhaps the real or log-space mean. The index flood method is a special case of the average parameter approach. The specific frequency approach employs regression relationships between drainage basin characteristics and particular quantiles of a flood frequency distribution.

Index Flood Method. The index flood procedure is a simple regionalization technique with a long history in hydrology and flood frequency analysis (Dalrymple, 1960). It uses data sets from several sites in an effort to construct more reliable flood-quantile estimators. A similar regionalization approach in precipitation frequency analysis is the station-year method, which combines precipitation data from several sites without adjustment to obtain a large composite record to support frequency analyses. The concept underlying the index flood method is that the distributions of floods at different sites in a "region" are the same except for a scale or index-flood parameter which reflects the size, rainfall and runoff characteristics of each watershed. Generally the mean is employed as the index flood (Hosking and Wallis, 1997).

Average Shape Parameter. As at-site records increase in length, procedures that estimate two parameters, with at-site data to be used with a regional shape parameter, have been shown to perform better that index flood methods in many cases (Stedinger and Lu, 1995). For record lengths of even 100 years, 2-parameter estimators with a good estimate of the third shape parameter**,** are generally more accurate than are 3-parameter estimators (Lu and Stedinger, 1992; Stedinger and Lu, 1995). However, whether or not it is better to also regionalize the coefficient of variation depends upon the heterogeneity of the regions and the coefficients of variability of the flows. In regions with high coefficients of variation (and high coefficients of skewness) index flood methods are more attractive.

Regional Regression. Regional analysis can be used to derive equations to predict the values of various hydrologic statistics (including means, standard deviations, quantiles, and normalized regional flood quantiles) as a function of physiographic characteristics and other parameters. Stedinger and Tasker (1985, 1986a, 1986b) developed a specialized Generalized Least Squares (GLS) regression methodology to address the regionalization of hydrologic statistics. Advantages of the GLS procedure include more efficient parameter estimates when some sites have short records, an unbiased model-error estimator, and a better description of the relationship between hydrologic data and information for hydrologic network analysis and design.

Design Event-Based Precipitation-Runoff Modeling

Precipitation-runoff modeling is typically used as an event-based method for determining extreme floods. A single set of hydrometeorological parameters and watershed characteristics are used to simulate a design flood event. The major inputs to a design event-based precipitation-runoff model are: (1) climate data (rainfall, snowfall, and other variables needed to predict snowmelt); (2) losses (infiltration/interception); (3) physical watershed characteristics for runoff and routing simulations (drainage areas, watershed and channel slopes, lag times, antecedent moisture, etc.); (4) precipitation-runoff transformation function; and (5) runoff conveyance/routing mechanisms. Model output includes runoff hydrographs at user-specified locations, maximum peak discharges, and total

runoff volumes. Examples of this type of model include HEC-1 (USACE, 1990) and RORB (Laurenson and Mein, 1995).

Stochastic Event-Based Precipitation-Runoff Modeling

In the stochastic approach, hydrologic model inputs are treated as random variables. Monte Carlo sampling procedures are used to allow the input variables to vary in accordance with their observed distributions, including the observed dependencies among some climatic and hydrologic parameters. The use of the stochastic approach with regional precipitation information allows the estimation of flood magnitude-frequency curves for flood peak discharge, flood runoff volume, and reservoir level. An example of this type of model is discussed by Barker et al. (1997).

Atmospheric Storm Modeling and Continuous Precipitation-Runoff Modeling

This method combines the work of atmospheric modelers and regional precipitation analysis to derive a precipitation magnitude-frequency curve (Chin et al., 1997). The atmospheric model is used to generate storms over the watershed, and the findings from the regional analysis are used to estimate the annual exceedance probability of point and areal precipitation generated by the model. Using distributed precipitation-runoff modeling, snowpack and other antecedent conditions can be combined to estimate a simulated flood frequency curve using a Monte Carlo approach.

Data Generation and Continuous Simulation Modeling

The data generation and continuous simulation modeling approach is based on Monte Carlo generation of long and detailed sequences of hydrometeorological variables, including precipitation, air temperature, and wind speed and direction. In order to represent spatial differences across the watershed adequately, it is necessary to generate hydrometeorological variables for several sites concurrently. Hydrological models of watershed behavior and hydraulic models of confluences, wave effects and reservoir outlets are used to simulate the reservoir water level continuously. An estimated magnitude-frequency relationship of maximum reservoir stages is input to the risk assessment (Calver and Lamb, 1996).

Combining Methods and Data Types

No single approach is capable of providing the needed characterization of extreme floods over the full range of annual exceedance probabilities that may be required for risk assessment. In particular, characterization of floods with AEPs less than 1 in 10,000 can be expected to require that results from a number of approaches, based on multiple data sources, need to be combined to yield a composite flood frequency description. The application of several independent methods and types of data applicable to the same range of annual exceedance probabilities will increase the credibility and resulting confidence in the results.

Table 2 lists various methodologies that were considered for characterizing extreme floods to support dam safety risk assessment. A flood frequency analysis must be combined with each of these methodologies to assign annual exceedance probabilities to the floods.

The framework developed for Reclamation does not propose a specific methodology for rigorously combining information from these differing data sources and methodologies in an overall statistical framework. In some cases the information may be combined statistically, and in other cases one set of results may be used as a bound on the frequency distribution obtained by analysis of other data. Clearly, this process will require a measure of judgement. Regardless of the approach taken for combining results, it should incorporate sound physical and scientific reasoning for weighting or combining results.

All floods characterized for the risk assessment process should display the uncertainties resulting from the analysis. As the risk assessment moves from the screening and scoping levels to the decision level, uncertainty should be reduced and better quantified so that appropriate information is included in the dam safety decision-making process.

Table 2. Applicability of Hydrologic Methods of Analysis to Various Risk Assessment Levels

Method of Analysis	Risk Assessment Level		
	Screening	Scoping	Decision
Flood frequency analysis	Yes	Yes	Yes
Design event-based precipitation-runoff modeling	No	Yes	Yes
Stochastic event-based precipitation-runoff modeling	No	Yes	Yes
Distributed simulation modeling	No	No	Yes
Atmospheric modeling and distributed precipitation-runoff modeling	No	No	Yes

Evaluation of Uncertainty

Uncertainty can be evaluated by applying Monte Carlo analysis to the overall risk assessment calculations. For example, consider the estimation of threat to life consequences and probability of failure associated with an existing dam and various risk reduction alternatives. One is concerned with uncertainty due to such risk assessment inputs as flood frequency distribution parameters, system response estimates, population at risk, warning time, and estimated loss of life. Then in each iteration of Monte Carlo analysis, one could generate likely values of each of these inputs and evaluate the threat to life and probability of failure. The expected annual life loss and the annual exceedance probability of failure, which are both used as Reclamation Public Protection Guidelines (USBR, 1997b), could be computed for each iteration. By generating many replicates, one obtains samples that describe the possible values of these risk measures (performance metrics).

Averaging over the replicates provides "expected" values of the quantities reflecting both the modeled probability distributions of the phenomena (risk assessment inputs) that are considered to be random variables, and the uncertainty in the parameters describing those distributions. The sample standard deviations describe the variability of the performance metrics. Replicates can be

used to estimate frequency distributions which can be used for describing and evaluating the decision implications of uncertainty in the risk assessment inputs.

Calibration to Flood Frequency Quantiles

The ability of a flood event model to reproduce historic events certainly gives some confidence to the validity of subsequent estimates. However, even in a well gaged watershed the annual exceedance probabilities of the calibration floods are likely to range between 1 in 5 to 1 in 20, and only occasionally up to 1 in 100. While it would be expected that floods of these magnitudes will activate some floodplain storage, the non-linear nature of drainage basin flood response is such that the routing characteristics of larger events may be considerably different. Thus, while calibration of a model provides valuable information on the flood response of a drainage basin, caution is needed when using the calibrated model to estimate floods of much larger magnitudes (Pilgrim and Cordery, 1993).

Calibration to flood frequency quantiles using design rainfall inputs can provide important information on flood response characteristics for extreme design events (Nathan and Bowles, 1997; Nathan, 1992). With this approach, design rainfall information is prepared for a specified AEP, and then used with a given set of model parameters and input assumptions to derive a design hydrograph. The peak (or volume) of the design hydrograph can then be compared to the corresponding quantile obtained from a combined at-site/regional flood frequency analysis. The model inputs associated with the greatest uncertainty can be varied within appropriate limits to ensure agreement with the selected flood quantile. Model calibration should be undertaken for a range of AEPs to ensure a consistent variation of parameters with flood magnitude or AEP.

For risk-based studies based on a "design storm concept", it is necessary to adopt an AEP-neutral approach, where the objective is to derive a flood with an AEP equivalent to its concomitant precipitation (Nathan and Bowles, 1997). The factors that influence the transfer between precipitation and runoff can be characterized by probability distributions, and ideally the design hydrograph should be determined by considering the joint probabilities of all the input factors. Monte-Carlo methods are ideally suited to the AEP-neutral objective, as they accommodate the observed variability of the inputs while still preserving the interdependencies between parameters. Simpler approaches may be appropriate, where the decrease in rigor is offset by the computational convenience and the transparency of the adopted functional relationships. For the least important parameters it may be appropriate to adopt a single representative (mean) value instead of the full distribution. However, the relationship between rainfall and runoff is non-linear, and adoption of a single representative value for the major inputs will introduce bias into the transformation. Accordingly, for more important inputs it is necessary to adopt a joint probability approach. The nature of the method can be tailored to suit the relative importance of the parameter concerned.

Conclusions

A framework has been developed for characterizing extreme floods for the purposes of dam safety risk assessment. By incorporating regional information on precipitation, floods, and paleofloods with good at-site records, it is possible to provide scientifically credible flood estimates to annual exceedance probabilities as low as 1 in 100,000, although higher AEP limits may exist in

many cases. In general, the scientific limit to which the flood frequency relationship can be extended based upon available data will fall short of the PMF for a site. PMF estimates provide a useful reference to past practice and can be compared with floods characterized for risk assessment; however, there is limited scientific basis for assigning an annual exceedance probability to the PMF.

No single approach is capable of providing the needed characterization of extreme floods over the full range of AEPs required for risk assessment. Therefore, the results from several methods and sources of data should be combined to yield a composite characterization. The application of several independent methods applicable to the same range of AEPs will increase the credibility and resulting confidence of the results.

Uncertainties associated with descriptions of flood flow exceedance probabilities are likely to be substantial and an important attribute for the characterization of extreme floods. Flood characterization should include a "best estimate" of the annual exceedance probability of floods of different magnitudes and a description of the uncertainty in such results. Such uncertainties need to be honestly represented and considered throughout the risk assessment process.

Acknowledgments

The U.S. Bureau of Reclamation's Dam Safety Office sponsored the Workshops and other activities which have resulted in the proposed framework for characterization of extreme floods for dam safety risk assessment. Some twenty professionals from the U.S., Canada, Australia and Europe participated in this effort and each contributed in some way to the resulting framework. These individuals were: David Achterberg, Victor Baker, David Bowles, David Cattanach, Sanjay Chauhan, John England, David Goldman, Chuck Hennig, Don Jensen, Lesley Julian, Jong-Seok Lee, Dan Levish, Jim Mumford, Rory Nathan, Dan O'Connell, Dean Ostenaa, Duncan Reed, Mel Schaefer, Lou Schreiner, Jery Stedinger, Robert Swain, Jim Thomas, and Ed Tomlinson. This paper was also presented at the Eighteenth U.S. Committee on Large Dams Annual Meeting and Lecture held in Buffalo, New York and is included in the conference proceedings.

References

Baker, V.R., 1987. Paleoflood hydrology and extraordinary flood events: *Journal of Hydrology*, v. 96, p. 79-99.

Barker, B., M.G. Schaefer, J. Mumford, and R. Swain, 1997. *A Monte Carlo Approach to Determine the Variability of PMF Estimates*, Final Report on Bumping Lake Dam for the USBR Dam Safety Office, 30 pp.

Calver, A. and R. Lamb, 1996. Flood frequency estimation using continuous rainfall-runoff modeling, *Phys. Chem. Earth*, 20, 5/6, p. 479-483.

Chin, W.Q., G.M. Salmon, and W. Luo, 1997. Distributed Physically-Based Precipitation-Runoff Models for Continuous Simulation of Daily Runoff in the Columbia River Basin, British Columbia, presented at the Canadian Electricity Association Electricity '97 Conference and Exposition, April 23, 1997, Vancouver B.C.

Cudworth, A.G., Jr., 1989. *Flood Hydrology Manual,* A Water Resources Technical Publication, US Department of the Interior, Bureau of Reclamation, US Government Printing Office, Denver, CO, 243 pp.

Cohn, T.A., W.L. Lane, and W.G. Baier, 1997. An algorithm for computing moments-based flood quantile estimates when historical flood information is available, *Water Resour. Res.,* 33(9) , p. 2089-96.

Dalrymple, T., 1960. Flood frequency analysis, U.S. Geological Survey*, Water Supply Paper* 1543-A.

Fill, H., and J. Stedinger, 1997. Using regional regression within index flood procedures and an empirical Bayesian estimator, submitted to *J. of Hydrology,* April, 1997.

Hosking, J.R.M., and J.R. Wallis, 1997. *Regional Frequency Analysis: An Approach Based on L-moments,* Cambridge Univ. Press, 224 pp.

House, P.K., and P.A. Pearthree, 1995. A geomorphic and hydrologic evaluation of an extraordinary flood discharge estimate: Bronco Creek, Arizona, *Water Resources Research*, v. 31, no. 12, p. 3059-3073.

Interagency Advisory Committee on Water Data, 1982. *Guidelines for Determining Flood Flow Frequency,* Bulletin 17B, U.S. Department of the Interior, U.S. Geological Survey, Office of Water Data Coordination, Reston, Virginia.

Laurenson, E.M. and R.G. Mein, 1995. RORB: Hydrograph Synthesis by Runoff Routing: in Singh, V.P. (ed.) *Computer Models of Watershed Hydrology*, Water Resources Publications, Highlands Ranch, CO, p. 151-164.

Lu, L., and J.R. Stedinger, 1992. Variance of 2- and 3-parameter GEV/PWM quantile estimators: formulas, confidence intervals and a comparison, *Jour. of Hydrol., 138(½),* p. 247-268.

Nathan, R.J., 1992. The derivation of design temporal patterns for use with generalized estimates of probable maximum precipitation, *Civil Engineering Transactions*, *I.E. Aust.*, CE34(2), p. 139-150.

Nathan R.J. and D.S. Bowles, 1997. A probability-neutral approach to the estimation of design snowmelt floods, *Conference proceedings, 24th Hydrology and Water Resources Symposium*, Auckland, New Zealand.

National Research Council, 1988. *Estimating Probabilities of Extreme Floods, Methods and Recommended Research,* Report by the Committee on Techniques for Estimating Probabilities of Extreme Floods, National Academy Press, Washington D.C.

O'Connell, D.R.H., 1997. FLFRQ3, Three-Parameter Maximum Likelihood Flood-Frequency Estimation with Optional Probability Regions using Parameter Grid Integration: Users Guide (Beta Edition).

Pilgrim, D.H., and I. Cordery, 1993. "Flood Runoff", Chapter 9 in Maidment, D.R. (ed.) *Handbook of Hydrology*, McGraw-Hill, New York, p. 9.1-9.42.

Stedinger, J.R., and G.D. Tasker, 1985. Regional hydrologic analysis, 1. Ordinary, weighted and generalized least squares compared, *Water Resour. Res.,* 21(9), p. 1421-32.

Stedinger, J.R., and G.D. Tasker, 1986a. Correction to 'Regional hydrologic analysis, 1. Ordinary, weighted and generalized least squares compared,' *Water Resour. Res.*, 22(5), p. 844.

Stedinger, J.R., and G.D. Tasker, 1986b. Regional hydrologic analysis, 2. Model error estimates, estimation of sigma, and log-Pearson Type 3 distributions, *Water Resour. Res.*, 22(10), p. 1487-1499.

Stedinger, J.R., R. Surani, and R. Therivel, 1988. Max Users Guide: A Program for Flood Frequency Analysis using Systematic-Record, Historical, Botanical, Physical Paleohydrologic and Regional Hydrologic Information Using Maximum Likelihood Techniques, Department of Environmental Engineering, Cornell University.

Stedinger, J.R., R.M.Vogel, and E. Foufoula-Georgiou, 1993. Frequency Analysis of Extreme Events, Chapter 18, *Handbook of Hydrology*, D.Maidment (ed.), McGraw-Hill, Inc., New York.

Stedinger, J.R. , and L. Lu, 1995. Appraisal of Regional and Index Flood Quantile Estimators, *Stochastic Hydrology and Hydraulics,* 9(1), p. 49-75.

U.S. Army Corps of Engineers, 1990, *HEC-1 Flood Hydrograph Package, User's Manual*, Hydrologic Engineering Center, Davis, CA, 283 pp.

U.S. Bureau of Reclamation, 1997a. *Risk Assessment Methods for Dam Safety Decision Making*, Draft, U.S. Department of Interior, Denver, CO.

U.S. Bureau of Reclamation, 1997b. *Guidelines for Achieving Public Protection in Dam Safety Decision Making*, U.S. Department of Interior, Denver, CO, 19 pp.

Von Thun, J.L. and J.D. Smart, 1996. Risk assessments support dam safety decisions, *USCOLD Newsletter*, Issue No. 110, Nov 1996, U.S. Committee on Large Dams.

Bureau of Reclamation Hydrologic Research

Presented at the FEMA Workshop on Hydrologic Research Needs for Dam Safety

By
Robert E. Swain, Louis C. Schreiner, and Daniel R. Levish

Introduction

The U.S. Bureau of Reclamation is now making extensive use of quantitative risk assessment in support of dam safety decision-making (Von Thun and Smart, 1996). An important input to Dam Safety Risk Assessment is the development of probabilistic extreme flood estimates. The focus has shifted from routing a single "maximum" event (i.e. the probable maximum flood, PMF) to consideration of the entire range of plausible inflow flood events, and ultimately to the magnitude-frequency relationship of maximum reservoir stages.

Reclamation has identified the need for a review of its present procedures for developing probabilistic extreme flood estimates and their associated uncertainties for use in dam safety risk assessment. Where practical, Reclamation would like to develop improved procedures. The following sections of this paper describe ongoing hydrologic research activities for use in dam safety analysis.

Flood Hydrology Database

A variety of hydrologic data are used as input in flood frequency analyses, probabilistic hydrographs, stochastic rainfall-runoff models and other hydrology studies aimed at making flood hazard probability statements for use in risk analyses. The physical understanding and modeling of extreme flood events requires collection and review of a variety of flood hydrology data including peak discharge and mean daily stream flow records, precipitation (rainfall and snowfall) and temperature data, soil data, paleoflood information, extreme rainfall data, and many other sources of information. A searchable database that includes organized and connected lists of available data, visual selection capability, and links to the data would allow faster and more thorough assessment.

The purpose of this research is to continue development of a hydrology database that will include a variety of hydrology data such as peak discharge estimates, paleoflood data, precipitation and temperature data, as well as potential sources of infiltration characteristics and other geologic properties of drainage basins. These data would be used as input into flood frequency analyses, probabilistic hydrograph development, and prediction of basin response in stochastic modeling of extreme flooding. This project focuses on the development of a flood hydrology database that identifies, summarizes, and links hydrologic data that is needed for developing flood frequency analyses and probabilistic hydrographs, as input for stochastic rainfall-runoff models, and other hydrology studies. The eventual goal of this project is to provide spatial and temporal data for use in probabilistic flood hazard studies in the 17 western states.

A variety of data including information on extreme peak discharge have been gathered for the Sierra Nevada region of northern California. Paleoflood data have been gathered throughout the western U.S., as well as in a database at the University of Arizona, tree.ltrr.arizona.edu/~katie/paleofld.html. Currently, Reclamation has a paleoflood database in Microsoft Access and hydrology database in Arcview exist as separate databases. These databases need to be integrated into one database in order to efficiently store and access information for flood-related studies. In addition, computer code and a user interface have been developed for the hydrology database that will allow the user to access records by graphically selecting an area. By the end of 2002, a preliminary user-friendly database is scheduled for completion. This data information system will require updating and continual maintenance.

Revision and Update of Precipitation-Frequency Studies for the United States and Its Possessions

Since the mid 90's, meteorologists in both Reclamation's Flood Hydrology Group and River Systems & Meteorology Group have been addressing the need to revise and update precipitation-frequency estimates for the United States. The demand for this work is obvious in that precipitation-frequency atlases presently used by Reclamation are woefully outdated, with the far majority of the previous studies dating back 30 to 40 years ago, and lack extensions to important meteorological parameters (duration, area, return period, etc.). This information is used in establishing hydrologic design criteria for the safety evaluation of water control structures (dams, canals, levees, culverts, etc.), design of other types of construction (roads, bridges, flood warning systems, etc.), and for establishing project operational criteria. Results of this work will provide consistent precipitation-frequency information that can be incorporated in risk assessments that are used in current/future flood hydrology studies.

The project is a cooperative effort among several federal, state, and local agencies involved in water resource management. The National Weather Service (NWS), Hydrometeorological Design Studies Center (HDSC) is the lead agency for accomplishing the work with participation from other agencies (financial, in-kind-services) dependent on their interest/needs to provide support for the particular region under investigation. Because of the large amounts of data to process and the need to test new meteorological and statistical analysis techniques, the United States and its Possessions were broken into nine separate zones. Presently, four of these zones are under development in varying degrees. These zones include: Semiarid Southwest, the Ohio River Basin and Surrounding States, Hawaii, and Puerto Rico and the Virgin Islands. Work on a fifth study region, the Upper Midwest, has been started by Reclamation to assemble maximum daily precipitation (prior to 1949) data. For the next couple of years, Reclamation expects to continue with data set development for the Upper Midwest, but concentrate its effort on development of Depth-Area (DA) relationships used to adjust point precipitation-frequency values to representative areal average precipitation-frequency estimates.

The Semiarid Southwest, Ohio River Basin and Surrounding States, and Puerto Rico and the Virgin Islands zones are scheduled for completion in 2002. Hawaii is scheduled for completion in 2003. Current updates/progress reports concerning all work underway is available at: http://www.nws.noaa.gov/oh/hdsc. The precipitation-frequency work as completed will be published as NOAA Atlas 14, Volume (#). It is expected that the entire Atlas will be completed by 2006.

Probabilistic Flood Hydrographs

Flood runoff hydrographs integrate the drainage basin and channel response to precipitation and snowmelt, given some initial, variable state of moisture throughout the watershed. Probabilistic flood hydrographs are developed to assess the adequacy of the spillway and reservoir flood/surcharge space to temporarily store a portion of the flood volume, and to attenuate or pass the hydrograph peak without overtopping the dam. Flood hydrographs are needed for situations where: the reservoir inflow peak discharge is greater than the maximum spillway capacity; the reservoir has a large, carry-over storage; and/or the reservoir has dedicated flood control space. The focus of this research is to develop a simplified approach for estimating probabilistic hydrographs that can be used for appraisal or feasibility level studies, and to develop a simplified method of extrapolating flood frequency curves.

Basic streamflow hydrograph methods (e.g., Chow et al., 1988; Bras, 1990) are used to estimate properties for probabilistic hydrographs. These methods include peak and one-day mean discharge identification, selection of hydrograph shape and duration, base flow identification and separation, and direct runoff volume estimation. Peak discharge and mean-daily streamflow records are used because this source is the best information on flood magnitudes that are likely to occur in the future, based on what occurred in the past (Pilgrim and Cordery, 1993).

The key idea is calibration or scaling of hydrographs to match a particular peak discharge for a given probability. The approach relies completely upon the specification of a peak flow frequency curve that describes the probabilities of interest. Peak discharge estimates, n-day maximum mean flows, and observed hydrographs at the site of interest are used as a sample to represent potential extreme flood shapes and volumes. The largest peak and volume hydrographs are utilized as a basis to scale.

There are five major assumptions for developing the hydrographs: (1) the probability of peak discharge is sufficient to represent a probability of the composite hydrograph; (2) unit hydrograph (e.g., linearity) assumptions apply to the basin; (3) direct runoff volumes can be estimated from daily flow hydrographs; (4) peak discharge - maximum mean n-day flow relationships can be extrapolated; and (5) the recorded streamflow observations, historical information, and paleoflood data provide an adequate sample to base extrapolations to extreme floods.

The anticipated completion date for this project is early 2002.

Improved Flood Frequency Extrapolations and Runoff Modeling

The purpose of this research project is to develop improved methods to extrapolate flood frequency curves and develop extreme flood hydrographs. The major approach to flood frequency extrapolation will be based on a combination of rainfall extrapolation and derivation from physically based runoff mechanisms. Rainfall-runoff models will be used to derive the peak discharge frequency distribution from input basin characteristics and precipitation, and be used as the basis for frequency curve extrapolation. The CASC2D rainfall-runoff model will be evaluated and tested for application at Reclamation sites, and compared with a stochastic event runoff model (SEFM) developed by Dr. Melvin Schaefer for Reclamation. CASC2D is a 2-dimensional, distributed rainfall-runoff model that has successfully reproduced the 1997 Fort Collins flood. The main precipitation and stochastic components used in SEFM will be added to CASC2D. It is anticipated that model selection and extrapolation functions can be derived from the watershed topography, hydraulic routing characteristics, and precipitation characteristics at Reclamation dams. Input rainfall will be derived from frequency analysis or from stochastic storm generation. Flood frequency and hydrograph uncertainty bounds will be approximated by simulation. Models will be compared on a large (>500 mi^2) basin where paleoflood data are available.

Progress has been made in developing hydrograph-scaling techniques for appraisal and feasibility studies that require low effort and expense. These techniques have been applied to several projects such as Pineview/Deer Creek, Red Willow, North Platte, and Folsom Dams. Internal and external reviewers have pointed out several shortcomings of that work including, assumptions of linear runoff and extrapolation, use of observed hydrographs, failure to separate rainfall and snowmelt, and the challenges of using the techniques at larger basins (greater than about 500 mi^2). This research project attempts to address many of these concerns.

This research can be applied to Dam Safety projects where flood peaks and hydrographs are needed with return periods that exceed 1,000 years. The extrapolation research can be applied to sites where loss of life is large, as floods with return periods greater than 10,000 years are sometimes needed. The research will be span three fiscal years and conclude in 2004.

Rainfall-Runoff Modeling Using National Weather Service 1,000-year Return Period Precipitation Estimates at Causey Dam, Utah

Recently, the Flood Hydrology Group completed a study where the frequency estimates were extrapolated to a return period of 200,000 years. The method used a two-point extrapolation to 200,000 years using the mean of the gage data and the mean of the paleoflood range. This was the first attempt to extrapolate frequency data beyond a 10,000-year return period and several assumptions were made that may not be accurate. For example, the stream gage data in the Wasatch Range are dominated by snowmelt events, yet the distribution selected in the study was based on rainfall distributions. The

intention of this study is to provide another independent data point and to verify the conclusions reached in the previous analysis.

This investigation will use the draft precipitation values developed by the National Weather Service (NOAA Atlas 14, Vol 1, DRAFT) to produce a 1,000-year assumed thunderstorm event at Causey Dam, Utah. These values will be input to a rainfall-runoff model (HEC-1 or FHAR) to develop the 1,000-year thunderstorm flood event for Causey Dam. This peak discharge estimate will be compared with the frequency analysis developed for Causey Dam. Causey Dam was selected as the test case because there is existing at site paleoflood data to use in comparison, the drainage area is relatively small (137 mi^2), and it has a significant amount of streamflow and other comparative data developed. The estimated completion date would be June 2001.

Probabilistic Flood Hazard Workshop

The introduction of risk analysis for dam safety signaled a significant change in the way the Dam Safety Office and the Technical Service Center conduct flood hazard assessments. The purpose of this project is to compile, review, and evaluate current state-of-the-knowledge on probabilistic techniques used in flood hazard assessment. External experts in various aspects of flood hazards will be brought in to Reclamation on an individual basis. It is intended that each person present a Technical Update Lecture (1-2 hours). Members of the Flood Hydrology Group will subsequently meet with them to discuss their research in detail and potential technology transfer to Reclamation.

About 12 experts participated in the workshop last year. These experts have helped the Flood Hydrology Group map out future methods, improve current methods, and plan a program for probabilistic flood hazard analysis to meet Dam Safety Office needs.

References

Bras, R.L. (1990) Hydrology, An Introduction to Hydrologic Science. Addison-Wesley, Reading, MA, 643 p.

Chow, V.T., Maidment, D.R. and Mays, L.W. (1988) Applied Hydrology. McGraw-Hill, New York, 572 p.

Pilgrim, D.H. and Cordery, I. (1993) Flood Runoff. In Handbook of Hydrology, Maidment, D.R. (ed.), McGraw-Hill, New York, Ch. 9, pp. 9.1-9.42.

Von Thun, J.L. and J.D. Smart (1996) Risk assessments support dam safety decisions, USCOLD Newsletter, Issue No. 110, Nov 1996, U.S. Committee on Large Dams.

Page left intentionally blank

GUIDELINES FOR ACHIEVING PUBLIC PROTECTION IN DAM SAFETY DECISIONMAKING

UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Reclamation
Denver, Colorado

June 15, 2003

(Replaces Interim Guidelines dated April 4, 1997)

TABLE OF CONTENTS

I. Introduction ……..….1

II. Risk Assessment Framework for Dam Safety Decisionmaking ……..…...……. 3
- A. Background ……3
- B. Terminology ……4
- C. Risk Framework ……..5
- D. Decisionmaking ……...6

III. Public Protection (Risk Evaluation) Guidelines ……8
- A. Evidence of a Developing Failure Mode ……8
- B. Annual Probability of Failure ……8
- C. Estimated Risk ……9

IV. Determining Appropriate Actions ……..…….……..12
- A. Development and Presentation of Risk Estimates ……..12
- B. Assessment of Risk Results ……....14
- C. Large Downstream Populations …….....16
- D. Examples of Alternative Actions ……...…….16
- E. Formulation of Appropriate Risk Reduction Alternatives ……..……18
- F. Unrecognized Risks ……...……..18

I. Introduction

Purpose of Guidelines - The Bureau of Reclamation (Reclamation) is responsible for about 370 storage dams and dikes that form a significant part of the water resources infrastructure for the western United States. As the owner of these facilities, Reclamation is committed to providing the public and the environment with adequate protection from the risks which are inherent to collecting and storing large volumes of water for later distribution and/or release. This document presents:

- The basis and guidance for a risk-based approach to decisionmaking
- Guidelines for evaluating risks at Reclamation dams
- Guidelines for developing and presenting the risk estimates
- Guidelines for interpreting/assessing the risk results
- Example actions that can be taken to address risk at dams
- Guidelines for maintaining a focus on risk reduction when implementing agency actions

The guidelines are intended to ensure adequate and consistent levels of public protection when evaluating and modifying existing dams and appurtenant structures and when designing new dams and/or structures.

Considering a Full Range of Loading Conditions - Historical design and analysis methods have focused on selecting a level of protection based on loadings from extreme events and conditions. These extreme events comprise the upper bound of loadings considered to be reasonably probable. The civil engineering profession generally agrees that dams and dikes designed to withstand extreme loadings meet an acceptable standard of public safety. In addition to ensuring public safety for extreme events, Reclamation also is committed to providing public safety for smaller events and loading conditions, which occur more frequently. For example, an enlarged spillway designed for a probable maximum flood loading condition may increase the risks to the public for lesser events. Risk assessment provides a framework for addressing the most effective way to provide public protection over the full range of loading conditions.

Need for Probabilistic Methods - As a water resources management agency, Reclamation strives to provide decisionmakers with pertinent information that is founded upon current or emerging water resources management and public safety practices. Over the past decade, there has been an increasing trend in water resources analysis toward using probabilistic design methods to evaluate the effectiveness of expending funds for enhancing public safety. There has also been greater recognition that even the most restrictive design standards result in some likelihood of failure even though the likelihood may be very small.

Application - This document addresses the incorporation of risk-based evaluations into Reclamation's dam safety decisionmaking process to help assess public risks and allocate resources. While there are many issues that may be evaluated in a risk context, this document focuses on the life loss and the public trust components of decisionmaking. Similar applications of risk-based analysis techniques may be used to address economic consequences within the

framework of the *Principles and Guidelines* for water resources planning.[1] Risk-based analysis may also be used to evaluate environmental and social issues in accordance with the National Environmental Policy Act (NEPA) by addressing the likelihood of the possible outcomes that may result from the various loads that a dam experiences. The implementation of risk-based analysis should consider both usefulness and cost effectiveness in its use.

[1] Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies from the Water Resources Council, March 10, 1983.

II. Risk Assessment Framework for Dam Safety Decisionmaking

A. Background

The mission of the Reclamation Dam Safety Program is:

> "To ensure that Reclamation facilities do not present unreasonable risks to the public, public safety, property, and/or the environment."

The Dam Safety Program is authorized under the Reclamation Safety of Dams Act of 1978.[2] This Act was passed in response to several dam failures in the 1960's and 1970's, including the failure of Teton Dam, a large Reclamation storage dam. The Act provides for action to be taken when it is determined that a structure presents an unacceptable risk:

> "In order to preserve the structural safety of Bureau of Reclamation dams and related facilities, the Secretary of the Interior is authorized to perform such modifications as he determines to be reasonably required."

To determine the risks associated with its structures, Reclamation has established procedures to analyze data and assess the condition of its structures. Prior to the failure of Teton Dam, consideration of dam safety issues was addressed though periodic examinations and project specific requests for Congressional funding to make necessary modifications to dams. The failure of Teton Dam demonstrated a need for a more comprehensive approach to evaluating and addressing dam safety issues.

In 1979, a committee of Federal agency representatives commissioned by the President developed the *Federal Guidelines for Dam Safety* to promote prudent and reasonable dam safety practices among Federal agencies. While the Federal Guidelines recognized that risk-based analysis was a recent addition to the tools available for assessing dam safety, they encouraged Agencies to conduct research to refine and improve the techniques necessary to apply risk-based analysis to dam safety issues:

> "The agencies should individually and cooperatively support research and development of risk-based analysis and methodologies as related to the safety of dams. This research should be directed especially to the fields of hydrology, earthquake hazard, and potential for dam failure. Existing agency work in these fields should be continued and expanded more specifically into developing risk concepts useful in evaluating safety issues."[3]

Reclamation has established a risk-based framework to meet the objectives of its program, the Dam Safety Act, and the Federal Guidelines. Risk-based procedures are used to assess the safety of Reclamation structures, to aid in making decisions to protect

---

[2] The Reclamation Safety of Dams Act of 1978, Public Law 95-578.

[3] Federal Guidelines for Dam Safety, Ad Hoc Interagency on Dam Safety, Federal Coordinating Council for Science Engineering and Technology, Washington, D.C., June 25, 1979.

the public from the consequences of dam failure, to assist in prioritizing the allocation of resources, and to support justification for risk reduction actions where needed. Risk assessment for dam safety decisionmaking integrates the analytical methods of risk-based analysis along with the sound professional judgment of engineers, contractors and review boards in determining reasonable actions to minimize risk at Reclamation facilities.

B. Terminology

The following terminology is provided for terms that are used throughout these guidelines for defining the risk-based framework for dam safety decisionmaking:

Risk – The product of the likelihood of an adverse event and the consequences of that event

Failure Mode - A potential failure mode is a physically plausible process for dam failure resulting from an existing inadequacy or defect related to a natural foundation condition, the dam or appurtenant structures design, the construction, the materials incorporated, the operations and maintenance, or aging process, which can lead to an uncontrolled release of the reservoir.

Risk Analysis – A procedure to identify and quantify risks by establishing potential failure modes, providing numerical estimates of the likelihood of an event in a specified time period, and estimating the magnitude of the consequences. The risk analysis should include all potential events that would cause unintentional release of stored water from the reservoir.

Risk Evaluation – The establishment of Reclamation guidelines for agency response to estimated risks.

Risk Assessment – The use of risk estimation for a given dam in the decisionmaking that leads to agency response according to risk evaluation guidelines.

Consequences – Estimated losses that result from an adverse event leading to a dam failure scenario.

Failure Probability, Consequences, and Risk Estimates – The mean values calculated from Monte Carlo or similar analyses that include explicit treatment of input uncertainty. Also, the calculated numerical values when single point estimates are used in the calculations and the point values are considered reasonable and plausible estimates of the mean rather than extreme values in a range. These estimated mean values are also called the expected values. *(Note: This definition must be applied in order to achieve effective and consistent application of these guidelines.)*

C. Risk Framework

Risk analysis is a tool that enables technical specialists and decisionmakers to better understand possible failure mechanisms and the elements of risk involved in the various issues related to dam safety. It provides an overall picture of risks, the potential impacts of proposed actions, and the resulting costs (economic, social and other). The results of risk analyses can contribute to efficient accomplishment of the dam safety program by quantifying engineering judgments that allow for the evaluation of:

- Factors contributing the greatest risk at a given site,
- The facilities with the greatest risk,
- Identification of additional analyses and/or data collection that are needed to better understand critical uncertainties,
- Anticipated risk reduction effectiveness of alternative courses of action,
- Allocations of dam safety program funds that will contribute the greatest overall risk reductions.

The risk framework consists of several steps leading to agency decisions regarding appropriate actions to be taken to address dam safety risks at Reclamation's high- and significant-hazard dams. These steps are summarized as follows:

Risk Identification – As part of the ongoing dam safety evaluations for each high- and significant-hazard dam, Reclamation identifies the conceivable modes of dam failure. These failure modes are then monitored (through performance monitoring and examinations) for any indication of changes in performance that would be indicative of a dam progressing toward a failure condition or toward a significant risk to the public. If such indications are found, the issue is referred for further evaluation of the estimated risk. If failure modes are deemed likely, action to reduce risk may be taken.

Risk Estimation – Once a dam safety issue has been identified, it is necessary to assess and quantify the risk to the public as information to be used by the decisionmakers. The quantification of risk involves the estimation of the likelihood (probability) of an unintentional release of stored water and an estimation of the consequences resulting from the unintentional release. To facilitate developing the risk estimates, it is frequently convenient to break the estimating process down into three components including: estimating the likelihood of an initiating condition existing or an event occurring, estimating the likelihood of an unintentional release of the reservoir given the event or initiating condition, and estimating the consequences (life loss) given the unintentional release of the reservoir.

Risk Evaluation – Once risks have been estimated for a dam, decisionmakers need a framework for evaluating the risks to determine if action is required to reduce risks. There is currently no commonly accepted industry standard for determining what risks are considered acceptable.

The guidelines portion of this document provides for evaluation of risk by two measures. The first measure, the annual probability of failure, addresses the public's expectation that Reclamation dams should not fail by evaluating the probability of an unintended release of the reservoir. It also addresses the expectation that risk to the most exposed individual will be managed. The second measure addresses the expected value of life loss expressed on an annual basis which combines the annual failure probability estimates with estimates of the expected life loss consequences given a dam failure. The first measure addresses agency and individual risk, while the second measure addresses the life loss component of societal risk.

Risk Reduction Actions – When decisionmakers have determined that a risk reduction action is required, there are usually a number of prudent alternative actions that can be taken. Dam safety decisionmaking involves the selection of an appropriate course of action for a given issue based on the magnitude of the risk, the degree of confidence in (or uncertainties associated with) the estimated risk, and the likelihood of additional information providing a significantly enhanced understanding of the risks associated with the identified issues.

Roles of analysis approaches - Although risk-based and standards-based (design standards, codes or criteria) approaches are often considered to be competing approaches, each have a role in Reclamation's decisionmaking process. Risk assessment is a diagnostic tool used throughout the evaluation, design, and construction process that helps decisionmakers formalize and document dam safety decisions. Standards are used to ensure that the selected corrective actions are well designed and implemented. In other words, risk-based approaches help decision makers choose the appropriate courses of action while standards-based approaches assure sound implementation of those actions.

D. Decisionmaking

Policy - Reclamation policy for dam safety decisionmaking delegates decisionmaking responsibility to the Regional Directors in collaboration with the Chief, Dam Safety Office and the appropriate Area Manager.[4] The Technical Service Center (TSC) staff provides significant technical advice that is critical to decisionmaking. The risk framework serves as a tool for aiding decisionmakers in the determination of needs for risk reduction actions as well as the evaluation of different risk reduction actions that could be taken to address the identified issues.

Public Trust Responsibility - Decisionmaking to accomplish the Dam Safety Program is complex and must consider risk to the public as well as economic, environmental, and cultural impacts. Thus, it is difficult to be prescriptive when developing guidance for making decisions. While the technical analysis of risks associated with a dam can not become the sole decisionmaking factor, it must be recognized that addressing these risks in a technically consistent and timely fashion is an important part of sustaining the public's trust in Reclamation to manage these facilities in the best interest of the nation.

[4] Decisions Related to Dam Safety Issues, Reclamation Manual / Policy FAC P02, Bureau of Reclamation, Denver, Colorado, June 23, 1998.

This public trust responsibility includes operating Reclamation facilities with reasonable assurance of the safety of persons in the vicinity of and downstream of the dams.

Process - Dam safety decisionmaking is similar to many other aspects of water resources management in that decisions regarding reasonable courses of action are not always initially agreed upon by all stakeholders. The most important part of the decisionmaking process is recognizing that it will generally involve building consensus regarding the appropriate actions to be taken. However, in the event of an emergency, the time for developing consensus may be severely shortened or nonexistent. Such a situation would require the Regional Director to act quickly to avoid or minimize consequences.

III. Public Protection (Risk Evaluation) Guidelines

Measures of Risk - These guidelines focus on two assessment measures of risks related to Reclamation structures: 1) the probability of a dam failure and 2) the life loss consequences resulting from the unintentional release. The annual probability of failure guideline addresses agency exposure to dam failure. As a water resource provider, Reclamation must maintain and protect its dams and dikes that store water. The second measure addresses the life loss component of societal risk. Protection of human life is of primary importance to public agencies constructing, maintaining, or regulating civil works.

Risk Analysis Methods - Reclamation's risk analysis process involves the development of event trees that identify all of the known and potential events, states of nature (existing conditions, site characterization, etc), dam responses, exposure conditions, and consequences. The overall risk from the facility is defined as the accumulation of all risks associated with each of the possible paths through the event trees. The methods to analyze the risks associated with annual dam failure probability and life loss are briefly described in the following two sections. Additional information on the methodology for performing risk analysis can be found in *"Dam Safety Risk Analysis Methodology."*[5]

Potential Applications - Although these guidelines focus on life loss as a dam failure consequence, other consequences, such as environmental and economic consequences, may be applied on specific projects where the decisionmaking process would be enhanced by presentation of the entire breadth of consequences and risks. Economic and/or environmental risk assessment may be performed when the potential for life loss does not provide sufficient or appropriate input for a decision regarding modification of a structure.

A. Evidence of a Developing Failure Mode

If there is evidence of a developing failure mode, there is a clear need to take action to reduce risk. These situations should be brought to the immediate attention of the dam safety decisionmakers to assure a timely response by the agency. Once the evidence is determined to be credible, efforts should focus on those risk reduction actions that can be taken to quickly reduce the potential for life loss or an unintended release of the reservoir regardless of any risk estimates.

B. Annual Probability of Failure (Previously Tier 2)

Measurement Purpose - To manage an effective Dam Safety Program on behalf of the Federal government and to assure public confidence in the performance of public works, dam failures and associated large consequences need to be avoided. A high level of national safety and stewardship of public assets is expected of Reclamation as an agency

[5] Dam Safety Risk Analysis Methodology, Bureau of Reclamation, Denver, Colorado, Version 3.3, September 1999.

specifically entrusted to manage a large inventory of dams. Unintended release of the reservoir can cause significant downstream damage and disruption to routine activities. Once an unintended reservoir release occurs, public trust is compromised and public expectations may impose severe and costly constraints on projects. The greater the inventory of dams and the time of exposure, the more difficult it becomes to ensure that the agency will not experience a dam failure.

Measurement Definition - For comparison to this guideline, the annual probability of failure is defined as the probability of a structural failure or condition that results in an unintentional release of the reservoir that would be expected to result in loss of life. The annual probability of failure is totaled for all specific loading conditions (seismic, static, hydrologic, improper operation, etc.) The probability of events that are not expected to cause life loss are not included, even though there may be some unintended loss of reservoir storage. For example, if a structure accommodates large flows through rockfill without breaching and without causing life loss, then the flow condition would not be included in the probability of failure calculation. Events or conditions that can result in an unintentional reservoir release are referred to as failure modes. These include failure due to loadings from normal and extreme events.

Guideline - To ensure a responsible performance level across the inventory of Reclamation Dams, it is recommended that decisionmakers consider taking action to reduce risk if the estimate of annual failure probability exceeds 1 chance in 10,000. Table 1 provides guidelines to evaluate the need and urgency to implement risk reduction activities based on the annual failure probability estimates:

Table 1. – Guidelines to evaluate Annual Probability of Failure Estimates	
Estimates for annual probability of failure > 0. 0001	The justification to implement risk reduction actions increases as the estimates become greater than .0001. Actions considered reasonable and prudent should be considered for implementation when the annual probability of failure estimate is in this range. A variety of possible actions may be appropriate (see Section IV.D).
Estimates for annual probability of failure < 0. 0001	The justification to implement risk reduction actions diminishes as the estimates become smaller than .0001. Risk reduction action costs, uncertainties in the risk estimates, scope of consequences, operational and other water resources management issues play an increased role in decisionmaking. Actions considered reasonable and prudent should be considered for implementation when the annual probability of failure is in this range.

C. Estimated Risk (Annualized life loss - Previously Tier 1)

Measurement Purpose - Reclamation's primary dam safety concern is to ensure that its structures do not cause life loss. The estimated risk is calculated for each specific loading category (seismic, static, hydrologic, improper operation, etc.) at a dam based on the estimated life loss from dam failure.

Measurement Definition – For dam safety decisionmaking, risk of life loss is measured as the product of the probability of dam failure and the consequences (life loss) associated with that failure. This product is the expected annualized life loss at a given dam for a given loading condition and is referred to as the estimated risk of life loss.

Guidelines - Table 2 provides guidelines to evaluate the need and urgency to implement risk reduction activities based on the estimated risk:

Table 2. – Guidance for Estimated Risk	
Estimated risk is portrayed to be >. 01 lives/year	Reclamation considers that there is justification for taking expedited action to reduce risk. While there is a full range of possible risk reduction actions that can be taken (see section IV.D), Reclamation should focus on those that can quickly reduce risk or improve understanding of the uncertainties associated with the risk. As confidence increases that the risk is in this range, actions considered should concentrate more on reducing the risk than reducing the uncertainties. Any reassessment of the risk should be done prior to increased storage if at all possible, and every effort should be made to complete the reassessment within 90 days of determining the need for expedited risk reduction action.
Estimated risk is portrayed between .01 and .001 lives/year	Reclamation considers that there is justification for taking action to reduce risk. When the range of risk estimates falls in this range, there are a wide variety of possible actions which may be appropriate. However, the actions can be scheduled into the dam safety program and coordinated with other needs at the facility or at other facilities. Actions to reduce risks should be implemented on a schedule that is consistent with budgeting and appropriations processes. Typically, risk reduction should be accomplished within 7 years of a decision that risks need to be reduced. When there is an indicated need for risk reduction, the time spent on additional loading definition, data collection, and risk assessment should be completed in a reasonable timeframe. While it is desirable for this timeframe to be within a year, other times may be considered reasonable by decisionmakers based on the severity of the identified risks. Decisions on adequate time frames should be documented in appropriate decision documents.
Estimated risk is portrayed to be < .001 lives/year	The justification to implement risk reduction actions or conduct additional studies diminishes as estimated risks become smaller than .001. Risk reduction action costs, uncertainties in the risk estimates, scope of consequences, operational and other water resources management issues play an increased role in decisionmaking. Actions considered reasonable and prudent should be considered for implementation when the risk is in this range.

Risk to Small Populations - When life loss estimates are low (less than 10) for a given

loading category, a threshold estimated risk of .001 can potentially expose a small population to failure events with relatively high probabilities. Risk to an individual from dam failure for these cases may be similar to other societal risks such as auto accidents and disease. Accordingly, risks associated with a Reclamation storage facility could contribute significantly to the life risks of an individual in the exposed population. In these cases, the guidelines related to annual probability of failure (section IV.A) serve as an upper limit of exposure to such small populations.

IV. Determining Appropriate Actions

A. Development and Presentation of Risk Estimates

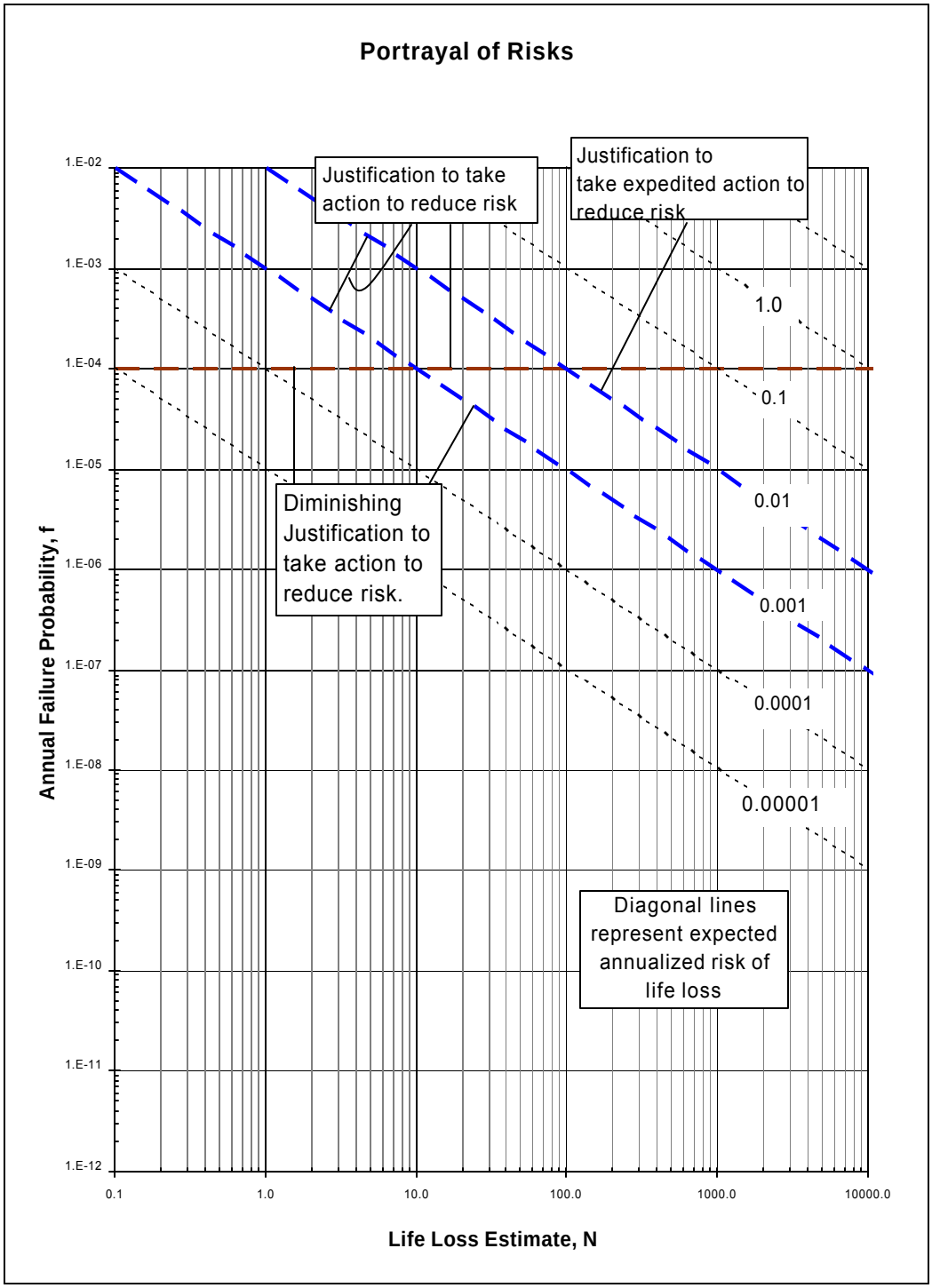
Use of Risk Estimates - Risk analysis provides a means to quantify judgment and to identify the parameters that contribute to risk at a site. The intent of a risk assessment is to review the failure modes for a dam, to decompose the failure modes into separate events, to assign probabilities to the events, and to provide a range of risk estimates so that risks can be compared to these guidelines. Valuable outcomes of the risk assessment include an improved understanding of the critical issues at a dam and a clearer identification of the issues that are the most significant contributors to risk. This knowledge can be used to focus attention on those issues, which, if mitigated, will provide the greatest reduction of risk to the public.

CFR Risk Estimates - Since the risk estimating process during the Comprehensive Facility Review (CFR) is not a detailed team effort, it may have a higher level of uncertainty than an issue evaluation risk analysis. The results of a CFR risk assessment should be presented as the mean estimate or the expected value of risk. If the senior engineer feels that significant assumptions need to be made, resulting in more than one possible scenario to be considered, a range of risk estimates may be presented. If a range of estimates is provided, the CFR must clearly state the specific assumptions or reasons that form the basis of the range of estimates. If the risk estimate is presented as a single point, decision makers should be cognizant of the fact that the estimate actually has a degree of uncertainty associated with it.

Issue Evaluation Risk Estimates - Detailed team risk analyses should also address the uncertainty associated with the risk estimate. Typically in issue evaluation team risk analyses, probability density functions are assigned to the estimates in an event tree. Techniques such as Monte Carlo simulation can be used to show the variability in a number of trials that sample the assigned probability density functions. The risk estimate is defined to be the arithmetic mean of the values computed for all trials. Sensitivity studies may be performed by assigning other reasonable density functions and noting the change in both the variability of the trial estimates and the calculated mean risk estimate. Such sensitivity studies provide the decisionmakers with an estimate of a range of the risk estimate based on the risk model used by the team. If the scatter plots of the Monte Carlo calculation trials are presented, it should be carefully explained that the individual points are not risk estimates as defined in Section II.B. These scatter plots may be useful in analysis and may help communicate the key factors influencing the risk estimates.

Displaying Risk Estimates - The range of risk estimates (annual probability of dam failure and expected annual life loss) should be presented for each load category on an f-N diagram as shown in Figure 1. The f-N diagram illustrates the probability of dam failure, the potential consequences, and the expected annual life loss risk associated with a given load category on one diagram. The guidelines for considering risk reduction action are illustrated as dashed bold lines on the f-N diagram.

Figure 1. - The f-N Chart for Displaying Probability of Failure, Life Loss, and Risk Estimates



Communicating the Basis of Risk Estimates - It is important to note that the key objective of the risk analysis is to communicate the current understanding of risk to the decisionmakers. Decisions will be facilitated by elaboration on the reasons the risk might be higher or lower and the additional information that might better define the risk. For example, the range of risk estimates might not be continuous if there is an important lack of information or if there are alternate interpretations of the available information about a structure. There could be one range of risk estimates that is high and another that is low with the difference being the assumption about the information that is lacking or the interpretation of the available information. This sort of risk estimate communication can be very useful to the decisionmakers when proposals for gathering additional data or for more detailed technical analysis are considered.

B. Assessment (Use and Interpretation) of Risk Results

Action Based Decisionmaking - Dam Safety issues may be identified as Reclamation operates, maintains, monitors, inspects, or analyzes a structure. When issues arise, further data collection, investigation, and related analysis may be required to better understand the public safety or economic implications. Reclamation will address the identified issues by taking an action, prioritizing and scheduling an action, or by documenting a decision that no action is necessary. In general, many issues are raised without implications on continued operation of the facility. The dam safety decisionmakers should consider the potential severity of issues being addressed in the context of the dam safety program objectives and determine if continued normal operation of the facility is appropriate. If a decision is made to continue normal operations while issues are being addressed, then that decision should be documented.

Prioritization - Reclamation has limited financial resources available to address issues. It is critical to not only identify future actions but also to identify the priority or the time frame associated with these actions. The priority for initiating actions to address risks depends in part on available resources and on the risks throughout Reclamation's dam inventory. The intent is to make the greatest reduction in risk throughout the inventory of Reclamation dams within the resource limitations of the program while at the same time assuring that no dam presents an unreasonable risk.

Uncertainty - The quantification of risk estimates is dependent on data and analysis regarding the design, construction, and current condition of a dam, as well as the identified loads that the dam could be subjected to over its operating life. All of this information has some level of uncertainty associated with it. It is acknowledged that the quantification of risk estimates is subjective and is a function of group dynamics, the experience and associated judgment of group members, and the available information for a dam. Thus, uncertainty in the risk estimates is expected. As a consequence, there can be a range of actions that may be suggested for a given range of risk estimates.

Assessing Ability to Reduce Uncertainty - When making a decision regarding future actions, one should consider the risk estimates, the issues most influencing the risks, the

sensitivity of the risks to particular inputs, the cost of additional actions, and the potential for reducing uncertainty. Uncertainty may be reduced by performing additional actions such as collecting more data, by performing more analysis, or by performing a more detailed analysis of the risks. However, there are occasions when additional efforts may not result in significant reduction in uncertainty. It is important to recognize when this is the case and consider the anticipated value of the additional efforts to reduce uncertainty as a factor in selecting a course of action.

Risk Estimate Ranges (range of means) Straddling the Guidelines - In gathering the information necessary for dam safety decisionmaking, the decisionmaker will never have complete or perfect data on which to base the decision. Accordingly, there is some degree of uncertainty in the risk estimates for each dam. When significant uncertainties or assumptions related to a lack of data or interpretations of data result in a range of risk estimates, the results may straddle the guideline values with portions of the risk estimates range portrayed both above and below the guidelines. In these cases, it is important for decisionmakers to assess the portion of the risk estimate range that exceeds the guidelines to determine if it is significant enough to warrant further action or studies. The entire range should be used to assess the need for future actions as well as an aid in setting the priority for initiating the actions. If the range extends into the zone that justifies expedited risk reduction, studies to better define the risk should be the minimum response of the agency.

Level of Analysis Considerations - Because CFR analyses are not detailed team efforts, decisions based on CFR-based risk assessments are typically related to improvements in monitoring, collection of additional data, or performance of additional analyses to reduce uncertainty or improve confidence in the risk estimates. Decisions to change operations or initiate modifications are generally not made as a result of these analyses.
Issue evaluation risk analyses are more extensive analyses of risk and draw on a broader range of expertise. These analyses may require additional data collection, additional analyses, and include a more detailed breakdown and analysis of risks. Risk estimates developed during this activity are often computed using a Monte Carlo simulation and should include sensitivity studies to determine a potential range for the risk estimate.

Risk Reduction Objective - It is important to reduce risk as low as can reasonably be achieved if it is decided to pursue a risk reduction action. As a result, it is desirable to lower the entire range within which the risk estimate would be expected to fall given the uncertainties. An evaluation of the effect of modification alternatives on the range of the risk estimate will enter into the selection of the preferred alternative. In other words, selection of a preferred alternative should focus on moving the range of the risk estimate sufficiently below the guidelines to assure that the dam safety issue doesn't resurface due to slight differences in interpretations of the risk.

Consideration of Future Developments - Future growth in the downstream flood plain, increases in the loading estimates, and changes in the state-of-the-art, may result in increases in risk estimates. Thus, the more risk reduction achieved, the less likely it becomes that future studies will conclude that the risks no longer meet Reclamations guidelines. Risk reduction goals should be considered on a cost versus risk reduction

basis. Ideally, a menu of options, associated costs, and impacts on risk should be considered by the decisionmakers so that prudent decisions can be made.

C. Large Downstream Populations

When the probability of a given loading category is relatively high and there is high potential for downstream life loss, a very low probability of unintended release is required by these guidelines. In such cases, Reclamation focuses on ensuring that there are sufficient protective (defensive design) measures incorporated into the structure. These protective measures either increase confidence in the structure's ability to perform satisfactorily without unintended releases, or increase confidence in Reclamation's ability to detect adverse performance with sufficient lead time to intervene and either prevent an unintended release or provide adequate warning to the public.

In some cases, risk reduction actions may be taken to increase confidence in the performance of the structure even though the dam shows no significant signs of adverse performance. In these cases, decisionmakers should work with the technical experts to ensure that there are sufficient redundancies in the design and operations of the facility to instill confidence in the future performance of the structure.

D. Examples of Alternative Actions

With increased justification for action, there is a need to propose alternative actions that will adequately address the risk and/or probability of failure at the dam. It is important to recognize that there is a broad range of actions that can be taken. These actions can range from further investigations to better understand the uncertainties associated with the risks to decisions to modify structures. In many cases, the chosen course may involve a combination of several actions.

Dam safety decisionmaking generally involves the selection of an appropriate course of action for a given issue based on the magnitude of the risk, the degree of confidence in (or uncertainties associated with) the estimated risk, and the likelihood of additional information providing a significantly enhanced understanding of the issues. The state of knowledge regarding the dam safety issues can lead to a variety of possible actions. While the risks associated with each individual facility pose a unique situation, the following are some of the types of actions which can be taken to either improve Reclamation's understanding of the uncertainties associated with the estimated risk, or to improve confidence in the ability of a structure to perform satisfactorily.

Risk Management Activities:

> **Refine Analyses** – If a risk estimate warrants action primarily due to uncertainties in key elements contributing to the risk, decisionmakers may consider gathering additional information in a timely fashion to assist in quickly reassessing the risk. In pursuing this activity, the decisionmakers should satisfy themselves that there are no immediately developing failure modes. Any expedited reassessment of the risk should be done prior to increased storage if at all possible, and every effort should be made to complete the reassessment within

90 days of determining the need for action. If the reassessment indicates expedited risk reduction action is needed, a decision concerning the risk reduction measures should be made and documented.

Reservoir restrictions - While a reservoir restriction is technically an operational change, it can result in a significant and immediate change in the risk at a dam. The risk reduction results from a reduction in the loading condition and the failure probability. Another benefit is that the reduced storage and reduced head leads to less potential for adverse consequences in the event of poor performance of the structure. However, the loss of storage can have a dramatic impact on water users and the environment. Therefore, consideration of a reservoir restriction requires consideration of both the expected reduction in risk and the certainty of the lost project benefits that accrue from limiting storage in the reservoir.

Increased monitoring - If the risks associated with a failure mode are such that successful intervention would likely be possible or better warning could be provided to local authorities, a potential course of action is to improve Reclamation's ability to detect the existence of the conditions which would be indicative of the failure mode developing (i.e. seepage, deformation, etc.)

Operational changes - In some cases, risks can be reduced at a dam by making changes in the operational and/or maintenance practices at a dam. Examples include establishing minimum gate openings to minimize potential for cavitation, checking gates for drift from their set positions, or alternate procedures for filling reservoirs to lower risks at critical times of the year.

Revised Emergency Action Plan (EAP) - The potential for adverse consequences can be minimized by reviewing the potential failure modes and by developing clear guides to decisionmaking for the types of emergency situations that can be envisioned. Existing EAPs have been developed to detect emergency events based on site specific loading conditions. If a new loading condition or potentially adverse response has been identified for a dam, then the EAP initiating conditions, emergency response levels, expected actions for each response level, and hazard specific appendices can be revised to reflect the current conditions or concerns at the facility. While this course of action will not reduce the probability of an adverse response of the structure, it can help to ensure that people understand the risks at the dam and know how to respond appropriately. This may result in a reduction of the life loss risk.

Loading definition - An important part of understanding risk lies in determining the frequency with which unlikely events affect a dam. In some cases, it is beneficial to gather data that will improve the understanding of the frequency-magnitude relationship of the loading conditions that can potentially lead to failure modes. This information would be used to reanalyze the risks.

Data collection - When there is a lack of knowledge of key properties of a facility, there can be considerable uncertainty in its performance. A prudent

action may be to collect information so the performance of the dam can be better predicted. This additional data would be used to reanalyze the risks.

Structural Modifications - When non-structural actions are not expected to adequately address the risks at a facility, structural modifications to the dam may be considered when additional information will not change the risk outcome. The intent of such modifications is to increase confidence in the satisfactory performance of the structure under the applied loading conditions. Throughout the design and construction process, the risks should be evaluated to assure that design and construction decisions are consistent with the risk reduction objectives.

E. Formulation of Appropriate Risk Reduction Alternatives

Role of Risk Estimates - A key to formulating risk reduction alternatives is using the risk analysis information to assure that proposed alternatives will result in effective risk reduction. When developing the alternatives, the event trees should be reviewed to evaluate which events or conditions are the most significant contributors to the overall risk and/or probability of failure. In some cases, very significant risk reductions can be accomplished by focusing on a specific event or condition. In other cases, with multiple sources of risk, several issues may have to be addressed simultaneously in order to reduce risk and the associated probability of failure to appropriate levels.

Accumulation of Risk Over Time - During a risk reduction action, one should remember that Reclamation's goal is to reduce overall risk. This includes the sum of the risk from before, during, and after a risk reduction action. To minimize this total, it is important to proceed promptly with a risk reduction action when the risk values are high because delay in risk reduction increases the time accumulation of risk. Likewise, it is important to consider risks during construction, because these risks contribute to the accumulation of risk over time. Addressing an annualized potential for dam failure that could be relatively small by incurring a much higher probability of dam failure during the period of time that the dam is being modified may not be appropriate because it raises accumulated risk during the life of the dam to a level higher than would be incurred by not pursuing risk reduction action at all. This factor may influence the choice of modification alternatives and reservoir operations during construction. It should not be used to support a "do nothing'' alternative.

F. Unrecognized Risks

Reclamation recognizes that there will always be a potential for risk associated with unknown conditions at a dam that have not been recognized in the analysis. Therefore, an active examination, monitoring, and evaluation program should be in place to provide a mechanism for early detection of developing and/or potential problems. This early detection information should be used to assess changes in the perceived risks at individual dams, and to prioritize funding for the Dam Safety Program for risk reduction activities. The CFR process provides a framework for assuring that there is a periodic opportunity to reassess risk due to changes in the state-of-the-art of dam design or

changes in dam performance. If no such changes are applicable and no new risks are recognized, then the CFR risk assessment serves as a confirmation of previous risk analyses.

D.10. U.S. Fish and Wildlife Service



1.1 What is the purpose of this chapter? This chapter describes the policy and division of responsibilities for managing the Fish and Wildlife Service's (Service) Dam Safety Program.

1.2 What is the Service policy? Our policy is to:

A. Ensure that no dam creates an unacceptable risk to public safety and welfare, property, the environment, or cultural resources, and

B. Maintain high standards in the practices and procedures we use for planning, engineering design, construction, repairs, operation, maintenance, emergency preparedness, and evaluation of existing dams.

1.3 What are the authorities for the Dam Safety Program?

A. National Dam Inspection Act of 1972 (Public Law 92-367).

B. Executive Order 12148, Federal Emergency Management, July 20, 1979.

C. Water Resources Development Act, Dam Safety Act of 1986 (Public Law. 99-662).

D. Water Resources Development Act of 1996 (Public Law. 104-303).

E. Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams, Federal Emergency Management Agency 97, Interagency Committee on Dam Safety, October 1998.

F. Recommended Guidelines for Dam Safety--Inspection of Dams, Corps of Engineers, 1974.

G. The Dam Safety Act of 2006 (Public Law 109-460).

H. Federal Guidelines for Dam Safety, Federal Emergency Management Agency 93, April 2004.

I. 753 DM, Dam Safety and Security Program.

1.4 Who is responsible for the Dam Safety Program?

A. The **Director** ensures there are resources and policy in place to implement our Dam Safety Program.

B. The **Assistant Director – Business Management and Operations** is responsible for the overall integrity of our Dam Safety Program.

C. Regional Directors are responsible for:

(1) The safety and operation of facilities in their Regions, including dams, dikes, levees, and other water diversion and control structures.

(2) Budget requests for maintenance funding for dams, including routine annual maintenance and correcting Priority 1 and Priority 2 deficiencies identified in the Safety Evaluation of Existing Dams (SEED) inspections.

(3) Appointing a Regional Dam Safety Officer.

D. The **Chief, Division of Engineering** is responsible for:

(1) Managing our Dam Safety Program,

(2) Developing and interpreting dam safety policy, and

(3) Appointing the Service Dam Safety Officer.

E. The **Service Dam Safety Officer (SDSO)** is responsible for:

(1) Developing and recommending plans, technical guidelines, standards, and procedures for our Dam Safety Program.

(2) Ensuring that our Dam Safety Program complies with applicable laws, policies, and technical recommendations governing Federal dam safety activities.

(3) Preparing technical guidelines and standards for and implementing the SEED inspection and rehabilitation programs by:

(a) Performing periodic SEED inspections and notifying the Project Leader of the inspection findings,

(b) Managing and maintaining an inventory and a comprehensive database on all Service dams, and

(c) Serving as a liaison with other Service programs for dam inspections and rehabilitation.

(4) For high and significant hazard dams:

(a) Preparing budget requests for:

(i) Project planning,

(ii) Engineering design,

(iii) Analysis and studies,

(iv) Construction management for emergency repairs, and

(v) Safety rehabilitation and construction.

(b) Developing Standing Operating Procedures (SOPs) and Emergency Action Plans (EAPs) and updating them for major repairs or rehabilitation.

(c) Project planning, design, and construction for new dams and for rehabilitation, modification, or emergency repairs to existing dams.

(5) For low hazard dams, providing independent review of project planning, engineering design, and construction management for dam safety rehabilitation and construction.

(6) Serving as the Service's representative on:

(a) Dam safety technical committees,

(b) Departmental working groups, and

(c) As liaison with other Government agencies.

(7) Assisting Regional Dam Safety Officers in implementing SOPs and Emergency Action Plans.

(8) Performing periodic Emergency Action Plan exercises (see 361 FW 2).

(9) Providing technical engineering support and expertise to the Regions.

(10) Providing dam safety training to the Regions, Project Leaders, and dam operating staff.

F. At the discretion of the Regional Director, **Assistant Regional Directors – Budget and Administration** are responsible for providing advice and guidance to the Regional Engineers and the Regional Dam Safety Officers in their Regions in exercising their dam safety responsibilities.

G. At the discretion of the Regional Director and working through the Assistant Regional Director – Budget and Administration, **Regional Engineers** are responsible for:

(1) Implementation and oversight of the Region's Dam Safety Program and designation and supervision of the Regional Dam Safety Officer.

(2) Technical support and assistance to the Regional Director, Regional office supervisors, and Project Leaders for the operation and maintenance of dams within the Region.

(3) Assisting the Regional Dam Safety Officer in developing and implementing SOPs and Emergency Action Plans.

H. Regional Dam Safety Officers (RDSO):

(1) Must have experience in and knowledge of the planning, design, construction, safety inspection, and operation of dams.

(2) Are responsible for:

(a) Providing technical support to the Regional Director to ensure that the Region's dam safety program complies with applicable laws, policies, and technical recommendations governing Federal dam safety activities.

(b) Providing technical assistance to Project Leaders for dam operation and maintenance.

(c) Assisting the Service Dam Safety Officer in developing and updating SOPs and Emergency Action Plans and assisting Project Leaders to implement them.

(3) Are the designated emergency planning officers, who:

(a) Annually test, verify, update and certify Emergency Action Plans, and

(b) Provide technical and decisionmaking support to Project Leaders during unusual or emergency events.

(4) Provide technical leadership and oversight of project planning, engineering design, and construction management for dam safety for low hazard inventory and non-inventory dam:

(a) Rehabilitation,

(b) Modifications,

(c) Emergency repairs, and

(d) New construction.

(5) Review observation and instrumentation data from dams, and contact the Division of Engineering and the Service Dam Safety Officer to request consultation.

I. Project Leaders are responsible for:

(1) Operating, maintaining, and keeping the dams for which they are responsible safe.

(2) Sending to the Regional Director funding requests for:

(a) Routine annual and regular maintenance,

(b) Operations and monitoring, and

(c) Priority 1 and Priority 2 recommendations identified in SEED inspections (see 361 FW 2 for more information about SEED inspections).

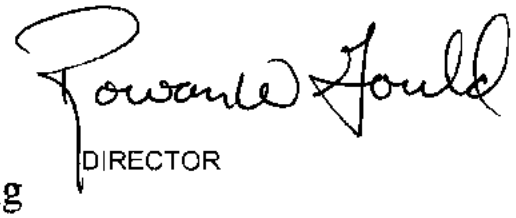
(3) Ensuring operating staff are adequately trained on all relevant dam safety matters.

(4) Ensuring the safety of employees and visitors who may be impacted by dam failure or misoperation.

(5) Implementing Emergency Action Plans, security plans, and SOPs.

(6) Ensuring that all of the monitoring and recording of dam instrumentation data is complete and sent to the Regional Dam Safety Officer and the Service Dam Safety Officer in accordance with SOPs.

(7) Performing periodic informal inspections in accordance with SOPs.



Acting DIRECTOR

Date: September 12, 2008

2.1 What is the purpose of this chapter? This chapter describes the standards and requirements of our Dam Safety Program.

2.2 What terms do you need to know to understand this chapter?

A. Cross-dike or interior dike. A cross-dike or interior dike:

(1) Is an artificial embankment constructed to subdivide a reservoir or provide vehicular access across a reservoir,

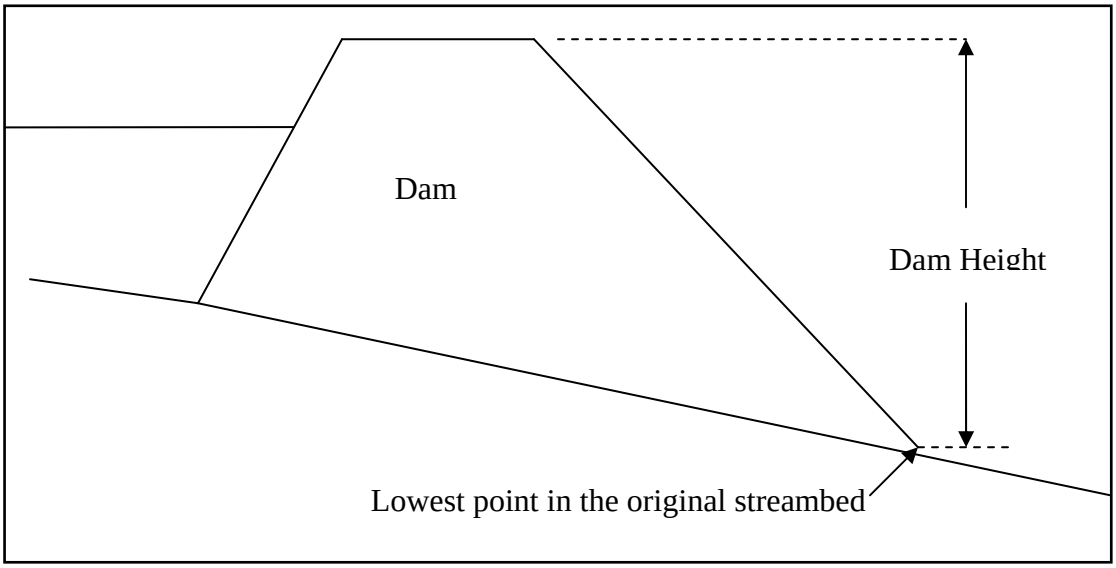
(2) Does not provide any additional water storage above the maximum storage of the dam that creates the reservoir, and

(3) May be considered a dam if the difference in the water surface elevation from upstream to downstream of the dike can be more than 3 feet.

B. Dam. A dam is an artificial barrier, including appurtenant works, constructed to impound water for permanent storage or flood control storage.

C. Dam Height. A dam's height is the vertical distance between the lowest point on the dam crest and the lowest point in the original streambed measured at the toe of the dam (see Figure 1).

Figure 1: Dam Height



D. Hazard Classification. Hazard classification is a rating based on the potential loss of life or property damage downstream of a dam if the dam were to fail or be misoperated. We do not determine hazard classification based on the existing condition of a dam and its appurtenant structures.

E. **Hydraulic Height**. A dam's hydraulic height is the vertical distance between the maximum design water level and the lowest point in the original streambed measured at the toe of the dam.

F. Inflow Design Flood. The Inflow Design Flood is the rate of water coming into the reservoir over time that the dam must be able to safely pass through a combination of spillway and outlet works and attendant surcharge storage.

G. Inventory Dam. We include a dam in the Service Inventory of Dams and the National Inventory of Dams if it meets the following criteria:

(1) It has a storage capacity at maximum water storage elevation in excess of 15 acre-feet, and:

(a) It exceeds 25 feet in height from the natural bed of the stream (or a watercourse) to the maximum water storage elevation measured at the downstream toe of the dam, or

(b) If it is not across a stream channel or watercourse, it exceeds 25 feet in height measured from the lowest elevation of the outside limit of the dam, to the maximum water storage elevation; or

(2) It exceeds an impounding capacity at maximum water storage elevation of 50 acre-feet **and** a height measured as section 2.2 G(1) above describes in excess of 6 feet; and

(3) It has a high or significant hazard classification.

H. Maximum Water Storage Elevation. The maximum water storage elevation is the highest elevation of water that the dam can impound, including temporary storage of flood water.

I. Maximum Design Water Level. The maximum design water level is the highest elevation of water determined as a result of safely passing the Inflow Design Flood (see section 2.15A).

J. Noninventory Dam. Noninventory dams are:

(1) Low hazard dams that do not meet the criteria in section 2.2G, and

(2) Interior dikes or cross dikes located within an impoundment.

K. Probable Maximum Flood (PMF). The Probable Maximum Flood is the runoff flow of water that we expect from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in a drainage area under study.

L. Structural Height. The structural height of a dam is the vertical distance between the lowest point on the crest of the dam and the lowest point of the excavated foundation.

2.3 How does the Service classify dams? We classify dams based on hazard potential and a dam's size.

A. Hazard Classification. The hazard classification for a dam gives us the minimum requirements for security, investigation, design, and construction.

(1) The Regional Dam Safety Officer (RDSO) or a member of the Service's Dam Safety inspection team provides a preliminary hazard classification recommendation.

(2) The Division of Engineering analyzes the hazard classification, when appropriate, in accordance with the latest version of the Federal Emergency Management Agency (FEMA) 333, Department of the Interior (753 DM), and the Bureau of Reclamation (BOR) guidelines, (i.e., Downstream Hazard Classification

Guidelines, Assistant Commissioner Engineering and Research (ACER) Technical Memorandum (TM) #11).

(3) A hazard classification panel assigns a formal hazard classification to all Service dams by using the RDSO's preliminary hazard classification recommendation, the Division of Engineering's hazard classification analysis, and other data.

(a) The panel consists of a Service Dam Safety Officer (SDSO) designee(s), the affected RDSO and an RDSO from another Region. The panel provides a written determination to the SDSO.

(i) A majority vote of the panel is required to classify new dams, and

(ii) A unanimous vote of the panel is required to change the hazard classification of existing dams.

(b) The hazard classification panel determines the formal classification of a dam in accordance with the guidelines in section 2.3A(2).

(4) The RDSO reviews the hazard classification of low hazard inventory dams and noninventory dams at least every 6 years.

(5) The RDSO or the SDSO may request the reclassification of a dam.

B. Size Classification. The RDSO or a member of the Service's Dam Safety inspection team determines the size classification of a dam. They use the dam height or the water storage capacity at maximum water storage elevation, whichever yields the larger size classification, to determine the size of a dam.

(1) Small dams are structures that are less than 40 feet high or that impound less than 1,000 acre-feet of water.

(2) Intermediate dams are structures that are 40 to 100 feet high or that impound 1,000 to 50,000 acre-feet of water.

(3) Large dams are structures that are more than 100 feet high or that impound more than 50,000 acre-feet of water.

2.4 What is the Service's Safety Evaluation of Existing Dams (SEED) inspection program?

A. The SEED Inspection program.

(1) Purpose. The purpose of the SEED Program is to ensure protection of life and property and to assure the integrity of our inventory dams and appurtenant structures (also see The Federal Guidelines for Dam Safety FEMA 93, 2004). Periodic inspections disclose conditions that might disrupt operation or threaten dam safety.

(2) Correction of Deficiencies. We must correct any deficiencies noted as a result of inspections. The Division of Engineering will set priorities and completion dates to correct deficiencies in accordance with the relative level of failure potential and downstream consequences. To determine priorities for maintenance, repair, or removal, the Division of Engineering looks at the adequacy of structures and facilities to continue serving the purpose for which they were constructed and identifies the extent of deterioration.

B. Types of Inspections. There are four types of inspections:

(1) Informal inspections are visual examinations carried out during day-to-day operations. They provide frequent surveillance of the general appearance and functioning of the dam and its appurtenances to identify, as soon as possible, any readily observable changes. For each high and significant hazard dam, Project Leaders and staff perform these inspections in accordance with the dam's Standing Operating Procedures (see section 2.5).

(2) Formal SEED inspections assess the safety and integrity of all aspects of a dam. Formal inspections are comprehensive searches for evidence of deterioration of materials, developing weaknesses, and unsafe hydraulic or structural conditions. Engineers perform these inspections which include:

(a) Field examinations,

(b) Photographic or video recording of all physical features,

(c) Examination of any adjacent endangering conditions,

(d) Review and evaluation of all recorded performance data, including engineering loadings, analytical methods, instrumentation and spillway discharge measurements,

(e) Evaluation of the performance of the dam and a comparison of the long-term examination record with current conditions,

(f) An overall condition rating, and

(g) Recommendations to maintain or improve the integrity of the dam.

(3) Intermediate SEED inspections are visual site investigations conducted to identify deterioration of materials, developing weaknesses, and unsafe hydraulic or structural conditions.

(a) Engineers perform these inspections which consist of:

(i) Field examinations,

(ii) Photographic or video recording of all physical features, and

(iii) Examination of any adjacent endangering conditions.

(b) Intermediate inspections do not include a comprehensive evaluation of the engineering loadings and analytical methods to predict dam performance.

(4) Special inspections are made following (or during, if possible) unusual floods, significant earthquakes, mishaps, or the appearance of unexpected dam performance. These inspections determine the extent of any damage and the need for emergency repair or other action.

C. Frequency of Inspections.

(1) Project Leaders and dam operators perform informal inspections routinely during day-to-day operations in accordance with SOPs.

(2) The frequency of formal and intermediate inspections is based on the hazard classification of the dam.

(a) High and significant hazard dams are inspected every 3 years, alternating between a formal SEED inspection and an Intermediate SEED inspection.

(b) Low hazard dams are inspected every 6 years, alternating between a formal SEED inspection and an Intermediate SEED inspection. (The SDSO may change the frequency based on size and condition of the dam.)

(3) The frequency of special inspections depends on the occurrence of an unusual event (e.g., seepage through the dam has become turbid). Those responsible for the dam must be alert to identify situations or events that may require special inspections.

D. Reporting Dangerous or Unusual Conditions.

(1) The SEED Inspector must immediately report dangerous or unusual conditions to the Project Leader and the RDSO.

(2) In response to a dangerous or unusual condition, the RDSO must immediately:

(a) Initiate appropriate response in accordance with the dam's Emergency Action Plan (see section 2.6 and 361 FW 3), and

(b) Contact the SDSO and the Regional Safety Manager if an inspection indicates imminent danger or threat of serious injury or significant property damage.

E. Inspection Reports.

(1) Use written checklists for informal inspection reports. They contain enough information to determine whether or not further action is necessary and may be obtained from the SDSO or the RDSO.

(2) Formal and intermediate inspection reports are written reports prepared in a format consistent with established Service guidelines.

F. Inspectors.

(1) Inspectors for Informal Inspections: These inspectors:

(a) May be Project Leaders, dam operators, and other Service personnel who are in the vicinity of the dam in the course of their regular activities. The RDSO may request an individual to conduct informal inspections of a dam.

(b) Should have a basic knowledge of dams so they can recognize unusual conditions, abrupt changes from previous conditions, and obvious new defects such as seepage, cracks, and displacements.

(2) Inspectors for Formal, Intermediate, and Special Inspections:

(a) High and Significant Hazard Dams: Staff from the Division of Engineering, RDSOs, or consultants perform SEED inspections for high and significant hazard dams. Members of the inspection team must include a Registered Professional Engineer trained in the safety inspection of dams.

(b) Low Hazard Dams: Staff from the Division of Engineering, RDSOs, or consultants perform SEED inspections for low hazard dams. Dam safety professionals must perform the inspections under the direct supervision of a Registered Professional Engineer trained in the safety inspection of dams.

2.5 What are the requirements for writing Standing Operating Procedures (SOPs)?

A. The SDSO must:

(1) Prepare SOPs for all high and significant hazard dams using the Service format.

(2) Update SOPs associated with major repair or rehabilitation to high and significant hazard dams.

B. The RDSO must annually review and update, as appropriate, the SOPs for each high and significant hazard dam within the Region.

2.6 What are the requirements for writing and implementing Emergency Action Plans? The SDSO must prepare Emergency Action Plans for all high and significant hazard dams (see 361 FW 3 for more information about Emergency Action Plans).

A. The RDSO:

(1) Must annually review the Emergency Action Plan for each high and significant hazard dam within the Region in accordance with procedures outlined in the Emergency Action Plans.

(2) Is responsible for:

(a) Annual testing, verification, and certification of Emergency Action Plans by November 1st.

(b) Submitting a verification statement, in accordance with the SOPs, along with any revisions to the Emergency Action Plans, to the SDSO annually on or before November 30th.

(c) Distributing revisions of the Emergency Action Plan to the plan holders.

B. The SDSO is responsible for:

(1) Performing Emergency Action Plan periodic tests every 6 years concurrent with Formal SEED inspections and tabletop exercises concurrent with Intermediate SEED inspections, and

(2) Updating Emergency Action Plans associated with major repair or rehabilitation to high and significant hazard dams.

2.7 What is the approval process and procedure for building new dams?

A. Review and Approval. Table 2-1 shows who must review and approve or decline to approve all plans, designs, drawings, and construction specifications for Service dams by performing a Qualified Engineering Review and Approval:

Table 2-1: Who Must Review and Approve Plans, Designs, Drawings, and Specifications	
Type of Dam	**Approving Official(s)**
Noninventory dams	The RDSO

Table 2-1: Who Must Review and Approve Plans, Designs, Drawings, and Specifications	
Type of Dam	**Approving Official(s)**
Low hazard inventory dams	The RDSO and SDSO
High and significant hazard dams	The SDSO (The SDSO must also obtain an independent review by an outside organization, such as the Bureau of Reclamation, the Army Corps of Engineers, or a consultant.)

B. Project Planning, Design, and Construction.

(1) The SDSO or a designee serves as the project manager for planning (including environmental impacts), design, permitting and construction of high and significant hazard dams.

(2) The Regional Engineer designates the RDSO or another qualified engineering staff person to be the project manager for planning (including environmental impacts), design, permitting and construction of all low hazard, inventory dams, and noninventory dams.

(3) The RDSO classifies all new dams as either inventory or noninventory dams. The RDSO sends this determination, along with the vital statistics of the dam, to the SDSO. The SDSO adds the dam to the Service inventory, if appropriate.

2.8 How does the Service address newly acquired dams? Before acquiring new lands, we must identify any dams being conveyed with the property. We must inspect and classify the dams and clearly identify any needed rehabilitation or repair costs before we acquire the land.

A. The RDSO must ensure that a SEED inspection is performed as part of the Engineering Assessment we conduct for all proposed land acquisitions (see 341 FW 2). See section 2.4 for more information about the SEED inspection program

(1) The SEED inspection should describe:

(a) The condition of the dam,

(b) The cost of any work required to bring the dam up to Service safety standards, and

(c) Future costs and liabilities associated with the dam.

(2) The RDSO must review the SEED report and approve it before it can be included with the Engineering Assessment. The Engineering Assessment must clearly state any significant deficiencies and costs associated with the dam(s) and must be included in the Decision Document the Region's Engineering Division gives to the Regional Director for approval (see 341 FW 1).

B. The RDSO must ensure that SEED II studies are performed on all newly acquired dams. The SEED II study is a detailed assessment of the design and condition of the dam and normally includes hydrologic and hydraulic, structural, and geotechnical analyses (stability, seepage, liquefaction, etc).

C. The acquisition contract or other legally enforceable agreement should include the cost associated with work required to bring the dam up to Service safety standards, including modifications, repairs, and development of Emergency Action Plans and SOPs. Land acquisition budget requests should include the costs for SEED inspections and SEED II studies (see 341 FW 3).

2.9 What is the process for rehabilitating, modifying, or repairing an inventory dam?

A. We must follow the same approval process and procedures for major rehabilitation, modification, or emergency repair of inventory dams as for new dams (see section 2.7).

B. Major rehabilitation or modification may include:

(1) Raising a dam crest,

(2) Enlarging or replacing spillways and outlets, and

(3) Constructing auxiliary or emergency spillways.

C. Major rehabilitation, modification, or emergency repair does not include annual operation and maintenance work such as repairs to gates, repair of erosion on embankments, simple concrete repair, etc.

2.10 How do Project Leaders request funding for safety modifications, operations and monitoring, and rehabilitation of dams? Table 2-2 shows who should request funding for modifying and operating dams.

Table 2-2 Requesting Funding		
Type of Project	**Responsible Official(s)**	**How Requested**
A. Routine maintenance, operations and monitoring and minor repairs of high and significant and low hazard dams	Project Leaders and Regional Service Asset Maintenance Management System (SAMMS) Coordinators	Resource Management funds through SAMMS
B. Priority 1 and 2* recommendations except recommendations for engineering studies or major repair or rehabilitation	Project Leaders and Regional SAMMS Coordinators	Resource Management funds through SAMMS the year they are identified in SEED inspections
C. Planning, design, and construction of major rehabilitation or modification to low hazard dams and appurtenances and noninventory dams	Project Leader, in consultation with the RDSO and the Regional Engineer	Resource Management or Construction funds through SAMMS or the Construction 5-year Plan
D. Planning, design, and construction of major rehabilitation or modification to high and significant hazard dams and appurtenances	SDSO, through the Chief, Division of Engineering	Construction funds through the Construction 5-year Plan

***P1** Recommendations indicate that the normal condition of the structure is impaired and the safety of the structure is in jeopardy.
P2 Recommendations are mainly maintenance deficiencies.

2.11 How does the Service coordinate with State Dam Safety Programs? We consult on the design and safety of dams with the Dam Safety Program officials in the States in which we own, operate, or propose to construct a dam. We also invite State officials to participate in safety inspections and Emergency Action Plan exercises.

2.12 What are the requirements for privately funded dams on Service property?

A. To allow construction of a privately funded dam on Service property the proposed dam must satisfy the requirements in section 2.7, and the SDSO must review and approve a Professional Engineer's certification of the dam. The Professional Engineer must be licensed by the State in which the dam will be located.

B. The certification must at least attest to the following:

(1) The hazard and size classification of the dam;

(2) The proposed project has been designed by a Professional Engineer, qualified in dam design and construction, to meet Federal standards for dam design, construction, and rehabilitation including, but not limited to, the Federal Guidelines for Dam Safety (FEMA 93, 2004) and Service design standards;

(3) The project design and specifications have been reviewed and approved by the State dam safety program staff;

(4) There is a dedicated funding source for future operation, inspection, maintenance, and repairs of the dam;

(5) If the dam is a high or significant hazard dam, there is an Emergency Action Plan in effect for the dam that meets the requirements of Emergency Action Planning for Dam Owners (FEMA 64, 2004); and

(6) Federal and State permits will be obtained prior to construction.

2.13 How are privately owned dams on Service property inspected?

A. The non-Federal entity who owns the dam or lessee is responsible for ensuring the dam complies with State regulations and the Federal Guidelines for Dam Safety (FEMA 93 April, 2004). Although Service inspection teams do not inspect private dams, the SDSO maintains a list of the dams.

B. Responsibilities for dam safety must be identified in the Memorandum of Understanding or lease agreement that authorizes use of Service lands. Responsibilities should include ensuring the owner/lessee contacts the Project Leader and the RDSO if significant dam safety deficiencies or unusual circumstances are identified on a private dam on Service property.

2.14 What are the requirements for State dam projects to which the Service provides funding?

A. We may provide funds to supplement approved State dam safety projects on a cost-sharing basis through the Federal Aid Program.

B. For all inventory dams for which we provide funds (see section 2.2G), we must obtain:

(1) Reasonable assurances that the State has a dedicated funding source to safely operate and maintain the dam and that there is an Emergency Action Plan for any high and significant hazard dams, and

(2) Certification from the State Dam Safety Official, signed by a Registered Professional Engineer licensed in the requesting State, that proposed projects involving the construction, enlargement, or rehabilitation of any dam (including appurtenant works) satisfies the criteria for our inventory and meets Federal requirements. The certification must attest to the following:

(a) The hazard and size classification of the dam are correct and its present condition and deficiencies have been accurately identified;

(b) The proposed project has been designed by a Professional Engineer, qualified in dam design and construction, to meet Federal standards for dam design, construction, and rehabilitation including, but not limited to, the Federal Guidelines for Dam Safety (FEMA 93, 2004), and any other technical requirements identified in the Federal Aid project agreement documents;

(c) A Registered Professional Engineer qualified in the design and construction of dams completed the State's technical review of the project design and specifications;

(d) There is a dedicated funding source that will provide for future operation, inspection, maintenance, and repairs of the dam;

(e) If the dam is a high and significant hazard dam, there is an Emergency Action Plan in effect for the dam that meets the requirements of Emergency Action Planning for Dam Owners (FEMA 64, 2004); and

(f) Federal and State permits will be obtained prior to construction.

C. The requirements in section 2.14B do not apply to noninventory Federal Aid dams.

2.15 What are the technical standards for the Dam Safety Program? The planning, design, construction, and rehabilitation of all inventory dams must follow the technical standards below and in 361 FW 1 and 3.

A. Inflow Design Flood. The Inflow Design Flood is the rate of inflow discharge into the reservoir over time that the dam must be able to safely pass through a combination of spillway and outlet works and attendant surcharge storage.

(1) Service inventory dams must meet the Inflow Design Flood standards in Exhibit 1.

(2) The Project Leader must obtain a waiver from the Inflow Design Flood standards in Exhibit 1:

(a) For high or significant hazard dams from the Chief, Division of Engineering and the SDSO.

(b) For low hazard inventory dams from the SDSO and the RDSO.

(3) Approval of Inflow Design Floods other than those in Exhibit 1 may be granted only after performing an incremental damage assessment or risk-based analysis to determine if a waiver is appropriate.

(a) Studies and mapping must clearly demonstrate that consequences of dam failure at flood flows larger than the selected Inflow Design Flood will not increase projected loss of life and will have no significant incremental increase on property damage. All Inflow Design Floods must follow FEMA 97, Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams or a more conservative approach. Analysis must include existing structures and inhabitants and projected inhabitants and structures based on approved planning documents and over at least the next 20 years. The incremental

increase in property damage versus the potential frequency of floods must be clearly identified in a management decision chart.

(b) The RDSO or the SDSO must provide the proposed Inflow Design Flood using an incremental damage assessment or risk-based analysis to the affected State dam safety office for review and discussion.

(c) The minimum Inflow Design Flood for high and significant hazard dams must at least meet the 100-year flood frequency.

B. Freeboard Requirements. Freeboard is the vertical distance from the water surface to the top of the dam. Freeboard should meet the requirements of ACER TM No. 2, Freeboard Criteria and Guidelines for Computing Freeboard Allowances for Storage Dams, BOR 1992 or the latest revision.

C. Low-Level Outlets. All inventory dams must have a low-level outlet that can evacuate the major portion of the reservoir storage volume by gravity flow.

(1) Only the SDSO may approve waivers to this requirement.

(2) Criteria for reservoir draining should recognize site-specific conditions, economic aspects, and project needs to provide an acceptable balance between costs and rates of draining and filling. Draining times established for a dam reflect downstream channel capacity, level of risk to the dam, and hazard potential to the downstream areas. A low-level outlet works, in conjunction with other release facilities, should meet the requirements in Criteria and Guidelines for Evacuating Storage Reservoirs and Sizing Low-level Outlet Works, ACER TM No. 3, the Department of the Interior, BOR 1990 or the latest revision.

(3) For small low-hazard inventory dams, the low-level outlet works, in conjunction with other release facilities, should be located and sized to draw down the reservoir within 1 to 4 months, at a minimum, to the lower of the following levels:

(a) The reservoir level commensurate with a storage capacity that is 10 percent of that at the normal reservoir level, or

(b) The reservoir level with less than 50 percent of the hydraulic height.

D. Risk Analyses: The Division of Engineering may use risk assessments to identify appropriate repair criteria. The assessments predict the annual probability of loss of life and failure probabilities of the structure over a projected 50-year period.

(1) The average annual loss of life probability must be less than or equal to 1 in 1,000.

(2) The annual failure probability of the structure must be less than or equal to 1 in 10,000.

Acting DIRECTOR

Date: September 12, 2008

D.11. U.S. Forest Service



FSM 7500 - WATER STORAGE AND TRANSMISSION
CHAPTER ZERO CODE

Table of Contents

7501 – AUTHORITY 2
7502 – OBJECTIVES 3
7503 – POLICY 3
7504 – RESPONSIBILITY 5
7504.1 – Chief 7
7504.2 - Washington Office, Director of Engineering 7
7504.3 - Dam Safety Officer 7
7504.4 - Regional Foresters 7
7504.5 - Forest Supervisors 8
7505 - DEFINITIONS 9
7506 - REFERENCES 10
7509 - HANDBOOKS 10
7509.1 - Internal Service-wide Handbooks 10
7509.11 - Dams Management Handbook (FSH) 10

This title establishes policies, standards, and criteria for the investigation, design, construction, emergency planning and response, maintenance, and operation of water storage and transmission structures administered or permitted by the Forest Service. Water storage structures include class A, B, C, and D dams, including settling ponds and tailing dams. Water transmission structures include ditches, flumes, tunnels and penstocks.

7501 – AUTHORITY

The installation and operation of water storage and transmission facilities on National Forest System lands are carried out under the authorities and limitations of various laws and the regulations of the Secretaries of Agriculture and Army, as well as the Federal Energy Regulatory Commission. Key authorities are as follows:

1. Presidential Memorandum of October 4, 1979, directed Federal Agencies to implement the "Federal Guidelines for Dam Safety" published on June 25, 2979, by the Ad Hoc Interagency Committee on Dam Safety of the Federal Coordinating Council for Science, Engineering, and Technology, Washington, D.C., June 25, 1979, and to report implementation progress to the Federal Emergency Management Agency (FEMA).

2. Departmental Regulation 1043-18 establishes the U.S. Department of Agriculture (USDA) Dam Safety Committee, requires member agencies to name a Dam Safety Officer, assigns the Soil Conservation Service (SCS) Dam Safety Officer as the USDA contact for FEMA, and requires the Forest Service Dam Safety Officer to participate in technical dam safety activities with FEMA.

3. Title 36, Code of Federal Regulations, Part 251 and FSM 2700 establish that, authorized uses of lands managed by the Forest Service include special uses such as reservoirs, canals, ditches, flumes, pipelines and other facilities for the impoundment, storage, transportation, or distribution of water.

4. Title 18, Code of Federal Regulations, Part 4 provide that Federal Energy Regulatory Commission (FERC) regulations related to licenses and permits for dams, pipelines, and other water storage and transmission facilities related to power generation establish authority to require conditions for issuing a FERC license (FSM 2770).

5. Title 33, Code of Federal Regulations, Part 208 establishes that the Army Corps of Engineers has the authority to prescribe regulations for the use of storage allocated for flood control at all reservoirs constructed wholly or in part with Federal funds, with the regulations normally implemented by letters of understanding between the Corps of Engineers and the project owners.

6. Water Resources Development Act of 1992 (33 U.S.C. 2201) directs participation in updating and maintaining of the National Dam Inventory.

7502 – OBJECTIVES

Manage water storage or transmission structures administered or permitted by the Forest Service to:

1. Prevent sudden failure resulting in loss of life or extensive damage to property or the environment.

2. Efficiently and effectively achieve planned benefits such as fisheries enhancement, improved recreational opportunities, and increased livestock watering.

3. Protect the government's investment and interest in facilities.

4. Minimize the potential liability of the Forest Service from failures of Forest Service owned and permitted dams.

7503 – POLICY

The policies in this section apply with equal force whether the dam has a permanent reservoir or is a detention dam for temporary storage of flood waters. Except for inventory of dams, these standards and criteria may be modified on a case-by-case basis for moderate and low-hazard class D dams. Any dam up to but not more than 6 feet high, regardless of storage capacity, or which has a maximum storage capacity not greater than 15-acre feet, regardless of height, may be excluded from this policy unless there is a potentially significant downstream hazard.

1. Ensure that the design, construction, operation, and maintenance of Forest Service owned dams and dams authorized by special use permits or other instruments meet acceptable standards or withdraw them from service to the degree necessary to safeguard life and property.

2. Use funds from benefiting function(s) for technical work related to dams owned by the Forest Service and authorized under special use permit (FSM 7515).

3. Fully coordinate technical reviews, construction monitoring, and inspections with environmental and resource management review processes.

4. Do not relieve an owner of a dam from the responsibility for providing and maintaining a safe structure.

5. Do not duplicate reviews performed by State and other Federal Agencies, or the Engineer retained by the proponent, if those reviews meet Forest Service objectives and standards.

6. Use the Memorandum of Understanding with the Soil Conservation Service (SCS) as the basis for coordinating SCS-sponsored projects on National Forest System lands (FSM 1541).

7. Ensure the following conditions are met when existing dams are acquired by the Forest Service:

a. When dams are acquired voluntarily such as through land exchange--

(1) Ensure the overall decisionmaking process includes an engineering study that addresses the structural condition of the dam.

(2) Identify any hazards to existing downstream life and property, and identify potential hazards if future development should occur.

(3) If the dam requires rehabilitation, identify costs of repairs.

(4) Identify long-term costs of maintaining and operating the dam.

(5) Identify any benefiting functions (FSM 7515).

b. If a dam is acquired involuntarily, such as by abandonment, ensure proper administrative and legal steps have been followed and that the ownership has been vested in the United States (FSM 2716.4).

8. Comply with the policies on the following aspects of water storage and transmission facilities management identified in the cross-referenced sections of the Forest Service Manual:

a. Facilities located in wilderness areas (FSM 2320.3, 2323.42, 2326).

b. Flood plain management (Executive Order 11988 issued May 24, 1977) (FSM 2527).

c. Wetlands protection (Executive Order 11990, issued May 24, 1977) (FSM 1950, 2527).

d. Special uses management (FSM 2700).

7504 – RESPONSIBILITY

Exhibit 01 summarizes responsibilities assigned in this chapter.

7504 - Exhibit 01

Summary of Responsibilities

Activity	Chief (DE)	DSO	RF (RDE)	FS
1. Appoint Dam Safety Officer.	O			
2. Advise and update Chief.	X			
3. Represent Forest Service on Interagency Coordinator matters.	X			
4. Establish procedures.		X		
5. Ensure Service-wide coordination.		X		
6. Monitor and report.		X		
7. Review and approve design and safety evaluations, and approve water storage and transmission projects prior to use:				
a. Class A, B, C, and high hazard D dams.			O (RE)	
b. Design approval of water transmission and class D moderate and low hazard dams.			X	O
c. Inspect **ALL** dams and water transmission projects (A, B, C, and D).			X	O
8. Establish policy, standards, and criteria for:				
a. Dam safety and water transmission			O	
b. Design, construction, operation, and maintenance of class D moderate and low hazard dams.			O	

7504 - Exhibit 01--Continued

Activity	Chief (DE)	DSO	RF (RDE)	FS
9. Determine that work meets standards for the life of the project.			O	
10. Maintain dams inventory.			O	
11. Monitor and report on quality and effectiveness of dam management program.			O	
12. Provide training and assistance with emergency action plans.			O	
13. Ensure dams are operated and maintained in accordance with guidelines and standards.				X
14. Designate qualified personnel.				X
15. Ensure qualified personnel participate in management of permitted facilities.				X
16. Ensure inspections are completed at designated intervals by qualified personnel.				X
17. Ensure emergency action plans are prepared, maintained, and tested.				X
18. Maintain documents and records.				X

Notes:		
	X	Delegable
	O	Not Delegable
	DE	Director of Engineering, WO
	DSO	Dam Safety Officer
	RDE	Regional Director of Engineering
	FS	Forest Supervisor

7504.1 – Chief

The Chief reserves the authority to appoint a Dam Safety Officer for the Forest Service through the Washington Office, Director of Engineering.

7504.2 - Washington Office, Director of Engineering

It is the responsibility of the Director of Engineering to:

1. Advise the Chief of the adequacy of administrative and technical procedures used to manage dams and water transmission structures.

2. Periodically update the Chief on compliance with water storage and transmission objectives through reports such as the Biennial Report on Dams Safety provided to the Federal Emergency Management Agency.

3. Represent the Forest Service on interagency coordination matters within the Department of Agriculture on dams and water transmission structures.

7504.3 - Dam Safety Officer

It is the responsibility of the Dam Safety Officer to:

1. Establish procedures for conducting the dam safety activities of the Forest Service.

2. Coordinate Service-wide engineering aspects of the dam safety activities with other units, agencies, departments, and organizations.

3. Monitor and report on the quality and effectiveness of Regional administrative and technical practices.

7504.4 - Regional Foresters

It is the responsibility of Regional Foresters to:

1. Review and, if appropriate, approve or certify the acceptability of emergency action plans, designs, and safety evaluations for all classes of projects (FSM 7511), and also approve completed water storage and transmission projects prior to their use. This authority may be redelegated only to the Regional Staff Director for engineering activities. Authority for design approval or certification of water transmission and class D moderate- and low-hazard dams and inspections of all projects may be delegated to Forest Supervisors.

2. Establish policy, standards, and criteria for:

a. Dam safety and water transmission activities in the Region.

b. Design, construction, operation, and maintenance of class D moderate- and low-hazard dams.

3. To ensure that all construction, reconstruction, or major maintenance works:

a. Conform to sound engineering practice and Forest Service standards and criteria.

b. Function according to acceptable principles for the life of the structure.

4. Maintain a Regional dams inventory that contains, as a minimum, the elements found in FSM 7515.1.

5. Monitor and report on the quality and effectiveness of Forest administrative and technical engineering practices.

6. Provide training and assistance in preparing, maintaining, and testing emergency action plans by Forest Service and permit holder personnel.

7504.5 - Forest Supervisors

It is the responsibility of Forest Supervisors to:

1. Ensure that all water storage and transmission structures, government-owned or permitted by the Forest Service, are operated and maintained in accordance with the Federal Guidelines For Dam Safety (FSM 7501) and other applicable regulations and standards.

2. Designate qualified personnel to adequately accomplish the construction, operation, inspection, and management of Forest Service-owned dams.

3. Ensure that qualified personnel are participating in the management of permitted dams and water transmission facilities.

4. Ensure that all dams are inspected at designated intervals by qualified people.

5. Ensure that required emergency action plans are prepared and maintained, that personnel are trained, and that plans are tested at the designated intervals.

6. Maintain documentation and records of dams (FSM 7515).

7505 - DEFINITIONS

(FSM 7520.01 and FSH 7509.11).

Dam. Any artificial barrier, including appurtenant works, which impounds or diverts water.

Dam Height. (Also called Hydraulic Height.) For administrative classification of dams, height is the vertical distance in feet measured from the natural bed of the stream or watercourse at the downstream toe of the barrier or, if not across a stream channel or watercourse, from the lowest elevation of the outside limit of the barrier to the maximum water storage elevation.

Forest Service-owned Dams. Those facilities owned by the Government which are the complete responsibility of the Forest Service; as opposed to facilities owned by the Government but built and maintained by other Federal agencies, or facilities built under special use permit or United States Department of the Interior (USDI) easement.

Holder. The holder of a special-use permit to develop or operate a water storage or transmission facility on National Forest lands.

Independent Review. An engineering review conducted by qualified engineers not directly involved in the design of the project.

Inspect. To view closely and critically to detect errors or to determine quality and condition.

Maximum Storage Capacity. The total storage space, measured in acre-feet, in a reservoir at the maximum water storage elevation including storage of flood waters above the normal full storage elevation.

Maximum Water Storage Elevation. The water surface elevation for the reservoir at the dam face for the inflow design flood (FSM 7524.3).

Monitor. To compare performance with sources of information, and data, for conformance with accepted practice and principles, and to check for reasonable accuracy.

Normal Full Storage Elevation. The elevation of the crest of the lowest uncontrolled spillway (FSM 7523.01).

Qualified Engineer. A person who, by reason of training and experience, is assigned by the Forest Supervisor or Regional Forester to perform certain specific technical functions within the authorizing Line Officer's delegated authority. Technical qualifications should be appropriate for the technical requirements of the functions assigned. Consider the consistency of qualifications with engineers assigned similar work in State and private practice.

7506 - REFERENCES

1. Interagency Committee on Dam Safety. 1979. Federal Guidelines for Dam Safety. Washington, D.C. 39p.

2. Interagency Committee on Dam Safety. 1985. The Emergency Action Planning Guidelines. Washington, D.C. 39p.

3. Interagency Committee on Dam Safety. 1985. Federal Guidelines for Earthquake Analysis and Design of Dams. Washington, D.C. 45p.

4. Interagency Committee on Dam Safety. 1985. Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams. Washington, D.C. 37p.

5. Federal Emergency Management Agency. 1988. Glossary of Terms for Dam Safety. Washington, D.C. 18p.

7509 - HANDBOOKS

7509.1 - Internal Service-wide Handbooks

7509.11 - Dams Management Handbook (FSH)

This Handbook contains procedures and specific information related to the management of existing dams, both Forest Service dams and those authorized by a special use document. The Handbook also outlines procedures for technical administration of special use applications for proposed dams.

Table of Contents

7511 - CLASSIFICATION OF PROPOSED PROJECTS 2
7511.1 - Administrative Classification 2
7511.2 - Hazard Assessment Classification 2
7511.3 - Transmission Structures Classification 3
7512 - REVIEW AND APPROVAL OF PROPOSED PROJECTS 3
7512.1 - Environmental Review 3
7512.2 - Regional Engineering Review 4
7512.21 - Independent Review 4
7512.22 - Regional Design Certification 4
7512.3 - Washington Office Review 5
7513 - SUPERVISION OF PROJECT CONSTRUCTION 5
7514 - FUNDING AND BUDGETING 5
7515 - DOCUMENTATION AND RECORDS 6
7515.1 - Dams Inventory 6
7515.2 - Project File 6
7515.3 - Operation and Maintenance Plans 7
7515.31 - Operation Plan 7
7515.31a - Special Use Structures 7
7515.32 - Maintenance Plan 7
7515.32a - Special Use Structures 7
7515.33 - Maintenance Categories 8
7516 – INSPECTIONS 8
7516.1 - Informal and Special Inspections 9
7516.11 - Informal Inspections 9
7516.12 - Special Inspections 9
7516.2 - Operation and Maintenance Inspections 9
7516.21 - Operation and Maintenance Inspection Schedule 10
7516.22 - Followup Action 10
7516.23 - Dams Not Under Forest Service Jurisdiction 10
7516.3 - Safety Inspections and Hazard Assessment 11
7516.31 - Inspection and Hazard Assessment Schedule 11
7516.32 - Report Review and Approval 11
7517 - EMERGENCY ACTION PLANS 12
7517.1 - Forest Service Dams 12
7517.2 - Special Use Dams 12
7518 - STRUCTURAL FAILURE REPORT 12

7511 - CLASSIFICATION OF PROPOSED PROJECTS

The potential effect of water storage and transmission structures on the safety and economy of downstream areas varies with the size of the structure and with the amount and value of human-built improvements and natural amenities that exist downstream. The required scope of investigations, precision of design, quality and capacity of components, and subsequent cost vary with the hazard assigned to the dam.

Minimum acceptable criteria for design, operation, maintenance, and monitoring of dams are based on the administrative size and hazard classifications. All factors that might influence the potential hazard classification must be evaluated during the design and design review of the dam. The hazard rating should be consistent with the potential for loss of human life and damage to property that could be caused by a failure of the dam.

7511.1 - Administrative Classification

For administrative purposes, classify dams as follows:

1. Class A Projects. Dams that are 100 feet or higher or impound 50,000 acre-feet or more of water.

2. Class B Projects. Dams that are 40 feet but less than 100 feet high, or impound 1,000 but less than 50,000 acre-feet of water.

3. Class C Projects. Dams that are 25 feet but less than 40 feet high, or impound 50 but less than 1,000 acre-feet of water.

4. Class D Projects. Dams that are less than 25 feet high and impound less than 50 acre-feet of water.

7511.2 - Hazard Assessment Classification

Classify dams according to hazard potential based on the loss of human life or property damage that could occur if the structure failed.

1. Low Hazard. Dams built in undeveloped areas where failure would result in minor environmental or economic loss, damage would be limited to undeveloped or agricultural lands, and significant improvements are not planned in the foreseeable future. Loss of human life would be unlikely.

2. Moderate Hazard. Dams built in areas where failure would result in serious environmental damage or appreciable economic loss with damage to improvement, such as commercial and industrial structures, public utilities and transportation systems. No urban development and no more than a small number of habitable structures are involved. Loss of human life would be unlikely.

3. High Hazard. Dams built in areas where failure would likely result in loss of human life or excessive economic loss. Generally this would involve urban or community development with more than a small number of habitable structures.

7511.3 - Transmission Structures Classification

Classification of transmission structures such as pipelines and canals is left to the discretion of the Regional Directors of Engineering.

7512 - REVIEW AND APPROVAL OF PROPOSED PROJECTS

Plans and designs for new water storage and transmission projects proposed by the Forest Service or others, or for changes in, or major repair of, existing works must be reviewed and approved by the authorized officer (FSH 2709.11, sec. 53.2, clause B37) prior to construction. Approval shall be based on administrative review (FSM 7512.1) and engineering review (FSM 7512.2).

Coordination with other agencies is required to determine that:

1. Project plans are consistent with policies stated in FSM 7503.

2. Project plans include securing any needed water rights or permits from the State for water development or use (FSM 2540).

3. The projects are compatible with Forest plans.

4. The construction of the project can be effectively coordinated with other National Forest activities.

7512.1 - Environmental Review

Ensure that the scope and intensity of the environmental (FSM 1950) and administrative work for each project is complete and appropriate.

7512.2 - Regional Engineering Review

The scope and intensity of the engineering review varies with the complexity, extent, and hazard classification of the structures. See FSM 7504 for design review and approval authorities.

Engineering review and approval by the Regional Staff Director for engineering activities are not required for:

1. Water projects authorized by Federal law and under the jurisdiction of the Bureau of Reclamation, Corps of Engineers, or the Federal Energy Regulatory Commission.

2. Watershed-protection and flood-prevention projects (Pub. L. 566), flood-control projects (authorized by the Flood Control Act of 1944), or other projects reviewed and approved by the Soil Conservation Service (FSM 7503).

3. Dams not located on National Forest land even if all or part of the reservoir occupies National Forest land, unless salient features such as flooding of National Forest land require Forest Service involvement as part of the permitting process.

7512.21 - Independent Review

All high hazard dams and moderate hazard dams designated by the Regional Forester shall have an independent engineering review made by a qualified engineer (FSM 7505) not directly involved in the design process.

Independent reviews of special use projects may be accomplished by qualified Forest Service engineers, States or other agencies, or consultants not employed by the primary design firm.

7512.22 - Regional Design Certification

When review indicates the design is adequate, the Regional Staff Director for engineering activities shall certify approval or acceptability of the project drawings and specifications prior to their use by signing them. When drawings are issued in a bound set, the signing of the cover sheet may serve to certify the entire set.

Design changes made after the initial review or during construction must also be approved or certified as acceptable by the Regional Staff Director for engineering activities.

Designs submitted by special use applicants (FSM 2700) will be prepared and signed or stamped by a licensed engineer with professional experience consistent with the requirements for analyzing the size of the structure and the hazard involved.

Approval of designs prepared by Forest Service units indicates that the design is judged to be adequate from the standpoint of safety, economy, and function.

7512.3 - Washington Office Review

Review by the Washington Office is not required. Requests for assistance in Regional reviews may be made at any stage of design.

The dam safety officer may make design reviews of specific dams for the purpose of monitoring Regional programs.

7513 - SUPERVISION OF PROJECT CONSTRUCTION

Maintain continuing liaison between personnel concerned with project planning, design, construction, and operation. Individuals from each concerned discipline must know and understand the relevant activities of the others to determine technical adequacy.

Qualified engineers are required for:

1. Supervising site investigation work.

2. Designing all dams and water transmission systems.

3. Supervising or monitoring the inspection of construction activities.

4. Supervising or monitoring safety inspections, emergency action plans, and operation and maintenance plans.

7514 - FUNDING AND BUDGETING

Program funding to accomplish the safety requirements for Forest Service-owned dams shall be charged to the appropriate benefiting function(s). Budget for dam safety at the lowest budget level. The most current programming and budget directions for Forest Service dam administration, inspections, maintenance, and development are in each year's Program Budget Instructions. Regions and Forests may use management codes to track dam work in general, or to track by specific project, for example, new structures, modifications, safety repairs, and routine repairs.

Program funding from benefiting functions may be used for technical and safety related work for the administration of special use permits for dams and water transmission structures (FSM 7503, FSM 2720, and FSM 2780).

7515 - DOCUMENTATION AND RECORDS

Maintain and use the following records to identify and resolve problems with water storage and transmission structures:

1. Dams inventory.
2. Project files.
3. Operation and maintenance (O&M).
4. Inspections.
5. Emergency action plans.

7515.1 - Dams Inventory

The dams inventory provides the primary basis for administration of dams. Each Region shall maintain and update annually an inventory for class A, B, C, and D dams (permitted and Forest Service-owned) located on National Forest System lands (FSM 7504.4 and FSH 7509.11, sec. 11). Other dams owned or licensed by other Federal agencies may be inventoried for information purposes. Data elements for the dam inventory shall be those required to annually update the National Inventory of Dams (Pub. L. 99-662 and FSH 7509.11, sec. 08) maintained for all dams in the United States by the Federal Emergency Management Agency, Priority 1 and Priority 2 maintenance and repair needs and cost estimates for Forest Service-owned dams, and other data elements (FSM 7116) included in the Forest Service inventory for dams.

7515.2 - Project File

Maintain a project file for each Forest Service-owned or permitted dam (FSH 7509.11, ch. 10) or transmission structure. The file should be updated as needed over the life of the project with information on problems encountered, hazard assessment, repairs, operational changes, instrumentation, and inspections.

The responsibility for maintaining a project file for a dam under a special-use permit rests with the owner. However, Forests shall keep a supplemental file for each special use dam for such things as inspections, maintenance performed, and agreements.

7515.3 - Operation and Maintenance Plans

An operation plan and a maintenance plan are required. The responsibility for preparation of operation and maintenance plans rests with the owner. The plans for new dams shall be prepared during the design phase. The plans may be combined and may cover more than one structure if they are of a similar type (FSH 7509.11, ch. 20).

7515.31 - Operation Plan

Revise an operation plan as required by changes in project status or maintenance condition. Plans should reflect current operating agreements.

7515.31a - Special Use Structures

The authorization holder is responsible for preparation of the operation plan. The plan shall be coordinated with applicable State agencies. It shall be reviewed by a qualified engineer or authorized special-use personnel, as delegated, and approved by the authorized officer (FSM 2705).

A qualified engineer shall monitor each special use structure at least once every 5 years to ensure that it complies with the technical requirements of the permit. High hazard and controversial projects may necessitate more frequent monitoring.

7515.32 - Maintenance Plan

Review and update the maintenance plan annually to determine that current conditions are covered.

7515.32a - Special Use Structures

The authorization holder shall prepare the operating and/or maintenance plan in coordination with applicable State agencies. It shall be reviewed by a qualified engineer or qualified Forest Officer, as delegated, and approved by the authorizing official.

7515.33 - Maintenance Categories

The categories of maintenance needs are defined as:

1. Priority 1, Emergency. Maintenance needed to correct deficiencies affecting the safety of the structure or the public, or to correct conditions that may become critical to the safety of the structure or the public in the immediate future. Deficiencies in this category shall be corrected as soon as identified or the structure shall be withdrawn from service or the storage decreased to the extent needed to operate within acceptable parameters.

2. Priority 2, Nonemergency. Maintenance needed to restore functional use of the works, correct unsightly conditions, or prevent more costly damage. Integrity of the structure or public safety is not threatened.

3. Routine. Minor housekeeping-type maintenance normally included in the maintenance plan.

7516 – INSPECTIONS

Develop a systematic dam inspection program to identify routine maintenance and disclose conditions which might threaten life and property, so that timely corrective action can be taken (FSH 7509.11, ch. 40).

Some State regulations require State engineering inspection of non-Federal dams located on National Forest System lands. Some local agencies, such as municipal or county water agencies, flood control districts, and irrigation districts, make regularly scheduled inspections of works under their jurisdiction. When the scope and quality of such inspections are comparable to Forest Service requirements, the Regional Forester should work with appropriate State or local agencies to prevent duplication of effort. Such agreements should include provisions for periodic joint inspections.

Do not include in the Forest Service inspection program structures that are operated or inspected regularly by other Federal agencies, such as the Federal Energy Regulatory Commission, Bureau of Reclamation, or Corps of Engineers.

Include three types of inspections in the dam inspection program:

1. Informal and Special Inspections.

2. Operation and Maintenance Inspections.

3. Safety Inspections and Hazard Assessment.

7516.1 - Informal and Special Inspections

7516.11 - Informal Inspections

When any employees are in the vicinity of a Forest Service or special use dam, they should observe the overall condition and function of the structure. Any unusual conditions that seem critical or dangerous should be reported immediately to the Forest Officer responsible for dams. Particular attention should be given to evidence of (or changes in) leakage, erosion, sinkholes, boils, seepage, slope instability, undue settlement, displacement, tilting, cracking, deterioration, and improper functioning of drains and relief wells.

7516.12 - Special Inspections

Special inspections should be performed immediately after a dam has passed unusually large floods, the occurrence of an earthquake, sabotage, or when unusual events have been reported by operators or in informal inspections.

7516.2 - Operation and Maintenance Inspections

A qualified engineer shall periodically review operation, maintenance, and inspection records, and make a thorough inspection of each structure located on National Forest System land. Prepare a maintenance report for Forest Service dams to aid in scheduling routine maintenance, programming special repairs, and updating the inventory.

Authorizations for special use structures shall include requirements for owner-acquired inspection in accordance with the inspection plan. A qualified engineer (FSM 7505) shall monitor inspection reports to ensure compliance with technical standards (FSM 7504). When inspections are accomplished by State or local agencies under working agreements, the State or local agency report form is normally acceptable.

Compliance with established operation plans sometimes cannot be verified by inspection at the same frequency as inspection of maintenance. For structures which have administrative limitations on storage, reservoir stage, or water release imposed by the State or the Forest Service, operation logs and water stage or metering-device records (when required) should be checked periodically throughout the year.

7516.21 - Operation and Maintenance Inspection Schedule

Establish a reasonable and workable inspection schedule considering factors such as: type of structure, hazard rating, watershed characteristics, climate, purpose of reservoir, and type of spillway. The schedule should be based on a consideration of: (1) the conditions peculiar to the structure(s) involved, (2) the need for coordinating the work with other Forest inspections and evaluations, and (3) national and Regional guidelines and standards.

As a minimum, structures classed as high hazard (FSM 7511.2) shall be inspected annually, and also following earthquakes and periods of unusually heavy runoff.

7516.22 - Followup Action

When an inspection discloses operation or maintenance deficiencies, the Forest Supervisor shall:

1. For Forest Service structures, establish a reasonable maintenance schedule based on the priority of identified maintenance, and schedule appropriate restoration and repairs.

2. For special use structures, inform the owner promptly by letter and, if applicable, furnish a copy to the State. The notice should:

   a. Describe the deficiencies, and explain the nature and urgency of needed changes or repairs.

   b. Require the holder to submit a proposed maintenance schedule.

   c. Require the holder to certify by letter when the identified maintenance has been completed.

Any dam having deficiencies which seriously affect the integrity of the structure must be promptly repaired, or wholly or partially removed from service until repairs are made (FSM 7503). See FSM 2715 for direction on taking administrative action.

7516.23 - Dams Not Under Forest Service Jurisdiction

When a dam is located on private land or is under the jurisdiction of another Federal agency (and not subject to inspection by the Forest Service), and conditions endangering Forest Service lands are observed, the owner or the agency having jurisdiction over the dam shall be promptly notified. Notify the Regional Director and the Director, Division of Dam Safety, for the Federal Energy Regulating Commission (FERC) of any dams on Forest Service lands that are not under FERC license but appear to be under FERC jurisdiction.

7516.3 - Safety Inspections and Hazard Assessment

The Federal Guidelines for Dam Safety require the periodic inspection and evaluation of dams for the purpose of protecting human life and property. The documented safety inspection entails a review by highly trained specialists of all pertinent information, including records on design, construction, instrumentation, operation, maintenance, and inspection; and a detailed field inspection of the dam and appurtenant structures. Base the inspection on current design standards and practices. Adjust the effort and degree of detail involved for a safety inspection in accordance with the structure's size and hazard classification.

7516.31 - Inspection and Hazard Assessment Schedule

Prepare a schedule for safety inspection or hazard classification review for each dam. Perform and record safety inspections for high hazard dams at intervals not exceeding 5 years. Some dams may require more frequent safety inspections, depending on experience or project history, such as active seepage on face of dam or active surface erosion.

Perform and document hazard classification reviews at least every 5 years for moderate and low hazard dams.

1. Forest Service Dams. The Forest Service is responsible for safety inspections of Forest Service-owned dams. Safety inspections performed by other responsible agencies or licensed engineers by contract are acceptable.

2. Special Use Dams. The authorization holder is responsible for having safety inspections performed by a qualified engineer at the frequency prescribed in the special use authorization. Safety inspections performed by other responsible federal or State agencies are acceptable.

7516.32 - Report Review and Approval

The Regional Staff Director for engineering activities is responsible for review and approval of safety inspection reports (FSM 7504.3).

7517 - EMERGENCY ACTION PLANS

Prepare, test, and maintain emergency action plans for all high hazard dams. Emergency action plans, whether prepared by the Forest Service, permit holder, State, or other party should be prepared in a degree of detail commensurate with the hazard and coordinated with local officials. The schedule for personnel training and emergency action plan testing shall be the same as for inspections and hazard assessments (FSM 7516.21). See FSH 7509.11, ch. 50, for procedures and information to be included in a plan and how to test the plan. The emergency action plan will include flood inundation maps.

For new or proposed dams, prepare the emergency action plan during the design stage (FSM 7521.03). The plan must reflect construction activities for new dams and major reconstruction for existing dams.

Plans should be updated promptly after each change in involved personnel or their phone number. Personnel and phone number changes shall be made on the plan annually, as a minimum. A comprehensive review of the emergency action plan shall be made whenever safety inspections and hazard assessments are performed or reviewed (FSM 7516). Any changes in the plan must be provided to all plan holders. The comprehensive review shall include an assessment of the need for training and plan testing.

7517.1 - Forest Service Dams

The Forest Supervisor is responsible for preparing and testing the emergency action plan.

7517.2 - Special Use Dams

The authorization holder is responsible for preparing and testing the plan Emergency Action plan.

7518 - STRUCTURAL FAILURE REPORT

In case of the failure of a dam or a major appurtenant structure, promptly investigate and report the event as required in FSH 7509.11, ch. 60. See FSM 6730 for additional details on independent investigations.

Table of Contents

7521 – SCHEDULING 2
7521.03 – Policy 2
7522 - DESIGN RECORDS 2
7523 – PLANNING 3
7523.05 - Definitions 3
7524 - GENERAL DESIGN STANDARDS 3
7524.1 - Hydrology and Flood Routings 4
7524.11 - Incremental Damage Analysis 4
7524.2 - Hazard Assessment 4
7524.3 - Spillway Sizing 5
7524.31 - Spillway Sizing Standards 5
7524.32 - Exceptions to Spillway Sizing Standards 6
7524.33 - Spillway Design 8
7524.4 - Investigation and Design Criteria 8
7524.41 - Site Investigation 8
7524.42 - Structure Stability 8
7524.43 - Earthquake Design 9
7524.44 – Geosynthetics 9
7524.45 - Outlet Works 9
7524.46 – Flashboards 9
7524.47 – Access 9
7524.48 – Instrumentation 9
7524.49 - Additional Design Items 10
7525 - CHANNEL PLANNING, INVESTIGATION, AND DESIGN 10

7521 – SCHEDULING

Schedule management and engineering steps to:

1. Design dam in an effective and economic manner.

2. Ensure compliance with program objectives, environmental concerns, and public safety.

7521.03 – Policy

Ensure that the design of dams complies with the forest plan, feasibility studies, environmental impact assessments, site investigations, and that appropriate coordination and review occurs at all stages of the design process. Final design review and approval by the Regional Office and State and Federal regulatory agencies, as appropriate, must precede construction (FSH 7509.11, sec. 10). Reviews shall be appropriate for the size and hazard classification of the dam. Prepare the emergency action plan during the design phase when required (FSM 7517 and FSH 7509.11, ch. 50).

7522 - DESIGN RECORDS

Keep design records orderly and current to allow efficient review at any stage. Design records must be complete and understandable, since they may form the basis for later actions such as design changes, modification or addition of appurtenant works, investigation of structural deficiencies, periodic safety evaluations, hazard assessment, emergency action plans, and possible litigation. Scope and detail of the design record will vary with the complexity and risk of the project.

Design related correspondence should contain a full presentation of the pertinent facts and discussion, and document progress in selection of alternatives or other matters affecting the design.

A final design summary should provide a permanent record of the design analysis and decisions, and an index to the design records.

7523 – PLANNING

In the planning stage, consider alternate sites and structure types to meet objectives, minimize project costs, and minimize social and environmental impacts (FSM 1950). Constraints may include minimum stream flow requirements, water rights, forest plan requirements, project funds, the dam hazard class and environmental issues such as wetlands. The environmental analysis process should consider these constraints as well as the benefits of reservoir storage. Consider flood storage for Forest Service-owned dams when the potential benefits exceed additional construction costs.

Gather data needed to assess alternatives and to plan data collection for design from available maps, records, and site reconnaissance. Field surveys and subsurface investigations may be necessary, depending on complexity and risks of the project.

7523.05 - Definitions

(FSM 7505 and FSH 7509.11, sec. 05).

Freeboard. The vertical distance in feet between the maximum water storage level and the top of the dam.

Inflow Design Flood. (IDF). The largest flood, measured in cubic feet per second, that a given project is designed to pass safely. The reservoir inflow-discharge hydrograph used to estimate the spillway discharge capacity requirements, and corresponding maximum surcharge elevation in the reservoir.

Normal Storage. The storage space, measured in acre-feet, in a reservoir as measured from the low point of the upstream toe of the dam or from the inlet invert of the outlet conduit, whichever is lower, up to the crest of the lowest uncontrolled spillway.

Probable Maximum Flood. (PMF). The most severe flood, measured in cubic feet per second, that is considered reasonably possible at a site as a result of meteorological and hydrologic conditions.

7524 - GENERAL DESIGN STANDARDS

The level of design detail increases from preliminary to final design and with increasing size, value, and Forest Service hazard classification of the structure. The level of detail of the investigation, design, design reports, and drawings shall be adequate to construct a safe dam within acceptable factors of safety for the size and hazard classification of the structure. Design standards and procedures of the Soil Conservation Service, Bureau of Reclamation, and the Corps of Engineers are acceptable for water and sediment storage dams on National Forest lands.

U.S. Bureau of Mines design standards may be most appropriate for tailings dams. Other generally accepted standards and methods may be accepted on a case-by-case basis. Other authorities that have jurisdiction may require additional or more stringent standards.

7524.1 - Hydrology and Flood Routings

Use generally accepted procedures appropriate for the dam site, such as those established by the Soil Conservation Service, the National Weather Service, and the Bureau of Reclamation, for determining the design storm event and sizing the spillway. Consider site specific evaluations for accepting smaller inflow design hydrographs. Several analysis methods and flood routing trials may be required to establish the most appropriate design flood and to size the spillway.

7524.11 - Incremental Damage Analysis

Perform an analysis using one storm event with two flood routing conditions, that is (1) where the dam overtops without failure, and (2) where the dam overtops with failure, to determine flood damage and potential loss of life resulting from the sudden release of water stored in the reservoir. Incremental damage is the "additional" damage resulting from the greater flood stage of routing the flood with dam failure over that expected from routing without dam failure. In addition to flows from the reservoir, consider also flows from the tributaries downstream of the reservoir in the incremental analysis. The flood routings should extend downstream to a point at which no further significant incremental damage will occur.

7524.2 - Hazard Assessment

Determine a high hazard rating, and tentative moderate or low hazard rating, as defined in FSM 7511.2, based on the clear weather breach flood damage from the dam to a point downstream where the flood is contained within the channel banks. Consider the reservoir full to the crest of the uncontrolled spillway, and calculate the realistic time required for complete breach to occur for the type and size of dam. Consider and document reasonably foreseeable downstream development as well as existing development in the assessment.

Check moderate and low hazard ratings for a possible high hazard rating based on "Incremental Damage Analysis" determined by routing the inflow design storm without a dam failure, and with an overtopping dam failure. If analysis indicates that the failure of the dam causes no loss of human life or no additional excessive economic loss when compared to overtopping without failure, then the dam shall not be classified as high hazard (FSM 7524.32, ex. 01).

7524.3 - Spillway Sizing

7524.31 - Spillway Sizing Standards

Size the spillway to safely pass the inflow design flood shown in exhibit 01.

7524.31 - Exhibit 01

Minimum Required Inflow Design Flood

Hazard Potential	Size Class	Inflow Design Flood
HIGH	A	PMF*
	B	PMF
	C	PMF
	D	PMF
MODERATE	A	3/4 PMF
	B	1/2 PMF
	C	1/2 PMF
	D	1/2 PMF
LOW	A	100 YEAR**
	B	100 YEAR
	C	50 YEAR
	D	50 YEAR

* Probable Maximum Flood
** Return Frequency in Years

7524.32 - Exceptions to Spillway Sizing Standards

Smaller inflow design floods may be used if documented analysis shows that:

1. Overtopping the dam crest by the appropriate comparison flood as described in FSM 7524.31, exhibit 01 will not cause failure of the dam.

2. Through incremental damage analysis, failure would not cause additional loss of human life, and property damage is less than the cost of building additional spillway capacity.

To determine exceptions to spillway sizing standards (FSM 7524.31, exhibit 01), use the decision tree in FSM 7524.32, exhibit 01 for evaluating hazard classification and spillway size requirements based on incremental damage analysis for determining exceptions to FSM 7524.31, exhibit 01.

7524.32 - Exhibit 01

Decision Tree For Incremental Analysis

(1) Route a storm causing a full spillway (spillway at design capacity) through the dam without a dam failure. Is there potential loss of human life from this flood?

yes — no

(2) Route the same storm causing a full spillway through the dam with an overtopping dam failure. Is there potential loss of human life from this flood?

yes — no

(3) Is the potential loss of human life greater from the flood with an overtopping dam failure than from the flood without a dam failure?

yes — no

(4) Can a spillway size be found in which the potential loss of human life from the routed store is no greater with dam failure than from the routed storm without a dam failure?

no — yes

(5) This is a high hazard dam requiring a probable maximum flood size spillway.

(6) Use this storm to evaluate incremental damage, the additional damage that can be expected from the overtopping dam failure above the damage expected from the flood without a dam failure. What is the hazard classification based on incremental damage? Use the higher hazard classification from clear weather breach and incremental damage analysis.

Low — Moderate — High

(7) Is the savings from constructing this size spillway in comparison to constructing the spillway required from FSM 7524.31, exhibit 01, less than the incremental loss potential, including the cost of repairing the breached dam?

yes — no

(8) This size spillway can be constructed.

(9) Use the spillway size from FSM 7524.31, exhibit 01.

Existing dams which can pass at least 75 percent of the design flood will not need to be modified to increase spillway capacity to the 7524.31, exhibit 01 minimums until major reconstruction is implemented.

7524.33 - Spillway Design

The uncontrolled spillway capacity shall be sufficient to pass the inflow design flood. Flow capacity from unattended gates shall not be included in the design capacity calculation. Flow capacity from automatic gates or resident-attended gates may be included in the spillway design capacity calculation. For a reservoir without a flood pool, start routing the inflow design flood at the lowest uncontrolled spillway crest elevation. For a reservoir with a flood pool, start routing the inflow design flood at the elevation of the water surface that would exist after 10 days of drawdown from the 100-year flood pool.

7524.4 - Investigation and Design Criteria

Apply the site investigations and design criteria of sections 7524.41 through 7524.48 to new dams, enlargement of existing dams, or for dams considered structurally unsafe. Any variance from these criteria must be submitted to the Regional Staff Director for engineering activities for approval.

7524.41 - Site Investigation

Investigate and test a potential dam site to the extent appropriate to the size and hazard of the dam as well as for possible geologic features that influence the risk of failure. Low hazard dams and class C moderate hazard dams require, as a minimum, a field geology report with soil borings or test pits penetrating to bed rock or a distance equal to half the height of the dam. Additionally, class A and B moderate and all high hazard dams require borings that penetrate to bedrock or 1-1/2 times the height of the dam, whichever is shallower, and adequate field and laboratory testing of materials to determine stability and to perform a seepage analysis.

7524.42 - Structure Stability

Soil Conservation Service guidelines may be used to design low hazard earth dam side slopes. Analyze moderate and high hazard dam embankment stability to demonstrate that all pertinent static and dynamic loading conditions will not exceed allowable shearing stresses in the embankment or foundation. Ensure the factors of safety and allowable shear stresses used in the design are appropriate for the construction and operating conditions. In most cases, embankments should be designed for unrestricted rates of reservoir filling and drawdown.

7524.43 - Earthquake Design

Consider earthquake hazards in site investigation and analysis for all high and moderate hazard dams. Consider also earthquake related concerns such as fault displacement; soil liquefaction; cracking potential; type of structure; structure stability, abutment stability, and reservoir slope stability; overtopping effects; and required defensive measures such as emergency action plans.

7524.44 – Geosynthetics

Geosynthetic fabrics may be used in constructing low hazard dams. Geosynthetic fabrics may be used in moderate and high hazard dams for applications involving the structural stability of the dam (i.e., impermeable membrane cutoffs and internal filter drains) only after consultation with other Federal agencies or private engineering consultants experienced in designing dams and geosynthetic fabric installations.

7524.45 - Outlet Works

All dams except moderate hazard class D and low hazard class C and D dams and debris dams shall have outlet works capable of releasing the top 5 feet of the reservoir capacity within 5 days, and shall also be capable of draining at least two-thirds of the normal storage volume. When selecting minimum pipe diameter, also consider the potential for plugging and ease of inspection. Corrugated metal pipe is restricted to moderate hazard class D and low hazard class C and D dams, unless otherwise approved by the Regional Staff Director for engineering activities. Include the life-cycle cost when considering its use. Locate outlet control works on the upstream side of the dam.

7524.46 – Flashboards

Flashboards with shear pins or failure supports are not permitted in uncontrolled spillways. Other types of flashboards must be approved by the Regional Staff Director for engineering activities.

7524.47 – Access

Provide all weather road access for operation and maintenance of high hazard dams. Moderate hazard dams may be accessible by seasonal roads, and low hazard dams should be accessible for construction equipment. Access to dams in wilderness areas varies with circumstances and will be handled case by case.

7524.48 – Instrumentation

Where necessary, provide instrumentation for measurement of physical changes that could affect dam safety. Depending on the size, hazard and design of the dam, and the foundation conditions, consider installing an instrumentation system to observe changing conditions in the foundation, embankment, and abutments during construction, initial reservoir filling, and during project operation.

7524.49 - Additional Design Items

In addition to the criteria in FSM 7524.41-7524.48, the following items should be considered in dam design: sediment storage; residual freeboard above design flood stage for wave action; wave erosion protection; slope erosion protection; spillway erosion protection; internal erosion protection; and added embankment height to compensate for settlement. Earthen dam crest width (W) shall be a minimum of 10 feet and increase in width based on dam height (H), $W = (H + 35)/5$. Earthen dams over 100 feet high shall have a minimum crest width of 28 feet. Limit projected frequency of use of unlined earth and vegetated spillways to once in 50 years.

7525 - CHANNEL PLANNING, INVESTIGATION, AND DESIGN

See FSH 7509.11, section 82 for direction on channel layout.

FSM 7500 - WATER STORAGE AND TRANSMISSION
CHAPTER 7530 - CONSTRUCTION

Table of Contents

7530.2 - Objectives 2
7530.3 - Policy 2
7530.5 - Definitions 2
7531 - CONSTRUCTION MANAGEMENT 2
7531.1 – Inspection 2
7531.11 - Special Use Projects 2
7531.2 - Records and Reports 3
7531.21 - Forest Service Projects 3
7531.22 - Special Use Projects 3
7531.3 - Certification of Construction 3
7532 - INSPECTION OF CONSTRUCTION OPERATIONS 4
7532.1 - Forest Service Inspection of Special Use Projects 4

7530.2 - Objectives

1. To determine that the intent of a project design is met.

2. To ensure that new field information acquired on site during construction is properly incorporated in the design.

7530.3 - Policy

1. Construction inspection personnel shall maintain close coordination with design personnel, especially for design changes, throughout the period of project construction.

2. Forest Service officers shall not permit water to be stored behind a dam or water flow introduced into a canal or similar structure until the requirements outlined in FSM 7531.3 are met.

7530.5 - Definitions

Certificate of Compliance. An affidavit stating that a completed project conforms to the applicable specifications.

Continuous Inspection. The continuous presence of the inspector, or inspectors, at the work site while work is in progress.

Periodic Inspection. The intermittent presence of the inspector during the progress of the work.

7531 - CONSTRUCTION MANAGEMENT

7531.1 – Inspection

Provide inspection by personnel especially trained for, and regularly assigned to, similar work. Ensure continuous or periodic inspection is appropriate for the construction work in progress (FSM 7532).

Where an independent design review team has been established for a project, the team shall be given the latitude for direct contact with construction inspection personnel and for inspecting the project at their discretion.

7531.11 - Special Use Projects

1. Forest Service Monitoring. Monitor special use construction sufficiently to determine that:

a. Inspection by the holder's inspector is adequate, effective, and is conducted by qualified personnel.

b. The holder's engineer promptly submits planned construction schedules to the Forest Service.

c. The holder's engineer keeps the Forest Service informed of construction progress so that any required joint inspection at critical periods can be planned.

d. The holder's engineer obtains Forest Service approval of design changes prior to implementing those changes.

e. Proper attention is given to protection of adjacent lands and facilities from damage by construction operations.

2. State Coordination. Coordinate Forest Service monitoring and joint inspections with State and other involved agency representatives to promote efficiency and consistent communications.

7531.2 - Records and Reports

7531.21 - Forest Service Projects

Records and reports shall conform to the requirements of FSH 6309.31 and FSH 6309.32.

A final construction report shall be prepared for projects requiring Regional Forester approval (FSM 7504).

Keep the final construction report, including photographs taken during construction, in the project file for reference (FSH 7509.11, ch. 10).

7531.22 - Special Use Projects

Ensure that the holder complies with the terms and conditions of the permit as set out in FSH 2709.11, sec. 53.1, clause B37 to provide the Forest Service required information and record keeping.

7531.3 - Certification of Construction

Ensure that the holder complies with the terms and conditions of the permit as set out in FSH 2709.11, sec. 53.1, clause B37 for inspection of construction of the dam.

Approval of drawings and specifications does not authorize operation of the completed works. The structure may be operated only after the Regional Staff Director for engineering activities has certified in writing that the structure is acceptable for water storage or transmission, and approval is received from an authorizing official (FSM 7505). Additional construction approvals may be necessary from the State or other involved agencies.

The Regional Staff Director for engineering activities shall take such action as deemed necessary to verify compliance prior to granting approval to operate the structure.

7532 - INSPECTION OF CONSTRUCTION OPERATIONS

The primary responsibility for inspection rests with the party proposing construction. The Forest Service may monitor a special use holder's inspection procedures and documentation to verify adequacy.

7532.1 - Forest Service Inspection of Special Use Projects

1. Continuous Inspections. Continuous inspection is required when the quality of any work cannot be determined accurately by periodic inspection, or the work cannot readily be removed and replaced if rejected. Examples include:

a. Excavating the foundation when the depth must be determined during the course of the work or when the foundation is under water.

b. Placing compacted earthfill and filters.

c. Placing and bedding pipe.

d. Mixing and placing concrete and pneumatically applied mortar.

2. Periodic Inspections. Periodic inspection may be suitable for certain other types of work depending on the circumstances at the site, the construction schedule, or the contractor's level of ability. Examples include:

a. Clearing and grubbing.

b. Stripping or structure removal.

c. Constructing the forms.

d. Placing the steel reinforcements.

Appendix E. State Guidelines

E.1 Alabama
E.2 Alaska
E.3 Arizona
E.4 Arkansas
E.5 California
E.6 Colorado
E.7 Connecticut
E.8 Delaware
E.9 Georgia
E.10 Hawaii
E.11 Idaho
E.12 Illinois
E.13 Indiana
E.14 Iowa
E.15 Kansas
E.16 Kentucky
E.17 Louisiana
E.18 Maine
E.19 Maryland
E.20 Massachusetts
E.21 Michigan
E.22 Minnesota
E.23 Mississippi
E.24 Missouri
E.25 Montana
E.26 Nebraska
E.27 Nevada
E.28 New Hampshire
E.29 New Jersey
E.30 New Mexico
E.31 New York
E.32 North Carolina
E.33 North Dakota
E.34 Ohio
E.35 Oklahoma
E.36 Oregon
E.37 Pennsylvania
E.38 Puerto Rico
E.39 Rhode Island
E.40 South Carolina
E.41 South Dakota
E.42 Tennessee
E.43 Texas
E.44 Utah
E.45 Vermont
E.46 Virginia
E.47 Washington
E.48 West Virginia
E.49 Wisconsin
E.50 Wyoming



FEMA



FEMA

July 2012

E.1. Alabama



96306-2:n:01/28/2008:MCS/aw LRS2008-337

HB454
By Representatives Wood, Canfield, McCutcheon, Laird, Bridges and Fite
RFD Commerce
Rd 1 14-FEB-08

SYNOPSIS: This bill would provide for the inventory and classification of dams by the Water Resources Division of the Alabama Department of Economic and Community Affairs; to define terms associated with the safety of dams; to provide that no action for damages could be brought against the state by reason of any action taken or not taken by the state pursuant to this act; to authorize the promulgation of rules; and to provide for criminal and civil violations.

Amendment 621 of the Constitution of Alabama of 1901, now appearing as Section 111.05 of the Official Recompilation of the Constitution of Alabama of 1901, as amended, prohibits a general law whose purpose or effect would be to require a new or increased expenditure of local funds from becoming effective with regard to a local governmental entity without enactment by a 2/3 vote unless: it comes within one of a number of specified exceptions; it is approved by the affected entity; or the Legislature appropriates funds, or provides a local source of revenue, to the entity for the purpose.

The purpose or effect of this bill would be to require a new or increased expenditure of local funds within the meaning of the amendment. However, the bill does not require approval of a local governmental entity or enactment by a 2/3 vote to become effective because it comes within one of the specified exceptions contained in the amendment.

A BILL
TO BE ENTITLED
AN ACT

To provide for the inventory and classification of dams by the Water Resources Division of the Alabama Department of Economic and Community Affairs for the purpose of assuring the safety of state dams; to define certain terms associated with dams and dam safety; to provide that no action for damages shall be bought against the state by reason of any action taken or not taken by the state pursuant to this act; to authorize the promulgation of rules; to provide criminal and civil penalties for violations; and in connection therewith would have as its purpose or effect the requirement of a new or increased expenditure of local funds within the meaning of Amendment 621 of the Constitution of Alabama of 1901, now appearing as Section 111.05 of the Official Recompilation of the Constitution of Alabama of 1901, as amended.

BE IT ENACTED BY THE LEGISLATURE OF ALABAMA:

Section 1. This act shall be known and may be cited as the "Alabama Dam Inventory and Classification Act."

Section 2. (a) It is the purpose of this act to provide for the inventory and classification of dams in order to protect the health, safety, and welfare of all the citizens of the state.

(b) The Legislature finds and declares that the inventorying and classification of dams is properly a matter for regulation under the police powers of the state for the safety, protection, and welfare of the citizens of Alabama.

Section 3. As used in this act, the following terms shall have the following meanings:

(1) ABANDON or ABANDONMENT. To render a dam non-impounding by dewatering and making the dam incapable of impounding water.

(2) ADVERSE CONSEQUENCES. Negative impacts that may occur upstream, downstream, or at locations remote from a dam as a direct and proximate result of the existence or operation of the dam. The primary concerns for adverse consequence are loss of human life, loss of critical infrastructure, property damage, and lifeline disruption.

(3) ALTERATIONS or REPAIRS. Alterations, modifications, or repairs to existing dams or appurtenant works as may directly affect the safety of the dam or reservoir, as determined by the office.

(4) APPROVAL. Authorization in writing issued by the director to an owner who has applied to the office for permission to construct, reconstruct, enlarge, repair, alter, modify, remove, maintain, operate, or abandon a dam, and which specifies the conditions or limitations under which work is to be performed by the owner or under which approval is granted.

(5) APPURTENANT WORKS. The term includes, but is not limited to, such structures as spillways, either in the dam or separate therefrom; the reservoir and its rim; low-level outlet works; and liquid conduits such as tunnels, pipelines, or penstocks, either through the dam or its abutments.

(6) BREACH. Partial removal of a dam, creating a channel through the dam.

(7) CERTIFICATE. For a high hazard potential dam the term means a written authorization issued by the director to construct or operate, or both, a dam. For all other dams the term means a written acknowledgement of dam construction or removal solely for inventorying purposes.

(8) CONSTRUCT or CONSTRUCTION. The design, building, alteration, reconstruction, or enlargement of any dam for the impoundment or diversion of water or liquid substance and shall include any activity which, other than routinely as part of an approved maintenance program, repairs or restores the dam, or alters its design, shape, or structural characteristics.

(9) CRITICAL INFRASTRUCTURE. Systems and assets associated with or impacted by dams or impoundments, whether physical or virtual, so vital to Alabama that the incapacity or destruction of such a system or asset would have a debilitating impact on security, economic stability, public health or safety, or any combination of those matters, consistent with the "Critical Infrastructure Protection Act of 2001."

(10) DAM. Any artificial barrier, including appurtenant works, which impounds or diverts water, wastewater, or liquid-borne materials and which meets any of the following criteria:

a. Has an impounding capacity at maximum water storage elevation of at least 50 acre-feet.

b. Is 25 feet or more in height.

c. Will create a probable loss of human life in the event of failure or improper operation, regardless of height or storage capacity.

d. Will create a probable loss of critical infrastructure in the event of failure or of improper operation, regardless of height or storage capacity.

(11) DIRECTOR. The Director of the Office of Water Resources or his or her designee. The director or designee must be an engineer. The director must have a current license to practice engineering in the State of Alabama.

(12) ENGINEER. A qualified professional engineer. The term qualified professional engineer as used in this act is intended to mean an individual who has a background in civil engineering and meets all the following qualifications:

a. Is a licensed professional engineer in the state.

b. Is competent in areas related to dam investigation, design, construction, and operation for the type of dam being investigated, designed, constructed, or operated.

c. Has at least seven years of relevant experience in areas such as investigation, design, construction, reconstruction, enlargement, repair, alteration, maintenance, operation, breach, removal, or abandonment of dams.

d. Either (i) understands adverse dam incidents, failures, and the potential causes and consequences of failures; or (ii) is the state conservation engineer of the Department of Conservation and Natural Resources.

(13) ENLARGE or ENLARGEMENT. Any change in or addition to an existing dam or impoundment which raises or may raise the maximum water storage elevation of the liquid impounded by the dam or reservoir.

(14) HAZARD POTENTIAL. Possible adverse consequences that result from the release of water or stored contents due to failure or improper operation of the dam or appurtenant works. The hazard potential classification of a dam does not reflect in any way on the current condition of the dam and its appurtenant works, such as, but not limited to, the safety, structural integrity, or flood routing capacity.

(15) HEIGHT. The term means either (i) the distance from the natural bed of the impoundment, stream, or watercourse measured at the downstream toe of the dam to the maximum water storage elevation; or (ii) the distance from the lowest elevation of the outside limit of the dam, if the dam is not across a stream channel or watercourse, to the maximum water storage elevation.

(16) HIGH HAZARD POTENTIAL DAM. A dam assigned the high hazard potential classification where failure or improper operation will cause probable loss of human life.

(17) LOCAL UNIT OF GOVERNMENT. Any political subdivision of this state including, but not limited to, a county, city, town, or municipality, if the political subdivision provides local governmental services in a geographically limited area of this state as its primary purpose and it has the power to act primarily on behalf of that area.

(18) LOW HAZARD POTENTIAL DAM. A dam not assigned the moderate or high hazard potential classification.

(19) MAXIMUM WATER STORAGE ELEVATION. The elevation of the top of the dam.

(20) MODERATE HAZARD POTENTIAL DAM or SIGNIFICANT HAZARD POTENTIAL DAM. A dam assigned the moderate hazard potential classification where failure or improper operation results in no probable loss of human life but will cause probable loss of critical infrastructure.

(21) OFFICE. The Office of Water Resources, a division of the Alabama Department of Economic and Community Affairs or its successor.

(22) OPERATE or OPERATION. To take actions to control the impoundment or diversion of a liquid substance by a dam.

(23) OWNER. Any person who owns, controls, operates, maintains, or manages or proposes to construct, reconstruct, enlarge, repair, alter, remove, or abandon a dam or reservoir.

(24) PERSON. Any and all persons, natural or artificial, including any individual, entity, firm, association, organization, partnership, business, trust, corporation, company, any federal agency, authority, or corporation created by the United States of America, and the state and all political subdivisions, regions, districts, municipalities, counties, and public agencies thereof.

(25) PROBABLE LOSS OF CRITICAL INFRASTRUCTURE. The loss of critical infrastructure is likely to occur, is reasonably expected to occur, or is the actual result of any action or inaction.

(26) PROBABLE LOSS OF HUMAN LIFE. Loss of human life that will likely occur, is reasonably expected to occur, or is the actual result of any action or inaction.

(27) RECONSTRUCTION. Removal and replacement of an existing dam.

(28) REMOVE or REMOVAL. Complete elimination of a dam embankment or appurtenant works, or both.

(29) RESERVOIR or IMPOUNDMENT. Any basin which contains or will contain impounded water, wastewater, or liquid-borne materials by virtue of its having been impounded by a dam.

(30) RESPONSIBLE AUTHORITY. Those state, county, city, or other offices that are charged with maintaining public safety and that are listed in any emergency action plan required by this act or any rule promulgated pursuant to this act.

(31) RULES. The most recent policies, requirements, regulations, administrative rules, or standards adopted by the office pursuant to the Alabama Administrative Procedure Act, codified as Chapter 22, Title 41, Code of Alabama 1975, as amended, in order to enforce this act.

(32) STATE. The State of Alabama.

(33) SURFACE MINING ACT. Chapter 16, Title 9 of the Code of Alabama 1975, as amended.

Section 4. (a) In addition to any other powers and duties provided in this act, the director shall perform

the following duties:

(1) Exercise general supervision over the administration and enforcement of this act and the rules promulgated under this act.

(2) Advise, consult, cooperate, contract, and enter into cooperative agreements with persons, local units of government, and other governmental agencies or committees, including, but not limited to, the State Soil and Water Conservation Committee, the Alabama Department of Environmental Management, the Department of Conservation and Natural Resources, the Alabama Department of Transportation, the Alabama Association of Conservation Districts, or the Unites States Army Corps of Engineers for the purposes of carrying out this act.

(3) Take such other actions as may be necessary to carry out this act.

(4) Specify conditions under which any employee of the office or its agents may enter upon lands of owners of dams.

(5) Direct, conduct, and supervise investigations, as the director deems necessary to carry out the duties as prescribed in this section.

(b) In the performance of its duties, the office shall establish, adapt, modify, and repeal, by the promulgation of rules, such policies, requirements, conditions, or standards governing the inventory and classification of dams covered under this act, including, but not limited to, the following:

(1) Standards to govern the inventory of dams.

(2) Report necessary dam information to the National Performance of Dams Program, as requested.

(3) Report inventory and other necessary information to the National Inventory of Dams, as requested.

Section 5. (a) The office shall inventory the dams in the state and classify each dam into one of the following categories:

(1) Low hazard potential.

(2) Moderate hazard potential.

(3) High hazard potential.

(b) The office may gather necessary updated information regarding the characteristics of a dam and its surroundings in order to verify classification.

(c) The office may use information furnished to it by other persons to accomplish the purpose of this act and this section including, but not limited to, the classification of dams as set forth in subsection (a).

Section 6. (a) The following low hazard potential dams are not required to be included in the inventory of dams maintained pursuant to this act:

(1) Any dam which is less than six feet in height, regardless of its storage capacity.

(2) Any dam which has an impounding storage capacity at maximum water storage elevation of less than 15 acre-feet, regardless of its height.

(b) The following dams shall be exempt from all regulatory requirements of this act, except as necessary to maintain the inventory of dams pursuant to this act:

(1) Any dam owned and operated by any department or agency of the United States government, provided those dams are regulated in a manner that meets or exceeds the requirements of this act.

(2) Any dam licensed by the Federal Energy Regulatory Commission, or for which a license application is pending with the Federal Energy Regulatory Commission.

(c) Any dam regulated and permitted under the Surface Mining Act is exempt from this act so long as the dam is subject to regulation by the Surface Mining Act. However, if a dam so constructed is classified by the director as a high hazard potential dam, the owner, upon the completion of the mining activity in connection with which the dam was constructed, shall either drain and reclaim the impoundment formed by the dam pursuant to the mined land use plan approved under the Surface Mining Act or stabilize the impoundment as a lake pursuant to the mined land use plan and the rules promulgated under this act. If the impoundment is reclaimed as a lake and the dam which created the impoundment remains in place as a high hazard potential dam, then before the lake is deemed to be reclaimed so as to release the owner from his or her obligations under the Surface Mining Act, the owner shall certify to the director and the owners of the properties on which the high hazard potential dam is located that the high hazard potential dam is in full compliance with this act.

(d) The owners of exempt dams shall be required to submit information to the agency in accordance with rules promulgated under this act for purposes of maintaining the inventory.

Section 7. (a) The director, or any authorized agent or contractor, is authorized and shall be permitted by the owner to make a visual inspection of a high hazard potential dam.

(b) This act shall not be construed as exempting any existing dam from compliance with applicable engineering design standards or requirements.

(c) With regard to moderate and low hazard potential dams, the office is not required to perform structural inspections of a moderate or low hazard potential dam.

Section 8. (a) It shall be unlawful for any person to refuse entry or access to any authorized representative of the office who requests entry for purposes of fulfilling the requirements of this act and who presents appropriate identification. It shall also be unlawful to obstruct, hamper, or interfere with any representative while in the process of carrying out his or her official duties, including, but not limited to, classification determination pursuant to this act and the rules promulgated under this act.

(b) Any person who is aggrieved or adversely affected by an order or action of the director or the office may seek a review of the order or action in accordance with the Alabama Administrative Procedure Act, codified as Chapter 22, Title 41, Code of Alabama 1975, as amended, in order to enforce this act.

Section 9. (a) Nothing in this act shall be construed to constitute a waiver of the sovereign immunity of the state or the office.

(b) No legal or administrative action shall be brought against the state, the office, the director, or any

member, officer, or employee of the state or the office for damages sustained through the partial or total failure of any dam or for any action or inaction or responsibility pursuant to this act, including specifically, but not limited to, any action taken or not taken by the office, the director, or the employees, officers, or representatives of the office.

(c) Nothing in this act and any order, action, or advice of the director or the office or any representative thereof may be construed to relieve an owner of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

Section 10. Any person who engages in any violation of this act or the rules promulgated under this act shall be guilty of a Class C misdemeanor. Each day of a continued violation shall constitute a separate offense.

Section 11. As an alternative to criminal enforcement pursuant to Section 10, the director may impose civil penalties in accordance with the following provisions:

(1) Whenever the director has reason to believe that any person has violated any provision of this act or rules adopted pursuant to this act, or that a person has negligently or willfully failed or refused to comply with any final order of the director, the director may cause a hearing to be conducted before a hearing officer appointed by the office. Upon a finding that a person has violated any provision of this act, the rules promulgated under this act, or any certificate condition or limitation established pursuant to this act, or that a person has negligently or willfully failed or refused to comply with a final administrative order of the director, the hearing officer shall issue a written decision. The hearing and any administrative or judicial review thereof shall be conducted in accordance with applicable Alabama law.

(2) All civil penalties recovered under this section by the office or by the Attorney General shall be deposited into the State Treasury to the credit of the State General Fund, except that portion representing the reasonable costs incurred to recover the penalties. That portion representing recovery costs shall be deposited to the credit of the operating fund of the office or the Attorney General, whichever incurred such costs.

Section 12. Any owner whose dam is in existence as of the effective date of this act will be required to comply with this act and the rules promulgated under this act once notification has been given as to the classification of the dam by the agency.

Section 13. Although this bill would have as its purpose or effect the requirement of a new or increased expenditure of local funds, the bill is excluded from further requirements and application under Amendment 621, now appearing as Section 111.05 of the Official Recompilation of the Constitution of Alabama of 1901, as amended, because the bill defines a new crime or amends the definition of an existing crime.

Section 14. The provisions of this act are severable. If any part of this act is declared invalid or unconstitutional, that declaration shall not affect the part which remains.

Section 15. All laws or parts of laws which conflict with this act are repealed and superseded by this act.

Section 16. This act shall become effective immediately following its passage and approval by the Governor, or its otherwise becoming law.

Economic and Community Affairs Department

Water and Waterways

Popular Names

Dams and Reservoirs

Crimes and Offenses

Criminal Law and Procedure

Civil Immunity

State of Alabama

Safety

Public Safety

Water Resources Division

Office of Water Resources

E.2. Alaska



11 AAC 93.157. Hazard classification

(a) In order to determine design, operation, inspection, maintenance, emergency action, and reporting criteria under AS 46.17 and 11 AAC 93.151 - 11 AAC 93.201, the department will periodically review and classify each artificial barrier according to the barrier's potential danger to life or property, and will assign the barrier one of the following hazard potential classifications:

(1) a Class I (high) hazard potential classification, if the department determines that the failure or improper operation of the barrier will result in probable loss of human life;

(2) a Class II (significant) hazard potential classification, if the department determines that the failure or improper operation of the barrier will result in

(A) a significant danger to public health;

(B) the probable loss of or probable significant damage to homes, occupied structures, commercial property, high-value property, major highways, primary roads, railroads, or public utilities, other than losses described in (3)(B) of this subsection;

(C) other probable significant property losses or damage, other than losses described in (3)(B) of this subsection; or

(D) probable loss of or significant damage to waters identified under 5 AAC 95.011(a) as important for the spawning, rearing, or migration of anadromous fish; or

(3) a Class III (low) hazard potential classification if the department determines that the failure or improper operation of the barrier will result in

(A) limited impacts to rural or undeveloped land, rural or secondary roads, and structures;

(B) property losses or damage limited to the owner of the barrier; or

(C) insignificant danger to public health.

(b) As necessary to obtain accurate information for a review and classification under (a) of this section, the department will require the owner of an artificial barrier to submit the following information, on a form provided by the department and sealed by an engineer qualified under 11 AAC 93.193(a) :

(1) the type and height of the barrier and the impounding capacity of the reservoir at the maximum storage elevation;

(2) the name of the water body, the location of the barrier and a description of the area downstream;

(3) a proposed hazard potential classification, and any supporting information for that proposed classification; supporting information may include maps, an inundation map prepared in substantial accordance with 11 AAC 93.195, a dam break analysis, photographs, and engineering calculations.

(c) The department may reject a hazard potential classification proposed under (b)(3) of this section and require the owner to submit additional information if the department determines that the

(1) engineer who sealed that information is not qualified under 11 AAC 93.193(a) ; or

(2) information previously provided is insufficient for the department to assign that hazard potential classification.

(d) The department may assign an artificial barrier a higher hazard potential classification than one proposed under (b)(3) of this section. The department will assign the barrier a hazard potential classification based on the level of information readily available regarding the barrier and its potential hazards.

History: Eff. 8/16/89, Register 111; am 10/2/2004, Register 171

Authority: AS 46.17.010

AS 46.17.030

AS 46.17.050

AS 46.17.070

Editor's note: As of Register 186 (July 2008), and acting under AS 44.62.125 (b)(6), the regulations attorney made technical changes to 11 AAC 93.157(a) (2)(D), to reflect Executive Order 114 (2008). Executive Order 114 transferred functions related to protection of fish habitat in rivers, lakes, and streams from the Department of Natural Resources to the Department of Fish and Game.

11 AAC 93.159. Owner's periodic safety inspections

(a) The owner of a Class I or Class II dam shall provide for a periodic safety inspection of the dam at least once every three years. The owner of a Class III dam shall provide for a periodic safety inspection of the dam at least once every five years. The department may order a dam owner to provide for a periodic safety inspection more often than required by this subsection if the department determines that the dam might be unsafe or that more frequent inspections are necessary to protect public safety. Each periodic safety inspection and other work required by this section is at the owner's sole expense. Each periodic safety inspection must be detailed and comprehensive, and must meet the department's guidelines for periodic safety inspections. Those guidelines, set out in Chapter 10, Section 10.4 of the department's *Guidelines for Cooperation with the Alaska Dam Safety Program,* dated September 26, 2003 are adopted by reference.

(b) The periodic safety inspections required by this section must be performed by an engineer who has been approved under 11 AAC 93.193(b) . Before an inspection, the owner shall submit to the department, in writing, the qualifications of the engineer and the scope of the periodic safety inspection. The department will approve the scope of the inspection if the department determines that the scope is adequate to determine the safety of the dam and for the engineer to make reliable recommendations regarding operation and maintenance of the dam, inspections of the dam, and other aspects related to the safety of the dam.

(c) Within 30 days after the visual inspection of the dam is completed, the owner shall submit a periodic

safety inspection report to the department for approval, with as many copies as the department requires. The periodic safety inspection report must be sealed by the engineer approved under 11 AAC 93.193(b) to conduct the inspection. The engineer shall, in the report, make

(1) specific conclusions regarding the safety of the dam, including conclusions with respect to the condition of the dam and the potential for and consequences of any dam failure; and

(2) recommendations for any additional inspections, monitoring, studies, or construction that may be required to improve the safety of the dam.

(d) In response to a periodic safety inspection report, the department may

(1) approve the report, if the department determines that the report adequately reflects the safety of the dam and provides for the maintenance or improvement of the safety of the dam;

(2) request additional detail or clarification in the report;

(3) issue an order requiring the owner to perform additional inspections, studies, or analyses, or to submit additional information that the department determines is necessary to adequately assess the safety of the dam;

(4) revoke, under 11 AAC 93.173(k) , a certificate of approval to operate a dam; or

(5) issue a construction, operation, repair, maintenance, shutdown, or dam removal order that the department considers necessary to protect against dam failure or to protect life and property.

(e) Repealed 10/2/2004.

History: Eff. 8/16/89, Register 111; am 10/2/2004, Register 171

Authority: AS 46.17.010

AS 46.17.030

AS 46.17.050

AS 46.17.060

AS 46.17.070

Editor's note: Copies of Chapter 10, Section 10.4 of the department's *Guidelines for Cooperation with the Alaska Dam Safety Program,* adopted by reference in 11 AAC 93.159(a) , are available from the Department of Natural Resources, Division of Mining, Land and Water, Dam Safety and Construction Unit, 550 West 7th Avenue, Anchorage, Alaska 99501.

11 AAC 93.160. General requirements

Repealed 8/16/89.

11 AAC 93.161. State inspections

(a) The department may inspect a dam or artificial barrier, regardless of its size or hazard potential classification, after providing notice to the owner under AS 46.17.060 .

(b) If the department determines that providing two weeks' notice under AS 46.17.060 is not practical because the dam or barrier presents a potential immediate danger to life or property, the department will give the owner of the dam or barrier as much notice before the inspection as is reasonable under the circumstances.

(c) The owner of a dam shall reimburse the department for costs that the department incurs in making an inspection under this section, including the costs of conducting related dam safety studies and analyses and employing consulting engineers or contractors, if the department determines that a condition may exist that could adversely affect the safety of the dam and the

(1) owner has failed or refused to perform a periodic safety inspection in accordance with 11 AAC 93.159; or

(2) periodic safety inspection report submitted under 11 AAC 93.159(c) is inadequate, and the owner has failed to respond to a department order or request for additional information.

History: Eff. 8/16/89, Register 111; am 10/2/2004, Register 171

Authority: AS 46.17.010

AS 46.17.030

AS 46.17.050

AS 46.17.060

11 AAC 93.163. Emergency remedial action

(a) The department may take emergency remedial action to protect life or property from the risks created by the dam's operation or potential failure, if the department determines that one or more of the following conditions exist:

(1) the condition of a dam is sufficiently dangerous to preclude adequate time for the issuance of an order to the owner under 11 AAC 93.159(d) regarding the maintenance or operation of the dam;

(2) actual or potential flooding threatens the condition of the dam;

(3) the owner will not voluntarily comply with an order or does not have the present means to comply with an order from the department.

(b) In taking emergency remedial action under this section, the department may take supervisory control of the dam from the owner, over the owner's objection if necessary, until the emergency no longer exists. During the department's supervisory control of the dam, the owner, agents, and employees of the owner shall comply with all of the department's orders.

(c) The owner shall reimburse the state for the costs of any reasonably necessary emergency remedial action taken under this section, including the costs of any consultant, contractor, emergency response

agency, or other entity retained or requested by the department to respond to the emergency.

History: Eff. 8/16/89, Register 111; am 10/2/2004, Register 171

Authority: AS 46.17.010

AS 46.17.030

AS 46.17.050

AS 46.17.060

AS 46.17.070

11 AAC 93.164. Owner's emergency action plan

(a) The owner of a Class I or Class II dam shall develop and maintain an emergency action plan in accordance with this section.

(b) The department will approve an emergency action plan if

(1) the plan adequately protects life and property, given the particular risks presented to life or property if the dam fails or in anticipation of imminent dam failure;

(2) the plan provides adequately for the coordination of emergency responders in the community;

(3) the plan contains information that the department considers necessary to minimize danger to life and property; that information must include, if required by the department, a

(A) detailed inundation map, prepared in substantial accordance with 11 AAC 93.195;

(B) dam break analysis; and

(C) schedule for exercise and revision of the plan; and

(4) for a Class I dam, the plan is developed and maintained in accordance with

(A) the Federal Emergency Management Agency's *Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners* (FEMA 64), as revised as of October 1998 and adopted by reference; or

(B) other requirements that the department determines are necessary to protect life or property.

(c) The owner of a Class I or II dam shall review the emergency action plan at least annually, and shall submit any revision of the plan to the department for approval.

(d) The owner of a Class I or II dam shall exercise the emergency action plan to a level specified by the department as sufficient to maintain adequate preparation for an actual emergency, and shall revise the emergency action plan at least every three years, or at a frequency that the department determines sufficient to maintain adequate preparation for an actual emergency. The plan shall be revised after the

exercise in order to address any problems or areas for improvement identified during the exercise, and shall be submitted to the department for approval. Revised plans must be distributed to all persons with responsibilities identified in the plan.

(e) The owner of a Class II dam may include the emergency action plan in the operations and maintenance manual required under 11 AAC 93.167, 11 AAC 93.171, or 11 AAC 93.173.



11 AAC 93.195. Inundation maps and inflow design flood information

(a) An inundation map prepared under 11 AAC 93.157(b) or 11 AAC 93.164 must

(1) indicate the extent of flooding below a dam after failure under the normal operating level of the reservoir, under the inflow design flood, and under other scenarios as the department considers necessary to evaluate danger to life and property;

(2) identify downstream structures or other development, flood wave depth and arrival times, roads, evacuation routes, staging areas, and other information required by the department to minimize danger to life and property; and

(3) be based on a dam break analysis, if required.

(b) For purposes of 11 AAC 93.164 and 11 AAC 93.171, the information for determining the inflow design flood shall be developed in substantial accordance with

(1) the Federal Emergency Management Agency's *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams* (FEMA 94), as revised as of October 1998 and adopted by reference; or

(2) methods approved by the department that adequately assess and characterize the design hydrology, and that are based on the hazard potential classification assigned under 11 AAC 93.157.

(c) In this section, "inflow design flood" means the flood flow above which the incremental increase in the downstream flood caused by a failure of the dam does not result in any additional danger downstream.

History: Eff. 10/2/2004, Register 171

Authority: AS 46.17.010

AS 46.17.030

AS 46.17.050

AS 46.17.070

Editor's note: The Federal Emergency Management Agency's *Federal Guidelines for Dam Safety: Selecting and Accommodating In flow Design Floods for Dams,* adopted by reference in 11 AAC 93.195, may be viewed at the Department of Natural Resources, Division of Mining, Land and Water, Dam Safety and Construction Unit, 550 West 7th Avenue, Anchorage, Alaska.

11 AAC 93.197. Operation and maintenance manuals

(a) An owner that is required under 11 AAC 93.167, 11 AAC 93.171, or 11 AAC 93.173 to prepare or provide an operation and maintenance manual must describe in that manual, in detail, how a dam will

be operated, inspected and maintained, including

(1) a physical description of the dam;

(2) any operating limitations on the dam;

(3) critical design criteria;

(4) a schedule and procedures for routine safety inspections, monitoring, and maintenance of the dam;

(5) detailed instructions and maintenance procedures for operating valves, gates, or other equipment;

(6) maintenance procedures, calibration information, and instructions for instrumentation and for monitoring and alarm systems;

(7) site-specific visual inspection checklists; and

(8) other information requested by the department to provide sufficient detail regarding dam operation, inspection, and maintenance for the protection of life and property.

- **History: Eff. 10/2/2004, Register 171**

- **Authority:** AS 46.17.010

AS 46.17.030

AS 46.17.040

AS 46.17.050

AS 46.17.070

- **11 AAC 93.200. Fee for dam construction permit**

- Repealed 1/1/86.

- **11 AAC 93.201. Definitions**

- Unless the context requires otherwise, in AS 46.17 and 11 AAC 93.151 - 11 AAC 93.201,

(1) "alteration" has the meaning given in AS 46.17.900 ;

(2) "appurtenant works" has the meaning given in AS 46.17.900 ;

(3) "Class I dam" means a dam assigned a Class I (high) hazard potential classification under 11 AAC 93.157;

(4) "Class II dam" means a dam assigned a Class II (significant) hazard potential classification under 11 AAC 93.157;

(5) "dam" has the meaning given in AS 46.17.900 ;

(6) "department" means the Department of Natural Resources;

(7) "enlargement" has the meaning given in AS 46.17.900 ;

(8) "modification" means an enlargement or alteration;

(9) "owner" has the meaning given in AS 46.17.900 ;

(10) "record drawings" means plan, profile, and cross-section drawings that show the final configuration of a dam as constructed, including

(A) lines, grades, elevations, and size;

(B) types of material used for construction;

(C) reservoir area; and

(D) details of all appurtenant works, including spillways, outlet pipes, monitoring devices, and other equipment;

(11) "repair" has the meaning given in AS 46.17.900 ; "repair" does not include routine maintenance;

(12) "routine maintenance" means any work performed on a dam that

(A) is generally of a housekeeping nature; and

(B) does not affect or have the potential to affect the safety of the dam;

(13) "sealed" means prepared by an engineer or a person under that engineer's direct supervision, and bearing the signature and seal of that engineer as required by AS 08.48.221 and 12 AAC 36.185.

History: Eff. 8/16/89, Register 111; am 10/2/2004, Register 171

Authority: AS 46.17.010

AS 46.17.030

AS 46.17.900

Article 4
Temporary Water Use

Section

210. Temporary water use.

220. Procedure for temporary water use.

11 AAC 93.210. Temporary water use

(a) Procedures to authorize the temporary use of water, as provided in 11 AAC 93.220, will apply if the use continues for less than five consecutive years and the water applied for is not otherwise appropriated.

(b) A water right or priority is not established by a temporary water use authorization issued under 11 AAC 93.220. Authorized temporary water use is subject to amendment, modification, or revocation by the department if the department determines that amendment, modification, or revocation is necessary to supply water to lawful appropriators of record or to protect the public interest.

(c) Upon the commissioner's receipt of a written request from the permittee, an authorization for temporary use of water will, in the commissioner's discretion, be extended one time for good cause for a period of time not to exceed five years. The request for an extension of the authorization for temporary use of water must be accompanied by the fee prescribed by 11 AAC 05.010.

History: Eff. 2/8/67, Register 23; am 12/29/79, Register 72; am 11/7/90, Register 116; am 9/16/92, Register 123; am 8/20/2004, Register 171

Authority: AS 46.15.020

AS 46.15.040

AS 46.15.133

AS 46.15.155

Editor's note: As of Register 160 (January 2002), the regulations attorney made technical revisions under AS 44.62.125 (b)(6), and as authorized in ch. 100, sec. 12, SLA 2001, to change "temporary water use permit" to "authorization for temporary use of water" in 11 AAC 93.210(b) and (c).

11 AAC 93.220. Procedure for temporary water use



ALASKA DAM SAFETY LAWS AND REGULATIONS 2007

Citation

Laws establishing the Alaska Dam Safety Program (ADSP) are found in the Alaska Statutes (AS) Title 46 Chapter 17, effective May 31, 1987. Regulations are in the Alaska Administrative Code (AAC) Title 11, Chapter 93, Article 3, which were last amended October 2, 2004.

History

During the 1970s, several dams failed in both Alaska and the Lower 48. These incidents resulted in numerous deaths, including one in Alaska, and millions of dollars in property damage. As early as 1973, Alaska passed laws that attempted to regulate the construction of dams in the state. In 1975, Senate Bill 362 titled "An Act Relating to Supervision of Safety of Dams and Reservoirs" attempted to delegate responsibility to the Department of Public Works, but failed to pass the Ninth Legislative Session. On May 29, 1978, Governor Jay S. Hammond signed an agreement for the Alaska Department of Transportation and Public Facilities to jointly review specific dams with the USACE. Subsequent discussions within the state led to the conclusion that the ADNR had authority related to dam safety through the Water Use Act (AS 46.15) and 11 AAC 72.060, Dam Construction (1973). However, the ADNR expressed a great deal of concern because the statutes and regulations inadequately addressed important dam safety issues such as routine safety inspections, operation and maintenance, and liability.

On December 29, 1979, revised dam safety regulations became effective under Article 3 of 11 AAC 93, Dam Safety and Construction. By 1982, the Water Management Section of the Division of Land and Water Management began to organize the ADSP. The efforts of the entire staff of the central region Water Management Section were directed toward the dam safety program. Nevertheless, the section's civil engineer expressed concern about the ability of the ADNR to address important technical issues associated with dam safety, and the current regulations were again sharply criticized as inadequate. During the early 1980s, the ADNR (with support from consultants) conducted Phase I inspections and site visits of practically every dam that could be identified in the state, including those identified in the National Inventory of Dams. The USACE listed 175 dams in Alaska in 1981. By 1984, the ADSP was staffed with three positions and a $350,000 general fund budget.

In 1987, the state legislature passed the Alaska Dam Safety Act and AS 46.17, which elaborated on the basis for the state to "supervise" the safety of dams in Alaska. The state was required to employ a professional engineer for this purpose, but the staffing of the ADSP was reduced to that one individual and the budget was cut significantly. In 1989, the dam safety regulations were again promulgated under Article 3 of 11 AAC 93. These statutes and regulations were more comprehensive than previous versions, and were based on a model state dam safety program developed by the ASDSO and extensive review of dam safety regulations from other states.

The content of Article 3 of 11 AAC 93 was reviewed in detail and updated between 2000 and 2004. The regulations were revised to include important changes and clarifications about the hazard potential classification; dam owner's periodic safety inspections and emergency action plans; applications for construction, modification, repair, removal, and

abandonment of dams; certificates of approval issued by the department; incident reporting; qualifications for dam design and inspection engineers; and other important information. The original publication of the Guidelines for Cooperation with the Alaska Dam Safety Program (September 2003) was based on a draft version of the revised regulations. The current guidelines (June 2005) are revised to be consistent with the current, final version of the regulations adopted in October 2004.

Definitions

A *dam* is "an artificial barrier, and its appurtenant works, which may impound or divert water and which has or will have an impounding capacity at maximum water storage elevation of 50 acre-feet and is at least 10 feet in height measured from the lowest point at either the upstream or downstream toe of the dam to the crest of the dam; is at least 20 feet in height; or poses a threat to lives and property as determined by the department after an inspection" (AS 46.17.900(3)).

Dam height is the maximum vertical distance from the natural bed of the water course the upstream or downstream toe of the barrier, whichever yields the greater measurement, to the top of the barrier; or if the barrier is not across a watercourse, the maximum vertical distance from the lowest elevation of the outside limit of the barrier to the top of the barrier. (11 AAC 93.153).

Dam Classification

Dams are classified by hazard potential according to the following (11 AAC 93.157):

Class I for a dam whose failure would, in the opinion of the commissioner, result in probable loss of human life;

Class II for a dam whose failure would result in a significant danger to public health; the probable loss of or probable significant damage to homes, occupied structures, commercial property, high-value property, major highways, primary roads, railroads, or public utilities; other probable significant property losses or damage other than losses limited to the owner of the barrier; or, probable loss of or significant damage to waters identified under 11 AAC 195.010(a) as important for spawning, rearing, or migration of anadromous fish.

Class III for a dam whose failure would result in limited impacts to rural or undeveloped land, rural or secondary roads, and structures; property losses or damage limited to the owner of the barrier; or insignificant danger to public health.

Design Criteria

Hydrologic: From 11 AAC 93.195, the inflow design flood shall be developed in substantial accordance with:

(1) the Federal Emergency Management Agency's Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams (FEMA 94), as revised as of October 1998 and adopted by reference; or

(2) methods approved by the department that adequately assess and characterize the design hydrology, and that are based on the hazard potential classification assigned under 11 AAC 93.157.

In this section, "inflow design flood" means the flood flow above which the incremental increase in the downstream flood caused by a failure of the dam does not result in any additional danger downstream. For a Class I (high) hazard potential dam, the “probable maximum flood” is considered the maximum standard; for a Class III (low) hazard potential dam, a “100-year flood” is considered the minimum standard.

Seismic: From 11 AAC 93.171, seismic parameters for the location of the dam, including the peak ground acceleration, the maximum credible earthquake, the maximum design earthquake, and the operating basis earthquake, must be determined in substantial accordance with the guidelines from the United States Army Corps of Engineers' Earthquake Design and Evaluation for Civil Works Projects, publication ER 1110-2-1806, dated July 31, 1995 adopted by reference, or must be determined in substantial accordance with another approach approved by the department.

Other: From 11 AAC 93.171, an applicant must obtain approval of a proposal prepared by the qualified engineer that outlines the proposed scope of work, methodologies, levels of analysis, and approach to design and construct, repair, or modify a dam to adequately provide for the protection of life and property; the proposal must be based on the proposed size and type of the dam, and based on the hazard potential classification, and must include a description of the design quality assurance and quality control to be conducted during the design.

Jurisdiction/Powers of Department

The Department of Natural Resources supervises the safety of dams and reservoirs (AS 46.17.020). The department has the power to adopt regulations and issue orders necessary to carry out its duties (AS 46.17.030). A person may not construct, enlarge, repair, alter, remove, maintain, operate, or abandon a dam or reservoir without the approval of the department (AS 46.17.040). The department has the power to make inspections (AS 46.17.050). The department may enter a dam or reservoir premises without notice if there is reason to believe that a dam or reservoir may be unsafe or presents an imminent threat to life or property (AS 46.17.060). The department may order the owner to take action to protect life and property if it determines the dam or reservoir is unsafe (AS 46.17.070) and may invoke judicial action to enforce the laws and regulations (AS 46.17.080). The department may take supervisory control of the dam from the owner in emergency situations (11 AAC 93.163).

Permit/Approval Process

No person may abandon a dam, remove a dam, or begin the construction, enlargement, modification, or repair (except routine maintenance) of a dam without first applying for the commissioner's permission on a form provided by the commissioner, paying the applicable fees under 11 AAC 05.010, and receiving a certificate of approval from the commissioner for the proposed action. 11 AAC 93.171 defines a detailed application process that includes the following information and documents, unless the department determines that an item or document is not required for the protection of life or property: 1) an initial application package, 2) a preliminary design package, 3) a detailed design package, 4) a final construction package, 5) pre-construction plans, and 6) post-construction documentation. Additional details for each of these packages are described in the regulations. In addition, the applicant must propose a schedule for filing the information and documents required under this section that provides adequate opportunity for the department to review the safety

of the dam and for issuing the required certificates of approval. Furthermore, the applicant must demonstrate financial ability or provide financial assurance, for certain actions, for new dams or for modifications that increase the size of the reservoir or raise the hazard potential classification of the dam. The application must be prepared and sealed by a "qualified engineer" defined in 11 AAC 93.193.

Fees

The completed application form must be accompanied by a non-refundable deposit on the application fee described under 11 AAC 05.010(a)(8)(J), calculated based on preliminary estimates of the applicable costs. Before a Certificate of Approval to Construct a Dam is issued by the Department, the applicant must submit an application fee supplement based on a certified cost estimate of the project. The total fee is based on a based on a declining scale of the estimated project cost; i.e., 2% of first $100,000 of the estimated cost, 1% of the next $400,000, 0.5% of the next $500,000, and 0.25% of all costs in excess of $1,000,000. The cost estimate must include labor and materials for construction, engineering, site investigations, surveying, construction quality assurance and quality control, and other direct expenses.

Inspection Process

The owner of a Class I or Class II dam shall perform a periodic safety inspection on the dam at least once every three years. The owner of a Class III dam shall perform a safety inspection on the dam at least once every five years. All inspections required by the regulations must be accomplished at the owner's sole expense (11 AAC 93.159). The safety inspections must be performed by a qualified engineer with sufficient experience in dam design, construction, and safety appropriate for the type of dam inspected (11 AAC 93.193). If the commissioner determines that a condition may exist that may affect the safety of a dam, or determines that the owner inspection required by 11 AAC 93.159 has been inadequate, the commissioner may inspect the dam, at the owner's expense (11 AAC 93.161).

Frequency of Inspections

Hazard Classification	*Inspection Cycle*
High	3 years
Significant	3 years
Low	5 years

Owner's Non-Compliance/Violations/Penalties

The department has the authority to issue orders for remedial measures to be performed at the owner's expense (11 AAC 93.163). A person is guilty of a Class A misdemeanor if the person knowingly violates a provision of the laws or regulations (AS 46.17.150).

Emergencies

In an emergency situation the commissioner will, at the commissioner's discretion, take remedial action that the commissioner determines is necessary to protect life and property from the risks posed by the dam's operation or potential failure (11 AAC 93.163). The commissioner may take supervisory control of the dam from the owner, over the owner's

objection if necessary, until the emergency passes (11 AAC 93.163). Emergency action plans are required for all Class I and II dams. (11 AAC 93.164).

Liability

The laws and regulations "do not relieve the owner of a dam or reservoir of the duties or liabilities incident to the ownership or operation of the dam or reservoir." (AS 46.17.120). State liability is addressed in the laws or regulations. (AS 46.17.110)

Oversight

A person may not bring an action against the state, the department, or agents or employees of the state, for the recovery of damages caused by the partial or total failure of a dam or reservoir, or by the operation of a dam or reservoir, or by the operation of a dam or reservoir, or by an act or omission in connection with approval of construction, issuance of enforcement orders relating to maintenance or operation of the dam or reservoir, or control or regulation of the dam or reservoir. A person may bring an action against the state for the recovery of damages caused by an action undertaken by a dam owner that was negligently ordered by the state over the owner's objection (AS 46.17.110).

State Citations

	Statute	*Regulations*
Original	Water Use Act (AS 46.15) (1973)	11 AAC 72.060, Dam Construction (1973)
Last Amended	Alaska Dam Safety Act (AS 46.17) (1987)	Article 3 of 11 AAC 93, Dam Safety (2004)

Web Site: http://www.dnr.state.ak.us/mlw/water/dams/

E.3. Arizona



ARIZONA

Citation

The Arizona dam safety law is contained in Arizona Revised Statutes Title 45, Waters, Chapter 6, Dams and Reservoirs, Article I, Supervision of Dams, Reservoirs and Projects, ARS 45:1201-1223. The rules pertaining to the dam safety program are contained in the Arizona Rules and Regulations Pertaining to the Supervision of Dams, Chapter 15, R12-15-151 and 152-15-1201 through 1226. These rules and regulations were originally adopted on Nov. 2, 1978 and substantially revised in 2000.

Definitions/Dam Classification

Arizona Statutes Section 45-1201 defines a *dam* as any artificial barrier, including appurtenant works for the impounding or diversion of water, twenty-five feet or more in height or the storage capacity of which will be more than fifty acre-feet, but does not include
(a) any barrier that is or will be less than six feet in height, regardless of storage capacity
(b) any barrier that has or will have a storage capacity of fifteen acre-feet or less, regardless of height
(c) any barrier for the purpose of controlling liquid-borne material
(d) any barrier that is a release-contained barrier
(e) any barrier that is owned, controlled, operated, maintained or managed by the United States Government or its agencies or instrumentalities if a safety program that is as least as stringent as the state safety program applies and is enforced against the agent or instrumentality.

Dam height is defined as the vertical distance from the lowest elevation of the outside limit of the barrier at its intersection with the natural ground surface to the spillway crest elevation.

Release contained barrier is defined as a barrier that has the storage capacity that in the event of a failure would be contained within the property of its owner.

Hazard Classification Criteria
Hazard classification criteria are given in the Rules (R12-15-1206).

Category	Economic Loss
Very Low - Low	Minimal (underdeveloped to occasional structures or agriculture)
Significant	Appreciable (notable agriculture, industry, or other structure)
High	Excessive (extensive community, industry, agriculture), with probable loss of life

The size of each dam is defined according to the U.S. Army Corps of Engineers National Inventory of Dams standard.

Jurisdiction/Powers of Department

The law states that it is unlawful to construct, reconstruct, repair, operate, maintain, enlarge, remove, or alter any dam except upon prior approval of the director. The director is responsible for the approval process including adopting and revising rules and issuing general orders to effectuate this law. The director is also directed by law to supervise the operation and maintenance of all jurisdictional dams to safeguard life and property.

The law gives the director the right and responsibility to conduct investigations and assemble data to make a proper review of the design and construction process and may enter private property for such purposes.

It also gives the director the ability to issue a notice of noncompliance to prescribed provisions of approval to the owner or construction contractor and can order immediate compliance or can order work stoppage until compliance has been effected and approved by the director. Failure to follow this directive may render the approval revocable.

The director can order construction to cease and desist and can order the owner to appear at a hearing before the department to state his case for non-compliance. The decision is then up to the director as to continuation of the project.

The director is authorized to take any legal action necessary to enforce these statutory provisions.

Approval Process

Arizona law cites characteristics of the process to approve construction, reconstruction, repair, operation, maintenance, enlargement, removal, or alteration of a dam including what shall be included in the application process plus what should be in the plans and specifications and what other materials are required by the director. Rules R12-15-1207 describe the application process in detail--what should be in the application and how the filing fee is calculated. Rules R12-15-1215 describe what should be in the plans and specifications for construction, alteration, etc.
In these rules, it states that all plans and specifications accompanying an application for approval shall be prepared by or under the direction of a professional engineer, registered under Arizona law.

The law pertaining to repair specifies that the approval process may be waived if repair is needed immediately in order to safeguard life and property. The director must be informed prior to this action taking place.

Application Fees

The law gives the director the authority to establish filing fees based on the estimated cost of the dam. The fee shall not exceed 2% of this established cost. The fee must be paid before consideration of the application. All fees will be deposited in the dam repair fund. The following fee structure has been established by the rules (R12-15-151):

Application filing fee is based on:
1) Review of plans, studies of dam costs (in dollars):

-first $ 100,000	2.0%
-next $ 400,000	1.5%
-next $500,000	1.0%
-over $600,000	0.5%
2) Safety Inspections	
Per inspection	$100
Plus, per foot of height	$ 2
3) Other Charges	
Photocopies	.25 each
Computer reports:	
First page of report	$15
Additional pages	.25 each
Certified "True Copies"	$2.75/ Page

Approval of Application
By law, the director must inspect the dam upon completion of construction. If the inspection passes, the approval is made and a license is issued for use (the rules detail this process, R12-15-1214). The approval plan may be revised if after inspecting the work he believes amendments, modifications or changes are necessary.

According to law, the application must be approved in not less than 10 days from receipt nor retained more than 60 days unless more information is needed. Construction must commence within one year of approval and the director must be notified at least 10 days before construction begins. Time frame rules provide limits of 120 days for administrative review, and 60 days for substantive review.

Inspection Process
According to law, the director shall inspect after construction, repair , remodeling. or alteration, during operation and maintenance, and upon filing of a legitimate complaint concerning the safety of the dam. The rules specify criteria for the inspection process. Guidelines were developed to accompany the rules stating operation and maintenance frequency--they are as follows:

Hazard Potential	Storage Dam Inspection Frequency (at least once each)
Low – Very low	Five Years
Significant	Three Years
High	One Year

The rules state that the owner is responsible for safety during construction and after completion of the dam and inspection during and after construction, enlargement, repair, alteration, or removal in accordance with the plans and specifications as approved by the director.

Violations/Penalties
Arizona law defines a violation as failure to follow the law concerning construction, repair, enlargement, alteration, or removal of a dam or failure to carry out an order of the director. The violator is guilty of a class 2 misdemeanor for each day the violation continues.

If the director feels a violation has taken place, he must give the owner written notice to appear at a hearing before the department to show cause why the owner should not be penalized or be directed to cease and desist work. The director is then responsible for all decisions based on the hearing. If the violation continues, the director may retain a temporary restraining order or a permanent injunction from the state superior court.

The law states that a person determined to violate the law may be assessed a penalty not to exceed $1,000 per day of the violation. These monies go to the state general fund. A judge may stay the decision of the director upon appeal on a showing of good cause.

Emergencies
The law requires that the director determine if a dam is dangerous or if floods threaten its safety and can then employ immediate remedial measures to correct the problem. The law goes on to explain exactly what the director can do to the dam in this instance and says that he is in full charge of the dam until it is rendered safe or the emergency has terminated.

The law also states that the director may spend monies from the dam repair fund (Sect. 45-1212.01).

The owner is ultimately responsible for the costs of the remedial work. The law states that a lien shall be put against the owner's property to cover these costs. As he pays back the debt, the money collected goes back to the dam repair fund.

Liability

Section 45-1215 of the law states that no action shall be brought or maintained against the state, or any of its departments, agencies or officials thereof, or any of their employees or agents, for damages sustained through the partial or total failure of a dam or its maintenance by reason of control and regulation thereof by any of them pursuant to duties imposed upon them under the provisions of this chapter.

Nothing in this article shall relieve the owner or operator of a dam from the legal duties, obligations and liabilities arising from such ownership or operation.

Oversight

Section 45-1210-1211 explains the process by which a petition can be filed against any decision made by the director. It also explains has a board of review is formed to hear the petition.

Miscellaneous

Financing

The law states that the director may require a surety company bond in amount sufficient to secure the costs to the state in assuming the safety of a dam left partially constructed. This is required when the director questions the financial stability of the owner or contractor or otherwise deems the bond advisable.

The law also establishes funds to help finance the repair of unsafe dams:

The dam repair fund is made up of monies appropriated by the legislature and monies collected from a lien as described under "Emergencies" and is used for emergency remedial work. The dam repair fund also includes appropriate funds, inspection fees, filing fees, and principal and interest collected from dam repair loans. This money may be used for loans and grants (described below). Monies in these funds are exempt from Section 35-190 relating to lapsing of appropriations.

Non-emergency dam repair loans let the director grant loans to dam owners to defray the costs of repair which are necessary for safety reasons but not emergencies. Loans are for terms of not more than 20 years. The law goes on to prescribe interest rates, contractual arrangements, fund maintenance procedures, and defaulting procedures.

Dam repair grants may be granted for the same purposes as above and may be in addition to the loans.

Arizona Secretary of State - Ken Bennett

TITLE 12. NATURAL RESOURCES

AAC Table of Contents Order this Chapter

TITLE 12. NATURAL RESOURCES

CHAPTER 15. DEPARTMENT OF WATER RESOURCES

Supp. 07-3

(Authority: A.R.S. § 45-101 et seq.)

ARTICLE 1. FEES

Section
R12-15-101. Reserved
through
R12-15-150. Reserved
R12-15-151. Fee Schedule
R12-15-152. Expired

ARTICLE 2. PROCEDURAL RULES

Article 2, consisting of Sections R12-15-201 through R12-15-224, adopted effective June 13, 1984.

Section
R12-15-201. Expired
R12-15-202. Expired
R12-15-203. Expired
R12-15-204. Expired
R12-15-205. Expired
R12-15-206. Expired
R12-15-207. Correction of Clerical Mistakes
R12-15-208. Expired
R12-15-209. Expired
R12-15-210. Expired
R12-15-211. Expired
R12-15-212. Expired
R12-15-213. Expired
R12-15-214. Expired
R12-15-215. Expired
R12-15-216. Expired
R12-15-217. Expired
R12-15-218. Expired
R12-15-219. Expired
R12-15-220. Expired
R12-15-221. Expired
R12-15-222. Expired
R12-15-223. Expired
R12-15-224. Ex Parte Communications

ARTICLE 3. STOCKPOND AND OTHER SURFACE WATER RULES

Section
R12-15-301. Expired
R12-15-302. Expired
R12-15-303. Multiple applications for water rights
R12-15-304. Reserved
R12-15-305. Reserved
R12-15-306. Reserved
R12-15-307. Reserved
R12-15-308. Reserved
R12-15-309. Reserved
R12-15-310. Renumbered

ARTICLE 4. LICENSING TIME-FRAMES

Article 4, consisting of Sections R12-15-401 and Table A, adopted effective December 31, 1998; filed in the Office of the Secretary of State July 28, 1998 (Supp. 98-3).

Section
R12-15-401. Licensing Time-frames
Table A. Licensing Time-frames

ARTICLE 5. RESERVED

ARTICLE 6. RESERVED

ARTICLE 7. ASSURED AND ADEQUATE WATER SUPPLY

Article 7, consisting of Sections R12-15-701 through R12-15-725, adopted effective February 7, 1995.

Section
R12-15-701. Definitions - Assured and Adequate Water Supply Programs
R12-15-702. Physical Availability Determination
R12-15-703. Analysis of Assured Water Supply
R12-15-703.01. Repealed
R12-15-704. Certificate of Assured Water Supply
R12-15-705. Assignment of Type A Certificate of Assured Water Supply
R12-15-706. Assignment of Type B Certificate of Assured Water Supply
R12-15-707. Application for Classification of a Type A Certificate
R12-15-708. Material Plat Change; Application for Review
R12-15-709. Certificate of Assured Water Supply; Revocation
R12-15-710. Designation of Assured Water Supply
R12-15-711. Designation of Assured Water Supply; Annual Report Requirements, Review, Modification, Revocation
R12-15-712. Analysis of Adequate Water Supply
R12-15-713. Water Report
R12-15-714. Designation of Adequate Water Supply
R12-15-715. Designation of Adequate Water Supply; Annual Report Requirements, Review, Modification, Revocation

R12-15-716. Physical Availability
R12-15-717. Continuous Availability
R12-15-718. Legal Availability
R12-15-719. Water Quality
R12-15-720. Financial Capability
R12-15-721. Consistency with Management Plan
R12-15-722. Consistency with Management Goal
R12-15-723. Extinguishment Credits
R12-15-724. Phoenix AMA Calculation of Groundwater Allowance and Extinguishment Credits
R12-15-725. Pinal AMA - Groundwater Allowance and Extinguishment Credits Calculation
R12-15-726. Prescott AMA Calculation of Groundwater Allowance and Extinguishment Credits
R12-15-727. Tucson AMA Calculation of Groundwater Allowance and Extinguishment Credits
R12-15-728. Reserved
R12-15-729. Remedial Groundwater; Consistency with Management Goal
R12-15-730. Assured and Adequate Water Supply Fees

ARTICLE 8. WELL CONSTRUCTION AND LICENSING OF WELL DRILLERS

Article 8, consisting of Sections R12-15-801 through R12-15-821, adopted effective March 5, 1984.

Section
R12-15-801. Definitions
R12-15-802. Scope of Article
R12-15-803. Well Drilling and Abandonment Requirements; Licensing and Supervision Requirements
R12-15-804. Application for Well Drilling License
R12-15-805. Examination for Well Drilling License
R12-15-806. License Fee; Issuance and Term of Licenses; Renewal; Display of License
R12-15-807. Single Well License
R12-15-808. Revocation of License
R12-15-809. Notice of Intention to Drill
R12-15-810. Authorization to Drill
R12-15-811. Minimum Well Construction Requirements
R12-15-812. Special Aquifer Conditions
R12-15-813. Unattended Wells
R12-15-814. Disinfection of Wells
R12-15-815. Removal of Drill Rig from Well Site
R12-15-816. Abandonment
R12-15-817. Exploration Wells
R12-15-818. Well Location
R12-15-819. Use of Well as Disposal Site
R12-15-820. Request for Variance
R12-15-821. Special Requirements
R12-15-822. Capping of Open Wells
R12-15-823. Reserved
R12-15-824. Reserved
R12-15-825. Reserved
R12-15-826. Reserved
R12-15-827. Reserved
R12-15-828. Reserved
R12-15-829. Reserved
R12-15-830. Reserved
R12-15-831. Reserved
R12-15-832. Reserved
R12-15-833. Reserved
R12-15-834. Reserved
R12-15-835. Reserved
R12-15-836. Reserved
R12-15-837. Reserved
R12-15-838. Reserved
R12-15-839. Reserved
R12-15-840. Reserved
R12-15-841. Reserved
R12-15-842. Reserved
R12-15-843. Reserved
R12-15-844. Reserved
R12-15-845. Reserved
R12-15-846. Reserved
R12-15-847. Reserved
R12-15-848. Reserved
R12-15-849. Reserved
R12-15-850. Evaluation of Notices of Intention to Drill; Notification of Registered Site Locations; Vertical Cross-Contamination Evaluation
R12-15-851. Notification of Well Drilling Commencement
R12-15-852. Notice of Well Inspection; Opportunity to Comment

ARTICLE 9. WATER MEASUREMENT

Article 9, consisting of Sections R12-15-901 through R12-15-905, adopted effective December 27, 1982.

Section
R12-15-901. Definitions
R12-15-902. Installation of Approved Measuring Devices
R12-15-903. Approved Water Measuring Devices and Methods
R12-15-904. Water Measuring Method Reporting Requirements
R12-15-905. Accuracy of Approved Measuring Devices
R12-15-906. Repair and Replacement of Approved Measuring Devices
R12-15-907. Calculation of Irrigation Water Deliveries
R12-15-908. Measurement of Water by One Person on Behalf of Another
R12-15-909. Alternative Water Measurement Devices, Methods, and Reporting

ARTICLE 10. REPORTING REQUIREMENTS FOR ANNUAL REPORTS, ANNUAL ACCOUNTS, OPERATING FLEXIBILITY ACCOUNTS, AND CONVEYANCES OF GROUNDWATER RIGHTS

Section
R12-15-1001. Definitions
R12-15-1002. Form of Annual Account or Annual Report
R12-15-1003. Accuracy of Annual Reports
R12-15-1004. Annual Reports Filed on Behalf of a Responsible Party
R12-15-1005. Management Plan Monitoring and Reporting Requirements
R12-15-1006. Reporting Requirements for Holders of Recovery Well Permits
R12-15-1007. Reporting Requirements for Annual Account
R12-15-1008. Information Required to Maintain an Operating Flexibility Account
R12-15-1009. Credits to Operating Flexibility Account
R12-15-1010. Operating Flexibility Account; Tailwater
R12-15-1011. Statement of Operating Flexibility Account
R12-15-1012. Rule of Construction

R12-15-1013. Retention of Records for Annual Accounts and Annual Reports
R12-15-1014. Late Filing or Payment of Fees; Extension Penalties
R12-15-1015. Reporting Requirements for Conveyances of Grandfathered Rights and Groundwater Withdrawal Permits
R12-15-1016. Spillwater Reporting by Water Deliverers
R12-15-1017. Maintenance and Filing of Annual Reports Required by A.R.S. § 45-343

ARTICLE 11. INSPECTIONS AND AUDITS

Article 11, consisting of Sections R12-15-1101 and R12-15-1102, adopted effective August 31, 1992 (Supp. 92-3).

Section
R12-15-1101. Inspections
R12-15-1102. Audits

ARTICLE 12. DAM SAFETY PROCEDURES

Article 12, consisting of Sections R12-15-1201 through R12-15-1206, repealed; new Article 12, consisting of Sections R12-15-1201 through R12-15-1226 et seq., adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

Section
R12-15-1201. Applicability
R12-15-1202. Definitions
R12-15-1203. Exempt Structures
Table 1. Exempt Structures
R12-15-1204. Provision for Guidelines
R12-15-1205. General Responsibilities
R12-15-1206. Classification of Dams
Exhibit A. Repealed
Table 2. Size Classification
Table 3. Downstream Hazard Potential Classification
R12-15-1207. Application Process
R12-15-1208. Application to Construct, Reconstruct, Repair, Enlarge, or Alter a High or Significant Hazard Potential Dam
R12-15-1209. Application to Breach or Remove a High or Significant Hazard Potential Dam
R12-15-1210. Application to Construct, Reconstruct, Repair, Enlarge, Alter, Breach, or Remove a Low Hazard Potential Dam
R12-15-1211. Application to Construct, Reconstruct, Repair, Enlarge, Alter, Breach, or Remove a Very Low Hazard Potential Dam
R12-15-1212. Construction of a High, Significant, or Low Hazard Potential Dam
R12-15-1213. Completion Documents for a Significant or High Hazard Potential Dam
R12-15-1214. Licensing
R12-15-1215. Construction Drawings, Construction Specifications, and Engineering Design Report for a High, Significant, or Low Hazard Potential Dam
R12-15-1216. Design of a High, Significant, or Low Hazard Potential Dam
Table 4. Inflow Design Flood
Table 5. Minimum Factors of Safety for Stability
R12-15-1217. Maintenance and Repair; Emergency Actions
R12-15-1218. Safe Storage Level
R12-15-1219. Safety Inspections
R12-15-1220. Existing Dams
R12-15-1221. Emergency Action Plans
R12-15-1222. Right of Review
R12-15-1223. Enforcement Authority
R12-15-1224. Emergency Procedures
R12-15-1225. Emergency Repairs
R12-15-1226. Non-Emergency Repairs; Loans and Grants

ARTICLE 13. WELL SPACING REQUIREMENTS; REPLACEMENT WELLS IN APPROXIMATELY THE SAME LOCATION

Article 13, consisting of Sections R12-15-1301 through R12-15-1308, made by final rulemaking at 12 A.A.R. 2193, effective August 7, 2006 (Supp. 06-2).

R12-15-1301. Definitions
R12-15-1302. Well Spacing Requirements - Applications to Construct New Wells or Replacement Wells in New Locations Under A.R.S. § 45-599
R12-15-1303. Well Spacing Requirements - Applications for Recovery Well Permits Under A.R.S. § 45-834.01
R12-15-1304. Well Spacing Requirements - Wells Withdrawing Groundwater From the Little Colorado River Plateau Groundwater Basin for Transportation to Another Groundwater Basin Under A.R.S. § 45-544(B)(1)
R12-15-1305. Well Spacing Requirements - Applications to Use a Well to Withdraw Groundwater for Transportation to an Active Management Area Under A.R.S. § 45-559
R12-15-1306. Well Spacing Requirements - Applications for Water Exchange Permits Under A.R.S. § 45-1041
R12-15-1307. Well Spacing Requirements - Notices of Water Exchange Under A.R.S. § 45-1051
R12-15-1308. Replacement Wells in Approximately the Same Location

ARTICLE 1. FEES

R12-15-101. Reserved
through
R12-15-150. Reserved

R12-15-151. Fee Schedule

A. The Department shall only accept or take action on an application or filing upon payment of the appropriate fee as listed below. Payment may be made by cash, check, or by entry in an existing Department fee-credit account established pursuant to R12-15-152.

B. The following fees shall be paid:

1. SURFACE WATER FEE ($)
   - a. Application for permit to appropriate
     - i. Less than 50 acre feet 50.00
     - ii. 50 acre feet or more 75.00
   - b. Permit to appropriate
     - i. Less than 50 acre feet 25.00
     - ii. 50 acre feet or more 50.00
   - c. Claim of water right for a stockpond and application for certification 10.00
   - d. Certificate of water right for stockpond 30.00
   - e. Issue certificate of water right (except stockpond) 50.00
   - f. Application for severance and transfer of water right . 500.00
   - g. Application to transport water out of state 500.00
   - h. Assignment
     - i. Assignment of application for permit to appropriate, statement of claim, or claim of water right for a stockpond 10.00
     - ii. Assignment and reissuance of permit to appropriate 20.00
     - iii. Assignment and reissuance of certificate of water right (except stockpond) 35.00
     - iv. Assignment and reissuance of certificate of water right for a stockpond 20.00
2. GROUNDWATER
   - a. Application for groundwater withdrawal permit, modifications and renewals (except

applications for hydrologic testing and temporary dewatering permits) 150.00
b. Application for permit for hydrologic testing and temporary dewatering, modifications, and renewals 50.00
c. Groundwater withdrawal permit 50.00
d. Convey groundwater withdrawal permit (except for permits for temporary electrical energy generation, temporary dewatering, hydrologic testing, and groundwater replenishment district withdrawals) 35.00
e. Application for notice of authority to irrigate in an irrigation nonexpansion area 50.00
f. Convey or reissue notice of authority to irrigate in an irrigation nonexpansion area 35.00

3. WATER EXCHANGES
a. Statement of water exchange contract 100.00
b. Application for water exchange permit 150.00
c. Water exchange permit 100.00
d. Renew or modify water exchange permit 100.00
e. Notice of water exchange 150.00

4. WELLS
a. Reissue drilling card 10.00
b. Permit to drill new or replacement well 30.00
c. Registration of exempt well No charge
d. Registration of nonexempt well 10.00
e. Late registration of any well (post 7/16/82) 10.00
f. Well assignments (single or group of wells by same owner) 10.00
g. Well driller's licenses (except single well license) 50.00
h. Reissue or renew unexpired well driller's license 10.00
i. Reactivate expired well driller's license 20.00
j. Single well license No charge
k. Well capping 300.00
minimum
plus actual
expenses
over 300.00

5. GRANDFATHERED RIGHTS
a. Application for certificate of grandfathered right 75.00
b. Late application for certificate of grandfathered right 100.00
c. Convey or reissue certificate of grandfathered right 35.00
d. Application for type 1 nonirrigation grandfathered right associated with retired irrigation l and 50.00
e. Application to retire an irrigation grandfathered right from irrigation to nonirrigation 100.00
f. Application for restoration of retired irrigation grandfathered right 50.00
g. Purchase of flexibility account credit balance 100.00

6. SUBSTITUTION OF ACRES
a. Application to substitute irregularly shaped acres in an irrigation nonexpansion area or an active management area 50.00
b. Application to substitute flood-damaged acres in an irrigation nonexpansion area or an active management area 100.00
c. Application to substitute CAP acres in an irrigation nonexpansion area 50.00
d. Application to substitute, or to reverse substitution of, CAP acres in an active management area 100.00

7. ADEQUATE AND ASSURED WATER SUPPLY
Applications, certificates, licenses, reports, and permits relating to assured and adequate water supply . . . . . The applicable fee prescribed in Article 7 of this Chapter.

8. UNDERWATER WATER STORAGE SAVINGS AND REPLENISHMENT PROGRAM
a. Application for underground storage facility permit 750.00
b. Underground storage facility permit 500.00
c. Convey underground storage facility permit 300.00
d. Application for groundwater savings facility permit 500.00
e. Groundwater savings facility permit 350.00
f. Convey groundwater savings facility permit 300.00
g. Application for water storage permit 250.00
h. Water storage permit 100.00
i. Convey water storage permit 300.00
j. Application for recovery well permit
i. First 10 wells 50/well
ii. Over 10 wells 10/well
k. Recovery well permit
i. First 10 wells 50/well
ii. Over 10 wells 10/well

9. CERTIFICATES OF GROUNDWATER OVERSUPPLY
a. Application for certificate of groundwater oversupply 150.00
b. Certificate of groundwater oversupply 50.00

10. LAKES
a. Application for permit to fill or refill a body of water

i. Poor quality groundwater 150.00
ii. Interim 50.00
b. Permit to fill or refill a body of water
i. Poor quality groundwater 75.00
ii. Interim 30.00
c. Application for determination of substantial capital investment to fill or refill a body of water 50.00
d. Application and permit for temporary emergency use of water to fill a body of water 50.00
11. SAFETY OF DAMS
a. Application for review No charge
b. Application filing fee - review of plans and studies based upon dam cost
i. First $100,000 2.0%
ii. Next $400,000 1.5%
iii. Next $500,000 1.0%
iv. Remainder over $1,000,000 .5%
c. Safety Inspections
i. Per inspection 100.00
ii. Plus, per foot of height 2.00
12. WEATHER MODIFICATION
a. Application for weather modification license 100.00
b. License to manufacture or sell weather modification equipment 10.00
13. COPIES
a. Photocopies .25/page
b. Microfiche copies .30/page
c. Computer reports:
i. First page of report 15.00
ii. Additional page .25 each
d. Certified copies 2.75/page

C. In addition to the fees listed above, the applicant shall pay the Department the actual cost of mailing and/or publishing any legal notice required by statute.

Historical Note

Adopted effective October 8, 1982 (Supp. 82-5). Amended effective June 29, 1994 (Supp. 94-2). Amended effective March 3, 1995 (Supp. 95-1). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4). Amended by final rulemaking at 13 A.A.R. 3022, effective October 6, 2007 (Supp. 07-3).

R12-15-152. Expired

Historical Note

Adopted effective October 8, 1982 (Supp. 82-5). Section expired under A.R.S. § 41-1056(E) at 13 A.A.R. 1647, effective May 31, 2006 (Supp. 07-2).

ARTICLE 2. PROCEDURAL RULES

R12-15-201. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). The reference to R12-14-223 in subsection (C) corrected to read R12-15-223 (Supp. 93-1). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-202. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-203. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-204. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-205. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-206. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-207. Correction of Clerical Mistakes

Upon a motion or on the initiative of the Director, the Director may correct clerical mistakes in decisions, orders, rulings, any process issued by the Department, or other parts of the record, and errors in the record arising from oversight or omission. The Director shall give all parties and the Chief Counsel notice of any corrections made pursuant to this Section.

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Amended by final rulemaking at 13 A.A.R. 3022, effective October 6, 2007 (Supp. 07-3).

R12-15-208. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-209. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-210. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-211. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-212. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-213. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-214. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-215. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section number corrected (Supp. 93-1). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-216. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-217. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-218. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-219. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-220. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-221. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-222. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-223. Expired

Historical Note

Adopted effective June 13, 1984 (Supp. 84-3). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2159, effective February 28, 2001 (Supp. 01-2).

R12-15-224. Ex Parte Communications

A. During the course of a contested case or appealable agency action, a party shall not make an ex parte communication or knowingly cause an ex parte communication to be made to the Director or other Department employee or consultant who is or may reasonably be expected to be involved in the decision-making process of the contested case or appealable agency action.

B. During the course of a contested case or appealable agency action, the Department personnel listed in subsection (A) shall not make an ex parte communication or knowingly cause an ex parte communication to be made to a party or a person who will be materially and directly affected by the outcome of the contested case or appealable agency action.

C. Any of the Department personnel listed in subsection (A) of this Section who receives a written communication prohibited by this Section shall file a copy of the communication in the public docket and serve a copy on the Director, the Chief Counsel, and all parties to the contested case or appealable agency action. Any of the Department personnel listed in subsection (A) of this Section who receives an oral communication prohibited by this Section shall file a summary, stating the substance of the communication, in the public docket and serve a copy on the Director, the Chief Counsel, and all parties to the contested case or appealable agency action.

D. Upon receipt of an ex parte communication or a copy or summary of an ex parte communication made or knowingly caused to be made by a party in violation of this Section, the Director, to the extent consistent with the interests of justice and the policy of the underlying statutes and rules, may require the party to show cause why the party's claim or interest in the contested case or appealable agency action should not be dismissed, denied or disregarded because of the violation.

E. For purposes of this Section, "ex parte communication" means any written or oral communication relating to the merits of a contested case or appealable agency action, except:

1. Communications made in the course of official proceedings in the contested case or appealable agency action;
2. Communications made in writing, if a copy of the communication is promptly served on the Director, the Chief Counsel, and all parties to the contested case or appealable agency action;
3. Oral communications made after adequate notice, stating the substance of each communication, to all parties and the Chief Counsel;
4. Communications relating solely to procedural matters; and
5. As otherwise authorized by law.

Historical Note

Adopted effective June, 1984 (Supp. 84-3). Amended by final rulemaking at 13 A.A.R. 3022, effective October 6, 2007 (Supp. 07-3).

ARTICLE 3. STOCKPOND AND OTHER SURFACE WATER RULES

R12-15-301. Expired

Historical Note

Adopted effective October 8, 1982 (Supp. 82-5). Amended effective April 3, 1987 (Supp. 87-2). Amended effective May 7, 1990 (Supp. 90-2). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2012, effective February 28, 2001 (Supp. 01-2).

R12-15-302. Expired

Historical Note

Adopted effective October 8, 1982 (Supp. 82-5). Amended effective May 7, 1990 (Supp. 90-2). Section expired under A.R.S. § 41-1056(E) at 7 A.A.R. 2012, effective February 28, 2001 (Supp. 01-2).

R12-15-303. Multiple Applications for Water Rights

A. If two or more applications are filed with the Director pursuant to A.R.S. §§ 45-152 or 45-273 or both by or for the same applicant and for a right to use the same water, the Director shall consolidate the applications. If the applicant is otherwise entitled to both a permit to appropriate and a certificate of stockpond water right, the Director shall issue to the applicant either the permit to appropriate or the certificate of stockpond water right, whichever would give the applicant the higher priority.

B. If one or more applications are filed with the Director pursuant to A.R.S. §§ 45-152 or 45-273 or both by or for the same applicant and for a right to use the same water for which the applicant holds a permit to appropriate, a certificate of water right or a certificate of stockpond water right, the Director shall deny the application or applications unless the applicant relinquishes every permit to appropriate, certificate of water right and certificate of stockpond water right which the applicant holds for that same water. The applicant may relinquish every permit to appropriate, certificate of water right and certificate of stockpond water right on the condition that the Director issues a permit to appropriate or certificate of stockpond water right to the applicant for the same water. In that case, the relinquishment shall be effective when the Director issues the permit to appropriate or certificate of stockpond water right.

C. For purposes of this rule, "same water" means the same quantity of water from the same source for use at the same place for the same purpose. Water for which a right is applied or held pursuant to an application or permit to appropriate, certificate of water right or certificate of stockpond water right may be the same water in whole or in part as water for which a right is applied or held pursuant to a separate application or permit to appropriate, certificate of water right or certificate of stockpond water right.

Historical Note

Adopted effective April 3, 1987 (Supp. 87-2). Section R12-15-310 renumbered to R12-15-303 and amended effective May 7, 1990 (Supp. 90-2).

R12-15-304. Reserved

R12-15-305. Reserved

R12-15-306. Reserved

R12-15-307. Reserved

R12-15-308. Reserved

R12-15-309. Reserved

R12-15-310. Renumbered

Historical Note

Adopted effective April 3, 1987 (Supp. 87-2). Section R12-15-310 renumbered to R12-15-303 effective May 7, 1990 (Supp. 90-2)

ARTICLE 4. LICENSING TIME-FRAMES

R12-15-401. Licensing Time-frames

The following time-frames apply to licenses issued by the Department. In this Article, "license" has the meaning prescribed in A.R.S. § 41-1001. The licensing time-frames consist of an administrative completeness review time-frame, a substantive review time-frame, and an overall time-frame.

1. Within the administrative completeness review time- frames set forth in subsection (7), the Department shall notify the applicant in writing whether the application is complete or incomplete. If the application is incomplete, the notice shall specify what information or component is required to make the application complete.
2. An applicant with an incomplete application shall supply the missing information within 60 days from the date of the notice, or within such further time as the Director may specify, unless another time limit is specified by statute or applicable rule. If the applicant fails to complete the application within the specified time period, the Director may deny the application. Denial of an application under this provision does not preclude the applicant from filing a new application.
3. Within the overall time-frames set forth in subsection (7), unless extended by mutual agreement under A.R.S. § 41-1075, the Department shall notify the applicant in writing that the application is granted or denied. If the application is denied, the Department shall provide written justification for the denial and a written explanation of the applicant's right to a hearing or the applicant's right to appeal.
4. In computing any period of time prescribed by this rule, the day of the filing, notice or event from which the designated period of time begins to run shall not be included. The last day of the computed period shall be included, unless it is a Saturday, Sunday, or a legal holiday, in which event the period runs until the end of the next day which is not a Saturday, Sunday, or legal holiday. When the prescribed administrative completeness review time-frame or substantive review time-frame is less than 11 days, intermediate Saturdays, Sundays and legal holidays shall be excluded from the computation. The overall time-frame is the sum of the administrative completeness review time-frame and the substantive review time-frame calculated as prescribed by this Section.
5. Except as otherwise noted, the licensing time-frames do not include time for hearings. Time-frames in cases where a hearing is held are increased by 120 days.
6. The licensing time-frame rules are effective after December 31, 1998, as prescribed by A.R.S. § 41-1073(A), and apply to all applications filed after that date.
7. The licensing time-frames are set forth in Table A.

Historical Note

Adopted effective December 31, 1998; filed with the Office of the Secretary of State July 28, 1998 (Supp. 98-3). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

Table A. Licensing Time-frames

No.	License	Legal Authority	Completeness Review (Days)*	Substantive Review (Days)*	Overall Time-frame (Days)*
1	Filling a body of water with poor quality water	A.R.S. § 45-132(C)	30	60	90
2	Interim water use in body of water	A.R.S. § 45-133	30	60	90
3	Temporary emergency permit for use of surface water or groundwater in body of water	A.R.S. § 45-134	10	20	30
4	Permit to appropriate water (non-instream flow)	A.R.S. §§ 45-151 and 45-153	30	420	450
5	Permit to appropriate water (instream flow)	A.R.S. §§ 45-151 and 45-153	50	530	580
6	Change in use of water	A.R.S. § 45-156(B)	30	375	405
7	Exception to limitation on time of completion of construction	A.R.S. § 45-160	5	15	20
8	Primary reservoir permit	A.R.S. § 45-161	30	420	450
9	Secondary reservoir permit	A.R.S. § 45-161	30	420	450
10	Certificate of water right (non-instream flow)	A.R.S. § 45-162	20	100	120
11	Certificate of water right (instream flow)	A.R.S. § 45-162	20	190	210
12	Reissuance of permit or certificate held by the United States or State of Arizona	A.R.S. § 45-164(C)	10	80	90
13	Severance and transfer	A.R.S. § 45-172 (excluding 172.6)	30	390	420
14	Stockpond certificate	A.R.S. § 45-273	30	190	220
15	Transporting water from this state **	A.R.S. § 45-292	120	300	420
16	Waiver of water conserving plumbing fixture requirement	A.R.S. § 45-315	10	3	13
17	Irrigated acreage in an irrigation non-expansion area	A.R.S. § 45-437	30	90	120
18	Substitution of acres in an irrigation non-expansion area/flood damage	A.R.S. § 45-437.02	30	90	120
19	Substitution of acres in an irrigation non-expansion area/impediments to efficient irrigation	A.R.S. § 45-437.03	30	90	120
20	Reversal of substitution of acres irrigated with Central Arizona Project water	A.R.S. § 45-452(G)	30	90	120
21	Type 1 non-irrigation grandfathered right associated with irrigation land retired 1965-1980	A.R.S. §§ 45-463, 45-476.01, and 45-476	30	90	120
22	Type 2 non-irrigation grandfathered right	A.R.S. §§ 45-464, 45-476.01, and 45-476	30	90	120
23	Irrigation grandfathered right	A.R.S. §§ 45-465, 45-476.01, and 45-476	30	90	120
24	Substitution of acres in an active management area/flood damaged acres	A.R.S. § 45-465.01	30	90	120
25	Substitution of acres in an active management area/impediments to efficient irrigation	A.R.S. § 45-465.02	30	90	120
26	Type 1 non-irrigation right retired after 6/12/80	A.R.S. § 45-469	30	90	120
27	Restoration of retired irrigation grandfathered right	A.R.S. § 45-469(O)	30	90	120
28	Revised certificate for new or additional points of withdrawal for a Type 2 right	A.R.S. § 45-471(C)	45	135	180
29	Conveyance of irrigation grandfathered right for electrical energy generation	A.R.S. § 45-472(B)(2)	30	90	120
30	Conveyance of irrigation grandfathered right for non-irrigation use within service area	A.R.S. § 45-472(C)	30	90	120
31	Contract to supply groundwater	A.R.S. § 45-492(C)	15	90	105
32	Extension of service area to provide disproportionally large amount of water to large user	A.R.S. § 45-493(A)(2)	15	90	105
33	Addition/exclusion of acres by irrigation district	A.R.S. § 45-494.01(A)	30	90	120
34	Delivery of groundwater from an irrigation district to a general industrial use permit holder	A.R.S. § 45-497(B)	15	60	75
		A.R.S. §§ 45-513 and 45-			

35	Issuance/renewal/modification of dewatering permit	527	30	70	100
36	Issuance/renewal/modification of mineral extraction and metallurgical processing permit	A.R.S. §§ 45-514 and 45-527	30	70	100
37	Issuance/renewal/modification of general industrial use permit	A.R.S. §§ 45-515, 45-521, 45-522, 45-523, 45-524, and 45-527	30	70	100
38	Issuance/renewal/modification of poor quality groundwater withdrawal permit	A.R.S. §§ 45-516 and 45-527	30	70	100
39	Issuance/renewal/modification of temporary permit for electrical energy generation	A.R.S. §§ 45-517 and 45-527	30	70	100
40	Issuance/extension/modification of temporary dewatering permit	A.R.S. §§ 45-518 and 45-527	30	70	100
41	Emergency temporary dewatering permit	A.R.S. § 45-518(D)	3	7	10
42	Issuance/renewal/modification of drainage water withdrawal permit	A.R.S. §§ 45-519 and 45-527	30	70	100
43	Issuance/renewal/modification of hydrologic testing permit	A.R.S. §§ 45-519.01, 45-521, 45-522, 45-524, and 45-527	30	30	60
44	Change of location of use	A.R.S. §§ 45-520(A), 45-521, and 45-527	30	30	60
45	Conveyance of a groundwater withdrawal permit	A.R.S. § 45-520(B)	30	30	60
46	Transportation of groundwater withdrawn in McMullen Valley Basin to an active management area	A.R.S. § 45-552(B)	45	105	150
47	Transportation of groundwater withdrawn in Harquahala irrigation non-expansion area to an initial active management area	A.R.S. § 45-554(B)	45	105	150
48	Transportation of groundwater withdrawn in Big Chino subbasin to an initial active management area	A.R.S. § 45-555(B)	45	105	150
49	Well spacing requirements for withdrawing groundwater for transportation to an active management area	A.R.S. § 45-559	45	105	150
50	Groundwater replenishment district's preliminary or long-term replenishment plan **	A.R.S. § 45-576.03	As prescribed by A.R.S. § 45-576.03(A)	As prescribed by A.R.S. § 45-576.03 (B), (C), (D), and (E)	As prescribed by A.R.S. § 45-576.03
51	Conservation district or water district long-term replenishment plan **	A.R.S. §§ 45-576.03, 45-576.02(C), and 45-576.02(E)	As prescribed by A.R.S. § 45-576.03(I)	As prescribed by A.R.S. § 45-576.03(J), (K), (L), and (M)	As prescribed by A.R.S. § 45-576.03
52	Notice of intent to abandon a well	A.R.S. § 45-594 and A.A.C. R12-15-816	15	15	30
53	Well construction request for variance	A.R.S. §§ 45-594, 45-596(D), and A.A.C. R12-15-820	15	35	50
54	Well driller license	A.R.S. § 45-595(C)	25	105	130
55	Single well license	A.R.S. § 45-595(D)	25	105	130
56	Renewal or reactivation of well drilling license	A.R.S. § 45-595(C) A.A.C. R12-15-806	25	15	40
57	Notice of intent to drill	A.R.S. § 45-596, and A.A.C. R12-15-810	15	0	15
58	Well construction permit	A.R.S. § 45-599	30	60	90
59	Alternative water measuring devices	A.R.S. § 45-604 and A.A.C. R12-15-909	15	60	75
60	Underground storage facility permit	A.R.S. §§ 45-811.01 and 45-871.01	As prescribed by A.R.S. § 45-871.01(B)	As prescribed by A.R.S. § 45-871.01(D), (G), and (H)	As prescribed by A.R.S. § 45-871.01
61	Groundwater savings facility permit	A.R.S. §§ 45-812.01 and 45-871.01	As prescribed by A.R.S. § 45-871.01(B)	As prescribed by A.R.S. § 45-871.01(D), (G), and (H)	As prescribed by A.R.S. § 45-871.01
62	Storage facility permit renewal/conveyance/modification	A.R.S. §§ 45-814.01 and 45-871.01	As prescribed by A.R.S. § 45-871.01(B)	As prescribed by A.R.S. § 45-871.01(D), (G), and (H)	As prescribed by A.R.S. § 45-871.01
63	Water storage permit modification/conveyance	A.R.S. §§ 45-831.01 and 45-871.01	As prescribed by A.R.S. §§ 45-831.01(G) and 45-871.01(B) and (E)	As prescribed by A.R.S. §§ 45-831.01(G) and 45-871.01(D), (E), (G), and (H)	As prescribed by A.R.S. §§ 45-831.01(G) and 45-871.01
64	Recovery well permit	A.R.S. §§ 45-834.01 and 45-871.01	As prescribed by A.R.S. § 45-871.01(B)	As prescribed by A.R.S. § 45-871.01(F), (G), and (H)	As prescribed by A.R.S. § 45-871.01
65	Emergency temporary recovery well permit	A.R.S. § 45-834.01(D)	5	10	15
66	Issuance/renewal/modification of water exchange permit	A.R.S. §§ 45-1041, 45-1042, and 45-1045	As prescribed by A.R.S. § 45-1042(A)	As prescribed by A.R.S. § 45-1042 (B), (C), and (D)	As prescribed by A.R.S. § 45-1042
67	Modification of previously enrolled or permitted water exchange/non-Colorado River	A.R.S. § 45-1041(B)	60	90	150
68	Construction, enlargement, repair, alteration, or removal of a dam	A.R.S. §§ 45-1203, 45-1206, and 45-1207	120	60	180
69	Weather modification license	A.R.S. § 45-1601	15	60	75
70	Certificate of Assured Water Supply	A.A.C. R12-15-702, A.R.S. §§ 45-576 and 45-578	150	60	210
71	Designation or Modification of Designation of Assured Water Supply	A.A.C. R12-15-702 and R12-15-714; A.R.S. § 45-576	150	60	210
72	Analysis of Assured Water Supply/unplatted development plan	A.A.C. R12-15-712, A.R.S. § 45-576(H)	150	30	180
73	Assured Water Supply for State lands	A.A.C. R12-15-713, A.R.S. § 37-334(F)	30	60	90
74	Water adequacy report	A.A.C. R12-15-716, A.R.S. § 45-108	60	60	120
		A.A.C. R12-15-716,			

75	Designation or Modification of Designation of Adequate Water Supply	A.A.C. R12-15-725 A.R.S. § 45-108	150	60	210
76	Analysis of water adequacy/unplatted	A.R.S. § 45-108 A.A.C. R12-15-723	60	60	120
77	Adequate Water Supply for State lands	A.R.S. § 45-108 A.A.C. R12-15-724	30	60	90

* The computation of days is prescribed by subsection (4).
** Hearing is required.

Historical Note
Adopted effective December 31, 1998; filed with the Office of the Secretary of State July 28, 1998 (Supp. 98-3).

ARTICLE 5. RESERVED

ARTICLE 6. RESERVED

ARTICLE 7. ASSURED AND ADEQUATE WATER SUPPLY

R12-15-701. Definitions - Assured and Adequate Water Supply Programs
In addition to any other definitions in A.R.S. Title 45 and the management plans in effect at the time of application, the following words and phrases in this Article shall have the following meanings, unless the context otherwise requires:

1. "Abandoned plat" means a plat for which a certificate or water report has been issued and that will not be developed because of one of the following:
   a. The land has been developed for another use; or
   b. Legal restrictions will preclude approval of the plat.
2. "ADEQ" means the Arizona Department of Environmental Quality.
3. "Adequate delivery, storage, and treatment works" means:
   a. A water delivery system with sufficient capacity to deliver enough water to meet the needs of the proposed use;
   b. Any necessary storage facilities with sufficient capacity to store enough water to meet the needs of the proposed use; and
   c. Any necessary treatment facilities with sufficient capacity to treat enough water to meet the needs of the proposed use.
4. "Adequate storage facilities" means facilities that can store enough water to meet the needs of the proposed use.
5. "Affiliate" means a person who, directly or indirectly through one or more intermediaries, controls, is controlled by or is under common control with the person specified.
6. "AMA" means an active management area as defined in A.R.S. § 45-402.
7. "Analysis" means an analysis of assured water supply or an analysis of adequate water supply.
8. "Analysis holder" means a person to whom an analysis of assured water supply or an analysis of adequate water supply is issued and any current owner of land included in the analysis.
9. "Analysis of adequate water supply" means a determination issued by the Director stating that one or more criteria required for a water report pursuant to R12-15-713 have been demonstrated for a development.
10. "Analysis of assured water supply" means a determination issued by the Director stating that one or more criteria required for a certificate of assured water supply pursuant to R12-15-704 have been demonstrated for a development.
11. "Annual authorized volume" means, for an approved remedial action project, the annual authorized volume specified in a consent decree or other document approved by ADEQ or the EPA, except that:
    a. If no annual authorized amount is specified in a consent decree or other document approved by ADEQ or the EPA, the annual authorized volume is the largest volume of groundwater withdrawn pursuant to the approved remedial action project in any year prior to January 1, 1999.
    b. If the Director increases the annual authorized volume pursuant to R12-15-729(C), the annual authorized volume is the amount approved by the Director.
12. "Annual estimated water demand" means the estimated water demand divided by 100.
13. Approved remedial action project" means a remedial action project approved by ADEQ under A.R.S. Title 49, or by the EPA under CERCLA.
14. "Authorized remedial groundwater use" means, for any year, the amount of remedial groundwater withdrawn pursuant to an approved remedial action project and used by a municipal provider during the year, not to exceed the annual authorized volume of the project.
15. "Build-out" means a condition in which all water delivery mains are in place and active water service connections exist for all lots.
16. "CAP water" means:
    a. All water from the Colorado River or from the Central Arizona Project works authorized in P.L. 90-537, excluding enlarged Roosevelt reservoir, which is made available pursuant to a subcontract with a multi-county water conservation district.
    b. Any additional water not included in subsection 16(a) of this Section that is delivered by the United States Secretary of the Interior pursuant to an Indian water rights settlement through the Central Arizona Project.
17. "Central Arizona Groundwater Replenishment District" or "CAGRD" means a multi-county water conservation district acting in its capacity as the entity established pursuant to A.R.S. § 48-3771, et seq., and responsible for replenishing excess groundwater.
18. "Central distribution system" means a water system that qualifies as a public water system pursuant to A.R.S. § 49-352.
19. "CERCLA" or "Comprehensive Environmental Response, Compensation, and Liability Act of 1980" has the same meaning as prescribed in A.R.S. § 49-201.
20. "Certificate" means a certificate of assured water supply issued by the Director for a subdivision pursuant to A.R.S. § 45-576 et seq. and this Article.
21. "Certificate holder" means any person included on a certificate, except the following:
    a. Any person who no longer owns any portion of the property included in the certificate, and
    b. Any potential purchaser for whom the purchase contract has been terminated or has expired.
22. "Certificate of convenience and necessity" means a certificate required by the Arizona Corporation Commission, pursuant to A.R.S. § 40-281, which allows a private water company to serve water to customers within its certificated area.
23. "Colorado River water" means water from the main stream of the Colorado River. For purposes of this Article, Colorado River water does not include CAP water.
24. "Committed demand" means the 100-year water demand at build-out of all recorded lots that are not yet served water within the service area of a designation applicant or a designated provider.
25. "County water augmentation authority" means an authority formed pursuant to A.R.S. Title 45, Chapter 11.
26. "Current demand" means the 100-year water demand for existing uses within the service area of a designation applicant or designated provider, based on the annual report for the previous calendar year.
27. "Depth-to-static water level" means the level at which water stands in a well when no water is withdrawn by pumping or by free flow.
28. "Designated provider" means:
    a. A municipal provider that has obtained a designation of assured or adequate water supply; or
    b. A city or town that has obtained a designation of adequate water supply pursuant to A.R.S. § 45-108(D).
29. "Designation means a decision and order issued by the director designating a municipal provider as having an assured water supply or an adequate water supply.
30. "Determination of adequate water supply" means a water report, a designation of adequate water supply, or an analysis of adequate water supply.
31. "Determination of assured water supply" means a certificate, a designation of assured water supply, or an analysis of assured water supply.
32. "Development" means either a subdivision or an unplatted development plan.
33. "Diversion works" means a structure or well that allows or enhances diversion of surface water from its natural course for other uses.
34. "Drought response plan" means a plan describing a variety of conservation and augmentation measures, especially the use of backup water supplies, that a municipal provider will utilize in operating its water supply system in times of a water supply shortage. The plan may include the following:
    a. An identification of priority water uses consistent with applicable public policies.
    b. A description of sources of emergency water supplies.
    c. An analysis of the potential use of water pressure reduction.
    d. Plans for public education and voluntary water use reduction.
    e. Plans for water use bans, restrictions, and rationing.
    f. Plans for water pricing and penalties for excess water use.
    g. Plans for coordination with other cities, towns, and private water companies.
35. "Drought volume" means 80% of the volume of a surface water supply, determined by the director under R12-15-716 to be physically available on an annual basis to a certificate holder or a designated provider.
36. "Dry lot development" means a development or subdivision without a central water distribution system.
37. "EPA" means the United States Environmental Protection Agency.
38. "Estimated water demand" means:
    a. For a certificate or water report, the Director's determination of the 100-year water demand for all uses included in the subdivision;
    b. For a designation, the sum of the following:
       i. The Director's determination of the current demand;
       ii. The Director's determination of the committed demand; and
       iii. The Director's determination of the projected demand during the term of the designation; or
    c. For an analysis, the Director's determination of the water demand for all uses included in the development.
39. "Existing municipal provider" means a municipal provider that was in operation and serving water for non-irrigation use on or before January 1, 1990.
40. "Extinguish" means to cause a grandfathered right to cease to exist through a process established by the director pursuant to R12-15-723.
41. "Extinguishment credit" means a credit that is issued by the Director in exchange for the extinguishment of a grandfathered right and that may be used to make groundwater use

consistent with the management goal of an AMA.
42. "Firm yield" means the minimum annual diversion for the period of record which may include runoff releases from storage reservoirs, and surface water withdrawn from a well.
43. "Management plan" means a water management plan adopted by the director pursuant to A.R.S. § 45-561 et seq.
44. "Master-planned community" has the same meaning as provided in A.R.S. § 32-2101.
45. "Median flow" means the flow which is represented by the middle value of a set of flow data that are ranked in order of magnitude.
46. "Member land" has the same meaning as provided in A.R.S. § 48-3701.
47. "Member service area" has the same meaning as provided in A.R.S. § 48-3701.
48. "Multi-county water conservation district" means a district established pursuant to A.R.S. Title 48, Chapter 22.
49. "Municipal provider" has the same meaning as provided in A.R.S. § 45-561.
50. "New municipal provider" means a municipal provider that began serving water for non-irrigation use after January 1, 1990.
51. "Owner" means:
    a. For an analysis, certificate, or water report applicant, a person who holds fee title to the land described in the application; or
    b. For a designation applicant, the person who will be providing water service pursuant to the designation.
52. "Perennial" means a stream that flows continuously.
53. "Persons per household" means a measure obtained by dividing the number of persons residing in housing units by the number of housing units.
54. "Physical availability determination" means a letter issued by the Director stating that an applicant has demonstrated all of the criteria in R12-15-702(C).
55. "Plat" means a preliminary or final map of a subdivision in a format typically acceptable to a platting entity.
56. "Potential purchaser" means a person who has entered into a purchase agreement for land that is the subject of an application for a certificate or an assignment of a certificate.
57. "Projected demand" means the 100-year water demand at build-out, not including committed or current demand, of customers reasonably projected to be added and plats reasonably projected to be approved within the designated provider's service area and reasonably anticipated expansions of the designated provider's service area.
58. "Proposed municipal provider" means a municipal provider that has agreed to serve a proposed subdivision.
59. "Purchase agreement" means a contract to purchase or acquire an interest in real property, such as a contract for purchase and sale, an option agreement, a deed of trust, or a subdivision trust agreement.
60. "Remedial groundwater" means groundwater withdrawn pursuant to an approved remedial action project, but does not include groundwater withdrawn to provide an alternative water supply pursuant to A.R.S. § 49-282.03.
61. "Service area" means:
    a. For an application for an analysis of adequate water supply, a water report, or a designation of adequate water supply, the area of land actually being served water for a non-irrigation use by the municipal provider and additions to the area that contain the municipal provider's operating distribution system for the delivery of water for a non-irrigation use;
    b. For an application for a designation of adequate water supply pursuant to A.R.S. § 45-108(D), the area of land actually being served water for a non-irrigation use by each municipal provider that serves water within the city or town, and additions to the area that contain each municipal provider's operating distribution system for the delivery of water for a non-irrigation use; or
    c. For an application for a certificate or designation of assured water supply, "service area" has the same meaning as prescribed in A.R.S. § 45-402.
62. "Subdivision" has the same meaning as prescribed in A.R.S. § 32-2101.
63. "Superfund site" means the site of a remedial action undertaken pursuant to CERCLA.
64. "Surface water" means any surface water as defined in A.R.S. § 45-101, including CAP water and Colorado River water.
65. "Water Quality Assurance Revolving Fund site" or "WQARF site" means a site of a remedial action undertaken pursuant to A.R.S. Title 49, Chapter 2, Article 5.
66. "Water report" means a letter issued to the Arizona Department of Real Estate by the Director for a subdivision stating whether an adequate water supply exists pursuant to A.R.S. § 45-108 and this Article.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Amended by emergency rulemaking at 11 A.A.R. 2706, effective June 29, 2005 for 180 days (Supp. 05-2). Emergency renewed for 180 days at 12 A.A.R. 144, effective December 23, 2005 (Supp. 05-4). Emergency expired. Amended by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-702. Physical Availability Determination

A. A person may apply for a physical availability determination by submitting an application on a form prescribed by the Director with the fee required by R12-15-730, and providing the following information with the application:
    1. The proposed source of water for which the applicant is seeking a determination of physical availability,
    2. Evidence that the applicant has complied with subsection (C) of this Section, and
    3. Any other information that the Director reasonably deems necessary to determine whether water is physically available in the area that is the subject of the application.
B. Each applicant shall sign an application for a physical availability determination. If an applicant is not a natural person, the applicant's authorized officer, managing member, partner, trust officer, trustee or other person who performs similar decision-making functions for the applicant shall sign the application. If the applicant submits a letter, signed by the applicant and dated within 90 days of the date the application is submitted, authorizing a representative to submit applications for permits regarding the land to be included in the determination, the authorized representative may sign the application on the applicant's behalf.
C. An applicant for a physical availability determination shall demonstrate the following:
    1. The volume of water that is physically available for 100 years in the area that is the subject of the application, according to the criteria in R12-15-716.
    2. That the proposed sources of water will be of adequate quality, according to the criteria in R12-15-719.
D. After a complete application is submitted, the Director shall review the application and associated evidence to determine whether the applicant has demonstrated all of the criteria in subsection (C) of this Section. If the Director determines that the applicant has demonstrated all of the criteria in subsection (C) of this Section, the Director shall issue a physical availability determination.
E. Any person applying for a determination of assured water supply or a determination of adequate water supply may use an existing physical availability determination for purposes of R12-15-716. The Director shall consider any changes in hydrologic conditions for purposes of R12-15-716.
F. The issuance of a physical availability determination does not reserve any water for purposes of this Article.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-703. Analysis of Assured Water Supply

A. A person proposing to develop land that will not be served by a designated provider may apply for an analysis of assured water supply before applying for a certificate. An applicant for an analysis must be the owner of the land that is the subject of the application or have the written consent of the owner. The commissioner of the Arizona State Land Department may apply for an analysis for land owned by the state of Arizona or may consent to the inclusion of such land in an application.
B. An applicant for an analysis shall submit an application on a form prescribed by the Director with the fee required by R12-15-730, and attach the following:
    1. A title report, condition of title report, limited search title report, or recorded deed, dated within 90 days of the date the application is submitted, demonstrating the ownership of the land that is the subject of the application;
    2. A description of the development, including:
        a. A map of the land uses included in the development,
        b. A list of water supplies proposed to be used by the development,
        c. A summary of land use types included in the development, and
        d. An estimate of the water demand for the land uses included in the development; and
    3. Evidence that the applicant has complied with subsection (E) of this Section.
C. An applicant shall sign the application for an analysis. If an applicant is not a natural person, the applicant's authorized officer, managing member, partner, trust officer, trustee, or other person who performs similar decision-making functions for the applicant shall sign the application. If the applicant submits a letter, signed by the applicant and dated within 90 days of the date the application is submitted, authorizing a representative to submit applications for permits regarding the land to be included in the analysis, the authorized representative may sign the application on the applicant's behalf.
D. After a complete application is submitted, the Director shall determine the estimated water demand of the development.
E. The Director shall issue an analysis if an applicant demonstrates one or more of the following:
    1. Sufficient supplies of water are physically available to meet all or part of the estimated water demand of the development for 100 years, according to the criteria in R12-15-716.
    2. Sufficient supplies of water are continuously available to meet the estimated water demand of the development for 100 years, according to the criteria in R12-15-717.
    3. Sufficient supplies of water are legally available to meet the estimated water demand of the development for 100 years, according to the criteria in R12-15-718.
    4. The proposed sources of water are of adequate quality, according to the criteria in R12-15-719.
    5. Any proposed groundwater use is consistent with the management plan in effect at the time of the application, according to the criteria in R12-15-721.
    6. Any proposed groundwater use is consistent with the management goal, according to the criteria in R12-15-722.
F. For 10 years after the Director issues an analysis, or a longer period allowed under subsections (H) or (I) of this Section:
    1. If groundwater is a source of supply in the analysis and the applicant demonstrates that groundwater is physically available under subsection (E)(1) of this Section, the Director shall consider that supply of groundwater reserved for the use of the proposed development in subsequent determinations of physical availability pursuant to R12-15-716(B).
    2. If an analysis holder applies for a certificate for a subdivision located on land included in the analysis, the Director shall presume that a criterion demonstrated in the analysis remains satisfied with respect to the subdivision, unless the Director has received new evidence demonstrating that the criterion is not satisfied. If the Director issues the certificate, the Director shall reduce the volume of groundwater reserved pursuant to subsection (F)(1) of this Section by the amount of the estimated water demand for the certificate that will be met with groundwater.
G. The Director shall reduce the amount of groundwater considered reserved for use of the development upon request by the analysis holder. If the analysis holder requesting a reduction is not the person to whom the analysis was issued, the Director shall reduce the amount of reserved groundwater only if the person to whom the analysis was issued or that person's designee consents to the request for reduction. The person to whom the analysis was issued shall notify the Director in writing of the name of the person's designee for purposes of this subsection.
H. The analysis holder may apply to the Director for a five-year extension of the time period in subsection (F) of this Section by submitting an application on a form prescribed by the Director no

earlier than 36 months before the end of the time period and no later than 30 days before the end of the time period. If an extension is granted, the analysis holder may apply to the Director for an additional five-year extension by submitting an application on a form prescribed by the Director no earlier than 36 months before the end of the extended time period and no later than 30 days before the end of the extended time period. The Director shall extend the time period for no more than two successive five-year periods under this subsection if the analysis holder demonstrates one of the following:

1. The analysis holder has made a substantial capital investment in developing the land included in the analysis.
2. The analysis holder has made material progress in developing the land included in the analysis.
3. Progress in developing the land included in the analysis has been delayed for reasons outside the control of the analysis holder.

I. After the Director grants two five-year extensions pursuant to subsection (H) of this Section, the Director may extend the time period for additional five-year periods if the analysis holder files a timely application pursuant to subsection (H) of this Section and demonstrates one of the criteria in subsections (H)(1), (H)(2), or (H)(3) of this Section.

J. The Director shall review an application for an analysis or an application for an extension pursuant to subsections (H) or (I) of this Section pursuant to the licensing time-frame provisions in R12-15-401.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Amended by emergency rulemaking at 11 A.A.R. 2706, effective June 29, 2005 for 180 days (Supp. 05-2). Emergency renewed for 180 days at 12 A.A.R. 144, effective December 23, 2005 (Supp. 05-4). Emergency expired. Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-703.01. Repealed

Historical Note

New Section made by final rulemaking at 7 A.A.R. 3038, effective June 18, 2001 (Supp. 01-2). Section repealed by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-704. Certificate of Assured Water Supply

A. An application for a certificate shall be filed by the current owner of the land that is the subject of the application. Potential purchasers and affiliates may also be included as applicants.

B. An applicant for a certificate shall submit an application on a form prescribed by the Director with the fee required by R12-15-730 and provide the following:

1. One of the following forms of proof of ownership for each applicant to be listed on the certificate:
   a. For an applicant that is the current owner, one of the following:
      i. A title report, condition of title report, limited search title report, or recorded deed, dated within 90 days of the date the application is filed, demonstrating that the applicant is the owner of the land that is the subject of the application; or
      ii. Evidence that the CAGRD has reviewed and approved evidence that the applicant is the owner of the land that is the subject of the application;
   b. For an applicant that is a potential purchaser, evidence of a purchase agreement; or
   c. For an applicant that is an affiliate of another applicant, a certification by the other applicant of the affiliate status;
2. A plat of the subdivision;
3. An estimate of the 100-year water demand for the subdivision;
4. A list of all proposed sources of water that will be used by the subdivision;
5. Evidence that the criteria in subsections (F) or (G) of this Section are met; and
6. Any other information that the Director reasonably determines is necessary to decide whether an assured water supply exists for the subdivision.

C. Each applicant shall sign the application for a certificate. If an applicant is not a natural person, the applicant's authorized officer, managing member, partner, trust officer, trustee, or other person who performs similar decision-making functions for the applicant shall sign the application. If an applicant submits a letter, signed by the applicant and dated within 90 days of the date the application is submitted, authorizing a representative to submit applications for permits regarding the land to be included in the certificate, the authorized representative may sign the application on the applicant's behalf.

D. The Director shall give public notice of an application for a certificate as provided in A.R.S. § 45-578.

E. After a complete application is submitted, the Director shall review the application and associated evidence to determine:

1. The estimated water demand of the subdivision;
2. The amount of the groundwater allowance for the subdivision, as provided in R12-15-724 through R12-15-727; and
3. Whether the applicant has demonstrated all of the requirements in subsection (F) or subsection (G) of this Section.

F. Except as provided in subsection (G) of this Section, the Director shall issue a certificate if the applicant demonstrates all of the following:

1. Sufficient supplies of water are physically available to meet the estimated water demand of the subdivision, according to the criteria in R12-15-716;
2. Sufficient supplies of water are continuously available to meet the estimated water demand of the subdivision, according to the criteria in R12-15-717;
3. Sufficient supplies of water are legally available to meet the estimated water demand of the subdivision, according to the criteria in R12-15-718;
4. The sources of water are of adequate quality, according to the criteria in R12-15-719;
5. The applicant has the financial capability to construct adequate delivery, storage, and treatment works for the subdivision, according to the criteria in R12-15-720;
6. The proposed use of groundwater withdrawn within an AMA is consistent with the management plan in effect at the time of the application, according to the criteria in R12-15-721; and
7. The proposed use of groundwater withdrawn within an AMA is consistent with the achievement of the management goal, according to the criteria in R12-15-722.

G. If the Director previously issued a certificate for the subdivision, the Director shall issue a new certificate to the applicant if the applicant demonstrates that all of the requirements in subsection (F) are met or that all of the following apply:

1. Any changes to the plat for which the previous certificate was issued are not material, according to the criteria in R12-15-708;
2. If groundwater is a proposed source of supply for the subdivision, the proposed groundwater withdrawals satisfied the physical availability requirements in effect at the time the complete and correct application for the previous certificate was submitted;
3. Any proposed sources of water, other than groundwater, are physically available to satisfy the estimated water demand that will not be satisfied with groundwater, according to the criteria in R12-15-716;
4. Any proposed sources of water other than groundwater are continuously available to satisfy the estimated water demand that will not be satisfied with groundwater, according to the criteria in R12-15-717;
5. The proposed uses of groundwater withdrawn within an AMA were consistent with the achievement of the management goal according to the criteria in effect at the time the complete and correct application for the previous certificate was submitted; and
6. The applicant demonstrates that the requirements in subsections (F)(3) through (F)(6) of this Section are met.

H. Before issuing a certificate, the Director shall classify the certificate for the purposes of R12-15-705 and R12-15-706 as follows:

1. Type A certificate. The Director shall classify the certificate as a Type A certificate if the applicant meets the criteria in R12-15-720(A)(1) and all of the subdivision's estimated water demand will be met with one or more of the following:
   a. Groundwater served by a proposed municipal provider pursuant to an existing service area right;
   b. Groundwater served by a proposed municipal provider pursuant to a pending service area right, if the proposed municipal provider currently holds or will hold the well permit;
   c. CAP water served by a municipal provider pursuant to the proposed municipal provider's non-declining, long-term municipal and industrial subcontract;
   d. Surface water served by a proposed municipal provider pursuant to the proposed municipal provider's surface water right or claim;
   e. Effluent owned and served by a proposed municipal provider; or
   f. A Type 1 grandfathered right appurtenant to the land on which the groundwater will be used and held by a proposed municipal provider.
2. Type B certificate. The Director shall classify all certificates that do not meet the requirements of subsection (H)(1) of this Section as Type B certificates.

I. The Director shall review an application for a certificate pursuant to the licensing time-frame provisions in R12-15-401.

J. An owner of six or more lots is not required to obtain a certificate if all of the following apply:

1. The lots comprise a subset of a subdivision for which:
   a. A plat was recorded before 1980; or
   b. A certificate was issued before February 7, 1995;
2. No changes were made to the plat since February 7, 1995; and
3. Water service is currently available to each lot.

K. A new owner of all or a portion of a subdivision for which a plat has been recorded is not required to obtain a certificate if all of the following apply:

1. The Director previously issued a Type A certificate for the subdivision pursuant to subsection (H)(1) of this Section or R12-15-707;
2. Water service is currently available to each lot; and
3. There are no material changes to the plat for which the certificate was issued, according to the criteria in R12-15-708.

L. An owner of six or more lots in the Pinal AMA is not required to obtain a certificate if all of the following apply:

1. A plat for the subdivision was recorded before October 1, 2007;
2. There have been no material changes to the plat according to the criteria in R12-15-708, since October 1, 2007;
3. The proposed municipal provider was designated as having an assured water supply when the plat was recorded, but is no longer designated as having an assured water supply; and
4. Water service is currently available to each lot.

M. A person may request a letter stating that the owner is not required to obtain a certificate pursuant to subsection (J), (K), or (L) of this Section by submitting an application on a form prescribed by the Director and attaching evidence that the criteria of subsection (J), (K), or (L) are met. Upon receiving an application pursuant to this subsection, the Director shall:

1. Review the application pursuant to the licensing time-frame provisions in R12-15-401.
2. Determine whether the criteria of subsection (J), (K), or (L) of this Section are met.
3. If the Director determines that the criteria of subsection (J) of this Section are met, issue a letter to the applicant and the Arizona Department of Real Estate stating that the current owner is not required to obtain a certificate.
4. If the Director determines that the criteria of subsection (K) or (L) of this Section are met, issue a letter to the applicant and the Arizona Department of Real Estate stating that the current owner and any future owners are not required to obtain a certificate.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3). Amended by final rulemaking at 13 A.A.R. 1394, effective October 1, 2007 (Supp. 07-2).

R12-15-705. Assignment of Type A Certificate of Assured Water Supply

A. The certificate holder of a Type A certificate and the assignee may apply for approval of an assignment of the Type A certificate within the time allowed by A.R.S. § 45-579(A). The assignee may file the application if there is no certificate holder. The application shall be submitted on a form prescribed by the Director with the fee required by R12-15-730, and the applicant shall provide the following:
  1. One of the following forms of proof of ownership for each assignee:
    a. A title report, condition of title report, limited search title report, or recorded deed, dated within 90 days of the date the application is submitted to the Director and demonstrating that the assignee is the owner of the land that is the subject of the proposed assignment; or
    b. If the assignee is a potential purchaser, evidence of a purchase agreement;
  2. A current plat of the subdivision;
  3. An estimate of the 100-year water demand for the subdivision, based on the current plat;
  4. Certification by each applicant that:
    a. The proposed municipal provider has not changed and has agreed to continue to serve the subdivision after the assignment; and
    b. All water supplies listed on the current certificate are physically, continuously, and legally available to meet the estimated water demand of the subdivision after the assignment.

B. Each applicant shall sign the application for an assignment of a Type A certificate. If an applicant is not a natural person, the entity's authorized officer, managing member, partner, trust officer, trustee, or other person who performs similar decision-making functions for the applicant shall sign the application. If an applicant submits a letter, signed by the applicant and dated within 90 days of the date the application is submitted, authorizing a representative to submit applications for permits regarding the land included in the certificate, the authorized representative may sign the application on behalf of the applicant.

C. Upon receiving an application for an assignment of a Type A certificate, the Director shall post the notice required by A.R.S. § 45-579(E).

D. If the Director determines that the application meets the criteria of A.R.S. § 45-579(A), the Director shall issue a Type A certificate to each applicant. A Type A certificate issued under this subsection shall retain the issue date, the number of lots, and the estimated water demand shown on the original certificate, except as provided in subsection (E) of this Section. The Director shall determine that the application meets the criteria of A.R.S. § 45-579(A) if all of the following apply:
  1. The application is submitted within the time allowed by A.R.S. § 45-579(A);
  2. The assignee is the owner or a potential purchaser of the portion of the subdivision that is the subject of the assignment;
  3. There have been no material changes to the plat for which the original certificate was issued, according to the criteria in R12-15-708;
  4. Neither the applicant nor a predecessor in interest has impaired the manner in which consistency with management goal requirements were satisfied when the original certificate was issued; and
  5. The applicant makes the certifications required in subsection (A)(4) of this Section.

E. In the case of a partial assignment, the Director shall determine whether changes to the plat are material according to R12-15-708. The Director shall issue a Type A certificate to the assignee for the portion of the subdivision that is the subject of the assignment and for the number of lots and the estimated water demand of the current plat of the portion of the subdivision that is the subject of the assignment. The Director shall issue a Type A certificate to the certificate holder for the portion of the subdivision retained by the certificate holder and for the remainder of the number of lots and the remainder of the estimated water demand. The sum of the number of lots and the sum of the amount of the estimated water demand shown on each certificate shall equal the total number of lots and the total estimated water demand shown on the certificate being assigned.

F. The Director shall review an application for an assignment of a Type A certificate of assured water supply pursuant to the licensing time-frame provisions in R12-15-401.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Amended by final rulemaking at 8 A.A.R. 4390, effective November 22, 2002 (Supp. 02-3). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-706. Assignment of Type B Certificate of Assured Water Supply

A. The certificate holder of a Type B certificate or a certificate issued before the effective date of this Section that has not been classified pursuant to R12-15-707 and the assignee may apply for approval of an assignment of the certificate to another person within the time allowed by A.R.S. § 45-579(A). The assignee may file the application if there is no certificate holder. The application shall be submitted on a form prescribed by the Director with the fee required by R12-15-730, and the applicant shall provide the following:
  1. One of the following forms of proof of ownership for each assignee:
    a. A title report, condition of title report, limited search title report, or recorded deed, dated within 90 days of the date the application is submitted to the Director and demonstrating that the assignee is the owner of the land that is the subject of the proposed assignment; or
    b. If the assignee is a potential purchaser, evidence of a purchase agreement;
  2. A current plat of the subdivision;
  3. An estimate of the 100-year water demand for the subdivision, based on the current plat;
  4. Evidence that all necessary water rights, permits, licenses, contracts, and easements have been or will be assigned to the assignee of the certificate;
  5. Evidence that the assignee has the financial capability to construct adequate delivery, storage, and treatment works for the subdivision according to the criteria in R12-15-720;
  6. Evidence that all water supplies listed on the current certificate are physically, continuously, and legally available to meet the estimated water demand of the subdivision after the assignment;
  7. Evidence that the proposed municipal provider has not changed and has agreed to serve the subdivision after the assignment;
  8. If the applicant requests that the Director classify the certificate pursuant to subsection (E) of this Section, evidence that the requirements of R12-15-704(H)(1) are satisfied;
  9. Any other information that the Director reasonably deems necessary to determine whether the application meets the criteria of A.R.S. § 45-579.

B. Each applicant shall sign the application for an assignment of a certificate. If an applicant is not a natural person, the entity's authorized officer, managing member, partner, trust officer, trustee, or other person who performs similar decision-making functions for the applicant shall sign the application. If an applicant submits a letter, signed by the applicant and dated within 90 days of the date the application is submitted, authorizing a representative to submit applications for permits regarding the land to be included in the certificate, the authorized representative may sign the application on the applicant's behalf.

C. Upon receiving an application for an assignment, the Director shall post the notice required by A.R.S. § 45-579(E).

D. Except as provided in subsection (E) of this Section, if the Director determines that the application meets the criteria of A.R.S. § 45-579(A), the Director shall issue a Type B certificate to each applicant. A Type B certificate issued under this subsection shall retain the issue date, the number of lots, and the estimated water demand shown on the original certificate, except as provided in subsection (F) of this Section. The Director shall determine that the application meets the criteria of A.R.S. § 45-579(A) if all of the following apply:
  1. The application is submitted within the time allowed by A.R.S. § 45-579(A);
  2. The assignee is the owner or potential purchaser of the portion of the subdivision that is the subject of the assignment;
  3. There have been no material changes to the plat for which the original certificate was issued, according to the criteria in R12-15-708;
  4. The applicant demonstrates the financial capability to construct adequate delivery, storage, and treatment works for the subdivision according to the criteria in R12-15-720;
  5. All necessary water rights, permits, licenses, contracts, and easements have been or will be assigned to the assignee of the certificate;
  6. All water supplies listed on the current certificate are physically, continuously, and legally available to meet the estimated water demand of the subdivision after the assignment;
  7. Neither the applicant nor a predecessor in interest has impaired the manner in which consistency with management goal requirements were satisfied when the original certificate was issued; and
  8. The proposed municipal provider has agreed to serve the subdivision after the assignment.

E. The applicant may include in the application a request to classify the certificate as a Type A certificate. If the Director determines that the request meets the requirements of R12-15-704(H)(1), the Director shall classify the certificate as a Type A certificate.

F. In the case of a partial assignment, the Director shall determine whether changes to the plat are material according to R12-15-708. The Director shall issue a Type B certificate to the assignee for the portion of the subdivision that is the subject of the assignment and for the number of lots and the estimated water demand of the current plat of the portion of the subdivision that is the subject of the assignment. The Director shall issue a Type B certificate to the certificate holder for the portion of the subdivision retained by the certificate holder and for the remainder of the number of lots and the remainder of the estimated water demand. The sum of the number of lots and the sum of the amount of the estimated water demand shown on each certificate shall equal the total number of lots and the total estimated water demand shown on the certificate that is being assigned.

G. The Director shall review an application for an assignment of a Type B certificate pursuant to the licensing time-frame provisions in R12-15-401.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-707. Application for Classification of a Type A Certificate

A. A holder of a Type B certificate or a certificate issued before the effective date of this Section may apply to the Director to classify the certificate as a Type A certificate by submitting an application on a form prescribed by the Director with the fee prescribed in R12-15-730 and attaching evidence that the certificate meets the requirements of R12-15-704(H)(1).

B. At least one certificate holder shall sign the application for classification of a certificate as a Type A certificate. If the applicant is not a natural person, the applicant's authorized officer, managing member, partner, trust officer, trustee, or other person who performs similar decision-making functions for the applicant shall sign the application. If the applicant submits a letter, signed by the applicant and dated within 90 days of the date the application is submitted, authorizing a representative to submit applications for permits regarding the land to be included in the certificate, the authorized representative may sign the application on behalf of the applicant.

C. If the applicant demonstrates that the requirements of R12-15-704(H)(1) are met, the Director shall classify the certificate as a Type A certificate and issue a Type A certificate to each certificate holder.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R-12-15-708. Material Plat Change; Application for Review

A. A certificate or a water report is applicable to the original plat for which the certificate or water report was issued and to a revised plat, unless the plat changes are material according to subsections (C) and (D) of this Section.

B. If a plat is revised after the Director issues a certificate or a water report and the changes to the plat are material according to subsection (C) or (D) of this Section, the holder may:

1. Apply for a new certificate or water report for the revised plat,
2. Use the original plat for which the certificate or water report was issued, or
3. Revise the plat so that any changes are not material according to subsections (C) and (D) of this Section.

C. Changes to the plat for which a certificate or a water report has been issued are material if any of the following apply:
1. The number of lots on the plat has increased by more than:
a. For subdivisions of 6 to 10 lots: one lot;
b. For subdivisions of 11 to 499 lots: 10%, rounding up to the nearest whole number; or
c. For subdivisions of 500 lots or more: 50 lots.
2. The 100-year water demand for the revised plat exceeds the estimated water demand for the certificate, unless all of the following apply:
a. The 100-year water demand for the revised plat does not exceed the estimated water demand for the certificate by more than 10%, rounding to the nearest whole acre-foot, or by more than 25 acre-feet per year, whichever is less;
b. The 100-year water demand is not greater than the supply demonstrated to be physically, continuously, and legally available at the time of issuance of the certificate or water report, and that water supply remains physically, continuously, and legally available; and
c. For a certificate, one of the following applies:
i. The subdivision is enrolled as a member land in the CAGRD;
ii. Groundwater is not included as a source of supply; or
iii. The subdivision is located in the Pinal AMA and the 100-year water demand for the revised plat will not exceed the sum of the amount of the groundwater allowance and the amount of any extinguishment credits pledged to the certificate, including extinguishment credits pledged after the certificate was issued.
3. For a certificate, additional land is included in the plat, unless all of the following apply:
a. The land included in the original plat for which the certificate was issued is located in a master-planned community;
b. The outer boundaries of the master-planned community have not expanded;
c. If the land included in the original plat for which the certificate was issued is enrolled as a member land in the CAGRD, the additional land has also been enrolled in the CAGRD; and
d. A certificate has been issued for the additional land.

D. Changes to a portion of a plat are not material if one of the following applies:
1. The changes to the portion of the plat being reviewed are not material according to subsection (C) of this Section when compared to the equivalent portion of the plat for which the certificate was issued;
2. The changes to the entire revised plat are not material according to subsection (C) of this Section when compared to the entire plat for which the certificate was issued; or
3. For a partial assignment pursuant to R12-15-705 or R12-15-706, the plat for the portion of the subdivision retained by the certificate holder could be configured so that changes to the total number of lots and the estimated water demand for the entire subdivision, including the portion under consideration, are not material according to subsection (C) of this Section. For purposes of this subsection, the Director may require the applicant to submit evidence demonstrating whether changes to the plat are material. However, the Director shall not require the applicant to submit a plat for the retained portion of a subdivision, unless the materiality of changes to the plat cannot be determined with any other evidence.

E. A person may apply for a review of a revised plat to determine whether any changes to the plat are material as follows:
1. The applicant shall submit an application on a form prescribed by the Director with the fee required by R12-15-730 and shall attach the revised plat.
2. The Director shall review the revised plat and the plat for which the certificate or water report was originally issued to determine whether any changes are material according to the criteria in subsections (C) and (D) of this Section.
3. The Director shall issue a letter to the applicant stating whether any changes to the plat are material and identifying which changes, if any, are material. If the Director determines that the changes to the plat are not material, the Director's letter shall state that the certificate or water report is applicable to the revised plat.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-709. Certificate of Assured Water Supply; Revocation

A. The Director may revoke a certificate if an assured water supply does not exist.
B. The Director shall not revoke a certificate if any of the residential lots within the plat have been sold.
C. If the Director determines that a certificate should be revoked, the Director shall provide for an administrative hearing, in accordance with A.R.S. Title 41, Chapter 6, Article 10. To determine whether a certificate should be revoked, the Director shall use the standards in place at the time the original application was submitted for the certificate.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-710. Designation of Assured Water Supply

A. A municipal provider applying for a designation of assured water supply shall submit an application on a form prescribed by the Director with the fee required by R12-15-730 and provide the following:
1. The applicant's current demand;
2. The applicant's committed demand;
3. The applicant's projected demand for the proposed term of the designation;
4. The proposed term of the designation, which shall not be less than two years;
5. Evidence that the criteria in subsection (E) of this Section are met; and
6. Any other information that the Director determines is necessary to decide whether an assured water supply exists for the municipal provider.

B. An application for a designation shall be signed by:
1. If the applicant is a city or town, the city or town manager or a person employed in an equivalent position. The application shall also include a resolution of the governing body of the city or town, authorizing that person to sign the application; or
2. If the applicant is a private water company, the applicant's authorized officer, managing member, partner, trust officer, trustee, or other person who performs similar decision-making functions for the applicant.

C. The Director shall give public notice of an application for designation in the same manner as provided for certificates in A.R.S. § 45-578.
D. After a complete application is submitted, the Director shall review the application and associated evidence to determine:
1. The annual volume of water physically, continuously, and legally available for at least 100 years;
2. The term of the designation, which shall not be less than two years;
3. The applicant's estimated water demand;
4. The applicant's groundwater allowance; and
5. Whether the applicant has demonstrated compliance with all requirements in subsection (E) of this Section.

E. The Director shall designate the applicant as having an assured water supply if the applicant demonstrates all of the following:
1. Sufficient supplies of water are physically available to meet the applicant's estimated water demand, according to the criteria in R12-15-716;
2. Sufficient supplies of water are continuously available to meet the applicant's estimated water demand, according to the criteria in R12-15-717;
3. Sufficient supplies of water are legally available to meet the applicant's estimated water demand, according to the criteria in R12-15-718;
4. The proposed sources of water are of adequate quality, according to the criteria in R12-15-719;
5. The applicant has the financial capability to construct adequate delivery, storage, and treatment works in a timely manner according to the criteria in R12-15-720;
6. Any proposed groundwater use is consistent with the management plan in effect at the time of the application, according to the criteria in R12-15-721; and
7. Any proposed use of groundwater withdrawn within an AMA is consistent with the management goal, according to the criteria in R12-15-722.

F. The Director shall review an application for a designation of assured water supply pursuant to the licensing time-frame provisions in R12-15-401.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-711. Designation of Assured Water Supply; Annual Report Requirements, Review, Modification, Revocation

A. A designated provider shall include in the annual report required by A.R.S. § 45-632 the following information for the preceding calendar year:
1. The designated provider's committed demand;
2. The demand at build-out for customers with which the designated provider has entered into an agreement to serve water, other than committed demand;
3. A report regarding the designated provider's compliance with water quality requirements;
4. The depth-to-static water level of all wells from which the designated provider withdrew water; and
5. Any other information the Director may reasonably require to determine whether the designated provider continues to meet the criteria for a designation of assured water supply.

B. If there is a change of ownership, the subsequent owner of a designated provider shall notify the Director in writing of the change in ownership within 90 days.
C. The Director shall review a designation at least every 15 years following issuance of the designation to determine whether the designation should be modified or revoked. To determine whether the designation should be modified or revoked, the Director shall use the standards in place at the time of review.
D. The Director may modify a designation for good cause, including a merger, division of the designated provider, or a change in ownership of the designated provider.
E. A designated provider may request a modification of the designation at any time pursuant to R12-15-710.
F. The Director may revoke a designation if:
1. After notifying the designated provider and initiating a review of the designated provider's status, the Director determines that the designated provider has less water, according to the criteria in R12-15-710(E), than the amount required for a 100-year supply for the provider's:
a. Current demand,
b. Committed demand, and
c. Projected demand during the next two calendar years;

2. The designated provider fails to construct adequate delivery, storage, and treatment works in a timely manner;
3. ADEQ or another governmental entity with equivalent jurisdiction has determined, after notice and an opportunity for a hearing, that the designated provider is in significant noncompliance with A.A.C. Title 18, Chapter 4 and is not taking action to resolve the noncompliance; or
4. The designated provider has violated its management plan requirements for two or more consecutive calendar years, and one of the following applies:
a. The provider fails to amend its water use plan in a manner that the Director determines will achieve compliance, or
b. The provider fails to sign a stipulated agreement to remedy the violation.

G. If the Director determines that a designation of assured water supply should be revoked, the Director shall provide for an administrative hearing, in accordance with A.R.S. Title 41, Chapter 6, Article 10.

H. If a designated provider's designated status terminates, the provider may apply for re-designation at anytime after termination.

I. Notwithstanding any other provision in this Article, a decision and order of the Director designating a city, town, or private water company as having an assured water supply is not affected by this Article solely because the rule numbers cited in the decision and order may have changed after the effective date of the decision and order.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-712. Analysis of Adequate Water Supply

A. A person proposing to develop land outside an AMA that will not be served by a designated provider may apply for an analysis of adequate water supply before applying for a water report. An applicant for an analysis must be the owner of the land that is the subject of the application or have the written consent of the owner. The commissioner of the Arizona State Land Department may apply for an analysis for land owned by the state of Arizona outside an AMA or may consent to the inclusion of such land in an application.

B. An applicant for an analysis shall submit an application on a form prescribed by the Director with the fee required by R12-15-730, and attach the following:
1. A title report, condition of title report, limited search title report, or recorded deed, dated within 90 days of the date the application is submitted to the Director, demonstrating the ownership of the land that is the subject of the application;
2. A description of the development, including:
a. A map of the land uses included in the development,
b. A list of water supplies proposed to be used by the development,
c. A summary of land use types included in the development, and
d. An estimate of the water demand for the land uses included in the development; and
3. Evidence that the applicant has complied with subsection (E) of this Section.

C. An applicant shall sign the application for an analysis. If an applicant is not a natural person, the applicant's authorized officer, managing member, partner, trust officer, trustee, or other person who performs similar decision-making functions for the applicant shall sign the application. If the applicant submits a letter, signed by the applicant and dated within 90 days of the date the application is submitted, authorizing a representative to submit applications for permits regarding the land that is the subject of the water report, the authorized representative may sign the application on the applicant's behalf.

D. After a complete application is submitted, the Director shall determine the estimated water demand of the development.

E. The Director shall issue an analysis if an applicant demonstrates one or more of the following:
1. Sufficient supplies of water are physically available to meet all or part of the estimated water demand of the development for 100 years, according to the criteria in R12-15-716;
2. Sufficient supplies of water are continuously available to meet the estimated water demand of the development for 100 years, according to the criteria in R12-15-717;
3. Sufficient supplies of water are legally available to meet the estimated water demand of the development for 100 years, according to the criteria in R12-15-718;
4. The proposed sources of water are of adequate quality, according to the criteria in R12-15-719.

F. For 10 years after the Director issues an analysis, or a longer period allowed under subsections (H) or (I) of this Section:
1. If groundwater is a source of supply in the analysis and the applicant demonstrates that groundwater is physically available under subsection (E)(1), the Director shall consider that supply of groundwater reserved for the use of the proposed development in subsequent determinations of physical availability pursuant to R12-15-716(B).
2. If an analysis holder applies for a water report for a subdivision located on land included in the analysis, the Director shall presume that a criterion demonstrated in the analysis remains satisfied with respect to the subdivision, unless the Director has received new evidence demonstrating that the criterion is not satisfied. If the Director issues the water report, the Director shall reduce the volume of groundwater reserved pursuant to subsection (F)(1) of this Section by the amount of the estimated water demand for the water report that will be met with groundwater.

G. The Director shall reduce the amount of water considered reserved for use of the development upon request by the analysis holder. If the analysis holder requesting a reduction is not the person to whom the analysis was issued, the Director shall reduce the amount of reserved groundwater only if the person to whom the analysis was issued or that person's designee consents to the request for reduction. The person to whom the analysis was issued shall notify the Director in writing of the person's designee for purposes of this subsection.

H. The analysis holder may apply to the Director for a five-year extension of the time period in subsection (F) of this Section by submitting an application on a form prescribed by the Director no earlier than 36 months before the end of the time period and no later than 30 days before the end of the time period. If an extension is granted, the analysis holder may apply to the Director for an additional five-year extension by submitting an application on a form prescribed by the Director no earlier than 36 months before the end of the extended time period and no later than 30 days before the end of the extended time period. The Director shall extend the time period for no more than two successive five-year periods under this subsection if the analysis holder demonstrates one of the following:
1. The analysis holder has made a substantial capital investment in developing the land included in the analysis.
2. The analysis holder has made material progress in developing the land included in the analysis.
3. Progress in developing the land included in the analysis has been delayed for reasons outside the control of the analysis holder.

I. After the Director grants two five-year extensions pursuant to subsection (H) of this Section, the Director may extend the time period for additional five-year periods if the analysis holder files a timely application pursuant to subsection (H) of this Section and demonstrates one of the criteria in subsections (H)(1), (H)(2), or (H)(3) of this Section.

J. The Director shall review an application for an analysis or an application for an extension pursuant to subsections (H) or (I) of this Section pursuant to the licensing time-frame provisions in R12-15-401.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-713. Water Report

A. An application for a water report shall be filed by the current owner of the land that is the subject of the application.

B. An applicant for a water report shall submit an application on a form prescribed by the Director with the fee required by R12-15-730 and provide the following:
1. A title report, condition of title report, limited search title report, or recorded deed, dated within 90 days of the date the application is filed and demonstrating that the applicant is the owner of the land that is the subject of the application;
2. A plat of the subdivision;
3. An estimate of the 100-year water demand for the subdivision;
4. A list of all proposed sources of water that will be used by the subdivision;
5. If the applicant is seeking a finding that the subdivision has an adequate water supply, evidence that the criteria in subsection (E) of this Section are met; and
6. Any other information that the Director reasonably determines is necessary to decide whether an adequate water supply exists for the subdivision.

C. Each applicant shall sign the application for a water report. If an applicant is not a natural person, the applicant's authorized officer, managing member, partner, trust officer, trustee, or other person who performs similar decision-making functions for the applicant shall sign the application. If an applicant submits a letter, signed by the applicant and dated within 90 days of the date the application is submitted, authorizing a representative to submit applications for permits regarding the land to be included in the water report, the authorized representative may sign the application on the applicant's behalf.

D. After a complete application is submitted, the Director shall review the application and associated evidence to determine:
1. The estimated water demand of the subdivision;
2. Whether the applicant has demonstrated all of the requirements in subsection (E) of this Section.

E. The Director shall determine that the subdivision has an adequate water supply if the applicant demonstrates all of the following:
1. Sufficient supplies of water are physically available to meet the estimated water demand of the subdivision, according to the criteria in R12-15-716;
2. Sufficient supplies of water are continuously available to meet the estimated water demand of the subdivision, according to the criteria in R12-15-717;
3. Sufficient supplies of water are legally available to meet the estimated water demand of the subdivision, according to the criteria in R12-15-718;
4. The proposed sources of water will be of adequate quality, according to the criteria in R12-15-719;
5. The applicant has the financial capability to construct adequate delivery, storage, and treatment works for the subdivision according to the criteria in R12-15-720.

F. The Director shall issue a water report to the applicant that states whether the applicant has complied with the requirements in subsection (E) of this Section.

G. The Director shall review an application for a water report pursuant to the licensing time-frame provisions in R12-15-401.

H. The Director may review or modify a water report if the Director receives new evidence regarding the criteria in subsection (E) of this Section. The Director shall not modify a water report pursuant to this subsection if any of the residential lots included in the plat have been sold. To determine whether a water report should be modified pursuant to this subsection, the Director shall use the standards in place at the time the original application was submitted for the water report. If the Director modifies a water report, the Director shall:
1. Provide for an administrative hearing pursuant to A.R.S. Title 41, Chapter 6, Article 10; and
2. Notify the Arizona Department of Real Estate.

I. An owner of land that is the subject of a water report may request a modification of the water report at any time by submitting an application in accordance with subsection (B) of this Section. To determine whether a water report should be modified pursuant to this Section, the Director shall use the standards in place at the time of review.

J. A water report is subject to the provisions of R12-15-708.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-714. Designation of Adequate Water Supply

A. A municipal provider applying for a designation of adequate water supply shall submit an application on a form prescribed by the Director with the fee required by R12-15-730 and the

following:
1. The applicant's current demand;
2. The applicant's committed demand;
3. The applicant's projected demand for the proposed term of the designation;
4. The proposed term of the designation, which shall not be less than two years;
5. Evidence that the criteria in subsection (E) of this Section are met; and
6. Any other information that the Director determines is necessary to decide whether an adequate water supply exists for the municipal provider.

B. A city or town, other than a municipal provider, that is applying for a designation shall submit an application on a form prescribed by the Director with the fee required in R12-15-730, and provide the following:
1. The current demand of the applicant's service area;
2. The committed demand of the applicant's service area;
3. The projected demand of the applicant's service area for the proposed term of the designation;
4. The proposed term of the designation, which shall not be less than two years; and
5. Evidence that the requirements in A.R.S. § 45-108(D) are met.

C. An application for a designation shall be signed by:
1. If the applicant is a city or town, the city or town manager or a person employed in an equivalent position. The application shall also include a resolution of the governing body of the city or town, authorizing that person to sign the application; or
2. If the applicant is a private water company, the applicant's authorized officer, managing member, partner, trust officer, trustee, or other person who performs similar decision-making functions for the applicant.

D. After a complete application is submitted, the Director shall review the application and associated evidence to determine:
1. The annual volume of water that is physically, continuously, and legally available for at least 100 years;
2. The term of the designation, which shall not be less than two years;
3. The estimated water demand for the applicant's service area for 100 years; and
4. Whether the applicant has demonstrated compliance with all requirements in subsection (E) or (F) of this Section.

E. The Director shall designate the applicant has having an adequate water supply pursuant to subsection (A) of this Section if the applicant demonstrates all of the following:
1. Sufficient supplies of water are physically available to meet the applicant's estimated water demand, according to the criteria in R12-15-716;
2. Sufficient supplies of water are continuously available to meet the applicant's estimated water demand, according to the criteria in R12-15-717;
3. Sufficient supplies of water are legally available to meet the applicant's estimated water demand, according to the criteria in R12-15-718;
4. The proposed sources of water are of adequate quality, according to the criteria in R12-15-719; and
5. The applicant has the financial capability to construct adequate delivery, storage, and treatment works in a timely manner according to the criteria in R12-15-720.

F. The Director shall issue a designation pursuant to subsection (B) of this Section if the applicant demonstrates that the requirements of A.R.S. § 45-108(D) are met.

G. The Director shall review an application for a designation of adequate water supply pursuant to the licensing time-frame provisions in R12-15-401.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-715. Designation of Adequate Water Supply; Annual Report Requirements, Review, Modification, Revocation

A. By March 31 of each calendar year, a designated provider shall submit the following information for the preceding calendar year on a form provided by the Director:
1. The designated provider's committed demand;
2. The demand at build-out for customers with which the designated provider has entered into an agreement to serve water, other than committed demand;
3. A report regarding the designated provider's compliance with water quality requirements;
4. The depth-to static water level of all wells from which the designated provider withdrew water;
5. A report regarding volume of water withdrawn, diverted, or received from each source for delivery to customers;
6. Any other information the Director may reasonably require to determine whether the designated provider continues to meet the criteria for a designation of adequate water supply.

B. If there is a change of ownership, the subsequent owner of a designated provider shall notify the Director in writing of the change in ownership within 90 days.

C. The Director shall review a designation at least every 15 years following issuance of the designation to determine whether the designation should be modified or revoked.

D. The Director may modify a designation for good cause, including a merger, division of the designated provider, or a change in ownership of the designated provider. A designated provider may request a modification of the designation at any time pursuant to R12-15-714. To determine whether the designation should be modified, the Director shall use the standards in place at the time of review.

E. The Director may revoke a designation if:
1. After notifying the designated provider and initiating a review of the designated provider's status, the Director deter mines that the designated provider has less water, according to the criteria in R12-15-714(E), than the amount required for a 100-year supply for the provider's:
a. Current demand,
b. Committed demand, and
c. Projected demand for the next two calendar years;
2. The designated provider fails to construct adequate delivery, storage, and treatment works in a timely manner; or
3. ADEQ or another governmental entity with equivalent jurisdiction has determined, after notice and an opportunity for a hearing, that the designated provider is in significant noncompliance with A.A.C. Title 18, Chapter 4 and is not taking action to resolve the noncompliance.

F. To determine whether the designation should be revoked, the Director shall use the standards in place at the time of review. If the Director determines that a designation of adequate water supply should be revoked, the Director shall provide for an administrative hearing, in accordance with A.R.S. Title 41, Chapter 6, Article 10.

G. If a designated provider's designated status terminates, the provider may apply for re-designation at anytime after termination.

H. Notwithstanding any other provision in this Article, a decision and order of the Director designating a city, town, or private water company as having an assured water supply is not affected by this Article solely because the rule numbers cited in the decision and order may have changed after the effective date of the decision and order.

Historical Head

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-716. Physical Availability

A. The volume of a proposed source of water that is physically available to an applicant for a determination of assured water supply or a determination of adequate water supply is the amount determined by the Director to be physically available pursuant to subsections (B) through (L) of this Section.

B. If the proposed source is groundwater, the applicant shall submit a hydrologic study, using a method of analysis approved by the Director, that accurately describes the hydrology of the affected area. Except as provided in subsection (D) of this Section, the Director shall determine that the proposed volume of groundwater will be physically available for the proposed use if both of the following apply:
1. The groundwater will be withdrawn as follows:
a. Except as provided in subsection (B)(1)(b) of this Section, from wells owned by the applicant or the proposed municipal provider that are located within the service area of the applicant or the proposed municipal provider or from proposed wells that the Director determines are likely to be constructed for future uses of the applicant or the proposed municipal provider.
b. If the application is for a dry lot development, from wells that the Director determines are likely to be constructed on individual lots.
2. Except as provided in subsection (C) of this Section, the groundwater will be withdrawn from depths that do not exceed the applicable maximum 100-year depth-to-static water level according to the following:

Type and location of development	Maximum 100-year depth-to-static water level
a. Developments in Phoenix, Tucson, or Prescott AMAs, except dry lot developments	1000 feet below land surface
b. Developments in Pinal AMA, except dry lot developments	1100 feet below land surface
c. Developments outside AMAs, except dry lot developments	1200 feet below land surface
d. Dry lot developments	400 feet below land surface

3. The Director shall calculate the projected 100-year depth-to-static water level by adding the following for the area where groundwater withdrawals are proposed to occur:
a. The depth-to-static water level on the date of application.
b. The projected declines caused by existing uses, using the projected decline in the 100-year depth-to-static water level during the 100-year period after the date of application, calculated using records of declines for the maximum period of time for which records are available up to 25 calendar years before the date of application. If evidence is provided to the Director of likely changes in pumpage patterns and aquifer conditions, as opposed to those patterns and conditions occurring historically, the Director may determine projected declines using a model rather than evidence of past declines.
c. The projected decline in the depth-to-static water level during the 100-year period after the date of application, calculated by adding the projected decline from each of the following that are not accounted for in subsection (B)(3)(b) of this Section:
i. The estimated water demand of issued certificates and water reports that will be met with groundwater or stored water recovered outside the area of impact of the stored water, not including the demand of subdivided lots included in abandoned plats;

ii. The estimated water demand of designations that will be met with groundwater or stored water recovered outside the area of impact of the stored water; and
iii. The groundwater reserved for developments for which the Director has issued an analysis pursuant to R12-15-703 or R12-15-712.
d. The projected decline in depth-to-static water level that the Director projects will result from the applicant's proposed use over a 100-year period.

C. The Director shall lower the maximum 100-year depth-to-static water level requirement specified in subsection (B)(2) of this Section for an applicant seeking a determination of adequate water supply if the applicant demonstrates both of the following:
1. Groundwater is available at the lower depth; and
2. The applicant has the financial capability to obtain the groundwater at the lower depth, according to the criteria in R12-15-720.

D. If the proposed source is groundwater that will be withdrawn from a groundwater basin outside an AMA and transported into an AMA, the Director shall determine that the proposed volume of groundwater will be physically available if both of the following apply:
1. The groundwater will be withdrawn from wells owned by the applicant or the proposed municipal provider or from proposed wells that the Director determines are likely to be constructed for the future uses of the applicant or the proposed municipal provider.
2. Withdrawal of the groundwater will comply with any depth-to-static water level criteria, decline rate criteria, and volume limitation criteria prescribed by statute. If there are no applicable depth-to-static water level criteria prescribed by statute, withdrawal of the groundwater shall comply with the depth-to-static water level criteria in subsection (B)(2) of this Section.

E. Subject to subsection (L) of this Section, if the proposed source of water is surface water, other than CAP water, or Colorado River water, the Director shall determine the annual volume of water that is physically available for the proposed use, taking into consideration the priority date of the right or claim, by calculating 120% of the firm yield of the proposed source at the point of diversion as limited by the capacity of the diversion works; except that if the applicant demonstrates that an alternative source of water will be physically available during times of shortage in the proposed surface water supply, the Director shall determine the annual volume of water available by calculating 100% of the median flow of the proposed source at the point of diversion as limited by the capacity of the diversion works. The Director shall determine the firm yield or median flow as follows:
1. By calculating the firm yield or median flow at the point of diversion based on at least 20 calendar years of flow records from the point of diversion, unless 20 calendar years of records are unavailable and the Director determines that a shorter period of record provides information necessary to determine the firm yield or median flow; or
2. By calculating the firm yield or median flow at the point of diversion using a hydrologic model that projects the firm yield or median flow, taking into account at least 20 calendar years of historic river flows, changes in reservoir storage facilities, and projected changes in water demand. The yield available to any applicant may be composed of rights to stored water, direct diversion, or normal flow rights. If the permit for the water right was issued less than five years before the date of application, the Director shall require the applicant to submit evidence, as applicable, in accordance with this subsection.

F. Subject to subsection (L) of this Section, if the proposed source of water is CAP water, the Director shall determine the annual volume of water that is physically available for the proposed use as follows:
1. If the applicant or the proposed municipal provider has a non-declining, long-term municipal and industrial subcontract for CAP water, calculate 100% of the annual amount of water established in the subcontract.
2. If the applicant has a lease for Indian priority CAP water, calculate 100% of the annual amount of water established in the lease.
3. If the applicant has a subcontract for CAP water other than a non-declining, long-term municipal and industrial subcontract or a lease for Indian priority CAP water:
a. If the applicant submits evidence of sufficient backup water supplies, calculate 100% of the annual amount of water established in the subcontract. The applicant may establish backup water supplies by one or more of the following:
i. A drought response plan;
ii. Long-term storage credits;
iii. A contract for water with a multi-county water conservation district; or
iv. Evidence of other backup supplies that are physically, continuously, and legally available.
b. If the applicant does not submit evidence of sufficient backup water supplies pursuant to subsection (F)(3)(a) of this Section, calculate the percentage of the annual amount of water established in the subcontract that reasonably reflects the reliability of the applicant's CAP water supply.

G. Subject to subsection (L) of this Section, if the proposed source of water is Colorado River water, the Director shall determine the annual volume of water that is physically available for the proposed use as follows:
1. If the priority of the contract for Colorado River water provides reliability equal to or better than CAP municipal and industrial water, calculate 100% of the annual amount of water established in the contract.
2. If the contract for Colorado River water provides reliability that is less than CAP municipal and industrial water:
a. If the applicant submits evidence of sufficient backup water supplies, calculate 100% of the annual amount of water in the contract. The applicant may establish backup water supplies by one or more of the following:
i. A drought response plan;
ii. Long-term storage credits;
iii. A contract for water with a multi-county water conservation district; or
iv. Evidence of other backup supplies that are physically, continuously, and legally available.
b. If the applicant does not submit evidence of sufficient backup water supplies pursuant to subsection (G)(2)(a) of this Section, calculate the percentage of the annual amount of water established in the contract that reasonably reflects the reliability of the applicant's Colorado River water supply.

H. Subject to subsection (I) of this Section, if the proposed source of water is effluent, the Director shall determine the annual volume of water that will be physically available by evaluating the current, metered production or the projected production of effluent. The volume of effluent that is physically available shall not include the following:
1. If the effluent will be delivered directly from a wastewater treatment plant, the volume of effluent that exceeds the applicant's estimated water demand that will be met with effluent; and
2. The volume of effluent that does not comply with any applicable water quality requirements for the proposed use of the effluent.

I. If the proposed source of water is stored water to be recovered from recovery wells, the Director shall determine the volume of water that is physically available for the proposed use as follows:
1. If the stored water is represented by long-term storage credits in existence on the date of application, the amount that is physically available is the amount that may be recovered pursuant to the credits in a manner consistent with A.R.S. Title 45, Chapter 3.1, subject to subsection (I)(3) of this Section.
2. If the applicant proposes to use long-term storage credits that do not exist on the date of application or recover stored water on an annual basis pursuant to A.R.S. § 45-851.01, the Director shall evaluate the following in determining whether to include the proposed credits or the water proposed to be stored and recovered annually in the amount of water that is physically available for the applicant's proposed use:
a. The terms of a contract to obtain water to store in a storage facility;
b. The physical, continuous, and legal availability of the water proposed to be stored;
c. The presence of an existing storage facility that will be available for use for the proposed storage;
d. The existence of all required permits of an adequate duration; and
e. Whether recovery of the stored water will comply with subsection (I)(3) of this Section.
3. If the applicant proposes to recover the stored water from recovery wells located outside the area of impact of storage, the stored water will be considered physically available only if sufficient water exists for the withdrawals consistent with both of the following:
a. The maximum 100-year depth-to-static water level requirements established in subsection (B)(2) of this Section; and
b. Any criteria for the withdrawals prescribed in the management plan in effect at the time of the application.

J. If the applicant will obtain the source of water through a water exchange agreement, the Director shall determine that the water is physically available for the proposed use if the applicant submits evidence that the source of water the applicant or the applicant's customers will use will be physically available in accordance with the terms of this Section.

K. In the case of two or more pending, conflicting, complete and correct applications for determinations of assured water supply or determinations of adequate water supply, the Director shall give priority to the application with the earliest priority date. The priority date of an application for a determination of assured water supply or determination of adequate water supply shall be the date that a complete and correct application is filed with the Director. The Director shall consider an application complete and correct if it contains all the information required and the Director verifies that the information is accurate.

L. For a certificate applicant that proposes to use surface water, the Director shall determine that the proposed source is physically available only if the applicant demonstrates one of the following:
1. The land that is the subject of the application is a member land of the CAGRD.
2. The applicant has independently obtained the surface water supply.
3. The proposed municipal provider would satisfy the criteria in R12-15-722 if the municipal provider were subject to those requirements.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-717. Continuous Availability

A. The Director shall determine that an applicant will have sufficient supplies of water that will be continuously available for 100 years if the applicant submits sufficient evidence that adequate delivery, storage, and treatment works will be in place in a timely manner to make the water available to the applicant or the applicant's customers for 100 years and the applicant meets any applicable requirements in subsections (B) through (G) of this Section.

B. If the proposed source of water is groundwater, the applicant shall demonstrate that wells of a sufficient capacity will be constructed in a timely manner to serve the proposed uses on a continuous basis for 100 years.

C. If the proposed source of water is surface water other than CAP water or Colorado River water, the applicant shall demonstrate that a continuous supply will exist because of one or more of the following:
1. The projected volume to be diverted from the source is perennial at the point of diversion;
2. Adequate storage facilities will be available to the applicant in a timely manner to store water for use when a volume of surface water is not available at the point of diversion to satisfy the applicant's water demands;
3. The applicant has presented evidence of supplies of other sources of water that the Director has determined will be physically, continuously, and legally available to supplement the applicant's proposed surface water supplies;
4. The applicant or the proposed municipal provider will withdraw surface water from wells of sufficient capacity to meet the applicant's estimated water demand on a continuous basis for 100 years; or

5. The applicant has submitted a drought response plan that the Director has determined will conserve or augment a volume of water equal to the volume of water that is subject to drought.

D. If the proposed source of water is CAP water or Colorado River water, the applicant shall demonstrate that a continuous supply is available because of one or more of the following:
1. Adequate storage facilities will be available to the applicant in a timely manner to store water when a volume of CAP water or Colorado River water is not available to meet the applicant's water demands;
2. The applicant has presented evidence of supplies of other sources of water that the Director has determined will be physically, continuously, and legally available to the applicant to supplement the proposed CAP water or Colorado River water supplies; or
3. The applicant has submitted a drought response plan that the Director has determined will conserve or augment a volume of water equal to the volume subject to drought.

E. If the proposed source of water is effluent, the applicant shall demonstrate that the capability to use the effluent to meet the demands of the proposed use will not be affected by any fluctuations in the supply of the effluent.

F. If the proposed source of water is stored water to be recovered from recovery wells, the applicant shall demonstrate that recovery wells of a sufficient capacity will be constructed in a timely manner to serve the proposed use on a continuous basis for 100 years.

G. If an applicant will obtain the source of water through a water exchange agreement, the applicant shall demonstrate that the source of water the applicant or the applicant's customers will use will be continuously available in accordance with the terms of this Section.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Amended by emergency rulemaking at 11 A.A.R. 2706, effective June 29, 2005 for 180 days (Supp. 05-2). Emergency renewed for 180 days at 12 A.A.R. 144, effective December 23, 2005 (Supp. 05-4). Emergency expired. Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-718. Legal Availability

A. The Director shall determine that an applicant will have sufficient supplies of water that will be legally available for at least 100 years if the applicant submits all of the applicable information required by this Section.

B. If the applicant is an applicant for a certificate or a water report, the applicant shall submit the following, as applicable:
1. A Notice of Intent to Serve agreement between the owner of the land to be included in the subdivision and the proposed municipal provider, stating the proposed municipal provider's intent to serve the subdivision;
2. If the proposed municipal provider is a city or town, evidence indicating that the proposed subdivision is located within the incorporated limits of the city or town or evidence of the legal right of the city or town to serve water to the subdivision outside the city or town's incorporated limits; or
3. If the proposed municipal provider is a private water company, one of the following:
a. Evidence that the proposed municipal provider has a certificate of convenience and necessity approved by the Arizona Corporation Commission and the subdivision is located within the geographic area described in the certificate of convenience and necessity or any other area in which the Arizona Corporation Commission authorizes the private water company to serve water;
b. Evidence that the proposed municipal provider has an order preliminary issued by the Arizona Corporation Commission authorizing the municipal provider to provide water service and the proposed subdivision is located within the area described in the order preliminary; or
c. Evidence that the proposed municipal provider is not a public service corporation regulated by the Arizona Corporation Commission.

C. If the applicant is a private water company applying for a designation, the applicant shall submit evidence that the applicant has a certificate of convenience and necessity approved by the Arizona Corporation Commission, or has been issued an order preliminary by the Arizona Corporation Commission for a certificate of convenience and necessity, authorizing the applicant to serve the proposed use.

D. If a proposed source of water is groundwater to be withdrawn within an AMA, the applicant shall submit evidence that the applicant or the proposed municipal provider has one or more of the following:
1. A service area right;
2. An applicable non-irrigation grandfathered right to withdraw groundwater, in an amount sufficient to serve the proposed use; or
3. A pending notice of intent to establish a new service area and all of the following apply:
a. The notice of intent to establish a new service area identifies the proposed subdivision,
b. The applicant or the proposed municipal provider has obtained a permit for any wells used to establish the service area right,
c. The proposed municipal provider has obtained a water right or recovery well permit to establish the service area right, and
d. The water right is of sufficient volume and duration to meet the estimated water demand of the proposed subdivision until the anticipated date of issuance of a service area right.

E. If a proposed source of water is surface water other than CAP water or Colorado River water:
1. The applicant shall submit evidence that the applicant or the proposed municipal provider has a certificated surface water right, decreed water right, or a pre-1919 claim for the proposed source. If the applicant or the proposed municipal provider does not hold a surface water right or claim, but will receive water pursuant to a water right or claim that is appurtenant to the land that is the subject of the application, the applicant shall submit evidence of the water right or claim and evidence that the water right or claim may neither be legally withheld nor severed and transferred by the right holder or claimant.
2. If the certificated surface water right or decreed water right pre-dates the date of application by at least five years, or the applicant submits a pre-1919 claim, the applicant shall submit one of the following:
a. Evidence that the surface water supply has been used pursuant to the applicable water right or claim within the five years before the date of application;
b. Evidence that a court has determined that the right has not been abandoned; or
c. Evidence that the non-use would not have resulted in an abandonment of the right pursuant to A.R.S. § 45-189.
3. The Director shall determine that the volume of water that is legally available pursuant to a certificated surface water right, a decreed water right, or a pre-1919 claim is equal to the face value of the right or claim. If the right or claim is subsequently adjudicated, the Director shall determine the volume of water that is legally available based on the adjudicated amount of water.

F. Subject to subsections (M) and (N) of this Section, if a proposed source of water is CAP water, the applicant shall submit evidence that the applicant or the proposed municipal provider has entered into a subcontract with a multi-county water conservation district for the proposed volume of CAP water. The Director shall presume that a 50-year long-term, non-declining municipal and industrial subcontract is sufficient evidence of the legal availability of the volume of CAP water specified in the subcontract for 100 calendar years.

G. Subject to subsections (M) and (N) of this Section, if a proposed source of water is Colorado River water, the applicant shall submit evidence of one of the following:
1. The applicant or the proposed municipal provider has a contract with the United States Secretary of the Interior for the proposed supply; or
2. The applicant has obtained an allocation of Colorado River water from an entity to which all of the following apply:
a. The entity holds a contract for Colorado River water with the United States Secretary of the Interior;
b. The entity provides Colorado River water to the proposed municipal provider;
c. The entity has allocated a sufficient volume of the Colorado River water to the subdivision; and
d. The area that the entity may serve, described in the contract with the United States Secretary of the Interior, includes the subdivision.

H. If a proposed source of water is effluent, the applicant shall submit evidence that the applicant or the proposed municipal provider has the legal right to use the effluent.

I. If the applicant will obtain a proposed source of water through a written contract other than a water exchange agreement, a contract between a certificate applicant and the municipal provider proposed to serve the applicant, a contract with the United States Secretary of the Interior for Colorado River water, or a subcontract with a multi-county water conservation district, the applicant shall submit evidence that the person providing the water under the contract has a legal right to the water in accordance with the terms of this Section and that the terms of the contract will ensure that the proposed source of water will be delivered to the applicant or to the proposed subdivision. The Director shall determine the term of years for which the proposed source of water is legally available based on the term of years remaining in the contract. The Director shall determine the quantity of water legally available based on the volume established in the contract.

J. If the applicant will obtain a proposed source of water through a water exchange agreement, the applicant shall submit evidence that the water exchange agreement satisfies the requirements of A.R.S. Title 45, Chapter 4.

K. If the Director can determine the proposed source of water to be physically and continuously available only because of the use of storage facilities by the applicant or by the proposed municipal provider, the applicant shall submit evidence of the applicant's or the proposed municipal provider's legal right to store water in the storage facilities.

L. If the applicant proposes to use long-term storage credits, the applicant shall submit evidence that the applicant or the proposed municipal provider has the legal right to use the credits under A.R.S. Title 45, Chapter 3.1.

M. If a proposed supply of water is Colorado River water or CAP water leased from an Indian community, the applicant shall submit evidence that the water leased has a priority equal to or higher than CAP municipal and industrial water, evidence that the Indian community is expressly authorized by an Act of Congress to lease the water for use off Indian community lands, evidence of the lease, and evidence of one of the following:
1. The proposed water supply is available under the lease for at least 100 years from any time during the year in which the applicant submits the application.
2. The term of the lease has less than 100 years remaining in the year in which the applicant submits the application and a supplemental water supply, together with the leased water, provides a 100-year water supply. The applicant shall demonstrate that the supplemental water supply is physically, continuously, and legally available and, if such supplemental supply is groundwater, that use of the groundwater is consistent with the management goal of the AMA. If the supplemental supply is water recovered through the use of long-term storage credits, the applicant shall also submit the following, as applicable:
a. If the applicant is to use the long-term storage credits before the beginning of the lease term, evidence that the applicant or the proposed municipal provider has obtained a recovery well permit that allows the applicant or the proposed municipal provider to recover water pursuant to the long-term storage credits; or
b. If the long-term storage credits will be accrued in the future, evidence that the applicant or the proposed municipal provider will accrue the long-term storage credits within 20 years after the effective date of the designation, certificate, or water report by storing the water under an issued water storage permit at a permitted storage facility and that no more than 20 years of the applicant's supplemental water supply will be provided by the long-term storage credits.

N. If the Director previously determined that Colorado River water or CAP water leased from an Indian community was legally available to a designated provider for 100 years, the Director shall determine that the designated provider continues to have a legally available supply of water for 100 years for the annual amount of water available under the lease if:
1. The lease has at least 50 years remaining in its term or the lease has at least 40 years remaining in its term and the designated provider submits evidence to the Director of active and ongoing negotiations with the Indian community to renew or re-negotiate the lease; and
2. One of the following applies:
a. No more than 15% of the total water supplies that the designated provider establishes as physically, continuously, and legally available during any year are obtained through leases

with Indian communities;

b. Groundwater will be physically, continuously, and legally available to the designated provider at the end of the lease term to substitute for the leased water for the remainder of the 100-year period, and the projected use of groundwater is consistent with the management goal of the AMA. For purposes of this subsection, the designated provider may demonstrate that the proposed use is consistent with the management goal by entering into a written agreement with the Director under which the designated provider agrees to replace through replenishment or underground storage any groundwater used at the end of the lease term if groundwater use is not consistent with the management goal. The written agreement shall provide that specific performance is the only remedy in the event of default;

c. A non-groundwater source of water will be physically, continuously, and legally available at the end of the lease term to substitute for the leased water for the remainder of the 100-year period; or

d. The designated provider's governing board or council submits a resolution requesting that the designated provider be allowed to increase its projected use of Indian lease water from 15%, as allowed by subsection (N)(2)(a) of this Section, to 20%, and the Director finds that all of the following apply:

i. No more than 20% of the total water supplies that the designated provider establishes as physically, continuously, and legally available during any year are obtained through leases with Indian communities;

ii. No more than 15% of the total water supplies that the designated provider establishes as physically, continuously, and legally available during any year are obtained through any single lease with an Indian community; and

iii. The designated provider does not meet the requirements of subsections (N)(2)(a), (b), or (c) of this Section.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-719. Water Quality

A. Except as provided in subsection (B) of this Section, when reviewing an application for a determination of assured water supply or a determination of adequate water supply, the Director shall determine that the water supply is of adequate quality if one of the following applies:

1. The applicant certifies on the application that the applicant or the proposed municipal provider will be regulated by ADEQ, or another governmental entity with equivalent jurisdiction, as a public water system pursuant to A.R.S. § 49-351, et seq., unless ADEQ, or another governmental entity with equivalent jurisdiction, has determined, after notice and an opportunity for a hearing, that the public water system is in significant noncompliance with A.A.C. Title 18, Chapter 4 and is not taking action to resolve the noncompliance; or
2. The applicant has submitted results of a lab analysis demonstrating that the water meets water quality requirements in accordance with A.A.C. Title 18, Chapter 4, or that the water will meet these requirements after treatment that is required by law. The lab analysis shall be based on water withdrawn from a well representative of the well or wells from which water will be withdrawn for the proposed use, conducted in compliance with sample collection and analysis requirements in A.A.C. Title 18, Chapter 4, and completed within 60 days of the date the application is submitted to the Director. If ADEQ waives any of the water quality or sample collection and analysis requirements in A.A.C. Title 18, Chapter 4, the Director shall not require the applicant to meet the waived requirements.

B. If a well or a proposed well from which water will be withdrawn for the proposed use is located within one mile of a WQARF site or Superfund site, the Director shall determine that the water supply is of adequate quality only if the applicant submits a contaminant migration and mitigation analysis, demonstrating that the water supply will continue to meet the requirements in A.A.C. Title 18, Chapter 4 for 100 years. The contaminant migration and mitigation analysis may include the impact of any mitigation or treatment, including mitigation or treatment required pursuant to a consent decree.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-720. Financial Capability

A. The Director shall determine that an applicant for a certificate or a water report has the financial capability to construct adequate delivery, storage, and treatment works if the applicant demonstrates one or more of the following:

1. The applicant will submit its final plat to a qualified platting authority;
2. The applicant has constructed adequate delivery, storage, and treatment works, and water service is available to each lot; or
3. The applicant has posted a performance bond with the platting authority for the entire cost of adequate delivery, storage, and treatment works.

B. Upon receiving evidence that a platting authority has established standards for proof of financial capability to construct adequate delivery, storage, and treatment works, pursuant to A.R.S. § 9-463.01(C)(8) or A.R.S. § 11-806.01(G), the Director shall classify the platting authority as a qualified platting authority. The Director shall maintain a list of qualified platting authorities.

C. The Director shall determine that an applicant for a designation has the financial capability to construct adequate delivery, storage, and treatment works if the applicant demonstrates one or more of the following for each of those facilities:

1. The applicant has constructed adequate delivery, storage, and treatment works;
2. The applicant has entered into written agreements requiring a potential developer to construct adequate delivery, storage, and treatment works;
3. If the applicant is a city or town, the applicant has:
   a. Adopted a five year capital improvement plan that provides for the construction, or the commencement of construction, of adequate delivery, storage, and treatment works in a timely manner, and has submitted a certification by the applicant's chief financial officer that finances are available to implement that portion of the five-year plan; or
   b. Submitted evidence demonstrating that financing mechanisms are in place to construct adequate delivery, storage, and treatment works in a timely manner; or
4. If the applicant is a private water company, the applicant has received approval from the Arizona Corporation Commission for financing the construction of adequate delivery, storage, and treatment works.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-721. Consistency with Management Plan

A. The Director shall determine whether a designation applicant's projected use of groundwater withdrawn within an active management area is consistent with the management plan as follows:

1. If the applicant is providing water to customers as of the date of application, the applicant's projected water use is consistent with the management plan if either of the following apply:
   a. The applicant is in compliance with its applicable management plan requirements in the most recent calendar year for which data is available before the date of application; or
   b. The applicant has signed a stipulation and consent order that is in effect on the date of the application, or that becomes effective during the time of review of the application, to remedy non-compliance with the management plan requirements and the applicant is in compliance with the terms of the stipulation and consent order.
2. If the applicant has not commenced serving water to customers as of the date of application, the applicant shall submit a water use plan that demonstrates to the Director that compliance with management plan requirements will be achieved through the use of conservation or augmentation measures.
3. If the applicant has a pending request for an administrative review or variance from its management plan requirements, the Director shall not make a finding regarding compliance with this Section until the Director has issued a final decision and order on the request or the request has been withdrawn.

B. The Director shall determine that a certificate applicant's projected use of groundwater withdrawn within an AMA is consistent with the management plan if the applicant submits a water use plan for the subdivision that includes both of the following:

1. Information demonstrating that compliance with management plan requirements will be achieved through conservation or augmentation measures; and
2. All information required to calculate the water requirements for each proposed water use.

C. A certificate applicant for a subdivision of 50 or fewer lots is exempt from the requirements of this rule.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-722. Consistency with Management Goal

A. For the Phoenix, Prescott, or Tucson AMAs, the Director shall calculate the volume of groundwater that may be used consistent with the management goal of the AMA in which the proposed use is located for at least 100 years by adding the following:

1. The amount of the groundwater allowance, according to R12-15-724(A), R12-15-726(A), or R12-15-727(A).
2. The amount of any extinguishment credits pledged to the certificate or designation, according to R12-15-724(B), R12-15-726(B), or R12-15-727(B).
3. Any groundwater that is consistent with the achievement of the management goal pursuant to A.R.S. Title 45, Chapter 2.

B. The Director shall determine that a proposed groundwater use in the Phoenix, Prescott, or Tucson AMA is consistent with the management goal of the AMA if the volume calculated in subsection (A) of this Section is equal to or greater than the portion of the applicant's estimated water demand to be met with groundwater.

C. For a certificate in the Pinal AMA, the Director shall calculate the volume of groundwater that may be used consistent with the management goal of the AMA for at least 100 years by adding the following:

1. The amount of the groundwater allowance, according to R12-15-725(A)(1).
2. The amount of any extinguishment credits pledged to the certificate for a grandfathered right that was extinguished on or after October 1, 2007, according to R12-15-725(B).
3. The amount of any extinguishment credits pledged to the certificate for a grandfathered right that was extinguished before October 1, 2007. The Director shall calculate the amount of the extinguishment credits by multiplying the annual amount of the credits by 100.
4. Any groundwater that is consistent with the achievement of the management goal pursuant to A.R.S. Title 45, Chapter 2.

D. For a certificate in the Pinal AMA, the Director shall determine that the proposed groundwater use is consistent with the management goal of the AMA if the volume calculated in subsection (C) of this Section is equal to or greater than the portion of the applicant's estimated water demand to be met with groundwater.

E. For a designation in the Pinal AMA, the Director shall calculate the volume of groundwater that may be used consistent with the management goal of the Pinal AMA on an annual basis by adding the following:

1. The amount of the groundwater allowance, according to R12-15-725(A)(2). If any of the groundwater allowance is not used during a year, the unused groundwater allowance shall not be added to the volume calculated under this subsection for the following year.
2. The amount of any extinguishment credits pledged to the designation for a grandfathered right that was extinguished on or after October 1, 2007, according to R12-15-725(B), divided by 100. Extinguishment credits for a grandfathered right that was extinguished on or after October 1, 2007 may be used in any year.
3. The annual amount of any extinguishment credits pledged to the designation for a grandfathered right that was extinguished before October 1, 2007. The following shall apply if any of the extinguishment credits are not used during a calendar year:

a. If the extinguishment credits were pledged to the designation before October 1, 2007, any extinguishment credits not used during a calendar year shall be added to the volume calculated under this subsection for the following calendar year.
b. If the extinguishment credits are pledged to the designation on or after October 1, 2007, any of the extinguishment credits not used during a calendar year shall not be added to the volume calculated under this subsection for the following calendar year, except that if the extinguishment credits were originally pledged to a certificate before October 1, 2007 and are used to support the municipal provider's designation pursuant to R12-15-723(G)(2), any of the extinguishment credits not used during a calendar year shall be added to the volume calculated under this subsection for the following calendar year.

4. Any groundwater that is consistent with the achievement of the management goal pursuant to A.R.S. Title 45, Chapter 2.

F. For a designation in the Pinal AMA, the Director shall determine that the proposed groundwater use is consistent with the management goal of the Pinal AMA if the annual volume calculated in subsection (E) of this Section is equal to or greater than the portion of the applicant's annual estimated water demand to be met with groundwater.

G. Upon application, the following volumes of groundwater used by an applicant are considered consistent with the management goal:

1. If the Director determines that a surface water supply is physically available under R12-15-716 and the volume of the supply actually available during a calendar year is equal to or less than the drought volume for the supply, the volume of groundwater, other than the groundwater that is accounted for under subsection (A), (C), or (E) of this Section, withdrawn within the AMA that, when combined with the available surface water supply, is equal to or less than the drought volume.
2. Any volume of groundwater withdrawn within a portion of an AMA that is exempt from conservation requirements under A.R.S. Title 45 due to waterlogging. The Director shall review the application of this exclusion on a periodic basis, not to exceed 15 years.
3. Remedial groundwater that is consistent with the management goal according to the requirements of R12-15-729.

H. An applicant for a certificate of assured water supply for a dry lot subdivision of 20 lots or fewer is exempt from the requirements of this Section.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3). Amended by final rulemaking at 13 A.A.R. 1394, effective October 1, 2007 (Supp. 07-2).

R12-15-723. Extinguishment Credits

A. Except as provided in subsection (D) of this Section, the owner of a grandfathered right may extinguish the right in exchange for extinguishment credits by submitting the following:

1. A notarized statement of extinguishment of a grandfathered right on a form provided by the Director;
2. The grandfathered right number;
3. If the right being extinguished is a type 1 non-irrigation grandfathered right or an irrigation grandfathered right, evidence of ownership of the land to which the grandfathered right is appurtenant;
4. If the grandfathered right is located in the Prescott AMA, evidence that all of the following conditions are met:
   a. The land to which the right is appurtenant has not been and will not be subdivided pursuant to a preliminary plat or a final plat that was approved by a city, town, or county before August 21, 1998; and
   b. The land to which the right is appurtenant is not and will not be the location of a subdivision for which a complete and correct application for a certificate of assured water supply was submitted to the Director before August 21, 1998;
5. If the right being extinguished is an irrigation grandfathered right, evidence that the development of the land to which the right is appurtenant is not completed; and
6. Any additional information the Director may reasonably require to process the extinguishment.

B. The Director shall calculate the amount of extinguishment credits pursuant to R12-15-724(B), R12-15-725(B), R12-15-726(B) or R12-15-727(B). The Director shall notify the owner of the amount of extinguishment credits in writing. If the owner is extinguishing only a portion of the right, the Director shall issue a new certificate of grandfathered right for the remainder of the right.

C. A type 1 non-irrigation grandfathered right or an irrigation grandfathered right may be extinguished in whole or in part. A type 2 non-irrigation grandfathered right may be extinguished only in whole.

D. The following rights may not be extinguished in exchange for extinguishment credits:

1. An irrigation grandfathered right that is appurtenant to land that has been physically developed for a non-irrigation use. The Director shall not consider the land to be physically developed until the development is completed.
2. A type 1 non-irrigation grandfathered right, if the Director determines that the holder is likely to continue to receive groundwater from an undesignated municipal provider for the same use pursuant to the provider's service area right or pursuant to a groundwater withdrawal permit.
3. A type 2 non-irrigation grandfathered right that was issued based on the withdrawal of groundwater for mineral extraction or processing or for the generation of electrical energy.
4. On or after January 1, 2025, any grandfathered right that is in the Phoenix, Prescott, or Tucson AMAs.
5. Any grandfathered right in the Pinal AMA beginning in the first calendar year in which the allocation factor for the extinguishment of a grandfathered right is zero, pursuant to R12-15-725(B)(3) or (4).
6. A type 1 non-irrigation grandfathered right that was requested to be included by a city or town in the Tucson AMA in the determination made under A.R.S. § 45-463(F).

E. The owner of extinguishment credits may pledge the credits to a certificate or to a designation before the certificate or designation is issued by submitting with the application for the certificate or designation a notice of intent to pledge extinguishment credits on a form provided by the Director. The extinguishment credits shall be pledged to the certificate or designation upon issuance of the certificate or designation.

F. The owner of extinguishment credits may pledge the credits to a certificate or to a designation after the certificate or designation is issued by submitting a notice of intent to pledge extinguishment credits on a form provided by the Director. The Director shall notify the owner of the extinguishment credits and the certificate holder or designated provider that the credits have been pledged to the certificate or designation.

G. Extinguishment credits that have not been pledged to a certificate or designation may be conveyed within the same AMA. Extinguishment credits pledged to a certificate or designation shall not be conveyed to another person, except that:

1. If extinguishment credits are pledged to a certificate that is later assigned or reissued, any unused credits are transferred, by operation of this subsection, to the assigned or reissued certificate. If the certificate is partially assigned or reissued, a pro rata share of the unused extinguishment credits is transferred to each assigned or reissued certificate according to the estimated water demand.
2. If extinguishment credits are pledged to a certificate for a subdivision that is later served by a designated provider or a municipal provider that is applying for a designation, any unused extinguishment credits may be used to support the municipal provider's designation as long as the municipal provider serves the subdivision and remains designated. If the municipal provider is no longer serving the subdivision or if the municipal provider loses its designated status, any unused extinguishment credits shall revert, by operation of this subsection, to the certificate to which they were originally pledged.

H. The Director shall review a statement of extinguishment of a grandfathered right and a notice of intent to pledge extinguishment credits pursuant to the licensing time-frame provisions in R12-15-401.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3). Amended by final rulemaking at 13 A.A.R. 1394, effective October 1, 2007 (Supp. 07-2).

R12-15-724. Phoenix AMA Calculation of Groundwater Allowance and Extinguishment Credits

A. The Director shall calculate the groundwater allowance for a certificate or designation in the Phoenix AMA as follows:

1. If the application is for a certificate, multiply the applicable allocation factor in the table below by the annual estimated water demand for the proposed subdivision.

MANAGEMENT PERIOD	ALLOCATION FACTOR
Third	4
Fourth	2
Fifth	1
After Fifth	0

2. If the application is for a designation and the applicant provided water to its customers prior to February 7, 1995, multiply 7.5 by the total volume of water provided by the applicant to its customers from any source during calendar year 1994, consistent with the municipal conservation requirements established for the applicant pursuant to Section 5-103(A)(1) of the Second Management Plan for the Phoenix AMA.
3. If the application is for a designation and the applicant commenced providing water to its customers on or after February 7, 1995, the applicant's groundwater allowance is zero acre-feet.
4. For each calendar year of a designation, the Director shall calculate the volume of incidental recharge for a designated provider within the Phoenix AMA and add that volume to the designated provider's groundwater allowance. The Director shall calculate the volume of incidental recharge by multiplying the provider's total water use from any source in the previous calendar year by the standard incidental recharge factor of 4%. A designated provider may apply for a variance from the standard incidental recharge factor as provided in A.R.S. § 45-566.01(E)(1). The Director may establish a different incidental recharge factor for the designated provider if the provider demonstrates to the satisfaction of the Director that the ratio of the average annual amount of incidental recharge expected to be attributable to the provider during the management period, to the average amount of water expected to be withdrawn, diverted, or received for delivery by the provider for use within its service area during the management period, is different than 4%.

B. The Director shall calculate the extinguishment credits for the extinguishment of a grandfathered right in the Phoenix AMA as follows:

1. For the extinguishment of a type 2 non-irrigation grandfathered right, multiply the number of acre-feet indicated on the certificate by the difference between 2025 and the calendar year of extinguishment.
2. For the extinguishment of all or part of an irrigation grandfathered right, or all or part of a type 1 non-irrigation grandfathered right, multiply 1.5 acre-feet per acre by the number of irrigation acres associated with the extinguished irrigation grandfathered right or the number of acres to which the extinguished type 1 non-irrigation grandfathered right is appurtenant, and then multiply the product by the difference between 2025 and the calendar year of extinguishment, except that:
   a. If only a portion of an irrigation grandfathered right or a type 1 non-irrigation grandfathered right is extinguished, the Director shall include in the calculation only those acres associated with the portion of the right that is extinguished; and
   b. If an extinguished irrigation grandfathered right has a debit balance in the corresponding flexibility account established under A.R.S. § 45-467, the Director shall subtract the amount of the debit from the amount of the extinguishment.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-725. Pinal AMA - Groundwater Allowance and Extinguishment Credits Calculation

A. The Director shall calculate the groundwater allowance for a certificate or designation in the Pinal AMA as follows:

1. If the application is for a certificate, multiply the applicable allocation factor in the table below for the management period in effect on the date of application by the annual estimated water demand for the proposed subdivision.

.

MANAGEMENT PERIOD/DATE OF APPLICATION	ALLOCATION FACTOR
Third	10
Fourth	10
Fifth	5
After Fifth	0

2. If the application is for a designation:
   a. If the applicant was designated as having an assured water supply as of October 1, 2007:
      i. Multiply the applicant's service area population as of October 1, 2007 by 125 gallons per capita per day and multiply the product by 365 days. The service area population shall be determined using the methodology set forth in Section 5-103(D) of the Third Management Plan for the Pinal AMA.
      ii. Convert the number of gallons determined in subsection (A)(2)(a)(i) into acre-feet by dividing the number by 325,851 gallons.
      iii. Determine the number of residential lots within plats that were recorded as of October 1, 2007 but not served water as of that date, and to which the applicant commenced water service by January 1, 2010.
      iv. Multiply the number of lots determined in subsection (A)(2)(a)(iii) of this Section by 0.35 acre-foot per lot.
      v. Add the volume from subsection (A)(2)(a)(ii) of this Section and the volume from subsection (A)(2)(a)(iv) of this Section.
   b. If the applicant provided water to its customers before October 1, 2007 but was not designated as having an assured water supply as of that date, and a complete and correct application for designation is filed before January 1, 2012, multiply the applicant's service area population as of October 1, 2007 by 125 gallons per capita per day and multiply the product by 365 days. The service area population shall be determined using the methodology in Section 5-103(D) of the Third Management Plan for the Pinal AMA.
   c. If the applicant provided water to its customers before October 1, 2007 but was not designated as having an assured water supply as of that date, and a complete and correct application for designation is filed on or after January 1, 2012, the applicant's groundwater allowance is zero acre-feet.
   d. If the applicant commenced providing water to its customers on or after October 1, 2007, the applicant's groundwater allowance is zero acre-feet.
3. For each calendar year of a designation, the Director shall calculate the volume of incidental recharge for a designated provider within the Pinal AMA and add that volume to the designated provider's groundwater allowance. The Director shall calculate the volume of incidental recharge by multiplying the provider's total water use from any source in the previous calendar year by the standard incidental recharge factor of 4%. A designated provider may apply for a variance from the standard incidental recharge factor by submitting a hydrologic study demonstrating, to the satisfaction of the Director, that the ratio of the average annual amount of incidental recharge expected to be attributable to the designated provider during the management period to the average annual amount of water expected to be withdrawn, diverted or received for delivery by the designated provider for use within its service area during the management period is different than 4%. The hydrologic study shall include the amount of water withdrawn, diverted or received for delivery by the designated provider for use within its service area during each of the preceding five years and the amount of incidental recharge that was attributable to the designated provider during each of those years. The Director may establish a different incidental recharge factor for the designated provider upon such demonstration.

B. The Director shall calculate the extinguishment credits for the extinguishment of a grandfathered right in the Pinal AMA as follows:

1. For the extinguishment of a type 2 non-irrigation grandfathered right, multiply the number of acre-feet indicated on the certificate by the applicable allocation factor as determined under subsection (B)(3) or (B)(4) of this Section.
2. For the extinguishment of all or part of an irrigation grandfathered right, or all or part of a type 1 non-irrigation grandfathered right, an amount calculated by multiplying 1.5 acre-feet by the number of irrigation acres associated with the extinguished irrigation grandfathered right or the number of acres to which the extinguished type 1 non-irrigation grandfathered right is appurtenant, and then multiply that product by the applicable allocation factor as determined under subsection (B)(3) or (B)(4) of this Section, except that:
   a. If only a portion of an irrigation grandfathered right or a type 1 non-irrigation grandfathered right is extinguished, the Director shall include in the calculation only those acres associated with the portion of the right that is extinguished; and
   b. If an extinguished irrigation grandfathered right has a debit balance in the corresponding flexibility account established under A.R.S. § 45-467, the Director shall subtract the amount of the debit from the amount of the extinguishment credits.
3. Except as provided in subsection (B)(4) of this Section, in calculating the extinguishment credits for the extinguishment of a grandfathered right under subsection (B)(1) or (B)(2) of this Section, the Director shall use the allocation factor associated with the year in which the grandfathered right is extinguished, as shown in the table below.

	Allocation
Year	Factor
2007	100
2008	100
2009	100
2010	90
2011	88
2012	86
2013	84
2014	82
2015	80
2016	78
2017	76
2018	74
2019	72
2020	70
2021	68
2022	66
2023	64
2024	62
2025	60
2026	58
2027	56
2028	54
2029	52
2030	50
2031	48
2032	46
2033	44
2034	42
2035	40
2036	38
2037	36

2038	34
2039	32
2040	30
2041	28
2042	26
2043	24
2044	22
2045	20
2046	18
2047	16
2048	14
2049	12
2050	10
2051	8
2052	6
2053	4
2054	2
After 2054	0

4. If, before January 1, 2055, there is a moratorium on adding new member lands and member service areas in the Pinal AMA pursuant to A.R.S. § 45-576.06(A), in calculating the extinguishment credits for the extinguishment of a grandfathered right under subsection (B)(1) or (B)(2) of this Section, the Director shall use an allocation factor determined as follows:
   a. If the grandfathered right is extinguished while the moratorium is in effect, the Director shall use the allocation factor associated with the year in which the moratorium first became effective, as shown in the table in subsection (B)(3) of this Section.
   b. If the grandfathered right is extinguished when the moratorium is no longer in effect, the Director shall use the allocation factor associated with the year determined pursuant to this subsection, as shown in the table in subsection (B)(3) of this Section. The Director shall determine the year as follows:
      i. Subtract the year in which the moratorium first became effective from the year in which the moratorium ended.
      ii. Subtract the difference in subsection (B)(4)(b)(i) of this Section from the year in which the grandfathered right was extinguished.

Historical Note

Adopted effective February 7, 1995 (Supp. 95-1). Section repealed; new Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3). Section repealed; new Section made by final rulemaking at 13 A.A.R. 1394, effective October 1, 2007 (Supp. 07-2).

R12-15-726. Prescott AMA Calculation of Groundwater Allowance and Extinguishment Credits

A. The Director shall calculate the groundwater allowance for a certificate or designation in the Prescott AMA as follows:
1. If the application is for a certificate of assured water supply, the Director shall:
   a. Subtract the year of application from 2025,
   b. Multiply the number determined in subsection (A)(1)(a) by the applicant's annual estimated water demand, and
   c. Divide that product by two. The minimum volume that may be calculated in this subsection is zero acre-feet.
2. If the application is for a designation of assured water supply:
   a. Except as provided in subsections (A)(3) and (A)(5), if the applicant was in existence as of January 12, 1999, and the application is filed before calendar year 2026, the Director shall:
      i. Multiply by 100 the largest volume of groundwater determined by the Director to have been withdrawn by the applicant from within the Prescott AMA for use within the applicant's service area in any calendar year from 1995 through 1998, consistent with the municipal conservation requirements applicable under the second management plan for the Prescott active management area;
      ii. Determine the volume of the applicant's total water demand, from any source, for 1999, consistent with the municipal conservation requirements established for the applicant in the management plan in effect on the date of application;
      iii. Determine the volume of the applicant's total water demand, from any source, for 2014, consistent with the municipal conservation requirements established for the applicant in the management plan in effect on the date of application;
      iv. Subtract the volume calculated in subsection (A)(2)(a)(ii) from the volume calculated in subsection (A)(2)(a)(iii) and then multiply the difference by 26;
      v. Divide the product obtained in subsection (A)(2)(a)(iv) by two;
      vi. If any residential groundwater uses, including residential groundwater uses served by an exempt well, in existence on August 21, 1998, have been replaced by permanent water service from the applicant after August 21, 1998, multiply one-half acre-foot of groundwater by the number of housing units receiving the service and then multiply that product by 100;
      vii. Determine the volume of groundwater withdrawn by the applicant from within the Prescott active management area during the period beginning January 1, 1999, and ending December 31 of the calendar year before the date of the application;
      viii. Multiply the volume of groundwater withdrawn by the applicant from within the Prescott active management area in 1999 by the number of calendar years in the period beginning with 1999 and ending with the calendar year before the date of application;
      ix. Subtract from the volume calculated in subsection (A)(2)(a)(vii) the volume calculated in subsection (A)(2)(a)(viii). The volume calculated in this subsection shall not be less than zero; and
      x. Add the volumes calculated in subsections (A)(2)(a)(i), (A)(2)(a)(v), and (A)(2)(a)(vi), and then subtract from the sum the volume calculated in subsection (A)(2)(a)(ix).
   b. If the applicant did not exist as of January 12, 1999, or the date of application occurs after calendar year 2025, the groundwater allowance is zero acre-feet, except that if any residential groundwater uses, including residential groundwater uses served by an exempt well, in existence on August 21, 1998, have been replaced by permanent water service from the applicant after August 21, 1998, the groundwater allowance is a volume of groundwater computed by multiplying one-half acre-foot of groundwater by the number of housing units receiving the service and multiplying that product by 100.
3. For the purpose of determining the groundwater allowance under subsection (A)(2)(a), at the request of the applicant, the Director shall replace the volume of groundwater calculated in subsection (A)(2)(a)(ii) through (v) with the amount of groundwater necessary for the applicant to serve the residential lots described in subsection (A)(4):
   a. To compute this amount of groundwater, the Director shall:
      i. Determine the average dwelling occupancy within the applicant's service area and multiply that average occupancy by an amount of groundwater, calculated by multiplying 150 gallons per capita per day by 365 days; and
      ii. Multiply the product in subsection (A)(3)(a)(i) by the number of residential lots described in subsection (A)(4), and then multiply that product by 100.
   b. The Director shall not include the amount computed in subsection (A)(3)(a) within the amount of groundwater that the applicant may use under subsection (A)(2)(a) until a final plat for the lots has been recorded.
4. The Director shall include residential lots that will be served by the applicant in the calculation made under subsection (A)(3) if the lots meet all of the following criteria:
   a. A preliminary plat for the lots was submitted to the city, town, or county on or before August 21, 1998, and the final plat is subsequently recorded;
   b. The lots were not being served water on or before August 21, 1998; and
   c. Any one of the following applies:
      i. The lots were included within an application for certificate of assured water supply that was filed before August 21, 1998, the Director determined that the application was complete and correct as of August 21, 1998, and the Director subsequently issued a certificate of assured water supply for the lots.
      ii. A preliminary plat for the lots was approved by a city, town, or county on or before August 21, 1998. At the time the preliminary plat was approved, the subdivider of the lots obtained a written commitment of water service from a municipal provider that was designated as having an assured water supply and the provider demonstrated to the satisfaction of the Director that sufficient water is physically available to serve the lots under the criteria in R12-15-716.
5. For the purpose of determining the groundwater allowance under subsection (A)(2)(a), if the applicant makes the request described in subsection (A)(3), the Director shall replace the volume of groundwater calculated in subsection (A)(2)(a)(viii) with an amount of groundwater calculated as follows. The Director shall:
   a. Determine the number of calendar years in the period beginning with 1999 and ending with the calendar year before the date of application and multiply that number of years by the largest volume of groundwater determined by the Director to have been withdrawn by the applicant from within the Prescott active management area for use within the applicant's service area in any calendar year from 1995 through 1998, consistent with the municipal conservation requirements applicable under the second management plan for the Prescott active management area;
   b. Determine the average dwelling occupancy within the applicant's service area and multiply that average dwelling occupancy by an amount of groundwater calculated by multiplying 150 gallons per capita per day by 365 days;
   c. For each year in the period beginning with 1999 and ending with the calendar year before the date of application, determine the number of the residential lots that meet the criteria in subsection (A)(4) and were served water by the applicant as of July 1 of the relevant year and add the number of these residential lots determined for each year;
   d. Multiply the volume of groundwater calculated in subsection (A)(5)(b) by the number of residential lots in subsection (A)(5)(c); and
   e. Add the volumes of groundwater from subsections (A)(5)(a) and (A)(5)(d).

B. The Director shall calculate the extinguishment credits for extinguishing a grandfathered right in the Prescott AMA as follows:
1. For the extinguishment of a type 2 non-irrigation grandfathered right, multiply the number of acre-feet indicated on the certificate by the difference between 2025 and the calendar year of extinguishment.
2. For the extinguishment of an irrigation grandfathered right or a type 1 non-irrigation grandfathered right:
a. Through December 31, 2010:
i. If the irrigation acres associated with the extinguished right were irrigated for at least four of the six calendar years preceding January 1, 2000, multiply 1.5 acre-feet per acre by the number of irrigation acres associated with the extinguished right or the number of acres to which the extinguished right is appurtenant and multiply that product by 25.
ii. If the irrigation acres associated with the extinguished right were not irrigated for at least four of the six calendar years preceding January 1, 2000, multiply 1.5 acre-feet per acre by the number of irrigation acres associated with the extinguished right or the number of acres to which the extinguished right is appurtenant and multiply the product by the difference between 2025 and the year in which the statement of intent to extinguish is filed.
b. After December 31, 2010, multiply 1.5 acre-feet per acre by the number of irrigation acres associated with the extinguished right or the number of acres to which the extinguished right is appurtenant and multiply the product by the difference between 2025 and the year in which the statement of intent to extinguish is filed.

Historical Note
New Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-727. Tucson AMA Calculation of Groundwater Allowance and Extinguishment Credits
A. The Director shall calculate the groundwater allowance for a certificate or designation in the Tucson AMA as follows:
1. If the application is for a certificate, multiply the applicable allocation factor in the table below by the annual estimated water demand for the proposed subdivision.

MANAGEMENT PERIOD	ALLOCATION FACTOR
Third	8
Fourth	4
Fifth	2
After Fifth	0

2. If the application is for a designation and the applicant provided water to its customers before February 7, 1995, multiply 15 by the total volume of water provided by the applicant to its customers from any source during calendar year 1994, consistent with the municipal conservation requirements established for the applicant pursuant to Section 5-103(A)(1) of the Second Management Plan for the Tucson AMA.
3. If the application is for a designation and the applicant commenced providing water to its customers on or after February 7, 1995, the applicant's groundwater allowance is zero acre-feet.
4. For each calendar year of the designation, the Director shall calculate the volume of incidental recharge for a designated provider within the Tucson AMA and add that volume to the designated provider's groundwater allowance. The Director shall calculate the volume of incidental recharge by multiplying the provider's total water use from any source in the previous calendar year by the standard incidental recharge factor of 4%. A designated provider may apply for a variance from the standard incidental recharge factor as provided in A.R.S. § 45-566.01(E)(1). The Director may establish a different incidental recharge factor for the designated provider if the provider demonstrates to the satisfaction of the Director that the ratio of the average annual amount of incidental recharge expected to be attributable to the provider during the management period, to the average amount of water expected to be withdrawn, diverted, or received for delivery by the provider for use within its service area during the management period, is different than 4%.

B. The Director shall calculate the extinguishment credits for the extinguishment of a grandfathered right in the Tucson AMA as follows:
1. For the extinguishment of a type 2 non-irrigation grandfathered right, multiply the number of acre-feet indicated on the certificate by the difference between 2025 and the calendar year of extinguishment.
2. For the extinguishment of all or part of an irrigation grandfathered right, or all or part of a type 1 non-irrigation grandfathered right, multiply 1.5 acre-feet per acre by the number of irrigation acres associated with the extinguished irrigation grandfathered right or the number of acres to which the extinguished type 1 non-irrigation grandfathered right is appurtenant, and then multiply the product by the difference between 2025 and the calendar year of extinguishment, except that:
a. If only a portion of an irrigation grandfathered right or a type 1 non-irrigation grandfathered right is extinguished, the Director shall include in the calculation only those acres associated with the portion of the right that is extinguished; and
b. If an extinguished irrigation grandfathered right has a debit balance in the corresponding flexibility account established under A.R.S. § 45-467, the Director shall subtract the amount of the debit from the amount of the extinguishment.

Historical Note
New Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-728. Reserved

R12-15-729. Remedial Groundwater; Consistency with Management Goal
A. Use of remedial groundwater by a municipal provider before January 1, 2025, is deemed consistent with the management goal of the AMA in which the remedial groundwater is withdrawn and is excluded when determining compliance with management goal requirements in this Article if all of the following apply:
1. The Director determines that the remedial groundwater use is consistent with the management goal under subsection (F) or (H) of this Section or the remedial groundwater use is consistent with the management goal under subsection (J) of this Section; and
2. The municipal provider complies with the metering and reporting requirements in subsection (K) of this Section.

B. A municipal provider that is using remedial groundwater or that has agreed in a consent decree or other document approved by ADEQ or the EPA to use remedial groundwater may apply to the Director for a determination that the municipal provider's use of the remedial groundwater is consistent with the management goal of the active management area by submitting an application on a form provided by the Director with the information required in subsection (D) of this Section before January 1, 2010.

C. A municipal provider filing an application under subsection (B) of this Section for remedial groundwater use associated with a treatment plant in operation before June 15, 1999, may request an increase in the project's annual authorized volume at the time the application is filed. The Director shall grant the request and increase the annual authorized volume up to the maximum treatment capacity of the treatment plant if the municipal provider submits evidence that an increase in the annual authorized volume is necessary to further the purpose of the remedial action project and that the increase is not in violation of the consent decree or other document approved by ADEQ or the EPA for the remedial action project.

D. An applicant shall provide the following with an application submitted under subsection (B) of this Section:
1. A document evidencing ADEQ's or EPA's approval of the municipal provider's withdrawal and use of remedial groundwater, such as a remedial action plan, record of decision, or consent decree;
2. The volume of remedial groundwater that will be withdrawn and used annually by the municipal provider and the purpose for which the remedial groundwater will be used;
3. The time period during which the remedial groundwater will be withdrawn and used by the municipal provider;
4. A reference to the annual authorized volume provided in the document submitted pursuant to subsection (D)(1) of this Section or, if the document submitted pursuant to subsection (D)(1) does not specify the annual authorized volume for the project, the annual authorized volume claimed by the municipal provider and a written justification for that volume;
5. If the approved remedial action project is currently operating, the volume of remedial groundwater withdrawn pursuant to the project for each year before the year in which the application is filed;
6. The designated provider or certificate to which the remedial groundwater will be pledged;
7. If the municipal provider is requesting an increase in the annual authorized volume of the project pursuant to subsection (C) of this Section, evidence that the increase is necessary to further the purpose of the remedial action project and that the increase is not in violation of the consent decree or other document approved by ADEQ or the EPA for the project;
8. The name and telephone number of a person the Department may contact regarding the application; and
9. Any other information reasonably required to assist the Director in making the determination under subsection (F) of this Section.

E. After receiving an application under subsection (B) of this Section, the Director shall determine that the application is complete and correct if it contains all the information required in subsection (D) of this Section and the Director verifies that the information is accurate. If the Director determines that the application is complete and correct, the Director shall assign a priority date to the application according to the following:
1. If the Director determines that the application was complete and correct when filed, the priority date of the application is the date the application was filed.
2. If the Director determines that the application was not complete or correct when filed because of minor deficiencies, the Director shall notify the applicant of the deficiencies in writing and give the applicant 30 days to correct the deficiencies. If the applicant submits the necessary information to correct the deficiencies within 30 days after the date of the notice, the priority date of the application is the date the application was filed.
3. If the Director determines that the application was not complete or correct when filed and that the deficiencies are not minor, the Director shall notify the applicant of the deficiencies and give the applicant at least 60 days to submit the necessary information to correct the deficiencies. If the applicant submits the necessary information to correct the deficiencies within the time allowed by the Director, the priority date of the application is the date the applicant submits the necessary information to correct the deficiencies.

F. The Director shall approve a complete and correct application filed under subsection (B) of this Section if the Director determines that the applicant will use remedial groundwater before January 1, 2025. If the Director approves a municipal provider's application, the Director shall calculate the annual amount of remedial groundwater use that is deemed consistent with the management goal of the AMA as follows:
1. The Director shall determine the total annual amount of remedial groundwater use in all AMAs that is deemed to be consistent with the management goal under this subsection and subsections (H) and (I) of this Section for applications with a priority date earlier than the priority date of the municipal provider's application.
2. If the amount determined in subsection (F)(1) of this Section is less than 65,000 acre-feet and the difference between those amounts is equal to or greater than the municipal provider's authorized remedial groundwater use during the year, the amount of remedial groundwater use by the municipal provider that is deemed to be consistent with the management goal during the year is the amount of the municipal provider's authorized remedial groundwater use during the year.
3. If the amount determined in subsection (F)(1) of this Section is less than 65,000 acre-feet and the difference between those amounts is less than the municipal provider's authorized remedial groundwater use during the year, the amount of remedial groundwater use by the municipal provider that is deemed consistent with the management goal during the year is the amount of the municipal provider's authorized remedial groundwater use during the year up to the difference between the amount determined in subsection (F)(1) and 65,000 acre-feet, plus a percentage of the municipal provider's authorized remedial groundwater use during the year that exceeds the difference. The percentage is 50 percent for calendar years 2000 through 2009, 25 percent for calendar years 2010 through 2019, and 10 percent for calendar years 2020 through 2024.

4. If the amount determined in subsection (F)(1) of this Section is equal to or greater than 65,000 acre-feet, the amount of remedial groundwater use by the municipal provider that is deemed consistent with the management goal during the year is a percentage of the municipal provider's authorized remedial groundwater use during the year. The percentage is 50 percent for calendar years 2000 through 2009, 25 percent for calendar years 2010 through 2019, and 10 percent for calendar years 2020 through 2024.

G. If the Director determines that remedial groundwater use by a municipal provider is consistent with the management goal of the active management area under subsection (F) of this Section, the determination shall apply to remedial groundwater used by the municipal provider between the priority date of the application and January 1, 2025.

H. If, before the effective date of this Section, a municipal provider filed an application with the Director requesting that the Director determine that the provider's use of remedial groundwater pursuant to an approved remedial action project is consistent with the management goal of the active management area under Laws 1997, Ch. 287, § 52, as amended by Laws 1999, Ch. 295, § 50, the following shall apply:

1. If the Director approved the application before the effective date of this Section and determined the annual amount of remedial groundwater use by the applicant that will be considered consistent with the management goal, the Director's determination shall apply after the effective date of this Section and the Director shall include the annual amount of remedial groundwater use determined by the Director to be consistent with the management goal in the total amount of remedial groundwater determined in subsection (F)(1) of this Section.
2. If the Director did not approve the application before the effective date of this Section, the Director shall process the application under subsections (E) and (F) of this Section. If the Director approves the application, the Director's determination shall apply to remedial groundwater withdrawn and used by the municipal provider pursuant to the approved remedial action project from the priority date of the application until January 1, 2025.

I. A municipal provider that is using remedial groundwater that has been determined by the Director to be consistent with the management goal under subsection (F) or (H) of this Section may apply to the Director for an increase in the annual authorized volume of the approved remedial action project as follows:

1. The applicant shall submit an application on a form provided by the Director.
2. The Director shall determine that the application is complete and correct if it contains all of the required information and the Director verifies that the information is accurate.
3. If the Director determines that an application filed under this subsection is complete and correct, the Director shall assign a priority date to the application using the criteria in subsection (E) of this Section.
4. The Director shall approve the application if the municipal provider submits information that demonstrates one of the following:
   a. The annual authorized volume of the approved remedial action project has been increased in a consent decree or other document approved by ADEQ or the EPA; or
   b. An increase is necessary to further the purpose of the approved remedial action project, and the increase is not in violation of the consent decree or other document approved by ADEQ or the EPA for the project.
5. If the Director approves the application, the Director shall determine the additional annual amount of remedial groundwater use by the municipal provider that is deemed consistent with the management goal of the active management area, using the criteria in subsections (F) and (G) of this Section. The Director shall include the annual amount of remedial groundwater use determined by the Director to be consistent with the management goal under this subsection in the total amount of remedial groundwater determined in subsection (F)(1) of this Section.

J. Until January 1, 2025, use of remedial groundwater by a municipal provider during a year is deemed consistent with the management goal of the AMA in which the remedial groundwater was withdrawn without approval of the Director under subsection (F) or (H) of this Section if:

1. The total annual amount of remedial groundwater withdrawn from all wells pursuant to the approved remedial action project does not exceed 250 acre-feet; and
2. If remedial groundwater withdrawals pursuant to the approved remedial action project commenced before June 15, 1999, the municipal provider notified the Director in writing of the volume and duration of the anticipated withdrawals on or before August 15, 1999. If remedial groundwater withdrawals pursuant to the approved remedial action project commenced on or after June 15, 1999, the municipal provider gave written notice of the volume and duration of the anticipated withdrawals on or before August 15, 1999, or before the date the withdrawals commenced, whichever is later. If the municipal provider gives notice after the effective date of this Section, the municipal provider shall include or attach all of the following:
   a. A copy of a document evidencing ADEQ's or EPA's approval of the municipal provider's withdrawal and use of remedial groundwater, such as a remedial action plan, record of decision, or consent decree;
   b. The volume of remedial groundwater that will be withdrawn and used annually by the municipal provider and the purpose for which the remedial groundwater will be used;
   c. The time period during which the remedial groundwater will be withdrawn and used by the municipal provider;
   d. If the approved remedial action project is currently operating, the volume of remedial groundwater withdrawn pursuant to the project for each year before the year in which the application is filed;
   e. The designated provider or certificate of assured water supply to which the remedial groundwater will be pledged; and
   f. The name and telephone number of a person the Department may contact regarding the exemption.

K. A municipal provider withdrawing remedial groundwater that has been determined to be consistent with the management goal under subsection (F) or (H) of this Section or that is consistent with the management goal under subsection (J) of this Section shall meter the remedial groundwater withdrawals separately from groundwater withdrawn pursuant to another groundwater withdrawal authority. The municipal provider shall include in its annual reports, filed under A.R.S. § 45-632, the amount of remedial groundwater withdrawn during the reporting year that is consistent with the management goal under this Section and the purposes for which the remedial groundwater was used.

Historical Note

New Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

R12-15-730. Assured and Adequate Water Supply Fees

A. With respect to an application listed in subsection (B) of this Section, the Director shall accept or take action on the application only upon payment of the applicable fee as listed.

B. An applicant shall pay the following fees, as applicable:

APPLICATION	FEE ($)
1. Certificate	3000.00 for the first 20 lots; 3.00 for each additional lot; maximum 5000.00
2. Assignment of certificate issued after effective date of this Section	None
3. Reissuance of certificate issued after effective date of this Section, pursuant to R12-15-704(G)	None
4. Assignment of certificate issued before effective date of this Section, with or without request for classification as Type A certificate	250.00 for the first 20 lots; 0.50 for each additional lot; maximum 1000.00
5. Reissuance of certificate issued before effective date of this Section, pursuant to R12-15-704(G)	250.00 for the first 20 lots; 0.50 for each additional lot; maximum 1000.00
6. Classification as Type A, for certificate issued before the effective date of this Section (not included in assignment application)	250.00 for the first 20 lots; 0.50 for each additional lot; maximum 1000.00
7. Material plat change review	250.00
8. Designation or modification of designation that includes evaluation of physical, legal, and continuous availability or consistency with management goal	1000.00 for the first 1000 acre-feet; 0.50 for each additional acre-foot; maximum 10,000.00
9. Modification of designation that does not include evaluation of physical, legal, and continuous availability or consistency with management goal	500.00
10. Water report	900.00 for the first 20 lots; 2.00 for each additional lot; maximum 2000.00
11. Analysis	7500.00
12. Physical availability determination	5000.00

Historical Note

New Section made by final rulemaking at 12 A.A.R. 3475, effective September 12, 2006 (Supp. 06-3).

ARTICLE 8. WELL CONSTRUCTION AND LICENSING OF WELL DRILLERS

R12-15-801. Definitions

In addition to the definitions set forth in A.R.S. §§ 45-101, 45-402, and 45-591 and in R12-15-202, the following words and phrases in this Article shall have the following meanings, unless the context otherwise requires:

1. "Annular space" means the space between the outer well casing and the borehole wall. An annular space also means the space between an inner well casing and outer well casing.
2. "Aquifer" means an underground formation capable of yielding or transmitting usable quantities of water.
3. "Artesian aquifer" means an aquifer which is overlain by a confining formation and which contains groundwater under sufficient pressure for the water to rise above the top of the aquifer.
4. "Artesian well" means a well that penetrates an artesian aquifer.
5. "Bentonite" means a colloidal clay composed mainly of sodium montmorillonite, a hydrated aluminum silicate.
6. "Cap" means a tamper-resistant, watertight steel plate of at least one-quarter inch thickness on the top of all inside and outside casings of a well.
7. "Casing" means the tubing or pipe installed in the borehole during or after drilling to support the sides of the well and prevent caving.
8. "Confining formation" means the relatively impermeable geologic unit immediately overlying an artesian aquifer.
9. "Consolidated formation" means a naturally occurring geologic unit through or into which a well is drilled, having a composition, density, and thickness which will provide a natural hydrologic barrier.
10. "Department" means the Arizona Department of Water Resources.
11. "Director" means the Director of the Arizona Department of Water Resources.
12. "Drilling card" means a card which is issued by the Director to the well drilling contractor or single well licensee designated in the notice of intent or permit, authorizing the well drilling

contractor or licensee to drill the specific well or wells in the specific location as noticed or permitted.
13. "Exploration well" means a well drilled in search of geophysical, mineralogical or geotechnical data.
14. "Flowing artesian well" means an artesian well in which the pressure is sufficient to cause the water to rise above the land surface.
15. "Grout" or "cement grout" means cement mixed with no more than 50% sand by volume, and containing no more than six gallons of water per 94 pound sack of cement.
16. "Mineralized water" means any groundwater containing over 3000 milligrams per liter (mg/l) of total dissolved solids or containing any of the following chemical constituents above the indicated concentrations:
Constituent Concentration (mg/l)
Arsenic 0.05
Barium 1.0
Cadmium 0.01
Chromium (total) 0.05
Fluoride 4.0
Lead 0.05
Mercury 0.002
Nitrate (as N) 10.0
Selenium 0.01
Silver 0.05
17. "Monitor well" means a well designed and drilled for the purpose of monitoring water quality within a specific depth interval.
18. "Open well" means a well which is not equipped with either a cap or a pump.
19. "Perforations" means a series of openings in a casing, made either before or after installation of the casing, to permit the entrance of water into the well.
20. "Piezometer well" means a well that is designed and drilled for the purpose of monitoring water levels within a specific depth interval.
21 "Pitless adaptor" means a commercially manufactured watertight unit or device designed for attachment to a steel well casing which permits discharge from the well below the land surface and allows access into the well casing while preventing contaminants from entering the well.
22. "Polluted water" means water whose chemical, physical, biological, or radiological integrity has been degraded through the artificial or natural infusion of chemicals, radionuclides, heat, biological organisms, or mineralogical or other extraneous matter.
23. "Pressure grouting" means a process by which a grout is confined within the borehole or casing of a well by the use of retaining plugs, packers, or a displacing fluid by which sufficient pressure is applied to drive the grout into and within the annular space or interval to be grouted.
24. "Qualifying party" means a partner, officer, or employee of a well drilling contractor, who has significant supervisory responsibilities and who has been designated to take the licensing examination for that well drilling contractor.
25. "Single well license" means a license issued to a person which allows the drilling or modification of a single exempt well on land owned by that person.
26 "Vadose zone well" means a well constructed in the interval between the land surface and the top of the static water level.
27. "Vault" means a tamper-resistant watertight structure used to complete a well below the land surface.
28. "Well abandonment" means the modification of the structure of a well by filling or sealing the borehole so that water may not be withdrawn or obtained from the well.
29. "Well drilling" means the construction or repair of a well, or the modification, except for abandonment, of a well, regardless of whether compensation is involved, including any deepening or additional perforating, any addition of casing or change to existing casing construction, and any other change in well construction not normally associated with well maintenance, pump replacement, or pump repair.
30. "Well drilling contractor" means an individual, public or private corporation, partnership, firm, association, or any other public or private organization or enterprise that holds a well driller's license pursuant to A.R.S. § 45-595(B).

Historical Note
Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2).

R12-15-802. Scope of Article
This Article shall apply to man-made openings in the earth through which water may be withdrawn or obtained from beneath the surface of the earth, including all water wells, monitor wells and piezometer wells. It shall also apply to geothermal wells to the extent provided by A.R.S. § 45-591.01, and all exploration wells and grounding or cathodic protection holes greater than 100 feet in depth. However, this Article shall not apply to the following:
1. Man-made openings in the earth not commonly considered to be wells, such as construction and mining blast holes, underground mines and mine shafts, open pit mines, tunnels, septic tank systems, caissons, basements, and natural gas storage cavities.
2. Injection wells and vadose zone wells which are subject to regulation by the Arizona Department of Environmental Quality.
3. Oil, gas, and helium wells drilled pursuant to the provisions of A.R.S. Title 27.
4. Drilled boreholes in the earth less than 100 feet in depth which are made for purposes other than withdrawing or encountering groundwater, such as exploration wells and grounding or cathodic protection holes; except that in the event that groundwater is encountered in the drilling of a borehole, this Article shall apply.

Historical Note
Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2).

R12-15-803. Well Drilling and Abandonment Requirements; Licensing and Supervision Requirements
A. A person shall not drill or abandon a well, or cause a well to be drilled or abandoned, in a manner which is not in compliance with A.R.S. Title 45, Chapter 2, Article 10, and the rules adopted thereunder.
B. A person, other than a single well licensee or a bona fide employee of a well drilling contractor, shall not engage in well drilling or abandonment without first securing a well drilling license in accordance with R12-15-804, R12-15-805 and R12-15-806.
C. A qualifying party of a well drilling contractor shall provide direct and personal supervision of the contractor's employees to ensure that all wells are constructed and abandoned in accordance with this Article.

Historical Note
Adopted effective March 5, 1984 (Supp. 84-2). Section 12-15-803 amended and the text of former Section R12-15-804 renumbered to subsections (B) and (C) and amended effective June 18, 1990 (Supp. 90-2).

R12-15-804. Application for well drilling license
A. An applicant for a well drilling license shall submit a verified application of a form prescribed and furnished by the Director which contains the following information:
1. A designation of the classification of license sought by the applicant.
2. If the applicant is an individual, the individual's name, address and telephone number.
3. If the applicant is a partnership, the names, addresses, and telephone numbers of all partners, with a designation of any limited partners.
4. If the applicant is a corporation, association or other organization, the names, addresses and telephone numbers of the directors and of the president, vice president, secretary and treasurer, or the names, addresses and telephone numbers of the functional equivalent of such officers.
5. The address or location of the applicant's place of business, the mailing address if it is different from the applicant's place of business, and if applicant is a corporation, the state in which it is incorporated.
6. The name, address and telephone number of each qualifying party, the qualifying party's relationship to the applicant, and a detailed history of each qualifying party's supervisory responsibilities and well drilling experience, including previous employers, job descriptions, duties and types of equipment utilized.
7. The names, addresses and telephone numbers of three persons not members of each qualifying party's immediate family, who can attest to each qualifying party's good character and reputation, experience in well drilling, and qualifications for licensing.
8. Such additional information relevant to the applicant's or qualifying party's experience and qualifications in well drilling as the Director may require.
B. An applicant shall notify the Director in writing of any change in the information contained in the application within 30 days after such change.
C. The Director shall not issue a license under this Article if the applicant or a qualifying party lacks good character and reputation.
D. Prior to the issuance of a license, a qualifying party shall demonstrate three years of experience, dealing specifically with the type of drilling for which the applicant is applying for a license. This experience requirement may be reduced if the Director finds that the qualifying party has clearly and convincingly demonstrated a high degree of understanding and knowledge of well drilling techniques for the type of drilling for which the applicant is applying for a license. In no case, however, shall the practical experience requirement be less than two years.

Historical Note
Adopted effective March 5, 1984 (Supp. 84-2). Former Section R12-15-804 renumbered to R12-15-803(B) and (C), new Section R12-15-804 adopted effective June 18, 1990 (Supp. 90-2).

R12-15-805. Examination for Well Drilling License
A. The Director shall offer an examination for a well drilling license no less than six times yearly. The examination shall be administered to those eligible applicants whose applications were submitted at least 20 days prior to the date of the examination. The examination shall consist of a section on legal requirements, a section on general knowledge and one or more of six specialized sections. The section on legal requirements shall test the qualifying party's knowledge of A.R.S. Title 45, Chapter 2, Article 10, and the rules adopted thereunder. The section on general knowledge shall test the qualifying party's knowledge of general hydrologic concepts, principles, and practices in the well construction industry, and shall test knowledge of groundwater protection, pollution, water quality and public health effects. The specialized sections shall test the qualifying party's knowledge in the following classifications:
1. Cable tool drilling in rock and unconsolidated material.
2. Air rotary drilling in rock and unconsolidated material.
3. Mud rotary drilling in rock and unconsolidated material.
4. Reverse rotary drilling in rock and unconsolidated material.
5. Jetting and driving wells in unconsolidated material.
6. Boring and augering in unconsolidated material.
B. Only the qualifying party, department personnel, and persons having the express permission of the Director shall be permitted in the examination room while the examination is in progress.

The qualifying party shall not bring books or notes into the examination room, or communicate by any means whatsoever while the examination is in progress without the express permission of the presiding examiner. The qualifying party shall not leave the examination room while the examination is in progress without first obtaining the permission of the presiding examiner. The Director may disqualify an applicant for violation of this subsection.

C. To obtain a well drilling license, a qualifying party of the applicant shall pass the section on legal requirements, the section on general knowledge, and one or more specialized sections. Each section of the examination shall be graded separately. The passing grade on each section shall be 70 percent.

D. No person may take the examination more than twice during any 12 months.

E. The Director may exempt a qualifying party from taking the section on general knowledge, and one or more of the specialized sections, if the qualifying party provides proof of passing an equivalent examination given by the National Ground Water Association.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Section repealed, new Section adopted effective June 18, 1990 (Supp. 90-2). Amended by final rulemaking at 13 A.A.R. 3022, effective October 6, 2007 (Supp. 07-3).

R12-15-806. License Fee; Issuance and Term of Licenses; Renewal; Display of License

A. The fee for a well driller's license shall be fifty dollars. No additional fee shall be charged for amendments to licenses pursuant to subsection (B).

B. Upon submittal of the license fee and satisfactory completion of an examination, the Director shall issue the applicant a well drilling license. The license shall be numbered and shall state the specialized classifications of drilling activities for which the applicant is qualified and licensed. The applicant shall be licensed in only those classifications for which the qualifying party has passed the specialized sections of the examination. If the qualifying party subsequently passes other specialized sections, the applicant's license shall be amended.

C. A well drilling contractor shall notify the Director in writing within 30 days of the date on which the well drilling contractor no longer has a qualifying party for one or more of its specialized drilling classifications. Upon such notification, the Director may revoke or suspend part or all of the well drilling license of the well drilling contractor and require a new qualifying party to take and pass the examination.

D. A well drilling license shall expire each year on June 30th, unless renewed pursuant to subsection (E).

E. A person may renew a well drilling license by submitting an application for renewal on forms prescribed and furnished by the Director. The renewal fee shall be ten dollars. If the application and renewal fee are postmarked on or before June 30, the well drilling contractor may operate as a licensee until actual issuance of the renewal license. A license which has expired may be reactivated and renewed within one year of its expiration by filing the required application and 20 dollars. If a license has been expired for one or more years for failure to renew, the well drilling contractor shall apply for a new license and repeat the examination.

F. A well drilling contractor shall prominently display the well drilling license number on all well drilling rigs owned or operated by the contractor in this state. Good quality paint or commercial decal numbers shall be used in placing each identification number on the drilling rig. The license number shall not be inscribed in crayon, chalk, pencil, or other temporary markings.

Historical Note

Adopted effective March 5. 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2).

R12-15-807. Single Well License

A. An applicant for a single well license pursuant to A.R.S. § 45-595(D) shall submit a verified application on forms prescribed and furnished by the Director, which shall include:

1. The name and address of the applicant.
2. The location of the well and whether the applicant owns the land.
3. The type of drill rig to be used and the owner of the rig.
4. The proposed design of the well or method of abandonment.
5. The names of any people who will be assisting the applicant in the drilling or abandonment of the well, and whether the applicant will compensate them for their efforts.
6. The applicant's experience, if any, in well drilling or abandonment.
7. Such other information as the Director may require relevant to the applicant's experience and qualifications in well drilling or abandonment.

B. The Director shall offer the single well examination no less than six times yearly and shall administer the examination to those eligible applicants whose applications were submitted at least 20 days prior to the date of the examination.

C. The single well examination shall be of a form prescribed and furnished by the Director and shall test the applicant's knowledge of abandonment techniques, or those minimum well construction requirements and drilling techniques applicable to the proposed design of the well. The passing grade on the sections of the examination dealing with construction requirements and drilling techniques, respectively, shall be 70 percent.

D. Rule R12-15-805 relating to testing procedures shall be fully applicable.

E. Applicants who twice fail the examination shall wait a minimum of 90 days before re-testing.

F. Upon passing the examination, the applicant shall be issued a single well license, authorizing the applicant to drill or abandon one exempt well at the location specified in the application. The license shall be valid for a period of one year from issuance.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2).

R12-15-808. Revocation of License

The Director may revoke, suspend, or place on probationary status a well drilling license issued pursuant to R12-15-806, or a single well license, for good cause, including:

1. Intentionally making a misstatement of fact on any filing with the Department.
2. Violating any provision of A.R.S. Title 45, Chapter 2, Article 10, and the rules promulgated thereunder, or aiding and abetting in such a violation.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2). Section number corrected (Supp. 93-1).

R12-15-809. Notice of Intention to Drill

A notice of intention to drill required to be filed pursuant to A.R.S. § 45-596 shall be signed by the owner or lessee of the property upon which the well is to be drilled.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2).

R12-15-810. Authorization to Drill

A. A well drilling contractor or single well licensee may commence drilling a well only if the well drilling contractor or licensee has possession of a drilling card at the well site issued by the Director in the name of the well drilling contractor or licensee, authorizing the drilling of the specific well in the specific location.

B. In extraordinary situations not requiring a permit but only a notice of intention to drill, the Director may grant a request by telephone for emergency authorization of commencement of drilling prior to the actual receipt by the well driller of the drilling card. Within seventy-two hours after such a request is granted, the well driller shall file a written statement indicating the nature and reasons for the request, and the date, time and Department employee granting the request, and the well owner shall file a notice of intent to drill if such a notice has not previously been filed.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2). Amended to correct typographical error under A.A.C. R1-1-109 (Supp. 01-2). Amended by final rulemaking at 13 A.A.R. 3022, effective October 6, 2007 (Supp. 07-3).

R12-15-811. Minimum Well Construction Requirements

A. Well casing

1. Casing shall be of a sufficient strength and wall thickness to hold the borehole open and survive any necessary grouting. A person shall use only steel or thermoplastic casing in the construction of a well, unless the person has received a variance from the Director pursuant to R12-15-820. The well casing or an extension of the casing shall extend a minimum of one foot above ground level. When installing a pitless adaptor, the casing may be terminated below ground level for aesthetic reasons or freeze protection purposes. Casing made of, or which has been exposed to, hazardous or potentially harmful materials, such as asbestos, shall not be used.
2. All well casing joints or overlaps shall be made watertight to prevent the degradation of the water supply by the migration of inferior quality water. Except as provided in subsection (H) of this rule, any openings in the casing that will be above the water level in the well, such as bar holes, cracks or perforations, shall be completely plugged or sealed.
3. Thermoplastic casing shall be installed only in an over sized drillhole without driving. Thermoplastic casing shall conform with American Society for Testing and Materials Standard Specification F480-89 (1989), which is incorporated herein by reference and is on file with the Office of the Secretary of State. Rivets or screws used in the casing joints shall not penetrate the inside of the casing.
4. Steel casing shall be new or in like-new condition, free from pits or breaks, and shall conform with American Society for Testing and Materials Standard Specification A53-89a (1989), A139-89b (1989) or A312/A312M-89a (1989), whichever is applicable, all of which are incorporated herein by reference and are on file with the Office of the Secretary of State.
5. Copies of The American Society for Testing and Materials standard specifications referred to in subsections (3) and (4) above may be obtained with these rules at the Office of the Secretary of State of the State of Arizona, State Capitol, West Wing, Phoenix, Arizona 85007; from the Department of Water Resources, 3550 N. Central Avenue, Phoenix, AZ 85012; and from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. This rule does not include any later amendments or editions of those standard specifications.

B. Surface seal

1. Except as provided in subsections (2) and (4) of this subsection, and R12-15-817(B)(1), all wells shall be constructed with a surface seal as herein provided. The seal shall consist of steel casing, one foot of which shall extend above ground level, and cement grout placed in one continuous application from the bottom of the zone to be grouted to the land surface. If a pitless adaptor is utilized, the cement grout may terminate at the bottom of the pitless adaptor. The minimum length of the steel casing shall be 20 feet. The minimum annular space between the casing and the borehole for placement of grout shall be one and one-half inches. Curing additives, such as calcium chloride, shall not exceed ten percent of the total volume of grout. Bentonite as an additive shall not exceed five percent of the total volume. The minimum length of the surface seal shall be 20 feet. Any annular space between the outer casing and an inner casing shall be completely sealed to prevent contamination of the well.
2. All hand-dug wells shall be constructed with a watertight curbing extending, at a minimum, from one foot above the natural ground level to the static water level, or into the confining formation if the aquifer is artesian. The curbing shall consist of poured cement grout or casing surrounded by cement grout. Concrete block with cement grout and rock with cement

grout may also be used. The poured cement grout shall not be less than six inches thick. If casing is to be used, the minimum annular space between the casing and the borehole shall be three inches. Hand-dug wells shall be sealed at the surface with a watertight, tamper-resistant cover to prevent contaminants from entering the well.

3. All wells constructed by jetting or driving shall have cement grout placed in the annular space to a minimum depth of six feet. The minimum annular space between the casing and the borehole for placement of the grout shall be one and one-half inches.
4. All horizontal wells, to prevent leakage, shall be constructed with a surface seal consisting of steel casing and cement grout extending a minimum of ten feet into the land surface.

C. Access port. Every well with casing four inches in diameter or larger shall be equipped with a functional watertight access port with a minimum diameter of one-half inch so that the water level or pressure head in the well can be monitored at all times.

D. Gravel packed wells

1. If a gravel pack has been installed, the annular space between the outer casing and the inner casing shall be sealed, either by welding a cap at the top or by filling with cement grout from the bottom of the outer casing to the surface.
2. If a gravel tube is installed, it shall be sealed with a cap.

E. Vents. All vents installed in the well casing shall open downward and be screened to prevent the entrance of foreign material.

F. Removal of drilling materials

1. In constructing a water well, the well driller shall take all reasonable precautions to protect the producing aquifer from contamination by drilling materials. Upon completion of the well, the well driller shall remove all foreign substances and materials introduced into the aquifer or aquifers during well construction. For purposes of this subsection, "substances and materials" means all drilling fluids, filter cake, lost circulation materials, and any other organic or inorganic substances.
2. Materials known to present a health hazard, such as chrome-based mud thinners, asbestos products, and petroleum-based fluids, shall not be used as construction, seal or fill materials or drilling fluids.
3. Drilling fluids and cuttings shall be contained in a manner which prevents discharge into any surface water.

G. Repair of existing wells

1. If, in the repair of a well, the old casing is withdrawn, the well shall be recased in conformance with these rules.
2. If an inner casing is installed to prevent leakage of undesirable water into a well, the annular space between the casings shall be completely sealed by packers, casing swedging, pressure grouting or other methods which will prevent the movement of water between the casings.

H. Monitor wells

1. A monitor well may be screened up to ten feet above the highest seasonal static water level of record for the purpose of monitoring contaminants.
2. A monitor well shall be identified as such on the vault cover or at the top of the steel casing. Identification information shall include the well registration number.

I. Completion at the surface. In areas of traffic or public rights-of-way, wells may be constructed below the land surface in a vault. All other requirements in this Article shall apply.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2). The reference to R12-14-817(B)(1) in subsection (B)(1) corrected to read R12-15-817(B)(1) (Supp. 93-1). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-812. Special Aquifer Conditions

A. Artesian wells

1. The well casing shall extend into the confining formation immediately overlying the artesian aquifer and shall be grouted from a minimum of ten feet into the confining formation to the land surface to prevent surface leakage into and subsurface leakage from the artesian aquifer.
2. If leaks occur adjacent to the well or around the well casing, within 30 days the well shall be completed with the seals, packers, or casing and grouting necessary to eliminate such leakage or the well shall be abandoned according to R12-15-816.
3. If the well flows at land surface, the well shall be equipped with a control valve, or suitable alternative means of completely controlling the flow, which must be available for inspection at the well site at all times.

B. Mineralized or polluted water. In all water-bearing geologic units containing mineralized or polluted water as indicated by available data, the borehole shall be cased and grouted so that contamination of the overlying or underlying groundwater zones will not occur.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2).

R12-15-813. Unattended Wells

All wells, when unattended during well drilling, shall be securely covered for safety purposes and to prevent the introduction of foreign substances into the well.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Section number corrected (Supp. 93-1).

R12-15-814. Disinfection of Wells

A well drilling contractor shall disinfect any well from which the water to be withdrawn is intended to be utilized for human consumption or culinary purposes without prior treatment before removing the drill rig from the well site in accordance with the requirements contained in Engineering Bulletin No. 8, "Disinfection of Water Systems", issued by the Arizona Department of Health Services in August 1978, and Engineering Bulletin No. 10, "Guidelines for the Construction of Water Systems", issued by the Arizona Department of Health Services in May 1978, both of which are incorporated by reference and are on file with the Office of the Secretary of State. Copies of the Engineering Bulletins referred to above may be obtained with these rules at the Office of the Secretary of State of the State of Arizona, State Capitol, West Wing, Phoenix, Arizona 85007, and from the Department of Water Resources, 3550 N. Central Avenue, Phoenix, AZ 85012. This rule does not include any later amendments or editions of those Bulletins.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-815. Removal of Drill Rig from Well Site

The drilling rig shall not be removed from the well site unless the well is in one of the following conditions:

1. Constructed in full conformance with R12-15-811 and R12-15-812 and either sealed with a cap or equipped with a pump.
2. Abandoned in accordance with R12-15-816.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2).

R12-15-816. Abandonment

A. Well abandonment shall be performed only by a licensed well drilling contractor or single well licensee.

B. Except as provided in subsection (F) of this Section, the owner of a well shall file a notice of intent to abandon the well prior to abandonment, on a form prescribed and furnished by the Director, which shall include:

1. The name and mailing address of the person filing the notice.
2. The legal description of the land upon which the well proposed to be abandoned is located and the name and mailing address of the owner of the land.
3. The legal description of the location of the well on the land.
4. The depth, diameter and type of casing of the well.
5. The well registration number.
6. The materials and methods to be used to abandon the well.
7. When abandonment is to begin.
8. The name and well drilling license number of the well drilling contractor or single well licensee who is to abandon the well.
9. The reason for the abandonment.
10. Such other information as the Director may require.

C. The Director shall, upon receipt of a proper notice of intent to abandon, mail a well abandonment authorization card to the designated well drilling contractor or single well licensee.

D. Except as described in subsection (F) of this Section, a well drilling contractor or single well licensee may commence abandoning a well only if the driller has possession of an abandonment card at the well site, issued by the Director in the name of the driller, authorizing the abandonment of that specific well or wells in that specific location.

E. Within 30 days after a well is abandoned pursuant to this Section, the well drilling contractor or single well licensee shall file with the Director a Well Abandonment Completion Report on a form prescribed and furnished by the Director which shall include the date the abandonment of the well was completed and such other information as the Director may require.

F. In the course of drilling a new well, the well may be abandoned without first filing a notice of intent to abandon and without an abandonment card. If the well is abandoned pursuant to this subsection without first filing a notice of intent to abandon and without an abandonment card, the well drilling contractor or single well licensee shall provide the following information in the Well Abandonment Completion Report:

1. The legal description of the land upon which the well was abandoned and the name and mailing address of the owner of the land.
2. The legal description of the location of the well on the land.
3. The depth, diameter and type of casing of the well prior to abandonment.
4. The well registration number.
5. The materials and methods used to abandon the well.
6. The name and well drilling license number of the well drilling contractor or single well licensee who abandoned the well.
7. The date of completion of the abandonment of the well.
8. The reason for the abandonment.
9. Such other information as the Director may require.

G. The abandonment of a well shall be accomplished through filling or sealing the well so as to prevent the well, including the annular space outside the casing, from being a channel allowing the vertical movement of water.

H. A well drilling contractor or single well licensee shall construct a surface seal for a well that does not penetrate an aquifer, as follows:

1. If the casing is removed from the top 20 feet of the well, a cement grout plug shall be set extending from two feet below the land surface to a minimum of 20 feet below the land surface, and the well shall be backfilled above the top of the cement grout plug to the original land surface.
2. If the casing is not removed from the top 20 feet of the well, a cement grout plug shall be set extending from the top of the casing to a minimum of 20 feet below the land surface and the annular space outside the casing shall be filled with cement from the land surface to a minimum of 20 feet below the land surface.

I. In addition to the surface seal required in subsection (H):
1. A well penetrating a single aquifer system with no vertical flow components shall be filled with cement grout, concrete, bentonite drilling muds, clean sand with bentonite, or cuttings from the well.
2. A well penetrating a single or multiple aquifer system with vertical flow components shall be sealed with cement grout or a column of bentonite drilling mud of sufficient volume, density, and viscosity to prevent fluid communication between aquifers.

J. Materials containing organic or toxic matter shall not be used in the abandonment of a well.

K. The owner or operator of the well shall notify the Director in writing no later than 30 days after abandonment has been completed. The notification shall include the well owner's name, the location of the well, and the method of abandonment.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2). Amended by final rulemaking at 13 A.A.R. 3022, effective October 6, 2007 (Supp. 07-3).

R12-15-817. Exploration Wells

A. Notification. Prior to drilling one or more exploration wells, the well owner, lessee, or exploration firm shall file a notice of intention to drill on forms provided by the Director. If the notice of intention to drill is filed for the project as a whole, the drilling card shall be issued for the project as a whole.

B. Construction and abandonment.
1. If an exploration well which is to be left open for re-entry at a later date encounters groundwater, it shall be cased and capped in accordance with R12-15-811, R12-15-812, and R12-15-822. The minimal length of surface seal shall be either 20 feet, or five feet into the first encountered consolidated formation, whichever is less. If no groundwater is encountered, the well shall be cased, grouted and capped in such a manner so as to prevent contamination of the well bore from the surface.
2. Exploration wells not left open for re-entry shall be abandoned in accordance with R12-15-816.

C. Completion report. Within 30 days of project completion, the well owner, lessee, or exploration firm shall submit a project completion report on forms provided by the Director. The report shall include:
1. The exact number of wells drilled.
2. The depth to water encountered or detected, with reference to specific wells.
3. The abandonment method utilized, or construction details if completed for re-entry.
4. Any other information which the Director may require.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2).

R12-15-818. Well Location

Except for monitor wells and piezometer wells, no well shall be drilled within 100 feet of any septic tank system, sewage disposal area, landfill, hazardous waste facility, storage area of hazardous materials or petroleum storage areas and tanks, unless authorized in writing by the Director.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2).

R12-15-819. Use of Well as Disposal Site

No well may be used as a storage or disposal site for sewage, toxic industrial waste, or other materials that may pollute the groundwater, except as authorized by the Arizona Department of Environmental Quality.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2).

R12-15-820. Request for Variance

A. If extraordinary or unusual conditions exist, a well drilling contractor or owner may request a variance from the provisions of this Article.

B. The request for variance shall be in writing and shall set forth the location of the well site, the reasons for the request, and the recommended requirements to be applied. The Director may approve the request only if the well drilling contractor or owner has clearly demonstrated that the variance will not adversely affect other water users or the local aquifers.

C. A variance shall not be effective until the well drilling contractor or owner receives from the Director a written approval of the variance and a new drilling card stamped "variance issued."

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2).

R12-15-821. Special Requirements

If the Director determines that the literal application of the minimum well construction requirements contained in this Article would not adequately protect the aquifer or other water users, the Director may require that further additional measures be taken, such as increasing the length of the surface seal or increasing the well's minimum distance from a potential source of contamination.

Historical Note

Adopted effective March 5, 1984 (Supp. 84-2). Amended effective June 18, 1990 (Supp. 90-2).

R12-15-822. Capping of Open Wells

A. The owner of an open well shall either install a cap on the well or abandon the well in accordance with R12-15-816. Within five days after capping the well, the owner of the well shall file with the Department a notice of well capping on a form approved by the Director which shall include the following information:
1. The name and address of the well owner.
2. The name and address of the person installing the cap.
3. The well registration number.
4. The legal description of the location of the well.
5. The date the well was capped.
6. The method of capping.
7. The type and diameter of casing.

B. If no casing exists in an open well, or if the integrity of the existing casing is insufficient to allow installation of a cap, the well owner shall install a surface seal in accordance with R12-15-811(B) prior to capping.

C. The owner of a well on which a cap is installed shall make the cap tamper resistant by welding the cap to the top of the casing by the electric arc method of welding, except that the owner of a well may make the cap tamper resistant by securing the cap to the top of the casing with a lock during temporary periods of well maintenance, modification or repair, not to exceed 30 days, or at any time if the well is a monitor well or piezometer well.

Historical Note

Adopted as an emergency effective March 2, 1989, pursuant to A.R.S. § 41-1026, valid for only 90 days (Supp. 89-1). Emergency expired. Readopted without change as an emergency effective June 2, 1989, pursuant to A.R.S. § 41-1026, valid for only 90 days (Supp. 89-2). Emergency expired. Readopted without change as an emergency effective September 5, 1989, pursuant to A.R.S. § 41-1026, valid for only 90 days (Supp. 89-3). Emergency expired. Readopted without change as an emergency effective December 1, 1989, pursuant to A.R.S. § 41-1026, valid for only 90 days (Supp. 89-4). Emergency expired. Readopted without change as an emergency effective March 23, 1990, pursuant to A.R.S. § 41-1026, valid for only 90 days (Supp. 90-1). Permanent rule adopted with changes effective June 18, 1990
(Supp. 90-2). Amended by final rulemaking at 13 A.A.R. 3022, effective October 6, 2007 (Supp. 07-3).

R12-15-823. Reserved

through

R12-15-849. Reserved

R12-15-850. Evaluation of Notices of Intention to Drill; Notification of Registered Site Locations; Vertical Cross-Contamination Evaluation

A. The Director shall, upon receipt of a complete and correct notice of intention to drill form required under A.R.S. § 45-596, or upon receipt of an application for a permit under A.R.S. § 45-597 through 45-599, identify whether the proposed well will be drilled within a groundwater basin or subbasin in which there exists a site listed on the registry established under A.R.S. § 49-287.01(D). If the proposed well is situated within such a groundwater basin or subbasin, the Director shall notify the applicant and the authorized well drilling contractor in writing of the existence of the site and shall enclose a map indicating the boundaries of all listed sites within the groundwater basin or subbasin. The notification letter shall include the name, address, and telephone number of a Department contact person, along with a reference to the provision in R12-15-851 that requires the applicant to notify the Department in advance of the date drilling of the well will commence. The Department shall also specify in the notification letter whether the applicant is subject to the requirements of R12-15-851.

B. The Director shall, upon receipt of a complete and correct notice of intention to drill form required under A.R.S. § 45-596, or upon receipt of an application for a permit under A.R.S. § 45-597 through 45-599, identify whether the proposed well will be drilled within an area where existing or anticipated future groundwater contamination presents a risk of vertical cross-contamination, as defined in A.R.S. § 49-281(15). If the Director determines that the proposed well will be drilled in such an area, and if the Director finds that the requirements of R12-15-811 are insufficient to prevent the risk of vertical cross-contamination, the Director shall establish site-specific requirements pursuant to R12-15-812 and R12-15-821.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 469, effective January 3, 2000 (Supp. 00-1).

R12-15-851. Notification of Well Drilling Commencement

A well owner who has been issued a drilling card for a notice of intent to drill authorizing the drilling of a well located within a site listed on the registry established under A.R.S. § 49-287.01, shall provide written notice to the Director indicating the date drilling will commence. The well owner shall coordinate with the contracted well driller to ensure that the Department receives proper notification under this Section. This notification shall consist of a letter or facsimile transmission received by the Department at least 2 business days before drilling commences at the well site. The Department shall use notification letters required by R12-15-850(A) to inform well owners whether they are subject to the requirements of this Section.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 469, effective January 3, 2000 (Supp. 00-1).

R12-15-852. Notice of Well Inspection; Opportunity to Comment

A. At least 30 days before the beginning of a well inspection under A.R.S. § 45-605(A), the Director shall notify in writing all potentially affected well owners of record within a community involvement area established under A.R.S. § 49-289.02 or within other areas that the Director has selected for inspection of wells that may be contributing to vertical cross-contamination. The notices shall include a map of the community involvement area, remedial site, or a subsection of either, that the Department intends to inspect, indicating the location of affected wells of record. The notice shall indicate the approximate date the inspection will start, the approximate duration of the inspection, an access agreement defining what specific activities will occur during a well inspection, and the name, address, and telephone number of a Department contact person.

B. Once the Director has given notice of a well inspection under A.R.S. § 45-605(A), potentially affected well owners have 30 days from the date the letter is postmarked to comment on the proposed inspection. The Director, upon receiving a written request, may extend the comment period for a maximum of 30 additional days.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 469, effective January 3, 2000 (Supp. 00-1).

ARTICLE 9. WATER MEASUREMENT

R12-15-901. Definitions

In addition to the definitions set forth in A.R.S. §§ 45-101 and 45-402, the following words and phrases shall have the following meanings, unless the context otherwise requires:

1. "Approved measuring device" means an instrument, approved by the Director pursuant to R12-15-903 or R12-15-909(A) which measures the volume or flow rate of water withdrawn, delivered, received, transported, recharged, stored, recovered, or used, and which measurements, when used with an approved measuring method, allow for accurate computation of a volume of water.
2. "Approved measuring method" means a procedure, approved by the Director in R12-15-903 or R12-15-909(A), which, when used with an approved measuring device, will accurately calculate a volume of water.
3. "Flow rate" or "discharge" means the volume of water, including any sediment or other solids that may be dissolved or mixed with it, which passes through a particular reference section in a unit of time.
4. "Measured system" means a system through which water passes for the purpose of withdrawal, delivery, receipt, transportation, recharge, storage, replenishment, recovery or use.
5. "Responsible party" means an irrigation district or a person required by A.R.S. Title 45 or by a permit, rule, or order issued pursuant to A.R.S. Title 45, to use a measuring device or method approved by the Director.

Historical Note

Adopted effective December 27, 1982 (Supp. 82-6). Amended effective June 15, 1995 (Supp. 95-2). Amended to correct typographical error under A.A.C. R1-1-109 (Supp. 01-2).

R12-15-902. Installation of Approved Measuring Devices

A. A responsible party shall install an approved measuring device to monitor the volume of water withdrawn, delivered, transported, recharged, stored, replenished, recovered, and used.

B. A responsible party shall install and use a sufficient number of approved measuring devices to allow for the separate monitoring and reporting of the volume of water passing through the measured system pursuant to the following categories of rights:

1. Irrigation grandfathered rights,
2. Non-irrigation grandfathered rights,
3. Service area rights,
4. Groundwater withdrawal permits, and
5. Recovery well permits or water storage permits.

This subsection does not require separate measuring devices for rights within each category unless otherwise required by A.R.S. Title 45, a permit, rule, or order pursuant to that Title.

C. An approved measuring device which measures groundwater withdrawals shall be installed as close to the wellhead as is practical, consistent with the manufacturer's instructions. An approved measuring device which measures another point in the measured system shall be installed as close as is practical to the point of delivery, receipt, transportation, recharge, storage, replenishment, recovery, or use which the device is intended to measure, consistent with the manufacturer's instructions.

Historical Note

Adopted effective December 27, 1982 (Supp. 82-6). Amended effective June 15, 1995 (Supp. 95-2). Amended to correct typographical error under A.A.C. R1-1-109 (Supp. 01-2).

R12-15-903. Approved Water Measuring Devices and Methods

A. Any measuring device is approved by the Director if it is installed, maintained, and used in accordance with the manufacturer's recommendations, and if it meets the accuracy requirements set forth in R12-15-905(A).

B. An approved measuring device shall be used with an approved measuring method set forth in R12-15-903(C) or an alternative measuring method approved by the Director as provided in R12-15-909(A).

C. The following water measuring methods are approved by the Director:

1. Totalizing measuring method: This method requires an approved measuring device which continuously records the volume of water passing through the measured system;
2. Electrical consumption measuring method: This method requires measurements of either pipeflow rates or open-channel flow rates used in combination with electrical energy records;
3. Natural gas consumption measuring method: This method requires measurements of either pipe flow rates or open channel flow rates used in combination with natural gas energy records;
4. Hour meter measuring method: This method requires measurements of either pipe flow rates or open-channel flow rates used in combination with hour meter readings;
5. Elapsed time of flow method: This method requires measurements of flow rates used in combination with elapsed time of the flow. This method may be used only by a responsible party who receives water from an open channel or by a person or entity who delivers water in an open channel to one or more grandfathered rightholders or permit holders, if it is not possible to use the electrical or gas consumption measurement methods or hour meter measuring method.

Historical Note

Adopted effective December 27, 1982 (Supp. 82-6). Amended effective June 15, 1995 (Supp. 95-2).

R12-15-904. Water Measuring Method Reporting Requirements

A. A responsible party using one of the water measuring methods described in R12-15-903 shall file, with the annual report required by A.R.S. Title 45 and on a form prescribed by the Director, the following information, unless that information has not changed from that submitted in the annual report filed in the previous calendar year.

1. The approved measuring method used;
2. The type of approved measuring device used;
3. The make, model, and size of the approved measuring device used.

B. Except as provided in R12-15-904(B)(5) and R12-15-909(B) and (D), a responsible party shall file with the annual report the information required in subsection (A) of this Section and the following information on a form prescribed by the Director:

1. Totalizing measuring method:
   a. The initial totalizing meter reading for the reporting year taken prior to the first use of the measured system during the reporting year;
   b. The end totalizing meter reading for the year taken subsequently to the last use of the measured system during the reporting year;
   c. The units in which the water is measured;
   d. Whether the power meter serves uses other than the pump motor or engine;
   e. An estimate of the amount of any water passing through the measured system during measuring device malfunctions;
   f. If the well is in operation for more than a 30-day period, the results of a minimum of two flow-rate measurements per reporting year taken under normal system operating conditions. The responsible party shall not submit the results of the flow-rate measurements with the annual report unless a meter malfunction continues longer than 72 hours during the reporting year;
   g. The installation or overhaul date of the totalizing meter; and
   h. The name of the energy company supplying energy to the responsible party's measured system, its power account number, meter number, total energy consumption for the year, and the type of energy unit.
2. Electrical consumption measuring method:
   a. The results of a minimum of two flow-rate measurements per reporting year taken at least 30 days apart and under normal system operating conditions or, if the measured system is used during a single period of 30 days or less during the year, the result of one flow-rate measurement taken during that single period in that year under normal system operating conditions;
   b. The dates of the measurements;
   c. The discharges in gallons per minute;
   d. The time, in seconds, of ten cycles of the electric meter disk, power indicator pulse, or an alternative measurement, provided that the alternative means of measurement is approved in advance by the Director;
   e. The inside diameter of the discharge pipe;
   f. The multiplier (Kr) and disk constant (Kh) of the electric meter; and
   g. The name of the energy company supplying energy to the responsible party's measured system, its power account number, meter number, total energy consumption for the year, and the type of energy unit.
3. Natural gas consumption measuring method:

a. The results of a minimum of two flow-rate measurements per reporting year taken at least 30 days apart and under normal system operating conditions or, if the measured system is used during a single period of 30 days or less during the year, the result of one flow-rate measurement taken during that single period in that year under normal system operating conditions;
b. The dates of the measurements;
c. The discharges in gallons per minute;
d. The amounts of gas per second in cubic feet indicated by the gas meter;
e. The billing factors (F);
f. The inside diameter of the discharge pipe; and
g. The name of the energy company supplying energy to the responsible party's measured system, its power account number, meter number, total energy consumption for the year, and the type of energy unit.

4. Hour meter measuring method:
a. The results of a minimum of two flow-rate measurements per reporting year taken at least 30 days apart and under normal system operating conditions or, if the measured system is used during a single period of 30 days or less during the year, the result of one flow-rate measurement taken during that single period in that year under normal system operating conditions;
b. The dates of the measurements;
c. The discharges in gallons per minute;
d. The initial hour meter reading for the reporting year taken prior to the first use of the measured system during the reporting year;
e. The end hour meter reading taken subsequently to the last use of the measured system during the reporting year;
f. Whether the energy meter serves uses other than the pump motor or engine;
g. The installation or overhaul date of the hour meter; and
h. The name of the energy company supplying energy to the responsible party's measured system, its power account number, meter number, total energy consumption for the year, and the type of energy unit.

5. Elapsed time of flow measuring method: A responsible party using this measuring method shall not be required to submit the following information with the annual report but instead shall record and retain it for three years after the reporting year.
a. The responsible party or agent shall measure and record an initial flow rate taken at the start of flow for each delivery of water;
b. If the flow rate continues for more than eight hours, a subsequent measured flow-rate measurement shall be taken. If any subsequently measured flow-rate differs by more than 10% from the initial flow rate, and the delivery is not adjusted to conform with the initial flow rate, the responsible party or agent shall record the subsequent flow rate;
c. The time the flow begins and the time the flow ends for each delivery of water; and
d. The dates of the measurements.

C. A responsible party or person or entity who uses an approved measuring method or an approved alternative water measurement method shall save the records required by subsections (A) and (B) of this Section for three years after the reporting year.

Historical Note

Adopted effective December 27, 1982 (Supp. 82-6). Former Section R12-15-904 renumbered to R12-15-905, new Section adopted effective June 15, 1995 (Supp. 95-2). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-905. Accuracy of Approved Measuring Devices

A. A responsible party shall install, maintain, and use an approved measuring device and method in a manner which will ensure that its measurement error does not exceed 10% of the actual flow rate.

B. All measured systems shall be installed or constructed and thereafter maintained so as to allow the Director, using another measuring device, to check readily the accuracy of the measuring device utilized by the responsible party.

Historical Note

Adopted effective December 27, 1982 (Supp. 82-6). Former Section R12-15-905 renumbered to R15-15-906, new Section R12-15-905 renumbered from R12-15-904 and amended effective June 15, 1995 (Supp. 95-2).

R12-15-906. Repair and Replacement of Approved Measuring Devices

If an approved measuring device fails to perform its designated function for more than 72 hours, the responsible party shall notify the Director of the failure, in writing, within seven calendar days after the discovery of the failure of the device. The reason for such failure shall be stated, as well as the estimated date of return to service of the device. If the malfunction is discovered by the Director and the malfunction does not appear to be the result of an attempt to render the device inaccurate, the Director shall notify the responsible party of the malfunction. The responsible party shall return the measuring device to full service within 30 days of either original notice by the responsible party to the Director or by the Director to the responsible party, unless repair or replacement service or parts are not available. In such case, the responsible party shall notify the Director of the delay within seven days and the reasons for it. The responsible party shall take corrective action in such cases as soon as practical. In all cases, the responsible party shall notify the Director within seven days when the measuring device is returned to full service and shall submit on a form prescribed by the Director estimates of the volume of water, if any, passing through the measured system during the period the measuring device was out of service and a description of the method used to calculate the estimates.

Historical Note

Section R12-15-906 renumbered from R12-15-905 and amended effective June 15, 1995 (Supp. 95-2).

R12-15-907. Calculation of Irrigation Water Deliveries

If one or more irrigation grandfathered rights receive water by a common distribution system where water is measured with an approved device or method at the point of delivery to the common distribution system, but not at a point of delivery to each irrigation grandfathered right, each irrigation grandfathered rightholder or agent shall report the water used by either of the following methods:

1. Estimate the amount of water used based on a pro rata share of the acres irrigated, or
2. Estimate the amount of water used based on a combination of the pro rata share of the acres irrigated and the consumptive use of each crop grown.

Historical Note

Adopted effective June 15, 1995 (Supp. 95-2).

R12-15-908. Measurement of Water by One Person on Behalf of Another

A responsible party shall be liable for any fines, penalties, or other sanctions resulting from the installation, monitoring, use, or accuracy of any measuring device, method, or recordkeeping, notwithstanding that the installation, monitoring, use, or recordkeeping may have been done by an agent of the responsible party.

Historical Note

Adopted effective June 15, 1995 (Supp. 95-2).

R12-15-909. Alternative Water Measuring Devices, Methods, and Reporting

A. A responsible party may use an alternative water measuring device or method that differs from those described in R12-15-903 provided the device or method is approved in advance by the Director. The Director shall approve an alternative water measuring device or method if the device meets the requirements of R12-15-905. The Director may require from the responsible party such information as may be necessary to demonstrate that the alternative device or method meets the requirements of R12-15-905.

B. Responsible parties may substitute equivalent information for the information required on the annual report form or use reporting formats that differ from that required in R12-15-904, provided the substituted information or format is approved in advance by the Director.

C. Responsible parties may use estimation methods that differ from those described in R12-15-907 provided they are approved in advance by the Director.

D. A municipal provider is exempted from the reporting requirements under R12-15-904 and the provisions under R12-15-906 pertaining to notification to the Director of measuring device malfunctions regarding metered service connections, unless required to report by A.R.S. Title 45 or by a permit, rule, or order issued pursuant to A.R.S. Title 45.

E. Municipal providers and irrigation districts may notify the Director of measuring device malfunctions at the time of filing the annual report and in a manner that differs from the requirements of R12-15-906, provided the municipal provider or irrigation district implements a schedule of regular maintenance of measuring devices, repairs or replaces malfunctioning measuring devices within seven days of discovery of the malfunction, and the alternative notification is approved in advance by the Director.

Historical Note

Adopted effective June 15, 1995 (Supp. 95-2).

ARTICLE 10. REPORTING REQUIREMENTS FOR ANNUAL REPORTS, ANNUAL ACCOUNTS, OPERATING FLEXIBILITY ACCOUNTS, AND CONVEYANCES OF GROUNDWATER RIGHTS

R12-15-1001. Definitions

In addition to the definitions in A.R.S. §§ 45-101 and 45-402, the following words and phrases in this Article have the following meanings, unless the context otherwise requires:

1. "Annual account" means an accounting of water required to be filed pursuant to A.R.S. § 45-468.
2. "Annual report" means an annual report of water withdrawn, delivered, received, transported, recharged, stored, recovered, replenished or used as required by A.R.S. §§ 45-437, 45-467, 45-632, 45-875.01, 45-876.01, 45-877.01, 45-878.01 or 45-1004.
3. "Central Arizona project water" means Colorado River water delivered through the facilities of the central Arizona project, and surface water from any other source conserved and developed by dams and reservoirs in the central Arizona project and lawfully delivered by the United States or a multi-county conservation district.
4. "Decreed or appropriative surface water" means surface water which is delivered or used pursuant to a decreed or appropriative water right, except any such water which is included in central Arizona project water.
5. "Farm" means an area of irrigated land under the same ownership as defined in A.R.S. § 45-402, including the area of land described in a certificate of irrigation grandfathered right, as well as contiguous land that the owner is legally entitled to irrigate only with decreed or appropriative surface water.
6. "Maximum annual groundwater allotment" means the quantity of water in acre-feet obtained by multiplying the number of water duty acres for a farm by the current irrigation water duty

for the farm unit.
7. "Normal flow" means water delivered or used pursuant to a right to appropriate an unstored, natural flow of surface water.
8. "Operating flexibility account" means an accounting of water use pursuant to an irrigation grandfathered right as provided in A.R.S. § 45-467.
9. "Responsible party" means a person required by law to file an annual account or annual report.
10. "Spillwater" means surface water, other than Colorado River water, released for beneficial use from storage, diversion, or distribution facilities to avoid spilling that would otherwise occur due to uncontrolled surface water inflows that exceed facility capacity and to which one of the following applies:
    a. The water is released from the facility under written criteria for releasing water to avoid spilling that have been approved in writing by the Director.
    b. The water is released from the facility because an unreasonable risk exists that the storage capacity of the facility will be exceeded within the next 30 days because the facility is near capacity and either the inflow to the facility or the forecast runoff into the facility is equal to or greater than the quantity of water ordered from the facility.
    c. The water is released from the facility because an unreasonable risk exists that the storage capacity of the facility will be exceeded more than 30 days in the future because the forecast runoff into the facility exceeds current unused storage capacity and projected water demand during the forecast period, provided that the Director has made a written finding before the release that the forecast is reasonable.
11. "Surface water right acre" means land to which the owner is legally entitled to apply decreed or appropriative surface water.
12. "Tailwater" means water which, after having been applied to a farm for irrigation purposes,
    a. Is subsequently used for the irrigation of a different farm, without having entered the distribution system of a city, town, private water company or irrigation district, or
    b. Is delivered to an irrigation district in accordance with R12-15-1010. Such water, once having entered the distribution system of the irrigation district, loses its characterization as tailwater.
13. "Water deliverer" means a city, town, private water company or irrigation district delivering a combination of groundwater and any other type of water for irrigation purposes.

Historical Note

Adopted effective December 27, 1982 (Supp. 82-6). Section R12-15-1001 renumbered to R12-15-1003, new Section R12-15-1001 adopted effective December 12, 1990 (Supp. 90-4). Amended to correct typographical error under A.A.C. R1-1-109 (Supp. 01-2). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-1002. Form of Annual Account or Annual Report

A. A person filing an annual account or an annual report shall do so on a form prescribed by the Director, unless the person has requested and received the Director's prior written approval to use an alternative form.

B. A person may file both an annual account and an annual report in one document. A person required to file an annual account shall designate in the annual account whether the annual account is being filed also as an annual report.

Historical Note

Adopted effective December 12, 1990 (Supp. 90-4).

R12-15-1003. Accuracy of Annual Reports

The quantity of water a responsible party reports in an annual report as having been withdrawn, delivered, received, transported, recharged, replenished, stored, recovered, or used during a year shall not deviate from the quantity of water actually withdrawn, delivered, received, transported, recharged, replenished, stored, recovered, or used by the responsible party during the year unless both of the following apply:
1. The deviation is 10 percent or less.
2. The deviation is not the result of an intentional act of misrepresentation by the responsible party.

Historical Note

Section R12-15-1003 renumbered from R12-15-1001 effective December 12, 1990 (Supp. 90-4). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-1004. Annual Reports Filed on Behalf of a Responsible Party

A. A responsible party is liable for any fines, penalties, or other sanctions resulting from or attributable to the filing or content of an annual report filed on behalf of the responsible party by an irrigation district pursuant to A.R.S. § 45-632, or by another person in a form acceptable to the Director.

B. If a responsible party has not filed an annual report for a calendar year, and the Department receives an annual report for that calendar year purportedly filed on behalf of the responsible party by an irrigation district pursuant to A.R.S. § 45-632, or by another person in a form acceptable to the Director, there is a rebuttable presumption that the annual report was filed with the responsible party's knowledge, consent, and authorization.

Historical Note

Adopted effective December 12, 1990 (Supp. 90-4). Amended to correct typographical error under A.A.C. R1-1-109 (Supp. 01-2). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-1005. Management Plan Monitoring and Reporting Requirements

A responsible party who is required by a provision of a management plan to comply with monitoring and reporting requirements shall comply with such requirements and shall include all such information in an annual account or annual report.

Historical Note

Adopted effective December 12, 1990 (Supp. 90-4).

R12-15-1006. Reporting Requirements for Holders of Recovery Well Permits

A responsible party recovering water during a year pursuant to a recovery well permit shall include in the annual report required by A.R.S. § 45-875.01 the names of any persons, other than non-irrigation customers of cities, towns, private water companies and irrigation districts, to whom the responsible party delivered the recovered water during the year, the quantity of recovered water delivered to each person named, and the uses to which the recovered water was applied. If the recovered water included commingled groundwater, decreed or appropriative surface water other than spillwater, central Arizona project water, effluent or spillwater, the responsible party shall include in the annual report an estimate of the quantity of each type of water delivered to each person named in the annual report or put to a specific use by the responsible party.

Historical Note

Adopted effective December 12, 1990 (Supp. 90-4). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-1007. Reporting Requirements for Annual Account

A person required to file an annual account pursuant to A.R.S. § 45-468 shall account for water provided to the following classes of users:
1. Cities and towns,
2. Private water companies,
3. Irrigation districts,
4. Dairies,
5. Metal mining facilities,
6. Cattle feed lots,
7. Turf-related facilities,
8. Sand and gravel facilities,
9. Electrical power generation facilities,
10. Other industrial users.

Historical Note

Adopted effective December 12, 1990 (Supp. 90-4).

R12-15-1008. Information Required to Maintain an Operating Flexibility Account

A. A responsible party who withdraws, receives, or uses groundwater during a calendar year pursuant to an irrigation grandfathered right, including any in lieu water received pursuant to a groundwater savings facility permit issued pursuant to A.R.S. § 45-812.01, shall include the following information for the calendar year in an annual report filed pursuant to A.R.S. § 45-467 or 45-632:
1. The quantity of groundwater withdrawn from each well.
2. The quantity of groundwater withdrawn and delivered to another person for irrigation purposes.
3. The quantity of groundwater received from a city, town, private water company, or irrigation district, including any in lieu water received pursuant to a groundwater savings facility permit issued pursuant to A.R.S. § 45-812.01.
4. The quantity of groundwater received from a person other than a city, town, private water company, or irrigation district, including any in lieu water received pursuant to a groundwater savings facility permit issued pursuant to A.R.S. § 45-812.01.
5. The quantity of effluent received.
6. The quantity of decreed or appropriative surface water received, other than normal flow and spillwater.
7. The quantity of normal flow received.
8. The quantity of spillwater received.
9. The quantity of tailwater used.
10. The quantity of tailwater delivered in accordance with the provisions of R12-15-1010(A), and the farm or irrigation district to which the tailwater was delivered.
11. The quantity of central Arizona project water received.
12. The quantity of any surface water received and not accounted for pursuant to subsections (6) through (11) of this subsection.
13. The number of surface water right acres in the farm to which the irrigation grandfathered right is appurtenant.
14. The quantity of water used for the legal irrigation of acres in the farm to which irrigation grandfathered rights are not appurtenant. If the responsible party omits this information, the Director shall presume that the total amount of water received or used for the irrigation of the farm was applied to acres to which irrigation grandfathered rights are appurtenant.

15. Any other information the Director may reasonably require to accomplish the management goals of the applicable active management area.

B. A water deliverer shall include the following information for an accounting period in an annual account filed pursuant to A.R.S. § 45-468:
1. The quantity of groundwater delivered to each farm, including any in lieu water delivered pursuant to a groundwater savings facility permit issued pursuant to A.R.S. § 45-812.01.
2. The quantity of normal flow delivered to each farm.
3. The quantity of spillwater delivered to each farm.
4. The quantity of decreed or appropriative surface water, other than normal flow and spillwater, delivered to each farm.
5. The quantity of central Arizona project water delivered to each farm.
6. The quantity of decreed or appropriative surface water, other than normal flow and spillwater, delivered for use within the service area of the water deliverer, including all farm and non-farm deliveries.
7. The number of surface water right acres within the service area of the water deliverer.
8. The quantity of effluent delivered to each farm.
9. Any other information the Director may reasonably require to accomplish the purposes of A.R.S. § 45-468.

Historical Note
Adopted effective December 12, 1990 (Supp. 90-4). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-1009. Credits to Operating Flexibility Account

A. Except as provided in subsection (B) of this Section and in R12-15-1010, if the total amount of water from all sources other than spillwater used by a farm for irrigation purposes in a calendar year is less than the farm's maximum annual groundwater allotment for the year, the Director shall register the difference as a credit to the farm's operating flexibility account.

B. If a farm is within the service area of a water deliverer, the Director shall reduce the credit as calculated pursuant to subsection (A) of this Section by an amount equal to the difference between the farm's pro rata share of the total quantity of decreed or appropriative surface water, other than normal flow or spillwater, delivered by the water deliverer during the year for use within its service area, and the quantity of water actually received by the farm during the year. The Director shall determine the farm's pro rata share by dividing the number of surface water right acres in the farm that are within the service area of the water deliverer by the total number of surface water right acres within the service area of the water deliverer, and multiplying the quotient by the total quantity of decreed or appropriative surface water, other than normal flow or spillwater, delivered by the water deliverer during the year for use within its service area.

Historical Note
Adopted effective December 12, 1990 (Supp. 90-4). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-1010. Operating Flexibility Account; Tailwater

A. When calculating credits or debits to a farm's operating flexibility account for a year, the Director shall exclude from the total amount of water used on the farm during that year the amount of any tailwater that originated on the farm and that was delivered from the farm to another farm or to an irrigation district for irrigation purposes during the year if all of the following apply:
1. Prior to January 1 of the year in which the deliveries of tailwater take place, the Director approves a written plan to measure and record the tailwater deliveries. The plan shall include:
a. The installation and use of a totalizing water measuring device that will record tailwater deliveries with no greater than a 10 percent margin of error.
b. Procedures for keeping accurate records of the tailwater deliveries.
c. A description of how the tailwater will be delivered.
d. An identification of the farm or irrigation district to which the tailwater will be delivered.
2. The person has measured, recorded, and delivered the tailwater in accordance with the plan approved under subsection (A)(1) of this Section.
3. The tailwater was delivered directly from the farm on which it originated to:
a. A specified farm that used the tailwater for the legal irrigation of irrigation acres or surface water right acres on that farm, or
b. A specified irrigation district that delivered the tailwater for the legal irrigation of irrigation acres or surface water right acres within that district.

B. A person who delivers tailwater in accordance with subsection (A) of this Section, and a person who directly receives and uses the tailwater pursuant to subsection (A)(3)(a) of this Section, shall account for and report the tailwater as if it were comprised of a mixture of groundwater, decreed and appropriative surface water other than normal flow, central Arizona project water, spillwater, other surface water, and effluent, as applicable, in the same proportions as those types of water comprise the total amount of water other than normal flow received or withdrawn for irrigation use during the calendar year on the farm on which the tailwater originated.

C. A person who uses tailwater that has not been delivered and accounted for as provided in subsections (A) and (B) of this Section may credit against the person's use of groundwater in a calendar year the amount of the tailwater used during the calendar year if the use of such tailwater would cause a debit to be incurred. The credit shall be applied only against the person's operating flexibility account debits that otherwise would have been incurred that year and shall not be used to discharge debits from prior years or accumulate credits for future years. For purposes of calculating credits to the person's operating flexibility account, the Director shall treat tailwater as groundwater, unless reported otherwise according to its source.

D. An irrigation district that receives tailwater pursuant to subsection (A)(3)(b) shall account for the water in the same manner as other water in the district's distribution system.

Historical Note
Adopted effective December 12, 1990 (Supp. 90-4). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-1011. Statement of Operating Flexibility Account

A. The Director shall annually issue to each owner or user of an irrigation grandfathered right for which a current annual report has been filed a statement of the operating flexibility account setting forth the status of the operating flexibility account for the farm, based on the information submitted in the annual report filed for the right.

B. Upon a motion or on the initiative of the Director, the Director may amend a statement of operating flexibility account at any time to correct clerical mistakes or to adjust the balance of the account based on information submitted in an amended or late annual report. The Director shall give written notice of any amendments made pursuant to this subsection to the person to whom the statement of operating flexibility account was issued.

Historical Note
Adopted effective December 12, 1990 (Supp. 90-4). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-1012. Rule of Construction

Nothing in A.A.C. R12-15-1001 through R12-15-1011 shall be construed to determine the legality of any water use for which an accounting is required under these rules.

Historical Note
Adopted effective December 12, 1990 (Supp. 90-4).

R12-15-1013. Retention of Records for Annual Accounts and Annual Reports

The responsible party shall keep and maintain, for at least three calendar years following the filing of an annual account or an annual report, all records which may be necessary to verify the information and data contained therein.

Historical Note
Adopted effective December 12, 1990 (Supp. 90-4).

R12-15-1014. Late Filing or Payment of Fees; Extension Penalties

A. An annual account, an annual report, or a request for extension pursuant to subsection (E) of this rule shall be deemed to be filed at the time a complete annual account, a complete annual report or a request for extension is hand-delivered to any Department office, or at the time the envelope in which it is mailed is postmarked.

B. Except as provided in subsection (C) of this Section, groundwater withdrawal fees and long-term storage credit recovery fees are deemed paid at the time the fees are hand-delivered to any Department office, or at the time the envelope in which they are mailed is postmarked.

C. If any groundwater withdrawal fees or long-term storage credit recovery fees are paid with a negotiable instrument that is not honored and paid upon the Department's initial demand, the fees are deemed paid at the time the Department actually receives the fees in cash or when the negotiable instrument is honored and paid to the Department.

D. If an annual account or an annual report filed on or before the date required by the applicable statute is found by the Director to be incomplete, the Director shall notify the responsible party of the inadequacies and allow the responsible party 30 days from the date of the notice to provide the missing information in a form prescribed by the Director. If the responsible party does not provide the missing information within 30 days from the date of the notice, late penalties under A.R.S. §§ 45-437, 45-632, 45-875.01, 45-876.01, 45-877.01, 45-878.01 or 45-1004 shall begin to accrue on the 31st day following the date of the notice. The Director shall not recommend to a court, pursuant to A.R.S. §§ 45-634, 45-635, 45-881.01, 45-882.01, 45-1062 or 45-1063, that civil penalties be imposed through the first 30 days following the date of the notice. However, if the inadequacy included the failure to pay all groundwater withdrawal fees due or all long-term storage credit recovery fees due, late penalties under A.R.S. §§ 45-614 or 45-874.01 shall begin to accrue on April 1, except as provided in subsection (E) of this Section.

E. A responsible party required to file an annual account or annual report for a year may request a 30-day extension of the first day of accrual of the late penalties under A.R.S. §§ 45-437, 45-614, 45-632, 45-874.01, 45-875.01, 45-876.01, 45-877.01, 45-878.01 or 45-1004 and of the civil penalties that the Director may recommend that a court impose pursuant to A.R.S. §§ 45-634, 45-635, 45-881.01, 45-882.01, 45-1062 or 45-1063. The request shall be filed no later than the date the annual account or annual report is required to be filed under the applicable statute. The Director shall grant a request for a 30-day extension if good cause is shown. If the Director grants the request, the late penalties and civil penalties shall begin to accrue on the first day after the 30-day extension period, except that if the Director finds that the person making the request presented false or misleading information to the Director and the Director relied on that information in granting the request, the late penalties and civil penalties shall begin to accrue as if the request was not granted. The Director shall not grant an extension to a responsible party who was granted an extension in the preceding calendar year and who subsequently failed to file a complete annual account or annual report and pay all groundwater withdrawal fees and all long-term storage credit recovery fees due within the 30-day extension period.

Historical Note
Adopted effective December 12, 1990 (Supp. 90-4). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-1015. Reporting Requirements for Conveyances of Grandfathered Rights and Groundwater Withdrawal Permits

A. A person who is required by A.R.S. § 45-482 to notify the Director of a conveyance of a grandfathered right shall file a notice of conveyance, on a form prescribed by the Director, within 30 days of the conveyance. All parties to the conveyance may use a single form for the required notice. Except provided in subsection (B) of this rule, the notice of conveyance shall include an accounting of the amount of water withdrawn or received pursuant to that grandfathered right from January 1 to the date of conveyance for that calendar year.

B. If the person to whom a grandfathered right is conveyed is unable, because of extraordinary circumstances and good cause shown, to perform the accounting otherwise required by subsection (A) of this rule, the Director may waive the requirement for that person.

C. If a person, including a person who is granted a waiver pursuant to subsection (B) of this rule, fails to include the required accounting in a timely filed notice of conveyance pursuant to subsection (A) of this rule, the Director shall determine the amount of groundwater withdrawn or received pursuant to the grandfathered right from January 1 to the date of conveyance for that calendar year. Such a person shall bear the burden, in any subsequent administrative or judicial proceeding, of establishing by clear and convincing evidence that the Director's determination was incorrect.
D. A person requesting the Director's approval of a proposed conveyance of a groundwater withdrawal permit pursuant to A.R.S. § 45-520(B) shall include with such request the quantity of groundwater withdrawn pursuant to the groundwater withdrawal permit for that calendar year and all other information required to be submitted pursuant to A.R.S. § 45-632.

Historical Note
Adopted effective December 12, 1990 (Supp. 90-4).

R12-15-1016. Spillwater Reporting by Water Deliverers
A water deliverer that delivers spillwater during a year shall include the following information in the annual account or annual report submitted by the water deliverer for that year:
1. The total quantity of spillwater delivered for non-irrigation uses during the year.
2. The total quantity of spillwater delivered for irrigation uses during the year.
3. Any other information the Director may reasonably require to determine whether the water qualifies as spillwater under R12-15-1001(10).

Historical Note
New Section made by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-1017. Maintenance and Filing of Annual Reports Required by A.R.S. § 45-343
A community water system required to file an annual report under A.R.S. § 45-343 shall maintain the report on a calendar year basis and shall file the report with the Director no later than June 1 of each year for the preceding calendar year.

Historical Note
New Section made by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

ARTICLE 11. INSPECTIONS AND AUDITS

R12-15-1101. Inspections
A. For the purpose of this rule, "inspection" means an entry by the Director at reasonable times onto private or public property for any of the following purposes:
1. To obtain factual data or access to records required to be kept under A.R.S. §§ 45-632, 45-879.01, or 45-1004.
2. To inspect a well or another facility for the withdrawal, transportation, use, measurement, or recharge of groundwater under A.R.S. § 45-633.
3. To inspect a facility that is used for the purpose of water storage, stored water recovery, or stored water use under A.R.S. § 45-880.01(A).
4. To inspect a body of water under A.R.S. § 45-135 or to ascertain compliance with A.R.S. Title 45, Chapter 1, Article 3.
5. To inspect or to obtain factual data or access to records pursuant to any Section of A.R.S. Title 45 that requires the Director to adopt rules for conducting inspections, examining records, and obtaining warrants.
6. To inspect facilities used for the withdrawal, diversion, or use of water pursuant to a water exchange under A.R.S. § 45-1061.

B. Not less than seven days prior to an inspection, the Director shall mail notice of the inspection by first class letter to the owner, manager or occupant of the property. The notice shall include the statutory authorization and purpose for the inspection. The notice shall specify a date and time certain or a seven-day period within which the inspection may take place. If a request is made before the seven-day period, the Director shall schedule the inspection for a time certain within the seven-day period to allow an opportunity for a representative of the property to be present at the inspection. The notice shall include the name and telephone number of a Department employee who may be contacted to arrange such an appointment.
C. Whenever practical, Department employees shall minimize disruptions to on-going operations caused by an inspection.
D. If the property is controlled or secured against entry at the time specified in the notice of inspection but consent to the inspection was not denied, the Director shall give a second notice in the manner prescribed in subsection (B) before seeking a search warrant or its equivalent. The second notice shall request that a representative of the property be present at the inspection to accompany Department personnel.
E. If the Director gives notice of an inspection and is not permitted to conduct an inspection, the Director may apply for and obtain a search warrant or its equivalent.
F. Notice of inspection shall not be required under subsections (B) and (D) of this rule if the Director reasonably believes that notice would frustrate the enforcement of A.R.S. Title 45, or where entry is sought for the sole purpose of inspecting water measuring devices required pursuant to A.R.S. § 45-604.
G. The Director shall mail a copy of the report of the inspection either to the person to whom the notice of inspection was directed, or to the owner, manager or occupant of the property if no notice of inspection was given. The report shall include the date of the inspection and a short summary of the findings. If no notice was given, the report shall include an explanation of the reason for determining that notice would not be given, unless providing the explanation would frustrate enforcement of A.R.S. Title 45. An aggrieved person may file with the Director written comments on the report within 30 days after the report is mailed.
H. The owner, manager or occupant of the property may waive the provisions for notice contained in this rule.
I. The Director shall comply with the requirements of A.R.S. § 41-1009 when conducting inspections under this Section.

Historical Note
Adopted effective August 31, 1992 (Supp. 92-3). Amended effective July 22, 1994 (Supp. 94-3). Amended by final rulemaking at 11 A.A.R. 5395, effective February 4, 2006 (Supp. 05-4).

R12-15-1102. Audits
A. For the purpose of this rule, "representative" means
1. An officer or director of a corporation subject to the audit,
2. A general partner of a partnership subject to the audit, or
3. A person who appears at an audit and produces a signed authorization to act on behalf of the person subject to the audit.

B. This rule applies to audits conducted pursuant to A.R.S. §§ 45-633(C), 45-880.01, and any other Section of A.R.S. Title 45 that authorizes the Director to require a person to appear at the Director's office and produce records and information and that also requires the Director to adopt rules for conducting inspections, examining records, and obtaining warrants.
C. No less than 20 days prior to an audit, the Director shall mail notice of the audit by first class letter to the person that is the subject of the audit. The notice shall state the date, time and place of the audit. The notice shall specify the records or information which the person must produce. The notice shall also include the statutory authorization and purpose for the audit and the name and telephone number of a Department employee who may be contacted for further information. The audit shall be held at the Department's offices, unless the Director grants a request to have the audit conducted at a different location.
D. The person subject to the audit or a representative shall appear at the scheduled time and shall produce the records and information specified in the notice. The person subject to the audit or a representative may make one request to reschedule the audit, which the Department shall grant if practicable.
E. The Director shall mail a copy of the report of the audit to the person subject to the audit. An aggrieved person may file with the Director written comments on the report within 30 days after the report is mailed.
F. The person subject to the audit may waive the provisions for notice contained in this rule.

Historical Note
Adopted effective August 31, 1992 (Supp. 92-3). Amended effective July 22, 1994 (Supp. 94-3).

ARTICLE 12. DAM SAFETY PROCEDURES

R12-15-1201. Applicability
A. This Article applies to any artificial barrier meeting the specifications of A.R.S. § 45-1201(1) as interpreted by R12-15-1204. This Article applies to an application for the construction of a dam and reservoir; an application to reconstruct, repair, alter, enlarge, breach, or remove an existing dam and reservoir, including a breached or damaged dam; operation and maintenance of an existing dam and reservoir; and enforcement. A structure identified in R12-15-1203 is exempt from this Article.
B. This Article is applicable to any dam regardless of hazard potential classification, with the following exceptions:
1. R12-15-1208, R12-15-1209, R12-15-1213, R12-15-1221, R12-15-1225, and R12-15-1226 apply only to a dam classified as a high or significant hazard potential dam.
2. R12-15-1210 applies only to a dam classified as a low hazard potential dam. A low hazard potential dam is exempt from R12-15-1208, R12-15-1209, R12-15-1211, R12-15-1213, R12-15-1221, R12-15-1225, and R12-15-1226.
3. R12-15-1211 applies only to a dam classified as a very low hazard potential dam. A very low hazard potential dam is exempt from R12-15-1208, R12-15-1209, R12-15-1210, R12-15-1212, R12-15-1213, R12-15-1215, R12-15-1216, R12-15-1221, R12-15-1225, and R12-15-1226.
4. R12-15-1216(B) applies only to an embankment dam.

Historical Note
Adopted effective November 2, 1978 (Supp. 78-6). Former Section R12-15-01 renumbered without change as Section R12-15-1201 effective October 8, 1982 (Supp. 82-5). Section repealed; new Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1202. Definitions
In addition to the definitions provided in A.R.S. § 45-1201, the following definitions are applicable to this Article:
1. "Alteration or repair of an existing dam or appurtenant structure" means to make different from the originally approved construction drawings and specifications or current condition without changing the height or storage capacity of the dam or reservoir, except for ordinary repairs and general maintenance as prescribed in R12-15-1217.
2. "Appurtenant structure" means any structure that is contiguous and essential to the safe operation of the dam including embankments, saddle dikes, outlet works and controls, diversion ditches, spillway and controls, access structures, bridges, and related housing at a dam.
3. "Classification of dams" means the placement of dams into categories based upon an evaluation of the size and hazard potential, regardless of the condition of the dam.
4. "Concrete dam" means any dam constructed of concrete, including arch, gravity, arch-gravity, slab and buttress, and multiple arch dams. A dam that only has a concrete facing is not a concrete dam.
5. "Construction" means any activity performed by the owner or someone employed by the owner that is related to the construction, reconstruction, repair, enlargement, removal, or

alteration of any dam, unless the context indicates otherwise. Construction is performed after approval of an application and before issuance of a license.
6. "Dam failure inundation map" means a map depicting the maximum area downstream from a dam that would be flooded in the event of the worst condition failure of the dam.
7. "Department" means the Arizona Department of Water Resources.
8. "Director" means the Director of the Arizona Department of Water Resources or the Director's designee.
9. "Embankment dam" means a dam that is constructed of earth or rock material.
10. "Emergency spillway" means a spillway designed to safely pass the inflow design flood routed through the reservoir. If the flow is controlled by gates, it is a controlled spillway. If the flow is not controlled by gates, it is an uncontrolled spillway.
11. "Engineer" means a Professional Engineer registered and licensed in accordance with A.R.S. Title 32, Chapter 1, with proficiency in engineering and knowledge of dam technology.
12. "Enlargement to an existing dam or appurtenant structure" means any alteration, modification, or repair that increases the vertical height of a dam or the storage capacity of the reservoir.
13. "Flashboards" mean timber, concrete, or steel sections placed on the crest of a spillway to raise the retention water level that may be quickly removed at time of flood either by a tripping device or by designed failure of the flashboards or their supports.
14. "Flood control dam" means a dam that uses all of its reservoir storage capacity for temporary impoundment of flood waters and collection of sediment or debris.
15. "Hazard potential" means the probable incremental adverse consequences that result from the release of water or stored contents due to failure or improper operation of a dam or appurtenances.
16. "Hazard potential classification" means a system that categorizes dams according to the degree of probable incremental adverse consequences of failure or improper operation of a dam or appurtenances. The hazard potential classification does not reflect the current condition of the dam with regard to safety, structural integrity, or flood routing capacity.
17. "Height" means the vertical distance from the lowest elevation of the outside limit of the barrier at its intersection with the natural ground surface to the spillway crest elevation. For the purpose of determining jurisdictional status, the lowest elevation of the outside limit of the barrier may be the outlet pipe invert elevation if the outlet is constructed below natural ground.
18. "Impound" means to cause water or a liquid to be confined within a reservoir and held with no discharge.
19. "Incremental adverse consequences" means under the same loading conditions, the additional adverse consequences such as economic, intangible, lifeline, or human losses, that would occur due to the failure or improper operation of the dam over those that would have occurred without failure or improper operation of the dam.
20. "Inflow design flood" or "IDF" means the reservoir flood inflow magnitude selected on the basis of size and hazard potential classification for emergency spillway design requirements of a dam.
21. "Intangible losses" means incremental adverse consequences to property that are not economic in nature, including property related to social, cultural, unique, or resource-based values, including the loss of irreplaceable and unique historic and cultural features; long-lasting pollution of land or water; or long-lasting or permanent changes to the ecology, including fish and endangered species habitat identified and evaluated by a public natural resource management or protection agency.
22. "Jurisdictional dam" means a barrier that meets the definition of a dam prescribed in A.R.S. § 45-1201 that is not exempted by R12-15-1203 over which the Department of Water Resources exercises jurisdiction.
23. "Levee" means an embankment of earth, concrete, or other material used to prevent a watercourse from spreading laterally or overflowing its banks. A levee is not used to impound water.
24. "License" means license of final approval issued by the Director upon completion or enlargement of a dam under A.R.S. § 45-1209.
25. "Lifeline losses" mean disruption of essential services such as water, power, gas, telephone, or emergency medical services.
26. "Liquid-borne material" means mine tailings or other milled ore products transported in a slurry to a storage impoundment.
27. "Maximum credible earthquake" means the most severe earthquake that is believed to be possible at a point on the basis of geologic and seismological evidence.
28. "Maximum water surface" means the maximum elevation of the reservoir water level attained during routing of the inflow design flood.
29. "Natural ground surface" means the undisturbed ground surface before excavation or filling, or the undisturbed bed of the stream or river.
30. "Outlet works" means a closed conduit under or through a dam or through an abutment for the controlled discharge of the contents normally impounded by a dam and reservoir. The outlet works include the inlet and outlet structures appurtenant to the conduit. Outlet works may be controlled or uncontrolled.
31. "Probable" means likely to occur, reasonably expected, and realistic.
32. "Probable maximum flood" or "PMF" means the flood runoff expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region, including rain and snow where applicable. 1/2 PMF is that flood represented by the flood hydrograph with ordinates equal to 1/2 the corresponding ordinates of the PMF hydrograph.
33. "Probable maximum precipitation" means the greatest depth of precipitation for a given duration that is theoretically physically possible over a particular size storm area at a particular geographical location at a particular time of year.
34. "Reservoir" means any basin that contains or is capable of containing water or other liquids impounded by a dam.
35. "Residual freeboard" means the vertical distance between the highest water surface elevation during the inflow design flood and the lowest point at the top of the dam.
36. "Restricted storage" means a condition placed on a license by the Director to reduce the storage level of a reservoir because of a safety deficiency.
37. "Saddle dike or saddle dam" means any dam constructed in a topographically low area on the perimeter of a reservoir, required to contain the reservoir at the highest water surface elevation.
38. "Safe" means that a dam has sufficient structural integrity and flood routing capacity to make failure of the dam unlikely.
39. "Safe storage level" means the maximum reservoir water surface elevation at which the Director determines it is safe to impound water or other liquids in the reservoir.
40. "Safety deficiency" means a condition at a dam that impairs or adversely affects the safe operation of the dam.
41. "Safety inspection" means an investigation by an engineer or a person under the direction of an engineer to assess the safety of a dam and determine the safe storage level for a reservoir, which includes review of design reports, construction documents, and previous safety inspection reports of the dam, spillways, outlet facilities, seepage control and measurement systems, and permanent monument or monitoring installations.
42. "Spillway crest" means the highest elevation of the floor of the spillway along a centerline profile through the spillway.
43. "Storage capacity" means the maximum volume of water, sediment, or debris that can be impounded in the reservoir with no discharge of water, including the situation where an uncontrolled outlet becomes plugged. The storage capacity is reached when the water level is at the crest of the emergency spillway, or at the top of permanently mounted emergency spillway gates in the closed position. Storage capacity excludes dead storage below the natural ground surface.
44. "Surcharge storage" means the additional water storage volume between the emergency spillway crest or closed gates, and the top of the dam.
45. "Total freeboard" means the vertical distance between the emergency spillway crest and the top of the dam.
46. "Unsafe" means that safety deficiencies in a dam or spillway could result in failure of the dam with subsequent loss of human life or significant property damage.

Historical Note

Adopted effective November 2, 1978 (Supp. 78-6). Former Section R12-15-02 renumbered without change as Section R12-15-1202 effective October 8, 1982 (Supp. 82-5). Section repealed; new Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2). Amended to correct typographical error under A.A.C. R1-1-109 (Supp. 01-2).

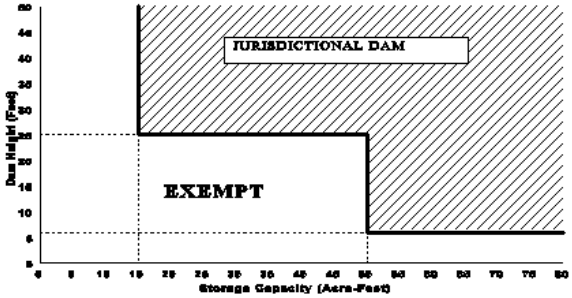
R12-15-1203. Exempt Structures

The following structures are exempt from regulation by the Department:
1. Any artificial barrier identified as exempt on Table 1 and defined as follows:
   a. Less than 6 feet in height, regardless of storage capacity.
   b. Between 6 and 25 feet in height with a storage capacity of less than 50 acre-feet.
   c. Greater than 25 feet in height with 15 acre-feet or less of storage capacity.
2. A dam owned by the federal government. A dam designed by the federal government for any non-federal entity or person that will subsequently be owned or operated by a person or entity defined as an owner in A.R.S. § 45-1201 is subject to jurisdiction, beginning with design and construction of the dam.
3. A dam owned or operated by an agency or instrumentality of the federal government, if a dam safety program at least as stringent as this Article is applicable to and enforced against the agency or instrumentality.
4. A transportation structure such as a highway, road, or railroad fill that exists solely for transportation purposes. A transportation structure designed, constructed, or modified with the intention of impounding water on an intermittent or permanent basis and meeting the definition of dam in A.R.S. § 45-1201 is subject to jurisdiction.
5. A levee constructed adjacent to or along a watercourse, primarily to control floodwater.
6. A self-supporting concrete or steel water storage tank.
7. An impoundment for the purpose of storing liquid-borne material.
8. A release-contained barrier as defined by A.R.S. § 45-1201(5).

Historical Note

Adopted effective November 2, 1978 (Supp. 78-6). Former Section R12-15-03 renumbered without change as Section R12-15-1203 effective October 8, 1982 (Supp. 82-5). Section repealed; new Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

Table 1. Exempt Structures



Historical Note
New Table adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1204. Provision for Guidelines
The Department may develop and adopt substantive policy statements that serve as dam safety guidelines to aid a dam owner or engineer in complying with this Article. The Department recommends that dam owners and engineers consult design guidelines published by agencies of the federal government, including the U.S. Bureau of Reclamation, the U.S. Army Corps of Engineers, the Natural Resources Conservation Service, and the Federal Energy Regulatory Commission, for the design of concrete, roller compacted concrete, stone masonry, timber, inflatable rubber, and mechanically-stabilized earth dams. The Director may require that other criteria be used or revise any of the specific criteria for the purpose of dam safety. An owner shall obtain advance approval by the Director of design criteria.

Historical Note
Adopted effective November 2, 1978 (Supp. 78-6). Former Section R12-15-04 renumbered without change as Section R12-15-1204 effective October 8, 1982 (Supp. 82-5). Section repealed; new Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1205. General Responsibilities
A. Each owner is responsible for the safe design, operation, and maintenance of a dam. The owner shall operate, maintain, and regularly inspect a dam so that it does not constitute a danger to human life or property. The owner of a high or significant hazard potential dam shall provide timely warning to the Department and all other persons listed in the emergency action plan of problems at the dam. The owner shall develop and maintain effective emergency action plans and coordinate those plans with local officials as prescribed in R12-15-1221.
B. The owner shall conduct frequent observation of the dam, as prescribed in the emergency action plan and as follows:
1. The owner shall increase the frequency of observation when the reservoir is full, during heavy rains or flooding, and following an earthquake.
2. The owner shall report to the Director any condition that threatens the safety of the dam as prescribed in R12-15-1224(A). The owner shall make the report as soon as possible, but not later than 12 hours after discovery of the conditions.
3. If dam failure appears imminent, the owner shall notify the county sheriff or other emergency official immediately.
4. The owner is responsible for the safety of the dam and shall take action to lower the reservoir if it appears that the dam has weakened or is in danger of failing.
C. The owner of a dam shall install, maintain, and monitor instrumentation to evaluate the performance of the dam. The Director shall require site-specific instrumentation that the Director deems necessary for monitoring the safety of the dam when failure may endanger human life and property. Conditions that may require monitoring include land subsidence, earth fissures, embankment cracking, phreatic surface, seepage, and embankment movements.
D. The owner shall perform timely maintenance and ordinary repair of a dam. The owner shall implement an annual plan to inspect the dam and accomplish the maintenance and ordinary repairs necessary to protect human life and property.
E. If a change of ownership of a dam occurs, the new owner shall notify the Department within 15 days after the date of the transaction and provide the mailing address and telephone number where the new owner can be contacted. Within 90 days after the date of the transaction, the new owner shall provide the name and telephone number of the individual or individuals who are responsible for operating and maintaining the dam.

Historical Note
Adopted effective November 2, 1978 (Supp. 78-6). Former Section R12-15-05 renumbered without change as Section R12-15-1205 effective October 8, 1982 (Supp. 82-5). Section repealed; new Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1206. Classification of Dams
A. Size Classification. Dams are classified by size as small, intermediate, or large. Size is determined with reference to Table 2. An owner or engineer shall determine size by storage capacity or height, whichever results in the larger size.
B. Hazard Potential Classification
1. The Department shall base hazard potential classification on an evaluation of the probable present and future incremental adverse consequences that would result from the release of water or stored contents due to failure or improper operation of the dam or appurtenances, regardless of the condition of the dam. The evaluation shall include land use zoning and development projected for the affected area over the 10 year period following classification of the dam. The Department considers all of the following factors in hazard potential classification: probable loss of human life, economic and lifeline losses, and intangible losses identified and evaluated by a public resource management or protection agency.
a. The Department bases the probable incremental loss of human life determination primarily on the number of permanent structures for human habitation that would be impacted in the event of failure or improper operation of a dam. The Department considers loss of human life unlikely if:
i. Persons are only temporarily in the potential inundation area;
ii. There are no residences or overnight campsites; and
iii. The owner has control of access to the potential inundation area and provides an emergency action plan with a process for warning in the event of a dam failure or improper operation of a dam.
b. The Department bases the probable economic, lifeline, and intangible loss determinations on the property losses, interruptions of services, and intangible losses that would be likely to result from failure or improper operation of a dam.
2. The 4 hazard potential classification levels are very low, low, significant, and high, listed in order of increasing probable adverse incremental consequences, as prescribed in Table 3. The Director shall classify intangible losses by considering the common or unique nature of features or habitats and temporary or permanent nature of changes.
a. Very Low Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life and would produce no lifeline losses and very low economic and intangible losses. Losses would be limited to the 100 year floodplain or property owned or controlled by the dam owner under long-term lease. The Department considers loss of life unlikely because there are no residences or overnight camp sites.
b. Low Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life, but would produce low economic and intangible losses, and result in no disruption of lifeline services that require more than cosmetic repair. Property losses would be limited to rural or agricultural property, including equipment, and isolated buildings.
c. Significant Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life but may cause significant or high economic loss, intangible damage requiring major mitigation, and disruption or impact on lifeline facilities. Property losses would occur in a predominantly rural or agricultural area with a transient population but significant infrastructure.
d. High Hazard Potential. Failure or improper operation of a dam would be likely to cause loss of human life because of residential, commercial, or industrial development. Intangible losses may be major and potentially impossible to mitigate, critical lifeline services may be significantly disrupted, and property losses may be extensive.
3. An applicant shall demonstrate the hazard potential classification of a dam before filing an application to construct. The Department shall review the applicant's demonstration early in the design process at pre-application meetings prescribed in R12-15-1207(D).
4. The Department shall review the hazard potential classification of each dam during each subsequent dam safety inspection and revise the classification in accordance with current conditions.

Historical Note
Adopted effective November 2, 1978 (Supp. 78-6). Former Section R12-15-06 renumbered without change as Section R12-15-1206 effective October 8, 1982 (Supp. 82-5). Section repealed; new Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

Exhibit A. Repealed

Historical Note
Exhibit repealed by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000; a Historical Note for Exhibit A did not exist before this date (Supp. 00-2).

Table 2. Size Classification

Category	Storage Capacity (acre-feet)	Height (feet)
Small	50 to 1,000	25 to 40
Intermediate	greater than 1,000 and not exceeding 50,000	higher than 40 and not exceeding 100

Large	greater than 50,000	higher than 100

Historical Note
New Table adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

Table 3. Downstream Hazard Potential Classification

Hazard Potential Classification	Probable Loss of Human Life	Probable Economic, Lifeline, and Intangible Losses
Very Low	None expected	Economic and lifeline losses limited to owner's property or 100-year floodplain. Very low intangible losses identified.
Low	None expected	Low
Significant	None expected	Low to high
High	Probable - One or more expected	Low to high (not necessary for this classification)

Historical Note
New Table adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1207. Application Process

A. An applicant shall obtain written approval from the Director before constructing, reconstructing, repairing, enlarging, removing, altering, or breaching a dam. Application requirements differ according to the hazard potential of the dam.
   1. To construct, reconstruct, repair, enlarge, or alter a high or significant hazard potential dam, the applicant shall comply with R12-15-1208.
   2. To breach or remove a high or significant hazard potential dam, the applicant shall comply with R12-15-1209.
   3. To construct, reconstruct, repair, enlarge, alter, breach, or remove a low hazard potential dam, the applicant shall comply with R12-15-1210.
   4. To construct, reconstruct, repair, enlarge, alter, breach, or remove a very low hazard potential dam, the applicant shall comply with R12-15-1211.

B. An application shall not be filed with the Director under the following circumstances:
   1. The dam is exempt under R12-15-1203;
   2. A dam owner starts repairs to an existing dam that are necessary to safeguard human life or property and the Director is notified without delay;
   3. The owner performs general maintenance or ordinary repairs as prescribed in R12-15-1217(A) or (B); or
   4. Breach, removal, or reduction of a very low hazard dam as prescribed in R12-15-1211(C).

C. An applicant is not required to comply with a requirement in this Article if the Director finds that, considering the site characteristics and the proposed design, the requirement is unduly burdensome or expensive and is not necessary to protect human life or property. The Director shall consider the size, hazard potential classification, physical site conditions, and applicability of a requirement to a proposed dam. The Director shall state in writing the reason or reasons the applicant is not required to comply with a requirement.

D. An applicant shall schedule pre-application conferences with the Department to discuss the requirements of this Article and to resolve issues essential to the design of a dam while the design is in preliminary stages. The Director shall view the dam site during the pre-application process. The following are examples of issues for pre-application conferences: the hazard potential classification, the approximate inflow design flood, the basic design concepts, and any requirements that may be found by the Director to be unduly burdensome or expensive and not necessary to protect human life or safety. In addition, the applicant may submit preliminary design calculations to the Department for review and comment. The Department shall comment as soon as practicable, depending on the size of the submittal and the current workload.

E. The Department shall review applications as follows:
   1. Applications will be received by appointment. During this meeting the Department shall make a brief review of the application to determine that the application contains each of the items required by R12-15-1208, R12-15-1209, R12-15-1210, or R12-15-1211.
   2. Following receipt of an application submitted under R12-15-1208, R12-15-1209, R12-15-1210, or R12-15-1211, the Director shall complete an administrative review as prescribed in R12-15-401(1) and notify the applicant in writing whether the application is administratively complete. If the application is not administratively complete, the notification shall include a list of additional information that is required to complete the application.
   3. After finding the application submitted under R12-15-1208, R12-15-1209, R12-15-1210, or R12-15-1211 administratively complete, the Director shall complete a substantive review as prescribed in R12-15-401(3) and notify the applicant in writing of the Director's approval or disapproval. If during this review period, the Director determines that there are defects in the application that would impact human life and property, a written notice of the defects shall be sent to the applicant.
   4. An applicant may request in writing that the Director expedite the review of an application by employing an expert consultant on a contract basis under A.R.S. § 45-104(D). The Director shall establish on-call contracts with expert consultants to facilitate the process of expediting review. The Director may retain a consultant to review all or a portion of the application as necessary to expedite the process in response to an owner's request or to comply with time-frame rules. Before conducting the review, the consultant shall provide the Director and the applicant with a proposed time schedule and cost estimate. If the applicant agrees to the consultant's proposal for an expedited review of an application and the Director employs the consultant, the applicant shall pay to the Department the cost of the consultant's services in addition to the application fees. The Director retains the authority to review and approve, disapprove, or modify the findings and recommendations of the consultant.
   5. The Director shall not approve an application in less than 10 days from the date of receipt.
   6. If the Director disapproves the application, the Director shall provide the applicant with a statement of the Director's objections.
   7. If the Director approves an application, the applicant shall submit in triplicate revised drawings and specifications that incorporate any required changes.
      a. The Director shall return to the applicant 1 set of final construction drawings and specifications with the Department's approval stamp to be retained onsite during construction;
      b. The Director shall retain for permanent state record 1 set of final construction drawings and specifications with the Department's approval stamp; and
      c. The Director shall retain for use by the Department during construction the 3rd set of final construction drawings and specifications with the Department's approval stamp.
   8. The Director shall impose conditions and limitations that the Director deems necessary to safeguard human life and property. Examples of the conditions of approval include but are not limited to:
      a. The applicant shall not cover the foundation or abutment with the material of the dam until the Department has been given notice and a reasonable time to inspect and approve them.
      b. The applicant shall start construction within 1 year from the date of approval.
      c. The applicant shall maintain a safe storage level for an existing dam being reconstructed, repaired, enlarged, altered, or breached.

F. An approval to construct a new dam or repair, enlarge, alter, breach, or remove an existing dam is valid for 1 year.
   1. If construction does not begin within 1 year, the approval is void.
   2. Upon written request and good cause shown by the owner, the time for commencing construction may be extended. An applicant shall not start construction before the Director reviews the application for changes and grants approval.

Historical Note
New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1208. Application to Construct, Reconstruct, Repair, Enlarge, or Alter a High or Significant Hazard Potential Dam

A. An application package to construct, reconstruct, repair, enlarge, or alter a high or significant hazard potential dam shall include the following prepared by or under the supervision of an engineer as defined in R12-15-1202(11).
   1. A completed application filed in duplicate on forms provided by the Director.
   2. A design information summary or checklist of items prepared in duplicate on forms provided by the Director.
   3. An initial application fee based on the total estimated project cost and computed in accordance with A.R.S. § 45-1204 and R12-15-151(B)(11).
   4. A detailed estimate of project costs. Project costs are all costs associated with construction of the dam and appurtenant works including preliminary investigations and surveys, engineering design, supervision of construction, and any other engineering costs.
   5. Two complete sets of construction drawings as prescribed in R12-15-1215(1).
   6. Two complete sets of construction specifications as prescribed in R12-15-1215(2).
   7. An engineering design report that includes information needed to evaluate all aspects of the design of the dam and appurtenances, including references with page numbers to support any assumptions used in the design, as prescribed in R12-15-1215(3). The engineering design report shall recommend a safe storage level for existing dams being reconstructed, repaired, enlarged, or altered.
   8. A construction quality assurance plan describing all aspects of construction supervision.
   9. A description of the use for the impounded or diverted water, proof of a right to appropriate, and a permit to store water as prescribed in A.R.S. §§ 45-152 and 45-161.
   10. A long-term budget plan and evidence of financing, prepared using customary accounting principles, that demonstrate that the applicant has the financial capability to construct, operate, and maintain the dam in a safe manner. If the applicant does not have evidence that can be verified by an independent audit of the financial capability to construct, operate, and maintain the dam in a safe manner, the Director may require a performance bond for the entire cost of the proposed construction work.

B. The following may be submitted with the application or during construction.
   1. An emergency action plan as prescribed in R12-15-1221.
   2. An operation and maintenance plan to accomplish the annual maintenance.
   3. An instrumentation plan regarding instruments that evaluate the performance of the dam.

Historical Note
New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1209. Application to Breach or Remove a High or Significant Hazard Potential Dam

A. An applicant shall excavate the dam down to the level of the natural ground at the maximum section. Upon approval of the Director, additional breaches may be made. This provision shall not

be construed to require more than total removal of the dam regardless of the flood magnitude. The breach or breaches shall be of sufficient width to pass the greater of:
1. The 100 year flood at a depth of less than 5 feet, or
2. The 100 year flood at a normal flood depth of not more than 2 feet at a distance of 2,000 feet downstream of the dam.

B. The sides of each breach shall be excavated to a slope ratio that is stable and not steeper than 1 horizontal to 1 vertical.

C. Each breach shall be designed to prevent silt that has previously been deposited on the reservoir bottom and the excavated material from the breach from washing downstream.

D. Before breaching the dam, the reservoir shall be emptied in a controlled manner that will not endanger lives or damage downstream property. The applicant shall obtain approval from the Director for the method of breaching or removal.

E. An application package to breach or remove a high or significant hazard potential dam shall include the following prepared by or under the supervision of an engineer as defined in R12-15-1202(11).
1. The construction drawing or drawings for the breach or removal of a dam, including the location, dimensions, and lowest elevation of each breach.
2. A long-term budget plan and evidence of financing, prepared using customary accounting principles, that demonstrate that the applicant has the financial capability to breach or remove the dam in a safe manner. If the applicant does not have evidence that can be verified by an independent audit of the financial capability to breach or remove the dam in a safe manner, the Director may require a performance bond for the entire cost of the proposed construction work.
3. A construction quality assurance plan describing all aspects of construction supervision.

F. Reduction of a high or significant downstream hazard potential dam to nonjurisdictional size may be approved by letter under the following circumstances:
1. The owner shall submit a completed application form and construction drawings for the reduction and the appropriate specifications, prepared by or under the supervision of an engineer as defined in R12-15-1202(11).
2. The construction drawings and specifications shall contain sufficient detail to enable a contractor to bid on and complete the project.
3. The plans shall comply with all requirements of this Section except that the breach is not required to be to natural ground.
4. Upon completion of an alteration to nonjurisdictional size, the engineer shall file as constructed drawings and specifications with the Department.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1210. Application to Construct, Reconstruct, Repair, Enlarge, Alter, Breach, or Remove a Low Hazard Potential Dam

A. An application package to construct, reconstruct, repair, enlarge, or alter a low hazard potential dam shall include the following prepared by or under the supervision of an engineer as defined in R12-15-1202(11).
1. A completed application filed in duplicate on forms provided by the Director.
2. An initial application fee based on the total estimated project cost, computed in accordance with A.R.S. § 45-1204 and R12-15-151(B)(11).
3. A detailed estimate of project costs. Project costs are all costs associated with construction of the dam and appurtenant works, including preliminary investigations and surveys, engineering design, supervision of construction, and any other engineering costs.
4. The seal and signature of the responsible engineer in accordance with A.A.C. R4-30-304.
5. A statement by the responsible engineer that classifies the dam as low hazard in accordance with R12-15-1206(B). The responsible engineer shall submit a map of the area that would be inundated by failure or improper operation of the dam. The responsible engineer shall demonstrate that failure or improper operation of the dam would be unlikely to result in:
   a. Loss of human life. The demonstration may be based on an emergency action plan for persons who may be in the area of inundation;
   b. Significant incremental adverse consequences; or
   c. Significant intangible losses, as defined in R12-15-1202(21) and identified and evaluated by a public natural resource management or protection agency.
6. Two complete sets of construction drawings as prescribed by R12-15-1215(1).
7. Two complete sets of construction specifications as prescribed by R12-15-1215(2).
8. An engineering design report that includes information needed to evaluate all aspects of the design of the dam and appurtenances, including references with page numbers to support any assumptions used in the design, as prescribed in R12-15-1215(3).
9. A description of the use for the impounded or diverted water, proof of a right to appropriate, and a permit to store water as prescribed in A.R.S. §§ 45-152 and 45-161.
10. A construction quality assurance plan clearly describing all aspects of construction supervision.
11. A long-term budget plan and evidence of financing, prepared using customary accounting principles, that demonstrate that the applicant has the financial capability to construct, operate, and maintain the dam in a safe manner. If the applicant does not have evidence that can be verified by an independent audit of the financial capability to construct, operate, and maintain the dam in a safe manner, the Director may require a performance bond for the entire cost of the proposed construction work.

B. An application package for the breach or removal of a low hazard potential dam shall include the following.
1. A completed application filed in duplicate on forms provided by the Director that contains the following information:
   a. The name and address of the owner of the dam or the agent of the owner.
   b. A description of the proposed removal.
   c. The proposed time for beginning and completing the removal.
2. An initial application fee based on the total estimated project cost and computed in accordance with A.R.S. § 45-1204 and R12-15-151(B)(11).
3. A statement by the responsible engineer demonstrating both of the following:
   a. That the dam will be excavated to the level of natural ground at the maximum section; and
   b. That the breach or breaches will be of sufficient width to pass the greater of:
      i. The 100 year flood at a depth of less than 5 feet, or
      ii. The 100 year flood at a normal flood depth of not more than 2 feet at a distance of 2,000 feet downstream of the dam.
      iii. Subsection (b) shall not be construed to require more than a total removal of the dam regardless of flood magnitude.
   c. That the sides of the breach will be excavated to a slope ratio that is stable and not steeper than 1 horizontal to 1 vertical.
4. A detailed estimate of project costs. Project costs are all costs associated with the removal of the dam and appurtenant works, including preliminary investigations and surveys, engineering design, supervision of removal, and any other engineering costs.

C. An applicant intending to reduce a low hazard potential dam to nonjurisdictional size shall submit a written notice to the Director at least no less than 60 days before the date that construction begins.

D. Within 45 days after receipt of a complete application package as prescribed by subsection (A) or (B), the Director shall either:
1. Determine that the dam falls within the low hazard potential classification; or
2. Issue a written notice that the dam does not fall within the low hazard potential classification.

E. The Director's determination that the proposed dam does not fall within the low hazard classification is an appealable agency action and subject to administrative and judicial review under A.R.S. Title 41, Chapter 6, Article 10.

F. Upon completion of construction, the owner shall notify the Department in writing. The owner shall not use the dam or reservoir before issuance of a license unless the Director issues written approval.

G. Within 90 days after completing construction, reconstruction, repair, enlargement, or alteration of a low hazard potential dam, the owner shall file the following.
1. An affidavit showing the actual cost of construction, reconstruction, repair, enlargement, or alteration of the dam. The owner shall submit a detailed accounting of the costs, including all engineering costs.
2. An additional fee or refund request computed in accordance with A.R.S. § 45-1209 and R12-15-151(B)(11), based on the actual cost of construction, reconstruction, repair, enlargement, or alteration.
3. A brief completion report summarizing the salient features of the project, including a description of the causes for any changes or deviations from the approved application package prepared by the engineer who supervised the construction, in accordance with A.R.S. Title 32, Chapter 1. The engineer shall indicate:
   a. That the dam has been designed and constructed in compliance with basic principles of dam construction currently being practiced in the industry;
   b. That the dam as constructed has structural integrity and flood routing capacity consistent with its hazard potential classification; and
   c. That the as constructed drawings and the report accurately represent the construction of the dam.
4. As constructed drawings prepared and sealed by the engineer who supervised the construction. The owner and the engineer shall maintain a record of the drawings.

H. Upon receiving the Director's written approval, the owner may operate the dam and appurtenant works. Within 30 days after receipt of the information in subsection (G), the Director shall issue to the owner either a license or a notice that the dam and appurtenant works shall not be operated because the dam and appurtenant works do not qualify as low hazard or were not built according to the submitted design. The license shall include conditions of operation, including:
1. The safe storage level of the reservoir;
2. A requirement that the dam be operated and maintained so that it does not constitute a danger to human life and property;
3. A requirement that the conditions resulting in the low hazard classification be maintained throughout the life of the dam; and
4. A requirement that the owner demonstrate in writing the low hazard classification in the manner prescribed by subsection (A)(5) every 5 years.

I. Within 90 days after completing removal of a low hazard potential dam, the owner shall file the following. The Director shall remove the dam from jurisdiction upon approval of the submittal.
1. An affidavit showing the actual cost of removal of the dam. The owner shall submit a detailed accounting of the costs, including all engineering costs.
2. An additional fee or refund request computed in accordance with A.R.S. § 45-1209 and R12-15-151(B)(11) based on the actual cost of removal.
3. A brief completion report, including a description of the causes for any changes or deviations from the approved application package prepared by the engineer who supervised the construction, in accordance with A.R.S. Title 32, Chapter 1. The engineer shall certify that the as removed drawings and the report accurately represent the actual removal of the dam.
4. As-removed drawings prepared and sealed by the engineer who supervised the removal. The owner and the engineer shall maintain a record of the drawings.

J. An owner shall immediately commence repairs necessary to safeguard human life and property and prevent failure and improper operation of a low hazard potential dam. The owner shall notify the Department as soon as reasonably possible and in all cases within 10 days of commencing the required repairs.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2). Amended by final rulemaking at 13 A.A.R. 3022, effective October 6, 2007 (Supp. 07-3).

R12-15-1211. Application to Construct, Reconstruct, Repair, Enlarge, Alter, Breach, or Remove a Very Low Hazard Potential Dam

A. An application package to construct, reconstruct, repair, enlarge, or alter a very low hazard potential dam shall include the following prepared by an engineer or a person under the supervision

of an engineer as defined in R12-15-1202(11).

1. A completed application filed in duplicate on forms provided by the Director that contains the following information:
   a. The name and address of the owner of the dam or the agent of the owner.
   b. The location, type, size, and height of the proposed dam and appurtenant works.
   c. The storage capacity of the reservoir associated with the proposed dam.
   d. The proposed time for beginning and completing construction.
   e. A description of the use for the impounded or diverted water and proof of a right to impound that water.
2. The means, plans, and specifications by which the stream or body of water is to be dammed, by-passed, or controlled during construction.
3. Maps, drawings, and specifications of the proposed dam.
4. An initial application fee based on the total estimated project cost and computed in accordance with A.R.S. § 45-1204 and R12-15-151(B)(11).
5. A detailed estimate of project costs. Project costs are all costs associated with construction of the dam and appurtenant works, including preliminary investigations and surveys, engineering design, supervision of construction, and any other engineering costs.
6. A statement by the responsible engineer that classifies the dam as very low hazard in accordance with R12-15-1206(B). The responsible engineer shall submit a map of the area that would be inundated by failure or improper operation of the dam. The responsible engineer shall demonstrate that failure or improper operation would be unlikely to result in:
   a. Loss of human life. The demonstration may be based on an emergency action plan for persons who may be in the area of inundation;
   b. Significant incremental adverse consequences; or
   c. Significant intangible losses, as defined in R12-15-1202(21) and identified and evaluated by a public natural resource management protection agency, because the dam has a size classification of either small or intermediate under R12-15-1206(A) and any release would be limited to the 100 year floodplain or property owned or controlled by the dam owner under long-term lease.
7. The seal and signature of the responsible engineer in accordance with A.R.S. Title 32, Chapter 1.
8. The drawings required by subsection (A)(3) shall include a plan view and maximum section of the dam; the outlet works; and the spillway plan, profile, and cross section.
9. The specifications required by subsection (A)(3) shall include the construction materials, testing criteria, and installation techniques.

B. The Director may make other requirements for drawings and specifications for the proposed repair or alteration of a very low hazard potential dam. In determining other requirements, the Director shall consider the size and extent of the repair or alteration, the portions of the dam that will be repaired or altered, and whether the requirements elicit a description of the proposed construction work that is adequate to allow the Director to evaluate the repair or alteration.

C. An owner intending to breach, remove, or reduce a very low hazard potential dam to nonjurisdictional size shall submit written notice to the Director at least 60 days before the date that construction begins.

D. After receipt of a complete application package as prescribed by subsection (A), the Director shall either:

1. Determine that the dam falls within the very low hazard classification and approve the application in writing; or
2. Issue a written notice that the dam does not fall within the very low hazard classification.

E. The Director's determination that the proposed dam does not fall within the very low hazard classification is an appealable agency action and subject to administrative and judicial review under A.R.S. Title 41, Chapter 6, Article 10.

F. Upon completion of construction, the owner shall notify the Department in writing. The owner shall not use the dam and reservoir before receipt of a license unless the Director issues written approval.

G. Within 90 days after completion of the construction, reconstruction, repair, enlargement, or alteration of a very low hazard potential dam, the owner shall file the following:

1. An affidavit showing the actual cost of construction, reconstruction, repair, enlargement, or alteration of the dam. The owner shall submit a detailed accounting of the costs, including all engineering costs.
2. An additional fee or refund request computed in accordance with A.R.S. § 45-1209 and R12-15-151(B)(11) based on the actual cost of construction, reconstruction, repair, enlargement, or alteration.
3. A brief completion report summarizing the salient features of the project, including a description of the causes for any changes or deviations from the approved application package prepared by the engineer who supervised the construction in accordance with A.R.S. Title 32, Chapter 1. The report shall include:
   a. That the dam has been designed and constructed in compliance with basic principles of dam construction currently being practiced in the industry;
   b. That the dam as constructed has structural integrity and flood routing capacity consistent with its hazard potential classification; and
   c. That the as constructed drawings and the report accurately represent the construction of the dam.
4. As constructed drawings prepared by the engineer who supervised the construction. The owner and the engineer shall maintain a record of the drawings.

H. Within 30 days after receipt of the information in subsection (G), the Director shall issue to the owner either a license or a notice that the dam and appurtenant works shall not be operated because the dam and appurtenant works do not qualify as very low hazard or were not built according to the submitted design. Upon receiving the Director's written approval, the owner may operate the dam and appurtenant works. The license shall include conditions of operation, including:

1. The safe storage level of the reservoir;
2. A requirement that the conditions resulting in the very low hazard classification be maintained throughout the life of the dam; and
3. A requirement that the owner demonstrate in writing the very low hazard classification in the manner prescribed by subsection (A)(6) every 5 years.

I. An owner shall immediately commence repairs necessary to safeguard human life and property and prevent failure or improper operation of a very low hazard potential dam. The owner shall notify the Department as soon as reasonably possible and in all cases within 10 days of commencing the required repairs.

J. The Department may periodically inspect construction to confirm that it is proceeding according to the approved design and that proper construction quality assurance is being exercised by the owner's engineer. The owner, or the owner's engineer under the direction of the owner, shall remedy any unsatisfactory condition using the contractor.

K. The owner shall provide the Department access to the dam site for purposes of inspecting all phases of construction, including the foundation, embankment and concrete placement, inspection and test records, and mechanical installations.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1212. Construction of a High, Significant, or Low Hazard Potential Dam

A. Before commencement of construction activities, the owner shall invite to a pre-construction conference all involved regulatory agencies, the prime contractor, and all subcontractors. At this meeting the Department shall identify, to the extent possible, the key construction stages at which an inspection will be made. At least 48 hours before each key construction stage identified for inspection, the owner or the owner's engineer shall provide notice to the Department.

B. The owner and the owner's engineer shall oversee construction of a new dam or reconstruction, repair, enlargement, alteration, breach, or removal of an existing dam. Failure to perform the work in accordance with the construction drawings and specifications approved by the Director renders the approval revocable. The owner's engineer shall exercise professional judgment independent of the contractor.

C. A professional engineer with proficiency in engineering and knowledge of dam technology shall supervise or direct the supervision of construction in accordance with the construction quality assurance plan.

D. The owner's engineer shall submit summary reports of construction activities and test results according to a schedule approved by the Department.

E. The owner shall immediately report to the Department any condition encountered during construction that requires a deviation from the approved plans and specifications.

F. The owner shall promptly submit a written request for approval of any necessary change and sufficient information to justify the proposed change. The owner shall not commence construction without the written approval of the Director unless the change is a minor change. A minor change is a change that complies with the requirements of this Article and provides equal or better safety performance.

G. Upon completion of construction, the owner shall notify the Department in writing. The Department shall make a final inspection. The owner shall correct any deficiencies noted during the inspection.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1213. Completion Documents for a Significant or High Hazard Potential Dam

Within 90 days after completion of the construction or removal work for a significant or high hazard potential dam and final inspection by the Department, the owner shall file the following.

1. An affidavit showing the actual cost of the construction. The owner shall submit a detailed accounting of the costs, including all engineering costs.
2. An additional fee or refund request based on the actual cost of the construction, computed in accordance with A.R.S. § 45-1209 and R12-15-151(B)(11).
3. One set of full sized as constructed drawings prepared and sealed by the engineer who supervised the construction. If changes were made during construction, the owner shall file supplemental drawings showing the dam and appurtenances as actually constructed.
4. Construction records, including grouting, materials testing, and locations and baseline readings for permanent bench marks and instrumentation, initial surveys, and readings.
5. Photographs of construction from exposure of the foundation to completion of construction.
6. A brief completion report summarizing the salient features of the project, including a description of the causes for any changes or deviations from the approved drawings and specifications that were made during the construction phase.
7. A schedule for filling the reservoir, specifying fill rates, water level elevations to be held for observation, and a schedule for inspecting and monitoring the dam. The owner shall monitor the dam monthly during the first filling.
8. An operating manual for the dam and its appurtenant structures. The operating manual shall include a process for safety inspections prescribed in R12-15-1219. The operating manual shall include schedules for surveillance activities and baseline information for any installed instrumentation as follows:
   a. The frequency of monitoring;
   b. The data recording format;
   c. A graphical presentation of data; and
   d. The person who will perform the work.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1214. Licensing

A. Upon review and approval of the documents filed under R12-15-1213 and finding that the construction at the dam has been completed in accordance with the approved plans and specifications and finding that the dam is safe, the Director shall issue a license. The license shall specify the safe storage level for the reservoir and shall specify conditions for the safe operation of the dam. The dam and reservoir shall not be used before issuance of a license unless the Director issues written approval. Procedures for issuance of a license for low and very low hazard potential dams are prescribed in R12-15-1210(H) and R12-15-1211(H), respectively.

B. A new license shall be issued in the following instances:

1. Upon change of ownership of a dam.
2. Upon change of the safe storage level.
3. Upon expiration of time to appeal a notice issued under R12-15-1223(B).
4. Upon expiration of time to appeal an order issued by the Director under R12-15-1223(D).
5. Upon expiration of time to appeal an order of a court.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1215. Construction Drawings, Construction Specifications, and Engineering Design Report for a High, Significant, or Low Hazard Potential Dam

The owner and engineer are responsible for complete and adequate design of a dam and for including in the application all aspects of the design pertaining to the safety of the dam.

1. Construction Drawing Requirements. The construction drawings required by R12-15-1208(5), R12-15-1209(E)(1), and R12-15-1210(A)(6) shall include the following:
   a. The seal and signature of the responsible engineer in accordance with A.A.C. R4-30-304.
   b. One or more topographic maps of the dam, spillway, outlet works, and reservoir on a scale large enough to accurately locate the dam and appurtenances, indicate cut and fill lines, and show the property lines and ownership status of the land. Contour intervals shall be compatible with the height and size of the dam and its appurtenances and shall show design and construction details.
   c. A reservoir area and capacity curve that reflect area in acres and capacity in acre-feet in relation to depth of water and elevation in the reservoir. The construction drawings shall show the spillway invert and top of dam elevations. The construction drawings shall also show the reservoir volume and space functional allocations. The construction drawings may include alternate scales as required for the owner's use.
   d. Spillway and outlet works rating curves and tables at a scale or scales that allow determination of discharge rate in cubic feet per second at both low and high flows as measured by depth of water passing over the spillway control section.
   e. A location map showing the dam footprint and all exploration drill holes, test pits, trenches, adits, borrow areas, and bench marks with elevations, reference points, and permanent ties. This map shall use the same vertical and horizontal control as the topographic map.
   f. Geologic information including 1 or more geologic maps, profile along the centerline, and other pertinent cross sections of the dam site, spillway or spillways, and appurtenant structures, aggregate and material sources, and reservoir area at 1 or more scales compatible with the site and geologic complexity, showing logs of exploration drill holes, test pits, trenches, and adits.
   g. One or more plans of the dam to delineate design and construction details.
   h. Foundation profile along the dam centerline at a true scale where the vertical scale is equal to the horizontal scale, showing the existing ground and proposed finished grade at cut and fill elevations, including anticipated geologic formations. The foundation profile shall include any proposed grout and drain holes.
   i. Profile and a sufficient number of cross sections of the dam to delineate design and construction details. The drawings shall illustrate and show dimensions of camber, details of the top, core zone, interior filters and drains, and other zone details. The profile of the dam may be drawn to different horizontal and vertical scales if required for detail. A maximum section of the dam shall be drawn to a true scale, where the vertical scale is equal to the horizontal scale. The outlet conduit may be shown on the maximum section if this is typical of the proposed construction.
   j. One or more dam foundation plans showing excavation grades and cut slopes with any proposed foundation preparation, grout and drain holes, and foundation dewatering requirements.
   k. Plan, profile, and details of the outlet works, including the intake structure, the gate system, conduit, trashrack, conduit filter diaphragm, conduit concrete encasement, and the downstream outlet structure. The drawings shall include all connection and structural design details.
   l. Plan, profile, control section, and cross sections of the spillway, including details of any foundation preparation, grouting, or concrete work that is planned. A complex control structure, a concrete chute, or an energy dissipating device for a terminal structure shall include both hydraulic and structural design details.
   m. Hydrologic data, drainage area and flood routing, and diversion criteria.
2. Construction Specification Requirements. The construction specifications required by R12-15-1208(6) and R12-15-1210(A)(7) shall include the following:
   a. The seal and signature of the responsible engineer in accordance with A.A.C. R4-30-304.
   b. The statement that the construction drawings and specifications shall not be materially changed without the prior written approval of the Director.
   c. A detailed description of the work to be performed and a statement of the requirements for the various types of materials and installation techniques that will enter into the permanent construction.
   d. The statement that construction shall not be considered complete until the Director has approved the construction in writing.
   e. The statement that the owner's engineer shall control the quality of construction.
   f. The following construction information:
      i. All earth and rock material descriptions, placement criteria, and construction requirements for all elements of the dam and related structures.
      ii. All concrete, grout, and shotcrete material and mix descriptions, placement and consolidation criteria, temperature controls, and construction requirements for all elements of the dam and related structures.
      iii. Material criteria and material testing, cleaning, and treatment. If foundation or curtain grouting is required, the specifications shall describe the type of grout, grouting method, special equipment necessary, recording during grouting, and foundation monitoring to avoid disturbance from grouting.
      iv. All materials testing that will be performed by the contractor for pre-qualification of materials, including special performance testing, such as water pressure tests in conduits. The Director shall accept materials that are pre-tested successfully and constructed in-place in accordance with specifications.
      v. A plan for control or diversion of surface water during construction. The design engineer may determine frequency of storm runoff to be controlled during construction, commensurate with the risk of economic loss during construction.
      vi. Criteria for blast monitoring and acceptable blast vibration levels, including particle velocities for the dam and other critical appurtenances. Monitoring equipment and monitoring locations shall be specified.
      vii. Instrumentation material descriptions, placement criteria, and construction requirements and a statement that instrumentation shall be installed by experienced speciality subcontractors.
3. Engineering Design Report Requirements. The engineering design report required by R12-15-1208(7) and R12-15-1210(A)(8) shall include the following:
   a. The seal and signature of the responsible engineer in accordance with A.A.C. R4-30-304.
   b. The classification under R12-15-1206 of the proposed dam, or for the proposed enlargement of an existing dam or reservoir.
   c. Hydrologic considerations, including calculations and a summary table of data used in determining the required emergency spillway capacity and freeboard, and design of any diversion or detention structures. The design report shall include input and output listings on both hard copy and computer diskette.
   d. Hydraulic characteristics, engineering data, and calculations used in determining the capacities of the outlet works and emergency spillway. The design report shall include input and output listings on both hard copy and computer diskette.
   e. Geotechnical investigation and testing of the dam site and reservoir basin. Results and analysis of subsurface investigations, including logs of test borings and geologic cross sections.
   f. Guidelines and criteria for blasting to be used by the contractor in preparing the blasting plan.
   g. Details of the plan for control or diversion of surface water during construction.
   h. Details of the dewatering plan for subsurface water during construction.
   i. Testing results of earth and rock materials, including the location of test pits and the logs of these pits.
   j. Discussion and design of the foundation blanket grouting, grout curtain, and grout cap based on foundation stability and seepage considerations.
   k. Calculations and basic assumptions on loads and limiting stresses for reinforced concrete design. The design report shall include input and output listings on both hard copy and computer diskette.
   l. A discussion and stability analysis of the dam including appropriate seismic loading, safety factors, and embankment zone strength characteristics. Analyses shall include both short-term and long-term loading on upstream and downstream slopes. The design report shall include input and output listings on both hard copy and computer diskette.
   m. A discussion of seismicity of the project area and activity of faults in the vicinity. The design report shall use both deterministic and statistical methods and identify the appropriate seismic coefficient for use in analyses.
   n. Discussion and design of the cutoff trench based on seepage and other considerations.
   o. Permeability characteristics of foundation and dam embankment materials, including calculations for seepage quantities through the dam, the foundation, and anticipated in the internal drain system. The design report shall include input and output listings on both hard copy and computer diskette. The design report shall include copies of any flow nets used.
   p. Discussion and design of internal drainage based on seepage quantity calculations. The design report shall include instrumentation necessary to monitor the drainage system and filter design calculations for protection against piping of foundation and embankment.
   q. Erosion protection against waves and rainfall runoff for both the upstream and downstream slopes, as appropriate.
   r. Discussion and design of foundation treatment to compensate for geological weakness in the dam foundation and abutment areas and in the spillway foundation area.
   s. Post-construction vertical and horizontal movement systems.
   t. Discussion of foundation conditions including the potential for subsidence, fissures, dispersive soils, collapsible soils, and sink holes.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1216. Design of a High, Significant, or Low Hazard Potential Dam

A. General Requirements.

1. Emergency Spillway Requirements. An applicant shall:
   a. Construct each spillway in a manner that avoids flooding in excess of the flooding that would have occurred in the same location under the same conditions before construction. The owner of a dam shall demonstrate that a spillway discharge would not result in incremental adverse consequences. In determining whether a spillway discharge of a dam would result in incremental adverse consequences, the Director shall evaluate whether the owner has taken any or all of the following actions: issuing public notice to downstream property owners, complying with flood insurance requirements, adopting emergency action plans, conducting mock flood drills, acquiring flow easements or other acquisitions of real property, or other actions appropriate to safeguard the dam site and flood channel.
   b. Include a control structure to avoid head cutting and lowering of the spillway crest for spillways excavated in soils or soft rock. In the alternative, the design may provide evidence acceptable to the Director that erosion during the inflow design flood will not result in a sudden release of the reservoir.
   c. Provide each spillway and channel with a minimum width of 10 feet and suitable armor to prevent erosion during the discharge resulting from the inflow design flood.
   d. Ensure that downstream spillway channel flows do not encroach on the dam unless suitable erosion protection is constructed.
   e. Ensure that each spillway, in combination with outlets, is able to safely pass the peak discharge flow rate, as calculated on the basis of the inflow design flood.
   f. Not construct bridges or fences across a spillway unless the construction is approved in writing by the Director. The Director's approval may include conditions regarding the design and operation of the spillway and fencing, based on safety concerns.
   g. Not use a pipe or culvert as an emergency spillway unless the Director approves the use following review of the dam design and site characteristics.
2. Inflow Design Flood Requirements
   a. Unless directed otherwise in writing by the Director, the inflow design flood requirements for determining the spillway minimum capacity are stated in Table 4.
   b. As an alternative to the requirements prescribed in Table 4, the Director may accept an inflow design flood determined by an incremental damage assessment study, based on the relative safety of the alternatives.
   c. The Director may accept site-specific probable maximum precipitation studies in determination of the inflow design flood.
   d. An applicant shall ensure that the total freeboard is the largest of the following:
      i. The sum of the inflow design flood maximum water depth above the spillway crest plus wave run up.
      ii. The sum of the inflow design flood maximum water depth above the spillway crest plus 3 feet.
      iii. A minimum of 5 feet.
3. Outlet Works Requirements. An applicant shall ensure that a dam has a low level outlet works that:
   a. Is capable of draining the reservoir to the sediment pool level. A low level outlet works for a high or significant hazard potential dam shall be a minimum of 36 inches in diameter. A low level outlet works for a low hazard potential dam shall be a minimum of 18 inches in diameter.
   b. For a high or significant hazard potential dam, has the capacity to evacuate 90% of the storage capacity of the reservoir within 30 days, excluding reservoir inflows.
   c. Has a filter diaphragm or other current practice measures to reduce the potential for piping along the conduit.
   d. Has accessible outlet controls when the spillway is in use.
   e. Has an emergency manual override system or can be operated manually.
   f. Is constructed of materials appropriate for loading condition, seismic forces, thermal expansion, cavitation, corrosion, and potential abrasion. The applicant shall not use corrugated metal pipes or other thin-walled pipes except as a form for a cast-in-place concrete conduit. The applicant shall construct outlet conduits of cast-in-place reinforced concrete. The applicant shall design each outlet to maintain water tightness. The applicant shall construct each outlet to prevent the occurrence of piping adjacent to the outlet.
   g. Has an operating or guard gate on the upstream end of any gated outlet.
   h. Has an outlet conduit near the base of 1 of the abutments on native bedrock or other competent material. The applicant shall support the entire length of the conduit on foundation materials of uniform density and consistency to prevent adverse differential settlement.
   i. Has an upstream valve or gate capable of controlling the discharge through all ranges of flow on any gated outlet conduit.
   j. Has a trashrack designed for a minimum of 25% of the reservoir head to which it would be subjected if completely clogged at the upstream end of the outlet.
   k. Has an air vent pipe just downstream of the control gate. The applicant shall include a blow-off valve at or near the downstream toe of the dam for an outlet conduit that is connected directly to a distribution system.
   l. Has an outlet conduit designed for internal pressure equal to the full reservoir head and for superimposed embankment loads, acting separately.
4. Dam Site And Reservoir Area Requirements
   a. An applicant shall demonstrate that reservoir storage during the inflow design flood will not result in incremental adverse consequences and that the design will not result in the inundation or wave damage of properties within the reservoir, except marina-type structures, during the inflow design flood. In determining whether a discharge will result in incremental adverse consequences, the Director shall evaluate whether the owner has taken any or all of the following actions: issuing public notice to upstream affected property owners, complying with flood insurance requirements, adopting emergency action plans, conducting mock flood drills, acquiring flood easements or other acquisitions of real property, or other actions appropriate to safeguard the dam site and reservoir. Permanent habitations are not allowed within the reservoir below the spillway elevation.
   b. The applicant shall clear the reservoir storage area of logs and debris.
   c. The applicant shall place borrow areas a safe distance from the upstream toe and the downstream toe of the dam to prevent a piping failure of the dam.
   d. The applicant shall keep the top of the dam and appurtenant structures accessible by equipment and vehicles for emergency operations and maintenance.
5. Geotechnical Requirements
   a. The applicant shall provide an evaluation of the static stability of the foundation, dam, and slopes of the reservoir rim and demonstrate that sufficient material is available to construct the dam as designed.
   b. The applicant shall not construct a dam on active faults, collapsible soils, dispersive soils, sink holes, or fissures, unless the applicant demonstrates that the dam can safely withstand the anticipated offset or other unsafe effects on the dam.
6. Seismic Requirements
   a. The applicant shall submit a review of the seismic or earthquake history of the area around the dam within a radius of 100 miles to establish the relationship of the site to known faults and epicenters. The review shall include any known earthquakes and the epicenter locations and magnitudes of the earthquakes.
   b. The applicant shall identify the location of active or potentially active faults that have experienced Holocene or Late Pleistocene displacement within a radius of 100 miles of the site.
   c. For a high or significant hazard potential dam, the applicant shall design the dam to withstand the maximum credible earthquake.
   d. For a low hazard potential dam, the applicant shall use probabilistic or deterministic methods to determine the design earthquake. The magnitude of the design earthquake shall vary with the size of the dam, site condition, and specific location.

B. Embankment Dam Requirements.
1. Geotechnical Requirements. Table 5 states minimum factors of safety for embankment stability under various loading conditions. For an embankment dam an applicant shall provide a written analysis of minimum factors of safety for stability.
   a. The analysis of minimum factors of safety shall include the effects of anisotropy on the phreatic surface position by using a ratio of horizontal permeability to vertical permeability of at least 10. The Director may require ratios of up to 100 if the material types and construction techniques will cause excessive stratification.
   b. The applicant shall use tests modeling the conditions being analyzed to determine the strengths used in the stability analysis. The stability analysis shall include total and effective stress strengths appropriate for the different material zones and conditions analyzed. The stability analysis shall use undrained strengths or strength parameters for all saturated materials.
   c. The applicant shall perform an analysis of the upstream slope stability for a partial pool with steady seepage considering the reservoir level that provides the lowest factor of safety.
   d. A stability analysis is not required for low hazard potential dams if the owner or the owner's engineer demonstrates that conservative slopes and competent materials are included in the design.
2. Seismic Requirements
   a. The applicant shall determine the seismic characteristics of the site as prescribed in subsection (A)(6).
   b. The applicant shall determine the liquefaction susceptibility of the embankment, foundation, and abutments. The applicant shall use standard penetration testing, cone penetration testing, shear wave velocity measurements, or a combination of these methods to make this determination. The applicant shall compute the minimum factor of safety against liquefaction at specific points and make a determination of whether the overall site is subject to liquefaction.
   c. The applicant shall determine the safety of the dam under seismic loading using a pseudo static stability analysis, computing the minimum factor of safety if the embankment, foundation or abutment is not subject to liquefaction and has a maximum peak acceleration of 0.2g or less, or a maximum peak acceleration of 0.35g or less, and consists of clay on a clay or bedrock foundation. The applicant shall use in the pseudo static stability analysis a pseudo static coefficient that is at least 60% of the maximum peak bedrock acceleration at the site.
   d. The applicant shall compute a minimum factor of safety against overtopping due to deformation and settlement in each of the following cases. The minimum factor of safety against overtopping can be no less than 2.5, determined by dividing the total pre-earthquake freeboard by the estimated vertical settlement in feet. The applicant shall determine the total vertical settlement by adding the settlement values of the upstream and downstream slopes.
      i. The minimum factor of safety in a pseudo static analysis is less than 1.0;
      ii. An embankment, foundation, or abutment is not subject to liquefaction, has a maximum peak acceleration of more than 0.2g or a maximum peak acceleration of more than 0.35g and consists of clay on a clay or bedrock foundation; or
      iii. The embankment, foundation or abutment is subject to liquefaction.
   e. The applicant shall perform a liquefaction analysis to establish approximate boundaries of liquefiable zones and physical characteristics of the soil following liquefaction for an embankment, foundation, or abutment subject to liquefaction. The applicant shall perform an analysis of the potential for flow liquefaction.
   f. Other, more sophisticated analytical procedures may be required by the Director for sites with high seismicity or low strength embankment or foundation soils.
3. Miscellaneous Design Requirements
   a. The design of any significant or high hazard potential dam shall provide seepage collection and prevent internal erosion or piping due to embankment cracking or other causes.
   b. The Director shall review the filter and permeability design for a chimney drain, drain blanket, toe drain, or outlet conduit filter diaphragms on the basis of unique site characteristics.
      i. The minimum thickness of an internal drain is 3 feet.
      ii. The minimum width of a chimney drain is 6 feet.
      iii. The applicant shall filter match an internal drain to its adjacent material.
      iv. The applicant shall design internal drains with sufficient capacity for the expected drainage without the use of drainpipes using only natural granular materials.
   c. The use of a geosynthetic is not permitted in a design if it serves as the sole defense against dam failure. The use of geotextiles and geonets as a filter or drain material or a

geomembrane liner is permitted only in a location that is easily accessible for repair or if its excavation cannot create an unsafe condition at the dam. A geosynthetic liner is allowed under special conditions and in specific situations if it is subject to monitoring and redundant safety controls. The Director may impose conditions, including monitoring appropriate to the hazard classification, inspection, and necessary repairs, each performed every 5 years.

d. The applicant shall use armoring on any upstream slope of an embankment dam that impounds water for more than 30 days at a time. If the applicant uses rock riprap, it shall be well-graded, durable, sized to withstand wave action, and placed on a well-graded pervious sand and gravel bedding or geotextile with filtering capacity appropriate for the site.

e. The applicant shall protect the downstream slopes and groins of an embankment dam from erosion.

f. The minimum width of the top of an embankment dam is equal to the structural height of the dam divided by 5 plus an additional 5 feet. The required minimum width for any embankment dam is 12 feet. The maximum width for any embankment dam is 25 feet.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

Table 4. Inflow Design Flood

Dam Hazard Class	Dam Size Classification	IDF Magnitude
Very Low	All Sizes	100-year
Low	All Sizes	0.25 PMF
Significant	Small	0.25 PMF
	Intermediate	0.5 PMF
	Large	0.5 PMF
High*	All Sizes	*

* For a high hazard potential dam, the applicant shall design the dam to withstand an inflow design flood that varies from .5 PMF to the full PMF, with size increasing based on persons at risk and potential for downstream damage. The applicant shall consider foreseeable future conditions.

Historical Note

New Table adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

Table 5. Minimum Factors of Safety for Stability1

Embankment Loading Condition	Minimum Factor of Safety
End of construction case - upstream and downstream slopes	1.3
End of construction case for embankments greater than 50 feet in height on weak foundations	1.4
Steady state seepage - upstream (critical partial pool) and downstream slope (full pool)	1.5
Instantaneous drawdown - upstream slope	1.2

1 Not applicable to an embankment on a clay shale foundation.

Historical Note

New Table adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1217. Maintenance and Repair; Emergency Actions

A. An owner shall perform general maintenance and ordinary repairs that do not impair the safety of the dam. General maintenance and ordinary repair activities listed under this subsection do not require prior approval of the Director. These repair activities include:
1. Removing brush or tall weeds.
2. Cutting trees and removing slash from the embankment or spillway. Small stumps may be removed provided no excavation into the embankment occurs.
3. Exterminating rodents by trapping or other methods. Rodent damage may be repaired provided it does not involve excavation that extends more than 2 feet into the embankment and replacement materials are compacted as they are placed.
4. Repairing erosion gullies less than 2 feet deep on the embankment or in the spillway.
5. Grading the surface on the top of the dam embankment or spillway to eliminate potholes and provide proper drainage, provided the freeboard is not reduced.
6. Placing additional riprap and bedding on the upstream slope, or in the spillway in areas that have sustained minor damage and restoring the original riprap protection where the damage has not yet resulted in erosion and weakening of the dam.
7. Painting, caulking, or lubricating metal structures.
8. Patching or caulking spalled or cracked concrete to prevent deterioration.
9. Removing debris, rock, or earth from outlet conduits or spillway channels and basins.
10. Patching to prevent deterioration within outlet works.
11. Replacing worn or damaged parts on outlet valves or controls to restore them to original condition or its equivalent.
12. Repairing or replacing fences intended to keep traffic or livestock off the dam or spillway.

B. General maintenance and ordinary repair that may impair or adversely effect safety, such as excavation into or near the toe of the dam, construction of new appurtenant structures for the dam, and repair of damage that has already significantly weakened the dam shall be performed in accordance with this Article. The Director may approve maintenance performed according to a standard detail or method of repair on file with the Department upon submittal of a letter. The Director shall determine whether general maintenance and ordinary repair activities not listed in subsection (A) will impair safety.

C. Emergency actions not impairing the safety of the dam may be taken before guidance can be provided by an engineer and do not require prior approval of the Director. Emergency actions do not excuse an owner's responsibility to promptly undertake a permanent solution. Emergency actions include:
1. Stockpiling materials such as riprap, earth fill, sand, sandbags, and plastic sheeting.
2. Lowering the reservoir level by making releases through the outlet or a gated spillway, by pumping, or by siphoning.
3. Armoring eroded areas by placing sandbags, riprap, plastic sheeting, or other available material.
4. Plugging leakage entrances on the upstream slope.
5. Increasing freeboard by placing sandbags or temporary earth fill on the dam.
6. Diverting flood waters to prevent them from entering the reservoir basin.
7. Constructing training berms to control flood waters.
8. Placing sandbag ring dikes or reverse filter materials around boils at the downstream toe to provide back pressure.
9. Removing obstructions from outlet or spillway flow areas.

D. Emergency actions impairing the safety of the dam require prior approval of the Director. An owner shall not lower the water level by excavating the spillway or embankment unless failure is imminent.

E. For all high and significant hazard potential dams, the emergency action plan shall be implemented with any emergency actions taken at the dam.

F. The owner shall notify the Director immediately of any emergency condition that exists and any emergency action taken.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1218. Safe Storage Level

The Director has the authority to determine the safe storage level for the reservoir behind each dam, including the storage level of an existing dam while it is being repaired, enlarged, altered, breached, or removed. The elevation of the safe storage level is stated on the license. The owner shall not store water in excess of the level determined by the Director to be safe. The owner shall not place flashboards or other devices in the emergency spillway without approval of an alteration of the dam in accordance with this Article.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1219. Safety Inspections

A. Except as provided in subsection (E), the Director shall conduct a dam safety inspection annually or more frequently for each high hazard potential dam, triennially for each significant hazard potential dam, and once every 5 years for each low and very low hazard potential dam.

B. An engineer is considered qualified to provide information to the Director regarding the safe storage level of a reservoir if the engineer:
1. Meets the criteria in R12-15-1202(11);
2. Has 3 years of experience in the field of dam safety; and
3. Has actual experience in conducting dam safety inspections.

C. A dam safety inspection includes:
1. Review of previous inspections, reports, and drawings;
2. Inspection of the dam, spillways, outlet facilities, seepage control, and measurement systems;
3. Inspection of any permanent monument or monitoring installations;
4. Assessment of all parts of the dam that are related to the dam's safety; and
5. A recommendation regarding the safe storage level of the reservoir.

D. The engineer shall submit a safety inspection report that describes the findings and lists actions that will improve the safety of the dam. The report shall include the engineer's recommendation of the safe storage level. The engineer shall use a report form approved by the Director.
E. Inspections by the Owner
1. An owner may provide to the Director, at the owner's expense, a safety inspection report that complies with the requirements of subsections (B), (C), and (D) in place of an inspection by the Department. The owner's engineer shall notify the Director and submit a written summary of the engineer's qualifications at least 14 days before the scheduled safety inspection.
2. The Director may refuse to accept an inspection that does not conform to this Article.
F. Inspections by the Department
1. The Director may enter at reasonable times upon private or public property and the owner shall permit such entry, where a dam is located, including a dam under construction, reconstruction, repair, enlargement, alteration, breach, or removal, for any of the following purposes:
a. To enforce the conditions of approval of the construction drawings and specifications related to an application for construction, reconstruction, repair, enlargement, alteration, breach, or removal.
b. To inspect a dam that is subject to this Article.
c. To investigate or assemble data to aid review and study of the design and construction of dams, reservoirs, and appurtenances or make watershed investigations to facilitate decisions on public safety to fulfill the duties of A.R.S. § 45-1214.
d. To ascertain compliance with this Article and A.R.S. Title 45, Chapter 6.
2. Upon receipt of a complaint that a dam is endangering people or property:
a. The Director shall inspect the dam unless there is substantial cause to believe the complaint is without merit.
b. If the complainant files a complaint in writing and deposits with the Director sufficient funds to cover the costs of the inspection, the Director shall make an inspection.
c. The Director shall provide a written report of the inspection to the complainant and the dam owner.
d. If an unsafe condition is found, the Director shall cause it to be corrected and return the deposit to the complainant. If the complaint was without merit the deposit shall be paid into the general fund.
3. The Director may employ qualified on-call consultants to conduct inspections.
4. Inspections under subsection (A) shall comply with the requirements of A.R.S. § 41-1009.

Historical Note
New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1220. Existing Dams
A. The requirements of this Article apply to existing dams, except as provided in subsections (B) and (C).
B. If the Director has determined that an existing dam is in a safe condition, the owner is not required to comply with R12-15-1216 unless the Director determines that it is cost effective to upgrade the dam to comply with the requirements of R12-15-1216 at the time a major alteration or major repair is planned. In determining whether it is cost effective to upgrade a dam, the Director shall consider:
1. The hazard potential classification of the dam;
2. Whether the cost of the upgrade would exceed 25% of the total cost of the major alteration or major repair; and
3. Whether there is a more cost effective alternative that would provide an equivalent increase in safety.
C. If the Director has determined that a dam is in an unsafe condition, the owner shall comply with the requirements in R12-15-1216. The owner is not required to comply with a requirement in this Article if the Director finds that, considering the site characteristics and the proposed design, the requirement is unduly burdensome or expensive and is not necessary to protect human life or property. The Director shall consider the size, hazard potential classification, physical site conditions, and applicability of a requirement to the dam. The Director shall state in writing the reason or reasons the owner is not required to comply with a requirement.
D. The owner shall ensure that installation of utilities beneath or through an existing dam is accomplished by open cuts or jacking and boring methods.

Historical Note
New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1221. Emergency Action Plans
A. Each owner of a high or significant hazard potential dam shall prepare, maintain, and exercise a written emergency action plan for immediate defensive action to prevent failure of the dam and minimize any threat to downstream development. The emergency action plan shall contain a:
1. Notification chart showing the priority for notification in an emergency situation. The owner shall notify local emergency response agencies, affected downstream populations, county emergency management agencies, and affected flood control districts;
2. Description of the demand reservoir and scope of the emergency action plan;
3. Delineation of potentially unsafe conditions, evaluation procedures, and triggering events that require the initiation of partial or full emergency notification procedures, based on the urgency of the situation;
4. Delineation of areas of responsibility of the owner and other parties. The emergency action plan shall clearly identify individuals responsible for notifications and declaring an emergency;
5. Specific notification procedure for each emergency situation anticipated;
6. Description of emergency supplies and resources, equipment access to the site, and alternative means of communication. The emergency action plan shall also identify specific preparedness activities required, such as annual full or partial mock exercises and updates of the emergency action plan; and
7. Map showing the area that would be subject to flooding due to spillway flows and dam failures.
B. The owner shall use the Director's model emergency action plan, which is available at no cost, or an equivalent model, for guidance in preparing the emergency action plan.
C. The owner shall submit a copy of the proposed emergency action plan for review by the Arizona Division of Emergency Management and all local emergency coordinators involved in the plan. The owner shall incorporate appropriate recommendations generated by the reviews and submit the revised emergency action plan to the Department.
D. The owner shall review and update the emergency action plan annually or more frequently to incorporate changes such as new personnel, changing roles of emergency agencies, emergency response resources, conditions of the dam, and information learned from mock exercises. The owner shall send updated portions of the plan to persons and agencies holding copies of the plan within 15 days after preparation of an update.

Historical Note
New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1222. Right of Review
A. An applicant or owner aggrieved by a decision of the Director regarding the determination of hazard classification, jurisdictional status, or the Director's application of this Article may seek review of an appealable agency action under A.R.S. Title 41, Chapter 6, Article 10.
B. An applicant or owner aggrieved by a decision of the Director that requires the exercise of professional engineering judgment or discretion or the assessment of risk to human life or property, such as the adequacy of an applicant's project documentation, dam design, safe storage level, requirements for existing dams, or maintenance, may seek review by a board of review under A.R.S. §§ 45-1210 and 45-1211.
C. The following actions are not subject to review:
1. Emergency measures taken under A.R.S. §§ 45-1212 or 45-1221.
2. Agency decisions made under A.R.S. §§ 41-1009(E) or (F).
3. Agency actions made exempt from review by law.

Historical Note
New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1223. Enforcement Authority
A. The Department may exercise its discretion to take action necessary to prevent danger to human life or property. The Director may take any legal action that is proper and necessary for the enforcement of this Chapter.
B. If the Director has cause to believe that a dam is unsafe or a person is violating or has violated a provision of this Article or A.R.S. Title 45, Chapter 6, Article 1, the Director may issue a notice directing the owner to remedy the safety deficiency or correct the violation. The owner may appeal a notice issued under this subsection as an appealable agency action in accordance with A.R.S. Title 41, Chapter 6, Article 10. If the owner does not appeal within 30 days after the date on the notice, the notice becomes final and may be incorporated as a condition of any license based on the duration of the requirement.
C. If the Director has cause to believe that a dam is unsafe or a person is violating or has violated a provision of this Article or A.R.S. Title 45, Chapter 6, Article 1, the Director may proceed under A.R.S. § 45-1221 to initiate a contested case under A.R.S. Title 41, Chapter 6, Article 10 by requesting an administrative hearing.
D. Following a written decision by an administrative law judge, the Director shall issue a decision and order accepting, rejecting, or modifying the administrative law judge's decision. Upon expiration of time to appeal, the decision and order becomes final and may be incorporated as a condition of any license based on the duration of the requirement.
E. If the Director has cause to believe that a dam is unsafe or a person is violating or has violated a provision of this Article or A.R.S. Title 45, Chapter 6, Article 1 the Director may commence an action in a court of appropriate jurisdiction if:
1. The violation is an emergency requiring appropriate steps to be taken without delay; or
2. The Director has cause to believe that use of the administrative procedure would be ineffective or that delay would ensue and a deterioration in the safety of the dam would occur.
F. If the Director commences an action it shall be brought in a court of appropriate jurisdiction in which:
1. The cause or some part of the cause arose; or
2. The owner or person complained of has his or her place of business; or
3. The owner or person complained of resides.
G. A person determined to be in violation of this Article; A.R.S. Title 45, Chapter 6; a license; or order may be assessed a civil penalty not exceeding $1,000 per day of violation. The Director may offer evidence relating to the amount of the penalty in accordance with A.R.S. § 45-1222.
H. A violation of A.R.S. Title 45, Chapter 6, Article 1 regarding Supervision of Dams, Reservoirs, and Projects is a class 2 misdemeanor, in accordance with A.R.S. § 45-1216.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1224. Emergency Procedures

A. The owner of a dam shall immediately notify the Department and responsible authorities in adjacent and downstream communities, including emergency management authorities, of a condition that may threaten the safety of the dam. The owner shall take necessary actions to protect human life and property, including action required under an emergency action plan or order issued under this Article.
   1. A condition that may threaten the safety of a dam includes:
      a. Sliding of upstream or downstream slopes or abutments contiguous to the dam;
      b. Sudden subsidence of the top of the dam;
      c. Longitudinal or transverse cracking of the top of the dam;
      d. Unusual release of water from the downstream slope or face of the dam;
      e. Other unusual conditions at the downstream slope of the dam;
      f. Significant landslides in the reservoir area;
      g. Increasing volume of seepage;
      h. Cloudy seepage or recent deposits of soil at seepage exit points;
      i. Sudden cracking or displacement of concrete in a concrete or masonry dam spillway or outlet works;
      j. Loss of freeboard or dam cross section due to storm wave erosion;
      k. Flood waters overtopping an embankment dam; or
      l. Spillway backcutting that threatens evacuation of the reservoir.
   2. In case of an emergency, the owner shall telephone the Arizona Department of Public Safety's emergency numbers at (800) 411-2336 or (602) 223-2000.

B. The Director shall issue an emergency approval to repair, alter, or remove an existing dam if the Director finds that immediate remedial action is necessary to alleviate an imminent threat to human life or property.
   1. The emergency approval shall be provided in writing on a form developed for this purpose.
   2. The emergency approval may contain conditions the Director determines are appropriate to protect human life or property.
   3. The emergency approval is effective immediately for 30 days after notice is issued unless extended in writing by the Director. The Director shall also send notice to the county flood control district of the county in which the dam is located, all municipalities within 5 miles downstream of the dam, and any additional persons identified in the emergency action plan.
   4. The Director may institute legal or administrative proceedings that the Director deems appropriate for violations of the emergency approval or conditions of the emergency approval.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1225. Emergency Repairs

A. The Director shall use monies from the dam repair fund, established under A.R.S. § 45-1212.01 to employ any remedial measure necessary to protect human life and property resulting from a condition that threatens the safety of a dam if the dam owner is unable or unwilling to take action and there is not sufficient time to issue and enforce an order.

B. The deputy director may authorize an expenditure not to exceed $10,000 from the dam repair fund for remedial measures under A.R.S. § 45-1212. The expenditure of any additional funds shall be approved by the Director.

C. The Director shall hold a lien against all property of the owner in accordance with A.R.S. § 45-1212.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

R12-15-1226. Non-Emergency Repairs; Loans and Grants

A. If the Director determines that a dam represents a threat to human life and property but is not in an emergency condition, the Director may use the dam repair fund, established under A.R.S. § 45-1212.01, as prescribed in this Article to defray the costs of repair.

B. Monies from the dam repair fund may be used for loans and grants to owners as provided in A.R.S. §§ 45-1218 and 45-1219.

C. To qualify for a loan or grant from the dam repair fund, a dam shall be classified as unsafe by the Director.

D. The Director may authorize grant funds for all or part of the cost of engineering studies or construction needed to mitigate the threat to human life and property created by a dam.
   1. The Director and the grantee shall execute a financial assistance agreement that includes terms of financial assistance, the work progress, and payment schedule.
   2. The Director shall disburse grant funds in accordance with the financial assistance agreement.
   3. The Director shall establish a priority ranking for grants based on factors including the potential for failure of a dam, the number of lives at risk, and the capability of the owner to pay a portion of the costs.

E. The Director may loan funds for engineering studies or for all or part of construction as prescribed in A.R.S. § 45-1218.
   1. The Director and the dam owner shall execute a loan repayment agreement. The loan repayment agreement shall be delivered to and held by the Department.
   2. The Director shall establish a priority ranking for loans based on factors including the potential for failure of a dam, the number of human lives at risk, and the capability of the owner to pay a portion of the costs.

Historical Note

New Section adopted by final rulemaking at 6 A.A.R. 2558, effective June 12, 2000 (Supp. 00-2).

ARTICLE 13. WELL SPACING REQUIREMENTS; REPLACEMENT WELLS IN APPROXIMATELY THE SAME LOCATION

R12-15-1301. Definitions

In addition to the definitions in A.R.S. §§ 45-101, 45-402, and 45-591, the following words and phrases in this Article shall have the following meanings, unless the context otherwise requires:
   1. "Abandoned well" means a well for which a well abandonment completion report has been filed pursuant to R12-15-816(E) or for which a notification of abandonment has been filed pursuant to R12-15-816(K).
   2. "Additional drawdown" means a lowering in the water levels surrounding a well that is the result of the operation of the well and that is not attributable to existing regional rates of decline or existing impacts from other wells.
   3. "Applicant" means any of the following:
      a. A person who has filed an application for a permit to construct a new well or a replacement well in a new location under A.R.S. § 45-599;
      b. A person who has filed an application for a recovery well permit under A.R.S. § 45-834.01 for a new well as defined in A.R.S. § 45-591 or, except as provided in A.R.S. § 45-834.01 (B)(2) or (3), an existing well as defined in A.R.S. § 45-591;
      c. A person who has filed an application for approval to use a well to withdraw groundwater for transportation to an active management area under A.R.S. § 45-559; or
      d. A person, other than a city, town, private water company, or irrigation district, who has filed an application for a water exchange permit under A.R.S. § 45-1041.
   4. "ADEQ" means the Arizona Department of Environmental Quality.
   5. "Contaminated groundwater" means groundwater that has been contaminated by a release of a hazardous substance, as defined in A.R.S. § 49-201, or a pollutant, as defined in A.R.S. § 49-201.
   6. "DOD" means the United States Department of Defense.
   7. "EPA" means the United States Environmental Protection Agency.
   8. "LCR plateau groundwater transporter" means a person transporting groundwater from the Little Colorado River plateau groundwater basin to another groundwater basin pursuant to A.R.S. § 45-544(B)(1).
   9. "Notice of water exchange participant" means a person, other than a city, town, private water company, or irrigation district, named as a participant in a water exchange in a notice of water exchange filed under A.R.S. § 45-1051.
   10. "Original well" means the well replaced by a replacement well in approximately the same location, except that if the replacement well is the latest in a succession of two or more wells drilled as replacement wells in approximately the same location under R12-15-1308 or temporary rule R12-15-840 adopted by the director on March 11, 1983, "original well" means the well replaced by the first replacement well in approximately the same location.
   11. "Remedial action site" means any of the following:
      a. The site of a remedial action undertaken pursuant to the comprehensive environmental response, compensation, and liability act ("CERCLA") of 1980, as amended, 42 U.S.C. 9601, et seq., commonly known as a "superfund" site;
      b. The site of a corrective action undertaken pursuant to A.R.S. Title 49, Chapter 6, commonly known as a leaking underground storage tank ("LUST") site;
      c. The site of a voluntary remediation action undertaken pursuant to A.R.S. Title 49, Chapter 1, Article 5;
      d. The site of a remedial action undertaken pursuant to A.R.S. Title 49, Chapter 2, Article 5, commonly known as a water quality assurance revolving fund ("WQARF") site;
      e. The site of a remedial action undertaken pursuant to the Resource Conservation and Recovery Act ("RCRA"), 42 U.S.C. 6901, et seq.; or
      f. The site of remedial action undertaken pursuant to the Department of Defense Environmental Restoration Program, 10 U.S.C. 2701, et seq., commonly known as a "Department of Defense site" or a "DOD site."
   12. "Replacement well" means a well drilled for the purpose of replacing another well.
   13. "Replacement well in a new location" means a replacement well that does not qualify as a replacement well in approximately the same location under R12-15-1308.
   14. "Replacement well in approximately the same location" means a replacement well that qualifies as a replacement well in approximately the same location under R12-15-1308.
   15. "Well" has the meaning prescribed in A.R.S. § 45-402. An abandoned well is not a well.
   16. "Well of record" means, with respect to an applicant, an LCR plateau groundwater transporter, or a notice of water exchange participant, any well or proposed well not owned by the applicant, LCR plateau groundwater transporter, or notice of water exchange participant, or proposed to be drilled by the applicant, LCR plateau groundwater transporter, or notice of water exchange participant, to which any of the following apply:
      a. The well is an existing well as defined in A.R.S. § 45-591 and the owner or operator has registered the well with the Department, unless the current well information on file with the Department identifies the sole purpose or purposes of the well as one or more of the following:

i. Cathodic protection;
ii. Use as a sump pump or heat pump;
iii. Air sparging;
iv. Injection of liquids or gasses into the aquifer or vadose zone, including injection wells that are part of an underground storage facility permitted under A.R.S. Title 45, Chapter 3.1;
v. Monitoring water levels or water quality, including a piezometer well;
vi. Obtaining geophysical, mineralogical, or geotechnical data;
vii. Grounding;
viii. Soil vapor extraction;
ix. Electrical energy generation pursuant to a temporary permit for electrical energy generation issued under A.R.S. § 45-517;
x. Dewatering pursuant to a dewatering permit issued under A.R.S. § 45-513 or a temporary dewatering permit issued under A.R.S. § 45-518;
xi. Drainage pursuant to a drainage water withdrawal permit issued under A.R.S. § 45-519; or
xii. Hydrologic testing pursuant to a hydrologic testing permit issued under A.R.S. § 45-519.01.

b. The well is a new well as defined in A.R.S. § 45-591 for which a notice of intention to drill was not filed pursuant to A.R.S. § 45-596 and for which a permit was not issued pursuant to A.R.S. §§ 45-599 or 45-834.01, and the owner or operator has registered the well with the Department, unless the current well information on file with the Department identifies the sole purpose or purposes of the well as one or more of the purposes in subsection (16)(a)(i) through (xii) of this Section;

c. A filing has been made for the well pursuant to A.R.S. § 45-596(A) or (B), unless any of the following apply:
i. The filing has expired pursuant to A.R.S. § 45-596(E);
ii. The filing identifies the sole purpose or purposes of the well as one or more of the purposes in subsection (16)(a)(i) through (xii) of this Section; or
iii. The well is an exempt well and the director is prohibited by A.R.S. § 45-454(D)(4) from considering impacts on the well when determining whether to approve or reject a permit application filed under A.R.S. § 45-599.

d. An application for a permit to drill the well has been received by the Department pursuant to A.R.S. § 45-599, unless the application has been rejected after exhaustion of all administrative and judicial appeals or the permit issued pursuant to the application has been revoked or has expired according to its terms or for failure to complete the well in a timely manner pursuant to A.R.S. § 45-599(G);

e. An application for a permit pursuant to A.R.S. §§ 45-514 or 45-516 has been received by the Department pursuant to A.R.S. § 45-521, unless the application has been rejected after exhaustion of all administrative and judicial appeals or the permit issued pursuant to the application has been revoked or has expired according to its terms or for failure to complete the well before expiration of the drilling authority; or

f. An application for a permit to drill a recovery well has been received by the Department pursuant to A.R.S. § 45-834.01, unless the application has been rejected after exhaustion of all administrative and judicial appeals or the permit issued pursuant to the application has been revoked or has expired according to its terms or for failure to complete the well in a timely manner pursuant to A.R.S. § 45-834.01(F).

Historical Note

New Section made by final rulemaking at 12 A.A.R. 2193, effective August 7, 2006 (Supp. 06-2).

R12-15-1302. Well Spacing Requirements - Applications to Construct New Wells or Replacement Wells in New Locations Under A.R.S. § 45-599

A. The director shall not approve an application for a permit to construct a new well or a replacement well in a new location under A.R.S. § 45-599 if the director determines that the withdrawals from the proposed well or wells will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B) of this Section.

B. The director shall determine that the withdrawals from the proposed well or wells will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells if any of the following apply:

1. Except as provided in subsection (D) of this Section, the director determines that the probable impact of the withdrawals from the proposed well or wells on any well of record in existence as of the date of receipt of the application will exceed 10 feet of additional drawdown after the first five years of operation of the proposed well or wells. To assist the director in making a determination under this subsection, the applicant may submit a hydrological study delineating those areas surrounding the proposed well or wells in which the projected impacts on water levels will exceed 10 feet of additional drawdown after the first five years of operation of the proposed well or wells. The director may require the applicant to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection;
2. The director determines that the proposed well or wells will be located in an area of known land subsidence and the withdrawals from the proposed well or wells will likely cause unreasonably increasing damage from additional regional land subsidence. To assist the director in making a determination under this subsection, the applicant may submit a hydrological study, which may include a geophysical evaluation, demonstrating the impact of the withdrawals from the proposed well or wells on regional land subsidence. The director may require the applicant to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection; or
3. Except as provided in subsection (E) of this Section, the director determines, after consulting with ADEQ, that withdrawals from the proposed well or wells will likely cause the migration of contaminated groundwater from a remedial action site to a well of record in existence as of the date of the receipt of the application, resulting in a degradation of the quality of the water withdrawn from the well of record so that the water will no longer be usable for the purpose for which it is currently being used without additional treatment, and that the damage to the owner of the well of record will not be prevented or adequately mitigated through the implementation of a program regulated under Title 49 of the Arizona Revised Statutes, or a program regulated by EPA or DOD. To assist the director in making a determination under this subsection, the applicant may submit a hydrological study demonstrating whether the withdrawals from the proposed well or wells will have the effect described in this subsection. The director may require the applicant to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection.

C. In making a determination under subsection (B)(1), (B)(2), or (B)(3) of this Section, if the proposed well is a replacement well in a new location, the director shall take into account the collective effects of reducing or terminating withdrawals from the well being replaced combined with the proposed withdrawals from the replacement well if the applicant submits a hydrological study demonstrating those collective effects to the satisfaction of the director.

D. If the director determines under subsection (B)(1) of this Section that the probable impact of the withdrawals from the proposed well or wells on one or more wells of record in existence as of the date of receipt of the application will exceed 10 feet of additional drawdown after the first five years of operation of the proposed well or wells, the director shall notify the applicant in writing of the location of the wells of record and the names and addresses of the owners of the wells as shown in the Department's well registry. The director shall not determine that the withdrawals from the proposed well or wells will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B)(1) of this Section if within 60 days after the date on the notice, or a longer time period approved by the director, the applicant submits one of the following for each well of record identified in the notice:

1. A signed and notarized consent form from the owner of the well of record consenting to the withdrawals from the proposed well or wells. The applicant shall use the consent form furnished by the director; or
2. Evidence satisfactory to the director that the address of the owner of the well of record as shown in the Department's well registry records is inaccurate and that the applicant made a reasonable attempt to locate the current owner of the well of record but was unable to do so.

E. If the director determines that withdrawals from the proposed well or wells will have the effect described in subsection (B)(3) of this Section on one or more wells of record in existence as of the date of receipt of the application, the director shall notify the applicant in writing of the location of the wells of record and the names and addresses of the owners of the wells as shown in the Department's well registry. The director shall not determine that the withdrawals from the proposed well or wells will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B)(3) of this Section if within 60 days after the date on the notice, or a longer time period approved by the director, the applicant submits one of the following for each well of record identified in the notice:

1. A signed and notarized consent form from the owner of the well of record consenting to the withdrawals from the proposed well or wells. The applicant shall use the consent form furnished by the director; or
2. Evidence satisfactory to the director that the address of the owner of the well of record as shown in the Department's well registry records is inaccurate and that the applicant made a reasonable attempt to locate the current owner of the well of record but was unable to do so.

F. At any time before a final determination under this Section, the applicant may:

1. Amend the application to change the location of the proposed well or wells or the amount of groundwater to be withdrawn from the proposed well or wells to lessen the degree of impact on wells of record or regional land subsidence; or
2. Agree to construct or operate the proposed well or wells in a manner that lessens the degree of impact on wells of record or regional land subsidence. The director shall indicate in the well permit that compliance with the agreement is a condition of the well permit.

Historical Note

New Section made by final rulemaking at 12 A.A.R. 2193, effective August 7, 2006 (Supp. 06-2).

R12-15-1303. Well Spacing Requirements - Applications for Recovery Well Permits Under A.R.S. § 45-834.01

A. The director shall not approve an application for a recovery well permit under A.R.S. § 45-834.01 that is filed for a new well as defined in A.R.S. § 45-591 or, except as provided in A.R.S. § 45-834.01(B)(2) or (3), for an existing well as defined in A.R.S. § 45-591, if the director determines that the recovery of stored water from the proposed well or wells will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B) of this Section.

B. The director shall determine that the recovery of stored water from the proposed well or wells will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells if any of the following apply:

1. Except as provided in subsection (D) of this Section, the director determines that the probable impact of the recovery of stored water from the proposed well or wells on any well of record in existence as of the date of receipt of the application will exceed 10 feet of additional drawdown after the first five years of the recovery of stored water from the proposed well or wells. To assist the director in making a determination under this subsection, the applicant shall submit with the application a hydrological study delineating those areas surrounding the proposed well or wells in which the projected impacts on water levels will exceed 10 feet of additional drawdown after the first five years of the recovery of stored water from the proposed well or wells;
2. The director determines that the proposed recovery well or wells will be located in an area of known land subsidence and the recovery of stored water from the proposed well or wells will likely cause unreasonably increasing damage from additional regional land subsidence. To assist the director in making a determination under this subsection, the applicant may submit a hydrological study, which may include a geophysical evaluation, demonstrating the impact of the recovery of stored water from the proposed recovery well or wells on regional land subsidence. The director may require the applicant to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection; or

3. Except as provided in subsection (E) of this Section, the director determines, after consulting with ADEQ, that the recovery of stored water from the proposed well or wells will likely cause the migration of contaminated groundwater from a remedial action site to a well of record in existence as of the date of receipt of the application, resulting in a degradation of the quality of the water withdrawn from the well of record so that the water will no longer be usable for the purpose for which it is currently being used without additional treatment, and that the damage to the owner of the well of record will not be prevented or adequately mitigated through the implementation of a program regulated under Title 49 of the Arizona Revised Statutes, or a program regulated by EPA or DOD. To assist the director in making a determination under this subsection, the applicant may submit a hydrological study demonstrating whether the recovery of stored water from the proposed well or wells will have the effect described in this subsection. The director may require the applicant to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection.

C. In making a determination under subsection (B)(1), (B)(2), or (B)(3) of this Section:
1. If the proposed recovery well is a replacement well in a new location, the director shall take into account the collective effects of reducing or terminating withdrawals from the well being replaced combined with the proposed recovery of stored water from the replacement well if the applicant submits a hydrological study demonstrating those collective effects to the satisfaction of the director.
2. If the proposed recovery well will be located within the area of impact, as defined in A.R.S. § 45-802.01, of an underground storage facility and the applicant will account for all of the water recovered from the well as water stored at the facility, the director shall take into account the effects of water storage at the facility on the proposed recovery of stored water from the recovery well if the applicant submits a hydrological study demonstrating those effects to the satisfaction of the director.

D. If the director determines under subsection (B)(1) of this Section that the probable impact of the recovery of stored water from the proposed recovery well or wells on any well of record in existence as of the date of receipt of the application will exceed 10 feet of additional drawdown after the first five years of operation of the proposed well or wells, the director shall notify the applicant in writing of the location of the wells of record and the names and addresses of the owners of the wells as shown in the Department's well registry. The director shall not determine that the recovery of stored water from the proposed recovery well or wells will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B)(1) of this Section if within 60 days after the date on the notice, or a longer time period approved by the director, the applicant submits one of the following for each well of record identified in the notice:
1. A signed and notarized consent form from the owner of the well of record consenting to the recovery of stored water from the proposed recovery well or wells. The applicant shall use the consent form furnished by the director; or
2. Evidence satisfactory to the director that the address of the owner of the well of record as shown in the Department's well registry records is inaccurate and that the applicant made a reasonable attempt to locate the current owner of the well of record but was unable to do so.

E. If the director determines that the recovery of stored water from the proposed recovery well or wells will have the effect described in subsection (B)(3) of this Section on one or more wells of record in existence as of the date of receipt of the application, the director shall notify the applicant in writing of the location of the wells of record and the names and addresses of the owners of the wells as shown in the Department's well registry. The director shall not determine that the recovery of stored water from the proposed recovery well or wells will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B)(3) of this Section if within 60 days after the date on the notice, or a longer time period approved by the director, the applicant submits one of the following for each well of record identified in the notice:
1. A signed and notarized consent form from the owner of the well of record consenting to the recovery of stored water from the proposed recovery well or wells. The applicant shall use the consent form furnished by the director; or
2. Evidence satisfactory to the director that the address of the owner of the well of record as shown in the Department's well registry records is inaccurate and that the applicant made a reasonable attempt to locate the current owner of the well of record but was unable to do so.

F. At any time before a final determination under this Section, the applicant may:
1. Amend the application to change the location of the proposed recovery well or wells or the amount of stored water to be recovered from the proposed recovery well or wells to lessen the degree of impact on wells of record or regional land subsidence; or
2. Agree to construct or operate the proposed recovery well or wells in a manner that lessens the degree of impact on wells of record or regional land subsidence. The director shall indicate in the recovery well permit that compliance with the agreement is a condition of the recovery well permit.

Historical Note

New Section made by final rulemaking at 12 A.A.R. 2193, effective August 7, 2006 (Supp. 06-2).

R12-15-1304. Well Spacing Requirements - Wells Withdrawing Groundwater From the Little Colorado River Plateau Groundwater Basin for Transportation to Another Groundwater Basin Under A.R.S. § 45-544(B)(1)

A. An LCR plateau groundwater transporter may not withdraw groundwater from a well or wells drilled in the Little Colorado river plateau groundwater basin after January 1, 1991, except a replacement well in approximately the same location or a well drilled after that date pursuant to a notice of intention to drill filed on or before that date, for transportation away from the basin pursuant to A.R.S. § 45-544(B)(1) if the director determines that the withdrawals for that purpose will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B) of this Section.

B. The director shall determine that the withdrawals of groundwater from the well or wells will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells if any of the following apply:
1. Except as provided in subsection (D) of this Section, the director determines that the probable impact of the withdrawals of groundwater from the well or wells on any well of record in existence when the withdrawals commenced or are proposed to commence will exceed 10 feet of additional drawdown after the first five years of the withdrawals. To assist the director in making a determination under this subsection, the LCR plateau groundwater transporter may submit to the director a hydrological study delineating those areas surrounding the LCR plateau groundwater transporter's well or wells in which the projected impacts on water levels will exceed 10 feet of additional drawdown after the first five years of the withdrawals. The director may require the LCR plateau groundwater transporter to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection;
2. The director determines that the well or wells from which the groundwater is withdrawn are located in an area of known land subsidence and the withdrawals of groundwater will likely cause unreasonably increasing damage from additional regional land subsidence. To assist the director in making a determination under this subsection, the LCR plateau groundwater transporter may submit to the director a hydrological study, which may include a geophysical evaluation, demonstrating the impact of the withdrawals on regional land subsidence. The director may require the LCR plateau groundwater transporter to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection; or
3. Except as provided in subsection (E) of this Section, the director determines, after consulting with ADEQ, that the withdrawals of groundwater from the well or wells will likely cause the migration of contaminated groundwater from a remedial action site to a well of record in existence when the groundwater withdrawals commenced or are proposed to commence, resulting in a degradation of the quality of the water withdrawn from the well of record so that the water will no longer be usable for the purpose for which it is currently being used without additional treatment, and that the damage to the owner of the well of record will not be prevented or adequately mitigated through the implementation of a program regulated under Title 49 of the Arizona Revised Statutes, or a program regulated by EPA or DOD. To assist the director in making a determination under this subsection, the LCR plateau groundwater transporter may submit to the director a hydrological study demonstrating whether the withdrawals of groundwater will have the effect described in this subsection. The director may require the LCR plateau groundwater transporter to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection.

C. In making a determination under subsection (B)(1), (B)(2), or (B)(3) of this Section, if a well from which the groundwater is withdrawn is a replacement well in a new location, the director shall take into account the collective effects of reducing or terminating withdrawals from the well being replaced combined with the withdrawals from the replacement well if the LCR plateau groundwater transporter submits a hydrological study demonstrating those collective effects to the satisfaction of the director.

D. If the director determines under subsection (B)(1) of this Section that the probable impact of the withdrawals of groundwater from the well or wells on any well of record in existence when the withdrawals commenced or are proposed to commence will exceed 10 feet of additional drawdown after the first five years of the withdrawals, the director shall notify the LCR plateau groundwater transporter in writing of the location of the wells of record and the names and addresses of the owners of the wells as shown in the Department's well registry. The director shall not determine that the withdrawals will
cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B)(1) of this Section if within 60 days after the date on the notice, or a longer time period approved by the director, the LCR plateau groundwater transporter submits one of the following for each well of record identified in the notice:
1. A signed and notarized consent form from the owner of the well of record consenting to the withdrawals. The LCR plateau groundwater transporter shall use the consent form furnished by the director; or
2. Evidence satisfactory to the director that the address of the owner of the well of record as shown in the Department's well registry records is inaccurate and that the LCR plateau groundwater transporter made a reasonable attempt to locate the current owner of the well of record but was unable to do so.

E. If the director determines that the withdrawals of groundwater from the well or wells will have the effect described in subsection (B)(3) of this Section on one or more wells of record in existence when the groundwater withdrawals commenced or are proposed to commence, the director shall notify the LCR plateau groundwater transporter in writing of the location of the wells of record and the names and addresses of the owners of the wells as shown in the Department's well registry. The director shall not determine that the withdrawals will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B)(3) of this Section if within 60 days after the date on the notice, or a longer time period approved by the director, the LCR plateau groundwater transporter submits one of the following for each well of record identified in the notice:
1. A signed and notarized consent form from the owner of the well of record consenting to the withdrawals. The LCR plateau groundwater transporter shall use the consent form furnished by the director; or
2. Evidence satisfactory to the director that the address of the owner of the well of record as shown in the Department's well registry records is inaccurate and that the LCR plateau groundwater transporter made a reasonable attempt to locate the current owner of the well of record but was unable to do so.

F. At any time before a final determination under this Section, the LCR plateau groundwater transporter may agree to construct or operate the well or wells in a manner that lessens the degree of impact on wells of record or regional land subsidence. Compliance with the agreement is a condition for the use of the well or wells to withdraw groundwater for transportation away from the basin pursuant to A.R.S. § 45-544(B)(1).

Historical Note

New Section made by final rulemaking at 12 A.A.R. 2193, effective August 7, 2006 (Supp. 06-2).

R12-15-1305. Well Spacing Requirements - Applications to Use a Well to Withdraw Groundwater for Transportation to an Active Management Area Under A.R.S. § 45-559

A. The director shall not approve an application to use a well or wells constructed after September 21, 1991, to withdraw groundwater for transportation to an active management area under A.R.S. § 45-559 if the director determines that the withdrawals for that purpose will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B) of this Section.

B. The director shall determine that the withdrawals of groundwater will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells if any of the following apply:
1. Except as provided in subsection (C) of this Section, the director determines that the probable impact of the groundwater withdrawals on any well of record in existence as of the date of receipt of the application will exceed 10 feet of additional drawdown after the first five years of the withdrawals. To assist the director in making a determination under this subsection, the applicant may submit a hydrological study delineating those areas surrounding the proposed well or wells in which the projected impacts of the groundwater withdrawals on water levels will exceed 10 feet of additional drawdown after the first five years of the withdrawals. The director may require the applicant to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection;
2. The director determines that the proposed well or wells will be located in an area of known land subsidence and the groundwater withdrawals will likely cause unreasonably increasing damage from additional regional land subsidence. To assist the director in making a determination under this subsection, the applicant may submit a hydrological study, which may include a geophysical evaluation, demonstrating the impact of the groundwater withdrawals on regional land subsidence. The director may require the applicant to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection; or
3. Except as provided in subsection (D) of this Section, the director determines, after consulting with ADEQ, that the groundwater withdrawals will likely cause the migration of contaminated groundwater from a remedial action site to a well of record in existence as of the date of receipt of the application, resulting in a degradation of the quality of the water withdrawn from the well of record so that the water will no longer be usable for the purpose for which it is currently being used without additional treatment, and that the damage to the owner of the well of record will not be prevented or adequately mitigated through the implementation of a program regulated under Title 49 of the Arizona Revised Statutes, or a program regulated by EPA or DOD. To assist the director in making a determination under this subsection, the applicant may submit a hydrological study demonstrating whether the groundwater withdrawals will have the effect described in this subsection. The director may require the applicant to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection.

C. If the director determines under subsection (B)(1) of this Section that the probable impact of the groundwater withdrawals on any well of record in existence as of the date of receipt of the application will exceed 10 feet of additional drawdown after the first five years of the withdrawals, the director shall notify the applicant in writing of the location of the wells of record and the names and addresses of the owners of the wells as shown in the Department's well registry. The director shall not determine that the groundwater withdrawals will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B)(1) of this Section if within 60 days after the date on the notice, or a longer time period approved by the director, the applicant submits one of the following for each well of record identified in the notice:
1. A signed and notarized consent form from the owner of the well of record consenting to the withdrawals. The applicant shall use the consent form furnished by the director; or
2. Evidence satisfactory to the director that the address of the owner of the well of record as shown in the Department's well registry records is inaccurate and that the applicant made a reasonable attempt to locate the current owner of the well of record but was unable to do so.

D. If the director determines that the groundwater withdrawals will have the effect described in subsection (B)(3) of this Section on one or more wells of record in existence as of the date of receipt of the application, the director shall notify the applicant in writing of the location of the wells of record and the names and addresses of the owners of the wells as shown in the Department's well registry. The director shall not determine that the groundwater withdrawals will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B)(3) of this Section if within 60 days after the date on the notice, or a longer time period approved by the director, the applicant submits one of the following for each well of record identified in the notice:
1. A signed and notarized consent form from the owner of the well of record consenting to the withdrawals. The applicant shall use the consent form furnished by the director; or
2. Evidence satisfactory to the director that the address of the owner of the well of record as shown in the Department's well registry records is inaccurate and that the applicant made a reasonable attempt to locate the current owner of the well of record but was unable to do so.

E. At any time before a final determination under this Section, the applicant may:
1. Amend the application to change the location of the proposed well or wells or the amount of groundwater to be withdrawn from the proposed well or wells to lessen the degree of impact on wells of record or regional land subsidence; or
2. Agree to construct or operate the proposed well or wells in a manner that lessens the degree of impact on wells of record or regional land subsidence. The director shall indicate in the permit that compliance with the agreement is a condition of the permit to use the well or wells to withdraw groundwater for transportation to an active management area under A.R.S. § 45-559.

Historical Note
New Section made by final rulemaking at 12 A.A.R. 2193, effective August 7, 2006 (Supp. 06-2).

R12-15-1306. Well Spacing Requirements - Applications for Water Exchange Permits Under A.R.S. § 45-1041

A. The director shall not approve an application for a water exchange permit filed under A.R.S. § 45-1041 by a person other than a city, town, private water company or irrigation district if the director determines that any new or increased pumping by the applicant from a well or wells within an active management area pursuant to the water exchange will cause unreasonably increasing damage to surrounding land or other water users under subsection (B) of this Section.

B. The director shall determine that new or increased pumping by the applicant from a well or wells within an active management area will cause unreasonably increasing damage to surrounding land or other water users if any of the following apply:
1. Except as provided in subsection (C) of this Section, the director determines that the probable impact of the new or increased pumping on any well of record in existence as of the date of receipt of the application will exceed 10 feet of additional drawdown after the first five years of the pumping. To assist the director in making a determination under this subsection, the applicant may submit a hydrological study delineating those areas surrounding the proposed well or wells in which the projected impacts of the new or increased pumping on water levels will exceed 10 feet of additional drawdown after the first five years of the pumping. The director may require the applicant to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection;
2. The director determines that the new or increased pumping will occur in an area of known land subsidence and the pumping will likely cause unreasonably increasing damage from additional regional land subsidence. To assist the director in making a determination under this subsection, the applicant may submit a hydrological study, which may include a geophysical evaluation, demonstrating the impact of the new or increased pumping on regional land subsidence. The director may require the applicant to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection; or
3. Except as provided in subsection (D) of this Section, the director determines, after consulting with ADEQ, that the new or increased pumping will likely cause the migration of contaminated groundwater from a remedial action site to a well of record in existence as of the date of receipt of the application, resulting in a degradation of the quality of the water withdrawn from the well of record so that the water will no longer be usable for the purpose for which it is currently being used without additional treatment, and that the damage to the owner of the well of record will not be prevented or adequately mitigated through the implementation of a program regulated under Title 49 of the Arizona Revised Statutes, or a program regulated by EPA or DOD. To assist the director in making a determination under this subsection, the applicant may submit with the application a hydrological study demonstrating whether the new or increased pumping will have the effect described in this subsection. If the applicant does not submit such a hydrological study with the application, the director may require the applicant to submit the study if the director determines that the study will assist the director in making a determination under this subsection.

C. If the director determines under subsection (B)(1) of this Section that the probable impact of the new or increased pumping on any well of record in existence as of the date of receipt of the application will exceed 10 feet of additional drawdown after the first five years of the pumping, the director shall notify the applicant in writing of the location of the wells of record and the names and addresses of the owners of the wells as shown in the Department's well registry. The director shall not determine that the new or increased pumping will cause unreasonably increasing damage to surrounding land or other water users under subsection (B)(1) of this Section if within 60 days after the date on the notice, or a longer time period approved by the director, the applicant submits one of the following for each well of record identified in the notice:
1. A signed and notarized consent form from the owner of the well of record consenting to the new or increased pumping. The applicant shall use the consent form furnished by the director; or
2. Evidence satisfactory to the director that the address of the owner of the well of record as shown in the Department's well registry records is inaccurate and that the applicant made a reasonable attempt to locate the current owner of the well of record but was unable to do so.

D. If the director determines that the new or increased pumping will have the effect described in subsection (B)(3) of this Section on one or more wells of record in existence as of the date of receipt of the application, the director shall notify the applicant in writing of the location of the wells of record and the names and addresses of the owners of the wells as shown in the Department's well registry. The director shall not determine that the new or increased pumping will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B)(3) of this Section if within 60 days after the date on the notice, or a longer time period approved by the director, the applicant submits one of the following for each well of record identified in the notice:
1. A signed and notarized consent form from the owner of the well of record consenting to the new or increased pumping. The applicant shall use the consent form furnished by the director; or
2. Evidence satisfactory to the director that the address of the owner of the well of record as shown in the Department's well registry records is inaccurate and that the applicant made a reasonable attempt to locate the current owner of the well of record but was unable to do so.

E. At any time before a final determination under this Section, the applicant may:
1. Amend the application to change the location of the proposed well or wells or the amount of the new or increase pumping to lessen the degree of impact on wells of record or regional land subsidence; or
2. Agree to construct or operate the proposed well or wells in a manner that lessens the degree of impact on wells of record or regional land subsidence. The director shall indicate in the water exchange permit that compliance with the agreement is a condition of the water exchange permit.

Historical Note
New Section made by final rulemaking at 12 A.A.R. 2193, effective August 7, 2006 (Supp. 06-2).

R12-15-1307. Well Spacing Requirements - Notices of Water Exchange Under A.R.S. § 45-1051

A. A notice of water exchange participant may not participate in a water exchange for which a notice is filed under A.R.S. § 45-1051 if the director determines that any new or increased pumping by the person from a well or wells within an active management area pursuant to the water exchange will cause unreasonably increasing damage to surrounding land or other water users under subsection (B) of this Section.

B. The director shall determine that new or increased pumping from the well or wells in an active management area will cause unreasonably increasing damage to surrounding land or other water users if any of the following apply:
1. Except as provided in subsection (C) of this Section, the director determines that the probable impact of the new or increased pumping on any well of record in existence when the pumping commenced or is proposed to commence will exceed 10 feet of additional drawdown after the first five years of the pumping. To assist the director in making a determination under this subsection, the notice of water exchange participant may submit to the director a hydrological study delineating those areas surrounding the notice of water exchange

participant's well or wells in which the projected impacts of the new or increased pumping on water levels will exceed 10 feet of additional drawdown after the first five years of the pumping. The director may require the notice of water exchange participant to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection;

2. The director determines that the new or increased pumping is in an area of known land subsidence and the pumping will likely cause unreasonably increasing damage from additional regional land subsidence. To assist the director in making a determination under this subsection, the notice of water exchange participant may submit to the director a hydrological study, which may include a geophysical evaluation, demonstrating the impact of the pumping on regional land subsidence. The director may require the notice of water exchange participant to submit such a hydrological study if the director determines that the study will assist the director in making a determination under this subsection; or
3. Except as provided in subsection (D) of this Section, the director determines, after consulting with ADEQ, that the new or increased pumping will likely cause the migration of contaminated groundwater from a remedial action site to a well of record in existence when the pumping commenced or is proposed to commence, resulting in a degradation of the quality of the water withdrawn from the well of record so that the water will no longer be usable for the purpose for which it is currently being used without additional treatment, and that the damage to the owner of the well of record will not be prevented or adequately mitigated through the implementation of a program regulated under Title 49 of the Arizona Revised Statutes, or a program regulated by EPA or DOD. To assist the director in making a determination under this subsection, the notice of water exchange participant may submit to the director a hydrological study demonstrating whether the new or increased pumping will have the effect described in this subsection. The director may require the notice of water exchange participant to submit such a study if the director determines that the study will assist the director in making a determination under this subsection.

C. If the director determines under subsection (B)(1) of this Section that the probable impact of the new or increased pumping on any well of record in existence when the pumping commenced or is proposed to commence will exceed 10 feet of additional drawdown after the first five years of the pumping, the director shall notify the notice of water exchange participant in writing of the location of the wells of record and the names and addresses of the owners of the wells as shown in the Department's well registry. The director shall not determine that the new or increased pumping will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B)(1) of this Section if within 60 days after the date on the notice, or a longer time period approved by the director, the notice of water exchange participant submits one of the following for each well of record identified in the notice:

1. A signed and notarized consent form from the owner of the well of record consenting to the new or increased pumping. The notice of water exchange participant shall use the consent form furnished by the director; or
2. Evidence satisfactory to the director that the address of the owner of the well of record as shown in the Department's well registry records is inaccurate and that the notice of water exchange participant made a reasonable attempt to locate the current owner of the well of record but was unable to do so.

D. If the director determines that the new or increased pumping will have the effect described in subsection (B)(3) of this Section on one or more wells of record in existence when the pumping commenced or is proposed to commence, the director shall notify the notice of water exchange participant in writing of the location of the wells of record and the names and addresses of the owners of the wells as shown in the Department's well registry. The director shall not determine that the new or increased pumping will cause unreasonably increasing damage to surrounding land or other water users from the concentration of wells under subsection (B)(3) of this Section if within 60 days after the date on the notice, or a longer time period approved by the director, the notice of water exchange participant submits one of the following for each well of record identified in the notice:

1. A signed and notarized consent form from the owner of the well of record consenting to the new or increased pumping. The notice of water exchange participant shall use the consent form furnished by the director; or
2. Evidence satisfactory to the director that the address of the owner of the well of record as shown in the Department's well registry records is inaccurate and that the notice of water exchange participant made a reasonable attempt to locate the current owner of the well of record but was unable to do so.

E. At any time before a final determination under this Section, the notice of water exchange participant may agree to construct or operate the well or wells in a manner that lessens the degree of impact on wells of record or regional land subsidence. Compliance with the agreement is a condition for the use of the well to pump water for the water exchange.

Historical Note

New Section made by final rulemaking at 12 A.A.R. 2193, effective August 7, 2006 (Supp. 06-2).

R12-15-1308. Replacement Wells in Approximately the Same Location

A. For purposes of A.R.S. §§ 45-544, 45-596, and 45-597, a replacement well in approximately the same location is a proposed well to which all of the following apply:

1. The proposed well will be located no greater than 660 feet from the original well, and the location of the original well can be determined at the time the notice of intention to drill the proposed well is filed;
2. Except as provided in subsections (A)(3) and (A)(4) of this Section, the proposed well will not annually withdraw an amount of water in excess of the maximum annual capacity of the original well. The director shall determine the maximum annual capacity of the original well by multiplying the maximum pump capacity of the original well in gallons per minute by 525,600, and then converting the result into acre-feet by dividing the result by 325,851 gallons. The director shall presume that the maximum pump capacity of the original well is the maximum pump capacity of the well in gallons per minute as shown in the Department's well registry records, except that:
   a. If the director has reason to believe that the maximum pump capacity as shown in the Department's well registry records is inaccurate, or if the applicant submits evidence demonstrating that the maximum pump capacity as shown in the Department's well registry records is inaccurate, the director shall determine the maximum pump capacity by considering all available evidence, including the depth and diameter of the well and any evidence submitted by the applicant; or
   b. If the Department's well registry records do not show the maximum pump capacity of the original well, the director shall not approve the proposed well as a replacement well in approximately the same location unless the applicant demonstrates to the director's satisfaction the maximum pump capacity of the original well;
3. If a well permit was issued for the original well under A.R.S. § 45-599, the proposed well will not annually withdraw an amount of groundwater in excess of the maximum annual volume set forth in the well permit;
4. If a recovery well permit was issued for the well to be replaced pursuant to A.R.S. § 45-834.01(B) and the permit sets forth a maximum annual volume of stored water that may be recovered from the well, the proposed well will not annually recover an amount of stored water in excess of the maximum annual volume set forth in the recovery well permit;
5. If the well to be replaced has been physically abandoned in accordance with R12-15-816, a notice of intention to drill the proposed well is filed no later than 90 days after the well to be replaced was physically abandoned; and
6. If the proposed well will be used to withdraw groundwater from the Little Colorado river plateau groundwater basin for transportation away from the basin pursuant to A.R.S. § 45-544(B)(1), one of the following applies:
   a. The original well was drilled on or before January 1, 1991, or was drilled after that date pursuant to a notice of intention to drill that was on file with the Department on that date; or
   b. The director previously determined that the withdrawal of groundwater from the original well for transportation away from the Little Colorado river plateau groundwater basin complies with R12-15-1304.

B. After a replacement well in approximately the same location is drilled, the replacement well may be operated in conjunction with the original well and any other wells that replaced the original well if the total annual withdrawals from all wells do not exceed the maximum amount allowed under subsection (A)(2), (A)(3), or (A)(4) of this Section, whichever applies.

C. A proposed well may be drilled as a replacement well in approximately the same location for more than one original well if the criteria in subsections (A)(1), (A)(5), and (A)(6) of this Section are met with respect to each original well and if the total annual withdrawals from the proposed well will not exceed the combined maximum annual amounts allowed for each original well under subsections (A)(2), (A)(3), or (A)(4) of this Section, whichever apply.

D. The director may include conditions in the approval of the notice of intention to drill the replacement well to ensure that the drilling and operation of the replacement well meets the requirements of this Section.

Historical Note

New Section made by final rulemaking at 12 A.A.R. 2193, effective August 7, 2006 (Supp. 06-2).

E.4. Arkansas



TITLE VII

RULES GOVERNING DESIGN AND OPERATION OF DAMS
[As Restated October, 1993]

TABLE OF CONTENTS

SUBTITLE		PAGE
I.	GENERAL PROVISIONS	
	701.1 PURPOSE	1
	701.2 AUTHORITY	1
	701.3 SCOPE OF REGULATIONS	1
	701.4 EXEMPTIONS	1
	701.5 PETITION BY AFFECTED PERSONS	1
	701.6 DUTIES, OBLIGATIONS, AND LIABILITIES OF DAM OWNERS	2
	701.7 NO LIABILITY BY COMMISSION, EMPLOYEES, OR AGENTS	2
	701.8 EXCEPTIONS	2
II.	PERMITS FOR DAMS	
	702.1 CONSTRUCTION PERMIT	2
	702.2 OPERATION PERMIT	2
	702.3 TRANSFER OF PERMIT	3
	702.4 WATER PLAN COMPLIANCE	3
	702.5 APPLICATION	3
	702.6 COMMISSION REVIEW	3
	702.7 PUBLIC NOTICE	3
	702.8 PUBLIC HEARING	3
	702.9 COMMISSION ACTION	3
III.	FEES	
	703.1 ESTIMATED APPLICATION REVIEW FEES	4
	703.2 FINAL COST REPORT	4
	703.3 FINAL APPLICATION REVIEW FEES	4
	703.4 ANNUAL PERMIT FEE	4
IV.	ENFORCEMENT	
	704.1 NOTICE OF NON-EMERGENCY DEFICIENCY	5
	704.2 PUBLIC HEARINGS	5
	704.3 COMMISSION ORDERS	5
	704.4 PENALTIES	5
	704.5 EMERGENCY REMEDIAL ORDERS	5
	704.6 APPEALS	5
V.	DESIGN CRITERIA	
	705.1 GENERAL STANDARDS	5
	705.2 REGISTERED PROFESSIONAL ENGINEER	6
	705.3 SIZE CLASSIFICATION CRITERIA	6
	705.4 HAZARD CLASSIFICATION CRITERIA	6
	705.5 SPILLWAY DESIGN FLOOD (SDF) FOR DAMS	7
	705.6 DOWNSTREAM RELEASES	8
	705.7 RESERVOIR DRAIN CONDUIT	9
	705.8 STRUCTURAL CRITERIA	9
VI.	CONSTRUCTION REQUIREMENTS	
	706.1 PLANS AND SPECIFICATIONS	9
	706.2 CONSTRUCTION INSPECTIONS	9

706.3 CONSTRUCTION RECORDS 9
Figure No. 1 - Seismic Zone Map 10
706.4 EROSION PROTECTION 11
706.5 FINAL INSPECTIONS 11
706.6 ENGINEER'S CERTIFICATION 11
706.7 RECORD DRAWINGS 11
706.8 PERMANENT REFERENCE MARKS 11

VII. EVALUATIONS OF EXISTING DAMS
707.1 TYPES OF EVALUATIONS 11
707.2 DEFICIENCIES 12
707.3 INTERIM ALTERNATIVES 12
707.4 VARIANCE 12

VIII. OPERATION AND MAINTENANCE
708.1 COMPLIANCE 12
708.2 EROSION PROTECTION 12
708.3 WOODY VEGETATION PROHIBITED: EMBANKMENT DAMS 12
708.4 WOODY VEGETATION PROHIBITED: CONCRETE OR MASONRY DAMS 13
708.5 OPERATION OF GATES AND CONTROLS 13
708.6 REPAIRS AND MODIFICATIONS 13
708.7 RECORDS 13

IX. INSPECTIONS
709.1 OWNER INSPECTION 13
709.2 COMMISSION INSPECTION 14
709.4 ASSISTANCE BY OWNER 14

X. EMERGENCY ACTION PLANS
710.1 EMERGENCY ACTION PLANS REQUIRED 14
710.2 APPROVAL OF EMERGENCY ACTION PLANS 14
710.3 CONTENTS OF EMERGENCY ACTION PLANS 14
710.4 ANNUAL EXERCISES AND DRILLS 14

XI. REMOVAL OF DAMS
711.1 APPROVAL OF PLANS REQUIRED 14
711.2 NOTICE TO DOWNSTREAM LANDOWNERS 15
711.3 RIGHTS OF OTHER LANDOWNERS 15
711.4 PROCEDURE FOR BREACHING 15
711.5 RESTORATION OF ORIGINAL STREAM CHANNEL ... 15
711.6 EROSION PROTECTION 15

XII. GLOSSARY

TITLE VII

RULES GOVERNING
DESIGN AND OPERATON OF DAMS
[As Restated October, 1993]

SUBTITLE I. GENERAL PROVISIONS

Section 701.1. PURPOSE.

A. Provide for the comprehensive regulation and supervision of dams for the protection of the health, safety, welfare, and property of the citizens of Arkansas.

B. Assure proper planning, design, construction, maintenance, monitoring and supervision of dams, including such preventive measures as are necessary to provide an adequate margin of safety.

Section 701.2. AUTHORITY.

Rules governing design and operation of dams within the State of Arkansas are promulgated under authority of Subchapter 2 of Chapter 22 of title 15 of the Arkansas Code of 1987.

Section 701.3. SCOPE OF REGULATIONS.

All dams within the State of Arkansas, except those owned by the United State Government or those exempted by Section 701.4, must have a valid construction and operation permit issued under the provisions of this title.

Section 701.4. EXEMPTIONS.

Dams meeting either of the following criteria are not subject to rules contained in this title, unless Section 701.5 of this title is successfully invoked.

A. Dams with height less than 25 feet.

B. Dams with normal storage less than 50 acre-feet.

C. Dams with crest elevations below the ordinary high water mark of the stream at that location.

Section 701.5. PETITION BY AFFECTED PERSONS.

Persons who believe themselves or their property to be endangered by failure of a dam which is below the size requirements specified in Section 701.4 may file a petition requesting that the Commission require permitting and compliance with dam safety regulations for that dam.

A. Commission Investigation. Upon receipt of such petition, the Executive Director shall immediately begin an investigation of the petitioner's allegations.

B. Public Hearing. As a part of the Commission's investigation, a Public Hearing shall be held within the county in which the dam is located. Notice of the hearing shall be published in a manner consistent with Section 702.8.

C. Commission Order. Upon consideration of staff findings and testimony received, the Commission shall issue an order either approving or denying the petitioner's request.

Section 701.6. DUTIES, OBLIGATIONS, AND LIABILITIES OF DAM OWNERS.

Nothing in these rules shall be construed to relieve an owner or operator of a dam or reservoir of the legal duties, obligations, or liabilities incident to ownership or operation.

Section 701.7. NO LIABILITY BY COMMISSION, EMPLOYEES, OR AGENTS.
No action shall be brought against the State or the Commission or its employees or agents for the recovery of damages caused by the partial or total failure of any dam or reservoir or through the operation of any dam or reservoir upon the grounds that the aforementioned parties are liable by virtue of any of the following:

A. The approval of the dam or reservoir, or approval of flood-handling plans during construction;

B. The issuance or enforcement of orders relative to maintenance and operation of the dam or reservoir;

C. Inspection, control and regulation of the dam or reservoir;

D. Measures taken to protect against failure during an emergency.

Section 701.8. EXCEPTIONS.
The Commission may grant exceptions to requirements contained within this title. Any variance from these rules must be supported by written approval of the Commission's Executive Director setting forth the reason for its granting and the limits placed thereon.

SUBTITLE II. PERMITS FOR DAMS

Section 702.1. CONSTRUCTION PERMIT.
A permit issued by the Commission is required prior to construction of any dam not exempted under Sections 701.3 or 701.4 of this title.

Section 702.2. OPERATION PERMIT.

A. Before water is deliberately impounded by closing drain gates on a newly constructed dam, an operation permit must be issued by the Commission. An operation permit will be issued by the Chief Engineer upon completion of final inspection and receipt of the Certificate of Substantial Compliance by the owner's engineer. (See Section 706.6).

B. An operation permit is required for all existing dams not exempted under Sections 701.3 or 701.4 of this title.

Section 702.3. TRANSFER OF PERMIT.
Within six (6) months after change of ownership of a permitted dam, the new owner shall notify the Commission. The Commission shall issue a dam permit in the name of the new owner.

Section 702.4. WATER PLAN COMPLIANCE.
Filing of an application to permit a proposed dam also serves as filing for Water Plan Compliance Certification as described in Section 602.5 of the Commission's rules. The water plan compliance process may run concurrently with the dam permit review.

Section 702.5. APPLICATION.
Applicants for dam permits must provide all applicable information requested on the form supplied by the Commission.

Section 702.6. COMMISSION REVIEW.

Upon receipt of application for dam permit, the Commission staff will review data presented to determine compliance with State law, Commission rules, and accepted engineering practices. If necessary, the staff may request additional data to insure compliance.

Section 702.7. PUBLIC NOTICE.
Upon completion of Commission review, the Executive Director will cause a Public Notice to be published two times, one week apart. The Public Notice will be placed in a newspaper having general circulation in the county in which the dam is/will be located. Information in the public notice will include: the owner's name and address, the dam's location and pertinent physical data describing the dam. In addition, the Public Notice will request that questions, comments and objections to the dam's permitting and/or requests for public hearing be forwarded in writing to the Commission for action within twenty (20) days after the second publication.

Section 702.8. PUBLIC HEARING.
If requested, the Executive Director shall cause a Public Hearing to be conducted within the county in which the dam is/will be located. Said hearing will be for the purpose of describing the proposed actions and taking testimony regarding the public view of the proposal. The Executive Director shall cause publication of a public notice describing the time, place and purpose of the Public Hearing. Copies of the public notice shall be furnished to the owner(s), complainant(s) and adjacent landowners (if known). Publication shall be in a newspaper having general circulation in the county in which the dam is/will be located. Notice shall be published twice, one week apart.

Section 702.9. COMMISSION ACTION.
A. If no Public Hearing is requested as a result of the Public Notice, the Executive Director will either approve or deny the permit request.
B. If a Public Hearing is requested as a result of the Public Notice, the Executive Director will approve or deny the permit request based upon the evidence presented.
C. Prior to issuance of the permit, a Water Plan Compliance Certification must be obtained as prescribed in Title VI of the Commission's rules, if applicable.

SUBTITLE III. FEES

Section 703.1. ESTIMATED APPLICATION REVIEW FEES.
Any application for permitting a proposed dam after March 24, 1993, shall be accompanied by a check for one percent (1%) of the estimated construction cost of the dam or $100.00, whichever is greater, except that no application review fee shall exceed $1000.00.

Section 703.2. FINAL COST REPORT.
The owner shall provide to the Commission a report of actual construction costs within forty-five (45) days after completion of construction.

Section 703.3. FINAL APPLICATION REVIEW FEES.
A. If the estimated application review fee exceeds the fee based on actual construction cost, an amount equal to the difference will be refunded.

B. If the fee based on construction cost exceeds the estimated application review fee, an amount equal to the difference will be paid to the Commission.

Section 703.4. ANNUAL PERMIT FEE.
The annual permit fee shall be computed as specified in Ark. Code Ann. §15-22-219, as may be amended from time to time.

Excerpt from Ark. Code Ann. §15-22-219:

> *Any person obtaining a permit under the provisions of §15-22-210 shall, in consideration therefor, pay to the Commission a fee equal to twelve cents (12¢ per acre-foot of water which the dam involved is designed to impound, but not less than twenty-five dollars ($25.00), nor more than ten thousand dollars ($10,000.00). The permit shall provide that the same fee shall be paid by that person to the Commission each year thereafter during which the dam is maintained, on or before the anniversary date of the issuance of the permit.*

The volume "the dam involved is designed to impound" is defined as the billing volume. (See Subtitle XII, GLOSSARY)

SUBTITLE IV. ENFORCEMENT

Section 704.1. NOTICE OF NON-EMERGENCY DEFICIENCY.
Upon discovery of a deficiency, which does not immediately threaten the dam's safety, the Chief Engineer will issue a letter specifying actions necessary to remedy the problem and requesting a schedule for implementing the required actions. Based on mutual agreement a consent order will be issued which will embody the agreed upon actions and timetable.

Section 704.2. PUBLIC HEARINGS.
In the event remedial measures for non-emergency deficiencies cannot be accomplished through the means of consent orders, the Executive Director shall cause a Public Hearing to be conducted to present the staff's proposed order and accept testimony. The hearing shall be conducted in the county in which the dam is located. Public notice of the hearing shall be provided in a manner consistent with Section 702.8 of this title.

Section 704.3. COMMISSION ORDERS.
After review of findings of the Public Hearing, the Commission may issue orders compelling specified actions.

Section 704.4. PENALTIES.
Non-compliance with commission rules or disregard of Commission orders may result in fines of up to $10,000. In general, penalties will be set by doubling the costs incurred by the Commission.

Section 704.5. EMERGENCY REMEDIAL ORDERS.
Upon discovery of a condition which renders a dam subject to rapid failure, the Executive Director may issue an Emergency Remedial Order describing actions which must be taken to protect life and property.

Failure to comply with these orders may result in penalties under Section 704.4.

Section 704.6. APPEALS.
Actions by the Commission may be appealed as described in Subtitle V of Title I, *rules of Organization and General Operation of the Arkansas Soil and Water Conservation Commission.*

SUBTITLE V. DESIGN CRITERIA

Section 705.1. GENERAL STANDARDS.
All dams must be designed in accordance with currently accepted engineering practices. Acceptable guidelines include those published and recommended by the U.S. Army Corps of Engineers; U.S. Department of Agriculture, Soil Conservation Service; U.S. Department of Interior, bureau of Reclamation; and Federal Energy Regulatory Commission.

Section 705.2. REGISTERED PROFESSIONAL ENGINEER.
Preparation of all plans and specifications, and the construction, enlargement alteration, repair or removal of dams subject to Commission review shall be under the supervision of an engineer registered in this state.

Section 705.3. SIZE CLASSIFICATION CRITERIA.
Size classification is based on the more stringent of two categories, either height of dam or maximum storage, and shall be in accordance with Table 1 of this section.

Table 1

SIZE CLASSIFICATION

SIZE	MAXIMUM STORAGE (ACRE-FEET)	HEIGHT (FEET)
Small	50 to 1000	25 to 40
Intermediate	• 1000 And < 50,000	•40 and < 100
Large	• 50,000	• 100

Section 705.4. HAZARD CLASSIFICATION CRITERIA.
All dams will be classified or reclassified as required to assure appropriate safety considerations. Hazard classification shall be based on the more stringent of either potential loss of human life or economic loss in accordance with Table 2 of this section. If doubt exists concerning classification, the more hazardous category must be selected.

NOTE: The hazard classification does not indicate the physical condition of a dam.

Table 2

HAZARD CLASSIFICATION

CATEGORY	LOSS OF HUMAN LIFE	ECONOMIC LOSS
Low	No	Minimal (No significant structures; pastures, woodland, or largely undeveloped land); less than $100,000.
Significant	No	Appreciable (Significant structures, industrial, or commercial development, or cropland); $100,000 to $500,000.
High	Yes	Excessive (Extensive public, industrial, commercial, or agricultural development); over $500,000.

NOTE: Loss of human life is based upon presence of habitable structures.

Section 705.5. SPILLWAY DESIGN FLOOD (SDF) FOR DAMS. The size and hazard classifications are combined to determine the hydrologic criteria for dams.

A. The minimum acceptable spillway design floods (SDFs) for dams are shown in Table 3.

B. The minimum hydrologic criteria may be reduced if properly prepared dam breach analyses show that dam failure during the SDF would cause an increase in flood level of one foot or less at, and downstream of, the first habitable structure or financially significant development.

Table 3

SPILLWAY DESIGN FLOOD FOR DAMS

HAZARD CLASSIFICATION		SIZE	SPILLWAY DESIGN FLOOD
Low		Small	.25 PMF
		Intermediate	.25 to .50 PMF
	*	Large	.50 to .75 PMF
Significant		Small	.25 to .50 PMF
		Intermediate	.50 to PMF
		Large	PMF
High		Small	.50 PMF to PMF
		Intermediate	PMF
		Large	PMF

NOTE: Where ranges are given in this table, the spillway design flood shall be determined by straight line interpolation, based upon the effective height of dam or maximum storage, whichever computed SDF is greater.

*SDF shall be extrapolated at the same rate of change as an intermediate size dam to a maximum of .75 PMF.

Section 705.6. DOWNSTREAM RELEASES.
Each dam constructed after the effective date of these regulations shall be equipped with a release port(s) designed to release a flow of water for instream and downstream riparian uses.

A. Minimum release quantities shall be sufficient to maintain existing instream and offstream uses and shall be defined after consideration of the best available low flow information.

B. Minimum release ports must be designed to operate without manual intervention.

Section 705.7. RESERVOIR DRAIN CONDUIT.
All proposed dams must include a permanent facility for draining the reservoir.

A. Such conduit shall have a minimum diameter of twelve (12) inches for watershed areas less than one square mile and eighteen (18) inches for watershed greater than one square mile. Such

conduits must be capable of lowering the surface of the reservoir at a rate not less than two (2) inches per day (at normal pool) while inflow to the reservoir is twice the annual average daily flow.

B. Operating equipment for the drain facility must be accessible from above the maximum design water surface, unless inlet design is such that the conduit is flowing at capacity at a lower elevation.

Section 705.8. STRUCTURAL CRITERIA.

As a minimum, the design must address the following:

A. Slope stability under all probable loading conditions.

B. Stability against sliding and overturning.

C. Adequacy of foundation for imposed loads.

D. Adequacy of energy dissipating devices at discharge points.

E. Adequacy of channels and conduits for expected flows.

F. Protection of embankments and other earth slopes from erosion.

G. Stability against seismic forces for all "High or Significant Hazard" dams in Seismic Zones 2 and 3. (See Figure 1.)

SUBTITLE VI. CONSTRUCTION REQUIREMENTS

Section 706.1. PLANS AND SPECIFICATIONS.

Written approval of plans and specifications must be obtained from the Chief Engineer prior to start of construction.

Section 706.2. CONSTRUCTION INSPECTIONS.

An agent of the design registered professional engineer must be on site during construction to ensure that techniques and materials used comply with plans and specifications.

Section 706.3. CONSTRUCTION RECORDS.

The applicant (or applicant's engineer) must retain construction records throughout the life of the dam. As a minimum, the records must include:

A. Daily log of construction activities.

B. Record of personnel and equipment on site.

C. Documentation of soil tests such as standard proctor, in-place density, and moisture.

D. Documentation of concrete cylinder tests.

E. Copies of all engineering change orders and field change notes.

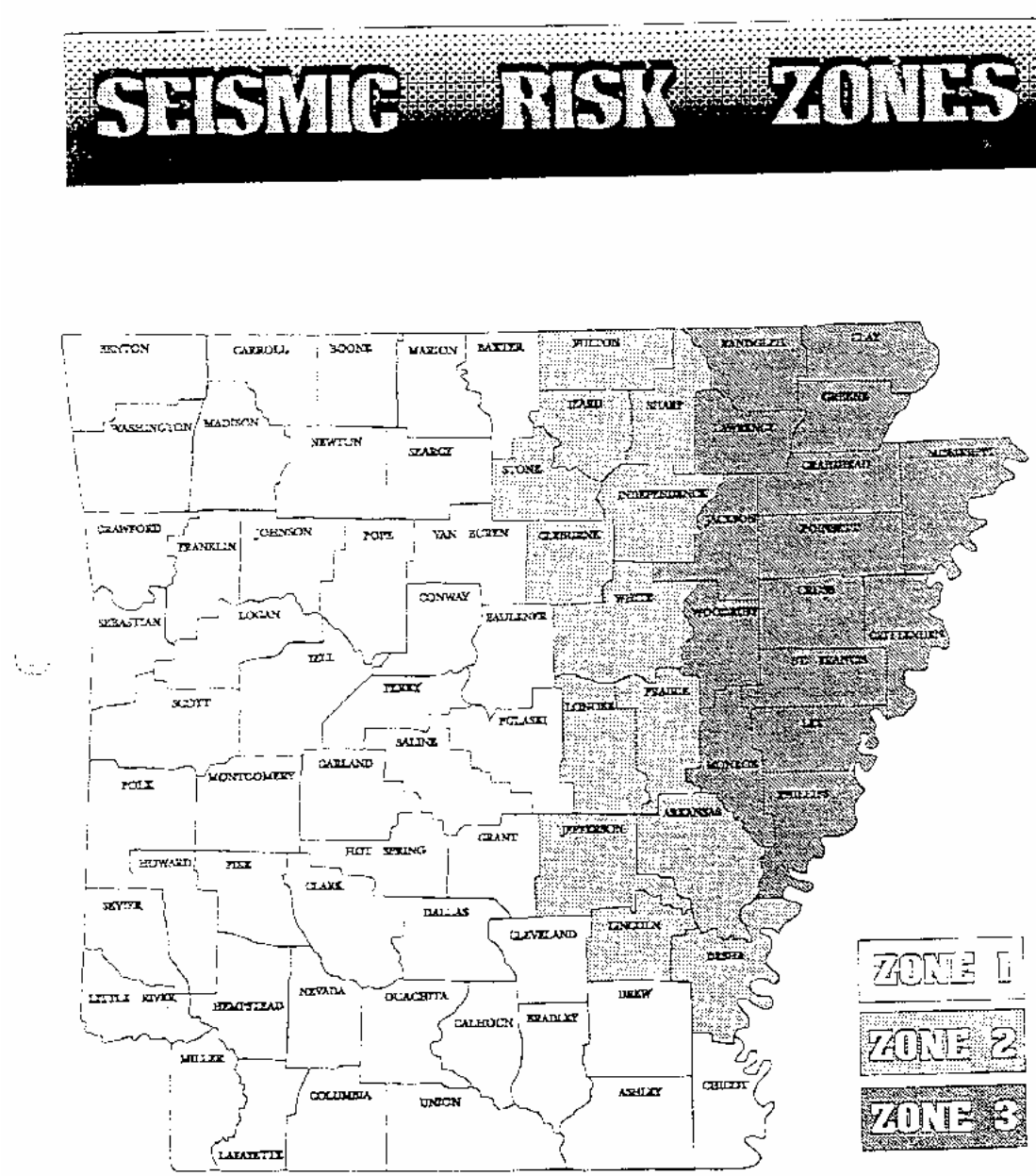


FIGURE 1

Section 706.4. EROSION PROTECTION

During construction, adequate measures must be taken to prevent excessive erosion and off site sedimentation. Suitable techniques include: temporary vegetation, mulching, staked straw bales, filter fences, and chemical stabilization. Other techniques may be sued is approved by the Chief Engineer.

Section 706.5. FINAL INSPECTION.
Upon substantial completion of construction, the owner must notify the Commission and schedule a final inspection of the work.

Section 706.6. ENGINEER'S CERTIFICATION.
Upon completion of construction, the project engineer shall file with the Commission a certificate of substantial compliance with approved plans and specifications.

Section 706.7. RECORD DRAWINGS.
Within sixty (60) days after completion of construction, the owner, or his engineer, shall submit to the Chief Engineer a complete set of record drawings of the project for filing as a permanent record with the Commission.

Section 706.8. PERMANENT REFERENCE MARKS.
Two or more permanent reference marks shall be established for future use near but not on the dam. Accurate longitude, latitude and elevation shall be shown on the record drawings. Elevations shall be referenced to the National Geodetic Vertical Datum of 1929.

SUBTITLE VII. EVALUATIONS OF EXISTING DAMS

Section 707.1. TYPES OF EVALUATIONS.

A. Spillway Design Flood. Existing dams will be evaluated periodically to determine if development of downstream areas warrants change in hazard classification and review of spillway design flood (SDF). Overtopping during the SDF may be allowed if properly prepared analyses demonstrate that: (1) overtopping will have a return interval greater than 25 years; and (2) the dam will withstand the projected overtopping without failure.

B. Structural. A complete evaluation of the structural integrity may include the following: geotechnical investigation, structural stability, seismic resistance, horizontal and vertical alignments, structural concrete reliability, erosion controls, inlet and outlet works, stilling basins, seepage, and others.

C. Operation and Maintenance. Evaluation of an existing structure shall include, but not be limited to: visual inspections and evaluations of potential problems such as leakage, seepage, cracks, slides, settlement, spillway blockages, conduit controls and other operational and maintenance deficiencies which could lead to failure of the dam. There may be sufficient evidence for a finding that an existing dam is inadequate.

Section 707.2. DEFICIENCIES.
Dams not meeting minimum acceptable standards (See Subtitle V and VIII) are deemed inadequate and therefore subject to necessary action under Subtitle IV.

Section 707.3. INTERIM ALTERNATIVES.

When the Commission considers the permanent upgrading or removal of an inadequate dam, the dam owner may request the Commission to consider interim alternatives including, but not limited to, temporary repairs, reservoir dewatering, insurance coverage, and downstream warning/evacuation plans. Consideration shall be given to the time required to overcome economic, physical and legal restraints to upgrading, the prospect of permanent repair, current use of the facility, degree of risk, and public welfare.

Section 707.4. VARIANCE.
Upon request by the owner of an existing dam which does not meet the minimum acceptable standards stated in Subtitles V and VIII of this title, the Chief engineer may authorize a variance from these criteria. The Chief Engineer's decision shall consider: (a) consequences of dam failure, (b) the owner's proposal for reduction of hazards, (c) barriers to upgrading of the structure, and (d) other pertinent factors.

SUBTITLE VIII. OPERATION AND MAINTENANCE

Section 708.1. COMPLIANCE WITH APPROVED DOCUMENTS.
Operation and maintenance must be performed in accord with documents filed by the owner or owner's engineer in obtaining the dam permit.

Section 708.2. EROSION PROTECTION.
Maintenance of adequate means to protect embankments, abutments, crests, and earthen channels from erosion is required.

Section 708.3. WOODY VEGETATION PROHIBITED: EMBANKMENT DAMS.
Growth of woody vegetation is not permitted on the spillway, crest, upstream or downstream embankments, and within twenty (20) feet of the downstream toe or groin of the dam.

A. Remediation: Trees with roots likely to extend to the crest of the dam shall be removed. Trees whose roots are unlikely to extend to the crest may remain if erosion control vegetation can be maintained and inspections can be accomplished. Trees larger than six (6) inches in diameter which are to be removed from embankments, must be removed together with roots larger than two inches. The resulting voids shall be repaired with compacted soil similar to the remaining embankment material. Smaller trees and brush, and those not on embankments may be cut and/or treated with herbicide.

B. Time for compliance: New growth must be removed before it shades out desirable vegetation generally on a two-year cycle. Where extensive tree and brush growth were established prior to adoption of these rules, a compliance schedule of up to five years may be approved provided that: (a) No evidence of significant immediate hazard is detected; (b) The compliance schedule includes a reasonable estimate for costs, and a rational procedure for accumulating necessary funds; (c) Vegetation is not so dense that effective inspections are impossible; and (d) Appropriate annual efforts are scheduled. The long-term schedule may be cancelled if evidence of immediate hazards is discovered in subsequent inspections.

Section 708.4. WOODY VEGETATION PROHIBITED; CONCRETE OR MASONRY DAMS.

No grass, vines, brush, trees or other vegetation is permitted to grow in cracks or joint of concrete or masonry structures.

A. Remediation: Vegetation shall be removed by manual, mechanical or chemical means or a combination thereof. Open cracks or joints shall be repaired by approved means.

C. Time for compliance: In the absence of conditions indicating immediate hazards, a schedule resulting in complete compliance within six months may be approved.

Section 708.5. OPERATION OF GATES AND CONTROLS.
All gates, valves and controls, must be maintained in operational condition. Operation of each such item must be tested at least annually, and such tests must be documented in the owner's permanent records. However, tests may be waived by the Chief Engineer if the design of drainage facilities and/or their condition is such that reclosing the drain would be impossible until the reservoir was substantially emptied.

Section 708.6. REPAIRS AND MODIFICATIONS.
Written approval by the Chief Engineer is required before repairs or modifications to a dam or appurtenances may be undertaken. Plans and specifications prepared by a registered professional engineer may be required for major actions.

Section 708.7. RECORDS.
Documentation of all owner's inspections, and repairs or modifications to the dam or appurtenances must be retained by the owner.

SUBTITLE IX. INSPECTION

Section 709.1. OWNER INSPECTIONS.
At least once per year and after each major storm event, the owner (or owner's agent) of all permitted dams must perform a visual inspection of the dam. Results of such inspections must be summarized on forms supplied by the Commission and mailed to the Commission office within 10 days of inspection. Commission staff may provide training or assistance in performing or interpreting inspections. Any deterioration of the dam or appurtenances must be reported to the Commission, and remedial measures undertaken after approval by the Chief Engineer.

Section 709.2. COMMISSION INSPECTIONS.
Commission personnel will periodically perform inspections of each permitted dam. Commission inspections are of three types: Maintenance and Operation; Dam Safety Evaluation; and Emergency. The frequency of inspections and evaluations will vary according to the hazard rating, size and condition of the dam. Emergency inspections will be performed when conditions warrant.

Section 709.3. ACCESS.
The owner or owner's agent must provide Commission personnel access to the dam during reasonable working hours for Commission inspections. Access during emergency conditions must be available to Commission personnel.

Section 709.4. ASSISTANCE BY OWNER.

The owner or owner's agent may be requested to provide limited assistance to Commission personnel in performing inspections. Requested assistance may include:

A. Operating gates, valves, and other controls.

B. Cutting excessive vegetation in preparation for inspections.

SUBTITLE X. EMERGENCY ACTION PLANS

Section 710.1. EMERGENCY ACTION PLANS REQUIRED.
An emergency action plan (EAP) must be prepared by the owner for all permitted high hazard dams.

Section 710.2. APPROVAL OF EMERGENCY ACTION PLANS REQUIRED.
Written approval of the Chief Engineer must be obtained for all EAPs.

Section 710.3. CONTENTS OF EMERGENCY ACTION PLANS.
Site conditions will dictate exact contents of specific EAPs. Guidelines for preparation of EAPs are available from the Commission.

Section 710.4. ANNUAL EXERCISES AND DRILLS.
Implementation of EAPs must include at least one tabletop exercise per year and one test drill every three years. The Commission's Chief Engineer must be notified at least one week in advance of either procedure.

SUBTITLE XI. REMOVAL OF DAMS

Section 711.1. APPROVAL OF PLANS REQUIRED.
Prior to removal, a plan for removal and revegetation must be approved by the Chief Engineer.

Section 711.2. NOTICE TO DOWNSTREAM LANDOWNERS.
Downstream landowners must be notified of the proposed action if any measure of flood protection would be lost due to the removal of the dam.

Section 711.3. RIGHTS OF OTHER LANDOWNERS.
Downstream landowners and those adjacent to the reservoir have the right to notice of projected changes in streamflow patterns or reservoir levels, but do not have the right to continued benefits at the dam owner's expense, unless the dam owner is contractually bound to provide such benefits.

Section 711.4. PROCEDURE FOR BREACHING.
The procedure for breaching must adequately guard against downstream flooding, erosion, and sedimentation.

Section 711.5. RESTORATION OF ORIGINAL STREAM CHANNEL.
Dimensions of the final cut through the dam must be defined in the plan and must be of sufficient size to prevent impounding water when streamflow equals the 100-year flood.

Section 711.6. EROSION PROTECTION.
The plan must provide for establishment of vegetation or other erosion protection measures sufficient to guard against deposition of excessive sediment off site.

SUBTITLE XII. GLOSSARY

Unless clearly indicated by context, the following words and terms, when used in this title, shall have meanings as defined below:

A. Billing volume - Normal storage designed to contain sediment accumulation over the life of the dam.
B. Chief Engineer - The Deputy Director/Chief Engineer of the Arkansas Soil and Water Conservation Commission.
C. Commission - The Arkansas Natural Resources Commission.
D. Construction costs - Estimated or actual material and labor costs, including excavation, embankment placement, spillways, gates, valves, and conduits. Shall not include costs of: land, reservoir clearing, engineering, water treatment facilities, or other costs not directly related to construction of the dam.
E. Dam - Any barrier, including one for flood detention, designed to impound liquid volumes. This shall not include highway, railroad or other roadway embankments, including low water crossings that may temporarily detain floodwater, levees designed to prevent inundation by floodwater, or closed dikes to temporarily impound liquids in the event of emergencies and those barriers not exempt by Sections 701.3 or 701.4 of this title.
F. Effective crest of the dam - The elevation of the lowest pint on the crest of the dam excluding spillways.
G. Executive Director - The Executive Director of the Arkansas Natural Resources Commission.
H. Height of dam - The vertical distance from the effective crest of the dam to the lowest elevation on the downstream toe of the dam.
I. Maximum storage - The volume of the impoundment created by the dam at the effective crest of the dam.
J. Minimum release - Daily quantity of water which must be released to preserve downstream riparian rights, permitted non-riparian rights or to meet instream water needs including, but not limited to those of fish and wildlife.
K. Normal storage - The volume of the impoundment created by the dam at the lowest uncontrolled spillway crest.
L. PMF (probable maximum flood) - The maximum runoff condition resulting from the most severe combination of hydrologic and meteorologic conditions that are reasonably possible for a given watershed. The PMF is the maximum runoff computed from the spatial and temporal distribution of the PMP over the watershed.
M. PMP (probable maximum precipitation) - The greatest theoretical depth of precipitation (rainfall equivalent) for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of the year.
N. Spillway design flood (SDF) - The largest flood the spillway must pass without overtopping a dam.

E.5. California



HYDROLOGIC ANALYSIS WITHIN CALIFORNIA'S DAM SAFETY PROGRAM

By Emil R. Calzascia[1] and James A. Fitzpatrick[2]

Introduction

The topography and climate of California are extremely diverse, ranging from low elevations at the coast to the high altitudes of the Sierras, from less than 3 inches of annual rainfall in the southeast desert basins to over 120 inches on the extreme north coast. Drainage basins for dams vary in size from portions of an acre to thousands of square miles. Stream gages are sparse in most areas and are essentially nonexistent in the undeveloped areas. Accurate estimation of rare flood flows from recorded data is especially difficult due to the lack of basic site-specific flow data from which the flood producing potential of a drainage basin can be predicted. However, estimates of rare floods must be developed for all damsites to be used in evaluation of spillway capacities. To this end, precipitation records are employed in lieu of actual flow data. A method was developed by California's Division of Safety of Dams (DSOD) to estimate flood hydrographs for ungaged or poorly gaged watersheds for use in spillway evaluation.

Outline of Method

DSOD requires that all dams within its jurisdiction be capable of adequately passing a selected design flood. A method has been devised by DSOD to determine the hydrologic adequacy of any spillway in California on a rational and consistent basis (DSOD, 1981).

The procedure can be divided into eight parts:

1. Assessment of the potential downstream hazard
2. Determination of appropriate storm return period
3. Development of precipitation
4. Development of synthetic unit hydrograph parameters
5. Development of loss rate parameters
6. Computation of the flood hydrograph
7. Routing of the flood hydrograph through the reservoir
8. Evaluation of the spillway adequacy

The following discussion will, elaborate on the basic concepts underlying these procedures, but will not present detailed design formulas or criteria.

---

[1]Senior Engineer, California Department of Water Resources, Division of Safety of Dams, P.O. Box 942836, Sacramento, California 94236-0001

[2] Principal Engineer, California Department of Water Resources, Division of Safety of Dams

Hazard Assessment

The hazard classification of any given dam is determined with respect to the dam's size and to the potential downstream damage due to failure of the structure. The classification is selected from a rating system that considers (1) reservoir capacity, (2) dam height, (3) estimated number of people that would be placed in peril and need to be evacuated in anticipation of dam failure, and (4) potential downstream property damage. Each factor is categorized as low, moderate, high or extreme. The method produces a composite numerical rating termed the Total Class Weight (TCW). The form, shown in Figure 1, is used as an aid to determine the TCW. With this system, small remote dams generally have a TCW of 2, while large urban dams might have a TCW of 36. The capacity of the reservoir and height of the dam are clearly defined. Estimated evacuation and potential downstream damage are uncertain and require an investigation of the potentially flooded area. This investigation includes estimating the population at risk, the possible loss of life, the physical property damage, the social consequences and the environmental impact. Through application to the many dams under its jurisdiction, DSOD has developed a coherent and uniform approach to conducting the damage investigations so that consistent total class weights are found.

DSOD does not allow the use of Economic Risk Analysis in the selection of a design flood for spillway evaluation. It is felt that the above procedure adequately addresses the issue of risk.

DAMAGE POTENTIAL CLASSIFICATION FOR

FLOOD ESTIMATE AND SPILLWAY ANALYSIS

Name of Dam _____ Type of Dam _____Dam No. _____

County _____ Located on _____

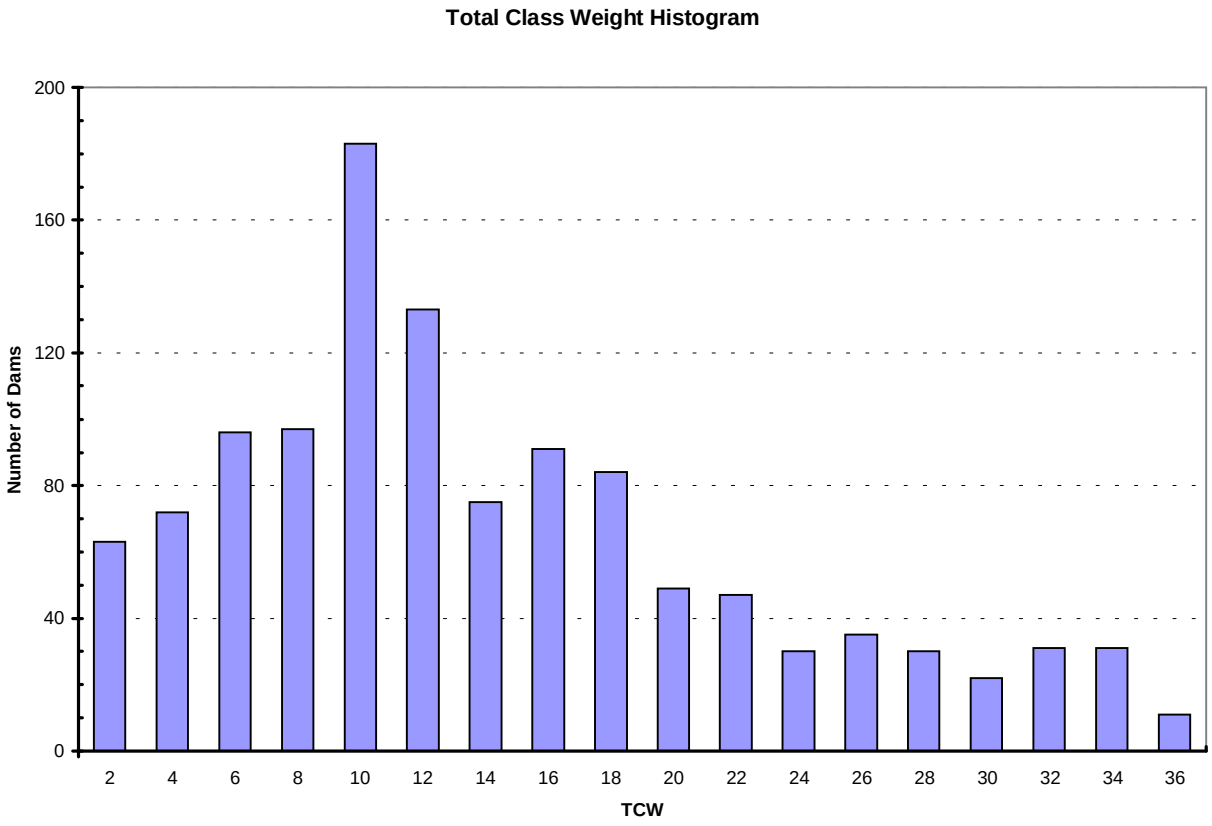
	Damage Potential Rating			
	Extreme	High	Moderate	Low
Capacity _____ AF	100,000 & Over	1,000-99,999	100-999	15-99
(circle weight)	6	4	2	0
Height _____ Ft.	150 & Over	100-149	50-99	6-49
(circle weight)	6	4	2	0
Estimated Evacuation _____	1,000 & Over	100-999	1-99	None
(circle weight)	12	8	4	0
Potential D/S Damage	High	Moderate	Low	None
(circle weight)	12	8	4	0

Total Class Weight _____

Figure 1

Precipitation

It is prudent to a allow a continuous range of design floods corresponding to the developed Total Class Weights. The minimum allowable design event required is a 1000 year storm which corresponds with a TCW of 4. The maximum event is a storm derived from the Probable Maximum Precipitation and is equated with a TCW of 30. The design event is interpolated between these limits at the computed TCW. Typically, probable maximum precipitation storms are required only for dams that impound 1000 acre-feet or more, are at least 50 feet high, would require an estimated evacuation of at least 1000 people, and have a damage potential of $25,000,000 or greater. However, most dams require a design storm falling between the 1000 year event and the probable maximum event. Figure 2 presents a histogram of TCW (as determined by DSOD) for all jurisdictional dams within California. As can be seen, less than 8 percent of all dams require a PMF.



If the TCW is 30 or greater, the design storm is the probable maximum precipitation (PMP) as determined by Hydrometeorological Report No. 36 (U.S. Weather Bureau, 1961) or Hydrometeorological Report No. 49 (National Weather Service, 1977), depending on geographical location. The estimated rainfall is determined directly for these reports.

If the TCW is less than 30, a statistical frequency estimate of the rainfall is chosen. It is assumed that extreme precipitation follows a Pearson Type III probability distribution, with a general skew of 1.3 for northern California and 1.5 for southern California.

The equation for precipitation is:

$$P_{ij} = M_i + k_j * S_i$$
$$= (1.0 + k_j * CV_i) * M_i$$

where:

P_{ij} = extreme precipitation value
M_i = average of extreme values
S_i = standard deviation
k_j = frequency factor
CV_i = coefficient of variation

where:

subscript $_i$ denotes the event duration
subscript $_j$ denotes the return period

The appropriate coefficient of variation for the drainage basin is obtained from Bulletin 195 (DWR, 1976). This publication is a statistical compilation of observed rainfall data for both long-term and short-term durations from measuring stations throughout California. The mean rainfall values for various time durations are found from Bulletin 195 or from other available rainfall records for stations in the vicinity of the given basin. These means combined with the proper number of standard deviations give the precipitation estimates.

The number of standard deviations (k,) required for a 1000 year storm is 4.96 for northern California and 5.23 for southern California. The equivalent number of standard deviations for the PMP is obtained from a generalized contour plot relating this upper limit to geographical location. Using a nonlinear proration between these two points (k_{1000},TCW_{1000} and k_{PMP},TCW_{PMP}), the k**,** for the given TCW is obtained. The corresponding return period is computed from the probability distribution.

The rainfall depth-duration values are estimated either by the PMP procedures or the above described statistical method. After adjustment for watershed area, the results are plotted on log-log scales and smoothed if necessary to obtain the depth-duration curve.

Unit Hydrograph

Where no known reliable hydrographs exist, recourse is made to the computation of a synthetic unit hydrograph by Clark's method (Clark, 1945). Clark's unitgraph parameters are obtained from a generalized study of observed rainfall and runoff events, which related these parameters to drainage basin characteristics by regression analysis (DWR, 1971). The study is applicable to the State of California except that area south of the Tehachapi Mountain Divide and the area east of the Sierra Nevada Divide. The study was limited to drainage basins approximately 30 square miles or less in area, in recognition that approximately 80 percent of the dams under jurisdiction of the Division of Safety of Dams have drainage areas of less than this size. Most of the damsites for large reservoirs have been exploited in California, and dams that will be constructed in the future will, for the most part, be smaller in size and have relatively small drainage areas. Future dams with large drainage basins will require special investigation.

The regression equations from the generalized study relate the drainage basin characteristics of

stream length, area, elevation, and ground cover to the time of concentration (t_c) and Clark's storage coefficient (R) for development of a basin-specific unit hydrograph. The study also presents guidelines for estimating loss rate parameters.

For coastal basins south of the Tehachapi Mountains, the unitgraph and loss rate parameters are obtained by the procedure given in the U. S. Army Corps of Engineers report entitled "Generalized Standard Project Rainflood Criteria-Southern California Coastal Streams", (Hydrologic Engineering Center, 1967).

Guidelines for southeastern California have been developed in a study (Mayer, 1987) similar to that for northern California. The region is subdivided into three subareas, with regression equations presented to develop unit hydrograph and loss rate parameters.

Flood Hydrograph

The flood hydrograph is developed using the computer program HEC-1 (Hydrologic Engineering Center, 1981). The program obtains the flood hydrograph by convolution of the effective rainfall increments with Clark's unitgraph.

Rainfall increments are determined from the depth-duration curve at specified time intervals and are then arranged into a storm pattern which places the maximum value at the center of the storm duration with successively smaller values placed alternately on each side (approximating a bell-shaped distribution). In general, the total precipitation duration is taken to be 72 hours. If routing will not significantly affect the peak outflow, a shorter storm (e.g., 24 hours) can be considered since the peak inflow will be about the same in either case.

It is assumed that antecedent storms have saturated the drainage basin so that loss rates are fairly low. For each time interval, the losses from rainfall due to surface retention and infiltration are estimated by the exponential loss rate function within HEC-1. These losses are deducted from the distributed precipitation to produce excess rainfall values for each time interval. The general criteria is that the percent runoff should not be less than 70 when the mean annual precipitation (MAP) at the basin is greater than 25 inches and should not be less than 60 when the MAP is 25 inches or less.

If applicable, allowances for snowmelt, base flow in the basin, runoff from prior storms, import of water etc., are added to the storm runoff hydrograph to obtain the design flood hydrograph for the watershed.

Flood Routing Through Reservoir

The design flood hydrograph is routed through the reservoir and spillway(s) to obtain the time-history of storage elevation, spillway discharge, tailwater elevation, etc. that describe passage of the flood through the reservoir. This is essentially a process of accounting for volumes of inflow, storage, and outflow throughout the duration of the flood. It is usually assumed that the reservoir is full at the beginning of the design flood. If there are several reservoirs in the watershed, the reservoir routing is repeated from the uppermost to the most downstream reservoir, in turn.

Evaluating Spillway Capacity

New embankment dams must pass the spillway design flood with a minimum of 1.5 feet of residual freeboard above the maximum reservoir flood stage. Additional freeboard is required for severe wave conditions from wind effects. Residual freeboard requirements for new concrete dams are based on the ability of the abutments and foundation to resist damage from overpour. Existing embankment dams must pass the spillway design flood without overtopping.

Refinements and Future Enhancements

It is the policy of DSOD to continually refine the developed methodology as new data becomes available and as the state-of-the-art advances. A reevaluation of the coefficients of variation, skew factors, and the appropriate probability distribution for precipitation is presently underway.

REFERENCES

California Department of Water Resources (1971), Rare Flood Estimates for Small Ungaged Watersheds in California, (Including revision of 1976); Division of Safety of Dams

California Department of Water Resources (1976), Rainfall Analysis for Drainage Design, Volume I: Short-Duration Precipitation Frequency Data and Volume II: Long-Duration Precipitation Frequency Data, Bulletin No. 195 Sacramento: State of California, Resources Agency

Clark, C. O. (1945), Storage and the Unit Hydrograph, Transactions of the American Society of Civil Engineers 110, p. 1419-1446

Division of Safety of Dams (1981), Hydrology Manual-Flood Estimates for Dams Sacramento: California Department of Water Resources

Hydrologic Engineering Center (March 1967), Generalized Standard Project Rainflood Criteria-Southern California Coastal Streams, Sacramento: U.S. Army, Corps of Engineers

Hydrologic Engineering Center (September 1981), HEC-1 Flood Hydrograph Package Davis, California: U.S. Army, Corps of Engineers

Mayer, R. G. (1987), Unit Hydrographs for Small Ungaged Watersheds in Southeastern California, Sacramento: California State University, Sacramento

National Weather Service (1977), Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages, Hydrometeorological Report No. 49 Washington D.C.: U.S. Department of Commerce

U.S. Weather Bureau (1961), Interim Report-Probable Maximum Precipitation in California (Including revision of 1969), Hydrometeorological Report No. 36. Washington D.C.: U.S. Department of Commerce

STATE OF CALIFORNIA

The Resources Agency

Department of Water Resources

Division of Safety of Dams

STATUTES AND REGULATIONS

PERTAINING TO

SUPERVISION OF

DAMS AND RESERVOIRS

FOREWARD

Since August 14, 1929, the State of California has supervised dams to prevent failure, to safeguard life, and to protect property. The legislation was a result of the failure of St. Francis Dam in March of 1928. Legislation enacted in 1965 revised the Statutes to include off-stream storage reservoirs as a result of the failure of Baldwin Hills Reservoir in December 1963.

Dams and reservoirs are defined in the California Water Code Sections 6002, 6003, and 6004. Certain exemptions are included in Sections 6004 and 6025. All dams under these definitions are subject to State supervision unless they are owned and operated by the United States. A careful reading of all the California Water Code sections and the California Code of Regulations sections included herein is strongly recommended for those who are regulated by these provisions. The schedule of fees is periodically adjusted in accordance with Section 6307 of the Water Code. The current fee structure is listed on the Division website under “Fees.”

This document contains Parts 1 and 2 of Division 3, Dams and Reservoirs, of the California Water Code (Statutes), Chapter 1 of Division 2, Title 23 Waters, of the California Code of Regulations (Regulations adopted by the Department of Water Resources), and an outline of Current Practices of the Department in Supervision of Dams and Reservoirs.

NOTICE

This compendium of laws governing dams and reservoirs has been compiled by the Department of Water Resources, Division of Safety of Dams, for convenient reference only and is not represented to be the official version of the statutes or the regulations. Notes, text, and history of repealed sections are not included in this reprint.

CONTENTS

CALIFORNIA WATER CODE
DIVISION 3. DAMS AND RESERVOIRS

	Sections	Page
PART 1. SUPERVISION OF DAMS AND RESERVOIRS	6000-6470	1
Chapter 1. Definitions	6000-6008	2
Chapter 2. General Provisions	6025-6031	4
Chapter 3. Administrative Provisions	6052-6056	6
Chapter 4. Powers of the Department	6075-6157	6
Article 1. Powers in General	6075-6081	6
Article 2. Maintenance and Operation	6100-6102	7
Article 3. Emergency Work	6110-6113	8
Article 4. Investigations and Studies	6120-6121	8
Article 5. Action and Procedure to Restrain Violations	6150-6157	9
Chapter 5. Applications	6200-6267	10
Article 1. New Dams and Reservoirs or Enlargements of Dams and Reservoirs	6200-6206	10
Article 2. Repairs, Alterations or Removals	6225-6230	11
Article 3. Dams Constructed Prior to August 14, 1929	6250-6253	12
Article 4. Approval of Applications	6260-6267	13
Chapter 6. Fees	6300-6309	13
Chapter 7. Inspection and Approval	6350-6407	17
Article 1. New or Enlarged Dams and Reservoirs	6350-6355	17
Article 1.5 Certificates of Approval	6357-6357.4	18
Article 2. Repaired or Altered Dams and Reservoirs	6360-6364	19
Article 3. Removal of Dams and Reservoirs	6370-6372	19
Article 4. Dams Completed Prior to August 14, 1929	6380-6382	20
Article 5. Complaints as to Unsafe Conditions	6390-6393	20
Article 6. Inspection During Progress of Work	6400-6407	20

CONTENTS (Continued)

	Sections	Page
Chapter 8. Offenses and Punishment	6425-6428.....	**22**
Chapter 9. Dams Under Construction Prior to August 14, 1929. . . .	6450-6452.....	**22**
Chapter 10. Dams and Reservoirs Under State Supervision Through 1965 Revisions of Part 1. . . .	6455-6470.....	**23**
Article 1. Dams and Reservoirs Completed Before 1965 Revisions.	6455-6461.....	**23**
Article 2. Dams and Reservoirs Under Construction Before 1965 Revisions.	6465-6467.....	**24**
Article 3. Fees for Dams or Reservoirs Under Construction Before 1965 Revisions.	6470.....	**25**
PART 2 FISHWAYS OVER DAMS.	6500-6501.....	**25**

CALIFORNIA CODE OF REGULATIONS
TITLE 23. WATERS
DIVISION 2. DEPARTMENT OF WATER RESOURCES

		Page
Chapter 1.	CHAPTER 1. DAMS AND RESERVOIRS	26
Article 1.	General Provisions	27
301.	Definitions.	27
302.	Purpose and Effect of Regulations.	27
303.	Evidence of Water Rights	27
304.	Civil Engineering Plans and Specifications	28
305.	Civil Engineering Supervision of Construction.	29
Article 2.	Applications for Construction, Enlargement, Repair, Alteration, or Removal of Dams or Reservoirs	29
310.	Applications for Construction or Enlargement	29
311.	Criteria for Determining Completeness	30
312.	Standard Terms	31
313.	Automatic Approval of Applications	31
314.	Filing Fee	32
Article 3.	Annual Fee	32
315.	Annual Fee	32
316.	Inoperative Dams	32
Article 4.	Small Dams Review Board.	33
320.	Small Dams Review Board.	33
321.	Scope of Review.	33
322.	Small Dam Defined.	33
323.	Time to Request Board Review; Filing Fee	34
324.	Time and Conduct of Review	34
325.	Findings of the Board.	34
Article 5.	Dams Owned by the Department of Water Resources.	35
330.	Consulting Board	35
331.	Scope of Review.	35
332.	Actions for Which Board is Retained.	35
333.	Periodic Review.	35

CURRENT PRACTICES OF THE DEPARTMENT OF WATER RESOURCES IN SUPERVISION OF DAMS AND RESERVOIRS

Page

Introduction. 38

Division of Safety of Dams. 38

Dams and Reservoirs in State Jurisdiction 38

Proposed Dams and Reservoirs. 38

Procedure for Construction or Enlargement of Dams and Reservoirs. 38

Procedure for Repair or Alteration of Dams or Reservoirs 40

Procedure for Removal of Dams and Reservoirs. 41

CALIFORNIA WATER CODE
Division 3. Dams and Reservoirs

DIVISION 3. DAMS AND RESERVOIRS

PART 1. SUPERVISION OF DAMS AND RESERVOIRS

Chapter 1. Definitions

6000. Unless the context otherwise requires, the definitions in this chapter govern the construction of this part.

6002. “Dam” means any artificial barrier, together with appurtenant works, which does or may impound or divert water, and which either (a) is or will be 25 feet or more in height from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the department, or from the lowest elevation of the outside limit of the barrier, as determined by the department, if it is not across a stream channel or watercourse, to the maximum possible water storage elevation or (b) has or will have an impounding capacity of 50 acre-feet or more.

6003. Any such barrier which is or will be not in excess of 6 feet in height, regardless of storage capacity, or which has or will have a storage capacity not in excess of 15 acre-feet, regardless of height, shall not be considered a dam.

6004. a) No obstruction in a canal used to raise or lower water therein or divert water therefrom, no levee, including but not limited to a levee on the bed of a natural lake the primary purpose of which levee is to control floodwaters, no railroad fill or structure, and no road or highway fill or structure, no circular tank constructed of steel or concrete, or both, no tank elevated above the ground, and no barrier which is not across a stream channel, watercourse, or natural drainage area and which has the principal purpose of impounding water for agricultural use shall be considered a dam.

b) No obstruction in the channel of astream or watercourse which is 15 feet or less in height from the lowest elevation of the obstruction and which has the single purpose of spreading water within the bed of the stream or watercourse upstream from the obstruction for percolation underground shall be considered a dam.

c) The levee of an island adjacent to tidal waters in the Sacramento-San Joaquin Delta, as defined in Section 12220, even when used to impound water, shall not be considered a dam and the impoundment shall not be considered a reservoir if the maximum possible water storage elevation of the impounded water does not

exceed four feet above mean sea level, as established by the United Stated Geological Survey 1929 datum.

d) No noncircular tank, constructed of steel or concrete, or both, that is constructed in a county of the third class by a public agency, under the supervision of a civil engineer registered in the state, that does not exceed 75 acre-feet in capacity or 30 feet in height, and no barrier that is not across a stream channel, watercourse, or natural drainage area and that has the principal use as a sewage sludge drying facility shall be considered a dam.

6004.5. "Reservoir" means any reservoir which contains or will contain the water impounded by a dam.

6005. "Owner" includes any of the following who own, control, operate, maintain, manage, or propose to construct a dam or reservoir:

(a) The State and its departments, institutions, agencies, and political subdivisions.

(b) Every municipal or quasi-municipal corporation.

(c) Every public utility.

(d) Every district.

(e) Every person.

(f) The duly authorized agents, lessees, or trustees of any of the foregoing.

(g) Receivers or trustees appointed by any court for any of the foregoing.

"Owner" does not include the United States.

6006. "Alterations", "repairs", or either of them, mean only such alterations or repairs as may affect the safety of the dam or reservoir.

6007. "Enlargement" means any change in or addition to an existing dam or reservoir, which raises or may raise the water storage elevation of the water impounded by the dam or reservoir.

6008. Water storage elevation means that elevation of water surface which could be obtained by the existing dam or reservoir, as previously operated, were there no outflow and were the reservoir full of water.

Chapter 2. General Provisions

6025. It is the intent of the Legislature by this part to provide for the regulation and supervision of dams and reservoirs exclusively by the State.

6025.5 a) Notwithstanding any other provision, subject to subdivision (b), the requirements for state regulation and supervision of safety of dams, as contained in this division, shall not be applicable to waste water treatment and storage ponds constructed as a part of a waste water control facility.

b) This section applies to those ponds specified in subdivision (a) only after the governing body of the city, county, district, or other agency which operates the waste water control facility adopts a resolution which (1) finds that the ponds have been constructed and operated to standards adequate to protect life and property, and (2) provides that the city, county, district, or other agency shall supervise and regulate the design, construction, operation, enlargement, replacement, and removal of the ponds after the effective date of the resolution.

c) This section applies only to ponds specified in subdivision (a) which (1) have a maximum height of 15 feet or less and a maximum storage capacity of 1,500 acre-feet or less, (2) have been designed by, and constructed under the supervision of, a registered civil engineer, and (3) are not across a stream channel or watercourse.

6025.6 a) An owner of a structure defined as a dam pursuant to Section 6002, but excluded from that definition pursuant to subdivision (d) of Section 6004 or otherwise exempted from the requirements of this chapter pursuant to Section 6025.5, shall comply with the requirements of Section 8589.5 of the Government Code and shall employ a civil engineer who is registered in the state to supervise the structure for the protection of life and property for the full operating life of the structure.

b) (1) The civil engineer supervising a dam pursuant to subdivision (a) shall take into consideration, in determining whether or not a dam constitutes, or would constitute, a danger to life or property, the possibility that the dam might be endangered by seepage, earth movement, or other conditions that exist, or might occur, in any area in the vicinity of the dam.

(2) If the civil engineer determines that a dam under his or her supervision constitutes, or would constitute, a danger to life

or property, the civil engineer shall notify the owner of the dam and recommend appropriate action.

c) The owner shall submit to the department the name, business address, and telephone number of each supervising civil engineer.

d) The department shall submit the information provided pursuant to subdivision (c) to the Office of Emergency Services on or before January 1, 1995, and on or before each January 1 thereafter. Any change in the information shall be submitted to the department on or before July 1 of each year.

6026. No city or county has authority, by ordinance enacted by the legislative body thereof or adopted by the people under the initiative power, or otherwise, to regulate, supervise, or provide for the regulation or supervision of any dams or reservoirs in this state, or the construction, maintenance, or operation thereof, nor to limit the size of any dam or reservoir or the amount of water which may be stored therein. This part shall not prevent a city or county from adopting ordinances regulating, supervising, or providing for the regulation or supervision of dams and reservoirs that (a) are not within the state's jurisdiction, or (b) are not subject to regulation by another public agency or body.

6027. Whenever supervision of safety of design or construction of a proposed or existing dam or reservoir is exercised by the United States or any of its agencies pursuant to a jurisdiction superior to that of the state, and the requirements made under authority of such jurisdiction are so contradictory with requirements made by the department under this part that a compliance cannot be made which will meet both federal and state requirements, then the state requirements shall be modified by the department sufficiently to make possible compliance with both federal and state requirements.

6028. No action shall be brought against the state or the department or its agents or employees for the recovery of damages caused by the partial or total failure of any dam or reservoir or through the operation of any dam or reservoir upon the ground that such defendant is liable by virtue of any of the following:

(a) The approval of the dam or reservoir.

(b) The issuance or enforcement of orders relative to maintenance or operation of the dam or reservoir.

(c) Control and regulation of the dam or reservoir.

(d) Measures taken to protect against failure during an emergency.

6029. Nothing in this part shall be construed to relieve an owner or operator of a dam or reservoir of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam or reservoir.

6030. The findings and orders of the department and the certificate of approval of any dam or reservoir issued by the department are final and conclusive and binding upon all state agencies, regulatory or otherwise, as to the safety of design, construction, maintenance, and operation of any dam or reservoir.

6031. Nothing in this part shall be construed to deprive any owner of such recourse to the courts as he may be entitled to under the laws of this State.

Chapter 3. Administrative Provisions

6052. The department shall employ such clerical, engineering, and other assistants as are necessary for carrying on the work of dam and reservoir supervision in accordance with this part.

6053. The department may employ consultants.

6054. When the safety and technical considerations pertaining to a certificate of approval, dam, reservoir, or plans and specifications require it, or when requested in writing to do so by the owner, the department shall appoint a consulting board of two or more consultants to report to the department on the safety features involved.

6055. The cost and expense of a consulting board if appointed on the request of an owner shall be paid by the owner.

6056. The department shall retain a board of three consultants who shall make an independent report to the director upon the issuance, modification, or renewal of any certificate of approval for any dam owned by the department.

Chapter 4. Powers of the Department

Article 1. Powers in General

6075. The department, under the police power of the state, shall supervise the construction, enlargement, alteration, repair, maintenance, operation, and removal of dams and reservoirs for the protection of life and property as provided in this part.

6076. All dams and reservoirs in the state are under the jurisdiction of the department.

6077. It is unlawful to construct, enlarge, repair, alter, remove, maintain, or operate any dam or reservoir except upon approval of the department as provided in this part.

6078. The department shall adopt and revise from time to time such rules and regulations and issue such general orders as may be necessary for carrying out, but not inconsistent with, the provisions of this part.

6079. In carrying out the provisions of this part the department may cooperate with the United States or any of its agencies.

6080. In making any investigations or inspections required or authorized by this part the department or its representatives may enter upon private property as may be necessary.

6081. In determining whether or not a dam or reservoir or proposed dam or reservoir constitutes or would constitute a danger to life or property, the department shall take into consideration the possibility that the dam or reservoir might be endangered by seepage, earth movement, or other conditions which exist or which might occur in any area in the vicinity of the dam or reservoir. Whenever the department deems that any such condition endangers a dam or reservoir, it shall order the owner to take such action as the department determines to be necessary to remove the resultant danger to life and property.

Article 2. Maintenance and Operation

6100. Supervision over the maintenance and operation of dams and reservoirs insofar as necessary to safeguard life and property from injury by reason of the failure thereof is vested in the department.

6101. The department may require owners to keep records of, and to report on, maintenance, operation, staffing, and engineering and geologic investigations and shall issue such rules and regulations and orders as necessary to secure maintenance and operation and to require staffing and engineering and geologic investigations which will safeguard life and property. In addition, the owner of a dam or reservoir or his agent shall fully and promptly advise the department of any sudden or unprecedented flood or unusual or alarming circumstance or occurrence affecting the dam or reservoir.

6102. The department, from time to time, shall make inspections of dams and reservoirs at state expense for the purpose of determining their safety but shall require owners to perform at their expense such work as necessary to disclose information sufficient to enable the department to determine conditions of dams and reservoirs in regard to their safety and to perform at their expense other work necessary to secure maintenance and operation which will safeguard life and property.

Article 3. Emergency Work

6110. The department shall immediately employ any remedial means necessary to protect life and property if either:

(a) The condition of any dam or reservoir is so dangerous to the safety of life or property as not to permit time for the issuance and enforcement of an order relative to maintenance or operation.

(b) Passing or imminent floods threaten the safety of any dam or reservoir.

6111. In applying the remedial means provided for in this article, the department may in emergency do any of the following:

(a) Lower the water level by releasing water from the reservoir.

(b) Completely empty the reservoir.

(c) Take such other steps as may be essential to safeguard life and property.

6112. The department shall continue in full charge and control of such dam or reservoir, or both, and its appurtenances until they are rendered safe or the emergency occasioning the action has ceased.

6113. The cost and expenses of the remedial means provided in this article, including cost of any work done to render a dam or reservoir of its appurtenances safe, shall be recoverable by the state from the owner by action brought by the department in the superior court of the county wherein the dam or reservoir or any part thereof is situated.

Article 4. Investigations and Studies

6120. For the purpose of enabling it to make decisions as compatible with economy and public safety as possible the department

shall make or cause to be made such investigations and shall gather or cause to be gathered such data as may be needed for a proper review and study of the various features of the design and construction of dams, reservoirs, and appurtenances.

6121. The department shall also make or cause to be made such watershed investigations and studies as may facilitate its decisions.

Article 5. Action and Procedure To Restrain Violations

6150. The department may commence an action or proceeding under this article, either by mandamus or injunction, for the purpose of stopping or preventing violations or threatened violations.

6151. An action or proceeding under this article may be commenced whenever any owner or any person acting as a director, officer, agent, or employee of any owner, or any contractor or agent or employee of such contractor is:

(a) Failing or omitting or about to fail or omit to do anything required of him by this part or by any approval, order, rule, regulation, or requirement of the department under the authority of this part; or

(b) Doing or permitting anything or about to do or permit anything to be done in violation of or contrary to this part or any approval, order, rule, regulation, or requirement of the department under this part.

6152. Any action or proceeding under this article shall be commenced in the superior court in and for the county in which (a) the cause or some part thereof arose, (b) the owner or person complained of has its principal place of business or (c) the person complained of resides.

6153. Any action or proceeding under this article shall be brought by petition in the superior court, alleging the violation or threatened violation complained of, and praying for appropriate relief by way of mandamus or injunction.

6154. The court shall specify a time, not exceeding 20 days after the service of the copy of the petition, within which the owner or person complained of shall answer the petition, and in the meantime the owner or person may be restrained.

6155. In case of default in answer or after answer the court shall immediately inquire into the facts and circumstances of the case.

6156. The court may join such parties as it deems necessary or proper in order to make its judgment, order, or writ effective.

6157. The final judgment in such action or proceeding shall either dismiss the action or proceeding or direct that the writ of mandamus or injunction issue or be made permanent as prayed for in the petition, or in such modified or other form as will afford appropriate relief.

Chapter 5. Applications

Article 1. New Dams and Reservoirs or Enlargements of Dams and Reservoirs

6200. Construction of any new dam or reservoir or the enlargement of any dam or reservoir shall not be commenced until the owner has applied for and obtained from the department written approval of plans and specifications.

6201. A separate application for each dam or reservoir shall be filed with the department upon forms to be provided by it, except that only one application need be filed for a dam and the reservoir which will contain the water impounded by the dam.

6202. The application shall give the following information:

(a) The name and address of the owner.

(b) The location, type, size, and height of the proposed dam or reservoir and appurtenant works.

(c) The storage capacity of the reservoir.

(d) Such other pertinent information as the department requires.

(e) As accurately as may be readily obtained,the area of the drainage basin, rainfall and streamflow records and floodflow records and estimates.

6203. The department may also require the following:

(a) Data concerning subsoil and foundation conditions and the materials entering into construction of the dam or reservoir.

(b) Investigations of, and reports on, subsurface conditions, involving such matters as exploratory pits, trenches and adits, drilling, coring, geophysical surveys, tests to determine leakage rates, and physical tests to measure in place the properties and behavior of foundation materials at the dam or reservoir site.

(c) Investigations of, and reports on, the geology of the dam or reservoir site and its vicinity, possible geologic hazards, availability and quality of construction materials, and other pertinent features.

(d) Such other appropriate information as may be necessary in a given instance.

6204. In instances wherein the physical conditions involved and the size of the dam or reservoir are such as to render the above requirements as to drainage areas, rainfall, streamflow, floodflow, and drilling or prospecting of site unnecessary, the department may waive the requirements.

6205. The application shall set forth the purpose for which the impounded or diverted water is to be used.

6206. The application shall be accompanied by maps and plans and specifications of such character and size and setting forth such pertinent details and dimensions as the department requires.

The maps and plans and specifications shall be a part of the application.

Article 2. Repairs, Alterations or Removals

6225. Before commencing the repair, alteration, or removal of a dam or reservoir, including the alteration or removal of a dam or reservoir so that it no longer constitutes a dam or reservoir as defined in this part, the owner shall secure the written approval of the department, except as provided in this article.

6226. The application shall give such pertinent information or data concerning the dam or reservoir, or both, as may be required by the department and such information as to other matters appropriate to a thorough consideration of the safety of such a change as may be required by the department.

6227. The application shall state the proposed time of commencement and of completion of construction.

6228. The application shall give the name and address of applicant, shall adequately detail, with appropriate references to the existing dam or reservoir, the changes which it is proposed to effect, and shall be accompanied by maps and plans and specifications which shall be a part of the application and which shall be of such character and size and set forth such pertinent details and dimensions as the department may require. The department may waive any of the requirements of this section if found by it unnecessary.

6229. In case of an emergency where repairs are necessary to safeguard life and property, repairs may be started immediately, but the department shall be notified at once of proposed repairs and of work under way.

6230. The proposed repairs and work shall be made to conform to such orders as the department issues.

Article 3. Dams Constructed Prior to August 14, 1929

6250. Unless application for approval of the dam has heretofore been made, every owner of a dam completed prior to August 14, 1929 shall, immediately after the effective date of this part, file an application for the approval of such dam.

6251. A separate application shall be made for each dam and shall be filed with the department upon forms to be supplied by it and shall supply such appropriate information concerning the dam as the department requires.

6252. The department shall give notice to file to owners who have failed to do so as required by this article, and a failure to file within 30 days after such notice shall be punishable as provided in this part.

6253. The notice provided for in this article may be given by registered mail and a return receipt signed by the owner shall constitute prima facie evidence of service.

Article 4. Approval of Applications

6260. Upon receipt of any application other than an application provided for in Article 3 of this chapter the department shall give its consideration thereto and shall approve or disapprove the same within the time provided in this article.

6261. A defective application made in a bona fide attempt to conform to the law and rules and regulations of the department shall not be rejected but notice of defect shall be sent to the applicant by ordinary and registered mail.

6262. If within 30 days of the date of mailing the notice the applicant does not file an amended and perfected application, the application shall be rejected and canceled unless for good cause shown the department allows the applicant further time.

6263. No application shall be approved in less than 10 days from its receipt but all applications shall be approved or disapproved as soon as practicable after the receipt of all data and information found necessary by the department.

6264. Approvals may be granted under terms, conditions, and limitations necessary to safeguard life and property.

6265. Actual construction shall be commenced within one year after date of approval, otherwise the approval becomes void.

6266. The department may, upon written application and for good cause shown, extend the time for commencing construction.

6267. Notice shall be given to the department at least 10 days before construction is to be commenced and such other notices shall be given to the department as it may require.

Chapter 6. Fees

6300. (a) The application for a new dam or reservoir or enlargement shall set forth the estimated cost, as defined in this article, of the dam or reservoir or enlargement and shall be accompanied by a filing fee based upon the estimated cost and according to the following schedule:

(1) For the first three hundred thousand dollars ($300,000), a fee of 3 percent of the estimated cost.

(2) For the next seven hundred thousand dollars ($700,000), a fee of 2 percent.

(3) For the next one million dollars ($1,000,000) a fee of 1 ½ percent.

(4) For the next one million dollars ($1,000,000), a fee of 1 ¼ percent.

(5) For the next two million dollars ($2,000,000), a fee of 1 percent.

(6) For the next two million dollars ($2,000,000), a fee of three-fourths of 1 percent.

(7) For all costs in excess of seven million dollars ($7,000,000), a fee of one-half of 1 percent.

(b) In no case, however, shall the minimum fee be less than three hundred dollars ($300).

6301. One filing fee only shall be collected for an enlargement to be effected by flashboards, sandbags, earthen levees, gates, or other works, devices, or obstructions which are, from time to time, to be removed and replaced or opened and shut and thereby operated so as to vary the surface elevation of the impounded water.

6302. For the purposes of this part, the estimated cost of the dam or reservoir or enlargement involved shall include the following:

(a) The cost of all labor and materials entering into the construction of the dam and appurtenant works or reservoir.

(b) The cost of preliminary investigations and surveys.

(c) The cost of the construction plant properly chargeable to the cost of the dam or reservoir.

(d) Any and all other items entering directly into the cost of the dam or reservoir.

6303. The costs of right-of-way, detached powerhouses, electrical generating machinery, and roads and railroads affording access to the dam or reservoir shall not be included among the items used in the determination of cost.

6304. An application shall not be considered by the department until the filing fee is received.

6305. In the event the actual cost exceeds the estimated cost by more than 15 percent, a further fee shall be required by the department before final approval and shall be 115 percent of the amount by which the original fee is less than it would have been had the cost it was based upon been the same as the actual cost. No further fee shall be required, however if such fee is to be computed at less than twenty dollars ($20).

6306. Applications for dams found by the department to have been less than 90 percent constructed on August 14, 1929, shall be accompanied by fees as much
less than provided for dams commenced after that date as the percentage of construction found by the department to have been completed on that date.

6307. (a) (1) The department shall adopt, by regulation, a schedule of fees to cover the department's costs in carrying out the supervision of dam safety.

(2) The revenue generated by the fees imposed under this section shall be adjusted periodically for cost-of-living increases. If the director determines that the revenue collected during the preceding fiscal year was greater or less than the cost to operate the program, the director shall adjust the fees to compensate for the overcollection or undercollection of revenue. The department shall provide a schedule of fees to the Legislature and to every dam owner that has a permit or has applied for a permit, when any adjustment is made to the fees under this section.

(b) (1) An annual fee shall be paid on or before January 31, 2004, July 1, 2004, and on or before July 1 of each succeeding year, based upon a fixed rate and height of the dam, including all enlargements thereto, substantially completed by or in operation on June 30, 2003, and on June 30 of each succeeding year. The fees collected on December 31, 2003, will be credited toward the fees due January 31, 2004. The annual fee shall be four hundred dollars ($400) per dam, plus one hundred ten dollars ($110) per foot of height. This fee shall be periodically adjusted, as described in subdivision (a).

(2) A penalty plus interest, as set forth in Section 6428 of the Water Code, shall be imposed for fees received after July 1 in any year, except that for the year 2003, the penalty plus interest shall be imposed for any fees received after January 31, 2004.

(c) For the purposes of this section, “height of the dam” means the vertical distance, to the nearest foot, from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the department, or from the lowest elevation of the outside limit of the barrier, as determined by the department, if it is not across a stream channel or watercourse, to the maximum possible water storage elevation.

(d) Notwithstanding subdivision (b), the department shall limit the total annual fee per dam to not more than seventy-five ($75) if both of the following apply:

(1) The dam has a storage capacity of not more than 100 acre-feet.

(2) The governing body of a private school or the governing board of a public school certifies that the dam is used as a subject of study by its students.

(e)(1) Notwithstanding subdivision (b), the department shall limit the total annual fee for dams or reservoirs located on farms or ranch properties to one hundred fifty dollars ($150) per dam, and sixteen dollars ($16) per foot of height.

(2) For purposes of this subdivision, “farm” has the same meaning as defined in Section 52262 of the Food and Agricultural Code.

(f)(1) Privately owned dams with less than 100 acre-feet of storage capacity shall be assessed an annual fee in accordance with paragraph (1) of subdivision (e).

(2) As used in this subdivision, “privately owned” does not include dams owned by municipalities, water districts or companies, irrigation districts, private, investor owned or publicly owned utilities, or public agencies.

6308. All fees, penalties, interest, fines, or charges collected by the department under this division shall be deposited in the Dam Safety Fund, which is hereby established in the State Treasury. The money in that fund shall be available to the department, upon appropriation by the Legislature, for the administration of the dam safety program.

6309. The fees provided for in this chapter shall be required of any “owner”, as defined in Section 6005.

Chapter 7. Inspection and Approval

Article 1. New or Enlarged Dams and Reservoir

6350. Immediately upon completion of a new dam or reservoir or enlargement of a dam or reservoir, the owner shall give a notice of completion to the department and as soon thereafter as possible shall file with the department supplementary drawings or descriptive matter showing or describing the dam or reservoir as actually constructed, including the following:

(a) A record of all grout holes and grouting.

(b) A record of permanent location points and bench marks.

(c) A record of tests of concrete or other material used in the construction of the dam or reservoir.

(d) Any other items which may be of permanent value and have a bearing on the safety and permanency of the dam or reservoir.

6351. In connection with the enlargement of a dam or reservoir, the supplementary drawings and descriptive matter need apply only to the new work.

6352. As soon as possible after giving notice of completion, the owner shall file an affidavit with the department stating the actual cost of the dam or reservoir in such detail as the department requires to determine whether a further fee is due. In the event the owner of a new or enlarged dam or reservoir, because of loss of records, recent change of ownership, or other causes beyond his control, is unable to report the actual cost of construction or enlargement, he shall file an affidavit to this effect, stating the reasons therefore, within 30 days after receiving a written request therefore from the department. The department shall then make its own appraisal of the cost of construction or enlargement and determine what further fee, if any, is required. Upon making a determination that a further fee is required, the department shall notify the owner by certified mail of the amount of such fee within 15 days and shall notify the owner that he may appear within 60 days thereafter before an authorized representative of the department to protest the amount of the fee, in whole or in part, determined by the department to be required, and the sufficiency of the appraisal upon which such determination was based.

6354. As soon as practicable the completed dam or reservoir shall be inspected by the department.

6355. A certificate of approval shall be issued upon a finding that the dam or reservoir is safe to impound water within the limitations prescribed in the certificate. Upon written request by an owner for a certificate of approval, the department shall issue the certificate if it finds that the dam or reservoir is safe to impound water within the limitations prescribed in the certificate. Pending issuance of a certificate of approval by the department, the owner of the dam or reservoir shall not, through action or inaction, cause the dam or reservoir to impound water.

Article 1.5. Certificates of Approval

6357. Each certificate of approval issued by the department under this part may contain such terms and conditions as the department may prescribe.

6357.1 The department may revoke any certificate of approval whenever it determines that the dam or reservoir constitutes a danger to life and property. Whenever it deems such action necessary to safeguard life and property, the department may also amend the terms and conditions of any such certificate by issuing a new certificate containing the revised terms and conditions.

6357.2 The owner of a dam or reservoir for which a certificate of approval has been issued shall not, through action or inaction, cause the dam or reservoir to impound water after the certificate terminates unless a new certificate is issued for the dam or reservoir. A new certificate shall be issued upon a finding by the department that the dam or reservoir is safe to impound water within the limits prescribed in the certificate.

6357.3 With respect to each certificate of approval or written consent for use of a dam which has been issued by the department or a predecessor of the department and which is in effect prior to the effective date of this article, the department shall, within one year from such effective date, issue a new certificate of approval, which shall supersede the previous certificate or written consent for use, or shall revoke the existing certificate or written consent for use if it finds that the dam or reservoir is not safe to impound water.

6357.4 Before any certificate of approval is revoked by the department, the department shall hold a hearing. Written notice of the time and place of the hearing shall be mailed, at least 20 days prior to the date set for the hearing, to the holder of the certificate. Any interested persons may appear at the hearing and

present their views and objections to the proposed action. Any petition for a writ of mandate to inquire into the validity of action of the department revoking a certificate of approval shall be commenced within 30 days after service of notice of the revocation on the holder of the certificate.

Article 2. Repaired or Altered Dams and Reservoirs

6360. Immediately upon completion of the repair or alteration of any dam or reservoir, the owner shall give notice of completion to the department and as soon thereafter as possible shall file with it supplementary drawings or descriptive matter showing or describing the dam or reservoir as actually repaired or altered together with such maps, data, records, and information pertaining to the dam or reservoir as repaired or altered as the department requires.

6362. As soon as practicable the dam or reservoir as repaired or altered shall be inspected by the department.

6363. A certificate of approval shall be issued upon a finding that the dam or reservoir is safe to impound water within the limitations prescribed in the certificate. Pending issuance of a new certificate of approval, the owner of the dam or reservoir shall not, through action or inaction, cause the dam or reservoir to impound water beyond the limitations prescribed in the existing certificate.

6364. The certificate of approval shall supersede any previous certificate of approval issued for the dam or reservoir so repaired or altered.

Article 3. Removal of Dams and Reservoirs

6370. Upon completion of the removal of a dam or reservoir such evidence as to the manner in which the work was performed and as to the conditions obtaining after the removal as the department requires shall be filed with the department.

6371. This evidence shall show that a sufficient portion of the dam has been removed to permit the safe passage of floods down the watercourse across which the dam was located.

6372. Before final approval of the removal of a dam or reservoir is issued, the department shall inspect the work and determine that all danger to life and property has been eliminated.

Article 4. Dams Completed Prior to August 14, 1929

6380. The department shall make inspections at State expense of all dams in the State completed prior to August 14, 1929.

6381. The department shall require owners to perform at their expense such work or tests as necessary to disclose information sufficient to enable the department to determine whether to issue certificates of approval or to issue orders directing further work at the owners' expense necessary to safeguard life and property.

6382. If, upon inspection or upon completion to the satisfaction of the department of all work that may be ordered, the department finds that the dam is safe to the full extent for which use is or will be made, a certificate of approval shall be issued.

Article 5. Complaints as to Unsafe Conditions

6390. Upon receipt of a written complaint alleging that the person or property of the complainant is endangered by the construction, maintenance, or operation of any dam or reservoir the department shall cause an inspection to be made unless the data, records, and inspection reports on file with it are found adequate to enable a determination whether or not the complaint is meritorious.

6391. If the complainant insists upon an inspection and deposits with the department a sum estimated by it to be sufficient to cover costs of an inspection, the department shall cause an inspection to be made despite its finding as to the sufficiency of its records to determine the alleged danger.

6392. If it is found that an unsafe condition exists, the department shall take such action as is necessary to render or cause the condition to be rendered safe and any money deposited to secure an inspection shall be returned.

6393. If, after an inspection is made on account of a complaint, the complaint is found by the department to have been without merit, any money deposited therefore shall be payable into the State Treasury.

Article 6. Inspection During Progress of Work

6400. During the construction, enlargement, repair, alteration, or removal of any dam or reservoir the department shall make continuous or periodical inspections at state expense for the purpose

of securing conformity with the approved plans and specifications but shall require the owner to perform at his expense such work or tests as necessary to disclose information sufficient to enable the department to determine that conformity with the approved plans and specifications is being secured.

6401. If, after any inspections, investigations, or examinations, or at any time as the work progresses, or at any time prior to issuance of a certificate of approval it is found by the department that amendments, modifications, or changes are necessary to insure safety, the department may order the owner to revise the plans and specifications.

6402. If conditions are revealed which will not permit the construction of a safe dam or reservoir the approval may be revoked.

6403. In the event that conditions imposed may be waived or made less burdensome without sacrificing a proper margin of safety, the department may authorize an owner to revise the plans and specifications accordingly.

6404. If at any time during construction, enlargement, repair, or alterations of any dam or reservoir the department finds that the work is not being done in accordance with the provisions of the approval and the approved plans and specifications or in accordance with the approval and revised plans and specifications, it shall give a written notice and order by registered mail or by personal service to the owner.

6405. The notice and order shall state the particulars in which the approval and approved plans and specifications or the approval and approved plans and specifications as revised are not being or have not been complied with shall order the immediate compliance with the approval and approved plans and specifications or with the approval and approved revised plans and specifications as the case may be.

6406. The department may order that no further work be done until such compliance has been effected and approved by the department.

6407. A failure to comply with the approval and approved plans and specifications as originally approved or as revised shall render the approval subject to
revocation by the department, if compliance is not made in accordance therewith after notice and order from the department as provided in this article.

Chapter 8. Offenses and Punishment

6425. Every person who violates any of the provisions of this part or of any approval, order, rule, regulation, or requirement of the department is guilty of a misdemeanor and punishable by a fine of not more than two thousand dollars ($2,000) or by imprisonment in the county jail not exceeding six months, or both. In the event of a continuing violation each day that the violation continues constitutes a separate and distinct offense.

6426. Any person who willfully obstructs, hinders, or prevents the department or its agents or employees from performing the duties imposed by this part or who willfully resists the exercise of the control and supervision conferred by this part upon the department or its agents or employees is guilty of a misdemeanor and punishable as provided in this article.

6427. Any owner or any person acting as a director, officer, agent, or employee of an owner, or any contractor or agent or employee of a contractor who engages in the construction, enlargement, repair, alteration, maintenance, or removal of any dam or reservoir, who knowingly does work or permits work to be executed on the dam or reservoir without an approval or in violation of or contrary to any approval as provided for in this part, or any inspector, agent, or employee of the department who has knowledge of such work being done and who fails to immediately notify the department thereof is guilty of a misdemeanor and punishable as provided in this article.

6428. Any owner who fails to pay any annual fee or any part of any annual fee required to be paid pursuant to Section 6307 within the time required shall pay a penalty of 10 percent of the annual fee or part of the annual fee, plus interest at the rate of one-half of 1 percent per month, or fraction thereof, from the date on which the annual fee or the part of the annual fee became due and payable to the state until the date of payment.

Chapter 9. Dams Under Construction Prior to August 14, 1929

6450. Any dam which the department finds was not 90 percent constructed on August 14, 1929 shall be subject to the same provisions as a dam commenced after that date.

6451. Construction work on such a dam may proceed, if an application for approval thereof is filed, until an order from the department is received approving the dam or specifying how its construction must be made or altered to render it safe. After

receipt of an order directing the construction of such a dam, work thereafter must be in accordance with the order.

6452. Dams found to be 90 percent or more constructed on August 14, 1929, shall be subject to the same supervision as dams which were completed prior to that date.

Chapter 10. Dams and Reservoirs Under State Supervision Through1965 Revisions of Part 1

Article 1. Dams and Reservoirs Completed Before 1965 Revisions

6455. Every owner of a dam or reservoir that falls within the definition of a dam or reservoir in this part by virtue of the amendment of Section 6002 or the addition of Section 6004.5 at the 1965 Regular Session of the Legislature and that was completed prior to September 17, 1965, shall immediately file an application with the department for the approval of such dam or reservoir; provided that this Chapter 10 shall not apply to any reservoir which contains the water impounded by a dam for which a certificate of approval is in effect on September 17, 1965.

6456. A separate application shall be made for each dam or reservoir and shall be filed with the department upon forms to be supplied by it and shall include or be accompanied by such appropriate information concerning the dam or reservoir as the department requires.

6457. The department shall give notice to file an application to owners of such dams or reservoirs who have failed to do so as required by this article, and a failure to file within 30 days after such notice shall be punishable as provided in this part.

6458. The notice provided for in this article may be given by registered or certified mail and a return receipt signed by the owner shall constitute prima facie evidence of service.

6459. The department shall make inspections of such dams or reservoirs at state expense.

6460. The department shall require owners of such dams or reservoirs to perform at their expense such work or tests as necessary to disclose information sufficient to enable the department to determine whether to issue certificates of approval or to issue orders directing further work at the owner’s expense necessary to safeguard life and property. For this purpose, the department may

require an owner to lower the water level of, or to empty, the reservoir.

6461. If, upon inspection or upon completion to the satisfaction of the department of all work that may be ordered, the department finds that the dam or reservoir is safe to impound water, a certificate of approval shall be issued. The owner of the dam or reservoir shall not, through action or inaction, cause the dam or reservoir to impound water following receipt by the owner of a written notice from the department that a certificate will not be issued because the dam or reservoir will not safely impound water. Before such notice is given by the department, the department shall hold a hearing. Written notice of the time and place of the hearing shall be mailed, at least 20 days prior to the date set for the hearing, to the owner of the dam or reservoir. Any interested persons may appear at the hearing and present their views and objections to the proposed action. Any petition for a writ of mandate to inquire into the validity of the action of the department shall be commenced within 30 days after receipt by the owner of a written notice from the department that a certificate of approval will not be issued.

Article 2. Dams and Reservoirs Under Construction Before 1965 Revisions

6465. Any dam or reservoir that falls within the definition of a dam or reservoir in this part by virtue of the amendment of Section 6002 or the addition of Section 6004.5 at the 1965 Regular Session of the Legislature and which the department finds was under construction and not 90 percent constructed on September 17, 1965, shall, except as provided in Section 6466, be subject to the same provisions in this part as a dam or reservoir commenced after that date. Every owner of such a dam or reservoir shall file an application with the department for the department's written approval of the plans and specifications of the dam or reservoir. Where an application for approval of the plans and specifications for a dam is pending before the department on September 17, 1965, such application shall be deemed to also constitute an application for approval of the plans and specifications of the reservoir which will contain the water impounded by the dam.

6466. Construction work on such a dam or reservoir may proceed, provided an application for approval of the plans and specifications therefore is filed, until a certificate of approval is received by the owner from the department approving the dam or reservoir or an order is received by the owner from the department specifying how the construction must be performed to render the dam or reservoir safe. After receipt of an order specifying how construction of a dam or

reservoir must be performed, work thereafter must be in accordance with the order.

6467. Such dams or reservoirs as are 90 percent or more constructed on September 17, 1965, shall be subject to the same supervision as dams or reservoirs which were completed prior thereto.

Article 3. Fees for Dams or Reservoirs Under Construction Before 1965 Revisions

6470. The owners of completed dams or reservoirs and dams or reservoirs that are 90 percent or more constructed that are made subject to the provisions of this part by the amendment of Section 6002 or the addition of Section 6004.5 at the 1965 Regular Session of the Legislature shall not be required to pay a fee in relation to applications filed with the department for approval of their dams or reservoirs. Applications for the approval of dams or reservoirs that are made subject to this part by said amendment or addition that are found by the department to have been less than 90 percent constructed on September 17, 1965, shall be accompanied by fees as much less than provided for dams or reservoirs commenced after that date as the percentage of construction found by the department to have been completed on that date.

PART 2. FISHWAYS OVER DAMS

6500. Whenever an application for approval of plans and specifications for a new dam, or for the enlargement of any dam, in any stream in this State, is filed pursuant to Part 1 of this division, a copy of the application shall be filed with the Fish and Game Commission as required by the Fish and Game Code.

6501. The provisions for the installation of fishways over or around dams and for the protection and preservation of fish in streams obstructed by dams are contained in Chapter 3 (commencing with Section 5900), Part 1, Division 6 of the Fish and Game Code.

CALIFORNIA CODE OF REGULATIONS

Title 23. Waters

Division 2. Department of Water Resources

Chapter 1. Dams and Reservoirs

Article 1. General Provisions

301. Definitions.

As used in this subchapter, the terms “dam”, “reservoir”, “owner”, “alteration”, enlargement”, and “water storage elevation” shall have the meanings given in Sections 6002 and 6004.5 through 6008 of the Water Code.

NOTE: Authority cited: Section 6078, Water Code. Reference: Sections 6002-6008, Water Code.

302. Purpose and Effect of Regulations.

The regulations in this subchapter are not intended to limit the authority of the department to act under the police power of the state to the extent authorized by law, when necessary to protect life and property from a dam or reservoir which constitutes, or which may constitute a danger to life and property, and they shall not be interpreted as depriving the department of such authority.

NOTE: Authority cited: Section 6078, Water Code. Reference: Sections 6075, 6081, and 6110, Water Code.

303. Evidence of Water Rights.

(a) The department will not issue a written approval to commence construction or enlargement of a dam or reservoir until the applicant or owner demonstrates evidence of adequate water rights in accordance with the requirements of this section.

(b) The applicant or owner shall provide the department with either:

(1) A copy of an entitlement to the use of water issued by the State Water Resources Control Board pursuant to Division 2, Part 2 (commencing with Section 1200) of the Water Code; or

(2) If the right to divert or use water does not depend on an entitlement identified in subsection (1) above, a statement of the legal basis of the right.

(c) The applicant or owner shall also provide the department with either:

(1) Evidence that a statement of water diversion and use has been filed with the State Water Resources Control Board pursuant to Division 3, Part 1, Chapter 5 (commencing with Section 5100) of the Water Code, or

(2) A statement either establishing that a statement of water diversion and use is not legally required, or showing good cause for not filing one.

(d) The department shall obtain a written statement from the staff of the State Water Resources Control Board stating whether the water right is adequate for the proposed dam and reservoir.

(e) If a right to divert or use water is based upon a claim of riparian rights, or rights to appropriate water established prior to 1914, and such claim is disputed by the State Water Resources Control Board, the department shall not withhold approval to commence construction solely upon the basis of such a dispute, provided that it is satisfied with the evidence of a water right provided pursuant to subsection (b) above.

(f) In the event that the State Water Resources Control Board has initiated proceedings to determine whether to authorize use of water, and no decision has been issued, written approval to commence construction or enlargement shall not be withheld pursuant to this section after the 120th day following either the date that the matter is submitted to the Board for decision after hearing or, if no hearing is held, the date on which the protest period closes.

NOTE: Authority cited: Section 6078, Water Code. Reference: Sections 1052, 6075, 6202(d), 6205, and 6264, Water Code.

304. Civil Engineering Plans and Specifications.

Plans and specifications which are submitted to the department shall be prepared by, or under the direction of, a civil engineer who is registered pursuant to California law and authenticated by him as provided in the Business and Professions Code, or be prepared by such other person as may be permitted under the provisions of said code to prepare such plans and specifications, in which case satisfactory evidence of such other person's right to

so act shall be submitted to the department when the plans and specifications are submitted.

NOTE: Authority cited: Section 6078, Water Code. Reference: Section 6206 Water Code; and Sections 6371, 6374-6375, Business and Professions Code.

305. Civil Engineering Supervision of Construction.

The work of construction, enlargement, repair, alteration or removal of a dam or reservoir shall be under the responsible charge of a civil engineer who is registered pursuant to California law or of such other person as may be permitted under the provisions of the Business and Professions Code to assume responsible charge of such work.

NOTE: Authority cited: Section 6078, Water Code. Reference: Section 6206, Water Code; Sections 6731, 6374-6375, Business and Professions Code.

Article 2. Applications for Construction, Enlargement, Repair, Alteration, Removal of Dams or Reservoirs

310. Applications for Construction or Enlargement.

(a) This section shall apply to applications for the department's approval of plans and specifications for the construction or enlargement of dams and reservoirs.

(b) Applications for construction or enlargement of a dam and reservoir shall be made on printed forms provided by the department. The department shall also provide written instructions for completing the application.

(c) The amount of information required will depend on factors such as the size of the proposed dam and reservoir, potential hazards, hydrology of the watershed, complexity of the site and proximity to active faults.

(d) Plans, maps, specifications and other information required for an application shall be provided in sufficient clarity and detail to be readily interpreted and studied, and to permit an adequate evaluation of the safety of the proposed work.

(e) The department may require the filing of any information, in addition to that specified in this section which, in its opinion, it considers necessary to determine the safety of the dam and reservoir.

(f) In addition to the information required by the Water Code Sections 6201-6206, and subsections (b)-(e), an application shall also include the following:

(1) Evidence of water rights, as required by Section 303.

(2) Information necessary to enable the department to comply with the requirements of the California Environmental Quality Act (Public Resources Code Sections 21000-21174). This information shall be either:

(a) A copy of the environmental impact report (EIR) or negative declaration prepared by a lead agency, or evidence that a lead agency is preparing or will prepare environmental documentation, or

(b) Data and information necessary for the department to act as a lead agency to prepare environmental documentation, where it is required by law to do so.

(3) Where the department acts as a responsible agency, the lead agency's EIR or negative declaration must be submitted to the State Clearinghouse.

(4) The fee as required by Water Code Section 6300, as made specific by Section 314 of this subchapter.

NOTE: Authority cited: Section 6078, Water Code. Reference: Sections 6200-6206, Water Code; and Sections 21002.1(d) and 21083, Public Resources Code.

311. Criteria for Determining Completeness.

(a) Applications will be considered complete when the department has received the completed, signed application form, the information and fee required in Water Code Sections 6201 and 6206 and Section 310(d)-(f), and the fee required by Sections 6300-6302 of the Water Code.

(b) The department on its own motion may waive any information required for a complete application, including but not limited to the requirements of Section 303 where it determines that it has sufficient information to commence and complete a review within applicable time limits, and that all requirements for issuance of an approval will be met within such time limits.

(c) The requirements published by the department pursuant to Section 310 shall set forth the procedures that the department will follow to review an application.

(d) Failure to comply with a request for information pursuant to such procedures within a reasonable time and in a reasonably responsive manner shall be cause for the department to disapprove the application.

NOTE: Authority cited: Section 6078, Water Code. Reference: Section 65941, Government Code.

312. Standard Terms

(a) The following are standard terms and conditions included in any approval of a dam safety application:

(1) Construction work shall be started within one year from date of approval.

(2) No foundations or abutments shall be covered by the material of the dam until the Department has been given an opportunity to inspect and approve the same.

(b) General Safety Requirement. In addition to the above terms and conditions, the law requires that a dam shall at all times be designed, constructed, operated and maintained so that it shall not or would not constitute a danger to life or property, and the Department may, at any time, exercise any discretion with which it is vested, or take any action necessary to prevent such danger.

NOTE: Authority cited: Section 6078, Water Code. Reference: Sections 6075, 6260-6267, Water Code.

313. Automatic Approval of Applications.

Applications approved in accordance with Government Code Section 65956 shall contain the terms and conditions set forth in Section 311. Such approvals may be revoked or modified at any time and under any conditions which would apply to any other approval granted under Division 3, Part 1 of the Water Code.

NOTE: Authority cited: Section 6078, Water Code. Reference: Section 65956, Government Code; and Sections 6260-6267, Water Code.

314. Filing Fee.

(a) Amount of Fee. The estimated cost of the dam and reservoir or enlargement as specified in Section 6302 of the Water Code shall include engineering, geologic, surveying, construction supervision, and administrative costs.

NOTE: Authority cited: Section 21082, Public Resources Code; Section 6078, Water Code. Reference Section: 21089 Public Resources Code; Sections 6301-6305, Water Code.

Article 3. Annual Fee.

315. Annual Fee.

(a) Determination of Amount. The department shall determine the amount of the fee in accordance with Section 6307 of the Water Code. Each owner shall be informed of the amount of the fee by April 30 of each year.

(b) Penalty for Delinquent Payment of Annual Fee. An owner who fails to pay any part of any annual fee on or before July 1, as required by Section 6307 of the Water Code, shall be penalized in accordance with Section 6428 of the Water Code.

NOTE: Authority cited: Section 6078, Water Code. Reference: Section 161, Water Code; and Sections 6307 and 6428, Water Code.

316. Inoperative Dams.

A dam will not be considered to be substantially completed or in operation for annual fee purposes, where the department determined that it has been rendered inoperative on other than a temporary basis. In making its determination the department will consider the following circumstances, among others, with respect to the dam:

(a) Alteration of the outlet facilities to assure maximum possible uncontrolled water release through the outlet works.

(b) Absence of water impounding capability under reasonably foreseeable conditions, taking into account the size of the drainage area.

(c) Absence of benefit from the dam and reservoir to the owner or others.

The Department may determine that a dam is no longer inoperative when investigation reveals that conditions which rendered the dam inoperative on other than a temporary basis have changed. In this event the dam will be considered substantially completed or in operation on the date such determination is made, and the annual fee shall be charged on a pro rata basis.

NOTE: Authority cited: Section 6078, Water Code. Reference: Section 6307, Water Code.

Article 4. Small Dams Review Board

320. Small Dams Review Board.

In the Department there shall be a Small Dams Review Board consisting of a chairperson who shall be the Division Chief, Division of Design and Construction; a qualified engineer or geologist appointed by the Division Chief, Division of Safety of Dams; and, for each review, a consulting engineer who would be agreed upon by the Department and the dam owner.

NOTE: Authority cited: Section 6078, Water Code. Reference: Section 6054, Water Code.

321. Scope of Review

(a) The Board shall be convened upon the request of any owner of a small dam or proposed small dam to review any decision or order of the department respecting any technical standard, study requested, engineering requirement or other technical matter required by the department where the owner disputes the basis for such requirement, the need for such requirement, or the facts found by the department.

(b) No review shall be undertaken if, in the opinion of the department, there exists an immediate hazard to life or property. This subsection shall not be construed to bar a Small Dams Review Board proceeding after, in the judgment of the department, an immediate hazard to life and property no longer exists.

NOTE: Authority cited: Section 6078, Water Code. Reference: Section 6054, Water Code.

322. Small Dam Defined.

“Small Dam” means any dam less than 25 feet in height with a reservoir storage less than 2,000 acre-feet.

NOTE: Authority cited: Section 6078, Water Code. Reference: Sections 6054 and 6055, Water Code.

323. Time to Request Board Review; Filing Fee.

(a) The owner must request board review within 60 days of the disputed departmental action. The request must be made to the Division Chief, Division of Safety of Dams, and must state the facts and circum-stances on which such owner bases his grievance.

(b) The owner shall remit, at the time the grievance is filed the amount of $250 to partially defray the cost and expense of the Board.

(c) If the Board meets for more than one day, the department shall bill the owner for its additional costs incurred for subsequent days.

NOTE: Authority cited: Section 6078, Water Code. Reference: Sections 6054 and 6055, Water Code.

324. Time and Conduct of Review.

The Board shall review the owner's grievance promptly after such grievance is filed. The review shall be conducted in an informal manner. The Board shall consider all relevant information and data presented by the owner, his engineer, or any other person.

NOTE: Authority cited: Section 6078, Water Code. Reference: Section 6054, Water Code.

325. Findings of the Board.

Based upon information and data secured during the review, the Board shall refer its findings to the Division Chief, Division of Safety of Dams, regarding the matter which led to the grievance. Decisions made by the Division Chief shall be final.

NOTE: Authority cited: Section 6078, Water Code. Reference: Section 6054, Water Code.

Article 5. Dams Owned by the Department of Water Resources

330. Consulting Board.

Pursuant to Section 6056 of the Water Code, the department shall retain a board of three consultants to report to the Director on the safety of dams owned by the department.

NOTE: Authority cited: Section 6078, Water Code. Reference: Section 6056, Water Code.

331. Scope of Review.

The consulting board shall make independent findings with regard to conditions which may affect the safety of the dam and reservoir as specified in Section 6081 of the Water Code, and the board shall also make independent findings that the dam is safe to impound water, as specified in Section 6355 of the Water Code.

NOTE: Authority cited: Section 6078, Water Code. Reference: Sections 6056, 6081, 6355, Water Code.

332. Actions for Which Board is Retained.

(a) The department shall retain a consulting board:

(1) To review the adequacy of the design of a dam and reservoir the department proposes to construct, or

(2) To review the safety of the completed construction and the terms and conditions to be included

in a certificate of approval for any dam owned by the department as issued, renewed or modified, no later than six months following any such action.

(b) Where a board is retained to review the adequacy of the design of a dam and reservoir, it shall report its findings to the Director prior to the approval of an application to construct or enlarge the dam.

NOTE: Authority cited: Section 6078, Water Code. Reference: Section 6056, Water Code.

333. Periodic Review.

In addition to the times specified in Section 332, the department shall retain a review board at least once every five years to review the operational performance of department owned dams. The Federal Power Commission's five year independent review may be substituted if it is comparable to the review required by this article.

NOTE: Authority cited: Section 6078, Water Code. Reference: Section 6056, Water Code.

CURRENT PRACTICES
OF THE
DEPARTMENT OF WATER RESOURCES
IN
SUPERVISION OF DAMS AND RESERVOIRS

Introduction

The following is provided to help the reader comply with the requirements of the foregoing sections of the Water Code (WC) and the California Code of Regulations (CCR). Current practices of the Department of Water Resources in supervision of dams and reservoirs in State jurisdiction are given. Information required for applications is outlined. (CCR 310)

Division of Safety of Dams

Responsibility for supervision of dams and reservoirs is assigned to the department and delegated to the Division of Safety of Dams (DSOD).

Dams and Reservoirs in State Jurisdiction

Water Code Sections 6000 to 6004.5 and 6025.5 identify dams and reservoirs that are in State jurisdiction. Note that dams and reservoirs owned by the United States are not subject to State jurisdiction except as otherwise provided by federal law.

The Division will review the physical description on request of existing or proposed impoundments and determine if they are or will be in State jurisdiction. Plans for proposed impoundments are usually required before determinations can be made.

Proposed Dams and Reservoirs

The Division of Safety of Dams inspects sites, reviews preliminary plans, and comments on firm proposals for proposed dams and reservoirs. It attempts to inspect representative field exploration, unique laboratory testing, etc., for proposed facilities. However, any comments based on preliminary plans and data are not binding on the Division's later consideration of applications.

In matters relating to the California Environmental Quality Act (CEQA), the Department of Water Resources is the lead or responsible agency for dams and reservoirs. Environmental consideration for dams and reservoirs not directly related to safety is assigned to the Department's four districts. Usually, the Division of Safety of Dams makes preliminary reviews of dam and reservoir proposals, as discussed above, before environmental documentation is prepared. Other water related concerns are handled by the appropriate district.

Procedure for Construction or Enlargement of Dams and Reservoirs

1. If adequate water rights are not already held, file an application for water rights with the State Water Resources Control Board, Division of Water Rights, 901 P Street, Sacramento, California 95814. Evidence of water rights is required before a construction or enlargement application can be approved. (CCR 303)

2. Pre-application meetings are not required by the statutes or regulations. Practice, however, has shown that early involvement

of DSOD in projects is most beneficial for aggressive project schedules. CEQA scoping meetings, early site visits to view exploration, preliminary design discussions, project schedule reviews, and submittal of preliminary 60 percent plans, specifications, and geologic data are recommended to expedite review leading to final approval.

3. File application for construction or enlargement of dam. (CCR 310) Include:

   (a) Application forms (DWR 3) in duplicate to Department of Water Resources, Division of Safety of Dams, P.O. Box 942836, Sacramento, California 94236-0001, (2200 X Street, Suite 200), plus one copy to the Fish and Game Commission in-care of the State Department of Fish and Game, 12th Floor, Resources Building, 1416 Ninth Street, Sacramento, California 95814, if the dam is in a stream. (WC 6500) Sign all copies.

   (b) Plans prepared by registered civil engineer pursuant to California law. (CCR 304) Such plans shall be filed in duplicate in the form of paper prints. Unsigned, nearly complete, prints should be submitted.

   (c) Specifications in duplicate. Nearly complete specifications should be submitted.

   (d) Filing Fee. (WC 6300-6309 and CCR 314). The Current fee structure is listed on the Division Website under "Fees."

   (e) Certain additional information may be desirable, or may be required, depending upon the magnitude of the project. Such added information may include soils data, logs of borings or other exploratory data, geologic reports, hydrologic data, structural and hydraulic design notes, etc.

   (f) Information to enable the department to comply with the California Environmental Quality Act and regulations. This information is as appropriate:

      (1) A copy of the final adopted environmental impact report or initial study--negative declaration prepared by a lead agency, or

      (2) Data and information necessary for the department to act as lead agency to prepare the environmental documentation.

The environmental documentation in either case must be submitted to the State Clearinghouse for processing as required by State law.

4. Within 30 days after receipt of an application, the Division informs the applicant that the application is complete or of the information necessary to make it complete.

5. After review of plans, specifications, etc., and inspection of the site, changes in the plans and specifications, and any supplemental data necessary for approval, will be identified.

6. Submit signed drawings in triplicate and final specifications in duplicate for application approval when review comments are resolved.

7. All civil engineering work is to bear the seal or stamp of the responsible civil engineer and shall be signed across the face with the expiration of the certificate shown on or adjacent to the seal. Civil engineering work includes plans, specifications, reports, and documents which are prepared under the Civil Engineering Practice Act.

8. Notify the Division when construction is to begin and keep DSOD field engineers informed as to the status of construction work at all times. Inspections are made during construction as deemed necessary. No foundations or abutments shall be covered until the DSOD field engineer has inspected and approved them.

9. Upon completion of construction, notify the Division by letter. Final inspections are made as soon as practicable after notice is received.

10. As soon as possible after completion of the dam and final inspection by the division's field engineer, file the following:

    (a) Affidavit of cost of construction. Attach breakdown of costs, including engineering.

    (b) Additional filing fee if final cost exceeds estimated cost by more than 15 percent.

    (c) As-constructed plans, if required, in the form of paper prints.

11. A Certificate of Approval will be issued upon a finding that the dam and reservoir are safe to impound water within the limitations prescribed in the certificate. Impoundment of water must not commence until this certificate is issued.

Procedure for Repair or Alteration of Dams or Reservoirs

The procedure is the same as for construction or enlargement except for the following:

1. Evidence of water rights is not required.

2. Use application form DWR 4.

3. Plans and specifications may not be required for minor repair work.

4. Repair and maintenance qualify for an exemption under the California Environmental Quality Act.

5. Only two sets of signed plans are required for application approval.

6. The Certificate of Approval is only modified when the alteration or repair lowers the approved water surface elevation.

Procedure for Removal of Dams and Reservoirs

The procedure is the same as for construction or enlargement except for the following:

1. Evidence of water rights is not required.

2. Use application form DWR 5.

3. Only two sets of signed plans are required for application approval.

4. The Certificate of Approval, if any, is returned to the Department.

Draft
Simplified Dam Failure Analysis for Inundation Mapping Using HEC-1

By
J. J. DeVries[1]

Introduction

This paper describes a simplified approach to dam failure analysis using HEC-1 to provide input hydrographs for the hydrodynamic model Mike 21. Mike 21 was used in combination with digital elevation models (DEM) to analyze the dambreak flood and produce inundation maps.

The California Office of Emergency Services (CA OES) was directed by the Governor of the State of California to develop dam failure inundation maps for all non-federal dams in the state. The flood mapping was done using a 2-D hydrodynamic model (Mike 21) using existing topographic information available from the USGS. Nearly 500 dam failure inundation maps were produced in a four-month period. The purpose of this study was not to produce detailed dam-failure flood maps, but to reveal those dams for which detailed mapping studies are required. This was a screening study and not a study to provide the final detailed inundation maps for individual dams.

The modeling tools were chosen on the basis of convenience of use and the ability to link the generation of flood maps to the inundation process. CA OES selected two models: a modified version of NWS DAMBRK and the Danish Hydraulic Institute Mike 21 model for the dambreak flood analyses. However, nearly all of the maps were based on the 2-D Mike 21 modeling.

Mike 21 requires an input hydrograph since the program does not simulate a dam failure or provide reservoir routing to compute the outflow hydrograph through the breach as it develops with time. HEC-1 has these features so it was used to simulate the dam failures. HEC-1 also has an option for writing the calculated hydrograph data to user-formatted files. A utility program was used to reformat the HEC-1 output as Mike 21 input.

The database for dam and reservoir characteristics for the State of California is maintained by the Division of Dam Safety of the California Department of Water Resources for dams under their jurisdiction. The information includes the height of the dam, crest elevation and length, reservoir storage capacity, and reservoir area.

To simulate a dam failure HEC-1 requires breach characteristics, including total failure time, and an elevation-capacity curve for the reservoir. These were developed from the published values of crest elevation, crest length, dam height, and reservoir storage capacity.

Background

The California Office of Emergency Services dam failure inundation mapping and emergency procedure program applies to dams meeting specific size requirements making them subject to the jurisdiction of the State of California. Dams owned by agencies of the United States government are not under the jurisdiction of this program. The legislative intent of the original CA OES seismic safety of dams legislation was to establish emergency procedures for the evacuation and control of populated areas below

[1] David Ford Consulting Engineers and State of California

dams which could be used to save lives and reduce injury in the event of a dam failure. Dam owners submit inundation maps to CA OES for review and approval in accordance with guidance issued by CA OES. Inundation maps represent the best estimate of where water would flow if a dam failed completely and suddenly with a full reservoir. Based upon approved inundation maps, or the delineated areas, cities and counties with territory in the mapped areas are required to adopt emergency procedures for the evacuation and control of populated areas below the dams.

HEC-1 dam failure analysis

Breach analysis—Because a large number of dams had to be analyzed, it was not possible to define specific characteristics for each dam am and reservoir. Dams were classified as either an earth or rockfill dam or a concrete dam. The following table shows the parameters for the two types of dams.

Assumptions concerning dam failure:

- "Sunny-day" failure
- Reservoir is full
- Failure is rapid

  Earth dam: 15 minutes for full failure

  Concrete dam: 9 minutes for full failure
- Failure is for full height of dam
- The maximum expected breach width occurs

Table 1. Dam breach parameters:

Parameter	Earth/rockfill Dams	Concrete Dams
Side slope of breach	**1.0**	**0.2**
Time until breach reaches its maximum size (hr)	**0.25**	**0.15**
Bottom width of breach (ft)	**5 * H**	**1 * H**
Discharge through turbines(cfs)	**10, 100, 1000**	**Value kept as small as possible.**
Elevation of water surface in reservoir at failure	**Weir Crest Elevation**	**Weir Crest Elevation**
Inflow at upstream end of reservoir	**Small dams : 10 cfs Medium dams: 100 cfs Large dams : 1000 cfs**	**Inflow to reservoir = discharge through turbines**

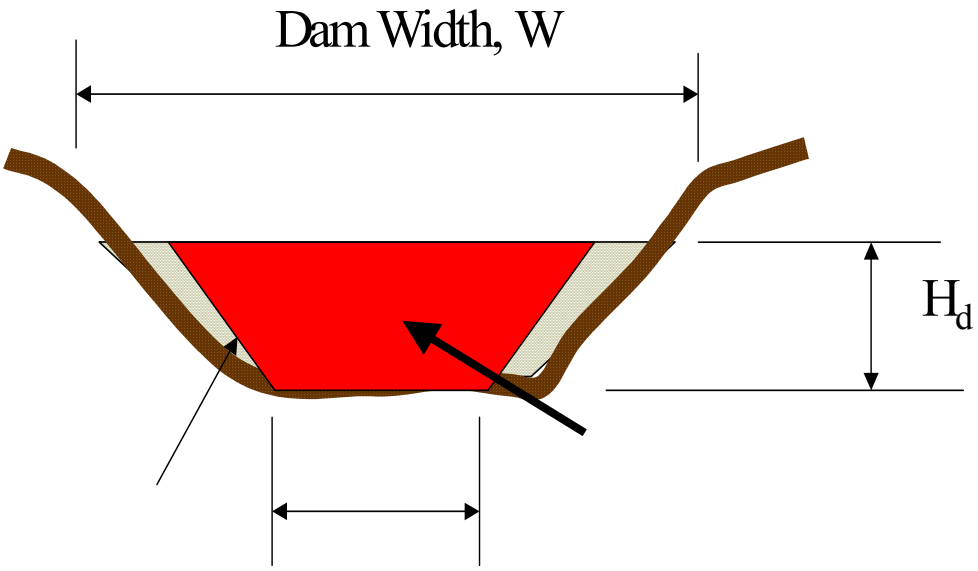


Figure 1. Breach geometry for earthen dams

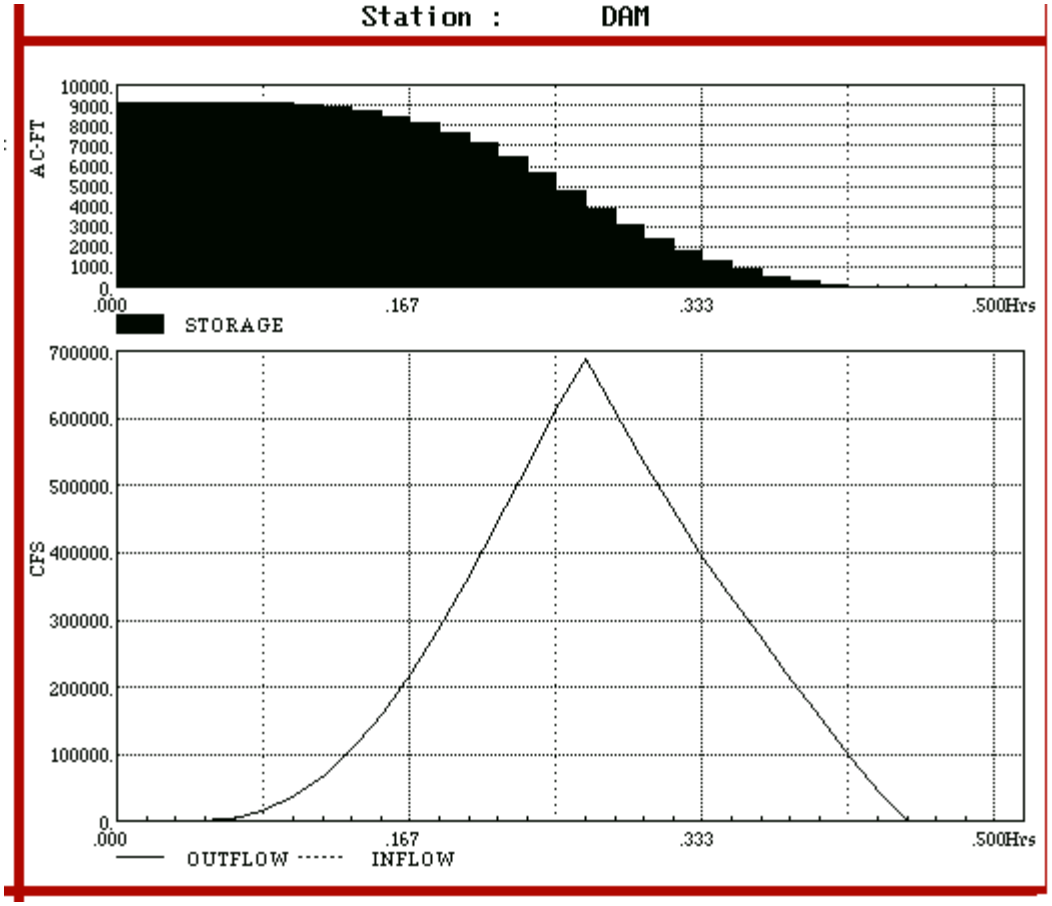


Figure 2: Dam failure hydrograph generated by HEC-1

Hydrodynamic model

MIKE 21 BACKGROUND

The version of Mike 21 used in this study simulates water level variations and flows in response to a variety of forcing functions in water bodies. The water levels and flows are resolved on a rectangular grid covering the area of interest when provided with the bathymetry, bed resistance coefficients, wind field, hydrographic boundary conditions, etc. The system solves the full time-dependent non-linear equations of continuity and conservation of momentum. The solution is obtained using an implicit ADI finite difference scheme of second-order accuracy.

Mike 21 parameters:

The only changes to the modeling parameters used for all individual inundation models were to the Manning's n values used for boundary resistance. Higher values were used in canyon areas than in the floodplains. A single value was used for the entire model. No effort was made to vary Manning's n by land use. Each 30-meter grid cell was represented by a single elevation value and a single roughness coefficient. The dam failure hydrograph generated by HEC-1 had an initial steady flow and a constant base flow added at the end of the hydrograph. Model stability problems occurred without adding these to the hydrograph.

Table 2. Parameters used in Mike 21.

Parameter	Value used
Eddy Viscosity	**5 m^2/s**
Wind Conditions	**No wind**
Dry Depth	**0.04 m**
Flood Depth	**0.10 m**
Manning's n - Canyons	**0.06 to 0.08**
Manning's n - Floodplain	**0.04 to 0.05**

Results

The assumptions used produced conservatively large flows from the simulated dam failure; the Manning's n-values were considered conservatively low; and many of the detailed features of the surface geometry were not represented in the 30-m DEMs. It was concluded that the inundation maps developed using these data typically over-predict expected inundation areas that could occur as a result of a dam failure.

A primary purpose of this study was to identify dams for which flooding due to dam failure could cause major risk to people and property. It is the dam owner's responsibility to submit inundation maps to CA OES for review and approval in accordance with guidance issued by CA OES. Based on the results of this study various dam owners were directed to have dam failure inundation studies made.

Several maps developed in this study were compared with inundation maps prepared by engineering firms for dam owners. None of the previous comparison studies used two-dimensional flood models. In general the tools used for dambreak flood analysis have been the one-dimensional unsteady-flow DAMBRK model or steady flow one-dimensional models (HEC-RAS or HEC-2). For the latter, dambreak flood hydrographs were generated by HEC-1 or the National Weather Service model BREACH.

Maps developed in this study showed good agreement with maps produced in previous studies, especially in steeper areas and areas with well-defined channelizing features. The results differed in flatter floodplain areas, especially where flow could split around small hills and other topographic forms.

More accurate definition of potential inundation areas could be obtained using two-dimensional hydrodynamic models. However, accurate topographic information is required. The widely available 30-m DEMs do not provide very accurate information on topography, and more detailed topographic data should be obtained.

Conclusions

This study was conducted to establish emergency procedures for the evacuation and control of populated areas below dams that could be used to save lives and reduce injury in case of a dam failure. Inundation maps represent the best estimate of where water would flow if a dam failed completely and suddenly with a full reservoir. Based upon approved inundation maps, or the delineated areas, cities and counties with territory in the mapped areas are required to adopt emergency procedures for the evacuation and control of populated areas below the dams.

More detailed investigations of individual dams would produce more accurate definition of potential inundation areas, and these are expected to be done in the future. The results from this study were judged to be appropriate in the light of the purpose of the study, and on the basis of comparisons of inundation maps submitted by dam owners appeared to provide approximately the same level of accuracy as obtained by commonly used inundation mapping methods.

Page left intentionally blank

Current Hydrologic Practices, Problems, and Needs
Within California's Dam Safety Program

By
Melissa Collord

Introduction

There are over 1,200 dams within the jurisdiction of the California Department of Water Resources (DWR), Division of Safety of Dams (DSOD). The dams are located throughout the state and have drainage basins that vary in size from portions of an acre to thousands of square miles. DSOD requires that all dams within its jurisdiction be capable of adequately passing a selected design flood. A method was developed by DSOD to estimate flood hydrographs for ungaged or poorly gaged watersheds for use in spillway evaluation.

Methodology

The procedure devised by DSOD in 1981 to determine the hydrologic adequacy of any spillway in California consists of eight parts:

1. Assessment of the potential downstream hazard
2. Determination of appropriate storm return period
3. Development of precipitation
4. Development of synthetic unit hydrograph parameters
5. Development of loss rate parameters
6. Computation of the flood hydrograph
7. Routing of the flood hydrograph through the reservoir
8. Evaluation of the spillway adequacy

The following discussion will focus on parts 4 thru 6, their basic concepts and shortcomings.

Unit Hydrograph

DSOD utilizes Clark's method to develop a synthetic unit hydrograph. Clark's unitgraph parameters are obtained from a generalized study, conducted in 1971, of observed rainfall and runoff events, which related these parameters to drainage basin characteristics by regression analysis. The study is applicable to the State of California except the area south of the Tehachapi Mountain Divide and the area east of the Sierra Nevada Divide. The regression equations relate the drainage basin characteristics of stream length, area, elevation, and ground cover to the time of concentration (t_c) and Clark's storage coefficient (R) for development of a basin-specific unit hydrograph. The study also presents guidelines for estimating loss rate parameters.

Flood Hydrograph

The flood hydrograph is developed using the computer program HEC-1 (Hydrologic Engineering Center, 1981). The program obtains the flood hydrograph by convolution of the effective rainfall increments with Clark's unitgraph. Losses due to surface retention and infiltration are estimated by the exponential loss rate function within HEC-1. The general criteria is that the percent runoff should not be less than 70 when the mean annual precipitation (MAP) at the basin is greater than 25 inches and should not be less than 60 when the MAP is 25 inches or less.

If applicable, allowances for snowmelt, base flow in the basin, runoff from prior storms, import of water, etc., are added to the storm runoff hydrograph to obtain the design flood hydrograph for the watershed.

Problems Faced

The regression equations provide a rational, consistent and simplistic method to developing a basin-specific synthetic unit hydrograph. However, with the advent of faster and more sophisticated computers and programs, such as HEC-HMS, calibration of basin models has become easier and a more widely used approach. The optimization feature in HEC-HMS estimates unit hydrograph and loss rate parameters with observed rainfall and flow data. Unfortunately, there still exists the problem of a lack of basic hydrologic data in most small drainage basins. This makes it impossible to calibrate a basin's unitgraph and loss rate or to check the reasonableness of a synthetic unit hydrograph. Therefore, we highly recommend that more research be conducted into developing unit hydrographs and determining loss rates for small ungaged basins.

Modeling large ungaged drainage basins that range in size from 100 to 1000 square miles present an even more difficult task. In addition to determining the unit hydrograph parameters for each subbasin, channel routing or lag time must now be included in the analysis. The methods that are available in determining routing parameters (DSOD typically uses the Muskingum routing method) are imprecise and our level of confidence in accurately defining the routing conditions is low.

Utilization of HEC-HMS as our primary tool to perform our hydrology and reservoir routing calculations will occur in a very gradual process as more staff members are exposed or are given training to operate the program. Several staff members have already received some training on HEC-HMS, but are unable to use the program since the exponential loss rate function is no longer available and in some cases snowmelt calculation is needed. DSOD can certainly modify loss rate assumptions to be compatible with HEC-HMS, but we do encourage HEC to incorporate snowmelt calculations into HMS as soon as practical.

E.6. Colorado

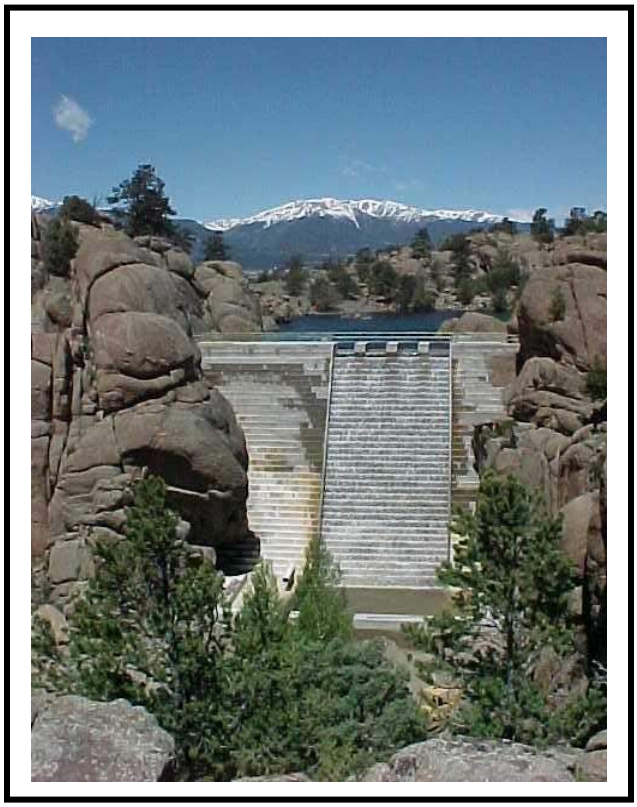


STATE OF COLORADO

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER RESOURCES
OFFICE OF THE STATE ENGINEER
DAM SAFETY BRANCH

RULES AND REGULATIONS FOR DAM SAFETY AND DAM CONSTRUCTION





EFFECTIVE DATE: JANUARY 1, 2007

2-CCR 402-1

1313 SHERMAN STREET
ROOM 818 CENTENNIAL BUILDING
DENVER, COLORADO
TELEPHONE 303-866-3581
FACSIMILE 303-866-3589
WEBSITE:
http://water.state.co.us

STATE OF COLORADO

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATER RESOURCES

OFFICE OF THE STATE ENGINEER

RULES AND REGULATIONS

FOR

DAM SAFETY AND DAM CONSTRUCTION

2-CCR 402-1

Effective Date:
January 1, 2007

OFFICE OF THE STATE ENGINEER

RULES AND REGULATIONS FOR DAM SAFETY AND DAM CONSTRUCTION

TABLE OF CONTENTS

RULE	PAGE
1. Title	1
2. Authority	1
3. Scope and Purpose	1
4. Definitions	1
5. Requirements for Construction or Enlargement of Jurisdictional Size Dams or Reservoirs	8
6. Requirements for Alteration, Modification, or Repair of an Existing Dam	37
7. Requirements for Removing or Breaching an Existing Dam	39
8. Fees	40
9. Construction of Jurisdictional Size Dams	41
10. Acceptance of Construction of Jurisdictional Size Dams	43
11. Construction, Modification, Alteration, Repair, and Breach of Non-jurisdictional Size Dams	45
12. General Maintenance, Ordinary Repairs, and Emergency Actions	46
13. Determination of Safe Storage Level	48
14. Safety Inspections Performed by the Owner's Engineer	48
15. Dam Owner's Responsibilities	49
16. Emergency Action Plans (EAP)	52
17. Exempt Structures	53
18. Restriction of Recreational Facilities within Reservoirs	54
19. Waiver or Delay of Enforcement of Rules by the State Engineer	55
20. Appeal of Requirements or Approval	55
21. Rules by Reference	55
22. Severability	55
23. Revision	55
24. Statement of Basis and Purpose Incorporated by Reference	56
25. Effective Date	56

Office of the State Engineer

Rules and Regulations
For
Dam Safety and Dam Construction

Rule 1. Title:

The title of these Rules and Regulations is "The Rules and Regulations for Dam Safety and Dam Construction." They may be referred to herein collectively as the "Dam Safety Rules" or "Rules" and individually as a "Rule".

Rule 2. Authority:

These Rules are promulgated pursuant to the authority granted the State Engineer in sections 37-87-102 and 37-87-105, C.R.S.; and section 37-80-102(1k), C.R.S.; and section 24-4-103, C.R.S.

Rule 3. Scope and Purpose:

3.1 These Rules apply to any dam constructed or used to store water in Colorado. These Rules apply to applications for review and approval of plans for the construction, alteration, modification, repair, enlargement, and removal of dams and reservoirs, quality assurance of construction, acceptance of construction, non-jurisdictional dams, safety inspections, owner responsibilities, emergency action plans, fees, and restriction of recreational facilities within reservoirs. Certain structures defined in Rule 17 are exempt from these Rules.

3.2 The purpose of these Rules is to provide for the public safety through the Colorado Safety of Dams Program by establishing reasonable standards and to create a public record for reviewing the performance of a dam.

Rule 4. Definitions:

4.1 **Statutory Definitions -** The terms are defined in section 37-87-102, C.R.S., 37-87-122 C.R.S. and 35-49-103 C.R.S. and shall have the identical meanings when used in these Rules.

4.2 **Specific Definitions -** Unless expressly stated otherwise, the following terms when used in these Rules shall have the meaning indicated by this Rule. Words in the singular shall include the plural. Words in the masculine gender include the feminine and neuter.

4.2.1 "**Alteration, Modification, or Repair of an Existing Dam and Appurtenant Structures**" means to make different from the originally approved construction plans and specifications or the existing configuration, except for ordinary repairs and general maintenance as defined in Rule 12.

4.2.2 "**Appurtenant Structure**" means components other than the material structure of the dam itself such as the outlet works and controls, spillways and controls, access structures, bridges, and other systems directly related to the safe operation of a dam.

4.2.3 "**Breach Order**" is an order issued by the State Engineer, or the State Engineer's designee, for removal of all or part of a dam to permanently reduce the maximum storage level, minimize the risk of failure and/or the potential of damage downstream due to the failure of the dam.

4.2.4 "**Capacity**" is the volume of water a reservoir is capable of impounding at the high-water line, expressed in acre-feet. Dead storage below the natural surface of the ground or low-level outlet is generally excluded.

4.2.5 "**Dam**" means a man-made barrier, together with appurtenant structures, constructed above the natural surface of the ground for the purpose of impounding water. Flood control and storm runoff detention dams are included.

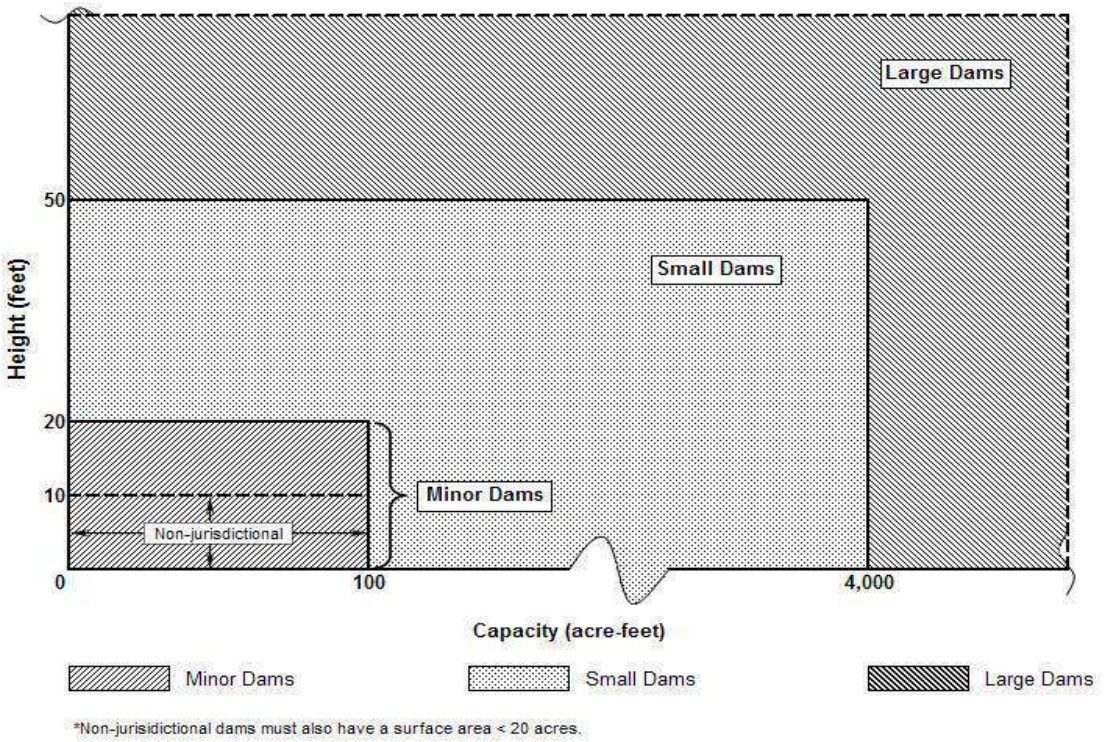
4.2.5.1 "**Jurisdictional Size Dam**" is a dam creating a reservoir with a capacity of more than 100 acre-feet, or creates a reservoir with a surface area in excess of 20 acres at the high-water line, or exceeds 10 feet in height measured vertically from the elevation of the lowest point of the natural surface of the ground where that point occurs along the longitudinal centerline of the dam up to the crest of the emergency spillway of the dam. For reservoirs created by excavation, or where the invert of the outlet conduit is placed below the surface of the natural ground at its lowest point beneath the dam, the jurisdictional height shall be measured from the invert of the outlet at the longitudinal centerline of the embankment or from the bottom of the excavation at the longitudinal centerline of the dam, which ever is greatest. Jurisdictional height is defined in Rule 4.2.19. The State Engineer shall have final authority over determination of the jurisdictional height of the dam.

4.2.5.2 "**Non-jurisdictional Size Dam**" is a dam creating a reservoir with a capacity of 100 acre-feet or less and a surface area of 20 acres or less and with a height measured as defined in Rules 4.2.5.1 and 4.2.19 of 10 feet or less. Non-jurisdictional size dams are regulated and subject to the authority of the State Engineer consistent with sections 37-87-102 and 37-87-105 C.R.S.

4.2.5.3 "**Minor Dam**" is a jurisdictional size dam that does not exceed 20 feet in jurisdictional height and/or 100 acre-feet in capacity (see Figure 1).

4.2.5.4 "**Small Dam**" is a dam with a jurisdictional height greater than 20 feet but less than or equal to 50 feet and/or a reservoir capacity greater than 100 acre-feet, but less than 4,000 acre-feet (see Figure 1).

4.2.5.5 "**Large Dam**" is a dam greater than 50 feet in jurisdictional height, and/or greater than 4,000 acre-feet in capacity (see Figure 1).



DAM SIZE DETERMINATION

Figure 1

4.2.5.6 "**Diversion Dam**" is a dam constructed for the purpose of diverting water from a natural watercourse into a canal, tunnel, ditch, or pipeline that typically impounds an insignificant volume of water, and for which the impacts of failure are not a significant public safety hazard.

4.2.5.7 "**Flood Control Dam**" is a special purpose dam that is normally dry and has an un-gated outlet structure for the controlled release of water impounded during and subsequent to a flood event. The jurisdictional size and classification of the dam are determined using the height and capacity of the reservoir to the emergency spillway elevation, or using the elevation of the maximum routed water surface elevation if no emergency spillway is provided.

4.2.6 "**Dam Failure Inundation Map**" is a map depicting the area downstream from a dam that would reasonably be expected to be flooded in the event of a failure of the dam.

4.2.7 "**Day**" as used in these Rules means a calendar day. For computation of time periods as used in these Rules, Colorado Rules of Civil Procedure 6(a) shall apply.

4.2.8 "**Emergency Action Plan (EAP)**" is a written document prepared by the dam owner, describing a detailed plan of actions for response to emergency or unusual events, including alerting and warning emergency officials in the event of a potential or imminent dam failure or other emergency related to the safety of the dam and public.

4.2.9 "**Engineer**" means a Professional Engineer registered and licensed in Colorado in accordance with section 12-25-101, C.R.S. The Engineer must be sufficiently qualified and experienced in the design, construction, and safety evaluation of the type of dam under consideration. The Engineer will be the Professional Engineer responsible for the design. In general, the Engineer is responsible for the following:

4.2.9.1 Demonstrating a minimum of five years of experience as a Professional Engineer in the design, construction, and safety evaluation of the type of dam under review.

4.2.9.2 Understanding all applicable regulatory requirements of the project and the required work and analyses needed to complete a safe design of the project.

4.2.9.3 Using current state of the practice methods and means to locate and design dams with safety as the primary goal and complete engineering methodology that represents the professional level of care exercised by qualified engineers.

4.2.9.4 Assembling and supervising a team of qualified engineers, engineering geologists/geological engineers and other professionals required to address all of the disciplines necessary for the design and construction of a dam.

4.2.10 "**Enlargement of an Existing Dam or Appurtenant Structure**" means any alteration, modification, or repair that increases the reservoir volume and/or jurisdictional height of a dam as defined in Rules 4.2.4 and 4.2.19.

4.2.11 "**Extreme Precipitation Event**" means a precipitation event based on Colorado extreme storm data approved by the State Engineer, maximized through modern meteorological techniques.

4.2.12 "**Extreme Storm Precipitation (ESP)**" means the maximum precipitation possible, as developed using the Dam Safety Branch's Extreme Precipitation Analysis Tool (EPAT) or a site-specific hydrometeorologic analysis. The greatest depth of precipitation for a given duration that is physically possible over a drainage basin through the application of modern meteorological techniques, based on Colorado extreme storm data approved by the State Engineer.

4.2.13 "**Freeboard**" means the vertical dimension between the crest (or invert) of the emergency spillway and the crest of the dam.

4.2.13.1 "**Residual Freeboard**" means the vertical dimension between the maximum water surface elevation at the peak of the inflow design flood and the lowest point on the crest of the dam at which the dam would be first overtopped.

4.2.14 "**Hazard Classification of a Dam**" is the placement of a dam into one of four categories based on the hazard potential derived from an evaluation of the probable incremental adverse consequences due to failure or improper operation of the dam.

Conditions for evaluation are absent flooding, and the reservoir is assumed to be full to the high water line. The hazard potential classification does not reflect the current condition of the dam with regard to safety, structural integrity, or flood routing capacity. (See Rule 5.4, Hazard Classification Study, for a more detailed description of determining which hazard category a given dam shall be placed.) The Hazard Classification evaluation method must be approved by the State Engineer.

4.2.14.1 "**High Hazard Dam**" is a dam for which loss of human life is expected to result from failure of the dam. Designated recreational sites located downstream within the bounds of possible inundation should also be evaluated for potential loss of human life.

4.2.14.2 "**Significant Hazard Dam**" is a dam for which significant damage is expected to occur, but no loss of human life is expected from failure of the dam. Significant damage is defined as damage to structures where people generally live, work, or recreate, or public or private facilities. Significant damage is determined to be damage sufficient to render structures or facilities uninhabitable or inoperable.

4.2.14.3 "**Low Hazard Dam**" is a dam for which loss of human life is not expected, and significant damage to structures and public facilities as defined for a "Significant Hazard" dam is not expected to result from failure of the dam.

4.2.14.4 "**No Public Hazard (NPH) Dam**" is a dam for which no loss of human life is expected, and which damage only to the dam owner's property will result from failure of the dam.

4.2.15 "**High Water Line**" is the water surface elevation of the reservoir at the crest (or invert) of the emergency spillway, or, if no emergency spillway exists, at the crest of the dam.

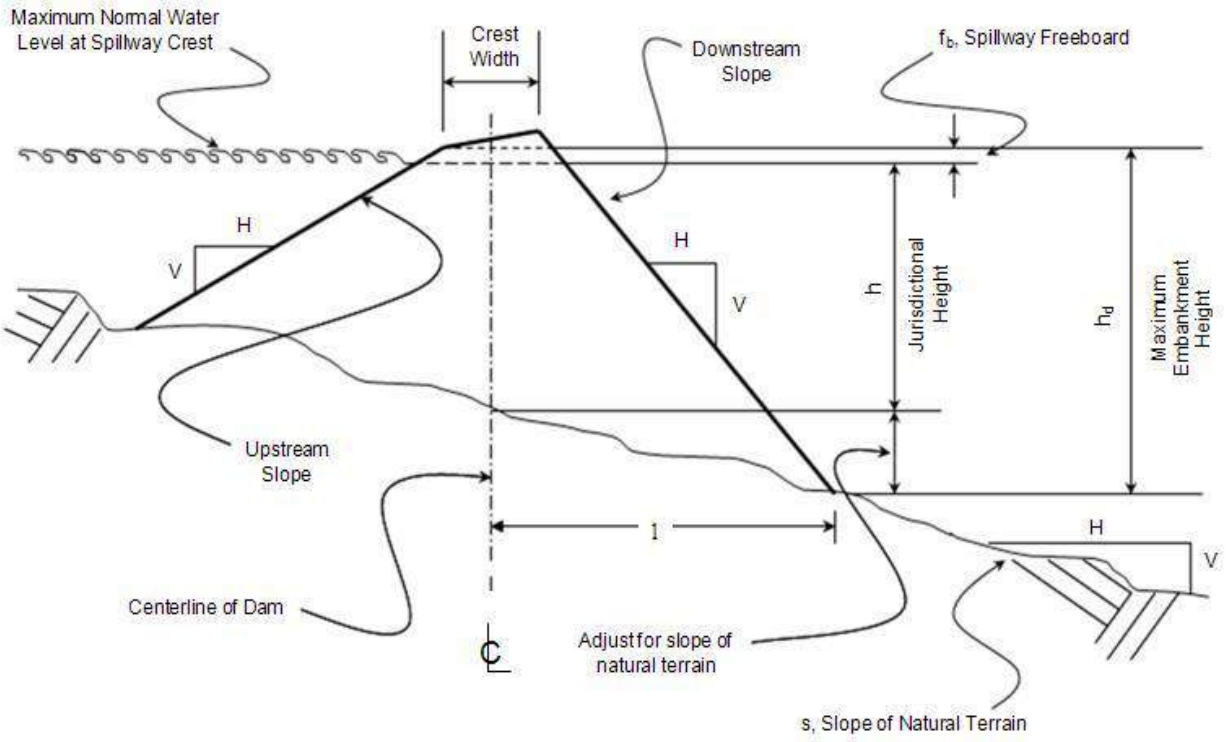
4.2.16 "**Impound Water**" means to accumulate water in a reservoir for immediate or future use, including the purpose of flood control and detention.

4.2.17 "**Incremental Damage Analysis**" means a comparative study of two floods of differing magnitude used to identify differential impacts for loss of human life and property damage in the zone above the lesser magnitude flood (incremental zone).

4.2.18 "**Inflow Design Flood**" **(IDF)** means the flood hydrograph used to determine if the emergency spillway's hydraulic capacity meets the safety standards as defined in Rules 5 and 6 (or in absence of a spillway, the reservoir is capable of *storing* the IDF). The required magnitude of the IDF is defined by these Rules.

4.2.19 "**Jurisdictional Height**" means the vertical dimension measured from the elevation of the lowest point of the natural surface of the ground, or from the invert of the outlet pipe if excavated below the natural surface of the ground, whichever is lower, where the low point occurs along the longitudinal centerline of the dam, up to the spillway crest of the emergency spillway. For existing dams, the jurisdictional height shall be measured by using the slope of

the downstream channel and the height of the dam at the downstream toe by extrapolating the measured height to the longitudinal centerline of the dam. The formula for determining the vertical height of existing dams is: $h = h_d - f_b - (s*l)$; where h = jurisdictional height, h_d = height of dam from downstream toe, f_b = freeboard, s = slope of the natural surface of the ground downstream of the dam, and l = measured or computed horizontal distance between the downstream toe and the longitudinal centerline of the dam. The State Engineer shall have final authority over determination of the height of the dam (see Figure 2).



Determination of Dam Vertical Height at the Maximum Cross Section

Figure 2

4.2.20 "**Natural Surface of the Ground**" means the undisturbed ground surface before excavation, or the undisturbed bed of a natural watercourse.

4.2.21 "**Normal Water Line**" means the elevation of the water at the crest of the principal or service spillway.

4.2.22 "**One-hundred-year Flood**" means a potential flood having a magnitude (peak discharge) which is expected to be equaled or exceeded on the average once during any one-hundred-year period (recurrence interval) and has a one percent chance of being equaled or exceeded during any year (0.01 exceedance probability). The terms “one-hundred-year flood" and "one percent chance flood” are synonymous.

4.2.23 "**Outlet**" means a conduit (usually regulated by gates or valves) used for controlled or regulated releases of impounded water from the reservoir.

4.2.24 "**Owner**" means any person, private or non-profit company, special district, federal, state, or local government agency, or any other entity in direct routine control of a dam and reservoir, and/or directly involved in the physical operation and maintenance of a dam, or proposes to construct a dam. Changes in ownership shall be immediately filed with the State Engineer.

4.2.25 "**Permit**" means a written approval for dam construction, which will be provided by the State Engineer upon approval of the dam plans and specifications. The written approval may be signed by the State Engineer or Deputy State Engineer and identify all contingencies.

4.2.26 "**Plans**" means all necessary drawings, cross-sections, tables, notes, maps and other information necessary to accompany the construction specifications for design review and approval and construction observation and approval.

4.2.27 "**Probable Maximum Precipitation (PMP)**" means the theoretically greatest depth of precipitation for a given duration that is physically possible over a drainage basin at any specific time of year. The PMP values are normally determined from the appropriate Hydrometeorological Report (HMR) (HMR 49 for west of the continental divide, HMR 52 for the eastern plains and HMR 55A for the Front Range). The 100-year, 50-year, and 25-year events are normally determined from the National Weather Service NOAA Atlas #2 "Precipitation-Frequency Atlas of the Western United States" Volume III-Colorado, U.S. Department of Commerce, NOAA, National Weather Service, Silver Springs, Maryland, 1973, (later amendments, editions, or subsequent publications not included).

4.2.28 "**Reservoir**" means a body of water impounded by a dam.

4.2.29 "**Restriction Order**" means an order issued by the State Engineer to limit the maximum water surface elevation of a reservoir as an interim measure to immediately reduce the possibility of failure and risk to the public and property until investigations of a problem can be performed or structural modifications can be made to repair the problem or breach the dam.

4.2.30 "**Routing Capacity**" means the capability of a reservoir and spillway system to attenuate flood inflows, and is calculated as the sum of the spillway discharge(s) and surcharge storage for a specific time increment, expressed in acre-feet.

4.2.31 "**Safe Storage Level**" means the maximum reservoir water surface elevation at which the State Engineer has determined that the dam is safe to impound water based on the safety inspection and/or evaluations.

4.2.32 "**Safety Inspection**" means an evaluation by an engineer to be used by the State Engineer in determining the reservoir's safe storage level. The safety inspection includes, but is not limited to, the review of previous inspections, instrumentation results, reports and

drawings; visual inspections of the dam and appurtenances, seepage control and measurement systems, and any permanent monument or monitoring installations.

4.2.33 "**Spillway**" means an appurtenant structure that conducts overflows from a reservoir.

4.2.33.1 "**Principal or Service Spillway**" means the overflow structure designed to limit or control the operating level of a reservoir, and first to be activated in runoff conditions. The principal or service spillway is designed to pass normal flows, and may not be designed to pass the entire Inflow Design Flood. The principal or service spillway is usually an open channel, pipe, or culvert.

4.2.33.2 "**Emergency Spillway**" means the appurtenant structure designed to pass the Inflow Design Flood in conjunction with the routing capacity of the reservoir and any principal or service spillway(s). Pipe or culvert spillways are not considered acceptable emergency spillways.

4.2.34 "**Spillway Crest**" means the elevation of the floor of a spillway, grade control structure, or ogee crest above which spillway flow begins.

4.2.35 "**Surcharge Storage**" means the volume of water temporarily stored within a reservoir between the high water line and the crest of the dam.

Rule 5. Requirements for Construction or Enlargement of Jurisdictional Size Dams or Reservoirs:

An owner proposing to construct or enlarge a jurisdictional dam or reservoir shall submit an application package, in a form acceptable to the State Engineer, and shall receive approval of the construction plans and specifications and Permit for Dam Construction from the State Engineer prior to commencing construction. The application package shall be prepared by an engineer and shall consist of the following:

1. Application Form
2. Construction Plans
3. Construction Specifications
4. Hazard Classification Report
5. Hydrology Report
6. Geotechnical Report
7. Design Report
8. Instrumentation Plan
9. Cost Estimate
10. Filing Fee

The requirements for each of these items are as follows:

5.1 **Application Form -** A completed application form provided by the State Engineer. This form will be the only information normally available to the public before the project is approved for construction. The application form shall be signed by the dam owner or an authorized representative of the dam owner. The engineer responsible for the preparation of the design and

construction may not act as an authorized representative of the dam owner unless written authorization for the engineer to act as the owner's representative is provided by the dam owner.

5.2 **Construction Plans -** Construction plans/drawings shall meet the following requirements:

5.2.1 The plans shall show the design of the dam and each appurtenant structure in sufficient detail so that the contractor or builder is able to construct the proposed structure from the plans and the specifications.

5.2.2 The front cover sheet of the plans shall have as a minimum, the name of the dam; the county, Water Division and Water District in which the dam is located; and a project location map. A list of the drawings that follow the cover sheet should be provided on the second sheet of the plans and a note should be added to the cover sheet indicating the location of the list of the drawings. The construction drawings and plans shall display the design engineer's seal (crimp type not acceptable) in accordance with current practice defined by The Bylaws and Rules of Procedure of the State Board of Registration for Professional Engineers and Professional Land Surveyors. The original signed mylar coversheet will be returned to the engineer after being approved and signed by the State Engineer. The original signed mylar cover sheet with any appropriate revisions is required to be returned to the State Engineer at the completion of the construction project in accordance with Rule 10. The design engineer's certification statement, the State Engineer's approval signature block, and the design engineer's AS-CONSTRUCTED statement shall be located in the lower right quadrant of the cover sheet in the following format:

Design engineer signature
Printed Name, Colo. P.E. No. xxxxx

Approved on the _____day of _____20___.

_____
State Engineer
By:_____
Deputy State Engineer

And,

These plans represent the AS-CONSTRUCTED conditions of _____ Dam to the best of our knowledge and judgment, based in part on information furnished by others, as of the _____ day of _____, 20__.

_____ _____
(Engineer's printed name) (Signature)

5.2.3 Drawings filed with the State Engineer shall be originals, drawn with permanent ink on high quality mylar or equivalent, or a high quality reproducible archival copy of the original, and shall be prepared in an appropriate scale so details are legible with an overall size of 24 inches high and 36 inches wide or 22 inches high and 34 inches wide.

5.2.4 Drawings shall have a minimum margin of two inches on the left and 1/2-inch on the right, top, and bottom.

5.2.5 All drawings shall have bar scales to allow scaling of reduced drawings.

5.2.6 All drawings shall have a 1/2- by 3-inch space for the State Engineer's file number inside the margin in the lower right-hand corner. A unique project file number will be assigned by the State Engineer prior to final approval of the project documents for construction and shall be placed in bold characters on all of the drawings.

5.2.7 Each sheet shall be numbered sequentially with the first sheet being sheet number one along with the total number of sheets; e.g., 1 of 6.

5.2.8 Minimum lettering size on full size drawings (24 inches high and 36 inches wide or 22 inches high and 34 inches wide) shall be 12 pitch.

5.2.9 Spillway and outlet discharge rating curves and tables, and reservoir area-capacity curves and tables meeting requirements of Rule 5.9.6 shall be placed on the drawings.

5.3 **Construction Specifications -** Construction Specifications shall meet the following requirements:

5.3.1 The front cover of the specifications shall show the title or name of the dam (identical to the title on the plans), the county, the Water Division and the Water District in which the dam is located. The specifications shall display the design engineer's seal (crimp type not acceptable) in accordance with current practice defined in The Bylaws and Rules of Procedure of the State Board of Registration for Professional Engineers and Professional Land Surveyors. The first page behind the front cover shall show the name of the dam (identical to the name on the plans), the county, Water Division and Water District in which the dam is located, the engineer's certification statement, seal and signature, and the State Engineer's approval statement as follows:

Approved on the _____ day of _____, 20__
_____, State Engineer
By: _____, Deputy State Engineer

5.3.2 The specifications shall have an index.

5.3.3 Final specifications shall be bound and submitted on white 8 1/2 by 11-inch paper. Specifications bound in a loose or loose-leaf manner, including 3-ring binders, are not acceptable.

5.3.4 The general conditions shall include statements that the plans and specifications cannot be significantly changed without the prior written approval of the State Engineer in accordance with Rule 9.1.8.

5.3.5 The general conditions shall include the provision that construction shall not be considered complete until the State Engineer has accepted the construction in writing.

5.3.6 The specifications shall provide that the owner's engineer will monitor the quality of construction as specified in Rule 9. The engineer monitoring the construction for the owner is responsible for the quality of construction, compliance with the approved design and specifications, preparation of the necessary documentation for the State Engineer's review and approval of all construction change orders, and preparation of the project completion documents required in Rule 10.

5.3.7 The specifications shall include as a minimum, but are not limited to, the following:

5.3.7.1 The quality of materials used in construction;

5.3.7.2 The acceptable quality of workmanship;

5.3.7.3 The reference to applicable standards, if any;

5.3.7.4 The required tests and estimated frequency of testing; and,

5.3.7.5 The action to be taken if unsatisfactory materials or workmanship are discovered in the construction.

5.4 **Project Design Reports**

5.4.1 **Hazard Classification Report -** The hazard classification report shall identify the size and hazard classification category for the proposed dam, or enlarged existing dam. A report is not required for dams that are declared as High Hazard; however, a dam failure inundation map will be required for the Emergency Action Plan pursuant to Rule 16. The report shall include sufficient information regarding assumptions, calculations and data used to develop the dam failure flood hydrograph and an assessment of the impact of the dam failure upon the downstream floodplain. The dam shall be classified according to the definitions of Rule 4. The hazard classification report must be approved by the State Engineer, and shall be in a form that meets the State Engineer's requirements, including, but not be limited to:

5.4.1.1 Dam failure inundation maps are required for all dams classified as High and Significant Hazard. Inundation maps are required for dams classified as Low Hazard unless the dam is located in a remote area where no development exists downstream of the dam;

5.4.1.2 Cross-sections along the watercourse, drawn to scale, showing water surface elevations at critical locations where structures may be impacted by the flood wave. Cross-sections shall show discharge in cubic feet per second, average velocity in feet per second, and structures located in the flooded section. References to all computer programs, data sources and related documents used in the evaluation shall be included; and

5.4.1.3 Supporting documentation and tabulation of assumed parameters, including Manning's "n" values for the stream channel and the floodplain shall be included.

5.4.2 **Hydrology Report -** A hydrology report is required that presents the inflow design flood (IDF) for determining the required spillway capacity. The IDF may be determined through any of the four methods described in Rule 5.9.1; Extreme Precipitation Analysis Tool (EPAT), site specific hydrometeorologic analysis (SSHMA), Hydrometeorological Report (HMR), and Incremental Damage Analysis (IDA). The precipitation determined through use of the Extreme Precipitation Analysis Tool (EPAT) and site specific hydrometeorologic analysis is the most probable extreme precipitation event for the specific basin determined through modern meteorologic techniques and therefore, the IDF determined from the analysis is probable. No reduction of IDF is allowed for dams classified as High hazard or large size Significant hazard dams. The reduction in the IDF determined through the use of Hydrometeorological Report (HMR), is allowed as provided in Rule 5.9.1.5. Spillways designed in accordance with these Rules will not be required to be enlarged due to subsequent revisions to the IDF as a result of changes to the probable maximum precipitation estimates or EPAT extreme storm database unless, in the opinion of the State Engineer, there is a substantial threat to public safety.

5.4.2.1 The hydrology report is required to be reviewed and approved by the State Engineer and shall be in a form acceptable to the State Engineer and shall include, but not be limited to the following:

5.4.2.1.1 A topographical map delineating the drainage area tributary to the dam, with the drainage area size labeled in square miles; the location of the proposed dam by quarter section, section, township, range, and principle meridian; the bearing and distance from Station 0+00 on the dam to a section corner, or, the location of Station 0+00 on the dam determined by GPS, NAD83 datum, provided as UTM coordinates; the name of the natural watercourse on which the dam is located or indicate the dam is off-stream, and the name of the primary watercourse which the dam is tributary, or the name of the drainage basin in which the dam is located; and the elevation of the dam crest;

5.4.2.1.2 A description of all basin response factors, including the topography, geology, and vegetative cover of the tributary drainage area;

5.4.2.1.3 A summary of all hydrologic parameters for the method used, the inflow design flood hydrograph, volume of the flood, and hazard classification of the dam;

5.4.2.1.4 A spillway discharge rating table (in cubic feet per second) for each foot of elevation above the spillway crest up to the crest of the dam, including the equations used for determining the discharge rate; and

5.4.2.1.5 A table showing the reservoir area (in acres) and storage capacity (in acre-feet) for each foot of elevation from the invert of the outlet to the crest of the dam; and indicating the amount of dead storage (in acre-feet), elevation of the invert of the

outlet, elevation(s) of the spillway crest(s), and elevation of the dam crest. All elevations shall be based on USGS datum, referenced to the invert of the outlet.

5.4.3 **Geotechnical Report -** A geotechnical report is required that evaluates the suitability of the foundation, stability of the dam and the slopes along the reservoir rim, and addresses issues regarding suitability and quantity of material available for construction of the dam as designed. The geotechnical report shall include, but not be limited to, the following:

5.4.3.1 A geological assessment of the dam and reservoir site is required for all dams classified as High or Significant Hazard. The geological assessment shall address at a minimum regional geologic setting; local and site geology; geologic suitability of the dam foundation and reservoir area; slope stability and seepage potential of the reservoir and abutment areas; seismic history and potential; and other potential geological hazards posed by the site and proposed construction. The geological assessment shall include the preparation of a site-specific geological map based upon field observations and mapping by a geologist or geological engineer.

5.4.3.2 Foundation investigations for High and Significant Hazard dams shall include drilling to a depth 1.5 times the height of the dam or at least 10 feet into bedrock, whichever is less; logs of borings and test pits; standard penetration or other field density tests; field and laboratory classification of soils; measurement of the water level in each drill hole; in-situ permeability tests; gradation tests of foundation materials, especially at the locations of proposed drains; determination of liquefaction potential; and whether clay type foundation materials exhibit residual strength properties and dispersivity. Where tunneling or other underground construction is anticipated, subsurface investigation depths, orientations, methods and testing shall be tailored to the geologic setting and details of underground construction anticipated at each site. All investigations for underground facilities shall be performed under the direction of a qualified professional engineering geologist with prior relevant underground experience. The boring logs in the geotechnical report shall include detailed written descriptions of each sample and stratum encountered including observations of the drilling action, drilling and sampling methods and any other observations pertinent to developing a detailed understanding of the subsurface conditions. Graphical "stick" logs alone are not acceptable.

5.4.3.3 The report shall document the suitability of proposed borrow materials or other material sources to be used in construction for High and Significant Hazard dams. The following information and data are required, as a minimum, to be included in the Geotechnical Report:

5.4.3.3.1 Standard index tests and soil classification of all materials;

5.4.3.3.2 Compressibility and/or consolidation tests of soils;

5.4.3.3.3 Permeability of placed materials;

5.4.3.3.4 Shear strength of natural and placed materials (dynamic shear strength tests if applicable);

5.4.3.3.5 Proctor Compaction tests; and

5.4.3.3.6 Identification of potentially dispersive clays.

5.4.3.4 For Low Hazard dams, the report shall include field classification of soils, logs of borings and test pits, standard penetration test results, and the requirements of Rules 5.4.3.3.1, 5.4.3.3.2, and 5.4.3.3.5. The foundation exploration shall include drilling to a depth 1.5 times the height of the dam or 10 feet into bedrock, whichever is less.

5.4.3.5 For NPH dams, the report shall include, as a minimum, field and laboratory classification of natural and placed soils.

5.4.3.6 For all dams, except Minor Low Hazard and all NPH, with a spillway located on a soil foundation, the report shall include the following:

5.4.3.6.1 Laboratory Classification of soils along the alignment of the spillway;

5.4.3.6.2 A profile of soils along the channel extending to a depth of at least five feet below the bottom of the spillway; and

5.4.3.6.3 Density or bearing capacity of foundation soils beneath spillway structures except for riprapped or unlined sections of the channel.

5.4.3.7 For all dams, except minor Low Hazard and all NPH, with spillways located on a rock foundation, the report shall include a geologic description of the rock, description of the bedding and jointing patterns, and an evaluation of the site's suitability to accommodate the spillway.

5.4.4 **Design Report** - A Design Report shall be submitted with the application package. The report shall include information sufficient to evaluate the design of the dam and appurtenances, including references and page numbers, to support any assumptions or criteria used in the design. The report shall also include information on the construction sequence needed to complete the dam along with a summary of any water quality permits that will be required prior to the start of construction. The report shall include calculations and be sufficiently detailed to accurately define the final design of the proposed dam as represented in the construction plans. The following is a typical list of topics to be addressed in the design report:

5.4.4.1 Introduction - Project description and review process.

5.4.4.2 Project Components - Main dam, spillway, and outlet works.

5.4.4.3 Site Requirements - The dam site and reservoir area design requirements.

5.4.4.4 Flood Hydrology and Results of Flood Routings (a summary of Hydrology Report) - This section should include the final results of the routing of the IDF through the reservoir and spillway system for the purpose of determining the size of the spillway or spillways.

5.4.4.5 Spillway and Outlet Works Hydraulics - This should include spillway hydraulics and the development of a spillway discharge rating curve, stilling basin hydraulics, a tailwater rating curve including effects of streambed degradation, hydraulic design assumptions for the design of entire outlet system, and development of an outlet works discharge curve. Design of stilling basins for stepped chute spillways shall include assumptions, calculations, and applicable references for estimating energy dissipation and stilling basin entrance velocities.

5.4.4.6 Foundation Designs - These designs are to include information of local geology (alluvium and topsoil nature and engineering properties), bedrock nature and engineering properties, groundwater impacts, dam foundation requirements, foundation excavation requirements, surface treatment of foundation, seepage control and foundation drainage, piping control measures, downstream erosion, and overtopping control measures. (Refer to the Geotechnical Report requirements for additional requirements, Rule 5.4.3).

5.4.4.7 Seismic Hazard Assessment - This section include seismic sources (seismotectonic setting, historical seismicity, earthquake sources), ground motion hazard (ground motion attenuation, deterministic analysis, probabilistic analysis), and recommended ground motions (time histories).

5.4.4.8 Dam Analysis and Design - This section should include material properties (earth and/or concrete, foundation geology for dam, foundation strength parameters), analysis methodology and model results (load combinations, static analysis, dynamic analysis), conclusions and recommendations. In addition for Roller Compacted Concrete (RCC) dams, this section should also include required in-situ material properties for concrete or RCC, RCC trial mix program, mix proportions, and RCC placement requirements (RCC joint treatment, contraction joint spacing, upstream and downstream facing systems).

5.4.4.9 Structural Design - This section should include structural design criteria and allowable stresses, design of spillway crest, spillway walls and slabs, design of spillway foundation anchors, design of outlet works intake and outlet structures, and outlet conduit.

5.4.4.10 Dam Instrumentation - This section should include a description of the instrumentation per the requirements of Rule 5.5 and including any other monitoring devices and equipment such as automatic data acquisition system.

5.4.4.11 Mechanical and Electrical Design - Design of gates, valves, trash racks and mechanical systems, systems for operating gates and valves, and electrical power requirements and emergency backup power.

5.4.4.12 Quality Assurance and Quality Control Plan - Project management plan, project quality plan, and testing procedures and frequency requirements.

5.4.4.13 River Diversion During Construction - Anticipated construction scheduling and historical river flows, diversions hydrology and selection of diversion flood, proposed diversion system, and potential risks to public safety during construction.

5.4.5 **Project Design Report** - A Project Design Report incorporating all of the aforementioned reports into one design document is permitted. The report should fully document and provide defendable reasoning for the design of the dam and appurtenant structures.

5.5 **Instrumentation Plan -** An instrumentation plan is required and shall meet the following requirements:

5.5.1 All instrumentation shall be properly identified in the field to correspond to the identification of the instrumentation in the long-term monitoring plan required in Rule 10.

5.5.2 Gage rods shall be installed in the close proximity to the outlet on all dams. The zero mark of the gage shall be aligned with the invert elevation of the entrance to the outlet. The gage shall be clearly marked in feet and tenths of feet, and extend to within one foot of the crest of the dam. If the Division Engineer so requires, the gage shall be marked in hundredths of a foot. Markings and numbers on the gage rod shall be of sufficient size to allow for the reading of the gage rod from a distance 50 feet or further if the gage rod is placed on an intake tower within the reservoir.

5.5.3 High and Significant Hazard dams shall have the following minimum instrumentation:

5.5.3.1 Monuments that allow measurement of the horizontal and vertical movements of the dam, installed in accordance with industry standards and in a manner acceptable to the State Engineer. Control or benchmark monuments shall be placed on the abutments in areas not subject to movement;

5.5.3.2 Weirs, flumes, or other measuring devices installed in a manner acceptable to the State Engineer, to allow monitoring of seepage through the embankment or foundation. Positive drainage away from all seepage monitoring devices should be provided to prevent the device from becoming submerged;

5.5.3.3 Station markers at least every 100 feet along the crest of the dam; and

5.5.3.4 Piezometers to allow monitoring of the phreatic surface within the dam, installed in accordance with industry standards and in a manner acceptable to the State Engineer. As a minimum, the construction of the open well piezometers shall be in accordance with the requirements of a monitoring well as presented in the Division of Water Resources' "Rules and Regulations for Water Well Construction, Pump Installation and Monitoring

an Observation Hole/Well Construction," later amendments, editions or subsequent publications are not included.

5.5.3.5 Piezometers or equivalent instruments shall be installed to measure uplift pressures in the dam and foundation for concrete dams, when the reduction of uplift pressures are required to meet the factors of safety and stress requirements of the design of the dam.

5.5.3.6 Where drainage galleries are provided for concrete dams, seepage measuring devices should be provided at the appropriate locations and be accessible for making the necessary readings.

5.5.4 Low Hazard dams shall have weirs, flumes or other measuring devices installed, as approved by the State Engineer, to allow monitoring and measurement of leakage through the embankment or foundation.

5.5.5 NPH dams are not required to have instrumentation other than gage rods in accordance with Rule 5.5.2.

5.6 **Cost Estimate -** A detailed cost estimate of the construction of the dam including the engineering fees. The cost estimate will remain confidential until after the construction contract is executed.

5.7 **Fees -** A filing fee of $3.00 per $1,000.00 (or fraction thereof) of the cost estimate, limited to a maximum of $3,000.00, with a minimum filing fee of $100.00.

5.8 **Design Review Approvals and Limitations**

5.8.1 **Approval of Plans and Specifications -** Acceptable plans and specifications will be certified by the State Engineer or designee and approved for construction.

5.8.2 **Approval Limitation -** If construction, alteration, or repair of a reservoir dam is not commenced within five years of approval of the application, the State Engineer's approval shall be void. The owner must resubmit the application and receive approval before commencing construction, and shall meet the requirements of the current Rules.

5.8.3 **Design Review Limitation -** The design review performed by the State Engineer shall be limited to three years from the date of the review. Re-submittal of the design package shall be required if resolution of the design review comments does not occur within three years.

5.9 **Design Requirements**

5.9.1 **Inflow Design Flood (IDF) Requirements**

5.9.1.1 The IDF shall be determined considering basin size, the elevation of the basin, various soil permeabilities, the various vegetative covers, and other factors related to the routing of the storm event. Historical precipitation data of the National Weather Service may be used for determining the IDF provided applicable stochastic procedures are used as outlined in the National Weather Service NOAA Atlas #2 "Precipitation-Frequency Atlas of the Western United States" Volume III-Colorado, U.S. Department of Commerce, NOAA, National Weather Service, Silver Springs, Maryland, 1973, or other methods approved by the State Engineer.

5.9.1.2 The National Weather Service, NOAA, Atlas #2 "Precipitation-Frequency Atlas of the Western United States" Volume III-Colorado, U.S. Department of Commerce, NOAA, National Weather Service, Silver Springs, Maryland, 1973, may be used for determining the precipitation for l00-year, 50-year and 25-year rainstorm events for the purpose of calculating the magnitude of the resulting flooding.

5.9.1.3 Extreme Precipitation Analysis Tool - The Inflow Design Flood (IDF) requirements for determining the spillway capacity may be developed through the use of the Extreme Precipitation Analysis Tool (EPAT). The process and procedures for use of the EPAT are available from the State Engineer. The IDF requirement determined through the use of the EPAT Extreme Storm Precipitation (ESP) for determining spillway capacity are summarized in Table 5.1:

TABLE 5.1

INFLOW DESIGN FLOOD REQUIREMENTS
USING EPAT

DAM SIZE	HAZARD CLASSIFICATION			
	High	Significant	Low	NPH
Large	ESP	ESP	100 YR	50 YR
Small	ESP	0.5 ESP	100 YR	25 YR
Minor	ESP	100 YR	50 YR	25 YR

5.9.1.3.1 New Large, Small, and Minor High Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood (IDF) generated by the Extreme Storm Precipitation (ESP), unless an Incremental Damage Analysis (IDA) demonstrates a lesser inflow design flood is applicable.

5.9.1.3.2 New Large, Significant Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood (IDF) generated by the Extreme Storm Precipitation (ESP), unless an Incremental Damage Analysis (IDA) demonstrates a lesser inflow design flood is applicable.

5.9.1.3.3 New Small, Significant Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the inflow design flood generated by 50 percent of the Extreme Storm Precipitation (ESP), unless an Incremental Damage Analysis (IDA) demonstrates a lesser inflow design flood is applicable.

5.9.1.3.4 New Minor, Significant Hazard plus new Large and Small, Low Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the inflow design flood generated by a 24-hour, l00-year rainstorm event.

5.9.1.3.5 New Minor, Low Hazard dams and new Large, NPH Dams and enlargements shall have spillways capable of passing the inflow design flood generated by a 24-hour, 50-year rainstorm event.

5.9.1.3.6 New Small and Minor NPH dams and enlargements shall have spillways capable of passing the Inflow Design Flood (IDF) generated by a 24-hour, 25 year rainstorm event.

5.9.1.3.7 The minimum size spillway for all High Hazard, Significant Hazard, and Large and Small, Low Hazard jurisdictional size dams for which an IDA shows a smaller spillway is justifiable under Rule 5.9.7.1 shall be capable of passing the inflow design flood generated by a 24-hour, 100-year rainstorm event. For all other jurisdictional size dams, the minimum size spillway shall be capable of passing the IDF generated by the appropriate rainstorm event presented in the above table.

5.9.1.4 Hydrometeorological Report PMP - The Inflow Design Flood (IDF) requirements for determining the spillway capacity may be developed through the use of the most current Probable Maximum Precipitation (PMP) estimates from the Office of Hydrology, National Weather Service, NOAA Hydrometeorological Report Series. The PMP values are normally determined from the appropriate Hydrometeorological Report (HMR). Currently, HMR 52 and 55A are applicable for drainage basin located to the east of the Continental Divide and HMR 49 for drainage basin west of the Continental Divide. The IDF requirements for determining the spillway capacity using the appropriate HMR are summarized in Table 5.2:

TABLE 5.2

INFLOW DESIGN FLOOD REQUIREMENTS
USING HYDROMETEOROLOGICAL REPORTS (HMR)

DAM SIZE	HAZARD CLASSIFICATION			
	High	Significant	Low	NPH
Large	0.90 PMP	0.68 PMP	100 YR	50 YR
Small	0.90 PMP	0.45 PMP	100 YR	25 YR
Minor	0.45 PMP	100 YR	50 YR	25 YR

5.9.1.4.1 New Large and Small, High Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood (IDF) generated by 90 percent of the Probable Maximum Precipitation, unless an incremental damage analysis demonstrates a lesser inflow design flood is applicable.

5.9.1.4.2 New Minor, High Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood generated by 45 percent of the Probable Maximum Precipitation (PMP), unless an Incremental Damage Analysis (IDA) demonstrates a lesser IDF is applicable.

5.9.1.4.3 New Large, Significant Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood (IDF) generated by 68 percent of the Probable Maximum Precipitation (PMP), unless an Incremental Damage Analysis (IDA) demonstrates a lesser IDF is applicable.

5.9.1.4.4 New Small, Significant Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood (IDF) generated by 45 percent of the Probable Maximum Precipitation (PMP), unless an Incremental Damage Analysis (IDA) demonstrates a lesser IDF is applicable.

5.9.1.4.5 New Minor, Significant Hazard and new Large and Small, Low Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood (IDF) generated by a 24-hour, l00-year rainstorm event.

5.9.1.4.6 New Minor, Low Hazard dams, and new Large, NPH Dams and enlargements shall have spillways capable of passing the Inflow Design Flood generated by a 24-hour, 50-year rainstorm event.

5.9.1.4.7 New Small and Minor, NPH dams and enlargements shall have spillways capable of passing the Inflow Design Flood (IDF) generated by a 24-hour, 25-year rainstorm event.

5.9.1.4.8 The minimum size spillway for all High Hazard, Significant Hazard, and Large and Small, Low Hazard jurisdictional size dams for which an IDA shows a smaller spillway is justifiable under Rule 5.9.7.1 shall be capable of passing the Inflow Design Flood (IDF) generated by a 24-hour, 100-year rainstorm event. For all other jurisdictional size dams, the minimum size spillway shall be capable of passing the IDF generated by the appropriate rainstorm event presented in the above table.

5.9.1.5 Elevation Reduction - The HMR PMP used to determine the IDF may be reduced based on the average elevation of the drainage basin. The HMR PMP value may be adjusted for the determination of the IDF for drainage basins above 5,000 (ft) MSL in accordance with Table 5.3:

TABLE 5.3

HMR PMP INFLOW DESIGN FLOOD REQUIREMENTS
REDUCED FOR ELEVATION

DAM SIZE	STORM TYPE	ELEVATION	HAZARD CLASSIFICATION	
			High	Significant
Large	General Storm East	6,000 - 12,000 ft MSL	0.80 PMP	0.60 PMP
		Above 12,000 ft MSL	0.70 PMP	0.53 PMP
	General Storm West	5,000 - 8,000 ft MSL	0.80 PMP	0.60 PMP
		Above 8,000 ft MSL	0.70 PMP	0.53 PMP
	Local Storm	10,000 - 11,500 ft MSL	0.80 PMP	0.60 PMP
		11,501 - 13,000 ft MSL	0.70 PMP	0.53 PMP
		Above 13,000 ft MSL	0.60 PMP	0.45 PMP
Small	General Storm East	6,000 - 12,000 ft MSL	0.80 PMP	0.40 PMP
		Above 12,000 ft MSL	0.70 PMP	0.35 PMP
	General Storm West	5,000 - 8,000 ft MSL	0.80 PMP	0.40 PMP
		Above 8,000 ft MSL	0.70 PMP	0.35 PMP
	Local Storm	10,000 - 11,500 ft MSL	0.80 PMP	0.40 PMP
		11,501 - 13,000 ft MSL	0.70 PMP	0.35 PMP
		Above 13,000 ft MSL	0.60 PMP	0.30 PMP
Minor	General Storm East	6,000 - 12,000 ft MSL	0.40 PMP	Not Applicable
		Above 12,000 ft MSL	0.35 PMP	Not Applicable
	General Storm West	5,000 - 8,000 ft MSL	0.40 PMP	Not Applicable
		Above 8,000 ft MSL	0.35 PMP	Not Applicable
	Local Storm	10,000 - 11,500 ft MSL	0.40 PMP	Not Applicable
		11,501 - 13,000 ft MSL	0.35 PMP	Not Applicable
		Above 13,000 ft MSL	0.30 PMP	Not Applicable

5.9.1.6 Site Specific Hydrometeorologic Analysis - Site Specific Hydrometeorologic Analysis (SSHMA) may be used to determine the appropriate site specific extreme storm precipitation (SSESP) for the determination of the IDF. Site-specific evaluations are subject to approval by the State Engineer. Any procedures developed and approved by the State Engineer shall be used to determine the applicable Extreme Precipitation Event. Snowmelt conditions shall be considered as base flow when appropriate. The percentage reduction of the PMP as shown in Rule 5.9.1.5 are not applicable or allowed in the determination of site specific extreme storm precipitation or PMP values determined by the procedures and analysis provided for in this Rule for all High Hazard dams and Large Significant Hazard dams. The IDF requirement developed through the use of site specific analyses for determining spillway capacity are summarized in Table 5.4:

TABLE 5.4

INFLOW DESIGN FLOOD REQUIREMENTS
FOR SSHMA

DAM SIZE	HAZARD CLASSIFICATION			
	High	Significant	Low	NPH
Large	SSESP	0.75 SSESP	100 YR	50 YR
Small	SSESP	0.5 SSESP	100 YR	25 YR
Minor	SSESP	100 YR	50 YR	25 YR

5.9.1.7 Incremental Damage Analysis - An Incremental Damage Analysis (IDA) used to justify an Inflow Design Flood (IDF) less than the requirements of Rule 5.9.1.3 through Rule 5.9.1.6, shall be based on a comparison of two floods: first, a base flow flood of the minimum magnitude which exceeds the capacity of all spillways, resulting in overtopping of the dam routed through the downstream floodway assuming no dam is in place; and second, the dam failure flood which occurs due to overtopping, and is routed downstream with the base flow flood. The spillway capacity and IDF will be acceptable where it can be shown that the dam failure flood would cause no additional loss of life nor additional significant property damages downstream within the zone between the two floods.

5.9.1.7.1 No loss of life or significant damage is expected to occur if the increased depth of flow is two feet or less and the product of the flood flow velocity in the incremental zone and the depth of flow at critical locations along the floodway is less than seven.

5.9.1.7.2 Documentation for the IDA shall include but not be limited to: a plot showing both the base flow and dam break flood on topographic maps of the affected areas; cross-sections of the downstream channel showing flood stages, velocities, and discharges for the two floods at the critical locations; incremental damage and loss of life determinations; and a summary of all assumed hydraulic parameters. A table summarizing the results of the IDA at the various downstream cross sections showing that the criteria in Rule 5.9.1.7.1 has been satisfied shall be included in the IDA study report. Documentation shall also include, if deemed necessary by the State Engineer, channel profiles with the various flood stages, aerial photographs of the affected areas, and computer printouts showing flood discharges, stage, and velocities with respect to time.

5.9.1.8 The minimum freeboard requirements for new or enlarged dams shall be based upon the dam height required to prevent overtopping by wave action, or the sum of the inflow design flood maximum water surface level plus one foot of residual freeboard, but not less than five feet unless the State Engineer approves a lesser amount. Except for concrete dams where the design engineer has demonstrated that overtopping of the dam will not be detrimental to the safety of the dam, the inflow design flood can be

accommodated with zero residual freeboard or the overtopping depth at which the dam still meets the stability and stress requirements of Rule 5.9.5.

5.9.1.9 For any dam whose spillway is not designed to pass the inflow design flood as defined previously in Rule 5.9.1, the engineer may as an alternative, provide documentation of the analysis that overtopping of the dam by floods which exceed the spillway capacity up to the design flood will not cause failure of the dam. Otherwise, overtopping protection shall be provided.

5.9.1.10 Spillway Design Exemption - Spillways designed and constructed in accordance with the requirements of the Rules dated September 30, 1988 are exempt from the requirements of these Rules.

5.9.2 **Seismicity Design Requirements**

5.9.2.1 Dams classified as High or Significant hazard shall be analyzed for seismic stability. Seismic analysis for water storage dams shall be based on full reservoir under steady state seepage conditions. Flood control dams with ungated outlets shall be designed for earthquake loads under empty reservoir conditions and need not consider steady-state seepage for seismic analysis. Dams sited on active faults shall obtain a waiver from the State Engineer. To obtain a waiver, the analysis shall show that the location of the dam is unavoidable and the dam must be designed to withstand anticipated fault movement without compromising its integrity. Appropriate data sheets, calculation sheets and computer program output computations from manual or computerized analysis shall be provided. The seismic analysis shall meet the following minimum requirements:

5.9.2.1.1 A seismological investigation for the dam area and reservoir area. This study may be part of the geotechnical report for the structure, or may be a separate report. The study shall determine and justify the appropriate seismic parameters to be used for design. The seismic parameters shall be based on the following design earthquake:

5.9.2.1.1.1 Dams classified as High Hazard and with a height greater than or equal to 30 feet, other than flood control structures, shall be designed for the maximum credible earthquake or for an earthquake with a minimum 5000-year return frequency.

5.9.2.1.1.2 Dams classified as High Hazard and with a height less than 30 feet, other than flood control structures, shall be designed for either: a) the maximum credible earthquake or an earthquake with a minimum 5000-year return frequency, or b) for a peak ground surface acceleration equal to twice the acceleration for the site with a 2% chance of exceedance in 50 years (approximately 2500-year return frequency), as estimated and published by the U.S. Geological Survey.

5.9.2.1.1.3 Dams classified as Significant Hazard or High Hazard dams whose sole purpose is for flood control shall be designed for a 2% chance of exceedance in 50 years (approximately 2500-year return frequency).

5.9.2.2 An analysis of materials in the foundation, reservoir area and proposed embankment shall be completed to determine the potential for liquefaction, earthquake-induced sliding, or other seismic sensitivity, which may be accomplished as part of the geotechnical investigation.

5.9.2.3 Pseudostatic analysis for embankment dams will be acceptable for the following cases:

5.9.2.3.1 The embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D698, or at least 90% of the maximum modified Proctor density, ASTM D1557 or at least 70% relative density per ASTM D4253 and ASTM D4254, if Proctor testing is not appropriate; no materials prone to liquefaction are present in the foundation and the design peak bedrock acceleration is 0.20g or less; or

5.9.2.3.2 The embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D698, or at least 90% of the maximum modified Proctor density, ASTM D1557; potentially submerged portions of the embankment except for internal drain elements are constructed of clayey material; the dam is constructed on clayey soil or bedrock foundation and peak bedrock acceleration is 0.35g or less; and

5.9.2.3.3 All static stability safety factor requirements of these Rules are met; minimum freeboard requirements of these Rules are met; and the pseudostatic coefficient selected for analysis must be at least 50% of the design peak bedrock acceleration, but not less than 0.05g and the factor of safety under pseudostatic analysis shall be 1.0 or greater. In determining the factor of safety for pseudostatic analysis, a search for the critical failure surface shall be made.

5.9.2.4 Pseudostatic analysis for concrete dams will be acceptable and shall meet the requirements Rule 5.9.5.

5.9.2.5 For dams not satisfying the requirements for pseudostatic analysis, a deformation analysis is required. The resulting embankment must be capable of withstanding the design earthquake without breaching and with at least 3 feet of freeboard remaining after deformation. The analysis shall also assess the potential for internal erosion as a result of cracking during earthquake-induced deformation.

5.9.2.6 The seismic assessment shall also address the stability of appurtenant structures to the dam during the design earthquake, as appropriate, unless failure of an appurtenance due to earthquake does not represent an immediate threat to the dam, in which case a lesser operating basis earthquake may be used, as approved by the State Engineer.

5.9.3 **Geotechnical Investigation and Foundation Requirements**

5.9.3.1 Geological and geotechnical investigations are required to describe the geology and geotechnical conditions for construction of the dam and reservoir. The report shall include the geological and geotechnical analyses required for the design and construction of the dam. The report shall describe the foundation conditions for the dam and provide justification for foundation strength, deformation, sliding stability and seepage parameters assumed for design. The foundation requirements for design of the dam will vary based upon the foundation conditions, geology, rock jointing and faulting, dam size and use of the reservoir.

5.9.3.2 Geological and geotechnical engineering exploration shall be conducted under the supervision of a Licensed Professional Engineer or an Engineering Geologist experienced in geotechnical or geological engineering for dams.

5.9.3.3 Geological mapping is required for the dam and reservoir area. The geological mapping shall include the dam, dam abutments and the locations of appurtenant structures.

5.9.3.4 Subsurface investigations shall be conducted for all new dams and for all major modifications to existing dams. The subsurface investigation is typically required to evaluate the depth and geologic classification of the bedrock foundation excavatability and characterize the foundation competency under the dam. The subsurface investigation shall include, test holes, test pits, geophysical survey, insitu-testing, water packer test, pressure meter, and block shear tests.

5.9.3.5 The number and depth of test holes and test pits are typically based on the geological conditions, the complexity of the geological conditions and the size of the dam and depth of the reservoir. The number of foundation drill holes shall not be less than three.

5.9.3.6 Direct shear strength testing and compressive strength testing is required to evaluate design values for shear strength and bearing capacity. Strength properties of discontinuities and the weakest foundation materials are required, as these will generally control foundation behavior. Shear strength testing is also required on rock discontinuities including pre-existing shear planes or faults in the dam foundation. Typical test requirements could include stress-strain properties, shear wave velocity, density and tensile strength.

5.9.3.7 The geological and geotechnical basis for the foundation grouting design for the dam should be prepared. This documentation includes the basis for the design of the curtain grouting and consolidation grouting of the dam footprint.

5.9.3.8 Foundation excavation requirements necessary to provide a firm foundation for the dam shall be documented in the Geotechnical Report. The Geotechnical Report shall provide excavation requirements for shaping of the foundation to provide more uniform foundation stresses or to minimize dam cracking.

5.9.3.9 Foundation drainage design shall be provided including justification for reduction in uplift pressures on the dam. The efficiency of the drainage system to reduce uplift pressures under the dam shall be based upon the geology of the dam foundation. The ability to maintain the drainage system to meet the requirements assumed for the design of the dam shall be addressed.

5.9.3.10 Confirmation of foundation design assumptions is required after the foundation for the dam has been exposed. The project geologist and design engineer shall confirm foundation conditions assumed for the design. Changes in foundation conditions from assumptions made in the Geotechnical Report shall be communicated to the State Engineer when they are identified during construction. Changes to the foundation design for the dam shall be submitted to State Engineer's Office in a formal Change Order Request during construction per the requirements of Rule 9.

5.9.4 **Embankment Dam Design Requirements**

5.9.4.1 Stability Analysis - Embankment dams shall be designed to have stable slopes during construction, and under all conditions of reservoir operation, including rapid draw-down of the reservoir.

5.9.4.1.1 Factors of safety shall be evaluated by slope stability analyses methodologies that are acceptable to the State Engineer. The analysis models shall adequately represent, for the critical cross section (or sections) of the dam, the embankment geometry and internal zoning; shear strengths and unit weights of each material; pore water pressures; and external loading or other relevant factors. Shear strength and pore pressure assumptions used in stability analyses should be obtained from tests that appropriately model the loading condition being analyzed. Where appropriate, the analyses shall consider non-circular or wedge-shaped failure surfaces, as well as circular failure surfaces. All parameters and assumptions used in the analysis shall be summarized in a table, and justified in the Geotechnical Report. A scale drawing, utilizing the same scale for vertical and horizontal dimensions, shall be provided for each cross-sectional model used in the analysis, with the critical failure surface(s) identified. Appropriate data sheets and representative computer program output shall be provided in the report.

5.9.4.1.2 Minimum factors of safety for slope stability of embankment dams for various loading conditions other than seismic loading are summarized in Table 5.5.

TABLE 5.5

MINIMUM FACTORS OF SAFETY FOR SLOPE STABILITY
OF EMBANKMENT DAMS

Loading Condition	Minimum Factor of Safety[1]
Steady seepage with phreatic surface fully developed for reservoir at normal pool elevation	1.5
End of Construction	1.3
Rapid draw-down (upstream slope)	1.2

[1]Not applicable for embankment dams on clay shale foundations; residual shear strength may be appropriate and required factors of safety shall be determined on a case-by-case basis by the State Engineer.

5.9.4.1.3 For Low hazard or NPH dams, the State Engineer may waive the requirements for stability analysis if it can be demonstrated that conservative slopes and competent materials are used in the dam design. Dams classified as Low hazard or NPH shall have upstream slopes no steeper than 3:1 (horizontal:vertical), and downstream slopes no steeper than 2:1 (horizontal:vertical).

5.9.4.2 Seepage and Internal Drainage Design - The evaluation of the steady state seepage and internal drainage conditions shall be performed for all High and Significant Hazard Dams. The seepage and internal drainage analyses shall include, but not be limited to, the following:

5.9.4.2.1 Flow nets or numerical analysis computer programs shall be used in the analyses. Data sheets and output files from these analyses shall be provided or made available where requested. The hydraulic conductivity parameters used in these analyses shall be obtained from field permeability tests, laboratory permeability tests, or empirical/correlative permeability determinations, and the sources of the estimated hydraulic conductivities shall be clearly documented.

5.9.4.2.2 The analyses shall quantify the anticipated seepage beneath, around and through the dam. Seepage exiting on the downstream face of the dam shall not be permitted. Internal drains and filters shall be constructed of granular soil materials (sands and gravels), and the filter and drain zones shall be of sufficient thickness to be constructed without significant contamination or loss of continuity that would adversely impact the performance of these features.

5.9.4.2.3 The filter compatibility of the drain and embankment material shall be evaluated utilizing current state of the practice methodologies, such as those published by the Natural Resources Conservation Service, the U.S. Bureau of Reclamation or the U.S. Army Corps of Engineers.

5.9.4.3 For embankment dams, the following design considerations must be addressed and documented in the Design Report.

5.9.4.3.1 Geometric and Design Requirements - Dam geometry shall be supported by the slope stability and seismic analysis, and shall meet the following minimum requirements:

5.9.4.3.1.1 The crest width shall be equal to the jurisdictional height of the dam in feet divided by 5, plus 10 feet. The maximum crest width required shall be 25 feet.

5.9.4.3.1.2 The crest shall have a camber sufficient to maintain the design freeboard, based on the anticipated magnitude of crest settlement. The anticipated magnitude of crest settlement shall be based on engineering analyses. In no case shall the camber be less than 0.5 feet.

5.9.4.3.1.3 Guidelines for minimum dimensions of impervious core zones for zoned embankment dams up to 50 feet high are defined in the "Design of Small Dams," United States Department of the Interior, Bureau of Reclamation, Third Edition, 1987, U.S. Government Printing Office, Washington, D.C., 20402, (later amendments, editions or subsequent publications not included). Zone dimensioning for dams over 50 feet shall be evaluated using industry standard analyses.

5.9.4.3.1.4 Roads located on the dam crest shall have appropriate surfacing to provide a stable base that resists rutting and provides adequate traction for safety in wet conditions.

5.9.4.3.1.5 The crest design shall include details to protect impervious cores from desiccation or frost penetration, as approved by the State Engineer.

5.9.4.3.1.6 The crest shall be provided with adequate cross slopes to the upstream edge to prevent ponding.

5.9.4.3.1.7 Minimum dimensions for internal granular filter and drain zones shall meet requirements of Rule 5.9.4.2.

5.9.4.3.1.8 The embankment shall be protected against external erosion.

5.9.4.3.1.9 The downstream slope of the embankment dams shall be provided with a well maintained vegetative cover to prevent surface erosion from occurring. No landscaping or planting of trees or large vegetation shall be permitted within 25 feet of the footprint of the dam.

5.9.4.3.1.10 The shear strengths of the foundation soils (including suitable factors of safety) shall not be exceeded under any foreseeable loading conditions.

5.9.4.3.1.11 Seepage through the embankment, abutments, and foundation shall be controlled to prevent internal erosion and external sloughing.

5.9.4.3.2 Compaction Requirements - Material compaction requirements shall meet the minimum requirements:

5.9.4.3.2.1 Minimum compacted density for embankment materials shall be 95 percent of maximum dry density for ASTM D698 (Standard Proctor) or 90 percent for ASTM D1557 (Modified Proctor), as found in the 2006 "Annual Book of ASTM Standards", Section 04.08, Soil and Rock; 100 Barr Harbor Drive, West Conshohocken, PA 19428, (later amendments, editions or subsequent publications not included). Impervious zones with clay fines shall be controlled using Standard Proctor criteria to maintain the plastic nature of the material; and

5.9.4.3.2.2 The minimum density for cohesionless materials shall be 65 to 75 percent relative density as determined by ASTM D4253 and D4254 as found in the 2006 "Annual Book of ASTM Standards," Section 04.08, Soil and Rock; 100 Barr Harbor Drive, West Conshohocken, PA 19428, (later amendments, editions or subsequent publications not included).

5.9.4.3.3 Rock Riprap - Rock Riprap shall be well graded, durable and sized to withstand design wave action or channel velocities, and shall be placed on a well-graded pervious sand and gravel bedding or geotextile fabric. Soil cement for erosion protection may be used in lieu of rock riprap, but shall be designed and constructed in accordance with standards acceptable to the State Engineer. Slope protection for wave action is required to be provided on the entire upstream face of the dam, unless lesser coverage is justified based on engineering analysis and reservoir operational criteria and approved by the State Engineer.

5.9.4.3.4 Filters and Drains - The design of all drains, filter blankets, and toe drains shall be performed in accordance with Rule 5.9.4.2 and must be acceptable to the State Engineer.

5.9.4.3.5 Internal Drain Pipes - Pipes to collect and distribute seepage flows from internal filters and drains shall:

5.9.4.3.5.1 Be comprised of material that is non-corrodible and non-collapsible for the estimated overlying earth pressures and anticipated settlement or ground movement associated with dam construction.

5.9.4.3.5.2 Be surrounded with free-draining material that is filter compatible with the surrounding earth material in accordance with current filter criteria of such organizations as the Natural Resources Conservation Service, the U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers.

5.9.4.3.5.3 Have slots or perforations that are filter compatible with the surrounding free-draining material in accordance with current filter criteria of such organizations as the Natural Resources Conservation Service, the U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers.

5.9.4.3.5.4 Be installed in such a manner to be accessible for internal camera inspection and repair.

5.9.4.3.5.5 Be designed to flow with a water depth no greater than ¼ of the diameter of the pipe for the estimated seepage flows.

5.9.4.3.5.6 Be no smaller than 6 inches in diameter.

5.9.4.3.5.7 Discharge into locations where discharge flows can be evaluated and monitored, such as galleries, manholes, or daylight (ground surface) areas.

5.9.4.3.5.8 Be inspected after a maximum of 3 to 5 feet of fill placed over pipe, and again after remaining fill has been placed.

5.9.4.3.5.9 Be equipped with rodent screens in locations where the discharge ends of the pipes are accessible to animals.

5.9.4.3.5.10 Be designed with multiple discharge points in order to isolate seepage to various sections of the dam and foundation.

5.9.4.3.6 Geosynthetics - The use of geosynthetics shall be evaluated by the State Engineer on a case-by-case basis for each dam. Geosynthetics materials shall be used in accordance with the manufacturers' recommendations and intended use for each product. Use of geosynthetics shall comply with the following general design considerations:

5.9.4.3.6.1 Geosynthetics will not be accepted where the geosynthetic is the sole element employed to perform a function that is an element of the dam were failure of the geosynthetic, could result in a catastrophic release of the reservoir. Redundant design features are required whenever geosynthetics are used for these functions.

5.9.4.3.6.2 The use of a geotextile as a filter layer may be allowed if the geotextile is placed such that it does not jeopardize the stability or safety of the dam or appurtenant structures due to failure of the geotextile (such as clogging), and the geotextile can be repaired or replaced without jeopardizing the stability or safety of the dam.

5.9.5 **Concrete Dam Design Requirements**

5.9.5.1 For concrete dams, the following design considerations must be addressed and documented in the Design Report

5.9.5.1.1 Access to the dam crest shall be provided from at least one of the abutments of the dam. Access shall be provided to the side of the dam where the control of the outlet works used for the emergency release of the reservoir volume is situated.

5.9.5.1.2 The crest of the dam shall have a width of not less than 15 feet.

5.9.5.1.3 Concrete dam crests, if designed as emergency spillway, shall not be overtopped for floods more frequent than the 100-year storm. Emergency spillway discharge for flows up to the inflow design flood shall not cause excessive downstream erosion of the abutments and foundation.

5.9.5.1.4 If the design of the concrete dam includes drainage features and the reduction in uplift pressures is required to meet factors of safety and stress requirements, a gallery shall be provided in the dam to access, monitor and clean or re-drill the dam and foundation drains.

5.9.5.2 Arch Dam Design - Concrete arch dams are not specifically addressed in these Rules and shall be designed in accordance with principles provided in U.S. Bureau of Reclamation publication "Design of Arch Dams," 1977 or U.S. Army Corps of Engineers publication “Arch Dam Design” EM 1110-2-2201 1994, (later amendments, editions, or subsequent publications not included).

5.9.5.3 Gravity Dam Design - Concrete gravity dams (conventional or roller compacted concrete (RCC)) shall be designed in accordance with the following Rules and with principles provided in U.S. Bureau of Reclamation publication "Design of Gravity Dams," 1976, or U.S. Army Corps of Engineers publications “Gravity Dam Design” EM 1110-2-2200 1995 and “Roller-Compacted Concrete” EM 1110-2-2006 2000 (later amendments, editions or subsequent publication not included).

5.9.5.3.1 The structural stability and stress analyses of a concrete gravity dam for both non-overflow and spillway sections shall be performed using the gravity method of stress and stability analysis, as described in the aforementioned publications. The trial-load twist method of analysis may be used for the stability analysis when keyed or grouted transverse contraction joints are provided. The finite element method may be used to supplement the gravity method and to investigate specific features where areas of maximum stresses may occur within the dam and foundation.

5.9.5.3.2 Loads to be considered as a minimum in the stability and stress analyses are as follows: dead weight of the dam and appurtenant structures, headwater and tailwater pressures, uplift pressures in the dam and foundation, earth and silt pressures, ice pressure, seismic forces, and temperature, if appropriate. Ice pressure shall be equivalent to a force of 10,000 pounds per linear foot applied at one foot below the normal water surface elevation.

5.9.5.3.3 Concrete gravity dams shall be designed for full hydrostatic uplift pressures along appropriate planes within the dam and foundation. The uplift pressure shall vary linearly from full hydrostatic pressure at the upstream face of the dam to the tailwater pressure at the downstream dam face or zero if no tailwater conditions exist. Reduction in the uplift pressures will be allowed when dam and foundation drains are provided. The effectiveness of the drains will be required to be verified and monitored through the installation of piezometers.

5.9.5.3.4 The following loading conditions shall be investigated in the design of a concrete gravity dam, as a minimum. Other loading condition could be required depending on site conditions:

5.9.5.3.4.1 Usual Loading Condition – Reservoir at the normal water surface with minimum tailwater pressure, uplift pressures, and earth, silt and ice pressures, if applicable.

5.9.5.3.4.2 Unusual Loading Condition – Usual loading condition with no ice pressure and with hydrostatic pressures as a result of the flooding condition produced by the appropriate inflow design flood.

5.9.5.3.4.3 Extreme Loading Condition – Usual loading condition with no ice pressure and with seismic forces in the downstream direction.

5.9.5.3.5 The minimum factors of safety and allowable stresses as a result of the loading condition shall be as provided in Table 5.6:

TABLE 5.6

MINIMUM FACTORS OF SAFETY AND ALLOWABLE STRESSES FOR CONCRETE GRAVITY DAMS

Loading Condition	Resultant Location within Base	Min. Sliding Factor of Safety	Concrete Compressive Stress	Concrete Tensile Stress
Usual	Middle 1/3	3.0	$0.3\ f'_c$	0
Unusual	Middle 1/2	2.0	$0.5\ f'_c$	$0.5\ f_t$
Extreme	Within Base	1.0	$0.9\ f'_c$	$1.0\ f_t$

5.9.5.4 Roller Compacted Concrete Design Requirements - Design of new RCC dams shall meet all requirements for concrete dams regarding field investigations, testing, foundation treatment, stability and stresses. RCC dam design shall also meet the following additional requirements:

5.9.5.4.1 An RCC mix design study shall be submitted with the design report, containing proposed aggregate data, source of aggregate, strength test results, and proposed cementitious contents.

5.9.5.4.2 The dam design shall include adequate control of cracking in upstream facing system and RCC mass caused by thermal shrinkage of the concrete. Crack control provisions shall also include control of excessive heat of hydration by use of fly ash and limit in-place temperature of RCC.

5.9.5.4.3 Design dimensions shall be constructable with conventional earthwork equipment, particularly between the upstream face of the dam and the drainage gallery, and the "chimney section" width.

5.9.5.4.4 Adequate cold joint treatment shall be provided in the specifications to prevent formation of unbonded lift joints that are potential paths of seepage.

5.9.5.4.5 RCC dams with a structural height of 100 feet or higher shall be designed with a drainage gallery, when dam and foundation drains are provided.

5.9.5.4.6 Specifications shall include provisions for placing RCC under cold weather, hot weather, and rain.

5.9.5.4.7 RCC spillway chute steps shall be protected with conventional facing concrete, or equivalent protection, unless the State Engineer approves a lesser standard for good cause shown. Design of stilling basins for RCC stepped chute spillways shall include assumptions, calculations, and applicable references for estimating energy dissipation and stilling basin entrance velocities.

5.9.5.4.8 Outlet works gate and spillway towers shall be designed as temporary free-standing tower, if structures are proposed to be completed before any RCC placement.

5.9.5.5 Roller Compacted Concrete Dam Construction Requirements - The construction of RCC dams shall meet the following additional requirements.

5.9.5.5.1 An RCC test section shall be constructed outside the dam footprint at least 21 days before production placement of the RCC. The final design mix and the method of construction shall be approved by the SEO prior to production placement.

5.9.5.5.2 The Owner shall provide full-time qualified field observation during RCC production placement.

5.9.5.5.3 Locations of all cold joints shall be documented.

5.9.5.5.4 Representative RCC cores shall be taken from the completed dam to verify design strengths. RCC cores shall be 6-inch diameter.

5.9.5.5.5 Because a RCC dam can be completed within a short period of time, the dam shall be allowed to gain adequate strength before initial filling of the reservoir.

5.9.5.6 Concrete Slope and Overtopping Protection - The design of RCC and soil-cement dam rehabilitation shall meet the following additional requirements.

5.9.5.6.1 Soil-cement mix design shall meet guidelines of Portland Cement Association or the U.S. Bureau of Reclamation.

5.9.5.6.2 Soil-cement slope protection shall be designed for a minimum 56-day strength of 750 psi for durability considerations.

5.9.5.6.3 Soil-cement shall not be used for emergency spillway or embankment overtopping protection, unless it can be demonstrated that the soil-cement can withstand the anticipated flow rates and velocities.

5.9.5.6.4 RCC emergency spillway or RCC embankment overtopping protection shall not operate for floods more frequent than the 100-year storm.

5.9.5.6.5 Normal thickness of soil-cement or RCC shall be a minimum of 2 feet.

5.9.6 **Spillway and Outlet Works Design Requirements**

5.9.6.1 Spillway Design - All spillways shall be designed and constructed in a manner acceptable to the State Engineer and meet the following criteria.

5.9.6.1.1 The spillway flows must be safely routed back to the natural channel or drainage way that would exist if the dam were not built. Where the spillway channel discharges into an adjacent basin, apart from the drainage on which the dam is located, the owner shall possess title to the property, a right-of-way, or easement for the flood channel downstream to the location where the maximum discharge would no longer cause damage beyond what naturally would occur on the adjacent drainage.

5.9.6.1.2 Log booms or other methods approved by the State Engineer shall be installed in the spillway approach where logs and other debris may block spillway flow or damage the spillway structure.

5.9.6.1.3 Pipe emergency spillways are not acceptable.

5.9.6.1.4 The Design Report shall include discharge tables (in cubic feet per second) for all spillways showing the discharge for each foot of head between the crest of the spillways and dam. The equation(s) used for determining the discharge shall also be included. Crest elevations of all spillways and the dam shall be clearly noted on the table.

5.9.6.1.5 For floodwater detention and flood control dams, the required principal spillway and outlet conduit discharge rate shall be coordinated with the Division Engineer for the Water Division in which the dam is located.

5.9.6.2 Outlet Works Design - All outlet systems shall be designed and installed in a manner acceptable to the State Engineer and shall meet the following criteria:

5.9.6.2.1 The outlets for High Hazard dams shall be capable of releasing the top five feet of the reservoir capacity in five days, and for all other classes of dams as required by the State Engineer. The outlet shall be capable of releasing the entire reservoir in a reasonable period of time. In addition, outlets shall be capable of passing inflow to the reservoir with a minimum of ten feet of head, in order to meet the demands of downstream senior water rights and the owner's release requirements. The minimum size required for outlet conduits and controls is 12 inches. For all other Hazard dams, the outlets should be sized to draw down the reservoir under emergency conditions in a reasonable period of time, as determined by the State Engineer.

5.9.6.2.2 All principal outlets connected to a pipeline shall have a by-pass valve that will meet the capacity criteria as defined in Rule 5.9.6.2.1.

5.9.6.2.3 Outlet conduits for all dams, except for dams with un-gated outlets, shall have a guard gate installed at the upstream end of the conduit

5.9.6.2.4 Intake structures for outlet works shall have trash racks unless exempted by the State Engineer for good cause shown.

5.9.6.2.5 The Design Report shall include an outlet discharge table (in cubic feet per second) showing the discharge for each foot of head between the invert of the intake structure and the crest of the dam. The equation(s) used for determining the discharge shall also be included. Elevations of all outlets and spillways shall be clearly noted on the table.

5.10 **Reservoir and Water Diversion Requirements**

5.10.1 **Reservoir and Site Requirements**

5.10.1.1 The area to be submerged by the new or enlarged reservoir shall be cleared of logs and debris.

5.10.1.2 Borrow areas shall be located at least 200 feet from either toe of the dam. The dimension of this limit may be reduced using engineering analyses indicating that the reduced dimension will not negatively impact dam stability and/or foundation seepage.

5.10.1.3 The dam crest and appurtenant structures shall be accessible by equipment and vehicles for emergency operations and maintenance.

5.10.1.4 The dam owner shall possess title to the property, or a permanent easement, including permanent access, for a minimum distance of fifty feet or the height of the dam, whichever is greater, downstream from the downstream toe of the dam for the purpose of maintenance and the removal of trees and large vegetation along the downstream toe of the dam.

5.10.1.5 Pipelines, utility lines or any other construction that penetrate through dam abutment areas below the dam crest elevation, or that are within a distance of 50 feet or the height of the dam, whichever is greater, from either toe of the dam shall not be allowed without prior written approval by the State Engineer. To be considered for approval, such penetrations must be designed to protect against seepage and piping through trench backfill materials and avoid temporary or permanent impacts to dam stability, and must be documented with as-constructed survey data and installation details submitted to the State Engineer.

5.10.1.6 The design of a new reservoir or enlargement of an existing dam and reservoir shall not result in the inundation of properties (except marina-type structures) during the Inflow Design Flood (IDF) unless the dam owner owns or obtains flood right-of-ways for all areas which may be inundated by the reservoir surcharge. The owner shall submit a written statement certifying they own the properties, or own the right-of-way on all affected properties, or possess a right-of-way easement for the reservoir inundation zone.

5.10.1.7 Flood easements for spillway discharges shall meet the requirements of Rule 5.9.6.1.1.

5.10.2 **River Diversion During Construction Requirements**

5.10.2.1 A water diversion plan to control surface water during construction meeting the requirements of Rule 9 may be developed by the construction contractor based on information and requirements provided by the Engineer, or the Engineer may prepare these plans.

5.10.2.2 In developing the requirements of the plan during the project design, the design storm for the construction period, including the estimated volume or flow rate that must be managed during construction should be clearly specified in the Design Report.

5.10.2.3 The contractor may be allowed flexibility to develop the methods and means to divert the water in coordination with other aspects of the construction.

5.10.2.4 Regardless of who prepares the detailed water diversion plan, the plan must be prepared and submitted to the State Engineer for review in advance of construction of the diversion facilities in accordance with Rule 9. The plan must be prepared under the direction of a qualified Professional Engineer registered in the State of Colorado.

5.10.2.5 The water diversion plan meeting the intent of Rule 9 should include the following items.

5.10.2.5.1 Design drawings and specifications depicting the constriction of cofferdams, spillways, conduits, gates, or other temporary features that may be required to control the water.

5.10.2.5.2 Stability analysis of the cofferdam, under both normal and design flood loading condition.

5.10.2.5.3 Hydraulic calculations showing the capacity of spillways or conduits used for diversion.

5.10.2.5.4 The plan for the removal or abandonment of cofferdams, spillways, conduits, or other temporary features after construction is complete.

Rule 6. Requirements for Alteration, Modification, or Repair of an Existing Dam:

6.1 An owner proposing to alter, modify, or repair an existing dam shall submit an application package in a form acceptable to the State Engineer and receive approval of the construction plans and specifications from the State Engineer prior to construction. The provisions of Rule 6 shall apply to such application only to the extent directly related to work for which approval is being sought.

6.1.1 **Design Requirements -** The requirements of Rule 5 shall apply except as modified by Rules 6.1.2 and 6.1.3. A Hydrology Report, Geotechnical Report, Design Report, and Instrumentation Plan are required as a minimum to support the scope of the work described on the application.

6.1.2 **Application and Approval Requirements for High Hazard, Significant Hazard, and Large, Low Hazard Dams -** Plans for repair of an existing dam, or alteration of existing High Hazard, Significant Hazard, and Large, Low Hazard dams to non-jurisdictional size may be approved by the State Engineer by letter without meeting requirements set forth in Rules 5.2 and 5.3, subject to the following conditions:

6.1.2.1 A completed application form provided by the State Engineer shall accompany appropriate specifications and necessary drawings depicting minimum details for the repair or alteration. Plans and specifications must be prepared by an engineer. The provisions of Rules 5.6, 5.7, and 11 shall apply.

6.1.2.2 The plans and specifications shall contain sufficient detail to enable a contractor to prepare a bid and construct the repair, or alter the dam to non-jurisdictional size. The provisions of Rule 9 shall apply. The engineer shall give the State Engineer not less than 7 days notice of the start of construction.

6.1.2.3 Upon completion of repair or alteration, the engineer shall file as-constructed plans in conformance with Rule 5 and Rule 10.

6.1.2.4 The requirement for submitting as-constructed plans for altering an existing jurisdictional size dam to non-jurisdictional size dam will be determined by the State Engineer.

6.1.3 **Application and Approval Requirements for Small and Minor, Low Hazard and NPH Dams -** Plans for repair of Small and Minor, Low Hazard dams, or NPH dams; and plans for the alteration of all Low Hazard or NPH dams to non-jurisdictional size are exempt from the provisions of Rules 5, 6, 9, and 10, except as specified in Rule 6.1.3.1 through Rule 6.1.3.3.

6.1.3.1 Notice - The dam owner must provide at least thirty days advanced written notice to the State Engineer. The written notice must contain the name of the dam, the location of the dam, the name of the owner, and a clear description of the work to be performed.

6.1.3.2 Determination - If the State Engineer determines that plans and specifications prepared by an engineer are necessary for the repair, the owner will be notified within five working days from the date the owner's notice was received. A cost estimate and filing fee will also be required. The owner cannot begin construction until the plans and specifications are approved by the State Engineer. If plans and specifications are not required, the State Engineer will inform the dam owner of engineering and construction requirements, if any, and will perform construction inspections as determined necessary.

6.1.3.3 Project Completion - The dam owner must keep the State Engineer informed of the project status and provide the State Engineer with as-constructed drawings and specifications within sixty days following completion of the work. The as-constructed drawings must be drawn on good quality mylar with permanent ink (or equivalent), and the drawings shall be reproducible, and suitable for a long lasting permanent record.

6.1.4 **Inflow Design Flood Requirements -** The inflow design flood (IDF) requirements for all existing dams shall be determined in accordance with Rule 5. Structures with spillways designed and approved prior to 1988 and in accordance with the methods published in the U.S. Department of the Interior, Bureau of Reclamation, "Design of Small Dams," Second Edition 1973, (later amendments, editions or subsequent publications not included) shall be considered adequate for the original hazard classification. If the classification has changed, then the provisions of these Rules and specifically Rule 5 apply.

6.1.4.1 The methods of Rule 5 apply, but may be reduced for good cause shown. Spillways designed in accordance with these Rules will not be required to be enlarged due to subsequent revisions in ESP or PMP estimates, unless, in the opinion of the State Engineer, a substantial increased threat to public safety exists.

6.1.4.2 The minimum size spillway for all existing High Hazard dams and Large and Small Significant Hazard dams, for which an incremental damage analysis shows a smaller spillway is justifiable under Rule 5.9.1.7, is the spillway size required to safely accommodate the flood generated by a 24-hour, 100-year rainstorm event.

6.1.5 **Freeboard -** The minimum freeboard requirements for an existing dam shall be the maximum required to either prevent overtopping by wave action or to pass the IDF without overtopping, but not less than three feet.

6.2 **Approval Limitation -** If construction, alteration, or repair of a reservoir dam is not commenced within five years of approval of the application, the State Engineer's approval shall be void. The owner must resubmit the application and receive approval before commencing construction, and shall meet the requirements of the current Rules and Regulations.

6.3 **Design Review Limitation -** The design review performed by the State Engineer shall be limited to three years from the date of the review. Re-submittal of the design package shall be required if resolution of the design review comments does not occur within three years.

Rule 7. Requirements for Removing or Breaching an Existing Dam:

7.1 **Breach Plan and Application -** An owner proposing to permanently remove or breach a dam shall submit an application package in a form acceptable to the State Engineer prior to commencing work. Plans for Removal or Breach of a dam shall meet the following requirements:

7.1.1 **Application -** A completed application shall be submitted on a form provided by the State Engineer.

7.1.2 **High and Significant Hazard Dams -** For High and Significant Hazard dams, a breach plan shall be prepared by an engineer.

7.1.2.1 The dam shall be excavated down to the level of the natural ground, or as necessary in accordance with Rule 7.1.2.3, at the maximum section; and shall be of sufficient width to pass the 24-hour, 100-year flood with a maximum increase in reservoir depth of five feet. However, the maximum breach width shall not exceed the width of the original natural channel before the dam was constructed, regardless of the 100-year flood magnitude unless approved by the State Engineer for improved public safety.

7.1.2.2 The sides of the breach shall be excavated to a slope that is stable, but not steeper than 2:1 (two horizontal to one vertical). Slope stability analysis that provides an adequate factor of safety for steeper slopes may be accepted by the State Engineer, but in no case shall the slopes be steeper than 1:1.

7.1.2.3 The breach shall be designed to prevent silt previously deposited in the reservoir and material excavated for the breach from washing downstream.

7.1.2.4 Water impounded in the reservoir area shall be released in a controlled manner that will not endanger lives or damage downstream properties.

7.1.2.5 The drawing(s) of the plan for the breach of a dam shall include the location, dimensions and lowest elevation of the breach.

7.1.2.6 The removal or breaching of the dam shall be performed under the purview of an engineer.

7.1.2.7 The engineer shall submit written notice of the completion of the removal or breaching of the dam along with as-constructed plans in conformance with Rule 10.

7.1.3 **Low Hazard and NPH Dams -** For Low Hazard and NPH dams the owner shall submit a written notice of intent to breach the dam to the State Engineer. The State Engineer shall determine the size of the breach in accordance with the following:

7.1.3.1 The bottom width of the breach shall be one-half the height of the dam but not less than ten feet;

7.1.3.2 The side slopes of the breach shall not be steeper than one horizontal to one vertical;

7.1.3.3 The breach shall be to original ground at the low point in the foundation of the dam; and

7.1.3.4 The excavated material shall not be placed in the stream channel.

Rule 8. Fees:

The owner shall submit with the application for construction, enlargement, alteration, modification, or repair an amount equal to three dollars for each one thousand dollars or fraction thereof of the estimated cost of construction including engineering costs, but the maximum fee shall not exceed three thousand dollars, nor shall the minimum fee be less than one hundred dollars. When an owner resubmits an application that was previously received and disapproved by the State Engineer, the owner shall submit a new filing fee in accordance with the above. Checks shall be made payable to the Colorado Division of Water Resources.

Rule 9. Construction of Jurisdictional Size Dams:

9.1 **High and Significant Hazard Dams** - For all High and Significant Hazard dams, the owner shall provide an engineer experienced in dam design and construction, who shall be responsible for the following:

9.1.1 **Plan for Construction Observation -** Not less than 30 days prior to construction, the engineer must submit to the State Engineer a general plan for construction observation. The construction observation plan shall include:

9.1.1.1 The date of the start of construction;

9.1.1.2 Names and qualifications of the engineer and staff to be used on the project;

9.1.1.3 A construction observation schedule for the engineer and staff;

9.1.1.4 For dams on rock foundations, a schedule for observations of the foundation by a geologist, or engineering geologist;

9.1.1.5 A schedule for inspection of the gate installation by the gate manufacturer or its representative unless waived by the State Engineer;

9.1.1.6 Identification of the firm that will conduct the construction material tests in the field and in the laboratory; and

9.1.1.7 A schedule of the construction material tests.

9.1.2 **Approval -** Within ten working days of receipt, the State Engineer shall provide written comments and approval, or conditions for approval of the construction observation plan. Construction shall not commence without approval of the observation plan by the State Engineer.

9.1.3 **Pre-Construction Meeting -** Subsequent to submitting the construction observation plan, but no later than two weeks prior to commencement of construction, a meeting shall be held between the engineer, dam owner, State Engineer and the general contractor. The general contractor shall develop and thoroughly explain its construction control plan along with any anticipated construction difficulties. During this meeting, the means used to divert and care for the stream during construction will be identified by the contractor; and if reasonable, the plan will be approved by the State Engineer. The name of the contractors and any principals in charge shall be furnished to the State Engineer at the meeting. Project communication protocol between the owner, engineer and the State Engineer shall be established at the pre-construction meeting.

9.1.4 **Engineer's Observation -** The engineer shall observe the construction of the dam. It is the engineer's responsibility to observe the progress and quality of the construction to determine whether the construction is proceeding in accordance with the approved plans and specifications. The engineer shall endeavor to prevent defects and deficiencies in the construction of the dam and appurtenant structures, and shall disapprove or reject work failing to conform to the approved plans and specifications. To assure independent review and proper quality assurance, in cases where the engineer has a contractual relationship with the general construction contractor to provide engineering services, the owner shall provide an independent, third-party engineer to perform the engineering quality assurance observations.

9.1.5 **Construction Records -** The engineer shall maintain a record of construction that, as a minimum, shall include: daily activity and progress reports; all test results pertaining to construction; photographs sufficient to provide a record of foundation conditions and various stages of the construction through completion; all geologic information obtained; and construction problems and remedies.

9.1.6 **Progress Report -** A construction progress report summarizing the contents of Rule 9.1.5 shall be submitted to the State Engineer every 30 days or more frequently if directed by the State Engineer. A summary report of all the items in Rule 9.1.5 shall be submitted at the end of construction in accordance with Rule 10.

9.1.7 **Notice for Inspection -** The engineer shall give the State Engineer at least five days advance notice of initial materials placement on the dam's foundation, in the cutoff trench, outlet backfill, outlet foundation and any appurtenance requested by the State Engineer in the approval of the plan for construction observation, to allow for observation by the State Engineer.

9.1.8 **Change Order -** When unforeseen site conditions or material availability require that the construction work differ significantly from the approved plans and specifications, a change order, including details, must be provided by the engineer to the State Engineer. No change shall be executed until approved by the State Engineer. Major changes must be submitted in writing with supporting documentation, and approved in writing by the State Engineer. Minor changes may be transmitted verbally by the engineer and approved by the State Engineer verbally.

9.1.9 **Final Inspection -** The engineer shall give the State Engineer at least 10 days advance written notice prior to the projects final construction inspection.

9.1.10 **Completion of Construction -** The engineer shall notify the State Engineer of the completion of the construction in accordance with Rule 10.

9.2 **Low Hazard and NPH Dams -** Low Hazard and NPH dams require the owner to provide an engineer experienced in dam design and construction, who shall be responsible for the following:

9.2.1 **Construction Plan -** Not less than 30 days prior to construction or as soon as possible for dams whose construction season is affected by freezing weather, the engineer shall notify the State Engineer in writing of the date construction will begin, the name of the engineer in charge of the project, and the name of the contractor.

9.2.2 **Engineer Observation -** The engineer shall observe, or provide for the observation by a qualified technician directly responsible to the engineer, the construction work on the dam, the cutoff trench, and outlet works foundation to see that they are in substantial accordance with the approved plans. The engineer shall endeavor to guard against defects and deficiencies in the construction of the dam, and shall disapprove or reject work failing to conform to the approved plans and specifications.

9.2.3 **Inspection, Testing and Reporting -** Tests of construction materials shall be taken and inspections of the construction made to verify that the work is completed in accordance with the approved plans and specifications. Periodic progress reports shall be submitted as requested by the State Engineer. The engineer shall compile a record of all tests conducted, and any problems and remedies, for submittal to the State Engineer at the end of construction.

9.2.4 **Change Orders -** Change orders shall be submitted in accordance with Rule 9.1.8.

9.2.5 **Final Inspection -** The engineer shall give the State Engineer at least 10 days advance written notice prior to the projects final construction inspection.

9.2.6 **Completion of Construction -** The engineer shall notify the State Engineer of the completion of construction in accordance with Rule 10.

Rule 10. Acceptance of Construction of Jurisdictional Size Dams:

10.1 **Acceptance of Construction -** Construction for which application has been made pursuant to Rule 5 or Rule 6 shall not be deemed complete nor shall storage of water be permitted until the State Engineer furnishes to the owner a written statement of acceptance, unless temporary approval of storage is granted by the State Engineer. The acceptance shall specify the vertical height, freeboard, length of the dam, the capacity of the reservoir in acre-feet, and any limitation upon, or requirements for the use of the dam. The State Engineer shall furnish the acceptance or denial within 60 days of receipt of a complete notification of completion.

10.2 **Construction Completion Documents -** The engineer shall provide the following construction documentation within 60 days of the final construction inspection in order for the project to be deemed complete:

10.2.1 A written notification that the project is complete and in general conforms with the approved plans, specifications and change orders;

10.2.2 As-constructed drawings that meet the format requirements of Rule 5;

10.2.3 A final construction report containing the following information, if applicable, in accordance with the requirements of Rule 9; a summary of construction, problems encountered, and solutions implemented to resolve the problems; a summary of construction material tests and geologic observations; photographs of construction from exposure of the foundation to completion of construction;

10.2.4 A record of the location of permanent monuments and instrumentation as well as installation details and initial surveys and readings shall be submitted, if applicable;

10.2.5 A schedule for the first filling of the reservoir specifying fill rates, water level elevations to be held for observation, and a schedule for inspecting and monitoring the dam. No filling schedule is required for minor dams rated Low Hazard and all NPH dams or if waived by the State Engineer for good cause shown. The dam owner, however, shall monitor the dam frequently during the first filling; and

10.2.6 A long-term instrumentation monitoring plan for new dams and enlargements (except for minor Low Hazard and all NPH dams) that shall include: the frequency of monitoring; the data recording format; graphical presentation of data; and, the parties who will perform the work.

10.3 The engineer shall provide periodic review of the data included in the long-term monitoring plan on at least an annual basis for the first five years, whereupon the monitoring shall continue in accordance with Rule 15. The engineer shall submit the data and a written assessment of the dam's performance to the State Engineer annually.

10.4 Upon written request by the owner and for good cause shown, the State Engineer may temporarily approve storage of water prior to full compliance with Rule 10. The written request shall include a schedule for compliance with Rule 10, a certification letter signed and sealed by the engineer in accordance with Rule 10.2.1, a schedule for the first filling of reservoir in accordance Rule 10.2.5, and a monitoring plan for observing the behavior of the dam and appurtenances during the initial filling or refilling of the reservoir. For High and Significant Hazard dams, an Emergency Action Plan prepared in accordance with Rule 16 shall be developed by the owner and approved by the State Engineer prior to placing any water in the reservoir. Only a partial reservoir filling will be granted under this Rule. Final acceptance of the construction for full use of the reservoir will not be granted until the requirements of Rule 10 have been satisfactorily completed.

10.5 The engineer and/or owner shall submit an Emergency Action Plan that conforms to Rule 16 within 60 days after the final construction inspection.

Rule 11. Construction, Modification, Alteration, Repair, and Breach of Non-jurisdictional Size Dams:

11.1 **Notice of Construction -** Any person intending to construct a non-jurisdictional size dam other than a Livestock Water Tank or Erosion Control Dam, must submit notice of the intent to construct the dam on forms provided by the State Engineer not less than 45 calendar days prior to the proposed construction. The State Engineer shall determine the potential hazard for loss of life or significant damage due to failure of the structure and determine if the submittal of plans and specifications and approval of the plans and specifications by the State Engineer is required prior to construction. The forms shall be submitted to the Division Engineer of the Water Division in which the dam is to be located. The Division Engineer shall respond to the owner within 45 days after receipt of the complete notice of intent to construct form. All dam owners shall be required to comply with the applicable dam safety and water administration requirements.

11.2 **Modification or alteration to Non-jurisdictional Size Dam -** Jurisdictional size dams proposed to be modified or altered to non-jurisdictional size shall comply with the following requirements:

11.2.1 For High or Significant Hazard dams, the owner shall submit plans for approval in accordance with Rule 6.1.2.

11.2.2 For Low Hazard or NPH dams, the owner shall submit written notice of the intent to alter the dam to the State Engineer in accordance with Rule 6.1.3.

11.2.3 The engineer shall submit written notice of the completion of the project and file as-constructed plans in conformance with Rule 10.

11.3 **Repair and Breaching of Non-jurisdictional Dams -** Repair and breaching of existing non-jurisdictional size dams shall meet the following requirements:

11.3.1 Owners who intend to repair, modify, breach or entirely remove a non-jurisdictional dam shall submit written notice to the State Engineer prior to construction.

11.3.2 High or Significant Hazard non-jurisdictional size dams shall have the plans for repair or breaching prepared by an engineer and submitted to the State Engineer for approval before construction. The plans shall be of sufficient detail to allow review and provide for the quality control of the work and must meet the requirements of Rule 7.1.2, if the dam is being breached.

11.4 **Spillway Requirements -** Spillway sizing requirements shall meet the criteria for the appropriate hazard classification of the dam for a Minor size dam as specified in the appropriate Table of Inflow Design Flood Requirements in Rule 5.9.1.

11.5 **Construction of Non-Jurisdictional Size Dams under Rule 11 -** The construction of non-jurisdictional size dams under these provisions with freeboard in excess of five feet with the intent to convert the dam to a jurisdictional size structure with only minor modifications to the spillway will not be approved. The modification of a non-jurisdictional size dam to a jurisdictional size dam will not be permitted within 10 years of the construction of the original structure and/or without meeting the requirements of Rule 5.

Rule 12. General Maintenance, Ordinary Repairs, and Emergency Actions:

12.1 **General Maintenance -** General maintenance and ordinary repairs that do not require prior approval of the State Engineer for the purpose of this Rule shall be those activities that do not impair the safety of the dam. These maintenance and repair activities include:

12.1.1 Removal of brush or tall weeds.

12.1.2 Cutting of trees and removal of slash from the embankment or spillway. Removal of small stumps is acceptable provided no excavation of more than 3 feet into the embankment occurs. An engineer must oversee removal of trees and stumps larger than 12" diameter.

12.1.3 Rodent control, removal or extermination. Repair of minor rodent damage is acceptable provided it does not involve excavation of more than 3 feet into the embankment.

12.1.4 Repair of erosion gullies on the embankment or in the spillway. Large gullies that have already weakened the dam must be repaired in accordance with Rule 6.

12.1.5 Surface grading of the embankment crest or spillway to eliminate potholes and provide proper drainage provided that the freeboard is not reduced. Material placed on the dam crest to restore the design freeboard must be compacted to specifications outlined in Rule 5. The State Engineer must be provided notice prior to placement of material on the dam crest of greater than 1 foot in depth for approval. Placement of material in excess of 1 foot in depth to provide freeboard is not considered general maintenance.

12.1.6 Placement of additional riprap and bedding on the upstream slope, or in areas of the spillway that have sustained minor damage. Such placement shall be limited to restoring the original riprap protection where the damage has not yet resulted in weakening of the dam. An engineer must oversee restoration of the embankment.

12.1.7 Painting or caulking metal structures, or lubricating mechanical equipment.

12.1.8 Patching, sealing, or caulking spalled or cracked concrete surfaces to prevent deterioration.

12.1.9 Removing debris, rock, or earth from outlet conduits, outlet channels or spillway channels.

12.1.10 Patching or sealing surface damage to prevent further deterioration within outlet conduits.

12.1.11 Replacement of worn or damaged parts of outlet valves or controls to restore to original condition.

12.1.12 Repair or replacement of fences intended to keep traffic or livestock off the dam or spillway.

12.1.13 Landscaping of new and existing dams and spillway channels is not general maintenance and will not be allowed without the prior approval of the State Engineer. No trees or large vegetation shall be planted within 25 feet of the footprint of the dam.

12.2 **Excavation and Determination of General Maintenance -** General maintenance and ordinary repair which may impair safety such as excavation into or near the dam, construction of new appurtenant structures for the dam, and repair of damage which has already significantly weakened the dam must be done in accordance with Rule 6. When questions arise concerning this Rule, the determination of general maintenance and ordinary repair will be made by the State Engineer.

12.3 **Emergency Action -** Emergency actions not impairing the safety of the dam may be taken before consultation and guidance can be provided by an engineer, and do not require prior approval of the State Engineer. Emergency actions are interim solutions only and may not serve as a permanent solution to the problem being addressed. Additional remedial actions may be required after the emergency passes. Emergency actions may include:

12.3.1 Stockpiling materials such as riprap, earthfill, sand, sandbags and plastic sheeting;

12.3.2 Lowering the reservoir level by making controlled releases through the outlet or a gated spillway, by pumping, or by siphoning. Where large releases are to be made, the Division Engineer shall be notified;

12.3.3 Armoring eroding areas by placing sandbags, riprap, plastic sheeting, or other available material;

12.3.4 Plugging leakage entrances on the upstream slope;

12.3.5 Increasing freeboard by placing sandbags or temporary earthfill on the dam;

12.3.6 Diverting flood waters around the reservoir or closing inflow diversions;

12.3.7 Constructing training berms to control flood waters;

12.3.8 Placing sandbag ring dikes around boils at the downstream toe to provide back pressure; and/or

12.3.9 Removing obstructions from outlet or spillway flow areas.

12.4 **Emergency Excavation -** Lowering the water level by excavating the spillway or embankment is prohibited unless failure is imminent.

12.5 **Emergency Notification -** The State Engineer shall be notified as soon as reasonably possible of any emergency condition that exists and any emergency action taken with or without prior approval of the State Engineer.

12.6 **Emergency Action Plan -** For all High and Significant Hazard dams, the Emergency Action Plan must be implemented in conjunction with any emergency actions taken in accordance with Rule 12.

Rule 13. Determination of Safe Storage Level:

13.1 **Authority to Determine Safe Storage Level -** The State Engineer is assigned the responsibility to determine the safe storage level for every reservoir in the state. The reservoir owner shall not store water in excess of the amount so determined by the State Engineer to be safe.

13.2 **Restriction of Storage -** If the dam safety inspection or information from other reliable sources reveals problems affecting the safe storage level of the reservoir, the State Engineer will issue an order restricting reservoir operations until the problems have been resolved. The dam owner shall comply with the restriction order at all times. The restriction order will be removed or modified by the State Engineer only after receipt and approval of engineering evaluations which indicate that the problems have been adequately remediated and after completion of required repairs.

13.3 **Review of Potential Hazard Classification** - As part of the determination of safe storage level, the State Engineer will periodically review the classification of existing dams by evaluating the consequences of failure applying the definitions of Rule 4. If the State Engineer's review indicates the consequences of failure have increased or decreased due to changes in development within the dam failure inundation area, the State Engineer will assign an appropriate new classification and will require that, the dam meet the requirements of these Rules as they apply to the new classification, within a reasonable period of time.

Rule 14. Safety Inspections Performed by the Owner's Engineer:

14.1 **Owner Safety Inspection -** An owner may provide a safety inspection report to the State Engineer regarding the safe storage level of a reservoir. The State Engineer may utilize the owner's safety inspection report in lieu of a State Engineer safety inspection report if said report is written by a qualified engineer, as defined below. The owner's engineer must notify the State Engineer and submit a written summary of qualifications at least 14 days prior to the scheduled safety inspection.

14.2 **Engineer Qualifications -** An engineer shall be considered qualified to provide information to the State Engineer regarding the safe storage level of a reservoir if the engineer meets the following minimum qualifications:

14.2.1 Registration as a professional engineer in Colorado;

14.2.2 Three years of experience in the field of dam safety; and

14.2.3 Experience in conducting safety inspections of dams.

14.3 **Scope of Inspection -** Dam safety inspections by the owner's engineer shall include, but are not limited to: review of previous inspections, reports and drawings; site inspection of the dam, spillways, outlet facilities, seepage control and measurement system; and evaluation of data from permanent monument or monitoring installations, if any. The inspection shall include an assessment of all parts of the dam which are related to the dam's safety. (See Rule 15.1 for outlet inspection requirements.) The engineer shall prepare an inspection report that describes the findings, and lists actions the dam owner must take to improve the safety of the dam to an acceptable level. The report shall include the engineer's recommendation of the safe storage level.

14.4 **Retaining an Engineer** - If the owner elects to retain an engineer to conduct safety inspections, such inspections shall be conducted in accordance with current policies and Rules of the State Engineer.

Rule 15. Dam Owner's Responsibilities:

15.1 **Outlet Inspection -** It is the dam owner's responsibility to provide for inspection of outlet facilities associated with the dam. The frequency of outlet inspections and the requirements of those inspections are as follows:

15.1.1 High and Significant Hazard dams shall receive a Type A outlet inspection in conjunction with safety inspections, and Type B inspections at least once every ten years unless the condition indicates more frequent inspections are necessary. A Type B inspection of the entire outlet conduit shall only be required on dams without upstream gates if ordered by the State Engineer in conformity with Rule 15.1.4. Type B inspections may be waived where the condition of the outlet conduit would not be considered detrimental to the safety of the dam.

15.1.2 Low Hazard and NPH dams shall receive a Type A outlet inspection in conjunction with routine periodic safety inspections of the dam. A Type B inspection may be required by the State Engineer to determine the safe storage level.

15.1.3 Type A outlet inspections shall consist of observation of exposed surfaces of the inlet and discharge structures, control valves or gates and vaults; a test of the outlet valve(s) for proper operation, observation of the downstream end of the conduit and adjacent embankment for leakage; and observation of the dam (upstream slope, crest, downstream

slope or natural ground) in the vicinity of the outlet alignment for signs of distress which would indicate failure of the outlet system.

15.1.4 Type B outlet inspections shall consist of a complete Type A inspection, a close inspection of the interior of the conduits, outlet wells, and access ways, and operation of the outlet valve(s) or gates through the full operating range. In cases where the conduits are too small for a person to safely enter, the owner shall provide for an inspection using video or other remote sensing equipment capable of detecting flaws or imperfections within the conduit. A written report of inspection findings, including the opinion of the owner's engineer, must be submitted to the State Engineer unless waived by the State Engineer for good cause. A Type B inspection of the normally inundated outlet conduit of a dam without upstream guard gates shall be required only when existing baseline data available to the State Engineer is inadequate to permit an evaluation of the condition of the outlet conduit. Thereafter, such inspections shall only be required if the criteria set forth in ACER Technical Memorandum No. 6, U.S. Department of the Interior, Bureau of Reclamation, 1985, (later amendments, editions or subsequent publications not included) indicates the need for an inspection. In ordering such inspections, the State Engineer shall coordinate with the dam owner and make all reasonable efforts to prevent expense and waste of water consistent with ensuring dam safety.

15.1.5 At any time the water level in a dam without upstream gates on the outlet conduit will be lowered to the invert of the conduit, or the normally inundated conduit will be otherwise dewatered and available for inspection, the dam owner shall inform the State Engineer in writing. The dam owner is responsible to provide for inspection of outlet facilities associated with the dam and may take advantage of the low water level conditions to perform the necessary outlet inspection. The State Engineer may require an inspection of the conduit when conditions warrant and/or based on the period of time since the last outlet inspection.

15.2 **Owner Observations -** The owner is responsible for ensuring frequent observation of the dam, unless prohibited by weather or difficulty of access to the dam, especially at times when the reservoir is full, during heavy rains or flooding, and following an earthquake. When the reservoir water level is greater than half the full storage capacity, High and Significant Hazard dams shall be observed at least twice a month, and a Low Hazard dam shall be observed at least every three months. The observations shall be conducted in accordance with methods acceptable to the State Engineer. Conditions which threaten the safety of the dam must be reported to the State Engineer in accordance with the Emergency Action Plan for High and Significant Hazard dams as soon as reasonably possible, after discovery of the conditions. If dam failure appears imminent, the county sheriff (or local emergency manager) must be immediately notified. The owner is responsible for the safety of the dam and shall take action to lower the reservoir if it appears that the dam has weakened or is in danger of failing.

15.3 **Monitoring Instrumentation -** The owner of a dam is responsible for installing, maintaining, and monitoring the required instrumentation. All instrumentation plans shall be submitted to the State Engineer for review and approval prior to installation of instrumentation, survey monuments, weirs, flumes or other measuring devices.

15.3.1 The following minimum instrumentation is required on existing dams; however, the State Engineer may require additional instrumentation when he deems it necessary.

15.3.1.1 High Hazard dams shall have survey monuments to monitor horizontal and vertical movement of the dam and appurtenant structures, and weirs, flumes or other structures that are acceptable to the State Engineer to monitor seepage. Installation of piezometers to measure the internal water surface of the embankment or adjacent abutments and foundation of the dam may be required by the State Engineer for determination of the safe storage level in the reservoir.

15.3.1.2 Significant and Low Hazard dams shall have weirs, flumes or other structures that are acceptable to the State Engineer to monitor seepage. Significant Hazard dams may require piezometers be installed as described in Rule 15.3.1.1.

15.3.1.3 All dams shall have gage rods pursuant to Rule 5.

15.3.2 The dam owner shall measure seepage during each routine observation of the dam. Owners of High Hazard dams shall also be responsible for providing first order surveys of horizontal and vertical movement monuments. These surveys are required annually for five years (including the year of installation of the monuments) on new and recently enlarged dams, and then once every five years thereafter. The State Engineer may also approve other methods for monitoring movement monuments on the dam and may require monitoring at any frequency deemed necessary based upon review of inspection data and past measurement results.

15.3.3 The dam owner is responsible for ensuring that all instrumentation data is properly recorded in an acceptable format and sent to the State Engineer annually. The State Engineer may require that instrumentation data for High and Significant Hazard dams be evaluated by the owner's engineer and the analysis sent to the State Engineer annually, unless more frequent reporting is required by the State Engineer.

15.3.4 The dam owner shall promptly notify the State Engineer of any abnormal changes in the dam based on the results of evaluation of instrumentation data, as compared to historical patterns and trends.

15.4 **Responsibility for Maintenance -** The owner is responsible for adequate and timely maintenance of the dam. The owner shall establish an annual maintenance plan to ensure that the maintenance, as identified in Rule 12, is accomplished.

15.5 **Trash Racks -** The owner shall ensure that trash racks are installed on all outlet structures unless waived in writing by the State Engineer.

15.6 **Change In Ownership -** Changes in ownership of a dam shall be immediately filed with the State Engineer.

Rule 16. Emergency Action Plans (EAP):

16.1 **Emergency Action Plans (EAP) -** Owners of High and Significant Hazard dams shall prepare and maintain an Emergency Action Plan. An EAP is a formal document that identifies potential emergency conditions at a dam and specifies preplanned immediate actions to prevent failure of the dam, reduce the potential for loss of life, and minimize property damage downstream. An EAP shall contain, as a minimum, the following key elements:

16.1.1 **Emergency Condition Detection** – The conditions, incident, events, or measures for detection of an existing or potential emergency shall be described.

16.1.2 **Emergency Level Determination** – Guidance shall be provided for classifying the emergency level following incident detection using the system of:

16.1.2.1 Emergency Level 1 – A non-emergency incident, unusual event, or slowly developing situation, which if not mitigated, endangers the structural integrity of the dam or results in uncontrolled releases of water causing flooding downstream;

16.1.2.2 Emergency Level 2 – Potential dam failure situation, rapidly developing, and;

16.1.2.3 Emergency Level 3 – Urgent, dam failure is imminent or in progress.

16.1.3 **Notification and Communication -** Prioritized notification lists and flowcharts applicable to each of the emergency levels shall be provided to enable communication and notification of the emergency level and with applicable Local, State and Federal emergency agencies, engineering and construction support personnel, the State Engineer's office, and other affected parties as appropriate.

16.1.4 **Expected Actions** –Description of actions necessary to prevent a dam failure incident or to help reduce the effects of a dam failure and facilitate response to an emergency, including, but not limited to, identification of equipment, manpower, and material available for implementation of the plan.

16.1.5 **Inundation Mapping -** A dam failure inundation map for High and Significant Hazard dams showing the stream which will be flooded, including urban and rural impacts. Inundation mapping for High and Significant Hazard dams shall contain the following minimum information:

16.1.5.1 - Inundation mapping for High Hazard dams shall show the calculated extents of the dam breach flood wave. Include cross sections at critical locations showing lateral and vertical flood extents, flood wave velocity and flood wave arrival time. Inundation mapping shall be extended downstream to a location where no potential for loss of life and no significant property damage exist.

16.1.5.2 - Inundation mapping for Significant Hazard dams shall show the route of the dam breach flood wave, the estimated time of arrival of the flood wave at critical

sections, and the estimated lateral extent of inundation. The inundation mapping shall be extended downstream to a location where no significant property damage exists. The inundation mapping requirements for Significant Hazard dams may be modified for good cause, with the approval of the State Engineer.

16.1.6 **Termination** – A description of the roles and responsibilities for declaring that the emergency or incident at the dam is terminated, and a discussion of the requirements for follow up evaluation including, but not limited to, documenting the event in a summary report.

16.2 **EAP Guidelines -** The State Engineer's guidelines are available to aid in the preparation and/or revision of EAPs for all High and Significant Hazard dams.

16.3 **EAP Distribution -** The owner shall submit a copy of the EAP to the Colorado Division of Emergency Management (CDEM), all emergency response coordinators involved in the plan, and other affected parties, as necessary. A distribution list that includes the names and contact information for all parties who have been provided with a copy of the EAP shall be included in the EAP. The owner shall incorporate reasonable recommendations from the CDEM, the State Engineer, emergency coordinators, and other parties affected by the plan.

16.4 **EAP Updates –** The owner shall review the EAP annually and update as necessary and appropriate. The updates shall be distributed to all parties shown on the distribution list.

16.5 **EAP Testing -** The owner shall test the EAP as necessary to ensure the effectiveness of the EAP, that the EAP is up to date, and to obtain information for revisions or corrections, as deemed necessary. All Revisions and corrections shall be distributed to all parties on the distribution list.

Rule 17. Exempt Structures:

17.1 **Exempt Structures -** Existing or proposed structures not designed or operated for the purpose of impounding water above the natural surface of the ground other than flood detention are exempt from these Rules. Exempt structures include:

17.1.1 Highways, road-fills, and railroad embankments with an ungated outlet conduit;

17.1.2 Diversion dams if less than jurisdictional size, and all diversion dams of any size if Low Hazard or NPH;

17.1.3 Refuse embankments (e.g., solid waste disposal facilities); and,

17.1.4 Structures which store water only below the lowest point of the natural ground are exempt from these Rules, unless an outlet works is constructed to develop water.

17.2 **Mine Tailing Impoundments -** Mill tailing impoundments which are permitted under the Colorado Mined Land Reclamation Act, sections 34-32-101 through 125, C.R.S. or the Colorado Surface Coal Mining Reclamation Act, sections 34-33-101 through 137, C.R.S. are exempt from these Rules. Any solution process impoundment permitted under the Colorado Mined Land

Reclamation Act, or the Colorado Surface Coal Mining Reclamation Act, are exempt from these Rules and Regulations. Siltation structures which are permitted under the Colorado Surface Coal Mining Reclamation Act, sections 34-33-101 through 137, C.R.S. are exempt from these Rules.

17.3 **Uranium Mill Tailing Dams -** Uranium mill tailing and liquid impoundment dams permitted under the authority of the Colorado Department of Public Health and Environment are exempt from these Rules. Raw and potable water dams, sewage effluent dams, and water treatment sludge dams associated with the uranium mill are not exempt.

17.4 **Livestock Water Tanks -** Livestock Water Tanks as defined in the Livestock Water Tank Act of Colorado, Sections 35-49-101 through 116, C.R.S., are exempt from these Rules.

17.5 **Erosion Control Dams -** Erosion Control Dams as defined in Section 37-87-122, C.R.S., are exempt from these Rules.

Rule 18. Restriction of Recreational Facilities within Reservoirs:

18.1 **Restriction on Construction -** No person, including any state or federal agency, quasi-municipal corporation, or political subdivision, shall construct any permanent recreational structure within a reservoir below the elevation of the bottom of the spillway unless:

18.1.1 The facility is constructed to withstand partial or complete inundation without significant damage; or

18.1.2 The facility is necessary to the operation of the reservoir; and

18.1.3 The facility is capable of being restored with a minimum amount of cleaning or expense. Boat ramps, docks, and marinas are exempt from these Rules.

18.2 **Existing Facilities -** This Rule does not apply to facilities completed prior to July 1, 1984, but shall apply to any subsequent enlargements or modifications to such facilities.

18.3 **Construction Requirements -** Any person planning on constructing, enlarging, or modifying any facility coming under this Rule shall notify the State Engineer in writing 180 days in advance of construction. The notice shall include the following information:

18.3.1 The name and location of the reservoir and/or dam;

18.3.2 Whether the recreational facility is new, or an enlargement or modification to a facility completed prior to July 1, 1984;

18.3.3 A description of the facility, its intended purpose, and its location within the reservoir including depth below the high water line; and

18.3.4 A description of how the facility will be able to withstand the damage from the inundation without a significant amount of cleaning or expense to restore it.

18.4 **Approval Prior to Construction -** No person shall be allowed to construct, enlarge, or modify any facility coming under this Rule until approved by the State Engineer.

Rule 19. Waiver or Delay of Enforcement of Rules by the State Engineer:

The State Engineer may waive or delay the enforcement of any of the responsibilities of dam owners under the foregoing Rules in particular cases if, in the State Engineer's judgment, dam safety will not be reasonably impaired and the circumstances of the individual case so warrants. Such circumstances may include, but are not limited to, the benefits that would be realized by full enforcement, the cost or difficulty of complete compliance, the owner's good faith efforts to comply, the expected remaining life of the structure, and the impacts to beneficial use of water in Colorado.

Rule 20. Appeal of Requirements or Approval:

The applicant or any other person affected or aggrieved by the State Engineer's approval or disapproval of plans and specifications for construction of a reservoir/dam, or the alteration, modification, repair or enlargement of a reservoir or dam which will affect the safety of the structure may request an adjudicatory hearing before the State Engineer pursuant to section 1.1.4(2)(vi) of the Division of Water Resources' Procedural Regulations, 2 CCR 402-5. Such request must be made within thirty (30) days of the date of the State Engineer's determination and must identify the person(s) requesting the hearing and the basis upon which they believe error was committed in the determination. All adjudicatory hearings will be conducted pursuant to the requirements of the Division of Water Resources' Procedural Regulations and the State Administrative Procedures Act, section 24-4-105, C.R.S.

Rule 21. Rules by Reference:

Certified copies of the complete text of the materials incorporated by reference in these Rules shall be maintained by the Office of the Engineer and state publications depository and distribution center and shall be available for public inspection during business hours. The title and address of the Office of the State Engineer is: 1313 Sherman Street, Room 818, Denver, CO 80203.

Rule 22. Severability:

If any portion of these Rules and Regulations for Dam Safety and Dam Construction is found to be invalid, the remaining portion of the Rules shall remain in force.

Rule 23. Revision:

The State Engineer may revise these Rules and Regulations for Dam Safety and Dam Construction in accordance with section 24-4-103, C.R.S. Such revisions may be the result of new data or technology, or the submittal of a petition by an interested person pursuant to section 24-4-103(7), C.R.S. and 2 C.C.R. 402-5 1.1.3.B.2.

Rule 24. Statement of Basis and Purpose Incorporated by Reference:

The Statement of Basis and Purpose for the adoption of these Rules and Regulations for Dam Safety and Dam Construction is incorporated by reference as part of these Rules.

Rule 25. Effective Date:

These Rules shall become effective on January 1, 2007.

FOR REFERENCE

COLORADO REVISED STATUTES
TITLE 37, ARTICLE 87

RESERVOIRS

37-87-101. Storage of water.

(1) (a) The right to store water of a natural stream for later application to beneficial use is recognized as a right of appropriation in order of priority under the Colorado constitution. No water storage facility may be operated in such a manner as to cause material injury to the senior appropriative rights of others. Acquisition of those interests in real property reasonably necessary for the construction, maintenance, or operation of any water storage reservoir, together with inlet, outlet, or spillway structures or other facilities necessary to make such reservoir effective to accomplish the beneficial use or uses of water stored or to be stored therein, may be secured under the laws of eminent domain.

(b) State agencies shall, to the maximum extent practicable, cooperate with persons desiring to acquire real property for water storage structures.

(2) Underground aquifers are not reservoirs within the meaning of this section except to the extent such aquifers are filled by other than natural means with water to which the person filling such aquifer has a conditional or decreed right.

37-87-102. Definitions - natural streams and use thereof by reservoir owners.

(1) As used in this article, unless the context otherwise requires:

(a) "Mean annual flood" means a flood which has a magnitude (peak discharge) which is expected to be equalled or exceeded on the average once every 2.33 years and has a forty-three percent chance of being equalled or exceeded (0.43 exceedence probability) during any year, by application of the criteria defined in subsection (2) of this section.

(b) "Natural stream" means a place on the surface of the earth where water naturally flows regularly or intermittently with a perceptible current between observable banks, although the location of such banks may vary under different conditions.

(c) "One-hundred-year flood" means a flood which has a magnitude (peak discharge) which is expected to be equalled or exceeded on the average once during any one-hundred-year period (recurrence interval) and has a one percent chance of being equalled or exceeded during any year (0.01 exceedence probability). The terms "one-hundred-year flood", "one percent chance flood", and "intermediate regional flood" are synonymous.

(d) "One-hundred-year floodplain" means that area in and adjacent to a natural stream which is subject to flooding as a result of the occurrence of a one-hundred-year flood.

(e) "Ordinary high watermark" of any stream means the visible channel of a natural watercourse within which water flows with sufficient frequency so as to preclude the erection or maintenance of man-made improvements without special provision for protection against flows of water in such channel or the channel defined by the mean annual flood, whichever is greater.

(2) Whenever the records basic to a determination of probable future water flows, either with respect to this section or by other requirements of law, extend for a period of one hundred or more years, the calculation based upon those results shall be deemed conclusive. If such records do not extend for a period of one hundred or more years the determination shall be made by interpolation and correlation to a full one hundred years of records by relating them to known

records of water basins as similar as reasonably possible to the basin under consideration or by other acceptable methods.

(3) (a) In any case in which a determination of probable future surface water flows at any place in the state is required, the calculation shall be based upon past surface water runoff at the place in question supplemented as provided in this section. Such probable flows shall be determined by reference to the records of reliable stream gauging stations. A stream gauging station record shall be deemed reliable if made by the state of Colorado or the United States as part of a regular program of either of those entities, except as to any part of such records which the state engineer shall have designated as being unreliable, on the basis of facts so showing. Whenever a designation of probable future runoff is required at a place other than the location of a reliable stream gauging station, the determination of probable runoff at such other place shall be made by relating the probable future runoff at that place to the recorded runoff at a comparable gauging station or gauging stations by the interpolation of reasonable hydrologic, geologic, and natural vegetative factors supplemented as provided in this section. Unless clearly unrelated, the factors of the comparison shall include, but not be limited to, the following elements or characteristics:

(I) The water basin contributing to the probable future flow at the place where probable future runoff is to be determined, considering:

(A) The size;

(B) The altitude or altitudes;

(C) The various soil permeabilities;

(D) The various vegetative covers;

(II) The known runoff as determined by reliable stream gauging stations using interpolations when necessary from comparable gauging stations and relating interpolations to the characteristics of the basin measured by the comparable gauging stations as related to the basin of runoff being determined;

(III) The slope or slopes of the terrain whose surface runoff contributes to the surface water flows at the place at which a determination of probable future surface water flows is required.

(b) The state engineer shall promulgate rules pursuant to section 24-4-103, C.R.S., which include other factors for consideration in any area or situation in which calculations based on the criteria in paragraph (a) of this subsection (3) will probably be made more accurate by use of other or additional criteria. Whenever conditions are such that records of past precipitation are an appropriate factor, he may designate any portion of official precipitation records of agencies of the United States or of the state of Colorado which are appropriate in evaluating probable future water flows. He may approve use of factors referred to in this paragraph (b) with respect to particular areas or design of specific structures when requested to do so.

(c) No dam safety requirement shall be imposed to meet a potential hazard of a flood whose magnitude is such that the hazard would probably exist whether or not the dam failed.

(3.5) Whenever a determination of probable future surface water flows, or the probability of frequency of their recurrence, at any place in Colorado is required by relation to a longer period of flow than that for which there is a reliable record of flow as defined in subsection (3) of this

section, the determination shall be made by interpolation and correlation of known records to the longer period by relating known records of water basins as similar as reasonably possible to the place of determination or basin under consideration, or by use of geologic determinations, or by use of other methods reasonably calculated to formulate an accurate estimate of probable future flows or the probability of frequency of their recurrence at the place of determination of such flows.

(3.7) Calculations of probable flows or frequency of recurrence based upon application of the principles set forth in subsections (3) and (3.5) of this section shall relieve anyone acting in accordance with such principles of any liability respecting an occurrence different than that predicted. This exemption from liability shall apply to the state and its public officials or employees when acting in performance of their public duties.

(4) The owners of any reservoir may conduct the waters legally stored therein into and along any of the natural streams of the state, but not so as to raise the waters thereof above ordinary high watermark, and may take the same out again at any point desired if no material injury results to the prior or subsequent rights of others to other waters in said natural streams. Due allowance shall be made for evaporation and other losses from natural causes for the protection of all rights to the waters flowing in said streams, such losses to be determined by the state engineer.

37-87-103. Notice of release of stored waters.

The owners of reservoirs who avail themselves of the provisions of this section and section 37-87-102 shall give reasonable prior notice to the irrigation division engineer of the irrigation division in which the reservoir is located or to the chief administrative water official of such irrigation division of the date on which they desire to release stored waters into any natural streams, together with the quantity thereof in cubic feet per second of time, the length of period to be covered by such releases, and the name of the ditch, canal, pipeline, or reservoir to which the water so released from storage is to be delivered, to the end that the water officials in responsible charge of any stream into which such stored water is released shall have ample time in which to make the necessary observations measurements of flow and storage and records thereof and to provide for a proper patrol of the said stream, for the protection of the reservoir owner and also all other appropriators along the stream whose interests might be affected as a result of such reservoir release. Such notice may be given to the division engineer when the reservoir from which the water is to be released and the point where the water is to be taken from the stream or again stored are in the same water district.

37-87-104. Liability of owners for damage.

(1) Any provision of law to the contrary notwithstanding, no entity or person who owns, controls, or operates a water storage reservoir shall be held liable for any personal injury or property damage resulting from water escaping from that reservoir by overflow or as a result of the failure or partial failure of the structure or structures forming that reservoir unless such failure or partial failure has been proximately caused by the negligence of that entity or person. No entity or person shall be required to pay punitive or exemplary damages for such negligence in excess of that provided by law. Any previous rule of law imposing absolute or strict liability on such an entity or person is hereby repealed.

(2) No such entity or person shall be liable for allowing the inflow to such reservoir to pass through it into the natural stream below such reservoir.

(3) (a) No stockholder, officer, or member of a board of directors of an owner of a reservoir shall be liable for any personal injury or property damage resulting from water escaping from such reservoir or as a result of the failure or partial failure of the structure or structures forming such reservoir for which the owner shall have been found liable if a valid liability insurance policy, or adequate substitute as provided in paragraph (b) of this subsection (3), has been purchased by the owner of the reservoir and is in effect at the time such damage occurs. Such insurance policy shall insure against such damages and provide coverage in an amount of not less than fifty thousand dollars for each claim and in an aggregate amount of not less than five hundred thousand dollars for all claims which arise out of any one incident. The policy may provide that it does not apply to any act or omission of a stockholder, officer, or member of a board of directors of an owner if such act or omission is dishonest, fraudulent, malicious, or criminal. The policy may also contain other reasonable provisions with respect to policy periods, territory, claims, conditions, and other matters common to such policies of insurance. The limitation of liability pursuant to this paragraph (a) shall not apply to any criminal, fraudulent, or malicious act or omission by a member of the board of directors of the owner, an officer of the owner, or a stockholder of the owner, nor shall it apply to any ultra virus act of the owner or of a member of the board of directors, an officer, or a stockholder of such owner. The provisions of this paragraph (a) shall not be deemed to impose any liability upon a member of the board of directors, an officer, or a stockholder of the owner of a reservoir beyond that provided in section 7-42-118, C.R.S.

(b) An adequate substitute for such insurance may be in the form of:

(I) A good and sufficient bond, in an amount equal to such recovery limitations duly executed by a qualified corporate surety approved by the commissioner of insurance, conditioned upon the payment by the entity or person who owns, controls, or operates a water storage reservoir of any valid and final judgment for damages imposed within the judgment limitations established in this subsection (3);

(II) A good and sufficient escrow of acceptable securities, as defined in section 24-91-102, C.R.S., or an annual irrevocable letter or annual letters of credit issued by any national or state bank or any bank for cooperatives as chartered under Title III of the "Federal Farm Credit Act of 1971", as amended, and deposited with an escrow agent pursuant to an escrow contract or agreement requiring the escrow agent to pay from the escrow account amounts necessary to discharge a valid and final judgment for damages within the limits established in this subsection (3). Such escrow contract or agreement shall provide that it cannot be revoked or amended until after any claims for damage against such entity or person have been discharged or until applicable statutes of limitations pertaining thereto have expired.

(III) A combination of insurance and any of the substitutes described in this paragraph (b).

37-87-104.5. Notification of ownership of dam - when person in control deemed owner.

The person or persons actually in control of the physical structure of any dam shall be deemed, for determining liability arising from ownership of a dam and with respect to operation thereof, to be the owners thereof unless notice of the name and address of the true owner thereof, together

with reasonable evidence of such ownership, has been filed in the office of the state engineer by January 1, 1985. Any change in ownership shall be immediately filed in the office of the state engineer.

37-87-105. Approval of plans for reservoir - notice of modification.

(1) No dam shall be constructed in this state to impound water above the elevation of the natural surface of the ground for the purpose of creating a reservoir with a capacity of more than one hundred acre-feet of water or with a surface area at the high water line in excess of twenty acres or if the height of the dam will exceed ten feet measured vertically from the elevation of the lowest point of the natural surface of the ground, where that point occurs along the longitudinal centerline of the dam, up to the flow line crest of the spillway of the dam before plans and specifications for that dam have been filed in the office of the state engineer and approved by him in accordance with regulations established by the state engineer governing such structures.

(2) Repealed.

(3) In making his determination for approval, the state engineer shall be guided by dam, spillway, and construction regulations established pursuant to this article. Such regulations may include less stringent requirements than those dictated by consideration of probable maximum precipitation. The state engineer shall issue his written decision regarding the approval of plans and specifications within one hundred eighty days of submittal to him. The state engineer shall have authority to require the material used and the work of construction to be accomplished in accordance with regulations which the state engineer may establish. No work shall be deemed complete until the state engineer furnishes to the owners of such structures a written statement of acceptance, which statement shall specify the dimensions of such dam and capacity of such reservoir. The state engineer shall render his written decision regarding acceptance within sixty days of written notification by the owner that construction has been completed.

(4) No alteration, modification, repair, or enlargement of a reservoir or dam which will affect the safety of the structure shall be made without prior written notice and approval in accordance with this section to the state engineer. General maintenance, ordinary repairs, or emergency actions not impairing safety shall be excluded from the terms of this subsection (4).

37-87-106. Cost of inspections and observation. (Repealed)

37-87-107. Safety inspections - amount of water to be stored.

Dam safety inspections shall be made on all dams within the state by qualified, experienced personnel as often as the state engineer deems necessary or appropriate for the protection of public health and safety so that a determination of the amount of water which is safe to impound in the reservoir can be made by the state engineer. The dam safety inspections shall include, but shall not be limited to, review of previous inspections, reports and drawings, site inspection of the dam, spillways, outlet facilities, seepage control and measurement system, and permanent monument or monitoring installations, if any. Based upon inspection reports and other information affecting the safety of each dam, the state engineer shall determine the amount of water which is safe to impound in the reservoir. It is unlawful for the owners of any reservoir to

store in said reservoir water in excess of the amount so determined by the state engineer to be safe.

37-87-108. Withdrawal of excess water.

If the owners of any such reservoir impound water therein to a depth greater than that determined by the state engineer to be safe, it is the duty of the division engineer of the district wherein such reservoir is located to forthwith proceed to withdraw from said reservoir so much of the water as shall be in excess of the amount so determined by the state engineer to be safe, and the division engineer shall close the inlets to the same to prevent said reservoir from being refilled to an amount beyond what said state engineer has designated as being safe. If the owners of said reservoir, or any other persons, interfere with the division engineer in the discharge of said duty, the said division engineer shall call to his aid such persons as he deems necessary and employ such force as the circumstances demand to enable him to comply with the requirements of this section. Any costs incurred by the state engineer in rectifying a failure of compliance by the owner may be recovered in a suit for civil damages.

37-87-108.5. Emergency actions.

(1) If, in the opinion of the state engineer, conditions of any dam or reservoir are so dangerous to the health and safety of life or property as not to permit time for issuance and enforcement of an order relative to construction, modification, maintenance, or restriction of storage, or the dam is threatened by any large flood, the state engineer may immediately employ remedial measures necessary to protect such life and property.

(2) (a) The state engineer shall maintain complete control of any such dam or reservoir which, pursuant to subsection (1) of this section, has been determined to be dangerous to life or property until such dam or reservoir is deemed safe, or until any emergency conditions which precipitated the state engineer taking control of any such dam or reservoir, pursuant to subsection (1) of this section, have abated. The state engineer is hereby empowered to determine the proper time at which to relinquish control of any such dam or reservoir.

(b) For purposes of this paragraph (b), measures taken by the state engineer pursuant to subsection (1) of this section shall be deemed final action by the state engineer for purposes of judicial review. The owner or operator of any dam upon which the state engineer has employed remedial measures pursuant to subsection (1) of this section may seek judicial review of the propriety of such measures by filing an action in the state district court for the district in which such dam is located.

(3) (a) Any necessary and reasonable costs and expenses incurred by the state engineer in fulfilling the duties mandated by subsections (1) and (2) of this section in connection with a remedial or emergency action shall be recoverable by the state engineer from the owner of any such dangerous or threatened dam.

(b) Any owner failing or refusing, after written notice has been given, to pay the reasonable costs and expenses incurred by the state engineer pursuant to paragraph (a) of this subsection (3) shall be, upon complaint by the state engineer to the attorney general, subject to reasonable attorney fees incurred in the recovery of such costs and expenses.

(4) (a) All moneys collected by the state engineer pursuant to subsection (3) of this section shall be credited to the emergency dam repair cash fund created in section 37-60-122.5, to the extent necessary to replenish the account. Moneys collected in excess of such amount shall be credited to the Colorado water conservation board construction fund.

(b) The general assembly shall make annual appropriations from the emergency dam repair cash fund created in section 37-60-122.5, for the direct and indirect costs incurred by the state engineer in the performance of those duties authorized to be carried out by the state engineer in this section.

37-87-109. Complaint that reservoir is unsafe.

Upon complaint being made to the state engineer by one or more persons residing or having property in such a location that their homes or property would be in danger of destruction or damage in the event of a flood occurring on account of the breaking of the embankment of any reservoir within the state, that said reservoir is in an unsafe condition, or that it is being filled with water to such an extent as to render it unsafe, it is the duty of the state engineer to forthwith examine said reservoir and determine the amount of water it is safe to impound therein. If, upon such examination, the state engineer finds that said reservoir is unsafe, or is being filled with water to such an extent as to render it unsafe, it is his duty to immediately cause said water to be drawn from said reservoir to such an extent as will, in his judgment, render the same safe. If water is then flowing into said reservoir, he shall cause it to be discontinued

37-87-110. Engineer may use force.

The state engineer is authorized to use such force as is necessary to perform the duties required of him in section 37-87-109 and to have and exercise all of the powers conferred upon the division engineer by section 37-87-108. If, after any of such reservoirs have been examined by said state engineer, the owners thereof, or any other person, fills or attempts to fill them, or any of them, to a point in excess of the amount the state engineer has determined to be safe, then it is the duty of the division engineer of the district wherein such reservoir is located to proceed as directed by section 37-87-108. All direct, actual, and necessary expenses incurred in performing any action authorized by this section shall be recoverable by the state engineer from the owner of the affected reservoir and if not reimbursed may be collected by action brought by the state engineer in the district court of the county in which the reservoir, or part thereof, is located.

37-87-111. Expense of examination.

The person calling upon the state engineer to perform the duty required of him by section 37-87-109, if the request is frivolous or made in bad faith, shall pay him any invoiced expenses and mileage at the rate prevailing for state officers and employees under section 24-9-104, C.R.S., for each mile actually and necessarily traveled in going to and from said reservoir, and, should the state engineer find upon examination that such reservoir is in an unsafe condition, the owners thereof shall be liable for all expenses incurred in such examination.

37-87-112. Review of action of state engineer.

Any action of the state engineer under section 37-87-110 shall be subject to review in a de novo proceeding commenced by complaint of the owner in the district court in and for the county where the affected structure is located. When the state engineer has directed that certain measures shall be taken immediately for the protection of the public safety, any such judicial proceeding shall be accelerated on the court's calendar and determined immediately upon the conclusion of such proceeding. The judgment and action of the state engineer shall control until judicial determination of the cause.

37-87-113. Breakage of reservoir - damages. (Repealed)

37-87-114. Penalty - disposition of fines.

(1) Any reservoir owner or operator failing or refusing, after notice in writing has been given, to obey the reasonable directions of the state engineer as to the construction or safe operation of any reservoir shall be subject to a fine of not less than five hundred dollars for each offense, and each day's continuance after time of notice has expired shall be considered a separate offense. Such fines shall be recovered by civil action in the name of the people by the district attorney, upon the complaint of the state engineer, in the district court of the county where the injury complained of occurred. The proceeds of all fines, after payment of costs and charges of the proceedings, shall be paid into the county treasury for the use of the general fund of the county.

(2) Upon the complaint of the state engineer, the attorney general is authorized to commence proceedings against any reservoir owner or operator for refusing, after notice in writing has been given, to obey the directions of the state engineer as to the construction or safe operation of any reservoir to secure compliance with any such reasonable direction necessary for public safety in the district court of the county wherein any portion of such reservoir is located, pursuant to the Colorado rules of civil procedure; except that, if it appears to the court that the public safety is in jeopardy as the result of a failure to obey the directions of the state engineer, the court shall expedite the proceedings so that determinations may be made with respect to the directions of the state engineer commencing not later than twenty days from the service of the complaint on the owner or operator of a reservoir.

37-87-114.4. Annual report.

The state engineer shall submit an annual report to the general assembly by November 1 of each year concerning the activities of the state engineer and the division of water resources relating to sections 37-87-105 to 37-87-114 for the preceding fiscal year. In addition to the copies required to be filed as provided in section 24-1-136 (9), C.R.S., a copy of such report shall be provided to each of the following: The governor and the chairmen of the committees of reference of the senate and the house of representatives dealing with agriculture and natural resources. Such report shall include but not be limited to information on the following: Approvals of plans and specifications for construction of dams and reservoirs and for alterations, modifications, repairs, and enlargements; number of safety inspections made and the results thereof; use of appropriated funds; receipts generated for inspections of dams and reservoirs; rules and regulations adopted or amended; enforcement orders and proceedings; dam failures and reasons therefor; and other available data regarding the effectiveness of the state's dam and reservoir safety program.

37-87-114.5. Applicability of provisions - exemptions.

(1) The provisions of sections 37-87-105 to 37-87-114 shall not apply to:

(a) Structures not designed or operated for the purpose of storing water;

(b) Mill tailings impoundment structures permitted under article 32 or 33 of title 34, C.R.S.;

(c) Uranium mill tailings and liquid impoundment structures permitted under article 11 of title 25, C.R.S.; except that the state engineer shall render such consultation as necessary for the permitting of such structures;

(d) Siltation structures permitted under article 33 of title 34, C.R.S.; or

(e) Structures which store water only below the elevation of the natural surface of the ground.

37-87-115. Damages.

The provisions of this article are undertaken by the state of Colorado in the discretionary exercise of its governmental authority; therefor, neither the state of Colorado nor the state engineer, any member of his staff, or any person appointed by him shall be liable in damages for any act done by him or for his failure to act in pursuance of the provisions of this article. In addition, the state engineer, any member of his staff, and any person appointed by him shall have the same immunity from liability as other public employees pursuant to the provisions of article 10 of title 24, C.R.S.

37-87-116. Tax reduction where reservoirs located. (Repealed)

37-87-117. Landowner to submit plans. (Repealed)

37-87-118. State engineer's authority over construction. (Repealed)

37-87-119. Completion of dam. (Repealed)

37-87-120. Reduction in valuation for assessment. (Repealed)

37-87-121. Application to existing dams. (Repealed)

37-87-122. Erosion control dams.

(1) The provisions of sections 37-87-101 to 37-87-108 shall not apply to erosion control dams of the character defined in this section, unless such dams also come within the specification requirements of said sections.

(2) Erosion control dams for reservoirs may be constructed on watercourses, the channels of which have been determined by the state engineer to be normally dry, having a vertical height not exceeding fifteen feet from the bottom of the channel to the bottom of the spillway, and having a capacity not exceeding ten acre-feet at the emergency spillway level, upon approval of an application for such erosion control dam by the state engineer, which application shall be accompanied by a fee of fifteen dollars. The approval by the state engineer of an erosion control dam shall be chronologically numbered in order of approval and in concert with any livestock water tanks approved pursuant to section 35-49-109, C.R.S. When such reservoirs are to be constructed with such height exceeding fifteen feet and such capacity exceeding ten acre-feet, they shall be constructed in accordance with section 37-87-105.

(3) Such reservoirs may be constructed with a capacity in excess of two acre-feet if, at or below the two acre-feet level, an ungated outlet tube is installed, with twelve inches minimum diameter and large enough to assure adequate capacity to drain within thirty-six hours any impoundment in excess of two acre-feet.

(4) The state engineer shall prepare and keep on file at the office of the state engineer standard specifications for erosion control dams which shall be subject to revision by the state engineer and shall in general be used as a guide by persons proposing to construct such dams.

(5) The fees collected pursuant to subsection (2) of this section shall be deposited by the state engineer with the state treasurer, who shall credit all such fees to the general fund of the state.

37-87-123. Dam and reservoir information. (Repealed)

37-87-124. Restriction of facilities within reservoirs.

(1) The general assembly hereby declares that the prevention of seasonal flooding which causes destruction of property and crops, loss of livestock, and risk or loss of human life is manifestly of greater concern and benefit to this state than the availability of recreational facilities and other

facilities, not functionally related to the operation of the reservoir, constructed below the high water level of a reservoir.

(2) In order to achieve the purposes of subsection (1) of this section, no person, including any state or federal agency, quasi-municipal corporation, or political subdivision, shall construct any permanent recreational structure within a reservoir below the elevation at the crest of the spillway of the reservoir unless such facility is constructed in such a manner as to withstand partial or complete inundation and sustain minimal or no damage thereby or unless such facility is necessary to the operation of the reservoir. Said facility should be capable of being restored to full recreational use with a minimum amount of cleaning or expense. This subsection (2) and subsection (3) of this section shall not apply to facilities completed before July 1, 1984, but shall apply to any enlargement or remodeling of such facilities.

(3) The state engineer shall order the removal of any facilities constructed, enlarged, or remodeled in violation of this section. Such order may be appealed by the affected person or enforced by the state engineer pursuant to article 4 of title 24, C.R.S.

37-87-125. Notice of intent to construct impoundment structure.

Any person proposing to construct a reservoir for the purpose of storing water, other than a reservoir specified in section 37-87-105 (1) or a livestock water tank as described in section 35-49-103, C.R.S., shall submit notice thereof to the state engineer prior to the beginning of any construction. Such notice shall include the location of such proposed reservoir with reference to section, township, and range and the dimensions of the reservoir, the dam, and the spillway. If any reservoir is constructed without the notice required by this section, the state engineer may prohibit the storage of water in such reservoir or direct the withdrawal of water from such reservoir. The provisions of this section shall not apply to structures listed in section 37-87-114.5.

FOR REFERENCE

COLORADO REVISED STATUTES
TITLE 35, ARTICLE 49

LIVESTOCK WATER TANKS

35-49-101. Short title.

This article shall be known and may be cited as the "Livestock Water Tank Act of Colorado".

35-49-102. Legislative declaration.

It is the policy of the state of Colorado to encourage and improve range conditions for livestock within its borders through the construction of watering tanks, to provide a system of priorities of right of use thereof, and to protect adjudicated water rights and the public interest by providing an official record and reasonable public supervision of such watering tanks.

35-49-103. Definitions.

As used in this article, unless the context otherwise requires:

(1) "Livestock water tanks" includes all reservoirs created by dams constructed after April 17, 1941, on watercourses, the channels of which are normally dry as determined by the state engineer, having a capacity not exceeding ten acre feet and a vertical height not exceeding fifteen feet from the bottom of the channel to the bottom of the spillway to be used for stock watering purposes.

35-49-104. Statutes inapplicable.

The provisions of sections 37-87-101 to 37-87-108 and 37-87-114 to 37-87-115, C.R.S., shall not apply to livestock water tanks of the character defined in section 35-49-103.

35-49-105. Not used for irrigation.

No livestock water tanks constructed under the provisions of this article shall be used for irrigation purposes, and nothing contained in this article shall be construed as conferring upon the owner of any such livestock water tank a priority of use superior to any vested water right or to an adjudicated appropriation of water pursuant to state laws. Unless built upon an intermittent or perennial main stream, dams creating such livestock water tanks shall be deemed to have a rebuttable presumption that there is no injury to adjudicated water rights when built pursuant to the specifications set forth in section 35-49-103. If used solely for watering of livestock in areas known to be deficient in windmill water, having a pumping capacity of less than five gallons per minute, dams of greater capacity than those designated in section 35-49-103 may be constructed on any ephemeral stream, but in such event, the state engineer may require the construction of drainage facilities to reduce the water impounded in the reservoir to the capacity prescribed in section 35-49-103, within a thirty-six hour period.

35-49-106. Plans submitted to state engineer.

Anyone proposing to construct a dam for the creation of a livestock water tank, as described in section 35-49-103, shall submit to the state engineer for approval an application on a form provided by the state engineer showing the general location of such proposed dam with reference

to section, township, and range, location and dimensions of spillway, and the number, location, and size of dams already constructed within the watersheds of the dry channel on which such dam is proposed to be built. Nothing contained in this section shall be construed to specify plans and specifications of such technical detail or nature as to require preparation by an engineer or construction of such stock water tanks under the supervision of an engineer; it being the intent and purpose of the provisions of this section that the state engineer shall be apprised by the completed application of pertinent information sufficient to enable the state engineer to ascertain the general location of the water tank, its operation in relation to tanks already constructed, its relative priority rights, its effect on existing appropriations of water, its capacity, its dam dimensions, the necessary and reasonable factors of safety, and its compliance with the provisions of this article.

35-49-107. Construction requirements.

(1) The state engineer shall examine each application submitted and, if the state engineer approves the same, shall return one copy of each such application with the approval of the state engineer thereon to the person submitting the same and file the other copy at the office of the state engineer. If the state engineer disapproves such application, or any part thereof, the same shall be returned to the applicant for correction and revision. In cases where the state engineer deems it necessary, before approval thereof, the state engineer may inspect the proposed water tank site and make such independent investigation as necessary. Whether the state engineer approves such application, or disapproves it and returns the same for correction and revision, the state engineer shall act within fifteen days after the application is submitted. Until the approval by the state engineer of an application has been obtained, the construction of such dam is prohibited.

(2) The provisions of this section and section 35-49-112 specifying approval by the state engineer and providing a fee therefor shall not apply to dams having a vertical height not exceeding five feet from the bottom of the channel to the bottom of the spillway and which impound not more than two acre feet of water.

(3) Anyone proposing to construct a dam for the creation of a livestock water tank, as described in section 35-49-103, shall comply with section 35-49-106. Every owner of a proposed reservoir for stock watering purposes who desires to obtain a priority number for such structure shall comply fully with all pertinent provisions of this article.

35-49-108. State engineer to inspect dam.

When such a dam is completed the state engineer shall be notified of such completion and, thereafter, may inspect said stock water tank. If the state engineer finds that the construction fails to conform with the application approved by the state engineer, it then becomes the duty of the owner of such dam to make such change and corrections therein as the state engineer has determined to be necessary to correct such failure, and when the same have been made, the state engineer shall provide in writing approval of such structure. Approval shall be granted by the state engineer upon reasonable compliance with the approved application and standard specifications. A livestock water tank shall not be disapproved because of failure to observe technical engineering details in construction.

35-49-109. Priority determined, how.

The state engineer's certificate of approval of a livestock water tank on each normally dry stream and its tributaries shall be chronologically numbered in the order of approval and in concert with any erosion control dams approved pursuant to section 37-87-122, C.R.S. Priority of right as between such tanks located on or within the watershed of each such dry stream shall be determined by such numbers seriatim, number one being first in such right.

35-49-110. Standard plans - publication.

The state engineer shall prepare and keep in file at the office of the state engineer standard plans, drawings, and specifications for livestock water tanks, which shall be subject to revision by the state engineer and shall in general be used as a guide by persons proposing to construct such tanks. Publication of these plans shall be subject to the approval and control of the executive director of the department of natural resources.

35-49-111. When conduits not required.

Where, in the judgment of the state engineer, tanks upon any stream and its tributaries do not require conduits for purposes of safety or the protection of prior livestock water tank rights, it is lawful for the state engineer to approve an application not calling for conduits. Nothing in this section shall abrogate the right of any owner of a vested water right or appropriation of water to require such conduits in any case where necessary to protect such senior right.

35-49-112. Fees deposited in general fund.

Each application for a livestock water tank submitted to the state engineer under the provisions of this article shall be accompanied by a fee of fifteen dollars. This fee shall be deposited by the state engineer with the state treasurer who shall credit all such fees to the general fund of the state.

35-49-113. Assignment of priority number. (Repealed)

35-49-114. Approval required for reservoir. (Repealed)

35-49-115. Penalty.

The owner of any dam or reservoir failing to comply with the provisions of this article shall be subject to a penalty of not more than twenty-five dollars nor less than five dollars, to be recovered and disposed of as are fines for violations of section 37-87-114, C.R.S.

35-49-116. Appropriation - transfer of funds.

The general assembly shall annually appropriate from the general fund moneys for the administration of this article.

E.7. Connecticut



This document contains the Connecticut regulations for Dam Safety. This document was prepared by the State of Connecticut Department of Environmental Protection and is provided for the convenience of the reader. This is not the official version of the regulations. The official regulations are published by the State of Connecticut, Judicial Branch, Commission on Official Legal Publications in the Connecticut Law Journal. In the event there is inconsistency between this document and the regulations as published in the Connecticut Law Journal, the Connecticut Law Journal publication will serve as the official version.

DAM SAFETY REGULATIONS

Section 1. Subsection (a) of Section 22a-409-1 of the Regulations of Connecticut State Agencies is amended to read as follows:

Section 22a-409-1. Registration of dams and similar structures.

(a) Definitions. AS USED IN SECTION 22A-409-1 and 22A-409-2:

(1) "Abutment" means natural ground that borders on either end of the dam structure.

(2) "Acre-Foot" means a unit of volume equal to 43,560 cubic feet or 325,853 gallons (one foot depth over one acre).

(3) "Average Daily Traffic" (ADT) means a measure of the number of vehicles using a specific road in an average twenty-four hour period.

(4) "Appurtenance" means any structure or mechanism other than the dam itself which is associated with its operation.

(5) "Breach" means an alteration of a dam either deliberately or accidentally in such a way as to release its impounded waters.

(6) "Commissioner" means the Commissioner of Environmental Protection.

(7) "Dam" means any barrier of any kind whatsoever which is capable of impounding or controlling the flow of water, including but not limited to storm water retention or detention dams, flood control structures, dikes, and incompletely breached dams.

(8) "Dam Height" means the vertical distance from the crest of the dam or similar structure to the downstream toe of such dam or similar structure.

(9) "Embankment" means the fill material, usually earth or rock, placed with sloping slides providing a barrier which impounds water.

(10) "Flood" means a general and temporary condition of partial or complete inundation of normally dry land areas.

(11) "Hazard Potential" means probable damage that would occur if the structure failed, in terms of loss of human life and economic loss or environmental damage.

(12) "Owner" means any individual, firm, partnership, association, syndicate, company, trust, corporation, municipality, agency or political or administrative subdivision of the state, or any other legal entity of any kind holding legal title to the dam.

(13) "Structure" means the dam, its appurtenances, abutments and foundation.

(14) "Toe" means the base portion of the impounding structure which intersects with natural ground at the upstream and downstream sides.

Section 2. The Regulations of Connecticut State Agencies are amended by adding Section 22a-409-2. Dam Safety Inspection Regulations.

Section 22a-409-2. Dam Safety Inspection Regulations.

(a) Jurisdiction. All dams which must be registered pursuant to Section 22a-409 of the Connecticut General Statutes shall be under the jurisdiction of the Commissioner. Dams of the State, or any political subdivision thereof, and all dams within the State except those of the United States or its instrumentalities are included within the jurisdiction conferred by this section.

(b) Periodic inspections. The following dams shall be regularly inspected by the Department of Environmental Protection at a frequency as described in Section 22a-409-2(e)(2) of these regulations:

(1) Dams which pose a significant (B) or high (C) hazard to life or property as defined in Section 22a-409(d);

(2) Dams which are:

(A) greater than twenty-five (25) feet in height with an impoundment capacity greater than fifteen (15) acre-feet; or

(B) greater than six (6) feet in height but less than or equal to twenty-five (25) feet in height with an impoundment capacity greater than fifty (50) acre-feet; or

(3) All other dams with an impoundment capacity of three (3) acre-feet or more.

(c) Periodic Inspection Procedures.

(1) Each periodic inspection shall consist of, but not be limited to, the following:

(A) Visual inspection of the dam, its appurtenances, abutments, downstream toe and all other areas which could affect the safety of the dam. In addition, inspection and operation of mechanical systems, and inspection of the abutments downstream, the components of the dam which are under water during normal operation, or the interior of outlet conduits shall be made by the owner, if required by the Commissioner to more completely assess the condition of the dam;

(B) Review and analysis of available data on the design, construction, operation, maintenance and performance of the structure;

(C) Observation of the nature and extent of downstream development which would be subject to inundation in the event of a dam breach for purposes of assessing the potential hazard which the dam poses;

(D) Evaluation of the general condition of the structure, including when possible, assessment of its hydrologic and its hydraulic capabilities and structural stability.

(E) Evaluation of the operation, maintenance and inspection procedures employed by the owner.

(F) Evaluation of any other conditions which constitute or could constitute a hazard to the integrity of the structure.

(2) The inspection shall be performed by qualified personnel of the D.E.P. Dam Safety Program with technical training in the inspection of dams and under the supervision of a civil engineer.

(3) A standard dam inspection checklist based upon accepted standards of visual dam inspection and guidelines which direct the proper use of the checklist shall be prepared by the Commissioner and will be utilized by the inspection team. The Commissioner will issue a written report based on the findings of the periodic inspection which shall include, but not be limited to, the following:

(A) An assessment of the condition of the structure based on the visual observations, available data on the design, construction, operation, maintenance and performance of the structure, the hydrologic and hydraulic capacities and the structural stability of the structure;

(B) Recommendations for any emergency measures or actions, if required to assure the immediate safety of the structure;

(C) Recommendations for remedial measures and actions related to design, construction, operation, maintenance and inspection of the structure, if required; and

(D) Recommendations for additional detailed studies, investigations and analyses, if required; and

(E) Recommendations for routine maintenance and inspection by the owner, if required.

(4) The Commissioner shall furnish a copy of the written report to the owner.

(A) The owner shall within thirty (30) days of receipt of the written report, inform the Commissioner in writing of his or her schedule of implementation of any required recommendations.

(B) A copy of the report will be kept on file with the records of the Commissioner pertaining to dam safety.

(d) Classification of Dams:

(1) The Commissioner shall assign each dam to one of five classes according to its hazard potential. Such classification shall be determined by the Commissioner during the initial periodic inspection.

(A) A Class AA dam is a negligible hazard potential dam which, if it were to fail, would result in the following:

(i) no measurable damage to roadways;

(ii) no measurable damage to land and structures;

(iii) negligible economic loss.

(B) A Class A dam is a low hazard potential dam which, if it were to fail, would result in any of the following:

(i) damage to agricultural land;

(ii) damage to unimproved roadways (less than 100 ADT);

(iii) minimal economic loss.

(C) A Class BB dam is a moderate hazard potential dam which, if it were to fail, would result in any of the following:

(i) damage to normally unoccupied storage structures;

(ii) damage to low volume roadways (less than 500 ADT);

(iii) moderate economic loss.

(D) A Class B dam is a significant hazard potential dam which, if it were to fail, would result in any of the following:

(i) possible loss of life;

(ii) minor damage to habitable structures, residences, hospitals, convalescent homes, schools, etc.;

(iii) damage to or interruption of the use of service of utilities;

(iv) damage to primary roadways (less than 1500 ADT) and railroads;

(v) significant economic loss.

(E) A Class C dam is a high hazard potential dam which, if it were to fail, would result in any of the following:

(i) probable loss of life;

(ii) major damage to habitable structures, residences, hospitals, convalescent homes, schools, etc.;

(iii) damage to main highways (greater than 1500 ADT);

(iv) great economic loss.

(2) The classification of a Class A, BB, B, and C dam shall be reviewed during each periodic inspection.

(3) All dams will be subject to reclassification at any time the Commissioner determines that the hazard potential has changed.

(4) Potential future development of the area downstream from the dam that would be affected by its failure shall be considered in determining the classification.

(5) Where a dam is so located that its failure would likely cause a downstream dam to fail, the hazard classification of this dam shall be at least as great as that of the downstream dam.

(6) Potential damage to habitable structures will be considered minor when habitable structures are not within the direct path of the probable flood wave produced upon failure of a dam and when such structures will experience:

(A) No more than 1.5 feet of rise of flood water above the lowest ground elevation adjacent to the outside foundation walls; or

(B) No more than 1.5 feet of rise of flood water above the lowest habitable floor elevation of the structure; the lower of the elevations governing.

(7) The extent of potential damage resulting from a dam breach may, notwithstanding the above, justify designating damage as either major or minor. Such a designation may be made after a detailed analysis has established the relative impact of the probable dam breach and has considered the following factors:

(A) The conditions prior to and after a dam breach;

(B) The extent to which, access has been affected, both before and after a dam breach;

(C) The extent of damage.

(e) Inspection Schedule.

(1) The Commissioner or his representative may enter upon private property at any time to investigate or inspect any dam.

(2) The Commissioner shall periodically inspect all dams in accordance with the following schedule. These time periods are the minimum time between inspections, more frequent inspections may be performed at the discretion of the Commissioner.

HAZARD CLASS	INSPECTION FREQUENCY
Class A (low)	10 years
Class BB (moderate)	7 years
Class B (significant)	5 years
Class C (high)	2 years

(3) Inspections scheduled according to the time period set forth above, may be modified, at the discretion of the Commissioner, in special cases where it is desirable to observe a dam under particular conditions (i.e. wet season, dry season, foliage…).

(4) The Commissioner may require scheduled inspections on a more frequent basis if particular conditions exist which require more frequent monitoring.

(5) The Commissioner may require Class B and C dams to be inspected after the occurrence of a major flood event. The date of these post-flood inspections will be the starting date from which the date of the next regularly scheduled periodic inspection will be computed.

(6) The Commissioner shall exempt from periodic inspections, any dam which, after an initial inspection, impounds less than three (3) acre-feet of water, or any Class AA dam, unless the Commissioner determines that such dam poses a unique hazard.

(f) Inspection by the Owner.

(1) A dam owner may elect to employ the services of a professional engineer registered in the State of Connecticut, experienced in the design, construction and inspection of dams to inspect the owner's dam according to the following schedule:

HAZARD CLASS	INSPECTION FREQUENCY
Class A (low)	10 years
Class BB (moderate)	7 years
Class B (significant)	5 years
Class C (high)	2 years

(2) The owner shall furnish a copy of each completed inspection report in a format determined by the Commissioner within thirty (30) days of the date of the inspection to the DEP Dam Safety Program.

(3) The inspection report shall be sealed by a professional engineer registered in the State of Connecticut and shall include:

(A) Those items listed in Section 22a-409-2(c), and

(B) Correspondence from the owner stating his or her intent to implement such recommendations, if required.

(4) If the dam owner elects to comply with subdivisions (1) through (3), inclusive, the Commissioner shall periodically inspect the dam according to the following schedule:

HAZARD CLASS	INSPECTION FREQUENCY
Class A (low)	20 years
Class BB (moderate)	14 years
Class B (significant)	10 years
Class C (high)	6 years

The year the Commissioner inspects the dam, the owner shall be exempt from conducting his or her own inspection.

(g) New Dam Construction.

(1) All dams, and dams which have a high or significant hazard classification undergoing substantial repairs according to the permit authorization of the Commissioner, must be inspected by the professional engineer employed by the dam owner for construction services according to the following schedule:

(A) Upon first filling of the impoundment, after completion of new construction or substantial repairs, inspection should be performed to assure proper functioning of dam components.

(B) Upon attainment of full impoundment, inspections of the dam should be performed frequently for the first two (2) months.

(C) These dams shall be inspected at least annually for the first three (3) years of operation.

(D) After the third year of operation, these dams will be inspected according to the inspection schedule set forth in Section 22a-409-2-(e).

(E) The Commissioner may exempt from the requirements of this subsection repairs to high and significant hazard dams which he determines do not affect the immediate safety of the dam.

(2) The inspection report must be submitted by the owner's engineer to the Commissiner on a form prescribed by him, within thirty (30) days after:

(A) The last inspection performed during the first two (2) months after full impoundment was attained; and

(B) Each annual inspection as set forth in Section 22a-409-2(g)10(C).

(h) Fees for Inspection by the State.

(1) Each owner shall pay an inspection fee to cover the cost to the State of making both scheduled inspections and post-flood inspections. Such fee bill shall accompany the written report and shall be paid within thirty (30) days after receipt by the owner.

(2) The owner shall submit the inspection fee by check or money order payable to DEP Dam Safety Program.

(3) Pursuant to Sec. 22a-409 of the CT General Statutes, as amended by P.A. 6806, fees for Class A, BB, B and C dams are $525.00.

(4) The Commissioner shall waive the inspection fee for any dam which is owned by the State of Connecticut.

(i) Notification.

(1) The Commissioner shall notify a dam owner of the upcoming date for a regularly scheduled inspection at least ninety (90) days before the inspection.

(2) If, the Commissioner does not receive notification of the owner's intent to perform the inspection with his or her own engineer thirty (30) days prior to the date of the scheduled inspection, the Commissioner shall inspect the dam and charge the owner the appropriate fee.

(3) If after notification by the owner of his or her intent to perform the inspection, the Commissioner does not receive a copy of the inspection report within thirty (30) days of the scheduled inspection date, the Commissioner shall inspect the dam and charge the owner the appropriate fee.

(j) Responsibility of the Owner.

(1) Inspections by the State do not relieve an owner of the dam of the legal duties, obligations or liabilities incidental to the ownership or operation of the dam.

(2) The owner or his or her representative shall inspect the dam on a frequent basis to assure that no unsafe conditions are developing including but not limited to, weather related damage, animal activity or vandalism. Class B and Class C dams shall be inspected by the owner of his or her representative at least quarterly and a written record shall be maintained and be made available to the Commissioner upon request.

(3) The owner or his representative shall inspect the dam during and after the occurrence of major flood events to assure that the structure is withstanding the flood waters safely.

(4) The owner shall fully and promptly advise the Commissioner of any sudden or unpredicted floods, unusual circumstances or major changes in the condition of the dam.

(5) The owner shall report to the Commissioner any major damage which the dam suffered, such as, overtopping by flood waters, erosion of the spillway discharge channel and any major problems which are observed to have developed such as, new seepage or a significant increase in seepage quantities, settling, cracking or movement of the embankment or any component of the dam.

(6) To facilitate visual inspection during the intervals between regularly scheduled inspections, the dam owner shall be required to maintain the structure and adjacent area free of brush and tree growth.

(A) Brush and tree growth shall be cleared from embankments and within twenty-five (25) feet of the downstream toe and the abutment embankment contact;

(B) Grass or other suitable vegetative cover must be established and maintained on abutments and embankments.

(7) The owner shall maintain a written record of all inspections and maintenance work performed. This record shall include observations made regarding areas of concern on the structure and descriptions of the major and minor repairs performed and materials utilized.

Statement of Purpose: To establish a schedule for the frequency of inspection of dams and similar structures and the inspection fees for regularly scheduled inspection sufficient to cover the reasonable cost to the State of making these inspections. For further information, contact the Bureau of Water Management's Inland Water Resources Division, Dam Safety Section at (860) 424-3706.

Effective: 4/30/87

E.8. Delaware



DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

DIVISION OF SOIL AND WATER CONSERVATION

Statutory Authority: 7 Delaware Code, Chapter 42 (7 **Del.C.**, Ch. 42)

FINAL

Secretary's Order No. 2009-S-0044

5103 (DELAWARE DAM SAFETY REGULATIONS
Date of Issuance: November 16, 2009
Effective Date: December 11, 2009

Under the authority vested in the Secretary of the Department of Natural Resources and Environmental Control ("Department" or "DNREC") the following findings, reasons and conclusions are entered as an Order of the Secretary in the above-referenced rulemaking proceeding.

Background and Procedural History

This Order considers proposed regulation entitled "Delaware Dam Safety Regulations." The Department's Division of Soil and Water Conservation commenced the regulatory development process with Start Action Notice 2006-16, which was approved on ….DSWC's Dam Safety Program held 4 meetings with the regulatory advisory committee, as required by the Dam Safety Act (Act), and a public workshop on December 11, 2008.

The Department published the proposed regulations in the April 1, 2009 *Delaware Register of Regulation* and held a public hearing on April 27, 2009. The Department's presiding hearing officer, Robert P. Haynes, prepared a Hearing Officer's Report dated November 9, 2009 (Report). The Report recommends certain findings and the adoption of as a final regulation as "Delaware Dam Safety Regulations," attached to the Report as Appendix A (Regulation).

Findings and Discussion

I find that the Regulation is well-supported by the record developed by DSWC and adopt the Report to the extent it is consistent with this Order. DSWC's experts developed the record and the Regulation was drafted with the cooperation and coordination by members of the regulatory advisory committee. In addition, DSWC held a public workshop. As a result of the extensive informal regulatory development process, the proposed regulation only received two public comments. DSWC and the Report recommend that one comment's editorial and clarifying changes be reflected as non-substantive changes and the other comment was on a specific problem with one pond that did not require any change to the proposed regulation.

I find that the Department's experts in DSWC fully developed the record to support adoption of the final regulations. As final regulations, the Department will have improved authority to regulate dams, particularly the existing 53 dams that are subject to the Department's regulation. The regulation also will regulate to any new dams that fall within the size and classification that are subject to the regulation. The regulations will require annual inspections of high hazard dams and inspections of the significant hazard dams every two years. All dams will be subject to review and supervision by a licensed Delaware professional engineer. The dams that are regulated are public owned dams that have a certain height or size of impoundment or hazard classification to warrant regulation under the Act, or any privately owned dam that may seek to be regulated by agreement.

The regulation adopted by this Order provides more details and clarification to the owners of dams regulated by the Act. The regulation's procedures set forth how to apply to the Department for permission to design, construct, operate, maintain, inspect and abandon a regulated dam. The regulation that this Order adopts will provide a comprehensive and sound basis to regulate those dams in Delaware that are subject to regulation under the Act. In conclusion, the following findings and conclusions are entered:

1.) The Department has jurisdiction under its statutory authority to issue an Order adopting this final

regulation;

2.) The Department provided adequate public notice of the proposed regulation and provided the public with an adequate opportunity to comment on the proposed regulations, including at a public hearing;

3.) The Department held a public hearing on the proposed regulations in order to consider public comments before making any final decision, and has considered all relevant and timely public comments it received;

4) The Department's Hearing Officer's Report, including its recommended record and the Recommended Regulation, as set forth in Appendix A, are adopted to provide additional reasons and findings for this Order;

5.) The Recommended Regulation does not reflect any substantive changes from the Proposed Regulation published in the April 1, 2009, *Delaware Register of Regulations*;

6.) The Recommended Regulation should be adopted as a final regulation because it is consistent with the Act and its purposes to reduce the risk of loss of life and property damage from a failure of a dam subject to the Act's regulation, will enable the Department to administer its duties under the Act, and is well supported by documents in the record; and that

7.) The Department shall submit this Order approving the final regulation to the *Delaware Register of Regulations* for publication in its next available issue, and provide such other notice as the law and regulation require and the Department determines is appropriate.

Collin P. O'Mara
Secretary

5103 Delaware Dam Safety Regulations

Scope and Applicability

Legislation

The Delaware State Legislature passed House Bill No. 514 on June 30, 2004 to amend Section 1 Title 7 of the Delaware Code by enacting in Part IV a new "Chapter 42, Dam Safety." These Regulations have been promulgated pursuant to Title 7 of the Delaware Code, Chapters 42 and 60. The text of House Bill No. 514 is attached as Appendix A. The Act provides for the regulation of publicly owned dams that meet the definition of a dam as defined by the Act and these Regulations and have a hazard classification of High or Significant Hazard Potential.

Purpose of Regulations

It is the purpose of these Regulations to provide for the proper design, construction, operation, maintenance, and inspection of dams in the interest of public health, safety, and welfare, in order to reduce the risk of failure of dams and to prevent death or injuries to persons; damage to downstream property, infrastructure, and lifeline facilities; and loss of reservoir storage.

1.0 Regulating Agency

1.1 The Delaware Dam Safety Program shall be administered by the Delaware Department of Natural Resources and Environmental Control (Department). The program shall be administered and directed by an engineer, licensed in the State of Delaware, or by an individual otherwise clearly qualified by training and experienced in the design, construction, reconstruction, enlargement, repair, alteration, breach, removal, maintenance, operation, and abandonment of dams and reservoirs.

1.2 The Department shall have the authority to review and approve the design, construction, reconstruction, enlargement, alteration, repair, maintenance, operation, breach, abandonment, and removal of dams and reservoirs for the protection of life, property, public infrastructure, and lifeline facilities.

1.3 In making any investigation or inspection necessary to enforce these Regulations, the Department or its representatives may enter upon such private property of the dam owner as may be necessary.

1.4 When the Department determines that a dam and reservoir constitute a risk to life or property, the agency shall order the owner to take such action as necessary to remove the resultant risk to life and property.

1.5 No action shall be brought against the State of Delaware, or any agent of the Department, or any employee of the State of Delaware or the Department for damages sustained through the partial or total failure of any dam, its misoperation, or its maintenance by reason of any supervision or other action taken pursuant to or under these Regulations. Nothing in these Regulations shall relieve an owner or operator of a dam from the legal duties, obligations, and liabilities arising from such ownership and operation.

2.0 Definition of Terms

The following words, terms, and phrases, when used in these Regulations, shall have the meanings ascribed to them except where the context clearly indicates a different meaning:

"**Abandonment**" means to render a dam non-impounding by dewatering and filling the reservoir created by that dam with solid materials and by diverting the natural drainageway around the site.

"**Adverse consequences**" means negative impacts that may occur upstream, downstream, or at other locations remote from the dam. The primary concerns are loss of human life, economic loss (including property damage), disruption of lifeline facilities, and environmental impact.

"**Alterations**", "**modifications**" or "**repairs**" means only alterations, modifications, or repairs to existing dam and appurtenant structures that may directly affect the operation, performance, or safety of the dam, spillway, outlet works, ancillary structures, or reservoir, as determined by the Department. This definition does not include maintenance or minor repairs.

"**Application approval**" means authorization in writing issued by the Department to an owner who has applied to the agency for permission to construct, reconstruct, enlarge, repair, alter, remove, maintain, operate, or abandon a dam and which specifies the conditions or limitations under which work is to be performed by the owner or under which approval is granted.

"**Appurtenant works**" include, but are not limited to, structures such as spillways, either in or separate from the dam; the reservoir and its rim; low-level outlet works; and water conduits such as tunnels, pipelines, or penstocks either through the dam or its abutments.

"**As-Built Drawings**" or" **Record Drawings**" mean the approved post-construction plans;

(1) With verification of all significant as-constructed values, dimensions, and elevations; and

(2) Bearing the seal of the supervising engineer responsible for certifying that to the best of his/her knowledge, the construction was completed in accordance with the approved plans and specifications or with changes approved by the Department.

"**Auxiliary Spillway**" means the second used spillway during flood flows which is not the emergency spillway.

"**Breach**" means partial removal of a dam, creating a channel through the dam to the original stream bottom elevation.

"**Dam**" shall mean any artificial barrier, including appurtenant works, with the ability to impound or divert water, wastewater, or liquid-borne materials. No obstruction in a canal used to raise or lower water shall be considered a dam. A fill or structure for highway or railroad use, or for any other purpose that may impound water, may be subject to review by the Department and shall be considered a dam if the criteria in these Regulations are found applicable and if it is classified as a high hazard potential or significant hazard potential dam.

"**Danger reach**" means that area downstream of a dam that will be flooded by the sudden release of waters resulting from failure of the dam.

"**Days**" when used in establishing deadlines, means calendar days including Sundays and holidays.

"**Department**" means the Delaware Department of Natural Resources and Environmental Control.

"**Design freeboard**" means the minimum freeboard which would exist during passage of the design flood.

"**Dominant discharge**" means the flow rate capacity, in cubic feet per second, of the stream channel considering steady, uniform flow.

"**Emergency Action Plan**" (EAP) means a plan prepared by the dam owner and approved by the Department that identifies emergency conditions at a dam and specifies preplanned actions to minimize loss of life and property damage in the event of a potential dam failure.

"**Emergency condition**" means a sudden unforeseen occurrence or condition requiring exigency or a circumstance that the Department determines constitutes a present or imminent danger to the public health or safety or to the environment. This includes, but is not necessarily limited to: breaches and all conditions leading to or causing a breach, overtopping, or any other condition in a dam and its appurtenant structures that may be construed as unsafe or threatening to life or property.

"**Emergency Spillway**" means the spillway capable of passing the spillway design storm with the principal and/or auxiliary spillway blocked.

"**Enlargement**" means any change in or addition to an existing dam or reservoir, which raises or may raise the water storage elevation of the water impounded by the dam.

"**Floodplain**" means that area along or adjacent to a stream or a body of water of that is capable of storing or conveying flood waters. As used herein, "floodplain" may or may not be the same area depicted as a special flood hazard zone on the Flood Insurance Rate Maps prepared by the Federal Emergency Management Agency.

"**Formal inspection**" means the inspection by a Delaware licensed professional engineer to reevaluate the safety and integrity of the dam and appurtenant structures to determine if the structure meets current design criteria, including a field inspection and a review of the records on project design, construction and performance.

"**Freeboard**" means the vertical distance to the top of a dam above the maximum design water surface elevation.

"**Independent Review Board**" means one or more independent professional engineers who are qualified in the design, construction and rehabilitation of dams to perform a review of the project design and construction.

“**Informal Inspection**” means the visual inspection of the dam by the dam owner or operator to detect apparent signs of deterioration or other deficiencies of the dam structure or function.

"**Hazard potential**" means the possible adverse incremental consequences that result from the release of water or stored contents due to failure of the dam or appurtenances. The hazard potential classification of a dam does not reflect in any way on the current condition of the dam and its appurtenant structures (e.g., safety, structural integrity, flood-routing capacity).

"**Height of dam**" means the vertical distance from the lowest point on the downstream toe of the dam to the lowest point on the top of the dam, independent of low points caused by partial failure or collapse.

"**High Hazard Potential Dam**" shall mean any dam whose failure or misoperation will cause probable loss of human life.

"**Incremental**" means the difference in impacts, under the same conditions (e.g., flood, earthquake, or other event), that would occur due to failure of the dam or those that would have occurred without failure of the dam and appurtenances.

"**Inflow design flood**" means the size of flood coming into the reservoir that is used as a basis for designing the dam.

"**Low-hazard potential dam**" means any dam whose failure or misoperation is unlikely to cause loss of human life but may cause minor economic and/or environmental losses.

“**Maintenance**” means routine activities associated with keeping the dam and ancillary structures in safe operating condition, including, but not limited to such activities as mowing and vegetation removal, cleaning drains, painting metal parts, lubricating and exercising mechanical parts, cleaning debris from channels and trash racks, etc.

"**Maximum capacity**" means the storage volume of a reservoir, in acre-feet, at the lowest point on the top of dam independent of low points caused by partial failure or collapse.

"**Maximum storage elevation**" means the elevation of the lowest point of the top of dam independent of low points caused by partial failure or collapse.

“**Minor repairs**” means activities that restore sections of the dam, spillway, outlet works, and ancillary structures which exhibit minor deterioration to their intended state and that do not require the alteration (permanent or temporary) of any facilities that would effect performance, operation or safety of the dam as determined by the Department.

"**Normal depth**" means the maximum vertical distance from the streambed invert at the upstream toe of the dam to the normal water surface.

“**One-hundred year storm**” means the storm which is estimated to have a one percent chance, or one chance in 100, of being equaled or exceeded in one year.

“**Outlet**” means an opening through which water can be freely discharged from a reservoir for a particular purpose.

"**Overflow spillway**" means any operating, emergency, or other spillway that discharges with a free water surface over or around the dam as opposed to an orifice, gate, or conduit that discharges through or beneath the dam or nearby ground.

"**Owner**" shall include any one or more of the following who owns, controls, operates, maintains, manages, or proposes to construct, reconstruct, enlarge, repair, alter, remove, or abandon a dam or reservoir: the state and its departments, institutions, agencies, and political subdivisions; every municipal or quasi-municipal corporation; every public utility; every district; every person; the duly authorized agents, lessees, or trustees of any of the foregoing; and receivers or trustees appointed by any court for any of the foregoing.

"**Permit to Impound**" means authorization in writing issued by the Department to an owner who has complied with the conditions specified in the Provisional Certificate to Impound issued by the Department, or has completed construction, reconstruction, enlargement, repair, or alteration of a dam, and which specifies the conditions or limitations under which the dam and reservoir are to be maintained and operated.

"**Person**" means any person, firm, association, organization, partnership, business trust, corporation, or company.

"**Preliminary Hazard Classification**" means the initial hazard potential classification determined by the Department based on approximate methods, and is not based on detailed analyses as described in paragraph 5.3 of these Regulations.

"**Principal spillway**" means the primary or first used spillway during normal inflow and flood flows.

"**Probable**" means likely to occur; reasonably expected; realistic.

"**Probable Maximum Flood**" (PMF) means the most severe flood considered possible in a specific region based on the Probable Maximum Precipitation (PMP), as determined by the National Weather Service.

"**Probable Maximum Precipitation**" (PMP) means the theoretically greatest depth of precipitation for a given duration that is physically possible, over a given size storm area, at a particular geographic location, at a certain time of year.

"**Provisional Certificate to Impound**" means temporary authorization in writing issued by the Department to the owner of a dam that existed prior to June 30, 2004, and that the Department has determined meets the criteria for regulation as contained in paragraph 3.1 of these Regulations, and which specifies the conditions that must be met by the dam owner to obtain a Permit to Impound.

"**Reconstruction**" means removal and replacement of an existing dam.

"**Regular Inspection**" means the visual inspection of a dam by a Delaware licensed professional engineer to detect any signs of deterioration in material, developing weaknesses or unsafe hydraulic or structural behavior.

"**Removal**" means complete elimination of the dam embankment or structure to restore the approximate original topographic contours of the valley.

"**Reservoir**" means any basin that contains or will contain impounded water, wastewater, or liquid-borne materials because it has been impounded by a dam.

"**Secretary**" means the Secretary of the Delaware Department of Natural Resources and Environmental Control.

"**Significant Hazard Potential Dam**" shall mean any dam whose failure or misoperation will cause possible loss of life, economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns.

"**Standard project flood**" means the most severe flood considered reasonably characteristic of the specific region. This is calculated for a specific dam site using one or more of the recognized methods acceptable to the Department.

"**State or state**" means the State of Delaware.

"**Spillway**" means a structure other than low flow outlets, over or through which flood flows are discharged.

"**Spillway Design Storm**" means the storm upon which the hydraulic capacity of the spillway structure is designed.

"**Supervising Engineer**" shall mean the design engineer who is responsible for conducting dam construction quality assurance inspections in order to certify the construction has been completed in accordance with the approved plans and specifications.

"**Sunny day failure**" means the failure of a dam with the water level at the normal pool elevation and no rainfall.

"**Toe of dam**" means the junction of the downstream face of a dam with the ground surface or the invert of the outlet pipe whichever is the lowest point.

3.0 Permit-By-Rule

3.1 Applicability

3.1.1 These Regulations shall apply to any dam that is owned by the State or any county in the State, or any municipality, or any quasi-governmental agency of the State that is 25 feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier, or if it is not across a stream channel or watercourse, measured at maximum water storage elevation; or any dam having an impounding capacity, at maximum storage elevation, of 50 acre-feet or more; or any dam that is deemed by the Secretary to be a significant- or high-hazard potential structure due to its location or other physical characteristics.

3.1.2 It is unlawful to construct, reconstruct, enlarge, repair, alter, remove, maintain, operate, or abandon any dam or reservoir that comes under these Regulations except upon application approval of the Department.

3.2 Exclusions

3.2.1 These Regulations shall not apply to any dam that is not in excess of 6 feet in height regardless of storage capacity, or any dam having a storage capacity at maximum water storage elevation not greater than 15 acre-feet regardless of height, or any low-hazard potential dam constructed prior to June 30, 2004, unless deemed by the Secretary to be a significant or high-hazard potential structure due to its location or other physical characteristics.

3.2.2 These Regulations shall not apply to any private owner of a dam unless such owner executes a document with the Department requesting such coverage.

3.2.3 The requirements in these Regulations shall not apply to routine maintenance and operation not affecting the safety of the structure.

3.2.4 These Regulations do not apply to dams that are owned and operated by the Federal Government.

4.0 General Requirements and Prohibitions

4.1 Construction of New Dams

4.1.1 No owner shall begin the construction of any dam to which these Regulations apply without written approval from the Department. Owners intending to construct any dam to which these Regulations apply shall file with the Department a preliminary application that shall include a dam break analysis; the dam height; the maximum impounding capacity; the purpose, location, and determination of hazard class; and other information required by the Department. If, on the basis of this information, it is the opinion of the Department that the proposed dam is exempt from the provisions of these Regulations, the Department shall notify the owner that no approval from the Department pursuant to these Regulations will be required. If, on the basis of the submitted information it is the opinion of the Department that the proposed dam is not exempt, the Department shall notify the owner that construction shall not commence until a full application has been filed by the owner and such application approved in accordance with Sections 6.0 and 7.0 of these Regulations.

4.1.2 The Department shall require Emergency Action Plans (EAPs) and operation and maintenance (O&M) plans for high- or significant-hazard potential dams, and may also require of owners so notified the filing of any additional information it deems necessary, including, but not limited to, stream flow and rainfall data, maps, reports, plans, and specifications.

4.1.3 Every owner applying for approval of a dam subject to the provisions of these Regulations shall also file with the Department a Certificate from a qualified professional engineer licensed in the State of Delaware. The Certificate should state that the engineer is qualified and responsible for the design of the dam; that the design is safe and adequate; and that the engineer shall be responsible for construction quality assurance to certify that the construction has been completed in accordance with the approved plans.

4.1.4 The Department shall send a copy of each completed application to the Delaware Emergency Management Agency and other State, Federal, and local agencies it considers appropriate for review and comment.

4.1.5 Upon receipt of a full application in proper form, the Secretary shall give notice in an advertisement in a newspaper of general circulation in the county in which the activity is proposed and in a daily newspaper of general circulation throughout the State, providing:

4.1.5.1 An announcement of the fact that the application has been received;

4.1.5.2 A brief description of the nature of the application;

4.1.5.3 Notification of location(s) where a copy of the application may be inspected; and

4.1.5.4 Procedures to request a public hearing.

4.1.6 The Secretary shall hold a public hearing on an application if he receives a request from any party whose interests are substantially affected by the proposed application, as determined by the Secretary, if such request is received within 21 calendar days of the public notice. A notice shall

also be sent by mail to any person who has requested such notification from the Department and provides a name and address.

4.2 Repair, Alteration, or Removal of Existing Dams

4.2.1 Before commencing the repair, alteration, or removal of any dam to which these Regulations apply, application shall be made by the owner for written approval by the Department, except as otherwise provided by these Regulations. The installation of utility lines in a dam shall be considered an alteration to the dam and will require permitting under these regulations. The application shall state the name and address of the owner; shall adequately detail the changes it proposes to effect, as well as impacts or modifications to O&M plans and EAPs; and shall be accompanied by maps, plans, and specifications setting forth such details and dimensions as the Department requires.

4.2.2 The Department may waive the requirements of this Section for the repair or alteration of a dam if the proposed action is determined to be minor as defined by the Department by regulation. The application shall contain such other information concerning the dam and reservoir required by the Department; shall include information concerning the safety of any change that it may require; and shall state the proposed time of commencement and completion of the work.

4.2.3 When the Department determines an application has been completed, it may refer the application for agency review and report, as provided by paragraph 4.1.4 of these Regulations in the case of original construction. The application for repair, alteration, or removal of the dam shall be subject to the public notice requirements.

4.2.4 Upon receipt of a full application in proper form, the Secretary shall give notice in an advertisement in a newspaper of general circulation in the county in which the activity is proposed and in a daily newspaper of general circulation throughout the state, providing:

4.2.4.1 An announcement of the fact that the application has been received;

4.2.4.2 A brief description of the nature of the application;

4.2.4.3 Notification of location(s) where a copy of the application may be inspected; and

4.2.4.4 Procedures to request a public hearing.

4.2.5 The Secretary shall hold a public hearing on an application if he receives a request from any party whose interests are substantially affected by the proposed application, as determined by the Secretary, if such request is received within 21 calendar days of the public notice. A notice shall also be sent by mail to any person who has requested such notification from the Department and provides a name and address.

4.2.6 When repairs are necessary to safeguard life and property, they may be started immediately. The Department shall be notified as soon as practical but no longer than 24 hours after such repairs have commenced. The owner shall be required to submit as-built plans and certification from a professional engineer, licensed in Delaware, demonstrating that the repairs comply with these Regulations.

4.3 Supervision by Qualified Engineers; Reports and Modifications During Work

4.3.1 Any project for which the Department's approval is required under these Regulations shall be designed and the construction supervised by a licensed professional engineer in the State of Delaware with related experience in dam design and construction.

4.3.2 During the construction, enlargement, repair, alteration, or removal of any dam to which these Regulations apply, the Department may require such progress reports from the supervising engineer responsible for design and construction quality assurance as it deems necessary.

4.3.3 If, based on inspection reports, construction inspections, or other information, the Department finds that the work is not in compliance with the provisions of the approval and the approved plans and specifications; it shall give written notice to the person who received the approval and to the person in charge of construction of the dam. The notice shall state the particulars of the lack of compliance, and shall order immediate compliance with the terms of approval and the approved plans and specifications. The Department may order that no further construction work be undertaken until such compliance has been effected and approved by the Department. A failure to comply with the approval and the approved plans and specifications shall render the approval revocable unless compliance is made after notice, as provided in these Regulations.

4.4 Notice of Completion; Certification of Final Approval

4.4.1 Within 7 days of completion of construction, reconstruction, enlargement, repair, alteration, or removal of any dam to which these Regulations apply, notice of completion shall be given to the Department. Within 60 days thereafter, supplementary drawings or descriptive matter showing or describing the dam as actually constructed (as-built drawings) in compliance with the approval and the approved plans and specifications shall be filed with the Department in such detail as the Department may require.

4.4.2 Upon completion of the project, the supervising engineers, having inspected the work during construction and upon finding that the work has been done as required and that the dam is safe, shall file with the Department a Certificate and as-built plans demonstrating that the work has been completed in accordance with the approved design plans, specifications, and other requirements. After review of the supervising engineer's Certificate and as-built plans, unless the Department has reason to believe that the dam is unsafe or is not in compliance with any applicable rule or law, the Department shall grant final approval of the work in accordance with the Certificate, subject to such terms as it deems necessary for the protection of life and property.

4.4.3 Pending issuance of the Department's final approval, the dam shall not be filled except on written consent of the Department, subject to conditions it may impose.

4.5 Operation and Maintenance (O&M) of New or Existing Dams

4.5.1 The Department shall require that dam owners and operators develop, use, and update as necessary an operations and maintenance (O&M) Plan that provides guidance and instruction to personnel for the proper O&M of any reservoir or dam to which these Regulations apply in order to safeguard life and property.

4.5.2 The O&M Plan shall be subject to the approval of the Department and may be reviewed, modified, or amended by the Department as deemed necessary to safeguard life and property.

4.5.3 The Secretary may adopt, amend, modify, or repeal standards for the maintenance and operation of dams as may be necessary for the purposes of this Section. The Department may vary the standards applicable to the various dams giving due consideration to the type and location of the structure, the hazards to which it may be exposed, and the peril of life and property in the event of a failure or misoperation of the dam.

4.6 Monitoring and Inspection of New or Existing Dams

4.6.1 The Department shall require regular monitoring and inspection of any dam to which these Regulations apply, to safeguard life and property.

4.6.2 The Secretary may adopt, amend, modify, or repeal standards for the monitoring and inspection of dams as may be necessary for the purposes of this Section. The Department may vary the standards applicable to the various dams giving due consideration to the type and location of the structure, the hazards to which it may be exposed, and the peril of life and property in the event that a dam fails to perform its function.

4.7 Emergency Action Plans (EAPs) for New or Existing Dams

4.7.1 The owner of any new or existing dam that is regulated under these Regulations and is classified as a Class I High Hazard Potential, or Class II Significant Hazard Potential, in accordance with Section 5.0 of these Regulations, shall prepare an Emergency Action Plan (EAP) in accordance with the requirements of these Regulations.

4.7.2 The Department shall inform the Delaware Emergency Management Agency of any dam presenting a risk of peril of life and property in the event that the dam fails.

4.8 Permit to Impound

4.8.1 The owners of all existing dams regulated under these Regulations must apply for and obtain from the Department a Permit to Impound in accordance with the requirements of these Regulations.

4.8.2 Within 60 days of the satisfactory receipt of the Supervising Engineer's Certificate, as-built plans, the O&M Plan, and the EAP, from the owners of new dams or existing dams that have been modified, the Department will issue a Permit to Impound prior to the impoundment of water behind the dam.

5.0 Hazard Classification of Dams

5.1 General Requirements

5.1.1 Dams shall be classified in accordance with the federal classification system into three classes that are rated according to the potential damage that could be caused if the dams fail. Those three classes shall be designated as follows:

5.1.1.1 Class I High Hazard Potential

5.1.1.2 Class II Significant Hazard Potential

5.1.1.3 Class III Low Hazard Potential

5.1.2 Per state legislation and these Regulations, Class III Low-Hazard dams are exempt from the requirements of these Regulations.

5.1.3 The Department will use the guidelines in this section to classify dams according to hazard. Probable future development of the area downstream from the dam, which might be affected by its failure, will be considered in determining the hazard classification.

5.1.4 The Department may, at its discretion, change the hazard class of any proposed or existing dam.

5.2 Description of Hazard Class

5.2.1 Class I – High Hazard Potential: This classification includes any dam whose failure or misoperation will cause probable loss of human life. The existence of normally occupied homes in the area that are susceptible to significant damage in the event of a dam failure will be assumed to mean "probable loss of life." Recreational facilities below a dam, such as a campground or recreation area, may be sufficient reason to classify a dam as having a high-hazard potential.

5.2.2 Class II – Significant Hazard Potential: This classification includes any dam whose failure or misoperation will cause possible loss of human life, economic loss, environmental damage, and disruption of lifeline facilities, or can impact other concerns. This classification applies to predominantly rural agricultural areas, where dam failure may damage isolated homes, major highways, or railroads or cause interruption of service of relatively important public utilities.

5.2.3 Class III – Low Hazard Potential: This classification includes any dam whose failure or misoperation is unlikely to cause loss of human life but may cause minor economic and/or environmental losses. This classification applies to rural or agricultural areas where failure may damage farm buildings other than residences, agricultural lands, or non-major roads. Class III dams are exempted from the requirements of these Regulations.

5.3 Determination of the Hazard Class

5.3.1 The hazard classification shall be determined by establishing a danger reach downstream of the dam by conducting a dam breach analysis and routing the dam breach flood wave through the downstream valley. At the discretion of the Department, this analysis may require routing several spillway design floods through the danger reach, with and without the effects of failure of the dam, including at a minimum the following events:

5.3.1.1 100-year frequency flood

5.3.1.2 50 percent probable maximum flood (PMF)

5.3.1.3 Probable maximum flood (PMF)

5.3.1.4 A sunny day failure for dams with permanent pools

5.3.2 The applicant shall use computational methods for analyzing dam failure flooding that are generally acceptable in the engineering community and are verifiable, reliable, and acceptable to the Department.

5.3.3 The Department shall determine and assign the hazard classification according to the criteria above based on:

5.3.3.1 An evaluation of hydrologic calculations assuming ultimate development of the watershed using existing comprehensive plans and zoning; and

5.3.3.2 Review of potential damage within the danger reach.

5.3.4 Failure damage potential shall consider future development and use of the area flooded throughout the danger reach and the damage that would be expected from a complete breaching of the dam. If, in the opinion of the Department, future development is probable in the area flooded throughout the danger reach, the dam shall be categorized as Class I.

5.3.5 The classification of the proposed dam shall be assigned by the Department after the applicant has provided information on the potential damage within the danger reach, as defined herein. After

the classification has been assigned, the inflow design flood and spillway design may be established.

6.0 Application Procedures

6.1 Application Procedures for Existing Dams

6.1.1 Upon promulgation of these Regulations, the Department shall notify in writing the owner of each regulated dam that existed prior to June 30, 2004, that the Department has determined that they own, or have operational control over, a regulated dam and are subject to the provisions of these Regulations. The Department shall provide to each owner a copy of all information that the Department has gathered about the dam, including photographs, measurements, maps, plans, etc. The notification shall include the dam's Preliminary Hazard Classification as determined by the Department.

6.1.2 Within 90 days of receipt of the Department's notification that they own a regulated dam, each dam owner shall submit a letter to the Department acknowledging ownership or operational control of the dam and shall provide to the Department a copy of any existing information in the owner's possession concerning the dam (plans, surveys, engineering reports, etc.).

6.1.3 In the event that a dam owner wishes to dispute the Department's determination that they own or have operational control over a particular dam, that owner must submit a letter to the Department within 90 days of receipt of the Department's notification of ownership. The owner's letter to the Department shall provide documentation supporting the owner's claim of non-ownership or non-control. In cases of disputed ownership, the Department will review the documentation provided by the dam owner, and may conduct additional investigation as deemed necessary by the Department to resolve the dispute.

6.1.4 Upon receipt by the Department of the owner's acknowledgment of dam ownership, the Department will perform a condition assessment of each dam.

6.1.4.1 If the condition of the dam is determined to be satisfactory, the Department will issue to the owner a Provisional Certificate to Impound.

6.1.4.2 If the condition of the dam is determined to be unsatisfactory, the Department will notify the owner in writing of the deficiencies with the required actions by the owner with deadlines for remedying the unsafe or deficient conditions.

6.1.4.2.1 Within 30 calendar days of receiving notice of an unsatisfactory dam, the owner shall respond to the Department with their intended actions to remedy the deficiencies within the required timeframe.

6.1.4.2.2 Within 30 days of receiving the owner's intended actions, the Department shall make a determination as to whether or not a Permit to Construct, Alter, or Repair a Dam is required and issue a written directive to the owner as to the appropriate course of action.

6.1.4.2.3 If a Permit to Construct a New Dam or a Permit to Alter, Repair or Remove an Existing Dam is required, the owner shall follow the application procedures in Section 6.2 of these Regulations. If such permits are not required, the Department will issue to the owner a Provisional Certificate to Impound within 30 days of remedying the unsatisfactory conditions, as determined by the Department.

6.1.5 Upon issuance of the Provisional Certificate to Impound by the Department, the dam owner will be required to submit to the Department, the following minimum supporting documentation for each dam. The Provisional Certificate to Impound shall include a specific list of the items to be submitted for each dam, and a time frame for the submittal of each item.

6.1.5.1 Application fee in accordance with paragraph 7.2 of these Regulations

6.1.5.2 Basic information about the dam, including:

6.1.5.2.1 Dam location, including the County, nearest town, and stream on which the dam is located

6.1.5.2.2 A map showing the location of the dam

6.1.5.2.3 Dam type

6.1.5.2.4 Dam crest elevation and height, as measured from the downstream toe to the lowest point along the crest

6.1.5.2.5 Steepness of dam slopes

6.1.5.2.6 Seepage controls (if known)

6.1.5.2.7 Slope protection

6.1.5.2.8 Normal pool elevation

6.1.5.2.9 Spillway type and crest elevation

6.1.5.2.10 Spillway capacity in terms of flow

6.1.5.2.11 Storm event return frequency that the spillway is capable of passing without overtopping the dam

6.1.5.2.12 A dam break analysis and downstream danger reach map indicating structures, roads, railroads, critical infrastructure, and other man-made features that are within the danger reach

6.1.5.3 A report, prepared under the supervision of a Delaware-licensed professional engineer experienced with dams, that consists of a site inspection report, documentation of the above information, and an overall evaluation of the condition and safety of the dam and appurtenant facilities

6.1.5.4 An Operations and Maintenance (O&M) Plan

6.1.5.5 An Emergency Action Plan (EAP)

6.1.5.6 Any additional information that exists about the dam, which may include:

6.1.5.6.1 Plans, specifications, and/or engineering analyses and engineering reports

6.1.5.6.2 Inspection reports

6.1.5.6.3 Documentation of repairs and/or modifications to the dam

6.1.5.6.4 Photographs

6.1.5.6.5 Correspondence

6.1.5.6.6 Any other information that exists

6.1.6 The Department will evaluate the information provided by the applicant, make an assessment about its adequacy, and determine whether additional information is necessary to issue a Permit to Impound. The Department shall notify the applicant within 30 calendar days of receipt of the application package if any additional information is required and the nature of that additional information.

6.1.7 Within 90 calendar days of receiving all required information the Department shall issue a Permit to Impound to the dam owner.

6.2 General Application Procedures for Construction of a New Dam or the Repair, Alteration, or Removal of an Existing Dam

6.2.1 The procedures for applying for a Permit to Construct a New Dam or for a Permit to Alter, Repair, or Remove an Existing Dam, and for submitting the supporting engineering documents include the pre-application stage and the application stage, as described below.

6.2.2 The applicant for either type of dam permit referenced in 6.2.1 must use a Delaware-licensed professional engineer (Supervising Engineer) to prepare the plans and specifications and to supervise the inspection of construction, as required in Section 4.0 of these Regulations.

6.2.3 The Department may require any owner or operator of an existing dam to obtain a Permit to Alter, Repair, or Remove an Existing Dam in order to repair or alter the dam, spillway, outlet works, or other and appurtenances where:

6.2.3.1 Repair, alteration, or removal is necessary to for the protection of human health or safety; or

6.2.3.2 Alteration, repair, or removal is required to comply with the provisions of these Regulations, unless compliance is impracticable, and noncompliance poses no unacceptable threat to human health or safety, as determined by the Department.

6.2.4 Except as otherwise provided in these Regulations, any action or determination by the Department under these Regulations shall be subject to appeal to the Environmental Appeals Board in accordance with the provisions of 7 **Del.C.** § 6008.

6.2.5 Appeals of decisions by the Environmental Appeals Board shall be conducted pursuant to 7 **Del.C.** § 6009.

6.3 Pre-Application Stage for the Construction of New Dams or for the Repair, Alteration, or Removal of Existing Dams

6.3.1 The applicant must submit a written Preliminary Report that must include the following:

6.3.1.1 A general description of the dam and all appurtenances thereto, and the proposed dam classification, pursuant to the requirements of these Regulations. The description shall include the following:

6.3.1.1.1 A statement of the purpose for which the dam and appurtenances are to be used; and

6.3.1.1.2 A description of the potential effects of project construction and operation upon the environment.

6.3.1.2 Maps of the area within one-half mile of the dam and impoundment boundary, showing the following:

6.3.1.2.1 The location of the proposed dam and all appurtenances

6.3.1.2.2 The location of all structures

6.3.1.2.3 The county and nearest town

6.3.1.2.4 The boundary of the reservoir

6.3.1.2.5 The location of all streets and roads

6.3.1.2.6 The location of all major utilities, including pipe lines and transmission, telegraph, and telephone lines; all minor utilities shall be identified in the immediate vicinity of the dam impoundment area

6.3.1.2.7 The topography and scale

6.3.1.2.8 All other structures or facilities affected by the proposed dam, including the area downstream from the dam (state, county, and U.S. Geological Survey maps and aerial photographs may be used for this purpose)

6.3.1.2.9 Photographs of the site

6.3.1.3 A written report of the surficial conditions (geology, topography, land-use, existing structures and facilities, etc.), based upon a field reconnaissance by the applicant's engineer

6.3.1.4 Typical cross-sections of the dam and any dike(s) and levee(s), showing proposed elevations, pool levels, and top and bottom widths

6.3.1.5 Preliminary design data, tentative conclusions, and references. The design data shall address hydrologic features such as drainage area and rainfall data, the basis for proposed dam location, the basis for the type of structure and spillway proposed, the soils and geologic engineering criteria, and the basis for design and construction

6.3.1.6 The hydrologic design procedure and the storm durations that are used in the design

6.3.1.7 All documentation and information related to determining hazard classification

6.3.1.8 Other information required by the Department

6.3.2 At this time, the applicant shall also submit an application for a Subaqueous Lands Permit and any other State and Federal permits required.

6.3.3 The Department will review the pre-application, and within 30 days of its receipt, the Department will notify the applicant of what design criteria will apply. The Department may identify key issues for the applicant to address or may request additional information from the applicant.

6.3.4 Applicants for a permit to conduct minor repairs to an existing dam are not required to submit a preliminary report unless the Department determines it to be necessary.

6.4 Application Stage for the Construction of New Dams or for the Repair, Alteration, or Removal of Existing Dams

6.4.1 The application shall be on forms specified and supplied by the Department and must be accompanied by two copies of the final design report and five sets of all plans, drawings, designs, and specifications. Upon the written request of the applicant, the Department may waive certain requirements for documentation in the application stage set forth below for a permit to repair, alter, or remove an existing dam.

6.4.2 The application shall include a Final Design Report, which must contain the following:

6.4.2.1 A report of the field and laboratory investigation(s) of the foundation soils and/or bedrock**[, beneath the dam; and the soil, concrete and rock that will comprise the project structures;]** and a location map to identify borings and the materials that will comprise the dam and any dikes or levees. Stability, settlement, and seepage analyses are required, unless the applicant can demonstrate to the satisfaction of the Department that these analyses are not necessary.

6.4.2.2 The bases, references, calculations, and conclusions relative to hydrologic studies and design of spillway.

6.4.2.3 Structural and hydraulic design studies and calculations. Structural, hydraulic and hydrologic design procedures should be used, as established by one of the following: the U.S. Army Corps of Engineers, the **[~~U.S.~~]** Bureau of Reclamation, the **[~~U.S.~~]** Natural Resource **[~~and~~]** Conservation Service, the Federal Energy Regulatory Commission, and other procedures **[~~universally~~ broadly]** accepted as **[representing]** sound engineering practice

6.4.3 The application must include all drawings necessary to fully describe the proposal. Drawings must be prepared in accordance with the following:

6.4.3.1 All drawings must be prepared under the supervision of a Delaware-licensed professional engineer.

6.4.3.2 Drawings must clearly show the datum to which elevations shown are referred. The North American Vertical Datum of 1988 (NAVD 88) should be used wherever possible. If the N.G.V.D. datum is not used, an appropriate conversion equation must be indicated on the drawings. The Delaware State Plane Coordinate System, North American Datum of 1983 (NAD 83) shall be used as the horizontal datum reference.

6.4.3.3 The applicant must submit drawings showing the following information:

6.4.3.3.1 Existing conditions of the site including topography, property lines, easements, vegetation, existing structures and roads, etc.

6.4.3.3.2 A general plan of the dam, drawn to an appropriate scale, which must show proposed topography, the accurate position of all essential details, such as the spillway and its point of discharge into the stream; pipes through the dam, inlets, outlets, screen chambers, gate or valve houses, head-races, the canal mill or power plant, tailraces and downstream bridges that might cause backwater on the dam

6.4.3.3.3 A longitudinal section of the dam and cross-section of the valley at the site of the dam, showing the elevation of the crest of the dam; the elevation of the normal and design storm flow line of the lake or reservoir; the original surface of the ground; **[a general characterization of]** the nature and depth of the underlying strata; the probable depth of the excavation for the foundation of the dam and for the cutoff; foundation treatment; elevation of the restored surface of the ground; the location and elevation of all pipes or conduits passing through the dam; the core wall, if any; and the spillway structure

6.4.3.3.4 Typical cross sections, including a maximum section of the dam and of a spillway section that shall meet the following requirements;

6.4.3.3.4.1 Cross sections must show the original surface of the ground, **[a general characterization of]** subsurface conditions as disclosed by test pits or borings, the probable depth of excavations for the foundation and for cutoff or other seepage barriers, the elevations of the top of the dam, the crest of the spillway, and the normal flow line or water surface in the reservoir.

6.4.3.3.4.2 For earth dams, the following information shall be shown: the depth of stripping; the position, material, and dimensions of the cutoff or other seepage barriers; the width of the crest; the slopes and the nature and dimensions of the slope protection; the position and dimensions of the outlet pipes or conduits, and the seepage controls to control seepage along such structures; the disposition of different classes of embankment material if of varying composition; internal drains and filters; clay blankets; and other seepage barriers.

6.4.3.3.4.3 For concrete or other composite dams, the cross sections shall show all **[key structure]** dimensions and shall indicate the position and kinds of material to be included in the structure

6.4.3.3.5 If not clearly indicated on one or more of the drawings listed above, the following details shall be shown on additional detail sheets:

6.4.3.3.5.1 Detail of spillway or overflow, showing the length and depth of opening, together with the width and shape of the crest, grade, and shape of the approach and discharge channels, if any; methods of protecting the toe of the dam or end of the discharge channel from erosion; the dimensions of all walls, floors, and paving

6.4.3.3.5.2 Details of the intake and outlet works, showing the location and dimensions of all valves or sluice gates, intakes, screen chambers, racks, outlet towers, and gate houses and appurtenances

6.4.3.3.5.3 For **[~~reinforced~~]** concrete dams **[and reinforced concrete structures]**, detailed drawings must also be submitted, showing the size, spacing, and arrangement of all reinforcing steel **[~~and expansion~~]** joints**[, joint in-filling and other protective treatments.]**

6.4.3.3.5.4 Special drawings shall be submitted showing any special construction features not otherwise shown, such as pilings, fishways, aprons, materials used in the core wall, movable dams, tainter gates and mechanical devices, drains, and instrumentation

6.4.3.3.6 Sediment and erosion control practices

6.4.4 The application must include specifications, containing the following:

6.4.4.1 General provisions, specifying the rights, duties, and responsibilities of the owner, applicant, applicant's engineer, and the builder

6.4.4.2 The estimated project schedule and sequence of work

6.4.4.3 Technical provisions, describing carefully and in detail the approved work methods and procedures, standards for equipment and testing, materials to be used, and the results to be obtained

6.4.5 The applicant shall complete all investigations, including the following, prior to submission of the final design report that shall meet the following requirements:

6.4.5.1 The scope and the degree of precision of investigations required for a specific project shall be based on the complexities of the site, the importance of the proposed structure, and the hazard created by the proposed structure

6.4.5.2 The foundation investigation shall consist of borings, test pits, geophysical investigations, or other subsurface explorations and must be performed so as to **[~~accurately~~ reasonably]** define the soil and rock stratigraphy and the ground water conditions to the satisfaction of the Department

6.4.5.3 Laboratory testing of undisturbed and remolded soil**[, ~~specimens~~ concrete]** and**[/or]** rock samples may be required by the Department

6.4.5.4 The applicant must determine the nature and extent of materials that are proposed for use in the structure (e.g., **[earth and rock]** borrow material, concrete **[~~aggregate~~ constituents (cement, fly ash, coarse and fine aggregates, admixtures)]**, riprap stone, filter materials) and their structural properties when incorporated into the proposed structure

6.4.5.5 Stability analysis and calculations for the proposed structure to ensure safety against failure due to overturning, sliding, or overstressing must be submitted and approved by the Department

6.4.5.6 Topographic surveys must be performed with sufficient accuracy to locate the proposed construction and to define the volume of the storage in the reservoir and the flowage limits. The upstream and downstream areas must be investigated in order to delineate the area of potential damage in case of failure or flooding. Locations of baselines, centerlines, and other horizontal and vertical control points must be shown on the topographic map of the site

6.4.5.7 The drainage area must be accurately **[~~determined~~ delineated]**. Both present and projected future land use **[(based on available information))]** must be considered in determining the runoff characteristics of the drainage area. The most severe of these two conditions must be used in the design. The hydrologic assumptions and design calculations used in spillway designs shall be specified and shall include:

6.4.5.7.1 Drainage area size

6.4.5.7.2 Rainfall and runoff data

6.4.5.7.3 Reservoir inflow hydrographs

6.4.5.7.4 Reservoir area-capacity-elevation data

6.4.5.7.5 Spillway elevation-discharge data

6.4.5.7.6 Reservoir flood routings, except as otherwise provided in this subchapter

6.4.6 All applicants must submit an O&M Plan in accordance with these Regulations, and applicants for Class I and II dams shall prepare and submit an EAP that shall include at a minimum a dam breach analysis, inundation maps, and emergency notification and evacuation plans.

6.4.7 A permit for a dam does not imply approval of other permits. It is the responsibility of the applicant to obtain all other necessary local, State, and Federal permits.

6.4.8 The application to remove or breach a dam shall include the following:

6.4.8.1 Design report, and plans and computations to effect the breach, including size of breach, shape of breach, and disposal of spoil material

6.4.8.2 Plans and computations for stabilization of the lake bed, including the channel upstream of the breach, and for the control of sediment within the lake and downstream of the breach during and after the breach has been effected

6.4.8.3 Computations for design of the method and timing for dewatering the lake, unless waived by the Department

6.4.8.4 Computations detailing the effects of the breach on the downstream channel and demonstrating that the project will not adversely affect flooding conditions downstream during the 10-, 50-, and 100-year storms.

6.4.8.5 Specifications containing the technical provision that describe in detail the proposed work methods and equipment and, in addition, a work schedule for the entire project

6.4.8.6 A plan of the existing dam and lake along with surrounding property lines

6.4.8.7 A description of the potential effects of the dam removal or breach upon the environment

6.4.8.8 A description of the potential effects of the dam removal or breach upon life and property downstream of the dam

6.5 Actions by the Department Upon Applications

6.5.1 Public notice of application shall consist of an advertisement in a newspaper of general circulation in the county in which the activity is proposed and in a daily newspaper of general circulation throughout the state to include the fact that the application has been received, a brief description of the nature of the application, and the location(s) where a copy of the application may be inspected.

6.5.2 Following the receipt of requested comments, the Department shall approve, disapprove, or approve subject to conditions necessary to ensure safety, all applications pursuant to these Regulations.

6.5.3 A defective application shall not be rejected but notice of the defects shall be sent to the owner. If the owner fails to file a corrected application within 30 days of the date of the notice, the original application shall be canceled unless further time is allowed.

6.5.4 If the Department disapproves an application, one copy shall be returned with a statement of its objections. If an application is approved, the approval shall be attached thereto along with a Permit to Construct a New Dam or a Permit to Alter, Repair, or Remove an Existing Dam, as applicable, and a copy returned to the applicant. Approval shall be granted under terms, conditions, and limitations that the Department deems necessary to safeguard life and property.

6.5.5 Construction shall be commenced within 2 years after the date of approval of the application and completed within 5 years of commencement of construction, or the approval is void. The Department upon written application and demonstrated good cause may extend the time for commencing construction or for completing the construction. Notice by registered or certified mail shall be given the Department at least 10 days before construction is commenced.

7.0 Fees

7.1 General Provisions. The fees provided for in this subsection shall be required of all owners of dams that are regulated by these Regulations.

7.2 Application Fees for Existing Dams. Owners of existing dams shall submit a $500 application fee upon issuance of a Provisional Certificate to Impound by the Department.

7.3 Fees for the Construction of New Dams or for the Repair, Alteration, or Removal of Existing Dams

7.3.1 An applicant for the construction of a new dam or for the repair, alteration, or removal of an existing dam shall submit to the Department a fee of $500 at the time the Application is submitted.

7.3.2 The Department will not act on an application until the fee is submitted.

8.0 Requirements for Engineering and Design

8.1 Geotechnical Investigation

8.1.1 A geotechnical investigation shall be conducted to characterize the soil**[, concrete]** and rock conditions at the dam and spillway site and borrow areas (if appropriate) sufficient for design purposes. The investigations may consist of **[~~either~~]** intrusive **[and/]**or non-intrusive techniques that are deemed acceptable to the Department.

8.1.2 The means and methods for conducting the investigation of existing dams shall be selected so as not to jeopardize the integrity of the dam or ancillary facilities.

8.2 Spillway Requirements

8.2.1 The minimum Spillway Design Flood (SDF) used to calculate required spillway capacity shall be determined as follows:

8.2.1.1 Hazard Class I - The SDF shall be the PMF

8.2.1.2 Hazard Class II - the SDF shall be 50% of the PMF

8.2.1.3 Hazard Class III - the SDF shall be the 24-hour, 100-year frequency, Type II storm. Any later technology adopted by the U.S. Department of Agriculture, Natural Resources Conservation Service, may be substituted for the use of the Type II storm with the approval of the Department.

8.2.2 For existing dams, it is recognized that the relationships between valley slope and width, **[**~~T~~t**]**otal reservoir storage, drainage area, and other hydrologic factors have a critical bearing on determining the safe SDF. When appropriate, and upon the approval of the Department, an incremental flooding assessment may be used for the rational selection of a reduced spillway design for specific site conditions based on quantitative and relative impact analysis. The spillway should be sized so that the increased downstream damage resulting from overtopping failure of the dam would not be significant as compared with the damage caused by the flood in the absence of a dam overtopping failure. The minimum design storm for the dam shall be the 100-year storm.

8.2.3 All Class II and III dams shall, where practicable, incorporate in the proposed design the ability to make modifications necessary to increase the spillway capacity of the facility or other alternative measures if the downstream hazard potential increases.

8.2.4 All dams shall have an adequate storage for the SDF or have a spillway system that will safely pass the SDF without endangering the safety of the dam.

8.2.5 Each spillway shall include a satisfactory means of dissipating the energy of flow at its outlet without endangering the safety of the dam.

8.2.6 The capacity of the spillway system shall be equal to the peak inflow of the design flood unless the applicant demonstrates by flood routing procedures that the spillway system has the capacity to safely pass the resulting water flow.

8.2.7 Pipe conduits may be used for the primary (principal) spillway. When so used, the following requirements shall be met:

8.2.7.1 Pipe conduits shall be of such design as to safely support without leakage the total external loads in addition to the total internal hydraulic pressure. The type of construction material used shall be consistent with the anticipated life of the structure. Corrugated metal pipe shall not be used in the construction of new dams

8.2.7.1.1 For Class I and II dams, the minimum allowable inside dimension of the pipe conduit is 30 inches to allow for inspection.

8.2.7.1.2 For Class III dams, the minimum allowable inside diameter of the pipe conduit is 18 inches.

8.2.7.2 All pipe conduits shall convey water at the maximum design velocity without damage to the interior surface.

8.2.7.3 The pipe conduit must be designed so that negative pressures will not occur at any point along the primary (principal) spillway system.

8.2.7.4 Filter diaphragms or other seepage control methods approved by the Department must be installed to control seepage along the conduit.

8.2.7.5 Adequate allowances shall be incorporated in the design to compensate for differential settlement and possible elongation of the pipe conduit.

8.2.7.6 An anti-vortex device must be included in the design, unless the applicant can demonstrate that one is not necessary.

8.2.7.7 A **[self-cleaning]** trash rack, approved by the Department, shall be installed at the intake to prevent clogging of the pipe conduit.

8.2.7.8 An emergency spillway shall be provided.

8.2.7.9 Corrosion protection shall be provided for all steel pipes as necessary.

[8.2.7.10 Concrete cradles or encasements shall be provided for conduits through earth dams.]

8.2.7.**[~~10~~11]** All structural concrete and steel structures shall be designed to resist the anticipated design loads using current design methodologies acceptable to the Department.

8.2.8 Should a vegetated or unlined auxiliary spillway, approved by the Department, be installed, it must be able to pass the SDF without jeopardizing the safety of the structure and with a computed average frequency of use less than:

8.2.8.1 Once in 100 years for Class I dams,

8.2.8.2 Once in 50 years for Class II dams, or

8.2.8.3 Once in 25 years for Class III.

8.3 Outlet Works and Drawdown Requirements

8.3.1 Except for excavated impoundments, dams shall include a device to allow draining of the reservoir within a reasonable amount of time. The following factors shall be considered in determining the reasonable time period for drainage:

8.3.1.1 The risk and nature of a potential dam failure

8.3.1.2 The time likely to be available to avert a failure after notice of conditions threatening the safety or stability of the dam

8.3.1.3 The influence of rapid drawdown on the stability of the dam, its appurtenant works, and the natural upstream slopes of the reservoir

8.3.2 Unless the applicant demonstrates to the satisfaction of the Department that there is a need to locate a valve downstream from the dam and that the areas downstream of the dam will remain protected, all valves or sluice gates in pipe conduit drains must be installed upstream of the dam.

8.3.3 All pipe conduits used as drawdown drains for all dam classifications shall meet the requirements of Section 8.2.7, except that the minimum allowable inside dimension may be less than 30 inches.

8.4 Dam Requirements

8.4.1 The dam design shall designate what materials are suitable for the foundation of the dam, estimate the amount of foundation settlement, and describe the necessary foundation treatment for the structure.

8.4.2 The dam design shall designate what materials are to be used to construct the dam structure and provide the necessary design criteria for those materials. For embankment dams this includes, but is not limited to gradation, plasticity, strength, permeability, compaction and moisture criteria, lift thickness, and other properties that may be required by the Department. The source of the materials for embankment dams shall be designated. For concrete dams, the information provided shall include, but not be limited to the type of concrete, type of cement, aggregates, mix design, unconfined compressive strength, slump, and placement and curing procedures.

8.4.3 The applicant must demonstrate that the dam structure is stable under its various loading conditions, which must include at a minimum: during and after construction case, steady state case, maximum pool case, rapid drawdown case, and appropriate earthquake loading case. The engineering analysis and design shall follow current accepted engineering practices such as those of the U.S Army Corps of Engineers, the Natural Resources Conservation Service, the U.S. Bureau of Reclamation, the Federal Energy Regulatory Agency or other recognized standards and methodologies acceptable to the Department.

8.4.4 A seepage analysis shall be conducted to estimate the quantity of seepage that is anticipated to flow through, beneath, and/or around the dam. Unless it can be demonstrated that they are unnecessary, the design should include seepage reduction and/or control features to limit and/or collect and control seepage. Example techniques to reduce seepage include cut-off trenches, low-permeability cores, slurry trenches, or other proven methodologies acceptable to the Department. Example techniques for controlling and collecting seepage generally include drains, filters, and relief wells or other methodologies acceptable to the Department.

8.4.5 The design shall allow for certain freeboard as a minimum, not to be reduced under any circumstances during the operation of the dam and reservoir. The design freeboard is for that reservoir stage that will exist when the pool has reached maximum level during the spillway design flood with the outlet works and overflow spillway operating as planned. The freeboard is to be calculated to prevent overtopping and protect the dam against the destructive forces of waves, frost, settlement, and surface erosion.

8.4.6 The design shall provide for upstream slope protection against the action of waves and ice.

8.5 Other Requirements

8.5.1 Design references used shall be cited in the information submitted to the Department.

8.5.2 The Department may include, either at the time of granting a Permit to Construct a New Dam, or a Permit to Alter or Repair an Existing Dam or at a later date, a requirement that the owner provide and install devices necessary for the future inspection and surveillance of the dam. The number, type, and location of the devices shall be determined as a result of the Department's evaluation of the site and nature of the dam, the complexity of local natural conditions, and the degree of risk resulting from any future deterioration or failure. The requirement may include provisions for the measurement of the settlement of the crest or slopes of dams, the movement of walls in the valley or reservoir, the increases in pore water pressure in earth or increases in flow from drainage systems, and the installation of other devices required to detect serious changes in the structure or the affected area to allow the repair of deficiencies before more serious risk develops.

8.5.3 The applicant shall demonstrate to the Department that the riparian rights of downstream property owners will be protected during construction, during the period when the reservoir is being filled and during the life of the dam and reservoir.

8.5.4 The Department may require the design and installation of any additional or modified measures by any applicant for a dam permit where appropriate to ensure the protection of human health or safety.

8.5.5 In the case of multiple dams, when they are spaced so that the failure of an upstream dam or structure could endanger the safety of one downstream, the possibility of a multiple failure shall be considered in reviewing the design. **[~~Additional safety shall be provided in either structure by increasing the retarding storage or increasing the emergency spillway capacity, or both.~~]**

8.5.6 Utilities crossing within dam embankments are prohibited unless demonstrated to the satisfaction of the Department that such utilities will not jeopardize the safety of the dam.

9.0 Requirements for Construction

9.1 General Requirements

9.1.1 Construction shall be conducted under the **[~~oversight~~ observation]** of the Supervising Engineer as defined in these Regulations. The Supervising Engineer shall submit progress reports to the Department at least once each month during the construction period.

9.1.2 All applicants shall submit a written description of the work to be performed and schedule of the proposed construction, including:

9.1.2.1 The name and qualifications of the construction firm to perform the work, including the qualifications of their project manager and site superintendent

9.1.2.2 The estimated time to complete the construction activities

9.1.2.3 Where applicable, a description of the means by which stream flow will be diverted around or through the dam site, or otherwise kept from interfering with the work

9.1.2.4 The name of the Supervising Engineer and a description of the construction quality control and testing program including the number, names, and qualifications of on-site representatives working under the direction of the supervising engineer

9.1.2.5 Steps to be taken to minimize erosion and sediment production during construction

9.1.3 The Supervising Engineer shall submit the Construction Quality Control Plan as described below. The plan must be approved by the Department, prior to construction.

9.1.4 **[~~The diversion facility, as outlined above, must remain open and n~~N]**o water may be permanently stored in the reservoir until the applicant demonstrates to the Department that storage of water will neither interfere with construction activities nor create a hazard to life, health, or property.

9.1.5 The applicant shall promptly advise the Department of all proposed changes in the approved design, plans, or specifications. There may be no change in the approved design, plans, or specifications without prior approval of the Department. All approved changes must be recorded on the complete set of as-built plans, as required below. The Department may require the submission of revised designs at any time. Written prior approval from the Department is required for major modifications, which shall include significant changes in scale, use, design, impact, etc., of the project as initially approved. The Department may require written prior approval of any proposed modification.

9.1.6 Within 7 days of completion of construction, the Owner or Supervising Engineer shall notify the Department that construction has been completed.

9.1.7 Within 60 days of completion of construction, the Supervising Engineer shall submit the written Supervising Engineer's Certificate with accompanying project documentation as required in Section 9.3.3.

9.1.8 The Department may, in its discretion, require the owner to obtain the services of an independent review board to oversee the design and construction of any proposed or existing dam.

9.2 Construction Quality Control Plan Requirements. The Construction Quality Control Plan shall be prepared by the supervising engineer and submitted to the Department. The plan shall include the following:

9.2.1 A description of the work that is to be inspected

9.2.2 A description of the tasks to be used to adequately inspect the work to **[~~confirm~~ verify]** that it **[~~is being~~ has been]** conducted **[~~according to~~ in general accordance with]** the approved design, and the frequency or duration of site visits and inspections (such as full-time**[, ~~or half-time~~ during pre-defined critical activities, etc.]**)

9.2.3 A description of the field and laboratory testing, including the types and frequency of tests, the requirements for acceptable tests, and the procedures for **[~~dealing with~~ addressing]** test**[~~s~~ results]** that are out of compliance

9.2.4 The name(s) and qualifications of the site quality control representative(s) who will work under the direction of the Supervising Engineer

9.3 Documentation and Reporting Requirements

9.3.1 The Supervising Engineer shall submit periodic construction progress reports to the Department. Progress report forms and the frequency of reporting will be provided by the Department before construction.

9.3.2 A history of the construction shall be maintained at the construction site by the Supervising Engineer and shall include:

9.3.2.1 Date, location, and results of all materials tests made

9.3.2.2 Narrative of problems encountered during construction and changes in design. Necessity for these changes shall be reported to the **[~~Administration~~ Department]** for approval before proceeding with construction

9.3.2.3 “As built" plans

9.3.3 As required in Section 9.1.7, before filling the reservoir, the Supervising Engineer shall submit to the Department, the above information along with the Supervising Engineer’s Certificate stating that to the best of his/her knowledge, the completed structure has been constructed in **[general]** accordance with plans and specifications and changes approved by the Department. The Supervising Engineer’s Certificate shall state that the structure has been made ready for filling and that the pool area has been cleared of debris. The report shall describe the limitations on the amount of water restrained from flowing downstream and describe the methods to be followed for the surveillance of the project during the period when the structure is receiving its initial loading.

9.4 Department Inspections

9.4.1 The Department may inspect the dam during construction to ensure that it is being built in compliance with the designs, plans, and specifications submitted to the Department. Departmental inspections in no way relieve either the permittee or the Supervising Engineer from the responsibility of providing adequate inspection of the work.

9.4.2 If, at any time during the progress of the work, the Department finds that the work is not being performed in accordance with the approved designs, plans, and specifications and any approved changes, the Department will serve a written notice to that effect on the permittee or his

representative. Such notice will state the particulars with which the work has not complied. Additionally, the Department may order the immediate compliance with such designs, plans, specifications, and changes and order the suspension of all other work until compliance has been effected. If the owner or his representative fails to comply with this order, the permit under which construction is authorized may be revoked or suspended by the Department.

9.4.3 Within 60 days of receipt of the Supervising Engineer's Certificate and as-built plans (as required in Section 9.3.3), the Department will visit the site and issue its final approval with a Permit to Impound if it finds that the construction has been completed in **[general]** accordance with the approved designs, plans, specifications, and approved changes.

10.0Requirements for Operation, Maintenance and Inspections

10.1 General Requirements

10.1.1 The owners and operators of all dams regulated under these Regulations shall operate and maintain the dams according to the requirements of these Regulations.

10.1.2 Specific requirements include the following:

10.1.2.1 Develop and follow an O&M Plan, which provides guidance and instruction to project personnel for the proper operation, maintenance, surveillance, and inspection of the dam and reservoir.

10.1.2.2 Conduct routine surveillance and formal and informal inspections in accordance with the requirements of these Regulations and the O&M Plan.

10.1.2.3 Trees and other woody vegetation shall be prevented from growing on the dam unless waived by the Department.

10.1.2.4 Conduct in a timely manner and document any routine maintenance and any repair work performed at the dam and reservoir citing the date and work performed.

10.1.2.5 Prepare an EAP that complements the O&M Plan and provides detailed guidance on surveillance, including what constitutes an emergency situation and the actions to be followed in the event of an emergency.

10.1.2.6 Review and update **[if necessry]** the O&M Plan on a yearly basis and provide the updated plan to the Department by July 1 of each year.

10.2 Operation and Maintenance (O&M) Plan

10.2.1 The O&M Plan shall describe the steps to be followed by the owner to provide for the continued operation and maintenance of the dam and reservoir during the expected life of the structure. It shall consist of four parts as described in the following sections.

10.2.2 Part One of the O&M Plan shall include an introduction, project description, project authorizations, project history, and list of project **[~~contracts~~ contacts]**.

10.2.3 Part Two of the O&M Plan shall describe the steps to be followed by the owner to provide for the safe operation of the dam and reservoir and the continued minimum releases, withdrawals, etc.

10.2.4 Part Three of the O&M Plan shall describe what work is to be done at periodic intervals (or when necessary) to keep the structure in **[~~good~~ proper operating]** condition. This work could include

mowing or cutting bushy growth on embankments, preventing erosion or gullying of embankment surfaces, clearing toe drains, preventing trash and debris accumulation, protecting against **[or treating]** rust and spalling, and **[lubricating and]** exercising valves or other mechanical equipment. The description of this program shall be submitted to the Department for approval and inclusion among the required conditions of the construction period.

10.2.5 Part Four of the O&M Plan shall describe the requirements for surveillance and inspection of the dam and reservoir and shall reference the EAP in the event that severe deficiencies or signs of a potential emergency condition are encountered.

10.3 Surveillance and Inspections

10.3.1 The owner is responsible for the safety of the dam and for the necessary surveillance and inspections. The surveillance shall be performed by the owner, or a representative of the owner, and shall **[~~provide a close watch~~ focus]** on **[~~the~~]** conditions **[~~affecting~~ important to]** the dam's safety. The owner shall conduct Informal Inspections on at least a quarterly basis and promptly notify the Department of significant changes in condition. The Department has the right to require more frequent Informal Inspections by the owner, if deemed necessary.

10.3.2 The owners or operators of all Class I dams shall have a Regular Inspection performed annually **[~~under the supervision of~~ by]** a Delaware-licensed professional engineer. These inspections must be attended by a professional engineer assigned from the Department. Depending on the degree of hazard and/or condition of the dam, the Department may require the owner of a Class I dam to provide more frequent surveillance, which could be in the form of visual inspections and/or monitoring of instrumentation. The Department may also require the owner to have a Formal Inspection conducted by a Delaware-licensed professional engineer, if deemed necessary to confirm the safety of a given dam.

10.3.3 Owners or operators of Class II dams shall have a Regular Inspection performed at least once every 2 years under the supervision of a Delaware-licensed professional engineer. The Department may also require the owner to have a Formal Inspection conducted by a Delaware-licensed professional engineer, if deemed necessary to confirm the safety of a given dam.

10.3.4 All dam inspections shall be performed from March through December and in compliance with the following requirements:

10.3.4.1 A written guide provided by the Department for the preparation of a Report on Condition of the dam shall be used for all inspections.

10.3.4.2 Regular dam inspections shall be performed **[~~under the supervision of~~ by]** a Delaware-licensed professional engineer **[with experience in dam design and construction]**. The required report shall be submitted to the Department by the engineer within **[~~30~~ 90]** days of completion of the inspection. The report shall indicate the results of the inspection, documenting the condition of the dam and appurtenant facilities, and problems or deficiencies noted as well as the engineer’s conclusions and recommendations.

10.3.4.3 The Department may also require more frequent inspections during the first filling and initial stages of operation of a new dam.

10.3.4.4 Informal or routine inspections may be performed by the dam owner or operator and the Report on Condition shall be part of the owner's or operator's permanent file and, unless requested by the Department, reports shall not be submitted to the Department.

10.3.4.5 Formal Inspections shall be followed up with a report by the Delaware-licensed professional engineer with his/her opinion as to the conformance of the dam to currently accepted design standards and its overall safety with recommendations, as appropriate. The required report shall be submitted to the Department by the engineer within **[~~30~~ 90]** days of completion of the inspection.

10.3.4.6 The Department may extend the time for submission of the required material for up to 30 days, if the owner or operator justifies the need for such extension.

10.3.4.7 Failure by the permittee to inspect within the required time periods or failure to submit the Report on Condition may result in an order to drain the impoundment and/or any other remedy allowed by law.

10.3.4.8 For good cause, the Department may require the owner or operator of any dam to perform an inspection of any type at any time.

10.3.4.9 The owner or operator of all Class I and II dams shall prepare and use an EAP, as described in these Regulations.

10.4 Emergency Action Plan (EAP) and Procedures

10.4.1 The EAP for Class I and II dams shall describe the steps to be followed in the event of a potential emergency condition. This includes requirements for surveillance; definitions of a potential emergency situation; a warning plan for notifying persons whose lives, property, or health may be endangered by failure, improper operation, or other circumstances affecting the safety of the dam; and an action plan for steps to be followed at the dam to mitigate the potential emergency. The warning plan shall identify the most practical and expeditious means for notifying potentially affected persons in close proximity to the dam or property owners.

10.4.2 The EAP shall include:

10.4.2.1 Identification of designated dam inspectors, and designated alternates, to observe the dam during storms anticipated to exceed the 10-year-frequency storm event.

10.4.2.2 A requirement that the dam inspectors measure and record the pool level and observe the dam during storm events and passage of flood peaks.

10.4.2.3 Requirements for observations, including at a minimum the pool level, rate of pool level rise, debris accumulation in the spillway, excessive seepage, and signs of embankment distress.

10.4.2.4 Identification of predetermined pool elevations or signs of distress in the dam to trigger notification and evacuation phases of the plan.

10.4.2.5 Actions to be taken by the dam inspector under specific conditions, including notification of the local emergency management agency.

10.4.2.6 A description of primary and backup capabilities for communications with the local emergency management agency.

10.4.2.7 A notification flow chart showing the agencies and personnel, with telephone numbers, to be contacted to provide a warning or to initiate an evacuation, and the order in which they will be notified.

10.4.2.8 A description of the role of each agency involved in the evacuation.

10.4.2.9 Inundation maps developed from the appropriate dam break modeling discussed in Section 5.0 of these Regulations and danger reach identifying areas and structures to be evacuated, evacuation routes, and roads to be closed.

10.4.2.10 A list of the addresses of structures to be evacuated.

10.4.2.11 Identification of the appropriate local authority to issue evacuation notices and to determine when evacuees may return.

10.4.2.12 Intervention procedures to be taken by the dam owner to alleviate the hazardous condition.

10.4.2.13 Lists of local contractors and material suppliers to be used in the event of an emergency.

10.4.3 A dam owner shall submit the EAP for review and approval by the Department, the state and local emergency management agency, and other local agencies that have a role in the plan.

10.4.4 A dam owner shall review the EAP annually to verify pertinent data, including personnel, telephone numbers, and identification of structures that may have been built within the danger reach. By July 1 of each year, the owner shall submit to the Department modifications and updated information necessary to maintain the EAP, including an annual exercise of the action plan. If no changes have occurred during that year to warrant an updated EAP, the owner shall issue a written statement to the Department to that effect.

10.5 Repairs and Routine Maintenance

10.5.1 Repairs or alterations to existing dams shall be undertaken in accordance with Sections 4.0 and 6.0 of these Regulations.

10.5.2 The owner is not required to contact the Department prior to performing routine maintenance activities, as defined in these Regulations.

11.0 Enforcement Procedures

11.1 Administrative and Legal Actions

11.1.1 The Department may take any administrative or legal action necessary for the enforcement of these Regulations.

11.1.2 An action or proceeding under this subsection may be initiated whenever any owner or any person acting as an agent of any owner:

11.1.2.1 Fails to comply with the requirements imposed by these Regulations or by any application approval, Permit to Construct, Permit to Impound, order, rule, regulation, or requirement of the Department under the authority of these Regulations, or

11.1.2.2 Commits or allows the commission of violations of these Regulations or any application approval, Permit to Construct, Permit to Impound, order, rule, regulation, or requirement of the Department under these Regulations.

11.1.3 Violators of these Regulations shall be fined as follows:

11.1.3.1 Any person who violates any rule, regulation, order, or condition imposed in an approved document or other provision of these Regulations shall be fined not less than $200 or more than $2,000 for each offense. Each day that the violation continues shall constitute a separate offense. The Justice of the Peace Courts shall have jurisdiction of offenses brought under this subsection.

11.1.3.2 Any person who, after written notice to comply, intentionally or knowingly violates any rule, regulation, order, or condition imposed in an approved document or other provision of these Regulations shall be fined not less than $500 or more than $10,000 for each offense. Each day the violation continues shall constitute a separate offense. The Superior Court shall have jurisdiction over offenses brought under this subsection.

11.2 Investigations by the Department

11.2.1 The Department shall make investigations and assemble such data as it deems necessary for a proper review and study of the design and construction of any dams, reservoirs, and appurtenances to which these Regulations applies, and for such purposes the Department or its agents may enter upon private property.

11.2.2 The Department may employ or make such agreements with geologists, engineers, or other expert consultants and such assistants as it deems necessary to carry out the provisions of these Regulations.

11.3 Rights of Investigation, Entry, Access, Inspection, and Protective Action

11.3.1 The Department shall have the right to direct the conduct of such investigations as it may reasonably deem necessary to carry out its duties prescribed in these Regulations, and the Department shall have the right to conduct such investigations. For the purpose of inspections, the employees of the Department and agents of the Department have the right to enter at reasonable times on any property, public or private, for the purpose of investigating the condition, construction, or operation of any dam or associated equipment facility or property, and to require written statements or the filing of reports under oath, with respect to pertinent questions relating to the construction or operation of any dam.

11.3.2 No person shall refuse entry or access to any authorized representative of the Department who requests entry for purposes of inspection and who presents appropriate credentials; nor shall any person obstruct, hamper, or interfere with any representative while in the process of carrying out official duties.

11.3.3 Notwithstanding any other provisions of these Regulations, the Department, upon receipt of information that any dam may present an imminent and substantial hazard to the public health, safety, or welfare, may take such actions as it determines to be necessary to protect the public health, safety, or welfare. The Department may direct the owner or custodian of the dam to take such actions as are necessary to prevent, eliminate, or reduce the hazard. In the event the owner or custodian fails to take such actions, the Department shall have the right to take all appropriate or necessary action including, but not limited to, breaching or draining. The Department may initiate legal proceedings to recover the emergency costs from the dam owner.

11.4 Other Requirements. When the safety and technical considerations pertaining to an application approval, to a Permit to Impound, to a dam, to a reservoir, or to plans and specifications require it, or when requested in writing to do so by the owner, the Department may appoint an Independent Review Board of consultants to report to the Department on the safety features involved. The cost and expense of a consulting board, if appointed on the request of an owner, shall be paid by the owner.

12.0 Owner Financial Responsibility

The Department requires that the applicant post a construction bond, irrevocable letter of credit, or other security acceptable to the Department to ensure that funds are available to complete the construction of the proposed project and for continued maintenance of the project throughout the life of the structure.

12 DE Reg. 1288 (04/01/09) (Prop.)

E.9. Georgia



391-3-8-.09 Standards for the Design and Evaluation of Dams. Amended.(

(1)The design and/or evaluation of new and existing dams shall conform to accepted practices of the engineering profession and dam safety industry. Design manuals, evaluation guidelines, and procedures used by the following agencies can be considered as acceptable design or evaluation references, except as those references differ from Georgia Law and these regulations:
(a)U.S. Army Corps of Engineers;
(b)Natural Resources Conservation Service;
(c)U.S. Department of Interior, Bureau of Reclamation;
(d)Federal Energy Regulatory Commission;
(2)Other design and evaluation methods may be used to demonstrate compliance with the objectives of these rules, but are subject to the approval of the Director.
(3)Design and Evaluation of Dams under Paragraph (1) and (2) above shall, as a minimum, consider the following basic principles:
(a)All dams must be stable under all conditions of construction and/or operation of the impoundment. Details of stability evaluation shall be submitted to the Director for approval. Analyses using the methods, guidelines and procedures of the agencies listed in Paragraph (1) yielding the following Minimum Safety Factors can be considered as acceptable stability:
Earthen Embankments
1. End of Construction1.3
2. Steady State Seepage1.5
3. Steady State Seepage with Seismic Loading1.1
4. Rapid Drawdown (Upstream)1.3
5. Submerged Toe with Rapid Drawdown1.3
Concrete Structures (cohesion included)
1. Normal Reservoir 3.0
2. Normal Reservoir with Seismic Loading1.0
3. Design Flood2.0
(b)Details of the engineering evaluation of material properties in the dam or appurtenant structures shall be submitted to the Director for review and approval. Conservative selections for soil strength values shall be used for analyses or evaluations. Details of any foundation investigation and laboratory testing supporting assumed design or evaluation parameters shall be included for review.
(c)All dams and appurtenant structures shall be capable of withstanding seismic accelerations defined in the most current "Map for Peak Acceleration with a 2% exceedance in 50 years" for the contiguous United States published by the United States Geological Survey (a.k.a. NEHRP maps). The minimum seismic acceleration shall be 0.05g . The seismic accelerations may be reduced or seismic evaluation eliminated if the applicant's engineer can successfully demonstrate to the Director by engineering analyses or judgment that smaller seismic accelerations are appropriate or no seismic evaluation is needed.
(d)All dams shall have a means of draining the reservoir to a safe level as demonstrated by the applicant's engineer. The submittal by the applicant's engineer shall include the computation of the maximum time required to drain the reservoir. Exceptions to this rule

may be given by the Director based on an engineering evaluation demonstrating the lack of this capability would not endanger the public.
(e)All earthen embankments shall be protected from surface erosion by appropriate vegetation, or some other type of protective surface such as riprap or paving, and shall be maintained in a safe condition. Examples of appropriate vegetation include, but are not limited to, Bermuda, Tall Fescue, Centipede grasses and Lespedeza sericea. Inappropriate vegetation on existing dams such as trees shall be removed only after consultation with the Division or other qualified persons on the proper procedures for removal. Hedges and small shrubs may be allowed on existing dams if they do not obscure inspection or interfere with the operation and maintenance of the dam.
(f)Design Storm. Each dam shall be capable of safely passing the fraction of the flood developed from the PMP hydrograph depending on the subclassification of the dam. The design storm for each subclassification of a dam is as follows:
1. Small Dam25 percent PMP
2. Medium Dam33.3 percent PMP
3. Large Dam50 percent PMP
4. Very Large Dam100 percent PMP
Based on visual inspection and detailed hydrologic and hydraulic evaluation, including documentation of completed design and construction procedures, up to 10 percent lower requirement (22.5, 30, 45, 90) may be accepted on existing PL566 (including RC&D structures) and PL 534 Project Dams at the discretion of the Director, provided the project is in an acceptable state of maintenance. The design storm may be reduced on existing dams if the applicant's engineer can successfully demonstrate to the Director, by engineering analysis, that the dam is sufficient to protect against probable loss of human life downstream at a lesser design storm. Earth emergency spillways shall not function until the 50 year storm.
(g)Seepage Control. All dams shall be able to prevent the development of instability due to excessive seepage forces, uplift forces, or loss of materials in the embankment, abutments, spillway areas, or foundation. For new dams, seepage analysis for design, and inspection during construction shall be in sufficient detail to prevent the occurrence of critical seepage gradients.
(i)For new dams, the design shall include a seepage control method which meets the minimum acceptable safety standards, as determined by the Division. All internal drainage systems with pipe collection systems shall have cleanouts.
(ii)In existing dams, seepage shall be investigated by an engineer and appropriate control measures shall be taken as necessary.
(h)Monitoring Devices.
(i)Monitoring devices, including but not limited to piezometers, settlement plates, tell-tale stakes, seepage outlets and weirs, and permanent bench marks may be required by the Director for use in the inspection and monitoring of the safety of a dam during operation.
(ii)For new dams or existing dams where appropriate, a reservoir filling monitoring and surveillance plan to be implemented during reservoir filling or re-filling shall be submitted to the Director for approval prior to start of filling or re-filling.

(i).Design Life. The design life for proposed dams and reservoirs shall be adequate for the dams and reservoirs to perform effectively as planned, as determined by the following criteria:
(i)The time required to fill the reservoir with sediment from the contributing watershed; and
(ii)The durability of appurtenances and materials used to construct the dams.
(j)Freeboard. Appropriate freeboard for wave action shall be considered by an engineer through engineering analysis. The required freeboard shall be provided above the maximum reservoir surface elevation that would result from the inflow from the design storm for the structure. The resulting maximum reservoir surface elevation plus freeboard shall determine the elevation of the top of the dam. In lieu of determining the appropriate amount of freeboard by engineering analysis, a minimum of three (3) feet of freeboard shall be provided on earth dams.
(k)Existing concrete and/or masonry dams and appurtenant structures shall be structurally sound and shall have joints free of trees and other vegetation and shall show no signs of significant structural deterioration such as excessive cracks, spalling, efflorescence and exposed reinforcing steel.
(4). Other design standards may be imposed as deemed appropriate by the Director after review of design of new structures or through a visual inspection of an existing structure conducted pursuant to Rule 391-3-8-.08 (2)(b) of these regulations, or based on a review of the detailed engineering study prepared by an engineer.
Authority O.C.G.A. Secs. 12-5-370. **Administrative History.** Original Rule entitled "Permits for the Construction and Operation of New Dams" was filed as Emergency Rule 391-3-8-0.5-.09 on August 28, 1978, effective July 28, 1978, the date of adoption, to remain in effect for a period of 120 days or until the effective date of a permanent Rule covering the same subject matter superseding said Emergency Rule, as specified by the Agency. **Amended:** Permanent Rule of the same title adopted superseding Emergency Rule 391-3-8-0.5-.09. Filed August 31, 1978; effective September 20, 1978. **Amended:** Rule renumbered as Rule 391-3-8-.10 and Rule 391-3-8-.08 entitled "Design Standards for Existing Dams" amended and renumbered as Rule 391-3-8-.09. Filed October 29, 1985; effective November 18, 1985. **Amended:** F. Aug. 31, 1990; eff. Sept. 20, 1990. **Amended:** F. Oct. 5, 1998; eff. Oct. 25, 1998.

FEMA Workshop on Hydrologic Research Needs for Dam Safety Analysis

Hydrologic Practices in the State of Georgia and other states east of the Mississippi River

By
Francis E. Fiegle II, P. E.[1]

State of Georgia

The Georgia Safe Dams Act regulates high hazard dams that are either 25 feet tall or store more than 100 acre-feet of water at maximum pool. These regulated dams are evaluated to determine if they have adequate spillway capacity and wave action freeboard at maximum design pool to pass the design storm as defined by the Georgia Safe Dams Act (Act) and Rules for Dam Safety (Rules). The spillway capacity is prescribed in the Act based on the height of the dam and/or its maximum storage capacity.

1) Small dams - Those dams with a storage capacity not exceeding 500 acre-feet and a height not exceeding 25 feet - 25 percent PMP spillway design capacity.

2) Medium dams - Those dams with a storage capacity exceeding 500 acre-feet but not exceeding 1000 acre-feet or a height exceeding 25 feet but not exceeding 35 feet - 33 percent PMP spillway design capacity.

3) Large dams - Those dams with a storage capacity exceeding 1000 acre-feet but not exceeding 50,000 acre-feet or a height exceeding 35 feet but not exceeding 100 feet - 50 percent PMP spillway design capacity.

4) Very large dams - Those dams with a storage capacity exceeding 50,000 acre-feet or a height exceeding 100 feet - 100 percent PMP spillway design capacity.

Typically, the Georgia Safe Dams Program develops Visual Inspection Reports which are a streamed lined version of the old USACOE Phase I reports that were done in the late 1970's and early 1980's for state dam safety programs across the United States. In that report, our Program evaluates the spillway capacity of existing dams with respect to compliance with the Act and Rules. Except in rare instances, the hydrology evaluation uses the NRCS/SCS Curve Number, Lag Time methodology. Of note, because the spillway capacity requirements are set forth in the Act, and the design storm is restricted to the 6-hour PMP, the Program requires the use of Antecedent Moisture Condition III for the evaluation of spillway capacity. This dramatically affects the Curve Numbers used. We use HMR 51/52 to develop the design storm. The spillway rating curves are done using standard hydraulic practice accounting for weir, orifice, and full pipe flow for principal spillway pipes/open channel flow in earth emergency spillways, etc. This

[1] Program Manager - Georgia Safe Dams Program

information is imputed into the HECI model with a Type II distribution to evaluate the hydraulic adequacy of the dam.

On very large drainage basins, a unit hydrograph is developed based on existing stream data on the particular stream or one in the area with similar watershed characteristics.

For more detailed information, please see the attached section on Hydrology and Hydraulics, pages 28 to 33 of the Georgia Safe Dams Program's Engineering Guidelines. The Guidelines were developed in conjunction with consulting engineers who are involved with the design of dams in Georgia.

Other states east of the Mississippi River

Because there is a need for the state dam safety regulators to provide significant input on practices, research needs and development needs in the field of hydrology and hydraulics modeling, I polled 26 states east of the Mississippi River including: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, Kentucky, West Virginia, Tennessee, Virginia, North Carolina, South Carolina, Florida, Maryland, New Jersey, Mississippi, Louisiana, Arkansas, and Puerto Rico. Delaware and Alabama were not polled because they had no dam safety laws or programs. I received 19 state responses.

The following questions were asked in the survey and where appropriate, the number of responses are tallied. In some cases, a state regulatory agency may use/accept more than one methodology.

1. **What Hydrologic Model(s) are used/accepted by your state? Do you accept more than one methodology?**

    a. NRCS/SCS Curve Number/Lag Equations - 16
    b. HECI - 17
    c. HECHMS - 10
    d. USGS/State Regression Equations - 9
    e. Unit Hydrographs - 6
    f. Synder Unit Hydrograph - 5
    g. SITES - 6
    h. TR20- 5
    i. TR55 - 3
    j. HydroCAD 5.11 - 3
    k. Others - 1

2. **What are the difficulties/problems you encounter with these models**?

a. HEC1
    - DOS based program - glitches sometimes when loaded on a Windows Operating System.
    - PM card record is outdated for PMF determination in conjunction with the use of HMR51/52.
    - Time distribution of rainfall losses.
    - Unit hydrograph for eastern shore needs to be modified.
b. Lack of site specific data (mentioned 5 times.)
c. HECHMS
    - Does not have the ability to run multiple storm events
    - Bizarre results sometimes.
d. Engineers who do not know how to use the model appropriately. Identified as an issue by six states.
e. Hydro CAD 5.11/SCS unit hydrograph is limited a 24 hour duration storm, surcharge flows are not allowed.

Of note, two states reported no difficulties.

3. **Are extended flow periods (days) vs. single events an issue? Is it dependant on the size of the drainage basin or the location of the dam?**

Yes - One
No - Ten
Maybe - (extremely large drainage basin) - Seven

4. **Please rank the following issues in priority:**

a. low cost/rapid assessment of inflow flood (47 points)
b. extensive detailed investigative assessment of the inflow flood (54 points)
c. risk assessment vs. PMF (34 points)
d. determinate inflow design flood (55 points)
e. all equally important (20 points)

*To evaluate the responses, I assigned a point value of 5 to 1 for the priority ranking with 5 being the highest priority and 1 being the lowest priority.

5. **Any suggestions for short and long terms hydrologic needs and development?**

Short term hydrologic needs

A. HECHMS needs the following:

- level pool routing/results & summaries

- overtopping subroutine
- breaching subroutine
- multiplan feature
- printout of inputs
- other routing subroutines (Muskingum-Cunge)
- link HECRAS to HECHMS
- add Arcview
- develop multiple stage outlet modeling

B. Comparison of USGS Regression inflow curves vs. other methodology. Publish results for different parts of the country.

C. Cooperation between NWS and HEC and other Federal agencies.

Long-term hydrology needs

A. Update NRCS/SCS Curve Number methodology.
B. What is the appropriate time period of the design storm event? PMP is variable across the country and changes within a region.
C. Define what ancedent moisture condition is appropriate for what type of design storm.
D. Couple NEXRAD or IFLOWS for river basins for real time hydrologic forecasting (Virginia).
E. Further development of the Green-Ampt loss rate function nationwide.
F. Additional continuous stream gaging streams.

Conclusions and Recommendations:

The majority of the dams in the United States are regulated by the states. Hydrologic research should focus on creating models for design storms that will produce reasonably accurate results that do not involve extensive data gathering and interactive modeling. The results should be reproducible from universally accepted data sources.

I believe the short terms needs include the following:

- Complete HECHMS model development. Make it compatible with other software and link it to HECRAS, ARCVIEW, and NWS DAMBREAK.
- Improve cooperation between Federal Agencies to develop hydrologic data and software models that states can use.
- Do detailed comparison of various hydrologic methodologies that produce inflow floods including sensitivity evaluations. Make the comparison meaningful by region/sub region. Publish results.

Long term hydrologic needs include further development of certain hydrologic models/modeling methods.

- Update NRCS/SCS Curve Numbers and lag time routines.
- Better regionalization of PMP rainfall events.
- Define and update Antecedent Moisture Conditions.
- Further development of the Green-Ampt loss rate function nationwide. If this was as usable as the NRCS/SCS Curve Number/soils mapping methodology, modeling long terms storm event would be doable with reasonable results.

While I believe that accuracy in hydrologic modeling is important, so is a certain measure of conservatism to account for the undefined and unknown variables that exist in every drainage basin when dealing with public safety.

E.10. Hawaii



NOTICE TO PUBLIC

Addendum No. 1 to Proposed Hawaii Administrative Rules, Title 13, Subtitle 7, Chapter 190.1 as Required by the "Hawaii Dam and Reservoir Safety Act of 2007", Chapter 179D HRS - Dams and Reservoirs

The Department of Land and Natural Resources has posted the following Addendum No 1 to the Proposed Hawaii Administrative Rules, Title 13, Subtitle 7, Chapter 190.1 due to typographical errors in the dam size classification table of Section §13-190.1-4.1 "Additional design requirements". These corrections were made to this table under the impoundment size column, which is consistent with the similar table in the existing Dam Safety Inspection Guidelines.

Should there be any questions on this Addendum or any portion of the rules, please contact anyone of our dam safety staff:

Edwin Matsuda	Ph. (808) 587-0268
Denise Manuel	Ph. (808) 587-0246
Jimmy Leung	Ph. (808) 587-0238
John Dawley	Ph. (808) 587-0272

Internet posting: September 13, 2010

§13-190.1-4.1 Additional design requirements.

(a) Significant and high hazard dams shall also have a stability analysis of the structure demonstrating the stability of the embankment slopes for various loading conditions and minimum factors of safety generated by a methodology accepted by the department.

(b) Regulated dam spillways shall safely pass the appropriate inflow design flood:

Hazard Classification	**Size Classification**	**Inflow design flood**
Low	Small	100 year
	Intermediate	100 year
	Large	½ PMF
Significant	Small	½ PMF
	Intermediate	½ PMF
	Large	PMF
High	All Sizes	PMF

Category	**Impoundment**	
	Storage (Acre-feet)	**Height (feet)**
Small	<1000 and ≥50	<40 and ≥25
Intermediate	≥1,000 and <50,000	≥40 and <100
Large	≥50,000	≥100

Note: PMF or Probable Maximum Flood, is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is derived from the 24 hour probable maximum precipitation (PMP), which information is available from the National Weather Service, NOAA, Publication HMR-39, "Hydrometeorological Report No. 39 - Probable Maximum Precipitation in the Hawaiian Islands", or current standard. ½ PMF = PMF divided by two. 100 year is defined as the flood associated with the 1 percent probability storm event that is derived from

the 24 hour 100 year precipitation rate, which is identified in the US Weather Bureau Technical Paper No. 43 Rainfall-Frequency Atlas of the Hawaiian Islands and as updated by NOAA Atlas 14, Volume 4 Precipitation-Frequency Atlas of the United States, Hawaiian Islands, or current standard.

(c) Freeboard shall be the greater of the following:

(1) Two feet above the water level during the peak spillway flow associated with the inflow design flood;

(2) Sum of the wave run-up and reservoir setup resulting from a 100 mph wind speed during the peak spillway flow associated with the inflow design flood. (Eff.) (Auth: HRS §179D-6) (Imp: HRS §179D-8)

E.11. Idaho



Table of Contents

37.03.06 - Safety of Dams Rules

000. Legal Authority (Rule 0). 2
001. Title And Scope (Rule 1). 2
002. Written Interpretation (Rule 2). 2
003. Administrative Appeals (Rule 3). 2
004. -- 009. (Reserved). 2
010. Definitions (Rule 10). 2
011. -- 024. (Reserved). 4
025. Dam Size Classification And Risk Category (Rule 25). 4
026. -- 029. (Reserved). 5
030. Authority Of Representative (Rule 30). 5
031. -- 034. (Reserved). 5
035. Forms (Rule 35). 5
036. -- 039. (Reserved). 5
040. Construction Plans, Drawings And Specifications (Rule 40). 6
041. -- 044. (Reserved). 8
045. Operation Plan (Rule 45). 8
046. -- 049. (Reserved). 9
050. New Intermediate Or Large Dams (Rule 50). 9
051. -- 054. (Reserved). 14
055. Existing Intermediate Or Large Dams (Rule 55). 14
056. -- 061. (Reserved). 16
060. Small Dam Design Criteria (Rule 60). 16
061. -- 064. (Reserved). 16
065. Dams Storing Tailings And Water (Rule 65). 16
066. -- 999. (Reserved). 16

IDAPA 37
TITLE 03
CHAPTER 06

37.03.06 - SAFETY OF DAMS RULES

000. LEGAL AUTHORITY (RULE 0).
These rules are adopted pursuant to Chapter 17, Section 42-1714, Idaho Code, and implement the provisions of Sections 42-1709 through 42-1721, Idaho Code. (7-1-93)

001. TITLE AND SCOPE (RULE 1).

01. Title. (7-1-93)

02. Scope. (7-1-93)

a. The requirements that follow are intended as a guide to establish acceptable standards for construction and to provide guidelines for safety evaluation of new or existing dams. The rules apply to all new dams, to existing dams to be enlarged, altered or repaired, and maintenance of certain existing dams, as specifically provided in the rules. The Director will evaluate any deviation from the standards hereinafter stated as they pertain to the safety of any given dam. The standards are not intended to restrict the application of other sound engineering design principles. Engineers are encouraged to submit new ideas which will advance the state of the art and provide for the public safety. (7-1-93)

b. Under no circumstances shall these rules be construed to deprive or limit the Director of the Department of Water Resources of any exercise of powers, duties and jurisdiction conferred by law, nor to limit or restrict the amount or character of data, or information which may be required by the Director from any owner of a dam for the proper administration of the law. State sovereignty as expressed in Policy 1A of the adopted State Water Plan for independent review and approval of dam construction, operation and maintenance will not be waived due to any overlapping jurisdiction from federal agencies. (7-1-93)

002. WRITTEN INTERPRETATION (RULE 2).

003. ADMINISTRATIVE APPEALS (RULE 3).
Any owner who is aggrieved by a determination or order of the Director may request a hearing pursuant to the provisions of Section 42-1701A(3), Idaho Code, and the Department's adopted Rules of Procedure. (7-1-93)

004. -- 009. (RESERVED).

010. DEFINITIONS (RULE 10).
Unless the context otherwise requires, the following definitions govern these rules. (7-1-93)

01. Active Storage. The water volume in the reservoir stored for irrigation, water supply, power generation, flood control, or other purposes but does not include flood surcharge. Active storage is the total reservoir capacity in acre-feet, less the inactive and dead storage. (7-1-93)

02. Alterations, Repairs or Either of Them. Only such alterations or repairs as may directly affect the safety of the dam or reservoir, as determined by the Director. Alterations, repairs does not include routine maintenance items. (See Rule Subsections 055.02.a. and 055.02.b.) (7-1-93)

03. Appurtenant Structures. Ancillary features (e.g. outlets, tunnels, gates, valves, spillways, auxiliary barriers) used for operation of a dam, which are owned by the dam owner or the owner has responsible control. (7-1-93)

04. Board. The Idaho Water Resource Board. (7-1-93)

05. Certificate of Approval. A certificate issued by the Director for all dams listing restrictions imposed by the Director, and without which no new dams shall be allowed by the owner to impound water. A

certificate of approval is also required for existing dams before impoundment of water is authorized. (7-1-93)

06. Dam. Any artificial barrier together with appurtenant works, which is or will be ten (10) feet or more in height or has or will have an impounding capacity at maximum storage elevation of fifty (50) acre-feet or more. Height of a dam is defined as the vertical distance from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the Director, or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum water storage elevation. (7-1-93)

07. Small Dams. Artificial barriers twenty (20) feet or less in height that are capable of storing less than one hundred (100) acre-feet of water. (7-1-93)

08. Intermediate Dams. Artificial barriers more than twenty (20) feet, but less than forty (40) feet in height, or are capable of storing one hundred (100) acre-feet or more, but less than four thousand (4,000) acre-feet of water. (7-1-93)

09. Large Dams. Artificial barriers forty (40) feet or more in height or are capable of storing four thousand (4,000) acre-feet or more of water. (7-1-93)

10. Department Jurisdiction. The following are not subject to department jurisdiction: (7-1-93)

a. Artificial barriers constructed in low risk areas as determined by the Director, which are six (6) feet or less in height, regardless of storage capacity. (7-1-93)

b. Artificial barriers constructed in low risk areas as determined by the Director, which impound ten (10) acre-feet or less at maximum water storage elevation, regardless of height. (7-1-93)

c. Artificial barriers in a canal used to raise or lower water therein or divert water therefrom. (7-1-93)

d. Fills or structures determined by the Director to be designed primarily for highway or railroad traffic. (7-1-93)

e. Fills, retaining dikes or structures, which are under jurisdiction of the Department of Environmental Quality, designed primarily for retention and treatment of municipal, livestock, or domestic wastes, or sediment and wastes from produce washing or food processing plants. (7-1-93)

f. Levees, that store water regardless of storage capacity. Levee means a retaining structure alongside a natural lake which has a length that is two hundred (200) times or more greater than its greatest height measured from the lowest elevation of the toe to the maximum crest elevation of the retaining structure. (7-1-93)

11. Days Used in Establishing Deadlines. Calendar days including Sundays and holidays. (7-1-93)

12. Dead Storage. The water volume in the bottom of the reservoir stored below the lowest outlet and generally is not withdrawn from storage. (7-1-93)

13. Department. The Idaho Department of Water Resources. (7-1-93)

14. Design Evaluation. The engineering analysis required to evaluate the performance of a dam relative to earthquakes, floods or other site specific conditions that are anticipated to affect the safety of a dam or operation of appurtenant facilities. (7-1-93)

15. Director. The Director of the Idaho Department of Water Resources. (7-1-93)

16. Engineer. A registered professional engineer, licensed as such by the state of Idaho. (7-1-93)

17. Enlargement. Any change in or addition to an existing dam or reservoir, which raises or may raise the water storage elevation of the water impounded by the dam. (7-1-93)

18. **Factor of Safety**. A ratio of available shear strength to shear stress, required for stability. (7-1-93)

19. **Flood Surcharge**. A variable volume of water temporarily detained in the upper part of a reservoir, in the space (or part thereof) that is filled by excess runoff or flood water, above the maximum storage elevation. Flood surcharge cannot be retained either because of physical or administrative factors but is passed through the reservoir and discharged by the spillway(s) until the reservoir level has been drawn down to the maximum storage elevation. (7-1-93)

20. **Inflow Design Flood (IDF)**. The flood specified for designing the dam and appurtenant facilities. (7-1-93)

21. **Maximum Credible Earthquake**. The largest earthquake that reasonably appears capable of occurring under the conditions of the presently known geological environment. (7-1-93)

22. **Operation Plan**. A specific plan that will assure the project is safely managed for its intended purpose and which provides reservoir operating rule curves or specific limits and procedures for controlling inflow, storage, and/or release of water, diverted into, passed through or impounded by a dam. (7-1-93)

23. **Owner**. Includes any of the following who own, control, operate, maintain, manage, hold the right to store and use water from the reservoir or propose to construct a dam or reservoir. (7-1-93)

a. The state of Idaho and any of its departments, agencies, institutions and political subdivisions; (7-1-93)

b. The United States of America and any of its departments, bureaus, agencies and institutions; provided that the United States of America shall not be required to pay any of the fees required by Section 42-1713, Idaho Code, and shall submit plans, drawings and specifications as required by Section 42-1712, Idaho Code, for information purposes only; (7-1-93)

c. Every municipal or quasi-municipal corporation. (7-1-93)

d. Every public utility; (7-1-93)

e. Every person, firm, association, organization, partnership, business trust, corporation or company; (7-1-93)

f. The duly authorized agents, lessees, or trustees of any of the foregoing; (7-1-93)

g. Receivers or trustees appointed by any court for any of the foregoing. (7-1-93)

24. **Reservoir**. Any basin which contains or will contain the water impounded by a dam. (7-1-93)

25. **Storage Capacity**. The total storage in acre-feet at the maximum storage elevation. (7-1-93)

26. **Water Storage Elevation**. The maximum elevation of the water surface which can be obtained by the dam or reservoir. It is further defined as the storage level attained when the reservoir is filled to capacity (i.e. to the spillway crest) or an authorized storage level attained by installing flashboards to increase the reservoir capacity, or a specified upper storage limit, which is attained by operation of moveable gates that raises the reservoir to a controlled operating level. The maximum storage elevation is an equivalent term of water storage elevation. (7-1-93)

27. **Release Capability**. The ability of a dam to pass excess water through the spillway(s) and outlet works and otherwise discharge. (7-1-93)

011. -- 024. (RESERVED).

025. DAM SIZE CLASSIFICATION AND RISK CATEGORY (RULE 25).

01. Size Classification. The following table defines the height and storage capacity limits used by the Department to classify dams:

Size Classification	Height (ft)		Storage Capacity
Small	20 ft. or less	and	Less than 100 acre-ft.
Intermediate	More than 20 ft. but less than 40 ft.	or	100 Acre-ft or more, but less than 4000 acre ft
Large	40 ft. or more	or	4000 acre-ft., or more

(7-1-93)

02. Risk Category. The following table describes categories of risk used by the Department to classify losses and damages anticipated in down-stream areas, that could be attributable to failure of a dam during typical flow conditions.

Risk Category	Dwellings	Economic Losses
Low	No permanent structures for human habitation.	Minor damage to land, crops, agricultural, commercial or industrial facilities, transportation, utilities or other public facilities or values.
Significant	No concentrated urban development, 1 or more permanent structures for human habitation which are potentially inundated with flood water at a depth of 2 ft. or less or at a velocity of 2 ft. per second or less.	Significant damage to land, crops, agricultural, commercial or industrial facilities, loss of use and/or damage to transportation, utilities or other public facilities or values.
High	Urban development, or any permanent structure for human habitation which are potentially inundated with flood water at a depth of more than 2 ft. or at a velocity of more than 2 ft. per second.	Major damage to land, crops, agricultural, commercial or industrial facilities, loss of use and/or damage to transportation, utilities or other public facilities or values.

(7-1-93)

03. Determination of Size and Risk Category. The Director shall determine the size and risk category of a new or existing dam. (7-1-93)

026. -- 029. (RESERVED).

030. AUTHORITY OF REPRESENTATIVE (RULE 30).
When plans, drawings and specifications are filed by another person on behalf of an owner, written evidence of authority to represent the owner shall be filed with the plans, drawings and specifications. (7-1-93)

031. -- 034. (RESERVED).

035. FORMS (RULE 35).
Forms required by these rules are available from the Department to interested parties upon request. Construction of a small dam requires the filing of Form 1710 and construction of an intermediate or large dam requires the filing of Form 1712. (7-1-93)

036. -- 039. (RESERVED).

040. CONSTRUCTION PLANS, DRAWINGS AND SPECIFICATIONS (RULE 40).
The following provisions shall apply in submitting plans, drawings and specifications. (7-1-93)

01. Submission of Duplicate Plans, Drawings and Specifications. Any owner who shall desire to construct, enlarge, alter or repair any intermediate or large dam, shall submit duplicate plans, drawings and specifications prepared by an engineer for the proposed work to the Director with required fees. The Director may, however, require the submittal of plans, drawings and specifications prior to the construction of any dam. (7-1-93)

02. Applying for and Obtaining Written Approval. Construction of a new dam or enlargement, alteration or repairs on existing dams shall not be commenced until the owner has applied for and obtained written approval of the plans, drawings and specifications. Alteration or repairs do not include routine maintenance for which prior approval is not required. (See Rule Subsections 055.02.a and 055.02.b) (7-1-93)

03. Plans Shall Be Prepared on a Good Quality Vellum or Mylar. Transparent copies reproducible by standard duplicating processes, if accurate, legible and permanent, will be accepted. Plans may initially be submitted in the form of nonreproducible paper prints. After reviewing the plans, the Director will notify the owner of any required changes. (7-1-93)

04. Preparation and Submission of Plans. Plans and drawings shall be of a sufficient scale with an adequate number of views showing proper dimensions, so that the plans and drawings may be readily interpreted and so that the structure and appurtenances can be built in conformance with the plans and drawings. (7-1-93)

05. Information Included with Plans. Plans for new dams shall include the following information and plans for enlargement, alteration or repair of an existing dam shall include as much of the following information as required by the Director to adequately describe the enlargement, alteration or repair and the affect on the existing dam or its appurtenant facilities: (7-1-93)

a. A topographic map of the dam site showing the location of the proposed dam by section, township and range, and location of spillway, outlet works, and all borings, test pits, borrow pits; (7-1-93)

b. A profile along the dam axis showing the locations, elevations, and depths of borings or test pits, including logs of bore holes and/or test pits; (7-1-93)

c. A maximum cross-section of the dam showing elevation and width of crest, slopes of upstream and downstream faces, thickness of riprap, zoning of earth embankment, location of cutoff and bonding trenches, elevations, size and type of outlet conduit, valves, operating mechanism and dimensions of all other essential structural elements such as cutoff walls, filters, embankment zones, etc.; (7-1-93)

d. Detailed drawings showing plans, cross and longitudinal sections of the outlet conduits, valves and controls for operating the same, and trash racks; (7-1-93)

e. A curve or table showing the capacity of the reservoir in acre-feet vs gauge height (referenced to a common project datum) of the reservoir storage level, and the computations used in making such determinations. (7-1-93)

f. A curve or table showing the outlet discharge capacity in cubic feet per second vs gauge height of reservoir storage level, and the equation used in making such determination; (7-1-93)

g. A curve showing the spillway discharge capacity in cubic feet per second vs gauge height of the reservoir or flood surcharge level above the spillway crest and the equation used in making such determinations; (7-1-93)

h. Detailed drawings of spillway structure(s), cross-sections of the channel heading to and from the spillway and a spillway profile; (7-1-93)

i. Plans for flow measuring devices capable of providing an accurate determination of the flow of the stream above and below the reservoir, and a permanent reservoir or staff gauge near the outlet of the reservoir plainly

marked in feet and tenths of a foot referenced to a common project datum; (7-1-93)

j. Plans or drawings of instruments, recommended by the owner's engineer to monitor performance of intermediate or large dams to assure safe operation, or as may be required by the Director to monitor any dam regardless of size, that is situated upstream of a high risk area. (7-1-93)

06. Specifications. Specifications shall include provisions acceptable to the Director for adequate observation, inspection and control of the work by a registered professional engineer, during the period of construction. (7-1-93)

07. Changes to Specifications. The specifications shall not be materially changed without prior written consent of the Director. Significant design changes, while construction is underway, shall be submitted for the Director's review and approval. (7-1-93)

08. Inspections. The owner shall provide for and allow inspections by the Department to assure the dam and appurtenant structures are constructed in conformance with the approved plans and specifications, or as may be revised by the engineer and approved by the Director if there are unforeseen conditions discovered during site excavation or construction of the dam which potentially jeopardize the future integrity and safety of the dam. Certain stages of construction shall not proceed without inspection and approval by the Director, including the following: (7-1-93)

a. After clearing and excavation of the foundation area and cutoff trench and prior to placing any fill material. (7-1-93)

b. After installation of the outlet conduit and collars and before placing any backfill material around the conduit; (7-1-93)

c. After construction is completed and before any water is stored in the reservoir. (7-1-93)

d. At such other times as determined necessary by the Director. The Director will, upon seven (7) days notice, inspect and if satisfactory, approve the completed stage of construction. The Director may conduct inspections upon shorter notice upon good reason being shown or upon a schedule jointly agreed upon by the Director and the owner. (7-1-93)

09. Inspection, Examination and Testing of Materials. All materials and workmanship shall be subject to inspection, examination and testing by the Director at any and all times. (7-1-93)

10. Rejection of Defective Material. The Director shall have the right to require the owner or engineer to reject defective material and workmanship or require its removal or correction respectively. Rejected workmanship shall be corrected and rejected material shall be replaced with proper material. (7-1-93)

11. Suspension of Work. The Director may order the engineer to suspend any work that may be subject to damage by inclement weather conditions. (7-1-93)

12. Responsibility of Engineer. These provisions shall not relieve the engineer of his responsibility to assure that construction is accomplished in accordance with the approved plans and specifications or to suspend work on his own motion. (7-1-93)

13. Detailing Provisions of Specifications. The specifications shall state in sufficient detail, all provisions necessary to insure that construction is accomplished in an acceptable manner and provide needed control of construction to insure that a safe structure is constructed. (7-1-93)

14. Design Report. Owners proposing to construct, enlarge, alter or repair an intermediate or large dam shall submit an engineering or design evaluation report with the plans and specifications. The engineering report shall include as much of the following information as necessary to present the technical basis for the design and to describe the analyses used to evaluate performance of the structure and appurtenances. (7-1-93)

a. All technical reference(s); equations and assumptions used in the design; (7-1-93)

b. Hydrologic data used in determining runoff from the drainage areas; reservoir flood routing(s); and hydraulic evaluations of the outlet(s) and the spillway(s). (7-1-93)

c. Engineering properties of the foundation area and of each type of material to be used in the embankment. (7-1-93)

d. A stability analysis, including an evaluation of overturning, sliding, slope and foundation stability and a seepage analysis; (7-1-93)

i. Seismic design loads shall be evaluated and applied at all large dams to be located in significant or high risk areas, in Seismic Zone 3, which for purposes of these rules is the area in Idaho east of Range 22 East, Boise Meridian. The evaluation required of large dams, that are classified significant or high risk, shall use the maximum ground motion/ acceleration generated by the maximum credible earthquake, which could affect the dam site. (7-1-93)

ii. Seismic analysis may be required as determined by the Director for large dams located above high risk areas in Seismic Zone 2, which for purposes of these rules is the area in Idaho west of Range 22 East, Boise Meridian. (7-1-93)

15. Additional Information/Waiver. The Director may require the filing of such additional information which in his opinion is necessary or waive any requirement herein cited if in his opinion it is unnecessary. (7-1-93)

16. Alternate Plans. The Director may accept plans and specifications or portions thereof prepared for other agencies which are determined to meet the requirements of Rule 40. (7-1-93)

041. -- 044. (RESERVED).

045. OPERATION PLAN (RULE 45).
An operation plan is required as described in the following rules and shall provide procedures for emergency operations and include guidelines and procedures for inspection, operation and maintenance of the dam and appurtenances, including any instruments required to monitor performance of the dam during normal operating cycles, critical filling or flood periods, or as may be required to monitor new or existing dams subject to earthquake effects. (7-1-93)

01. New, Reconstructed or Enlarged Dams. Prior to the initial filling of the reservoir or refilling the reservoir for a reconstructed or enlarged dam in the following categories, the owner shall file with the Director an operation plan for review and approval: (7-1-93)

a. Small, high risk. (7-1-93)

b. Intermediate, significant risk. (7-1-93)

c. Intermediate, high risk. (7-1-93)

d. Large, any risk category. (7-1-93)

02. Existing Dams. Unless exempted by the Director, owners of the following categories of dams shall file an operation plan with the Director on or before July 1, 1992 for review and approval: (7-1-93)

a. Intermediate, high risk. (7-1-93)

b. Large, significant risk. (7-1-93)

c. Large, high risk. (7-1-93)

03. Alternate Plans. The Director may accept existing studies or plans in lieu of an operation plan if the Director determines the information provided fulfills the requirements of Rule 45. (7-1-93)

046. -- 049. (RESERVED).

050. NEW INTERMEDIATE OR LARGE DAMS (RULE 50).
The following minimum criteria shall be used to evaluate the design of intermediate or large earthfill dams in Idaho. These standards are intended to serve as guidelines for a broad range of circumstances, and engineers should not consider them as a restriction to the use of other sound engineering design principles. Exclusion from this established criteria will be considered by the Director on a case-by-case basis in approving plans and specifications and evaluating dams. Dams constructed of other materials shall comply with these criteria as found appropriate by the Director and with other engineering criteria approved by the Director. (7-1-93)

01. Embankment Stability. Slope stability analyses shall determine the appropriate upstream and downstream slopes. Unless slope stability analysis determines otherwise, the embankment slopes shall be:

Upstream slope	3:1 or flatter
Downstream slope	2:1 or flatter

(7-1-93)

a. For large high and significant hazard dams and intermediate high hazard dams the embankment shall be designed, constructed and maintained to assure stability under static loads and prevent instability due to seepage or uplift forces, or drawdown conditions. Transmission of seepage through the embankment, abutments and foundation shall be controlled to prevent internal removal of material and instability where seepage erodes or emerges. (7-1-93)

b. The design analysis shall consider the need for installing filters, filter fabric and/or toe drains to stabilize the fill and protect against piping of the embankment fill material. (7-1-93)

c. The minimum factor of safety for a dam under steady state condition shall be 1.5. During rapid drawdown of the reservoir, the minimum factor of safety for the embankment shall be 1.2. For dams constructed in Seismic Zone 3, the minimum factor of safety under seismic load shall be 1.0. (7-1-93)

d. The stability of an embankment subjected to earthquake ground motions can be analyzed by dynamic response or pseudo-static analyses. Pseudo-static analyses are acceptable for embankment dams constructed of soils that will not build-up excess pore pressures due to shaking, nor sustain more than fifteen percent (15%) strength loss during earthquake events, otherwise the stability of an embankment dam shall be analyzed by a dynamic response method. A pseudo-static analysis simplifies the structural analysis (i.e. the resultant force of the seismic occurrence is represented by a static horizontal force applied to the critical section to derive the factor of safety against sliding along an assumed shear surface). The value of the horizontal force used in the pseudo-static analysis, is the product of the seismic coefficient and the weight of the assumed sliding mass. (7-1-93)

e. Slope deformation analyses are required for dams located in Seismic Zone 3, that are constructed of cohesionless soils and/or on foundations which are subject to liquefaction, when the peak acceleration at the site is anticipated to exceed 0.15g. (7-1-93)

f. The design analyses for new dams located in high risk areas (in Seismic Zone 2 or 3) shall include geologic and seismic reports, location of faults and history of seismicity. (7-1-93)

g. Where in the opinion of the Director, embankment design or conditions warrant, instrumentation of the embankment and/or foundation will be required. (7-1-93)

h. The design analyses for new large dams located in high risk areas (in Seismic Zone 3) shall include an evaluation of potential landslides in the vicinity of the dam or immediate area of the reservoir, which could cause

damage to the dam or appurtenant structures, obstruct the spillway or suddenly displace water in the reservoir causing the dam to overtop. If potential landslides pose such a threat, they shall be stabilized against sliding, with a minimum factor of safety of 1.5. (7-1-93)

02. Top Width. The crest width shall be sufficient to provide a safe percolation gradient through the embankment at the level of the maximum storage elevation. The minimum crest width (top of embankment) shall be determined by:

W = H / 5 + 10 W = Width, in feet
H = Structural Height, in feet

The minimum top width for any dam is twelve (12) feet. (7-1-93)

03. Cutoff Trenches or Walls. Cutoff trenches shall be excavated through relatively pervious foundation material to an impervious stratum or zone. The trench shall be backfilled with suitable material, compacted to the specified density. The cutoff trench shall extend up the abutments to the maximum storage elevation. (7-1-93)

a. Cutoff trenches shall be wide enough to allow the free movement of excavation and compaction equipment. Side slopes shall be no steeper than one to one (1:1) for depths up to twelve (12) feet, and no steeper than one and one half to one (1 1/2:1) for greater depths to provide for proper compaction. Flatter slopes may be required for safety and stability. (7-1-93)

b. Concrete cutoff walls may be used to bond fills to smooth rock surfaces in a similar manner as cutoff trenches and shall be entrenched in the rock to a depth approximately one-half the thickness of the cutoff wall. Concrete cutoff walls shall be doweled into the rock a minimum of eight (8) inches with a maximum spacing of eighteen (18) inches for three-fourths (3/4) inch steel dowels. Concrete walls shall have a minimum projection of three (3) feet perpendicular to the rock surface and shall have a minimum thickness of twelve (12) inches. (7-1-93)

04. Impervious Core Material. The approved earth materials (silt soils are seldom acceptable) shall be zoned as shown in the plans and placed in the embankment in continuous, approximately level layers, having a thickness of not more than six (6) inches before compaction. Compaction shall be based on ASTM D-698. A minimum compaction of ninety-five percent (95%) is required. (7-1-93)

a. An acceptable working range of moisture content for the core material shall be established and maintained. (7-1-93)

b. The material shall be compacted by means of a loaded sheepsfoot or pneumatic roller to the required density. (7-1-93)

c. No rock shall be left in the core material which has a maximum dimension of more than four (4) inches. The core material shall be free of organic and extraneous material. (7-1-93)

d. The core material shall be carried up simultaneously the full width and length of the dam, and the top of the core material shall be kept substantially level at all times, or slope slightly toward the reservoir. (7-1-93)

e. No frozen or cloddy material shall be used, and no material shall be placed upon frozen, muddy or unscarified surfaces. (7-1-93)

f. All materials used in the dam shall meet the stability and seepage requirements as shown by a design analysis of the structure and shall be properly installed to meet these requirements. (7-1-93)

05. Drains. Toe or chimney drains or free draining downstream material shall be installed where necessary to maintain the phreatic line within the downstream toe. (7-1-93)

a. Filter design for chimney drains, filter blankets and toe drains in clay and silt soils shall be selected using the following design criteria, unless deviations are substantiated by laboratory tests. All tests are subject to

review and approval by the Director.

D15 filter/D15 base > 5 but < 20

D15 filter/D85 base < 5

D50 filter/D50 base < 25

D85 filter > 2 times diameter of pipe perforations, or 1.2 times width of pipe slots. (7-1-93)

b. Filter material requirements are determined by comparing the particle size distribution of the filter to the particle size distribution of the materials to be protected;

e.g. D50 filter
D50 material to be protected

Where D is the particle size passing a mechanical (sieve) analysis expressed as a percentage by weight. (7-1-93)

c. The base material should be analyzed considering the portion of the material passing the No. 4 sieve, for designing filters for base materials that contain gravel size particles. To assure internal stability and prevent segregation of the filter material, the coefficient of uniformity (D60/D10) shall not be greater than 20. (7-1-93)

d. The minimum thickness of filter blankets and chimney drains shall be twelve (12) inches, with the maximum size particle passing the one (1) inch sieve. The maximum particle size may be increased with increasing thickness of the filter, by the rate of one (1) inch per foot of filter. However, the maximum particle shall not exceed three (3) inches. Zoned filters and chimney drains must not be less than twelve (12) inches thick per each zone. The width of granular filters shall not be less than the width of the installation equipment unless the plans and specifications include construction procedures adequate to insure the integrity of a narrower width. (7-1-93)

e. Perforated drain pipes must have a minimum of six (6) inches of drain material around the pipe. The maximum particle size shall not exceed one-half (1/2) inch unless the layer thickness is increased at the rate of one (1) inch per foot of filter. Underdrains and collection pipes must be constructed of noncorrosive material. (7-1-93)

06. Freeboard. The elevation of the top of the embankment shall be constructed and maintained above the flood surcharge level to prevent the dam from overtopping during passage of the inflow design flood and to provide freeboard for wind generated waves. Camber shall be included in the design and incorporated in the construction of the top of the embankment, unless waived by the Director. Camber may be estimated by multiplying the structural height of the dam by five percent (5%). (7-1-93)

a. The height of wind generated waves (H) moving across a surcharged reservoir can be estimated by the following equation:

H = 1.95 (F1/2) where F = fetch, the distance in miles across the reservoir, measured perpendicular to the major axis of the dam. (7-1-93)

b. For large, high risk dams the minimum freeboard shall be two (2) feet plus wave height during passage of the one percent (1%) flood or equal to the surcharge elevation of the reservoir during passage of the inflow design flood whichever is greater. (7-1-93)

c. Estimation of the height of the wind generated wave using the empirical equation in Rule 050.06.a. shall not preclude a more conservative design including consideration of fill materials, embankment zoning, slope surface protection, drainage or other safety factors. (7-1-93)

07. Riprap. All dams which are subject to erosion shall be protected from wave action. The design engineer, with approval of the Director, shall determine whether or not rock riprap or other protection is necessary. (7-1-93)

a. Where rock riprap is used, it shall be placed on a granular bedding material, and extend up the slope, from three (3) feet below the normal minimum operating level to the top of the dam. (7-1-93)

b. Where riprap is required by Rule Subsection 055.07, pipes, cables, brush, tree growth, dead growth, logs, or floating debris are not acceptable substitutes for rock riprap and granular bedding material. (7-1-93)

08. Outlet Conduits. All reservoirs shall be provided with an outlet conduit of sufficient capacity to prevent interference with natural streamflow through the reservoir to the injury of downstream appropriators unless waived by the Director. In addition to any natural flow releases, the outlet conduit should be of sufficient capacity to pass at the same time, the maximum water requirement of the owner. A larger outlet conduit may be required to provide adequate release capability as determined by the Director. (7-1-93)

a. Outlet conduits shall be laid on a firm, stable foundation and normally not be placed on fills which can consolidate, allow differential settlement, and cause separation or misalignment of the pipe. Unless otherwise required, the outlet shall have a minimum inside diameter of twelve (12) inches. The conduits shall be of reinforced concrete or of metal pipe encased in concrete, poured with a continuous seal between the concrete and the trench except as otherwise approved by the Director. Void spaces and uncompacted areas shall not be covered over when the outlet trench is backfilled. Outlets shall be properly aligned on an established grade and may be supported on a concrete cradle, or otherwise supported and kept aligned when the outlet is covered. (7-1-93)

b. Asphalt dipped or other metal pipe is not acceptable unless it is encased in concrete. Exceptions may be made only where conditions warrant, but in no case shall the reasonable life expectancy of the pipe be less than the design life of the dam. (7-1-93)

c. All outlet conduits shall have a seepage path through the impervious zone at least equivalent in length to the maximum head above the downstream end of the system. Only one-third (1/3) the horizontal distance through the impervious zone will be utilized when calculating the length of the seepage path. Collars may be used to satisfy this requirement but all collars shall extend a minimum of two (2) feet outside the conduit for dams up to thirty (30) feet in height and a minimum of three (3) feet for dams above that height. Collars shall be spaced at intervals of at least seven (7) times their height and no collar may be closer to the outer surface of the impervious zone than the distance it extends out from the conduit. (7-1-93)

d. The use of multiple conduits is allowed only upon the written approval of the Director. (7-1-93)

09. Gates. All conduits shall be gated on the upstream end, unless otherwise approved by the Director, with either a vertical or an inclined gate. All conduits shall be vented directly behind the gate unless otherwise determined by the Director. Reservoirs storing water during the winter and subject to severe ice conditions shall have inclined gate controls enclosed in a protective sleeve which is buried. All gate stem pedestals shall be made of concrete. All trash racks shall slope toward the reservoir. At least one (1) of the sides of the inlet structure shall be open to allow water to flow into the outlet conduit and shall be covered with a trash rack. Trash racks should be designed with bars primarily in one (1) direction so they can be cleaned. If fish screens are used, they shall be placed over the trash rack and shall be removable for cleaning, or of the self-cleaning type. (7-1-93)

10. Outlet Controls. Outlet controls shall be installed at a stable location, on the crest or on an elevated platform, or within an enclosure when required, which is readily accessible, but secured to prevent unauthorized operation. (7-1-93)

11. Release Capability. Based on the size of the dam and on the risk category assigned by the Director, the release capability of a dam shall equal or exceed the inflow design flood in the following table:

Downstream Risk Category	Size Classification	Inflow Design Flood
Low	Small	Q50
	Intermediate	Q100

Downstream Risk Category	Size Classification	Inflow Design Flood
	Large	Q500
Significant	Small	Q100
	Intermediate	Q500
	Large	0.5 PMF
High	Small	Q100
	Intermediate	0.5 PMF
	Large	PMF

NOTE: The inflow design flood(s) indicated in the table include specific frequency floods (2%/50yr, 1%/100 yr.) expressed in terms of exceedance with a probability the flood will be equaled or exceeded in any given year (a fifty (50) year flood has a two percent (2%) chance of occurring in any given year and a one hundred (100) year flood has a one percent (1%) chance of occurring in any given year); or PMF - probable maximum flood, which may be expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is derived from the probable maximum precipitation (PMP) which is the greatest theoretical depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year. (7-1-93)

a. All spillways shall be stabilized for the discharge of flow by the use of concrete, masonry, riprap or sod, if not constructed in resistant rock. (7-1-93)

b. Where site conditions allow, the spillway shall be constructed independent of embankment dams. The spillway(s) shall guide the discharge of water away from the dam embankment so as not to erode or endanger the structure. (7-1-93)

c. The minimum base width of an open-channel spillway shall be ten (10) feet. Conduits or siphon pipes other than glory hole spillways are not acceptable substitutes for an open-channel spillway. (7-1-93)

d. The effectiveness of spillways shall be undiminished by bridges, fences, pipelines or other structures. (7-1-93)

e. Unless expressly authorized in writing by the Director, or approved as an integral part of an operation plan, stop logs or flashboards shall not be installed in spillways. (7-1-93)

12. Reservoir Site. The dam site shall be cleared of all trees, brush, large rocks, and debris unless otherwise waived by the Director. The reservoir site shall be cleared of all woody material, growth or debris that is large enough to lodge in the spillway, or outlet works, except as otherwise approved by the Director. (7-1-93)

13. Inspection and Completion Reports. As construction proceeds, it is the responsibility of the engineer to submit test reports (e.g. soil material analyses, density tests, concrete strength tests) along with periodic inspection and progress reports to the Director. (7-1-93)

a. Upon completion of construction the owner or his engineer shall provide the Director a short, written narrative account of all items of work. Record drawings and revised specifications shall be submitted to the Director if the completed project has been substantially changed from the plans and construction specifications originally approved. (7-1-93)

b. The engineer representing the owner shall certify that construction, reconstruction, enlargement, replacement or repair of the dam and appurtenances was completed in accordance with the record drawings and specifications, or as revised. (7-1-93)

051. -- 054. (RESERVED).

055. EXISTING INTERMEDIATE OR LARGE DAMS (RULE 55).
All dams regulated by the department shall be operated and maintained to retain the embankment dimensions and the hydraulic capacity of the outlet works and spillway(s) as designed and constructed, or as otherwise required by these rules. (7-1-93)

01. Analyses Required. The analyses required by Rule 40 are not applicable to existing dams except as required in Rule Subsections 055.01.a. and 055.01.e. unless for good cause, the Director specifically requires the analyses. Dams constructed of other than earth material shall comply with these criteria, as determined by the Director, or with other engineering criteria approved by the Director. (7-1-93)

a. For large, significant or high risk dams, the release capability required by Rule Subsection 050.11 shall be evaluated and applied to the structure. Dams of other size and risk are required to provide the release capability of Rule Subsection 050.11 but are not required to conduct the analyses. (7-1-93)

b. Every dam, unless exempted by the Director shall have a spillway with a capacity to pass a flood of one percent (1%) (two percent (2%) for small low hazard dams) occurring with the reservoir full to the spillway crest at the beginning of the flood while maintaining the freeboard required by Rule Subsection 050.06. (7-1-93)

c. The Director may waive the spillway requirement for dams proposing off stream storage or upon a showing acceptable to the Director. (7-1-93)

d. The release capability can include the capacity of spillway(s) and outlet(s), diversion facilities, or other appurtenant structures, and any approved operating procedures which utilize upstream storage, diversion and flood routing storage to pass flood events. The remainder of the required release capacity, if any, may be met by the following: (7-1-93)

i. Reconstruction, enlargement or addition of spillway(s), outlet(s), diversion facilities or other appurtenant structures. (7-1-93)

ii. A showing acceptable to the Director that failure of the dam during a flood of the specified magnitude described in Rule Subsection 050.11 would not substantially increase downstream damages over and above the losses and damages that would result from any natural flood up to that magnitude. (7-1-93)

iii. A showing acceptable to the Director that the release capability of the dam together with other emergency release modes such as a controlled failure or overtopping of the dam would not result in a larger rate of discharge than the rate of inflow to the reservoir. (7-1-93)

iv. A showing acceptable to the Director that limiting physical factors unique to the dam site exist that prevent construction of a spillway or other release capability mechanisms during a flood of the specified magnitude described in Rule Subsection 050.11 provided the owner implements storage operational procedures and/or provides for emergency warning to protect life and property. (7-1-93)

e. For large, high risk dams, the seismic design loads shall be evaluated and applied to dams located east of Range 22E, B.M. The evaluation shall use the maximum ground motion/acceleration generated by the maximum credible earthquake. (7-1-93)

f. The Director may accept existing studies relative to requirements of Rule Subsections 055.01.a. and 055.01.e., if the Director determines the information provided fulfills the requirements of Rule Subsections 055.01.a. and 055.01.e. (7-1-93)

g. The Director may allow until July 1, 1992 for completion of the analyses required in Rule Subsections 055.01.a. and 055.01.g. and may allow the owner of an existing dam a compliance period of up to ten years for completing the studies, to complete structural modifications or implement other improvements necessary to provide the release capability determined to be required (Rule Subsection 055.01.a.) or complete structural modifications necessary to assure the dam and appurtenant facilities will safely function under earthquake loads

(Rule Subsection 055.01.g.). (7-1-93)

h. Within thirty (30) days after completing the analyses required in Rule Subsection 055.01.a. or 055.01.g., the owner of an existing dam that is deficient in either case (Rule Subsection 055.01.a. or 055.01.g.) shall file with the Director a schedule outlining the dates work or construction items will be completed. (7-1-93)

02. Other Requirements. (7-1-93)

a. Routine maintenance items include the following: (7-1-93)

i. Eradication of rodents and filling animal burrows. (7-1-93)

ii. Removal of vegetation and debris from the dam. (7-1-93)

iii. Restoring original dimensions of the dam by the addition of fill material. (7-1-93)

iv. Addition of bedding or riprap material which will not increase the height or storage capacity. (7-1-93)

v. Repair or replacement of gates, gate stems, seals, valves, lift mechanisms or vent pipes with similar equipment. (7-1-93)

vi. Repair or replacement of wingwalls, headwalls or aprons including spalling concrete. (7-1-93)

b. The following are not routine maintenance items: (7-1-93)

i. Reconstruction of embankment slopes. (7-1-93)

ii. Replacement, reconstruction or extension of outlets. (7-1-93)

iii. Foundation stabilization. (7-1-93)

iv. Filter or drain construction or replacement. (7-1-93)

v. Spillway size alteration or modification. (7-1-93)

vi. Installation of instrumentation or piezometers. (7-1-93)

vii. Release capability modification. (7-1-93)

c. Items not specifically described in Rule Subsections 055.02.a. and 055.02.b. will be determined by the Director to be included in one rule or the other upon receipt of a written request from the owner or his representative seeking such a determination. (7-1-93)

d. Where riprap is required to prevent erosion and to maintain a stable embankment, pipes, cables, brush, tree growth, logs, or floating debris are not acceptable substitutes for rock riprap and granular bedding material. Dams or portions thereof which are stable without riprap, are not required to have riprap. (7-1-93)

e. Upon completion of reconstruction of a dam or feature of a dam included in Rule Subsection 055.02.b., the owner or his engineer shall provide the Director a short written narrative account of all items of work. Record drawings and revised specifications shall be submitted to the Director if the completed project has been substantially changed from the plans and construction specifications originally approved. (7-1-93)

f. Upon request, the owner of every dam shall provide his name and address to the Director and shall advise the Director of future changes in ownership. If the owner does not reside in Idaho, the owner shall provide the name and address of the person residing in Idaho who is responsible for the operation, maintenance and repair of the dam. (7-1-93)

056. -- 061. (RESERVED).

060. SMALL DAM DESIGN CRITERIA (RULE 60).
The following provisions apply to small dams. (7-1-93)

01. Design and Construction of Small Dams. Design and construction of small dams located in high risk areas as determined by the Director require submittal of fees, plans and specifications prepared by an engineer and shall follow the same general criteria established under Rules 40, 45, 50, and 55. Other small dams not determined to be in a high risk area shall follow the same general criteria established under Rules 50 and 55 or larger dams, except that submittal of plans, specifications and test results is not required. (7-1-93)

02. Notification Prior to Construction. The owner shall notify the Director in writing ten (10) calendar days prior to commencing construction. (7-1-93)

03. Approval Required. The owner shall not proceed with the following stages of construction without approval from the Director. (7-1-93)

a. After clearing and excavation of the foundation area and cutoff trench, and prior to placing any fill material; (7-1-93)

b. After installation of the outlet conduit, and before placing any backfill material around the conduit; (7-1-93)

c. After construction is completed, and before any water is stored in the reservoir; (7-1-93)

d. At such other times as determined necessary by the Director. The Director, will, upon seven (7) day notice, inspect and, if satisfactory, approve the completed stage of construction. (7-1-93)

04. Notification upon Completion of Construction. The owner shall in writing notify the Director upon completion of construction. (7-1-93)

061. -- 064. (RESERVED).

065. DAMS STORING TAILINGS AND WATER (RULE 65).

01. Construction of Dams Storing Fifty Acre-Feet or More. Construction of dams intended to store or likely to store fifty (50) acre-feet or more of water in excess of the water contained in the tailings material shall meet the requirements specified in Rules 40, 45, 50 and 55 of these rules. The Director may waive any or all of these requirements if, in the opinion of the Director, sound engineering design provided by the owner indicates such requirements are not applicable. (7-1-93)

02. Abandonment Plan. An abandonment plan which provides a stable, maintenance-free condition at any time tailings are not being actively placed for an extended period of time, as determined by the Director, shall be submitted to the Director by the owner of a dam storing tailings and water. This rule may be waived by the Director if determined not to be applicable. (7-1-93)

066. -- 999. (RESERVED).

Subject Index

A

Abandonment Plan, Dams Storing Tailings & Water 16
Active Storage 2
Additional Information/Waiver, Construction Plans, Drawings & Specifications 8
Alterations, Repairs or Either of Them 2
Analyses Required, Existing Intermediate or Large Dams 14
Applying for & Obtaining Written Approval, Construction Plans, Drawings & Specifications 6
Approval Required, Small Dam Design Criteria 16
Appurtenant Structures 2
Authority Of Representative 5

C

Certificate of Approval 2
Changes to Specifications, Construction Plans, Drawings & Specifications 7
Construction of Dams Storing Fifty Acre-Feet or More, Dams Storing Tailings & Water 16
Construction Plans, Drawings & Specifications 6
Cutoff Trenches or Walls, New Intermediate or Large Dams 10

D

Dam 3
Dam Size Classification & Risk Category 4
Dams Storing Tailings & Water 16
Days Used in Establishing Deadlines 3
Dead Storage 3
Definitions, IDAPA 37.03.06, Safety Of Dams Rules 2
Department Jurisdiction 3
Design & Construction of Small Dams, Small Dam Design Criteria 16
Design Evaluation 3
Design Report, Construction Plans, Drawings & Specifications 7
Detailing Provisions of Specifications, Construction Plans, Drawings & Specifications 7
Determination of Size & Risk Category, Dam Size Classification & Risk Category 5
Drains, New Intermediate or Large Dams 10

E

Embankment Stability, New Intermediate or Large Dams 9
Enlargement 3
Existing Dams, Operation Plan 8
Existing Intermediate Or Large Dams 14

F

Factor of Safety 4
Flood Surcharge 4
Forms 5
Freeboard, New Intermediate or Large Dams 11

G

Gates, New Intermediate or Large Dams 12

I

Impervious Core Material, New Intermediate or Large Dams 10
Inflow Design Flood (IDF) 4
Information Included With Plans, Construction Plans, Drawings & Specifications 6
Inspection & Completion Reports, New Intermediate or Large Dams 13
Inspection, Examination & Testing of Materials, Construction Plans, Drawings & Specifications 7
Inspections, Construction Plans, Drawings & Specifications 7
Intermediate Dams 3

L

Large Dams 3

M

Maximum Credible Earthquake 4

N

New Intermediate Or Large Dams 9
New, Reconstructed or Enlarged Dams, Operation Plan 8
Notification Prior to Construction, Small Dam Design Criteria 16
Notification Upon Completion of Construction, Small Dam Design Criteria 16

O

Operation Plan 8
Operation Plan, Assure the Project is Safely Managed 4
Other Requirements, Existing Intermediate or Large Dams 15
Outlet Conduits, New Intermediate or Large Dams 12
Outlet Controls, New Intermediate or Large Dams 12

P

Plans Shall be Prepared on a Good Quality Vellum or Mylar, Construction Plans, Drawings & Specifications 6
Preparation & Submission of Plans, Construction Plans, Drawings & Specifications 6

R

Rejection of Defective Material, Construction Plans, Drawings & Specifications 7
Release Capability 4
Release Capability, New Intermediate or Large Dams 12
Reservoir 4
Reservoir Site, New Intermediate or Large Dams 13
Responsibility of Engineer, Construction Plans, Drawings & Specifications 7
Riprap, New Intermediate or Large Dams 11
Risk Category, Dam Size Classification & Risk Category 5

S

Size Classification, Dam Size Classification & Risk Category 5
Small Dam Design Criteria 16
Small Dams 3
Specifications, Construction Plans, Drawings & Specifications 7
Storage Capacity 4
Submission of Duplicate Plans, Dam Drawings & Specifications 6
Suspension of Work, Construction Plans, Drawings & Specifications 7

T

Top Width, New Intermediate or Large Dams 10

W

Water Storage Elevation 4

E.12. Illinois



Joint Committee on Administrative Rules
ADMINISTRATIVE CODE

TITLE 17: CONSERVATION
CHAPTER I: DEPARTMENT OF NATURAL RESOURCES
SUBCHAPTER h: WATER RESOURCES
PART 3702 CONSTRUCTION AND MAINTENANCE OF DAMS
SECTION 3702.30 APPLICABILITY

Section 3702.30 Applicability

a) Classification

1) Dams will be categorized in one of three classes, according to the degree of threat to life and property in the event of a dam failure. The three classes of dams are:

A) Class I – Dams located where failure has a high probability for causing loss of life or substantial economic loss in excess of that which would naturally occur downstream of the dam if the dam had not failed. A dam has a high probability for causing loss of life or substantial economic loss if it is located where its failure may cause additional damage to such structures as a home, a hospital, a nursing home, a highly travelled roadway, a shopping center, or similar type facilities where people are normally present downstream of the dam. This is similar to U.S. Army Corps of Engineers HIGH HAZARD POTENTIAL category as defined in the Corps Guidelines, and the U.S. Soil Conservation Service Class (c) dams as defined in Soil Conservation Service Technical Release No. 60.

B) Class II – Dams located where failure has a moderate probability for causing loss of life or may cause substantial economic loss in excess of that which would naturally occur downstream of the dam if the dam had not failed. A dam has a moderate probability for causing loss of life or substantial economic loss if it is located where its failure may cause additional damage to such structures as to a water treatment facility, a sewage treatment facility, a power substation, a city park, a U.S. Route or Illinois Route highway, a railroad or similar type facilities where people are downstream of the dam for only a portion of the day or on a more sporadic basis. This is similar to U.S. Army Corps of Engineers SIGNIFICANT HAZARD POTENTIAL category and the U.S. Soil Conservation Service Class (b) dams.

C) Class III – Dams located where failure has low probability for causing loss of life, where there are no permanent structures for human habitation, or minimal economic loss in excess of that which would

naturally occur downstream of the dam if the dam had not failed. A dam has a low probability for causing loss of life or minimal economic loss if it is located where its failure may cause additional damage to agricultural fields, timber areas, township roads or similar type areas where people seldom are present and where there are few structures. This corresponds to U.S. Army Corps of Engineers LOW HAZARD POTENTIAL category and U.S. Soil Conservation Service Class (a) dams.

2) Dams will be categorized in one of three size classifications. Such size classifications shall be based on dam height and impounding capacity. If either the height or impounding capacity meets the minimum requirement for the larger size, the dam will be classified in the larger size category.

CLASSIFICATION	IMPOUNDING CAPACITY ACRE-FEET	DAM HEIGHT FEET
Small	Less than 1,000	Less than 40
Intermediate	Greater than 1,000 to Less than 50,000	Greater than 40 to Less than 100
Large	Greater than 50,000	Greater than 100

b) New Dams

1) Class I and II Dams

The owner of a proposed Class I or II dam shall obtain a OWR permit prior to the start of construction. The owner must do all construction and maintenance of the dam in accordance with this Part governing such Class I or II dam.

2) Class III Dams

A) The owner of a proposed Class III dam shall obtain a OWR permit prior to the start of construction if the dam meets any of the following criteria:

i) the drainage area of the proposed dam is 6400 acres or more in a Rural Area or 640 acres or more in an Urban Area, or

ii) the dam is 25 feet or more in height provided that the impounding capacity is greater than 15 acre-feet, or

iii) the dam has an impounding capacity of 50 acre-feet or more provided that the dam height is greater than 6 feet.

B) If a permit is required for the Class III dam under any of these criteria, then the owner must do all construction and maintenance of the dam in accordance with this Part governing Class III dams.

c) Existing Dams

The owner of a dam that was permitted and built in compliance with a OWR permit before September 2, 1980, and that is currently in good repair shall not be required, except in compliance with Sections 3702.150 or 3702.190, to make changes in the design, structure, or construction of such dam. The owner of a dam that was permitted and built before September 2, 1980, but is not in accordance with the OWR permit or is not in good repair, shall be required to meet all current standards for existing dams. The owner of a dam built after September 2, 1980, shall be required to meet all standards for proposed dams existing at the time of its construction. Operation, maintenance, inspection and financial responsibility standards must be complied with at all dams.

1) Class I and II Dams

A) OWR has developed an inventory of dams in Illinois. OWR and federal agencies have conducted and are conducting inspections of existing dams having a potential for loss of life or property damage in case of a dam failure. As inspection reports are completed, OWR will furnish in writing to the owner of the dam a detailed and specific list of defects discovered in the course of the inspection of the dam, including the specific nature of any inadequacies of the capacity of the spillway system and any indications of seepage, erosion or other evidence of structural deficiency in the dam or spillway; together with a statement of the applicable standards found in 17 Ill. Adm. Code 3702 which if complied with by the owner of the dam will put the dam into compliance with this Part.

B) If an inspection by OWR or in which OWR concurs finds that a dam is in an unsafe condition, OWR will notify the appropriate officials of the affected city or county, the State's Attorney of the county in which the dam is located, and the Illinois Emergency Management Agency (IEMA); and will assist IEMA) in any emergency actions deemed necessary by that agency.

C) OWR will notify the dam owner whose dam has been inspected if the owner must obtain a permit or amendment to an existing permit for the dam.

D) If an existing Class I or II dam has been inspected and found to have serious deficiencies requiring major modifications, then within 90 days after receipt of notice from OWR that a permit or amendment to an existing permit is required under this Part, the owner of a Class I or II dam must provide written assurance to OWR of the following: the owner's intention to rectify the deficiencies noted, the date which the owner will submit a completed permit application, the time frame for initiating and completing the appropriate remedial measures, and the methods and designs to be used for the remedial measures.

E) If an existing Class I or II dam has been inspected and found to have no serious deficiencies requiring major modifications, OWR will notify the owner of the dam that he must submit within 90 days a permit application including the following if such has not been previously

provided to OWR:

i) an Operating Plan (Section 3702.40(b)(4));

ii) a Maintenance Plan (Section 3702.40(b)(5));

iii) a Financial Responsibility Statement (Section 3702.40(b)(6)); and

iv) a Right of Access Statement (Section 3702.40(b)(7)(A)).

F) An owner initiating major modifications to an existing Class I or Class II dam must obtain a new permit or amendment to an existing permit prior to the initiation of the modifications.

2) Class III Dams

A) Using the inventory of dams or other similar information, OWR, over a period of time, upon receipt of a complaint or upon its own investigation, may contact owners of those existing Class III dams which

i) have a drainage area of 6400 acres or more in a Rural Area or 640 acres or more in an Urban Area, or

ii) are 25 feet or more in height, provided that the impounding capacity is greater than 15 acre-feet, or

iii) have an impounding capacity of 50 acre-feet or more provided that the dam height is greater than 6 feet.

B) OWR will inform the owners of such dams that they must submit to OWR a maintenance program and a statement indicating actions to be taken to remedy the noted deficiencies.

C) If an inspection by OWR or in which OWR concurs finds that a dam is in an unsafe condition, OWR will notify the appropriate officials of the affected city or county, the State's Attorney of the county in which the dam is located, and IEMA.

D) Owners of existing Class III dams in locations where there is potential for downstream urban development, which could cause a change in dam classification in the foreseeable future, when so notified by OWR, shall be required to report annually the existing land uses downstream of the dam. Extent of downstream land use to be reported is dependent upon factors such as slope and width of flood plain and density and intensity of downstream development. Extent downstream will not exceed 2 miles unless otherwise indicated by OWR. The owner may provide information indicating that an extent downstream which is shorter than 2 miles is appropriate. The width of flood plain shall be the width of the area inundated by the 100-year flood.

E) Owners of Class III dams desiring to make major modifications to their dams shall obtain a OWR permit or an amendment to an existing OWR permit for the work prior to the initiation of the modifications.

d) Designation by OWR of Dam Classification

Before assigning or changing the dam classification for a new or existing dam, OWR shall give notice and opportunity for hearing pursuant to Section 3702.170 to the applicant or existing dam owner and other interested persons of such action.

1) Initial Assignment of Dam Classification

A) New Dams

The classification of new dams will be based upon information available to OWR. Such information includes, but is not limited to, U.S.G.S. quadrangle maps of the downstream area, the preliminary report and support data from the owner's engineer, known elevations of structures downstream of the proposed dam, information from the public, and previous study data. Such information is available from in-house data and data supplied by the owner's engineer, the public, federal or state agencies. The owner of the proposed dam shall submit information to establish the degree of threat to life and property damage in the event of a dam failure.

B) Existing Dams

i) The classification of existing dams which have been inspected by the U.S. Army Corps of Engineers, other federal agencies, or OWR will be based upon the agency's inspection report.

ii) The classification of existing dams which have not been inspected by federal agency or OWR but which have had major modifications proposed by the dam owner will be processed as new dams in accordance with Section 3702.30(d)(1)(A).

2) Change in Dam Classification

Upon receipt and verification of information indicating that significant change in the degree of threat to life or property from a dam failure has occurred since the dam's original classification, the classification of that dam shall be changed to reflect the new hazard potential. Upon reclassification, the dam owner shall be subject to the applicable dam safety requirements for the current classification (Section 3702.30(c)).

e) Removal of Dams

`The owner of a Class I, II or III dam as defined in this Part, who wishes to remove his dam, shall obtain, prior to the initiation of the dam removal, a OWR permit to remove the dam in accordance with Section 3702.50 governing the removal of dams.

(Source: Amended at 11 Ill. Reg. 1941, effective January 13, 1987)

Joint Committee on Administrative Rules
ADMINISTRATIVE CODE

TITLE 17: CONSERVATION
CHAPTER I: DEPARTMENT OF NATURAL RESOURCES
SUBCHAPTER h: WATER RESOURCES
PART 3702 CONSTRUCTION AND MAINTENANCE OF DAMS
SECTION 3702.40 REQUIREMENTS FOR APPROVAL OF PERMITS FOR CONSTRUCTION OF NEW DAMS AND MAJOR MODIFICATIONS OF EXISTING DAMS

Section 3702.40 Requirements for Approval of Permits for Construction of New Dams and Major Modifications of Existing Dams

a) The following are OWR requirements which must be met in order to obtain a permit for construction of a new dam or major modification of an existing dam. Applicants are encouraged to submit to OWR a preliminary report for approval of concept prior to completion of the permit application form. The preliminary and all subsequent plans and reports shall be prepared under the direction of an engineer or other qualified personnel. The engineer or qualified personnel may be assisted by other professional personnel applying the disciplines of hydrologic engineering, hydraulic engineering, soil mechanics, structural engineering, or engineering geology.

b) OWR staff will be available for consultation prior to initiation of design studies, and at any time during the development of the permit application if questions should arise.

1) Structural and Geotechnical Design Requirements

The basis for OWR review and approval of the structural and geotechnical design requirements of Class I, II and III dams is the Corps Guidelines subject to modification as indicated in this Part. The criteria for structural and geotechnical design contained in the Corps Guidelines are minimum criteria. Variations from the criteria may be required or allowed by OWR for special physical conditions at the proposed site as necessary or appropriate to meet the interest of the overall structural and geotechnical requirements of this Part. Technical publications, other than the Corps Guidelines, may be used by OWR to assure the use of current and applicable data for the structural and geotechnical review of the dam design.

2) Hydrologic and Hydraulic Design Requirements

The basis for OWR review and approval of the hydrologic and hydraulic design requirements for Class I, II and III dams is the Corps Guidelines, subject to modifications as indicted herein. Technical publications other than the Corps Guidelines may be used to assure the use of current and

applicable data for the hydrologic and hydraulic review of dam design.

A) Proposed Dams

The following minimum spillway design floods shall be used for proposed structures:

i) Principal Spillway Design Flood

CLASSIFICATION	SIZE	PRINCIPAL SPILLWAY DESIGN FLOOD
Class I	All	100-yr.
Class II	All	50-yr.
Class III	All	25-yr.

ii) Total Spillway Design Flood

CLASSIFICATION	SIZE	PRINCIPAL SPILLWAY DESIGN FLOOD
Class I	Small	0.5 PMF
	Intermediate	1.0 PMF
	Large	1.0 PMF
Class II	Small	100-yr.
	Intermediate	0.5 PMF
	Large	1.0 PMF
Class III	Small	100-yr.*
	Intermediate	100-yr.
	Large	0.5 PMF

*For proposed Class III dams where the dam height multiplied by the impounding capacity is less than or equal to 300, no specific total spillway capacity is required.

iii) For all proposed Class II or III dams, a determination of alternatives for increasing the total spillway capacity to accommodate the PMF shall also be submitted to OWR. The initial dam design shall provide for the capability of increasing the spillway capacity. Future downstream land use, land use controls, and growth projections will be considered in the review of the spillway capacity design.

B) Existing Dams

The minimum spillway design flood for modifications to existing dams built after September 2, 1980 shall be the same as the criteria for proposed dams. The minimum spillway design flood for modifications to existing dams that were constructed and in service on or before September 2, 1980, are as follows:

i) Principal Spillway Design Flood

CLASSIFICATION	SIZE	TOTAL SPILLWAY DESIGN FLOOD
Class I	All	100-yr.
Class II	All	50-yr.
Class III	All	No specific requirement.

ii) Total Spillway Design Flood

CLASSIFICATION	SIZE	TOTAL SPILLWAY DESIGN FLOOD
Class I	Small	0.3 PMF
	Intermediate	0.6 PMF
	Large	0.6 PMF
Class II	Small	100-yr.
	Intermediate	0.3 PMF
	Large	0.6 PMF
Class III	Small	100-yr.*
	Intermediate	100-yr.
	Large	0.3 PMF

*For modifications to existing Class III dams where the height multiplied by impounding capacity is less than or equal to 300, no specific total spillway capacity is required.

iii) The Department may approve total spillway design capacities for existing dams other than the spillway design floods listed above. A total spillway design capacity less than the 100-yr. flood will only be allowed for small size, Class III structures with dam height multiplied by impounding capacity less than or equal to 300. Any submittal for variation from the above-listed spillway design flood must include a detailed hydraulic risk assessment that shows that additional spillway capacity will not provide a decrease in potential loss of life or property damage or a detailed economic risk assessment that shows that the chosen spillway design alternative provides the minimum rehabilitation costs plus damage losses; a detailed early warning and emergency evacuation plan coordinated with the local ESDA; and a list (with mailing addresses) of all persons living within the dam breach wave inundation area.

iv) All hearings regarding variation from the above-listed spillway design criteria shall be in accordance with Section 3702.170 of this Part.

C) For Class I and II dams, a dam breach wave analysis for downstream impacts from failure during the total spillway design flood and impoundment initially at normal pool shall be required for:

i) a nearly instantaneous total failure and

ii) should the applicant so desire, a failure to the degree and timing believed reasonable by the applicant.

D) Dewatering Capabilities

i) All new Class I and II dams, all new Class III dams unless exempted by OWR for functional reasons, and existing Class I and II dams requiring major modifications shall have a capability for dewatering the reservoir within a reasonable period of time. In determining a reasonable time period, OWR shall consider the damage potential posed by possible failure, risk and nature of potential failure, purpose of the dam and reservoir, capability and stability of available drainage courses to convey the waters released in the event of an emergency dewatering, and influence of rapid drawdown on stability of the dam. Although each permit must be considered based on its individual circumstances, in general, a reasonable time to dewater 50% of the normal pool storage volume is 7 days for Class I dams, 14 days for Class II dams and 30 days for Class III dams.

ii) No dewatering capability shall be required for any existing Class III dam or for any existing Class I or II dam which OWR determines to require no major modifications thereto under this Part.

E) Specific requirements for minimum freeboard allowances are not appropriate because of the many factors involved in such determinations. The applicant must assess the factors affecting the individual project and develop the appropriate minimum freeboard allowance. Many projects are reasonably safe without freeboard allowance because they are designed for overtopping, or because other factors minimize possible overtopping. Conversely, freeboard allowances of several feet may be necessary to provide a safe condition for some dams. Factors that should be considered include the duration of high water levels in the reservoir during the design flood; the effective wind fetch and reservoir depth available to support wave generation; the probability of high wind speed occurring from a critical direction; the potential wave runup on the dam based on roughness and slope; and the ability of the dam to resist erosion from overtopping waves.

F) The applicant must provide stilling basins or other appropriate structures or devices capable of dissipating the energy created at the outlet of the principal spillway and at dewatering outlets for all

flows.

3) Erosion Protection Requirements

A) As a minimum the applicant shall adequately protect by structural or nonstructural means the upstream face of earth embankment dams from an elevation below normal pool of two feet or 0.50 times the anticipated wave height (if greater than 2.0 feet) up to the minimum freeboard elevation. In addition, if normal pool water surface varies, the upstream face shall be protected within the range of variation.

B) The applicant shall vegetate or otherwise protect from erosion the downstream face and top of earth embankment dams. The applicant should design earth embankment dams to provide a dam section which can be easily maintained.

C) The applicant shall provide riprap or other appropriate protection as necessary at dam abutments, dam slope toes (the line of the dam embankment slopes where it intersects the natural ground at the upstream or downstream edge), spillways, stilling basins, and at other locations which, if left unprotected, could lead to damage to, or failure of the dam.

D) If the spillway design of the dam requires that an earth emergency spillway pass any portion of the 100-year flood, the applicant shall protect the earth emergency spillway against erosion consistent with the dam classification and physical characteristics of the dam site. The applicant must construct all earth emergency spillways on in situ material or on well compacted cohesive materials that will be stable during design flows.

E) The applicant shall submit plans for control of erosion and water pollution during the anticipated construction or major modifications, including plans for adequate measures to limit the erosion of the soil from exposed slopes after completion of construction. Such plans shall indicate that adequate control measures will be taken during construction to protect the quality of stream flow below the project site, and during the estimated time for filling.

4) Operating Requirements

An applicant for a Class I or II dam shall submit an operational plan specifying the method and schedule for the operation of the dam and the routine operating procedures to keep the dam in good working order, including an emergency warning plan. The emergency warning plan must outline the procedures to be followed during major storm events or other emergency situations. Under this plan, a person designated by the dam owner would monitor dam conditions, and would warn appropriate state and local officials if major problems require immediate repairs and would indicate how the owner plans to accomplish the needed repairs, and indicate if evacuation of persons in areas downstream of the dam may be necessary.

5) Maintenance Requirements

As a condition of each permit, dam owners shall submit a maintenance plan detailing the procedures and schedules to be followed to maintain the dam and its appurtenances in a reasonable state of repair. The maintenance plan shall include but not be limited to the following:

A) Class I and II Dams

The dam owner shall retain an engineer or other qualified personnel to make an initial inspection and report and subsequent inspections and reports as required by this Part. The owner of a Class I dam shall submit the report annually on forms furnished by OWR. The owner of a Class II dam shall submit the report every three years on forms furnished by OWR. In the intervals between the engineer or other qualified personnel reports on Class II dams, the owner shall file with OWR an annual statement on forms furnished by OWR stating that he is maintaining the dam in accordance with the maintenance plan prepared by his engineer or other qualified personnel and indicating any change in land use which may have occurred in the 100-year flood plain within the previously accepted limits downstream of the dam. The reports shall outline modifications made to the dam, any deficiencies found, detail the remedial measures necessary, and the method and time the owner will use to correct the deficiencies found. The dam owner may be required to provide additional inspections and reports by an engineer or other qualified personnel, following unusual storms or seismic events; provided such inspection procedures are required as a part of the maintenance plan approved by OWR in issuing a permit. A sketch showing land use in the flood plain downstream of the dam shall be included in the reports. The extent of downstream land use to be reported is dependent upon factors such as slope and width of the 100-year flood plain and the density and intensity of downstream development. The extent downstream will not exceed 2 miles unless otherwise indicated by OWR. The owner may provide information for review by OWR indicating that an extent downstream which is shorter than 2 miles may be appropriate.

B) Class III Dams

The owner of a new Class III dam or owner of an existing Class III dam qualifying under the provisions of Section 3702.30 (relating to the major modification of existing Class III dams), shall retain an engineer or other qualified personnel to make an initial inspection and report and subsequent inspections and reports on a 5-year interval, in accordance with this Part. The dam owner shall submit to OWR on forms furnished by OWR the engineer's initial report and subsequent fifth year reports. The reports shall include a description of flood plain land use downstream of the dam. In the intervals between the engineer's reports, the owner shall file with OWR an annual statement on forms furnished by OWR stating that he is maintaining the dam in accordance with the maintenance plan prepared by his engineer or other qualified personnel and indicating

any change in land use downstream of the dam. The extent of downstream land use to be reported is dependent upon factors such as slope and width of the 100-year flood plain and the density and intensity of downstream development. The extent downstream will not exceed 2 miles unless otherwise indicated by OWR.

6) Financial Responsibility of Owner

A) For Class I and II dams, the owner shall document that he has the financial capability to adequately maintain or breach his dam in a safe condition. This may be established by showing that the applicant has the resources and the authority to obtain funds in the amount required to safely breach the dam within 10 days of receipt of notice of the need to breach or repair. For public bodies, this may be done by showing taxing power or other revenue generating ability and passage of an appropriate ordinance or resolution indicating the authority to take such action if necessary. If the owner cannot adequately demonstrate this financial capability, OWR may require the applicant to post a performance bond. The amount of the bond will be that estimated by OWR as reasonably necessary to safely breach the dam in an environmentally sound manner if the condition of the dam becomes a threat to life or property. The owners shall notify OWR when each performance bond has been renewed or extended in time.

B) Except in emergencies, should the cost of repair to place the dam in a safe condition be less than the cost of breaching, the performance bond may be used to pay for repair, rather than breach of the dam.

7) Other Requirements

A) The owner shall grant the State the right of access to inspect the dam site and immediate vicinity before, during and after construction and for the life of the dam and appurtenances. Except under emergency conditions, such as when the dam is in imminent danger of failure or is in the process of failing, the State shall notify the owner at least 10 days in advance of any inspection.

B) For Class I and II dams, the owner shall notify OWR prior to initiating foundation preparations, including cut-off trench excavation.

C) For Class I and II dams, OWR will require the owner to have continuous inspection during construction. The construction shall be under the direction of an engineer, or other qualified personnel. For Class III dams, OWR may require the owner to have continuous inspection during construction if foundation conditions have not been completely determined or if the dam has been designed with minimal factors of safety.

D) For Class I and II dams – prior to commencing filling operations, or refilling operations after a drawdown, the applicant shall request

OWR inspection of the dam, and must receive authority from OWR before commencing filling. When drawdowns are performed on a frequent basis as a part of the approved operation plan, the authority is not necessary.

E) If OWR has not acted to grant or deny the authorization to fill within 30 days after receipt of request, the owner may proceed with filling or refilling operations.

F) For all new dams, or for major modifications to existing dams, the dam owner shall

i) own or have permanent flood easements for all land that will be inundated in the reservoir up to the proposed 100-year frequency flood pool elevation, or

ii) submit hydraulic computations showing that, for floods up to the 100-year frequency flood, the pool elevation will not be increased above existing conditions.

(Source: Amended at 11 Ill. Reg. 1941, effective January 13, 1987)

PROCEDURAL GUIDELINES
for
PREPARATION OF TECHNICAL DATA
to be included in
APPLICATIONS FOR PERMITS
for
CONSTRUCTION AND MAINTENANCE OF DAMS

STATE OF ILLINOIS
DEPARTMENT OF NATURAL RESOURCES
OFFICE OF WATER RESOURCES
ONE NATURAL RESOURCES WAY
SPRINGFIELD, ILLINOIS 62702-1271

TABLE OF CONTENTS

I. Introduction.....1

II. Preliminary Design Report.....2

III. Final Design Report.....4

IV. Hydrologic and Hydraulic Investigations.....4

V. Structural and Geotechnical Investigations and Design...18

VI. Operation Plan.....28

VII. Maintenance Plan.....28

VIII. Emergency Action Plan.....29

IX. Dam Removals and Abandonments.....30

Appendices

Appendix #1
Seismic Coefficients

Appendix #2
Sample Operation and Maintenance Manual

Appendix #3
Emergency Action Plan Development Information

I. INTRODUCTION

The "Rules for Construction and Maintenance of Dams" require that only engineers which are registered as a structural and/or professional engineer in The State of Illinois, under the Professional Engineering Practice Act [225 ILCS 325] and the Structural Engineers Act [225 ILCS 340], and with expertise in the investigation, design, construction, and operation of dams prepare the engineering data to be submitted with an application for a permit. These guidelines have been written with the intent of providing a basic understanding of the type of information that will need to be provided with an application for a permit to construct a new dam and to modify, remove or abandon an existing dam. They have also been prepared for the engineer to understand the methods of review that will be used by the staff of the Office of Water Resources in reviewing an application for a permit. Some of the information presented herein would also be applicable to the preparation of data for an application for permit to operate and maintain an existing dam.

Section IX of these guidelines has been developed to address and provide guidance concerning the issue of the removal of dams including the abandonment of slurry disposal impoundment dams. Abandonment may differ from removal of a dam in that abandonment may leave the embankment intact. However, both removal and abandonment usually result in the dam ultimately being eliminated from the Office of Water Resources regulatory purview.

It is not the intent of these guidelines to be dictatorial as to the methods to be used to achieve the required data. Rather, the user is provided information concerning generally accepted methods of testing, analysis, and computation.

Questions regarding the preparation of the documentation noted in these guidelines may be directed to the Office of Water Resources offices in Springfield (Tel. No. 217/782-3863), Bartlett (Tel. No. 847/608-3100 ext. 2025).

II. PRELIMINARY DESIGN REPORT

It is strongly recommended that applicants submit a preliminary design report to OWR for approval of the design concept prior to initiation of detailed design studies. This report should include:

A. Ownership and Engineer Information

1. The owner of the dam (names, addresses, telephone numbers)

2. The owner's engineer (names, addresses, telephone numbers, a description of expertise in the investigation, design, construction, and operation of dams, and a listing of previously acquired permits for dams from the Office of Water Resources or its predecessors)

B. Purpose, Location and Configuration - General information regarding the dam and appurtenances. This information should include a statement of the purpose for which the dam is to be used, a legal description of the location of the dam, calculations to verify the drainage area controlled by the dam, the height of the dam and the maximum impounding capacity of the dam.

C. Downstream Hazards and Breach Analysis - In order for OWR to provisionally determine the dam classification, as described in the "Rules for Construction and Maintenance of Dams", information describing the downstream area for a distance of at least two miles is required. This information should include the number of and access to homes and buildings, roads, utilities and other property that would be endangered should failure of the dam occur. Contoured aerial photographs or recent U.S. Geological Survey topographic maps may be used for this purpose. Submittal of additional data, including a dam breach analysis, may be necessary at some sites. If a dam breach analysis is submitted, it should include failures during a range of events from normal pool through the Probable Maximum Flood. The owner should also be cognizant of the possibility for development of the downstream area which could change the dam classification and require modifications to the dam. The original design should provide for these modifications to be more easily accomplished.

D. Topography - Maps showing the location of the proposed structure that include the location of county and State roads, access to the site, the outline of the reservoir at normal pool elevation, the drainage area limits, and the general topography of the dam site and reservoir area. Contoured aerial photographs or recent U.S. Geological Survey topographic maps may be used for this purpose.

E. Plans and Drawings - Preliminary drawings that include cross-sections, plans and profiles of the dam, proposed pool levels, and types of spillways.

F. Basic Design Criteria - Preliminary design criteria including a description of the size, ground cover conditions, and extent of development of the watershed; the proposed geotechnical and exploration testing program, geology and geotechnical engineering assumptions for the foundation and embankment materials; the proposed hydrologic and hydraulic analyses methods; and the type of materials to be used in the dam and the spillway system(s).

III. FINAL DESIGN REPORT

In order for the Office of Water Resources to assess the safety aspects of a dam from an engineering standpoint, the final design report submitted with the Permit Application must contain the information and calculations to verify the adequacy of the design for the given size and downstream hazard potential of the dam. The safety evaluation will be based upon the capability of the project to meet the minimum performance standards established in the "Rules for Construction and Maintenance of Dams". The remaining sections of these guidelines have been written as an aid in the preparation of the data required to support the application for permit.

Computer programs which are used in the preparation of data for submittal should either be federal public domain programs or have sufficient documentation submitted with a copy of the program to allow for the review of the program. Spreadsheet applications which include equations should also be submitted to allow for the review of their equations. The data generated by all computer programs and spreadsheet applications may not be accepted as correctly representing the information required to be submitted.

IV. HYDROLOGIC AND HYDRAULIC INVESTIGATIONS

Various methods of analyzing the hydrologic and hydraulic characteristics of a watershed, reservoir, and dam are available. Some of the procedures which are generally acceptable for determination of the hydrologic and hydraulic characteristics are presented in the paragraphs that follow. In general, procedures developed by the following agencies are acceptable: U.S. Army Corps of Engineers; U.S. Department of the Interior, Bureau of Reclamation; U.S. Department of Agriculture, Natural Resources Conservation Service; and U.S. Department of Commerce, National Weather Service. The Office of Water Resources will use the Corps of Engineers and the National Weather Service computer programs as its primary review aids. The programs typically used by OWR for review include: HEC-1, HEC-HMS, HEC-2, HEC-RAS, and FLDWAV.

A. Maximum Water Surface Based on Spillway Design Flood Peak Inflow:

When the total project uncontrolled spillway discharge capability at maximum pool exceeds the peak inflow of the spillway design flood, a reservoir routing is not required. Flood volume is not controlling in this situation and surcharge storage is either absent or insignificant in relation to the spillway and outlet capacity.

When the 100-year, 50-year, or 25 year floods are applicable under the provisions of the "Rules for Construction and Maintenance of Dams", and streamflow data at or near the dam site are available, the spillway design flood peak inflow can be determined by a flood frequency analysis. The recommended method is outlined in "Guidelines for Determining Flood Flow Frequency" by the U.S. Water Resources Council, Hydrology Committee, Bulletin 17B, Revised March, 1982.

When streamflow data are not available, the recommended method is described in the latest version of documents from the U.S. Geological Survey for estimating the magnitude and frequency of floods on rural streams in Illinois. Adjustments to the computed rural discharges must be made to account for urbanization in the watershed. The U.S. Geological Survey has also published documents to assist in the determination of this adjustment. The methods described in TR55, "Urban Hydrology for Small Watersheds") may also be used if the appropriate rainfall values (see Section B1 below) are used.

B. Maximum Water Surface Based on Spillway Design Flood Inflow Hydrograph:

When either the Probable Maximum Flood (PMF) peak or a fraction thereof is required, the "unit hydrograph-infiltration loss rate technique" is considered the most expeditious method of computing the spillway design flood (SDF) peak inflow for most projects. Both the peak and the volume are required in this analysis. Where the surcharge storage is significant, or where there is insufficient discharge capability at maximum pool to pass the peak inflow of the SDF, considering all possible operational constraints, a flood hydrograph is required. Determination of the probable maximum precipitation (PMP) or the 100, 50, or 25 year precipitations, whichever is applicable, and unit hydrographs will be required, followed by the determination of the spillway design flood hydrograph.

1. Rainfall and Distribution

The PMP value used for dam safety purposes should be of at least a 24-hour duration and should be obtained from the National Weather Service Hydrometeorological Report No. 51, "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian", June, 1978. The method of applying the PMP for HMR51 is described in a companion report, Hydrometeorological Report No. 52, "Application of Probable Maximum Precipitation Estimates - United States East of the 105th Meridian," August, 1982. Generalized rainfall reduction factors, such as the Hop Brook Factor, should not be used for the PMP estimates regardless of the source from which the estimates were obtained.

Rainfall values for frequency events, i.e. 100-year, 50-year and 25-year should be obtained from the Illinois State Water Survey (ISWS) Circular 172, "Frequency Distribution and Hydroclimatic Characteristics for Heavy Rainstorms in Illinois." The suggested method to distribute this rainfall is described in the ISWS publication, Circular 173, "Time Distributions of Heavy Rainstorms in Illinois".

2. Rainfall Excess

Rainfall excess is that portion of the rainfall which is not lost to infiltration, interception, and depression storage. Loss rates should be estimated for computing the rainfall excess. Consideration should be given to the seasonal variation of rainfall amounts, the associated ground cover, and the current land use. Also when applicable, snowmelt runoff rates and appropriate releases from upstream projects should be estimated.

The Natural Resources Conservation Service's weighted watershed curve number (CN) procedure is one of the most widely used methods for determining rainfall excess. If the applicant prefers, a rainfall-runoff relation for the studied basin, or one with similar characteristics, can be developed to determine the rainfall excess.

3. Unit Hydrograph

The unit hydrograph, i.e., the graph of discharge against time, is used to forecast the streamflow at a given point from one inch of direct runoff from a storm of specified duration. The duration selected should not exceed about 1/4 of the time of concentration. The time of concentration is the travel time of water from the hydraulically most distant point of the watershed to the point of interest. There are three basic approaches to the derivation of the unit hydrograph:

(A) Analysis of recorded runoff at a streamflow gaging station at or near the damsite on the same stream.

(B) Transposition of a unit hydrograph from another basin of comparable size and watershed runoff characteristics.

(C) Synthetic unit hydrographs based upon equations relating hydrograph parameters such as peak flow, time to peak, time base, etc. to the physical characteristics of the basin such as area, length, slope, etc.

Several of the more popular accepted methods of synthetic unit hydrograph derivation include:

(1) Clark's method used by the Corps of Engineers in the HEC-l and HEC-HMS computer programs.

(2) Natural Resources Conservation Service's curvilinear or triangular unit hydrograph.

(3) Snyder's method for Illinois developed by the Illinois State Water Survey.

4. Design Storm Inflow Hydrograph

Design storm refers to the intensity-duration combination of the precipitation which produces the most severe flood runoff and/or reservoir stage for the specified precipitation frequency. The time duration for a designated storm will vary depending on the hydrologic and physiographic characteristics of a specified watershed and the affect on the reservoir will depend on the storage-outflow relationship of the proposed reservoir. The design precipitation event is

divided into increments of time equal to the duration of the unit hydrograph using the appropriate distribution methods. The rainfall excess is determined by subtracting the appropriate loss rates from the rainfall depths to determine the runoff values. The ordinates of the unit hydrograph at the same time increment are then multiplied by the rainfall excess, lagged accordingly, then summed to determine the direct runoff inflow hydrograph.

If a storm hydrograph for a ratio of the PMF is required, the total PMF inflow hydrograph to the reservoir must be determined. The appropriate ratio should then be applied to the ordinates of the PMF inflow hydrograph. Ratios should not be taken of the PMP. If there are other dams or flow restrictive structures, upstream of the dam being analyzed, the total PMF hydrograph to the dam and its reservoir should be determined. Ratios can then be applied to the PMF to determine the response of the dam and reservoir to this design storm inflow hydrograph. Upstream dams and restrictive structures should be included in the analysis only if they are assured of remaining in their current configuration, such as a government owned and controlled flood control or water supply dam.

The use of a partial storm hydrograph (such as is noted in TR55, "Urban Hydrology for Small Watersheds") is not appropriate for use when the design storm inflow hydrograph is needed. These methods may be used to determine the peak inflow (see Section A above) if the appropriate rainfall values (see Section B1) are used.

5. Reservoir Area-Storage-Elevation Data

Reservoir surface area and storage capacity versus water surface elevation (tables or curves) are required. These data are usually determined by planimetry from topographic contour maps with scales equal to USGS 7.5 minute quadrangles or better.

6. Spillway Discharge-Elevation Data

Rating curves or tables are required for all discharge facilities contributing to the maximum design flood outflow hydrograph. If flow capacity is developed synthetically based upon semi-empirical equations for weir, orifice, or pipe flow, assumed coefficients and how they were selected should be stated and

referenced. When sufficient criteria and guidance are not available to determine the spillway flow capacity synthetically, a physical hydraulic model study should be performed with all model tests and performance results documented.

7. Downstream Tailwater Discharge-Elevation Data

A tailwater rating curve showing the downstream flow capacity versus elevation is required. Elevations of bankfull (at top of bank) channel capacity, principal and total spillway design floods, and 100-year flood immediately below the dam site should be noted. The method and support calculations used to determine the downstream water surface elevations (i.e., standard step backwater analysis, normal depth solution of Manning's equation, etc.) including all channel and overbank roughness, length, slope or cross section data and tailwaters due to a receiving waterway should be listed.

8. Design Storm Outflow Hydrograph

The outflow hydrograph from a dam spillway system may be estimated by either hydrologic or hydraulic routing methods. One of the simplest and most popular methods of reservoir routing is called the "Modified Puls" storage routing method. This method is described in most hydrology text books. It is also a feature of computer programs such as the Natural Resources Conservation Service's TR-48 or the Corps of Engineer's HEC-l and HEC-HMS. A hydraulic routing procedure is also acceptable and is a better method to be used for situations where a hydrograph is rapidly varying. The NWS computer program FLDWAV, the Corps of Engineers' computer programs UNET and HEC-RAS, and the USGS computer program FEQ have this capability.

C. Potential Upstream Flood Hazard Areas

Areas adjacent to the normal storage retention level that would be potentially subject to flooding should be examined to determine if a hazard to life or property could occur during sudden or frequent increases in the reservoir water surface elevation. Ownership or flood easement agreements are required from upstream property owners up to the 100-year flood elevation for new dams or for modifications to dams which include an increase in the reservoir water surface elevations.

D. Emergency and Normal Drawdown Capability

An assessment of the capability to reduce the reservoir storage within a reasonably rapid time interval to avert impending failure, or to facilitate repairs in the event of structural, embankment, or foundation problems should be made. The capability for dewatering the reservoir within a reasonable time period should be addressed with allowances for reservoir siltation and at least the typical base flow for the waterway. Gravity systems which have the capability of dewatering the entire reservoir should be provided. Other systems, such as siphons or pumps which dewater only a portion of the reservoir, will only be authorized for unique situations such as at existing dams without a current dewatering system. Factors that will be considered by OWR in determining the required drawdown time include: the purpose of the dam and reservoir; the risk and nature of a potential failure; the damage potential posed by possible failure; and the potential damage to downstream properties. Computations and assumptions used for calculating the total reservoir drawdown time and for an emergency drawdown of 50% of the normal pool storage volume, should be submitted. Recommended times for 50% drawdown are 7 days for Class I Dams, 14 days for Class II Dams, and 30 days for Class III Dams.

The capability and stability of available drainage courses to convey the waters released during a dewatering and the influence of a drawdown on the stability of the dam should be assessed. Except for emergency situations, the maximum drawdown rate should not typically exceed approximately 1.0 ft. per day.

E. Freeboard Design

Factors that should be considered in determining the minimum freeboard include the duration of high water levels in the reservoir during the design flood; the wind fetch and reservoir depth available to support wave generation; the probability of high wind speed occurring from a critical direction; the potential wave runup on the dam based on roughness and slope; and the ability of the dam to resist erosion from overtopping waves.

References for the method of analysis and the pertinent data utilized for determining the minimum freeboard should be submitted in order to verify that the dam is safe against overtopping during occurrence of the total spillway design flood and wave action using the maximum wave determination.

F. Upstream Face Protection

It is necessary to protect the upstream face of an earth embankment dam from wave erosion. The orientation, length, and purpose of the reservoir, the duration of higher reservoir stages, and the embankment material all affect the need for and the type of embankment protection. Upstream slope protection usually consists of rock riprap which should consist of a well graded, hard, durable rock. For small reservoirs with minimal change in pool elevation during flood events, a flat slope on the upstream face with a designed vegetative protection method can provide the necessary embankment protection.

The protection must also extend below the normal pool elevation a minimum of 2 ft. or 0.50 times the anticipated wave height (if greater than 2 ft.). In determining the elevation of the protection below the normal pool elevation beyond the minimum requirements, consideration should be given to the potential variation of the pool due to the purpose of the reservoir, operational factors, and the base flow of the inflow stream. The protection also serves the purpose of discouraging muskrats and other burrowing animals from burrowing a den into the embankment. The riprap and filter layer should extend at least 3 ft. below the pool elevation to offer a better deterrent to the animals.

G. Design of the Energy Dissipator Structures

Energy dissipators should be capable of sufficiently reducing the energy to insure against damage to the spillway or outlet system. Types of energy dissipators are numerous. Several of the more common type include the following: hydraulic jump stilling basin; impact-type dissipator; deflector bucket; submerged deflector bucket; plunge pool; and baffled chute. All design computations should include an assessment of the impact of a range of flows up to and including the total spillway design flood. The design should also address variations in the flows and tailwaters in the downstream channel due to flows from the principal and emergency spillways and in the receiving waterway.

A proper design should include the evaluation of the topographic features of the site, the relationship of storage capacity to flood volume, the geologic or foundation conditions, the type and height of the dam, and any other unique conditions pertaining to a particular site. In unusual situations when sufficient criteria and guidance are not available for analytical design, a

physical hydraulic model study should be performed with the model tests and performance results reported.

H. Dam Breach Wave Analysis

Analyses should be made to determine the most adverse failure conditions and the resulting peak outflows and water surface elevations downstream of the dam following failure of the dam. To provide sufficient information for classification of a dam, the breach analyses should also assume nearly instantaneous total (full height) failures covering a range of events from normal pool up to and including the probable maximum flood (PMF). For Class I and II dams, computations for the dam breach wave analysis are required for a nearly instantaneous total (full height) failure of the dam during normal pool and total spillway design flood conditions. Analyses completed for flood conditions should use the maximum reservoir elevation to initiate the modeled failure of the dam. However, if the maximum reservoir elevation overtops the dam, then the lower elevation of the maximum elevation or 1 ft. above the top of the dam should be used to initiate the modeled failure of the dam. Inundation maps on 7.5 minute quadrangles or better mapping should be provided for each failure condition studied.

The term "nearly instantaneous," for the purposes of this document, is the shortest time interval for which the computer model being used will provide mathematically stable results. This time is usually about 5 minutes and typically does not exceed 15 minutes and is consistent with failure times for earth embankment dams. The failure times for concrete dams are typically quicker than those for embankment dams.

Based upon dam failures which have occurred in the past, the average breach width for an embankment dam is usually in the range of 2 to 5 multiplied by the height of the dam. The side slopes of the breach of an embankment dam are typically greater than the angle of repose of the dam materials but may vary between vertical to 1 horizontal:1 vertical.

A dam breach analysis requires several steps: developing the reservoir inflow hydrograph; routing that hydrograph through the reservoir; selecting failure conditions for the structure (i.e., mode, shape, size, and time); calculating the outflow hydrograph from the failed structure; and modeling the movement of the flood wave downstream, including downstream tributary inflows, to determine travel

times, inundated areas, and maximum water surface elevations.

To determine the classification of a dam, the acquisition of additional information relative to the potentially impacted structures downstream of the dam may be necessary. Information such as the types of structures (residences, other building uses, infrastructure) within the breach inundation area, the low entry and first floor elevations of buildings, and the availability of alternate access routes to buildings if the primary access is damaged is typical. In general, the routing of the dam breach hydrograph should continue downstream to the point where the breach versus non-breach water surface profile elevation difference does not exceed 1 foot or the breach wave is contained within the channel.

Criteria, methodology, and computer programs developed by the National Weather Service, U.S. Corps of Engineers, and the U.S. Geological Survey, for simulating a hypothetical dam failure are, in general, acceptable. Simplified methods usually do not provide sufficient detail to be considered acceptable except in emergency situations where time does not allow a more detailed analysis. Documentation explaining theoretical aspects of the mathematical models, forecast ability, simulation accuracy, computer input parameter requirements, etc. are available directly from these federal agencies.

I. Hydrologic & Hydraulic Design References

The following list is provided to aid the design engineer and is not intended to be a complete listing of all available reference material.

General

"Handbook of Applied Hydrology" by Ven Te Chow, McGraw-Hill Book Company

"Handbook of Applied Hydraulics" by David & Sorensen McGraw-Hill Book Company

"Handbook of Hydraulics" by King and Brater McGraw-Hill Book Company

"Water Resources Engineering" by Linsley and Franzini, McGraw-Hill Book Company

Bureau of Reclamation

"Design of Arch Dams"

"Design of Gravity Dams"

"Design of Small Canal Structures"

"Design of Small Dams"

"Discharge Coefficients for Irregular Overfall Spillways", Engineering Monograph No. 9

"Hydraulic Design of Stilling Basin for Pipe or Channel Outlets", Research Report No. 24

"Hydraulic Design of Stilling Basins and Energy Dissipators", Engineering Monograph No. 25

"Unitgraph Procedures"

“Design Standards No. 13, Embankment Dams”

Corps of Engineers

“Shore Protection Manual,” Volumes 1-3

Engineering Manuals (EM):

1110-2-1602, Hydraulic Design of Reservoir Outlet Structures

1110-2-1603, Hydraulic Design of Spillways

1110-2-50, Low Level Discharge Facilities for Drawdown of Impoundments

1110-2-1450, Hydrologic Frequency Estimates

1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations

Engineering Technical Letters (ETL):

1110-2-221, Wave Runup and Wind Setup on Reservoir Embankments

1110-2-305, Determining Sheltered Water Wave Characteristics

Mine Safety and Health Administration

Engineering and Design Manual, Coal Refuse Disposal Facilities

Natural Resources Conservation Service

"SITES," Water Resource Site Analysis Program

National Engineering Handbook:

Section 4 - Hydrology

Section 5 - Hydraulic

Section 11 - Drop spillways

Section 14 - Chute spillways

Technical Releases (TR):

2, Earth Spillways

16, Rainfall-Runoff Tables for Selected Runoff Curve Numbers

20, Computer Program for Project Formulation-Hydrology

25, Design of Open Channels

29, Hydraulics of Two-Way Covered Risers

39, Hydraulics of Broad-Crested Spillway

48, Computer Program for Project Formulation-Structure Site Analysis "DAMS-2"

49, Criteria for the Hydraulic Design of Impact Basins

52, A Guide for Design & Layout of Earth Emergency Spillways

55, Urban Hydrology for Small Watersheds

56, A Guide for Design and Layout of Vegetative Wave Protection for Earth Dam Embankments

59, Hydraulic Design of Riprap Gradient Control Structures

60, Earth Dams and Reservoirs

61, Computer Program for Water Surface Profiles

Design Notes (DN):

DN-6 Riprap Lined Plunge Pool for Cantilever Outlet

DN-8 Entrance Head losses in Drop-Inlet Spillways

Federal Emergency Management Agency

"Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams".

National Weather Service

Hydrometeorological Report No. 51 - "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian"

Hydrometeorological Report No. 52 - "Application of Probable Maximum Precipitation Estimates - United States East of the 105th Meridian"

"BREACH": An Erosion Model for Earthen Dams

"FLDWAV": A Generalized Flood Routing Model

Illinois State Water Survey

Bulletin 70, "Frequency Distribution and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois"

Bulletin 71, "Rainfall Frequency Atlas of the Midwest"

Circular 172, "Frequency Distributions of Heavy Rainstorms in Illinois"

Circular 173, "Time Distributions of Heavy Rainstorms in Illinois"

Illinois WRC Research Report No. 107, "Criteria for Shore Protection Against Wind Generated Waves for Lakes and Ponds in Illinois"

Report of Investigation 65, "Model Test Results of Circular, Square, and Rectangular Forms of Drop-Inlet Entrance to Closed-Conduit Spillways"

Report of Investigation 67, "Hydraulic Jump Type Stilling Basins for Froude Number 2.5 to 4.5"

SWS contract Report 258, "Derivation and Regionalization of Unit Hydrograph Parameters for Illinois (Dam Safety Program)"

United States Geological Survey

"Equations for Estimating Clark Unit-Hydrograph Parameters for Small Rural Watersheds in Illinois", WRI 00-4184, 2000

"Technique For Estimating Flood-Peak Discharges and Frequencies on Rural Streams in Illinois", WRI 87-4707, 1987.

"Effects of Urbanization on the Magnitude and Frequency of Floods in Northeastern Illinois", WRI-79-36, 1979.

"River Mileages and Drainage Areas for Illinois Streams", Volumes l and 2, WRI 79-110, 1979.

"Time of Concentration and Storage Coefficient Values for Illinois Streams", WRI 82-13, 1982.

"A Technique for Estimating Time of Concentration and Storage Coefficient Values for Illinois Streams", WRI 82-22, 1982.

"Water Resources Data for Illinois"

"Investigation of Techniques to Estimate Rainfall-Loss Parameters for Illinois", WRI 87 4151, 1989.

Federal Highway Administration

Hydraulic Engineering Circulars:

No. 5 -"Hydraulic Charts for the Selection of Highway Culverts".

No. 10 -"Capacity Charts for the Hydraulic Design of Highway Culverts".

No. 13 -"Hydraulic Design of Improved Inlets for Culverts".

No. 14 -"Hydraulic Design of Energy Dissipators for Culverts & Channels".

No. 15 - "Design of Stable Channels with Flexible Linings".

Hydraulic Design Series No. 1 - "Hydraulics of Bridge Waterways".

Hydraulic Design Series No. 3 -"Design Charts for Open-Channel Flow".

V. STRUCTURAL AND GEOTECHNICAL INVESTIGATIONS AND DESIGN

A. Geotechnical Investigations

For all dams an investigation of the foundation and abutment soils or bedrock and the borrow materials that are to be used to construct the dam should be made. The foundation and abutments investigation should consist of borings, test pits and other subsurface exploration necessary to clearly define the existing conditions. The appropriate field and laboratory tests to be made should be based on the magnitude and type of the dam, as well as the characteristics of the foundation deposits, abutments, and materials available for use in the embankment. Some of the common tests made are Standard Penetration Tests (N-Values), unconfined compressive strength (q_u) tests, direct shear tests, triaxial tests, water content tests, Atterberg-limit tests, particle size analysis tests, Standard Proctor moisture-density relations, permeability tests, consolidation tests, and dispersion tests. Soils should be at least classified according to the Unified Soil Classification System.

In general, for embankment dams greater than 30 feet in height, the foundation and embankment soil shear strengths for the unconsolidated-undrained (Q), consolidated-undrained (R), and consolidated-drained (S or $\bar{R}$) conditions are to be based on actual test data from the dam site. One half the unconfined compressive strength ($q_u/2$) is usually adequate for the unconsolidated-undrained (Q) condition.

For embankments 30 feet or less in height, at least the unconfined compressive strengths (q_u) and the standard Penetration Test (N-Values) of the soils are to be determined from actual test data, unless unusual foundation

conditions exist which require a more thorough investigation. It is recommended that the R and S or $\bar{R}$ condition soil strengths also be determined from actual test data from the dam site.

B. Earth and Rockfill Embankments -- Structural Stability.

The embankment and foundation should be analyzed for stability against failure from sliding, sloughing, or rotation along potential failure surfaces using a phi value of "0". The following loading conditions should be investigated:

Case	Loading Condition	Minimum Factor of Safety w/o Seismic Forces	Minimum Factor of Safety w/ Seismic Forces
I	End of Construction	1.3*	N/A
II	Steady Seepage	1.5**	1.0
III	Sudden Drawdown	1.2***	N/A

* For embankments over 50 feet high on relatively weak foundations, use a minimum factor of safety of 1.4.

** The submitted design will be reviewed for an effective stress condition. A review using S or $\bar{R}$ with c=0 will also be performed. Where the analysis relies on the cohesion component to meet the minimum factor of safety, an analysis of the soil chemistry may be required.

*** The factor of safety should not be less than 1.5 when the drawdown rate and pore water pressures developed from flow nets are used in the stability analyses.

Computations of factors of safety for various loading conditions and shear strengths are readily made using computer programs. Several computer programs are available for the completion of the analysis including those developed by the federal agencies and many universities.

Seismic activity should be considered in the design of all dams in Illinois. The Peak Ground Acceleration values for 2% probability of exceedance in 50 years is shown in Appendix 1. Dams located in an area with a peak acceleration greater than 20%g must have a seismic stability

analysis using equivalent static load methods included in the application submittal package. The values found in Appendix 1 should be the minimum coefficient. Dynamic analysis methods should also be considered for dams in areas of high seismic activity.

So that earth embankment side slopes can be easily maintained and/or mowed, it is recommended that the downstream slope be no steeper than 3:1. Crown vetch or similar types of ground cover should not be planted on the slopes of earth embankments because it severely restricts the ability to inspect the slopes for sloughing, erosion, seepage, animal holes or excessive settlement.

C. Earth Embankments -- Seepage.

Adequate analyses should be made of anticipated seepage rates and pressures through the embankment, foundation and abutments. The analyses should show that the seepage flow through the embankment, foundation and abutments will be controlled so that no internal erosion takes place and no sloughing takes place in the area where the seepage emerges.

D. Earth Embankments -- Conduits.

Conduits through earth embankments are to be a pressure type conduit, such as reinforced concrete pressure pipe or cast-in-place reinforced concrete. However, non-pressure type conduits properly detailed may be allowed for Class III dams, 30 feet or less in height. Reinforced concrete pipe should meet one of the following specifications:

(A) ASTM C 361
(B) AWWA C 300
(C) AWWA C 301
(D) AWWA C 302

Reinforced concrete pipe should be supported on a concrete bedding or cradle, and reinforced where spreading might be a factor. The pipe joints should incorporate a rubber gasket set in a positive groove as described in the above specifications which will prevent its displacement from either internal or external pressure under the required joint extensibility.

Conduits other than the reinforced concrete pipes listed above may be used. For those designs the application should fully document that the proposed conduit will provide performance equal or superior to reinforced concrete pressure pipe.

It is recommended that all conduits which pass through an embankment have a filter constructed at the downstream end of the conduit to control any seepage along the conduit regardless of whether anti-seep collars are used.

E. Concrete Dams and Structures.

Concrete dams and structures appurtenant to embankment dams should be capable of resisting overturning, sliding and overstressing with adequate factors of safety for normal and maximum loading conditions. Loadings to be considered in the stability analyses include the water load on the upstream face of the dam; the weight of the structure; internal hydrostatic pressures (uplift) within the body of the dam, at the base of the dam and within the foundation; earth and silt loads; ice pressure, seismic and thermal loads, and other loads as applicable. A gravity structure should be capable of resisting all overturning forces.

The analysis of concrete stresses should be based on in situ properties of the concrete and foundation. Tensile stresses in unreinforced concrete are acceptable only in locations where cracks will not adversely affect the overall performance and stability of the structure. Foundation stresses should be such as to provide adequate safety against failure of the foundation material under all loading conditions.

Sliding of concrete gravity structures and of abutment and foundation rock masses for all types of concrete dams should be evaluated by the shear-friction resistance concept. The investigation should be made along all potential sliding paths. The shear-friction safety factor is obtained by dividing the resistance, including the applicable downstream passive wedge if appropriate, by the summation of horizontal service loads. Computed sliding safety factors approximating 3 or more for all loading conditions without earthquake, and 1.5 including earthquake, should indicate satisfactory stability, depending upon the reliability of the strength parameters used in the analyses. Designs based on Corps of Engineers, Bureau of Reclamation, or Natural Resources Conservation Service criteria are generally acceptable.

F. Concrete Design.

The loadings, allowable stresses, load factors, and safety factors for the design of concrete structures should be those appropriate for hydraulic structures. Concrete design should be in accordance with the applicable sections of the latest edition of the "Building Code Requirements for

Reinforced Concrete" (ACI 318); however, because hydraulic structures are subjected to a relatively severe environment and unknown loading conditions, due consideration should be given to the allowable stresses or "Z" values used so that adequate crack control is achieved. Working stress and strength designs should be based on 28-day concrete strengths not less than 3000 psi.

The following minimum clear cover of main reinforcement should be used:

Structures exposed to weather, or backfill, or submerged and can be made accessible
Bar Size Nos. 5 and less - - - - - - - - - - - - - 1 1/2"

Structures exposed to weather, or backfill, or submerged and can be made accessible
Bar Size Nos. 6 through 18 - - - - - - - - - - - - 2"

Structures submerged and cannot be made accessible
All Bar Sizes - - - - - - - - - - - - - - - - - - - 2 1/2"

Concrete cast against and permanently exposed to earth or rock
All Bar Sizes - - - - - - - - - - - - - - - - - - - 3"

All concrete construction, contraction, and expansion joints subject to hydrostatic pressure should be protected by the use of waterstops or other means.

G. Steel Design.

Structural steel design should be based on the applicable sections of the latest edition of the American Institute of Steel Construction (AISC) specifications. The applicable sections of the latest edition of the Standard Specifications for Highway Bridges adopted by the American Association of State Highway and Transportation Officials (AASHTO) are acceptable, as well as designs prepared using Corps of Engineers, Natural Resources Conservation Service or Bureau of Reclamation specifications.

H. Spillways and Energy Dissipators.

The range of spillways and energy dissipator types which can be used on a dam project is very large. If a standard design is used, reference to the standard used is acceptable for the structural design documentation. If a non-standard design is proposed, the structural design computations submitted should be based on the commonly accepted principles of structural analysis and design.

Underdrains and/or anchors should be considered in the design of chute spillways.

I. Filters and Drains.

When filters and/or drainage blankets are required because of a significant difference between the gradation of the material to be protected and the material of the drain, they should be designed to provide for the controlled flow of the water while precluding the movement of embankment and filter materials. Examples of situations where filters may be required are zoned embankments, rockfill dams, pipe underdrain systems, and chimney drains and drainage blanket systems. Typical filter design criteria are shown in the Bureau of Reclamation's "Design of Small Dams" and "Earth Manual".

J. Geosynthetics.

Geosynthetics may be used in dams as filters, drains and impermeable membranes. An important aspect of the use of geosynthetics is the choice of the appropriate material and opening size. The use of geosynthetics at many construction sites are not as sensitive to this correct choice as at dams. Generalized use of geosynthetics does not assure their performance or acceptability. Detailed analysis must be completed to assure adequate constructability and functionality exists.

Geosynthetic materials are commonly used in filter and drain applications. The geosynthetic often replaces several layers of a granular design. Caution should be used in the adoption of standards developed for other engineered solutions. The assumptions and performance standards may not be consistent with those required for dam safety.

K. Riprap.

Riprap should be designed for its expected use and anticipated water velocities. All riprap should be placed on a properly designed bedding to prevent the loss of the underlying base material, unless the gradation of the underlying base material is such that it will not infiltrate through the riprap. Properly designed geosynthetic materials can be used to provide the bedding. For most riprap gradations a sand layer is required between the riprap and a geosynthetic material to prevent damage to the material during construction.

L. Geotechnical and Structural References.

The following references are a representative sample of publications available which are related to dam design, construction and safety, but are not intended to be all inclusive of dam technology.

General

"Designing with Geosynthetics", Koerner

"Earth and Earth-Rock Dams", Sherard, Woodward, Gizienski, and Clevenger. (Wiley)

"Soil Mechanics in Engineering Practice", Terzaghi and Peck. (Wiley)

"Foundation Engineering", Peck, Hanson and Thornburn. (Wiley)

"Seepage, Drainage & Flow Nets", Cedergren. (Wiley)

"Foundation Engineering Handbook", Edited by Winterkorn and Fang. (Van Nostrand Reinhold)

"Soil Testing For Engineers", Lambe. (Wiley)

"Stability Analysis of Earth Slopes", Huang. (Van Nostrand Reinhold)

"Special Procedures for Testing Soil and Rock for Engineering Purposes", Special Technical Publication No. 479, ASTM.

Proceedings - Research Conference on Shear Strength of Cohesive Soils, ASCE, 1960.

Proceedings - Stability and Performance of Slopes and Embankments, ASCE, 1966.

Bureau of Reclamation

"Design of Small Dams"

"Design of Gravity Dams"

"Design of Arch Dams"

"Earth Manual"

"Hydraulic Design of Stilling Basins and Energy Dissipators", Engineering Monograph No. 25.

"Stilling Basin Performance; An Aid in Determining Riprap Sizes", Hydraulic Laboratory Report No. HYD-409.

"Concrete Manual"

"Design Standards No. 3" - Canals and Related Structures

Corps of Engineers

"National Program of Inspection of Dams", Volume I, Appendix D, "Recommended Guidelines for Safety Inspection of Dams"

"Shore Protection Manual," Volumes 1-3

Engineering Manuals (EM):

1110-2-1601, Hydraulic Design of Flood Control Channels

lll0-2-1901, Soil Mechanics Design-Seepage Control

lll0-2-1902, Stability of Earth and Rockfill Dams

lll0-2-1906, Laboratory Soils Testing

lll0-2-1908, Instrumentation of Earth and Rockfill Dams

lll0-2-1911, Construction Control for Earth and Rockfill Dams

lll0-1-2101, Working Stresses For Structural Design

lll0-2-2200, Gravity Dam Design

lll0-2-2300, Earth and Rockfill Dams General Design and Construction Considerations

lll0-2-2400, Structural Design of Spillways and Outlet Works

lll0-2-2702, Design of Spillway Tainter Gates

1110-2-4300, Instrumentation for Measurement of Structural Behavior of Concrete Gravity Structures

Engineering Technical Letters (ETL):

1110-2-222, Slope Protection Design for Embankments in Reservoirs

Hydraulic Design Criteria (HDC):

712-1, Stone Stability, Velocity vs. Stone Diameter

Natural Resources Conservation Service

National Engineering Handbook:

Section 6 - Structural Design

Section 11 - Drop Spillways

Section 14 - Chute Spillways

Technical Releases (TR):

18, Computation of Joint Extensibility Requirements

30, Structural Design of Standard Covered Risers

52, A Guide for the Design and Layout of Earth Emergency Spillways

54, Structural Design of SAF Stilling Basins

60, Earth Dams and Reservoirs

67, Reinforced Concrete Strength Design

69, Riprap for Slope Protection Against Wave Action

Design Note (DN)

6, Riprap Lined Plunge Pool for Cantilevered Outlet

Soil Mechanics Note (SMN)

1, Tentative Guides for Determining the Gradation of Filter Materials

Mining Safety and Health Administration

"Engineering and Design Manual, Coal Refuse Disposal Facilities", 1975.

Illinois Department of Transportation

"Soils Manual"

Illinois State Geological Survey

Bulletin 94, Pleistocene Stratigraphy of Illinois

Bulletin 95, Handbook of Illinois Stratigraphy

Circular 490, Glacial Drift in Illinois: Thickness and Character

American Society of Civil Engineers

"Current Trends in Design and Construction of Embankment Dams", Wilson and Marsal, 1979. (ASCE)

Federal Highway Administration

Hydraulic Engineering Circular

No. 14, Hydraulic Design of Energy Dissipators for Culverts and Channels

No. 15, Design of Stable Channels with Flexible Linings

VI. OPERATION PLAN

A documented plan of operation for normal conditions, flood events, and emergency conditions is required. This plan should include availability of the damtender, means of communication between the damtender and his supervising authority, method of gate operation (manual, automatic or remote control), a list of the names, addresses, and telephone numbers of people and agencies to contact during normal and emergency conditions, and a list of standing instructions for normal, flood, and emergency conditions. The actions to be taken at the dam during an emergency condition are a portion of the emergency action plan for the dam which is described in a following section.

A copy of the operation plan should be provided to the damtender and kept at the project site. An example operation and maintenance plan is included as Appendix A. This example is for the purpose of providing generalized guidance in the development of the specific plans for the dam being designed and is not a required format.

VII. MAINTENANCE PLAN

A maintenance plan must be submitted which includes a listing of the equipment and manpower necessary and a time schedule for performing routine inspections and the inspections required in the "Rules for Construction and Maintenance of Dams". This plan should, at a minimum, address the following items: prevention of the growth of trees and brush on the embankment, on the abutment, on the downstream area a minimum distance of one-half the height of the dam or 20 ft. from the toe of the embankment whichever is greater, and within the spillway system; maintenance of adequate vegetation to prevent erosion of the embankment and earth spillway and the method by which the vegetation will be maintained to allow adequate visual inspection of the embankments, spillways, and crest of the dam; removal of debris or other deleterious materials from the spillway systems; inspections as necessary to insure that all gates, orifices, dissipators and other appurtenances and all mechanical and electrical equipment that affect the operation of the dam and reservoir are kept in good repair and working order; and a time schedule for test operation of all spillway and outlet gates or other equipment that must operate to pass flood flows. The OWR document entitled “Guidelines and Forms for Inspection of Illinois Dams” also

provides a generalized listing of the items to be inspected and therefore the items that need to be considered in the development of the maintenance plan. The maintenance plan should be specific to the dam.

A copy of the maintenance plan should be provided to the damtender and kept at the project site. A detailed record of all maintenance is required, including dates and results of routine inspections, and complete information on all maintenance, rehabilitation, and improvements. This record should also include data on the structural behavior of the dam embankment and spillway system for all major flood and seismic events.

An example operation and maintenance plan is included as Appendix A. This example is for the purpose of providing generalized guidance in the development of the specific plans for the dam being designed and is not a required format.

VIII. EMERGENCY ACTION PLAN

An emergency action plan is a formal document which identifies potential emergency conditions at a dam and specifies the procedures to be taken by various entities in response to the noted emergency. The plan should address: accidents at the dam which could affect the operation of the dam or present a hazard to areas downstream of the dam; impending flood conditions even though the dam may not be in danger; and the potential failure of the dam. The inundation mapping prepared as a portion of the dam breach analyses should be included in this plan.

Emergency action plans are necessary to provide early warning and notification of an emergency. Emergency action plans must be site specific. The plan for a dam must address not only the specific characteristics of the dam but also the capabilities and resources of the dam owner and the emergency responders. Due to its need to be unique, an example plan is deliberately not included in these guidelines. An appropriate format for the development of an emergency action plan is available in the document entitled "Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners," prepared by the Interagency Committee on Dam Safety and the Federal Emergency Management Agency (FEMA-64).

OWR and the Illinois Emergency Management Agency offer a course on the development of emergency action plans for dams. Contact OWR's Division of Resource Management for schedule information.

IX. DAM REMOVALS AND ABANDONMENTS

This section provides guidance regarding the removal of dams and the abandonment of slurry disposal or similar material impoundment dams. However, both removal and abandonment usually result in the dam ultimately being eliminated from the Office of Water Resources regulatory purview.

Abandonment may differ from removal of a dam in that abandonment may leave the embankment intact. Dams which are typically considered for abandonment include slurry disposal, dredge disposal and fly ash disposal impoundment dams. The principles noted for the abandonment of these dams should be applicable to the abandonment of other similar structures.

B. INVESTIGATIONS AND EVALUATIONS FOR REMOVAL OF DAMS

The removal of a dam requires careful planning and design. The size, height, reservoir impounding capacity, upstream and downstream channel conditions, existing reservoir sediment deposits, degree of hazard in case of failure, as well as any other considerations which might be peculiar to a particular dam, all have impacts on the removal process.

A method to remove or reduce the stored water prior to initiating the breach of the dam must be determined. When available, use of the dam's dewatering structures would generally be the appropriate method of drawdown. For dams without dewatering structures, the installation of siphons or pumps may be an appropriate method. Items to consider in determining the drawdown rate should normally include the capacity of the dewatering structure, the flow into the reservoir from the tributary areas, the downstream channel's bank full flow capacity, and the affects of the speed of a reservoir drawdown on the embankment and shoreline.

The method to be used for the breach of the dam can vary from typical excavation with earth moving equipment for embankment dams to controlled blasting for concrete dams. The time necessary to accomplish the breach and the flows which may enter the reservoir during that time should be considered in determining the method.

The size of the breach, width and depth, needs to be large enough that a potential failure of the remaining portion of the dam and resultant release of stored water does not cause a significant increase in downstream water surface elevations. To prevent downstream damage, an assessment of water surface elevations at the breach is used as a means to establish the necessary breach size for flows up to and including the 100-year frequency flood. For configurations where the breach opening will be to the invert elevation of the channel at the downstream toe, a backwater analysis from the downstream channel and floodplain cross section to a natural channel and floodplain cross section located upstream of the dam can be used for the assessment. If a comparison of the increase in water surface elevations for the "with the dam" condition including the breach to the "without the entire dam" condition shows the increase to be less than 1 ft. in a rural area or 0.5 ft. in an urban area, the opening is considered to have a negligible backwater effect. For configurations where the breach opening will not be to the downstream channel invert (which is typical of sites for which a drop structure at the elevation of the sediment level in the reservoir is proposed), the water surface elevation comparison should be for a cross section at the upstream toe of the dam for the "with the dam" condition including the breach to the "without the entire dam" condition.

Sediment control during and after the breach must be considered for the removal of a dam. For the configuration where the breach opening will be to the invert elevation of the channel at the downstream toe and a structure to control the headcutting of the channel through the sediment is not proposed, the re-establishment of a channel in the reservoir bed to match the channel downstream of the dam is typically proposed. For the configuration where a structure is proposed to control the headcutting or to make the bottom of the breach at the top of the sediment in the reservoir, the structure and the distance through the breach opening to the downstream channel should be designed and constructed to be stable for flow conditions up to and including the 100-year frequency flood. Erosion control and re-establishment of an appropriate vegetative cover in the reservoir bed are also items which are necessary and are usually based on the conditions at the site and the final configuration of the area. For some low head run-of-the-river concrete dams for which there is significant continual flow in the river and an accumulation of sediment upstream of the dam, the creation of sediment basins downstream of the breached dam where the sediment will be removed on a regular basis may be necessary to limit the movement of sediment further downstream.

B. INVESTIGATIONS AND EVALUATIONS FOR ABANDONMENT OF DAMS

Upon the end of the useful life of a disposal impoundment it is often necessary for the owner of such a structure to reclaim and abandon it. This reclamation and abandonment is most frequently associated with slurry disposal at mining operations, reservoir sediment disposal at lake or river dredging operations, and ash disposal at power plants. Often this process is assumed by the owner to remove the associated dam structure from the dam safety regulatory jurisdiction. This assumption is usually based on the belief that the hardened surface of the impounded refuse material is characteristic of the entire volume of impounded material. However, studies have indicated that while this material may solidify on the surface after a period of time, a portion of the material below the surface remains fluid for an extended period of time. Thus, if the dam were to fail, the remaining fluid material could escape, possibly causing loss of life and/or significant property damage. Therefore, dams used in conjunction with disposal operations cannot be removed from Illinois dam safety regulation until it has been verified that the existing impounded material is not flowable and appropriate measures have been taken to prevent it from becoming flowable by recharging or seismic activity.

The following guidelines have been written in an attempt to provide general information regarding the methods of testing, analyses and computations which must be completed and submitted with an application for permit to support an owner's request for abandonment of a disposal impoundment dam.

An evaluation regarding a request to permit abandonment of a disposal impoundment structure will be based on the documentation and data addressing four issues: 1) the classification of the existing condition of the impounded material with respect to its fluid nature; 2) the liquefaction potential of the impounded material and the related stability of the containing dam; 3) the final surface configuration for the impoundment including the potential for resaturation of the impounded material, especially from any surface water impounding characteristics and the erosion potential of the surface material; and 4) the establishment of a follow-up inspection schedule to ensure the proposed plans have been effective and the submittal of record drawings.

1. Existing Impounded Material

The existing material which has been impounded must be analyzed and classified with respect to its fluid nature. To establish the characteristics of the material, actual field samples must be obtained, tested and evaluated. Testing and analyses, as appropriate, should be completed to determine such parameters as liquid limit, water content, yield shear strength, permeability, viscosity, particle grain size distribution, confining pressure and void ratio of the material. Piezometers or other observational devices may also be used to assist in the evaluation and classification process.

If the existing impounded material is found to be of a non-fluid nature then the liquefaction potential must be evaluated as described in Section 2. If the liquefaction potential is found to be low, then a plan to prevent resaturation as discussed in Section 3 would need to be developed.

If the existing impounded material is found to be of a fluid nature and abandonment is desired then design of an appropriate method to dewater the material must be developed. Additionally, a plan to prevent future resaturation of the impounded material must also be completed. To ensure a continued non-fluid state is maintained it is suggested that observational devices such as piezometers be installed and monitored for a period of not less than one year after initial dewatering has been completed. Upon completion of dewatering procedures the existing impounded material must be evaluated with respect to liquefaction potential (as discussed in Section 2).

2. Liquefaction Potential

The impounded material within a disposal impoundment dam must be evaluated to determine if the material is susceptible to liquefaction. If necessary, a computer model capable of analyzing the dynamic effects should be used.

If the material is found to be susceptible to liquefaction then no abandonment would be permitted unless plans for modifications to eliminate the liquefaction potential were completed and approved.

If the material is not susceptible to liquefaction the abandonment procedures may be permitted providing that the issues of Sections 1, 3 and 4 have been appropriately addressed and the containing embankment

is shown (by submitting appropriate support documentation) to be stable under static conditions.

3. Resaturation Potential

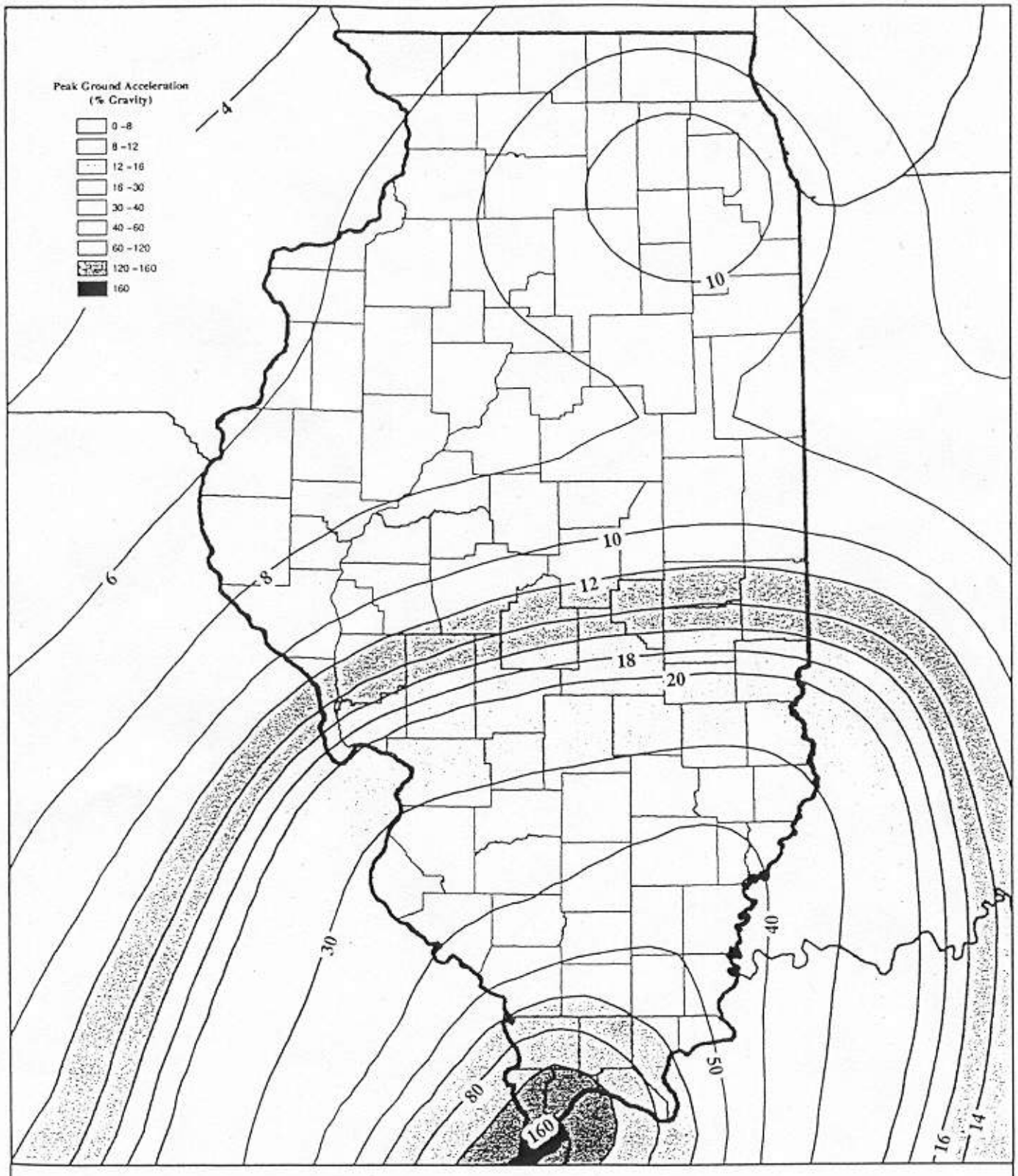
To prevent resaturation, water should not be permitted to pond on the surface of the slurry material or any cover material. Elimination of any existing surface impoundment on the slurry material will be required. Plans to prevent any future surface water impounding capability and the prevention of erosion on the final surface material should be required.

4. Final Inspection and Record Drawings

A final inspection and report by a professional engineer must be completed and submitted to the Office of Water Resources one year after the completion of the abandonment modifications to the dam. This inspection will evaluate and report the effectiveness of the abandonment designs. Record drawings should be submitted along with the final inspection report.

APPENDICES

APPENDIX NO. 1



Peak Ground Acceleration (Percent Gravity)
Two Percent Probability of Exceedance in 50 Years

Source: US Geological Survey
National Seismic Hazard Mapping Project
(Open-file Report 97-131) November, 1996

Office of
Water Resources
October 4, 2002

ILLINOIS
DEPARTMENT OF
NATURAL
RESOURCES

APPENDIX NO. 2

OPERATION AND MAINTENANCE MANUAL

UNKNOWN CREEK DAM

WHEREVER, ILLINOIS

WHICHEVER COUNTY

DATE

OPERATION AND MAINTENANCE MANUAL
UNKNOWN CREEK DAM
WHEREVER, ILLINOIS

TABLE OF CONTENTS

TITLE	PAGE
SECTION 1 - GENERAL	
Reasons for Development and Dissemination of O&M Manual	1
General Responsibilities Concerning Dams	2
SECTION 2 - DEFINITIONS	
	3
SECTION 3 - INFORMATION ABOUT THE DAM	
Location	7
Description of Dam and Appurtenances	7
Size Classification	8
Hazard Classification	8
Purpose of Dam	8
Pertinent Data	8
SECTION 4 - OPERATION ACTIVITIES	
Types of Dam Inspections	9
Review of Emergency Action Plan	13
SECTION 5 - MAINTENANCE ACTIVITIES	
	14

APPENDICES

Appendix A	Operation and Maintenance Inspection Checklist
Appendix B	Engineering Inspection Form
Appendix C	Herbicides
Appendix D	Operation and Maintenance of Sluice Gate

PLATES

Plate 1	Vicinity Map
Plate 2	Location map
Plate 3	Plan View of Dam
Plate 4	Typical Section Through Principal Spillway
Plate 5	Profile of Dam

SECTION 1

GENERAL

This operation and maintenance manual, (hereafter referred to as O&M manual), outlines objectives, proposed policies, responsibilities, and procedures for City of Wherever personnel who are responsible for the management of the Unknown Creek Dam.

REASONS FOR DEVELOPMENT AND DISSEMINATION OF THE O&M MANUAL

The Rivers, Lakes and Streams Act, (615 ILCS 5) Paragraph 23a includes the statement "The Department is authorized to carry out inspections of any dam within the State, and to establish standards and issue permits for the safe construction of new dams and the reconstruction, repair, operation and maintenance of all existing dams." (emphasis added).

Part 3702 of the 17 Illinois Administrative Code, Chapter I entitled the "Construction and Maintenance of Dams" details the requirements to obtain a permit for the construction, operation, and maintenance of a dam. Section 3702.40 b) includes the following statements:

> "4) An applicant for a Class I or II dam shall submit an operational plan specifying the method and schedule for the operation of the dam and the routine operating procedures to keep the dam in good working order, including an emergency warning plan.” and
>
> "5) As a condition of each permit, the dam owner shall submit a maintenance plan detailing the procedures and schedules to be followed to maintain the dam and its appurtenances in a reasonable state of repair."

Thus it is a requirement of all dam owners who have dams which fall under the jurisdiction of the Illinois Department of Natural Resources to operate and maintain them safely.

As a dam owner the City of Wherever is responsible for the safety of the public and for maintaining the structures within the City's jurisdiction for both safety and economy. The overall public interest is served by providing a document to serve as a basis for the safe and economical operation and maintenance of the dam during both emergency and day-to-day conditions.

GENERAL RESPONSIBILITIES CONCERNING DAMS

Specific information should be included either here or throughout the O&M plan. The following comments are noted for general guidance for development of the O&M plan.

City Council

The City Council should annually provide sufficient funding to safely maintain and operate the dam. The estimated annual funding requirements as of the date of this plan is $ _____. The City Council should also provide sufficient authority to personnel within city government to assure the performance of critical functions during emergencies.

Street Department

The Street Department may have specific responsibilities which should be outlined in the O&M plan. The responsibilities might include mowing of the dam; removal of debris from the spillways; placing needed rip rap; and providing trucks and other equipment, personnel, and material during emergency actions.

Water Department

The Water Department may have specific responsibilities which should be outlined in the O&M plan. The responsibilities might include the overall responsibility for the dam such as making emergency action decisions; inspecting the dam; operating and maintaining the dam's gates, valves, and electrical system; and providing equipment, personnel, and material during emergency actions.

Emergency Services and Disaster Agency

The city's Emergency Services and Disaster Agency should review, and revise if necessary, the Emergency Action Plan for the dam prior to the plan being submitted for permit approval. The Agency should be responsible to keep the information in the Emergency Action Plan for the dam current. It should coordinate with other agencies (local, county, state, federal) the responses to an emergency at the dam.

SECTION 2

DEFINITIONS

Abutment - That part of the valley side or concrete walls against which the dam is constructed. Right and left abutments are those on respective sides of an observer when viewed looking downstream. (Illustration 1 depicts the principal parts of a "typical" earthen dam and its appurtenant works.)

Appurtenant Works - The structures or machinery auxiliary to dams which are built to operate and maintain dams; such as outlet works, spillways, gates, valves, channels, etc.

Boil - A stream of water discharging from the ground surface downstream of the dam carrying with it a volume of soil which is distributed around the hole formed by the discharging water.

Berm - A horizontal step or bench in the sloping profile of an embankment dam.

Breach - A break, gap, or opening (failure) in a dam which releases impoundment water.

Concrete Block - An erosion protection method using interlocking concrete blocks, usually with openings that are filled with soil and grass.

Core - A zone of material of low permeability in an earthen dam.

Dam - A barrier built for impounding or diverting the flow of water.

Dike (Levee) - An embankment or structure built alongside a river to prevent high water from flooding bordering land.

Drain, Layer or Blanket - A layer of pervious material in a dam to facilitate the drainage of the embankment including such items as a toe drain, a weephole, and a chimney drain.

Drawdown - The resultant lowering of water surface level due to the controlled release of water from the impoundment.

Embankment - Fill material, usually earth or rock, placed with sloping sides.

Earthen Dam - Any dam constructed of excavated natural materials.

Emergency Action Plan - A predetermined plan of action to be taken to reduce the potential for property damage and loss of lives.

Failure - An incident resulting in the uncontrolled release of water from a dam.

Freeboard - The vertical distance between a stated water level and the top of a dam. (See Illustration 1.)

Gate or Valve - In general, a device in which a leaf or member is moved across the waterway to control or stop the flow.

Groin - The junction of the upstream or downstream face of the dam with the valley wall.

Maintenance - The upkeep, involving labor and materials, necessary for efficient operation of dams and their appurtenant works.

Operation - The administration, management, and performance needed to operate the dam and appurtenant works.

Operation and Maintenance Inspection - Inspections conducted by the dam operator. These inspections are frequent visual "walk-around" inspections of the dam surface and appurtenant works.

Outlet - An opening through which water can freely discharge for a particular purpose from an impoundment.

Phreatic Surface - The upper surface of saturation in an embankment.

Piping - The progressive development of internal erosion by seepage, appearing downstream as a hole or seam, discharging water that contains soil particles.

Riprap - A layer of large stones, broken rock or precast blocks placed in a random fashion usually on the upstream slope of an embankment dam, on a reservoir shore, or on the sides of a channel as a protection against current, wave and ice action.

Silt/Sediment - Soil particles and debris in an impoundment.

Slump/Slide Area - A portion of earth embankment which moves downslope, sometimes suddenly, often with cracks developing.

Spillway System - A structure or structures over or through which flows are discharged. If the flow is controlled by gates, it is considered a controlled spillway. If the elevation of the spillway crest is the only control of the flows, it is considered an uncontrolled spillway.

Emergency Spillway - A spillway designed to operate very infrequently, only during exceptionally large floods, usually constructed of materials expected to erode slowly.

Principal Spillway - The main spillway which controls both normal and flood flows and is constructed of non-erodible materials.

Auxiliary Spillway - A spillway which works in conjunction with the principal spillway to control flood flows and is constructed of non-erodible materials.

Stilling Basin - A basin constructed to dissipate the energy of fast flowing water, such as from a spillway, and to protect the stream bed from erosion.

Toe of Embankment - The junction of the face of the dam with the ground surface in the floodplain upstream or downstream of the dam.

Trash Rack - A structure of metal or concrete bars located in the waterway at an intake to prevent the entry of floating or submerged debris.

SECTION 3

INFORMATION ABOUT THE DAM

LOCATION

The Unknown Creek Dam is located in the southeast part of Wherever in the northwest part of Whichever County, Illinois. The dam is located on Unknown Creek in the southeast quarter of Section 4, Township 21 North, Range 9 East of the 4th Principal Meridian. Plate 1 shows the general vicinity of the dam within the State of Illinois, and Plate 2 is a location map.

DESCRIPTION OF DAM AND APPURTENANCES

The Unknown Creek Dam is an earth embankment structure approximately 31 feet high and 1480 feet long. The top of dam elevation is 740.8 and both faces of the dam slope at 3 horizontal to 1 vertical.

The appurtenant works consist of a 24 inch diameter concrete low flow pipe principal spillway, a reinforced concrete drop inlet auxiliary spillway with a dewatering gate, and an earth cut emergency spillway. The 24 inch diameter low flow pipe with a trash rack at its entrance and the drop inlet spillway both discharge through a 60 inch diameter concrete pipe into a reinforced concrete stilling basin at the downstream toe. The emergency spillway is located at the left abutment of the dam. (Left and right orientation is based on looking in the downstream direction.) The emergency spillway is a 150 foot wide earth cut with a concrete wall crest control section.

The principal and auxiliary spillway system is designed to pass the 100-year frequency storm with about 5.4 feet of freeboard, that is, without the emergency spillway functioning. The emergency spillway is designed to function for any storm event greater than the 100-year frequency storm. The combined spillway capacities are capable of passing 50 percent of the Probable Maximum Flood (PMF) with 2.9 feet of freeboard and 100 percent of the PMF with 1.3 feet of freeboard.

Plate 3 shows a plan view of the dam. Plate 4 shows a cross section of the dam embankment at the principal spillway. Plate 5 shows a profile of the dam.

SIZE CLASSIFICATION

With a maximum height of 31 feet and a maximum storage capacity of approximately 198 acre-feet, the dam is in the small size category.

HAZARD CLASSIFICATION

The Unknown Creek Dam is classified as a CLASS I, HIGH HAZARD POTENTIAL dam because of the high probability that, in the event of a dam failure, loss of life and/or property downstream of the dam would be substantial.

PURPOSE OF DAM

The dam serves to form a dry detention reservoir for the control of flooding on the Unknown Creek which flows through the southeastern part of Wherever.

PERTINENT DATA

Pertinent data about the dam, appurtenant works, and reservoir is presented in Table 1. Plates 3 through 5 show plans, sections and details of the dam and appurtenant works.

TABLE 1
PERTINENT DATA

DRAINAGE AREA	Square Miles	0.92
DAM		
Type	Earth Embankment	
Elevation, Top of Dam	Feet-NGVD	740.8
Height Above Streambed	Feet	31
Upstream Slope	Horiz:Vert	3:1
Downstream Slope	Horiz:Vert	3:1
Length, Crest	Feet	1480
Top Width	Feet	16
Streambed Elevation	Feet-NGVD	709.8
RESERVOIR		
Normal Pool Storage	Acre-Feet	0
Elevation, PMF Pool	Feet-NGVD	739.5
Storage, PMF Pool		Acre-Feet
177		
Length, PMF Pool	Miles	0.3
Storage, Top of Dam	Acre-Feet	198

TABLE I
(continued)

PRINCIPAL SPILLWAY		
Type	Uncontrolled flow through concrete pipe	
Size	Inch Diameter	24
Elevation, Inlet Invert	Feet-NGVD	714.0
Elevation, Outlet Invert	Feet-NGVD	713.5
Length	Feet	20
AUXILIARY SPILLWAY		
Type	Uncontrolled Drop Inlet	
Size	Feet	5′ X 5′
Elevation, Crest	Feet-NGVD	733.5
Length, Crest	Feet	16.5
DEWATERING GATE		
Type	Unseating head type sluice gate with cast iron flange frame and bronze seat facings Manufacturer : Model No. :	
Size	Feet	3′ X 3′
Inlet Invert Elevation	Feet-NGVD	725.0
OUTLET CONDUIT		
Type	Concrete Pipe	
Size	Inch Diameter	60
Elevation, Inlet Invert	Feet-NGVD	713.5
Elevation, Outlet Invert	Feet-NGVD	712.0
Length	Feet	124
STILLING BASIN		
Type	Impact	
Elevation, Floor 709.75		Feet-NGVD
Elevation, End Sill	Feet-NGVD	712.
Width	Feet	13.5
EMERGENCY SPILLWAY		
Type	Earth Cut Channel (grass lined)	
Control Section	Concrete Wall	
Elevation, Crest	Feet-NGVD	735.5
Length, Crest (Bed Width)	Feet	150
Width, Crest	Feet	1
Side Slopes	Horiz:Vert	3:1

Notes: (1) NGVD is referred to as the National Geodetic Vertical Datum, 1929.

SECTION 4

OPERATION ACTIVITIES

TYPES OF DAM INSPECTIONS

The inspection program includes two types of dam inspections. The first is regularly conducted by the Dam Operator and is referred to as an Operation and Maintenance Inspection. The second type of inspection, referred to as the Engineering Inspection, is conducted by a qualified engineering consulting firm approved by the City of Wherever, (all engineering inspection reports must be signed and sealed by an Illinois Registered Professional Engineer).

Operation and Maintenance Inspection:

Occasional "walk-around" inspections of the dam and appurtenant works are to be made by the Dam Operator. During these inspections, a checklist of items to be maintained and items to be observed should be recorded. Appendix A provides an example of the Operation and Maintenance Inspection Checklist to be utilized for these inspections. Illustration 2 identifies some potential problem indicators at a "typical" earthen dam.

Frequency: Monthly and during and after unusual events such as heavy rainfall or an earthquake.

Inspection Items: During each inspection the following items should be noted in particular:

(1) Water Level - A staff gage which can be easily seen when the reservoir is full should be installed or painted on the drop inlet. Maximum reservoir levels as a result of heavy rainfall should be recorded.

(2) Earth Embankment - Walk the crest, abutments, groins, side slopes, downstream toe and upstream toe or at the waterline of the dam concentrating on surface erosion, seepage, cracks, settlements, slumps, slides, and animal burrows. These are described as follows:

Surface Erosion - Removal of vegetative cover by water action or pedestrian or vehicle usage forming deep ruts or gullies.

Seepage - The passage of water through and/or underneath the earth embankment abutment and natural groundline or at the contact between the embankment and outlet works can be indicated by cattails or other wet environmental vegetation, erosion channelization, or slumping on the embankment face.

Cracks - Deep cracks usually indicate the movement of the dam and/or the foundation and can be in either the longitudinal (along the length of the dam) or transverse (across the dam) directions. Cracking can be an indicator of the beginning of slumps. Shallow cracks may develop during the summer when the surface soils of the embankment become severely dried and are usually of no concern in regard to the safety of the dam.

Settlement - Settlement is indicated by depressions or low spots and can be signs of consolidation of the dam or foundation or the loss of material beneath the settlement area.

Slumps/Slides - Slow or sudden movements of the earth embankment slope on either face toward the toe of the dam.

> If seepage indicates the presence of soil particles, or if deep cracks, settlement, slumps, or slides are noticed, a qualified engineer should be contacted immediately for consultation.

Animal Burrows - Animal burrows result in a loss of earth embankment material and can provide seepage paths for water through the embankment.

(3) Vegetation - Grass should be a thick vigorous growth to stabilize embankment soils and prevent erosion from occurring. Note the height of the grass; if greater than 1 foot, a mowing of the area should be scheduled before the next inspection. There should be NO trees on the earth embankment and NONE within a minimum of 20 feet of the embankment toes or concrete structures. There should be NO trees in the emergency spillway.

(4) Trash Racks - Check to make sure that the trash racks are unobstructed, operating well, and allowing for the free flow of water.

(5) Drop Inlet Spillway - Check for any debris or other obstructions around the inlet crest and at the bottom of the drop inlet which may block or restrict the free flow of water. Check for the development of any rusty areas on the concrete, and seepage, cracking, breaking, or spalling of the concrete. Check the vent pipes for overall condition and alignment and to ensure that the pipes are clear and unobstructed. (Do not place your hand or any tool near the inlet of the vent pipe if flows are passing over the crest of the auxiliary spillway as suction through the vent pipe may be occurring.)

(6) Outlet Works - Check for any debris or other obstructions within the impact basin which may block or restrict the free flow of water. Check for the development of any rusty areas on the concrete, and seepage, cracking, breaking, or spalling of the concrete. Check to make sure weepholes are clear and operating properly. Check for any erosion occurring at the embankment/structure junction.

(7) Concrete Block and Rip Rap - Check to make sure that the blocks and rip rap are remaining in a uniform position. Freeze/thaw action or flow over the blocks or rip rap may tend to lift or fracture them, thus requiring replacement or leveling to maintain the necessary level of protection. NO trees or woody vegetation should be growing through the blocks or rip rap.

(8) Mechanical Equipment - Check for any debris or other obstructions around the dewatering gate which may block or restrict the free flow of water. Operate the gate from the fully closed to the fully open position taking note of the physical and operating conditions of the system. Lubricate the stem, stem guides, wedges and hoisting mechanism a minimum of two (2) times a year. NOTE: Except in emergencies, the drawdown of water using the dewatering gate should be limited to 0.5 foot per day to

minimize upstream slope stability problems. (Refer to Appendix D for operation and maintenance of the sluice gate.)

(9) Fences - Check for damage, accumulated debris, operation of gates and locks, and adequacy of locations (this may change with time as people access the area or development occurs in the area).

(10) Drains - The change in location or amount of flows discharging from the toe drain should be recorded. If a significant change has occurred, a qualified engineer should be contacted for consultation.

(11) Emergency Spillway - Check for settlement or cracking of the crest control wall. Check for any logs, tree or brush growth, and other debris in the spillway, upstream and downstream areas which may restrict the flow of water.

(12) Downstream Floodplain - Check the floodplain downstream of the dam for a distance of at least 100 feet for signs of seepage or boils.

Records: A log book of activities occurring at the dam is to be kept current by the Dam Operator. The log book should be reviewed during the Engineering Inspection and may be helpful during budget preparations. This book should contain at least the following documentation:

(1) Completed operation and maintenance inspection checklists
(2) Additional visual observations
(3) A list of maintenance performed
(4) A list of any unusual occurrences at the dam
(5) A copy of the engineering inspection reports

Engineering Inspection:

The engineering inspection is to be conducted by a qualified engineering consulting firm approved by the City of Wherever. The inspection will provide a thorough evaluation of the condition of the dam and appurtenances. Appendix B is an example of the inspection report form which is to be utilized for these inspections.

Frequency: The Unknown Creek Dam is classified as a CLASS I, HIGH HAZARD POTENTIAL dam. Class I dams are to be inspected annually.

Inspection Items: The engineer will thoroughly inspect the items noted under Operation and Maintenance Inspection in addition to the following items:

(1) Principal and Auxiliary Spillways - Check for signs of seepage, structural cracking or spalling of concrete, misalignment of pipe, joint separation or differential settlement.

(2) Emergency Spillway - Check for signs of structural cracking or spalling of the concrete crest control wall. Check for signs of degradation of the embankment on the right of the emergency spillway to assure that emergency spillway flows do not attack the left downstream dam groin.

Records: The Dam Inspection Report form, Appendix B, will be completed by the inspecting engineer and will be signed and sealed by an Illinois Registered Professional Engineer. This report will document problem areas and deficiencies; recommend remedial actions for problem areas; and establish time requirements for dealing with the problems. The original report will be retained in the City of Wherever's Unknown Creek Dam file and a copy of the report will be submitted to the Illinois Department of Natural Resources, Office of Water Resources.

REVIEW OF EMERGENCY ACTION PLAN

The emergency action plan should be reviewed annually to assure that all contacts, addresses, telephone numbers, etc. are current. Changes to the plan should be made as appropriate but only with the concurrence of the Wherever office of the Emergency Services and Disaster Agency and of the Department of Natural Resources, Office of Water Resources. Copies of any revisions should also be forwarded to all personnel that have the plan.

SECTION 5

MAINTENANCE ACTIVITIES

Timely repairs are a must after problem areas have been identified. The dam operator is to perform the work required to correct items noted in the operation and maintenance and engineering inspections. Such items include mowing, seeding, tree and brush removal, painting, greasing, replacing riprap, repairing fences and locks, clearing debris, etc. Common maintenance items are pictured in Illustration 2. The maintenance activities specified in the following sections are minimum requirements. NOTE: NO alterations or repairs to structural elements should be made without the assistance of a qualified engineer and the concurrence of the Illinois Department of Natural Resources, Office of Water Resources.

Debris: Remove all trash, logs and other debris which may obstruct flow into the principal spillway pipe, drop inlet, and emergency spillway or block passage from their discharge channels.

Concrete Block and Rip Rap: Replace or level blocks and rip rap as needed to provide adequate protection against erosion.

Vegetation Control:

(1) A good grass cover on the embankment should be maintained by seeding, fertilizing and mulching areas which are refilled, barren, or thinly vegetated. Seeding mixtures used for maintenance reseeding shall result in a cover compatible with adjacent cover. The seeding mixture used at the time of the dam's construction was _____ .

(2) Grassed areas such as the embankment, the emergency spillway, and areas beyond the embankment toes for a distance of at least 20 feet should be mowed at least twice annually and at any time the height of the grass exceeds 1 foot.

(3) All eroded areas should be filled and compacted, reseeded, fertilized and mulched to establish a thick erosion resistant cover.

(4) All trees and brush on the dam embankment should be removed to prevent development of a root system which could provide seepage paths. Herbicides utilized for tree and brush control are discussed in Appendix C.

(5) The emergency spillway area should be kept clear of weeds, brush and trees.

(6) All trees and brush should be removed from the outlet channel to a distance of approximately 100 feet downstream from the stilling basin.

(7) All brush and trees should be removed to a distance of approximately 20 feet beyond both toes of the dam.

Animal Damage: Rodent holes should be filled with compacted clayey dirt and reseeded. If rodents become a nuisance, an effective rodent control program as approved by the Illinois Department of Natural Resources District Wildlife Biologist should be implemented.

Concrete: Spalled and cracked areas on concrete structures should be patched to guard against any further deterioration of the structure. Concrete construction joints should be filled with a suitable joint filler such as a bituminous sealant to protect against weathering.

Drains: All drains and weepholes should be kept open and functional by cleaning them of silt and debris.

Painting: All metal work, fencing, railing, etc. should be properly prepared and repainted as necessary to protect against rusting.

Signs: All warning signs and staff gages should be maintained (repaired, painted, or replaced) as needed.

Vent Pipes: All obstructions should be cleared from the vent pipes.

Sedimentation: Sedimentation of this reservoir is estimated to occur at the rate of approximately 1 ac-ft per year, which is about 1.1% of the initial reservoir storage at the crest of the drop inlet. As sediment accumulates in the reservoir less storage is available for the control of flood waters from the watershed. Efforts should be made to work with the U.S. Department of Agriculture, Natural Resources Conservation Service and the upstream land owners to minimize the sediment being transported to the reservoir. A location for the placement of the sediment removed from the reservoir (if upstream of the dam, above the top of the dam) should be determined.

Mechanical Equipment: The hoisting mechanism, stem and guides, wedges, nuts and bolts should be cleaned and lubricated at least two (2) times per year. (Refer to Appendix D for operation and maintenance of the sluice gate.)

APPENDIX A

OPERATION AND MAINTENANCE INSPECTION CHECKLIST

OPERATION AND MAINTENANCE INSPECTION CHECKLIST

Dam Name :_____
Date and Time of Inspection :_____
Name of Inspector :_____
Reservoir Elevation :_____

ITEM	NO	YES	IF YES
Surface Cracks	___	___	Contact Superintendent
Slump or Slide on the upstream or downstream face	___	___	Contact Superintendent
Erosion from runoff, wave action or traffic	___	___	Repair and stabilize
Embankment, abutment or spillway seepage	___	___	Contact Superintendent
Seepage or flows of muddy water	___	___	Contact Superintendent and ESDA
Uneven settlement	___	___	Contact Superintendent
Uneven concrete blocks	__	___	Level and stabilize
Trees, brush or burrow holes on the embankment	___	___	Remove trees and brush, fill holes
Spillways or trash racks blocked	___	___	Clear immediately
Exposed metal is rusty	___	___	Clean and paint
Concrete deterioration or cracks	___	___	Contact Superintendent
Pipe joint separation	___	___	Contact Superintendent
Scour	___	___	Contact Superintendent
Vent pipe blocked	___	___	If no flow over drop inlet, clear
Height of Grass ___ inches			If more than 1 foot, schedule mowing

Comments :_____
_____

APPENDIX B

ENGINEERING INSPECTION FORM

(See OWR document entitled “Guidelines and Forms for Inspection of Illinois Dams”)

APPENDIX C

HERBICIDES

HERBICIDES

Site personnel should check with the Illinois Department of Natural Resources, Regional Fisheries Biologist and the Regional Wildlife Biologist before using any herbicide. Read the product label prior to use and follow the use directions and precautions accordingly.

On March 1, 1979 the U.S. Environmental Protection Agency (U.S.E.P.A.) halted the use of the herbicide 2, 4, 5-T in parks and recreation areas. The use of silvex (2, 4, 5-TP) around water has also been banned.

The Agronomy Department at the University of Illinois and the Aquatic Biology Section of the Department of Natural Resources, Office of Scientific Research and Analysis indicate that the herbicides containing the 2, 4-D or 2, 4-DP are legal for use in parks and recreation areas and effective for controlling brush and woody growth. Some examples of approved herbicides are:

1) Tordon RTU by DOW Chemical. (Can be obtained with blue dye.)

2) WEEDONE 170 by Union Carbide

3) WEEDONE, 2, 4-DP by Union Carbide

4) A 1% to 2% solution of ROUNDUP

5) Garlon by DOW Chemical

6) Banvel by Sandoz

Your distributor may carry brand name herbicides other than those listed above. Be certain that the product <u>does not</u> contain the ingredients 2, 4, 5-T or 2, 4, 5-TP. An example of an <u>unacceptable</u> product is ESTERON 2, 4, 5 by DOW Chemical.

APPENDIX D

OPERATION AND MAINTENANCE OF SLUICE GATE

MAINTENANCE

The maintenance on a sluice gate is minimal but very important. The gate, itself, requires no periodic maintenance or lubrication. It is critical that the operating stems be periodically cleaned and greased. Manufacturers recommend that stems be cleaned and greased at least once every six months. Dirty grease or lack of grease will increase the operating force necessary to open or close the gate and will accelerate the wear in the stem nut. Manufacturers of sluice gates recommend the following lubricants for this use:

Lubriplate Lithium Base No. 630AA or AAA
Texaco Multi-Fax Heavy Duty No. 2
Conoco All Purpose Superlube
Shell Alvania No. 1 or No. 2 EP
Mobilox Grease No. 2 EP
Valvoline Val-Lith No. 2 EP

At least once a year, all grease fittings on manual floor stands should be lubricated with a small amount of heavy duty grease designed to remain pliable and not dry out over long periods and wide temperature ranges. For best results the floor stand should be greased when being operated. For the first three or four turns of the crank, grease should be applied to each fitting after each turn. This will insure adequate lubrication of all parts. Over lubrication is not possible. Manufacturers recommend the following lubricants for this application:

Mobilgrease Special
Mobilplex No. 45

The exposed non-operating surfaces of the gate, stem guides, and hoisting mechanism should be cleaned and painted as conditions require or permit. All machined corrosion-resistant metal faces must be thoroughly protected during the cleaning and painting.

OPERATION

There isn’t a sluice gate manufacturer who will guarantee a leak-proof gate. AWWA Specifications maintain that leakage for a seating head gate should not exceed 0.1 gpm per foot of perimeter. For unseating head gates with heads of up to 20 ft., the specifications indicate that leakage should not exceed 0.2 gpm per foot of perimeter.

As an example: a 24-inch diameter circular opening gate would have a circumference of 6.25 ft. If an unseating head gate operates under a head of 20 ft. the allowable leakage would be 1.26 gpm. That is, the gate could pass 1.26 gpm without requiring adjustment. When there is excessive leakage through the gate seating surfaces, the wedges should be re-adjusted per the manufacturer's instructions. These adjustments should not be attempted without adequate instruction, help, tools, replacement parts, and safety equipment.

Sluice gates are designed and constructed to operate satisfactorily under the design operating conditions. Care should be taken in the operation of the gate to assure that the design operating conditions are not exceeded. If, in the operation of the gate, an obstruction is met, either in the opening or closing direction, the obstruction must be removed, before continuing the operation of the gate. Excessive force must never be placed on the gate or gate stem by the operator in an effort to move the gate further. Manual operators are designed so that the maximum pull on the crank need not exceed 40 pounds when the gates are opened or closed against the specified operating head. If a problem arises in the operation of the gate, the operator should consult the Superintendent and a determination will be make as to the corrective action to be taken.

Prior to opening a sluice gate, the following checklist activities should be performed:

(1) Gate, wedges, stem, stem guides and hoist mechanism inspected.

(2) All sand, stones, and other debris cleaned from the top of the gate, wedges, and stem guides.

(3) Stem and stem guides cleaned and lubricated.

(4) Guides cleaned and lubricated.

(5) Hoisting mechanism lubricated.

When operating the gate, record the number of turns of the crank to open the gate. Repeat the number of turns to close the gate. After closure, check the gate for leakage. If leakage is "excessive" or greater than prior to opening, the wedges may need adjusting. <u>Do not force the crank to attempt to close the gate.</u> If any problems are encountered, the Superintendent should be notified immediately.

PLATES

(Specific plates or figures appropriate for the dam should be included here.)

APPENDIX NO. 3

EMERGENCY ACTION PLAN

UNKNOWN CREEK DAM

WHEREVER, ILLINOIS

WHICHEVER COUNTY

DATE

EMERGENCY ACTION PLAN
UNKNOWN CREEK DAM
WHEREVER, ILLINOIS

TABLE OF CONTENTS

TITLE	PAGE
SECTION 1 - EMERGENCY DETECTION, EVALUATION AND ACTIONS	
Seepage	1
Reservoir Whirlpool	3
Slide	3
Cracks	4
Burrow Holes	5
SECTION 2 - RESPONSIBILITIES	
	5
PLATES	
Plates 1-5	Dam Breach Inundation Maps
Plate 6	Granular Blanket "Inverted Filter"
Plate 7	Boil Ring

EMERGENCY ACTION PLAN
UNKNOWN CREEK DAM

(The information that follows identifies the procedures to be followed in the event of a heavy rainfall or a dam failure. An example of a complete plan is specifically not included. OWR and the Illinois Emergency Management Agency offer a course on the preparation of emergency action plans for dams. Guidance on the development of a plan can be obtained in the document entitled "Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners," prepared by the Interagency Committee on Dam Safety and the Federal Emergency Management Agency (FEMA-64). The plan should be coordinated with emergency services personnel prior to submittal to OWR for permitting of the dam construction. Some of the items which relate to actions to be taken at the dam are included for consideration and guidance.)

EMERGENCY DETECTION, EVALUATION AND ACTIONS

The following section explains some of the problems which may occur at a dam, how to make a rapid evaluation of the problem, and what action should be taken in response to the problem. This section presents only generalized information for the dam operator to aid in a first response to a problem. Any suspected problem should be reported and assistance from a qualified engineer should be obtained as soon as possible.

This section will be placed in the following format:

PROBLEM
- INDICATOR
  - HOW TO EVALUATE PROBLEM
    - ACTION TO BE TAKEN

SEEPAGE

Wet area, on downstream embankment slope or any other area downstream of the embankment, with very little or no surface water or very minor seeps.

- This condition may be caused by infiltration of rain water which is not serious, or may be the start of a serious seepage problem which would be indicated by a quick change to one of the conditions below.
  - No immediate action required; note location for future comparison.

Same wet area as above with moderate seeps of clear or relatively clear water and rate of flow not increasing.

- Measure the flow periodically and note any changes in clarity.

No immediate action required; note location, flow rate, and clarity for future comparison. During reservoir flood stages the seepage area should be watched for any changes.

Same wet area as above with moderate seeps of clear or relatively clear water and rate of flow increasing.

Measure the flow periodically and note any changes in clarity. Inspect the downstream area for any new seeps.

Contact a qualified engineer for an immediate inspection. Observe the condition constantly for any further changes in flow rate or clarity unless notified otherwise by the engineer.

Piping (seepage with the removal of material from the foundation or the embankment) with moderate to active flows of cloudy to muddy water.

If the water is cloudy to muddy and the rate of flow is increasing, this condition could lead to failure of the dam.

Immediate action is necessary. Open the dewatering gate completely. If no whirlpool is noted on the upstream side of the dam, place an "Inverted Filter" over the seepage area on the downstream side of the dam (see Plate 6). The filter should consist of a 3 to 5 ft. thick blanket of material graded from coarse sand and pea gravel at the bottom to 3-inch stone at the top. If needed, use larger stones on the top of the filter. Use filter cloth at the bottom of the filter if available. Do not try to "plug" or stop the flow of water from this location. Try to reduce the movement of material using this filter while allowing the flow to pass through it. Notify the Emergency Services and Disaster Agency Office for evacuation of the dam breach area, (see Plates 1-5).

If, along with the piping, there is an upstream swirl (whirlpool) caused by water entering through the abutments of embankment, failure may be imminent.

Notify the Emergency Services and Disaster Agency Office for evacuation of the dam breach area, (see Plates 1-5), open the dewatering gate completely, and attempt to construct the inverted filter over the seepage area on the downstream side of the dam as noted above. The thickness of the section will generally be greater than 5 ft. Plugging of the upstream entrance of the "pipe" should also be attempted using large rock or anything else that is available (rolls of fencing, bed springs, cars, large hay bales, etc.). If the large material placed in the hole appears to have reduced the

flow, follow with progressively smaller material in an attempt to seal the entrance.

Boils (soil particles deposited around a water exit forming a cone, varying from a few inches in diameter spaced 2 to 3 ft. apart to isolated locations several feet in diameter in the floodplain downstream of the dam) may show the same types of flow as noted above.

Evaluation of the problem is the same as noted above for the various flow conditions, i.e., clear and constant, clear and increasing, and cloudy or muddy and increasing.

Actions to be taken are essentially the same as those noted above. An additional method to try to control the movement of material from a boil is the construction of a boil ring or ring dike. An example of a boil ring is shown in Plate 7. In placing the ring it must be remembered that the work is not being done to stop the flow of water but rather to stop the movement of material. When the ring reaches an elevation where the water that is discharging from the ring is flowing clear the work should stop and the flows monitored for changes.

RESERVOIR WHIRLPOOL

Water flowing in a swirling motion in an area on the upstream side of the dam.

During high reservoir stages when the drop inlet is completely submerged, debris may come together above the drop inlet and due to flows at the inlet move in a rotating motion. If there is no evident downstream exit of "piping" as noted above and the rotating debris is over the drop inlet, then it can be assumed that there is no piping failure. If the whirlpool is over a section of the embankment or abutment, the situation is critical and failure of the dam may be imminent.

Notify the Emergency Services and Disaster Agency Office for evacuation of the dam breach area, (see Plates 1-5). Take the actions noted above under "piping".

SLIDE

Movement of a portion of the embankment, either the upstream or downstream slope, toward the toe of the dam.

Various degrees of severity of a slide require different responses. The first condition is that the slide does not pass through the crest and does not extend into the embankment more than 5 ft., measured perpendicular to the slope.

For this condition, a qualified engineer should be consulted before any repairs are initiated to determine the cause of the slide and to recommend any modifications to prevent future slides. The downstream side of the dam should be watched for the emergence of any water either through the slide or opposite the slide. If discharging water is noted, the area the slide should be treated as a seepage location and monitored as noted above.

The second condition is that the slide passes through the crest and that the reservoir elevation is more than 10 ft. below the lowered crest.

Use the same actions as noted above and notify the Emergency Services and Disaster Agency of the situation so they may be prepared to act if the condition worsens.

The third condition is that the slide passes through the crest and the reservoir elevation is less than 10 ft. below the lowered crest.

This condition is critical and failure of the dam should be considered imminent. Notify the Emergency Services and Disaster Agency Office for evacuation of the dam breach area, (see Plates 1-5). Armor the crest of the lowered portion of the embankment and try to restore the lost freeboard. If seepage is also occurring, take the appropriate actions as noted above.

CRACKS

Cracks in the embankment can occur either in the longitudinal (along the length of the dam) or transverse (across the dam from upstream to downstream) direction.

Some cracking of the surface soils may occur when they become dry. This cracking is to be expected and no further action is required.

Longitudinal cracking can indicate the beginning of a slide or be an uneven settlement of the embankment.

Monitor the crack for future changes and contact a qualified engineer for assistance in the evaluation of the crack and recommended repairs.

Transverse cracking can indicate uneven settlement or the loss of support below the crack. Such cracks usually occur over an outlet conduit, near the abutments, or in the taller portion of the embankment.

If the crack does not extend completely across the dam and the reservoir elevation is more than 10 feet below the base of the crack, monitor the crack for future changes and contact a qualified engineer for assistance in the evaluation of the

crack and recommended repairs. If the crack extends across the dam and the reservoir level is less than 10 feet below the base of the crack, both the upstream and downstream sides of the dam should be protected with a plug and inverted filter (as noted above under seepage) and the Emergency Services and Disaster Agency should be notified of the situation so they may be prepared to act if the condition worsens.

BURROW HOLES

Holes in the embankment, varying in size from about 1 inch to 1 foot in diameter, caused by animals.

If the holes do not extend through the embankment the situation is usually not serious. Some animal holes will have soil pushed out around the hole in a circular fashion which may look like a boil (crayfish or crawdad). Watch for the movement of water and soil particles from these holes to determine whether they are boils.

Backfill as deeply as possible with impervious material. If rodents become a nuisance, an effective rodent control program, as approved by the Illinois Department of Natural Resources District Wildlife Biologist, should be implemented.

RESPONSIBILITIES

[This section should clearly specify responsibilities that are specific to this dam. General guidance for the positions noted for the City of Wherever are included but should be revised as appropriate for the dam and owner.]

PREPAREDNESS

Visual inspections of the dam and its appurtenances will be made on a routine basis per the schedule noted below. Items that will be monitored are those noted for the operation and maintenance inspection and are noted here again. The O&M inspection checklist should be completed for each inspection.

Inspection Items: During each inspection the following items should be noted in particular:

(1) Water Level - A staff gage which can be easily seen when the reservoir is full should be installed or painted on the drop inlet.

Maximum reservoir levels as a result of heavy rainfall should be recorded.

(2) Earth Embankment - Walk the crest, abutments, groins, side slopes, downstream toe and upstream toe or at the waterline of the dam concentrating on surface erosion, seepage, cracks, settlements, slumps, slides, and animal burrows. These are described as follows:

Surface Erosion - Removal of vegetative cover by water action or pedestrian or vehicle usage forming deep ruts or gullies.

Seepage - The passage of water through and/or underneath the earth embankment abutment and natural groundline or at the contact between the embankment and outlet works can be indicated by cattails or other wet environmental vegetation, erosion channelization, or slumping on the embankment face.

Cracks - Deep cracks usually indicate the movement of the dam and/or the foundation and can be in either the longitudinal (along the length of the dam) or transverse (across the dam) directions. Cracking can be an indicator of the beginning of slumps. Shallow cracks may develop during the summer when the surface soils of the embankment become severely dried and are usually of no concern in regard to the safety of the dam.

Settlement - Settlement is indicated by depressions or low spots and can be signs of consolidation of the dam or foundation or the loss of material beneath the settlement area.

Slumps/Slides - Slow or sudden movements of the earth embankment slope on either face toward the toe of the dam.

> If seepage indicates the presence of soil particles, or if deep cracks, settlement, slumps, or slides are noticed, a qualified engineer should be contacted immediately for consultation.

Animal Burrows - Animal burrows result in a loss of earth embankment material and can provide seepage paths for water through the embankment.

(3) Vegetation - Grass should be a thick vigorous growth to stabilize embankment soils and prevent erosion from occurring. Note the height of the grass, if greater than 1 foot, a mowing of the area should be scheduled before the next inspection. There should be NO trees on the earth embankment and NONE within a minimum of 20 feet of the embankment toes or concrete structures. There should be NO trees in the emergency spillway.

(4) Trash Racks - Check to make sure that the trash racks are unobstructed, operating well and allowing for the free flow of water.

(5) Drop Inlet Spillway - Check for any debris or other obstructions around the inlet crest and at the bottom of the drop inlet which may block or restrict the free flow of water. Check for the development of any rusty areas on the concrete and seepage, cracking, breaking, or spalling of the concrete. Check the vent pipes for overall condition and alignment and to ensure that the pipes are clear and unobstructed. (Do not place your hand or any tool near the inlet of the vent pipe if flows are passing over the crest of the auxiliary spillway as suction through the vent pipe may be occurring.)

(6) Outlet Works - Check for any debris or other obstructions within the impact basin which may block or restrict the free flow of water. Check for the development of any rusty areas on the concrete and seepage, cracking, breaking, or spalling of the concrete. Check to make sure weepholes are clear and operating properly. Check for any erosion occurring at the embankment/structure junction.

(7) Concrete Block and Rip Rap - Check to make sure that the blocks and rip rap are remaining in a uniform position. Freeze/thaw action or flow over the blocks or rip rap may tend to lift or fracture them, thus requiring replacement or leveling to maintain the necessary level of protection. NO trees or woody vegetation should be growing through the blocks or rip rap.

(8) Mechanical Equipment - Check for any debris or other obstructions around the dewatering gate which may block or restrict the free flow of water. Operate the gate from the fully closed to the fully open position taking note of the physical and operating conditions of the system. Lubricate the stem, stem guides, wedges and hoisting mechanism a minimum of two (2) times a year. NOTE: Except in emergencies, the drawdown of water using the dewatering gate should be limited to 0.5 foot per day to minimize upstream slope stability problems. (Refer to Appendix D for operation and maintenance of the sluice gate.)

(9) Fences - Check for damage, accumulated debris, operation of gates and locks, and adequacy of locations (this may change with time as people access the area or development occurs in the area).

(10) Drains - The change in location or amount of flows discharging from the toe drain should be recorded. If a significant change has occurred, a qualified engineer should be contacted for consultation.

(11) Emergency Spillway - Check for settlement or cracking of the crest control wall. Check for any logs, tree or brush growth, and other debris in the spillway, upstream and downstream areas which may restrict the flow of water.

(12) Downstream Floodplain - Check the floodplain downstream of the dam for a distance of at least 100 feet for signs of seepage or boils.

Areas downstream of the dam may experience flooding due to local runoff at times when the reservoir water level is low. However, high reservoir levels are an indicator of potential downstream flooding and are used in this plan to provide steps for various actions to be taken. The following schedule of inspections and evacuation procedures will be followed:

(1) Normal Conditions Surveillance

Under normal water level elevations (up to elevation 732.0) the embankment and appurtenant structures will be observed by the dam operator on a monthly basis.

(2) "Unusual" Storm Conditions

During and immediately following unusual storm and flood events (reservoir level equal to or greater than elevation 732.0) the dam operator will make visual inspections of the dam and its appurtenances at a minimum of every hour if it is currently raining and every 12 hours if it is not raining. Flooding in some areas downstream of the dam may occur for heavy rainfall events occurring in a short period of time. As reservoir levels increase above this elevation larger areas of flooding downstream of the dam may occur.

The dam operator is responsible to notify the Emergency Services and Disaster Agency (ESDA) in Wherever when the reservoir levels exceed elevation 732.0. The ESDA office will be responsible for notifying individuals and coordinating their evacuation and return in the event an emergency occurs.

If the reservoir level reaches elevation 734.0, the dam and appurtenances will be inspected at 1-hour intervals if it is currently raining and at 8-hour intervals if it is not raining.

If the reservoir level reaches elevation 735.5 and it is currently raining, the dam operator is responsible to notify ESDA. The dam and appurtenances will be inspected continuously if it is currently raining and at 4-hour intervals when the rain has stopped.

If the reservoir level reaches elevation 736.0 and it is currently raining, the dam operator is responsible to notify ESDA. The dam and appurtenances will be inspected continuously until the reservoir level falls to elevation 735.0 and the rain has stopped.

When the reservoir level reaches elevation 736.5 and it is currently raining, the dam operator is responsible to notify ESDA to evacuate all residents within the dam breach wave area (see Plates 1-5). The dam and appurtenances will be inspected continuously until the reservoir level falls to elevation 735.0 and the rain has stopped.

ESDA will not allow residents to return to the flood wave area until: 1) the lake level is below elevation 735.0, 2) the dam and appurtenances have been inspected by an engineer to determine if damage has occurred, and 3) all damages indicating a weakened condition of the dam have been remedied.

If there is no inflow to the reservoir the estimated time for the reservoir level to drop from the crest of the emergency spillway

(735.5) to the crest of the drop inlet (733.5) is 4.5 hours. With no inflow, the estimated time for the reservoir level to drop from the crest of the drop inlet (733.5) to the flow line of the low flow pipe (714.0) is 20 hours. If the low flow pipe or drop inlet are not allowing the reservoir level to drop due to debris accumulation or damage, the dewatering gate should be opened or portable pumps should be used to lower the reservoir level. The lower reservoir level will allow for the removal of debris, the repair of damage, and the re-establishment of storage in the reservoir.

EQUIPMENT AND MATERIALS LOCATIONS

The following equipment and materials are available at these sites:

Backhoe
Location, Contact Person, Tel. No.

Dump Truck
Location, Contact Person, Tel. No.

Grader
Location, Contact Person, Tel. No.

Crawler Tractor
Location, Contact Person, Tel. No.

Sand Bags
Location, Contact Person, Tel. No.

Sand
Location, Contact Person, Tel. No.

Gravel
Location, Contact Person, Tel. No.

Riprap
Location, Contact Person, Tel. No.

Pumps
Location, Contact Person, Tel. No.

PLATES

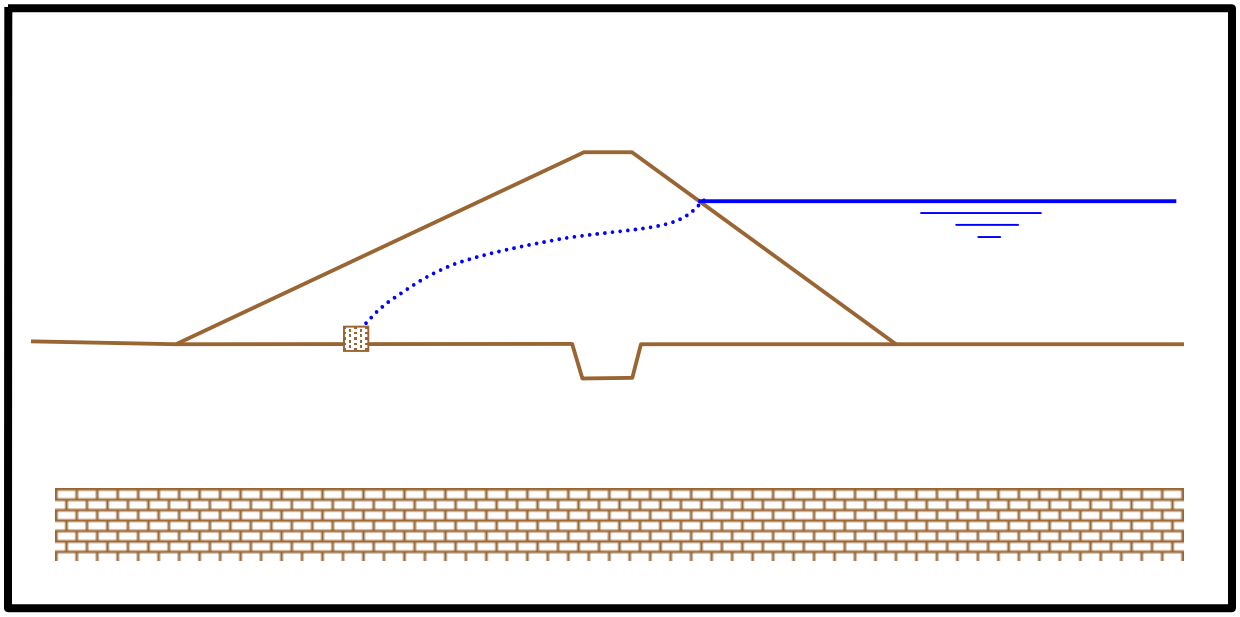
(Specific plates or figures appropriate for the dam should be included here.)

E.13. Indiana



GENERAL GUIDELINES FOR NEW DAMS AND IMPROVEMENTS TO EXISTING DAMS IN INDIANA

2001 Edition



Department of Natural Resources
Division of Water
Indianapolis, Indiana

2010 Appendix A, Appendix B Revisions included

GENERAL GUIDELINES FOR NEW DAMS AND IMPROVEMENTS TO EXISTING DAMS IN INDIANA

2001 Edition

Department of Natural Resources
Division of Water
Indianapolis, Indiana

2010 Appendix A, Appendix B Revisions included

PREFACE – January 1, 2001

These guidelines are directed to project engineers, technical professionals and owners involved in the design and construction of a proposed dam or the modification of an existing dam that is under the jurisdiction of the Indiana Department of Natural Resources (IDNR). The intent of these guidelines is to provide direction to experienced dam design professionals so that the final product, the dam, is safe and the owner's investment in professional engineering is maximized.

The majority of information given in this document is general and provides many of the dam safety technical principles used throughout the country. The Project Engineer in charge of the design of a dam must be a registered professional engineer and have the training and experience to properly apply these guidelines to the specifics of the site and the needs of the owner. If the owner's Project Engineer follows these guidelines and an appropriate engineering design package is submitted to Indiana DNR's Division of Water, the time to obtain approval on the proposed work will be significantly reduced.

These guidelines were modeled after Georgia's Safe Dam Program Engineering Guidelines, 1998 edition. Special thanks are extended to Georgia's Dam Safety personnel and the private engineering community practicing in Georgia for the special opportunity to utilize much of their work in these guidelines.

A committee of 17 professionals from the private engineering community and IDNR contributed significant time to the development of these guidelines. These individuals are listed below:

Siavash Beik	George Crosby	Richard Rampone
Soliman Sherkawi	Jon Stolz	Jack Winters
Ed Board	Scott Ludlow	Chris Ritz
Kenneth Smith	Dave Warder	Dennis Zebell
George Bowman	Christopher Murphy	Jim Sell
Mellissa Stefanovich	Bob Wilkinson	

Special thanks to Debbie Michaels for keying in the text, making revisions to draft copies of this document, and for making copies for distribution, and to Lenny Noens, Herb Bollinger, and Dave Knipe, the north, central, and south engineering basin managers, respectively, for their assistance with the final draft of the hydrology and hydraulics section.

The Federal Emergency Management Agency (FEMA) provided partial funding for the project and the Association of State Dam Safety Officials (ASDSO) encouraged the Division of Water to publish these guidelines. The backing of these two organizations in this project and their long-term support of dam safety efforts in Indiana are appreciated.

Dr. Brian J. Swenty, P.E., Associate Professor and Chair, Mechanical and Civil Engineering Department, University of Evansville, Evansville, Indiana edited the guidelines.

PREFACE – February 1, 2010

Revisions to the guidelines were made in February 2010 to provide clarification in the development of emergency action plans and to properly define hazard class. The definition of hazard classification was developed and defined in regulation and reference to an adapted table is not warranted.
To provide this clarity and new definition,

Appendix A - Table 3 was removed and replaced with the context of the enacted regulation that defines hazard class.

Also, Appendix B – The original "Outline of an Emergency Action Plan" was removed and replaced with a cover sheet that directs the reader to the "Indiana Dam Safety Inspection Manual – Updated 2007" version and Part 4 of that manual. The new Part 4 is entitled "Emergency Preparedness" and represents the recommended guidance for preparation of an Emergency Action Plan (EAP). Templates for an EAP are included in the "Updated 2007 Indiana Dam Safety Inspection Manual".

Table of Contents

TABLE OF CONTENTS

SECTION	TOPIC	PAGE
Section 1	OVERVIEW	1.1
Section 2	FIELD SURVEY	2.1
Section 3	GEOLOGICAL AND GEOTECHNICAL CONSIDERATIONS	3.1
Section 4	HYDROLOGY AND HYDRAULICS	4.1
Section 5	PLANS AND SPECIFICATIONS	5.1
Section 6	CONSTRUCTION MONITORING	6.1
Appendix A	HAZARD CLASSIFICATION	A.1
Appendix B	EMERGENCY ACTION PLAN - OUTLINE OF AN EMERGENCY ACTION PLAN - INSPECTION CHECKLIST	B.1
Appendix C	GEOTECHNICAL ADDENDUM - IN-SITU/FIELD TESTING - INSTRUMENTATION	C.1
Appendix D	RAINFALL DISTRIBUTION & PROBABLE MAXIMUM PRECIPITATION	D.1
Appendix E	SELECTED PLAN SHEETS FOR ILLUSTRATIVE PURPOSES & PARTIAL LIST OF SPECIFICATION ITEMS FOR SAMPLE DAM	E.1
Appendix F	COMMON PITFALLS	F.1
Appendix G	SPECIAL CONSTRUCTION MONITORING REPORTS	G.1
Appendix H	CORRECTION FORM	H.1

Overview

Section 1
OVERVIEW

The general guidelines contained in this manual are useful for the design of small to medium sized dams with the following typical characteristics:

- An earth embankment with appurtenant works constructed to remain stable under a variety of loading conditions for the design life of the structure.
- A properly sized principal spillway that will convey the runoff from normal rainfall events.
- An emergency spillway channel placed an adequate distance from the earth embankment that will operate infrequently and safely pass runoff from the design storm without overtopping the dam.

Guidance on analyses and design issues for innovative, untested, or high-risk dam designs is not covered in these guidelines. The extent of engineering tests, analyses, studies, evaluations, and assessments that are needed to justify an atypical design is beyond the scope of this manual. Further, the time to conduct the additional and extensive engineering analysis and review can be significant when compared to the typical dam described above.

Because each project requires site-specific considerations, these guidelines should not be viewed as a "cookbook" for the design, repair, modification or construction of a dam. The intent of this document is to outline the general technical data, engineering computations, and plans that need to be submitted with the permit application for the proposed work. If these guidelines are followed, the time necessary for the technical review and approval should be reduced. Questions concerning these guidelines should be addressed to the Division of Water at the Indiana Department of Natural Resources, 402 W. Washington Street, Indianapolis, Indiana, 46204.

Dams are complex structures that typically require a multidisciplinary analysis and design approach. Over the years, there have been many incomplete engineering submittals to the Department of Natural Resources (IDNR) that lacked adequate detail in a particular technical area (hydrologic/hydraulic, geotechnical, geological, surveying or structural). The analysis and design of a dam should be supervised by a Project Engineer who is a registered professional engineer. A complete engineering submittal requires adequate technical input and support from hydrologic, hydraulic, geotechnical, geological, structural, and mechanical engineers, as well as licensed land surveyors. It is important for the Project Engineer to consider archaeological and environmental issues in the design or modification of a dam.

An understanding of the roles of the various stakeholders is necessary for the design, construction, and operation of a safe dam.

1.1 Owner's Role

The storage of water is a hazardous activity; it creates increased risk to lives and property situated downstream of the dam. The owner of a dam is responsible for operating and maintaining the dam in a safe manner.

Under Indiana law, IC 14-27-7; "The owner of a dam ... and appurtenant works shall keep the structures and appurtenant works in the state of repair and operating condition required by the following":

- The exercise of prudence.
- Due regard for life or property.
- The application of sound and accepted engineering principles.

A property owner desiring to construct a dam should retain the services of a registered professional engineer experienced in the design and construction of dams and spillways. It is common practice for the owner and the engineer to discuss the owner's needs, the intended purpose of the dam, and the project budget before any design work is performed. During the design process, the owner remains in close contact with the engineer to periodically review the design and the desired project goals.

During construction, the owner works closely with both the engineer and the contractor. Unforeseen site conditions are frequently uncovered that require the owner to approve design changes. The Division of Water should be contacted before field changes are made to the approved plans.

After construction, an owner assumes the role as the primary caretaker of the project. Routine inspection and maintenance allows early detection of many problems that could occur with a dam. The owner should inspect the dam often, keep records of observations and measurements and learn as much as possible about the operation and maintenance of the dam.

Although a dam can be designed and constructed to be a safe structure, lack of routine maintenance and repair, or changing conditions, can eventually cause the dam to become unsafe. If a dam is not in compliance with State law, the owner will be required to improve the dam to bring it into compliance.

The owner may want to confer with an experienced attorney to assess the liabilities of owning a dam.

1.2 Role and Selection of a Project Engineer

The analysis and design of a dam should be supervised by a Project Engineer, who is a registered professional engineer with specialized expertise. These activities require an understanding of hydrology, hydraulics and the behavior of the materials used to construct and support the dam. The Project Engineer will likely need specialized technical input and

support from hydraulic, geotechnical, geological, structural, and mechanical engineers as well as licensed land surveyors.

The primary role of a Project Engineer is to provide leadership in the planning, design, and construction of a dam. A Project Engineer is responsible to see that all technical aspects of the dam and site have been completely evaluated. To accomplish this, the Project Engineer works closely with the owner to establish clear objectives and thoroughly evaluate the proposed dam site. A Project Engineer should have the experience necessary to combine the owner's objectives with the site's potential to develop a design for a safe dam. The Project Engineer supervises the preparation of the permit application, plans, specifications and engineering report, but the engineer's involvement does not end with the submittal to IDNR's Division of Water. It is vitally important that the Project Engineer be involved in the construction of the dam to assist the owner is resolving unforeseen problems at the site and ensure that the dam is constructed in accordance with the approved design. Once the dam has been constructed and the reservoir has filled, the Project Engineer should certify that the dam was constructed in accordance with the design plans and submit as-built drawings to the Division of Water.

Because the design of a dam requires a professional engineer who possesses unique abilities, it is preferable to select a Project Engineer based on qualifications rather than fee. While fee-based competition may result in lower initial design costs, lower costs are often associated with inexperienced engineers and frequently limit the engineer's ability to conduct detailed evaluations that are necessary to develop a cost effective and innovative design. Furthermore, a low design cost often results in a significant increase in the cost of construction as well as long term costs associated with operation and maintenance of the dam.

The Project Engineer should be selected on the basis of technical qualifications, experience with similar projects, reputation with other clients, and capability to meet the owner's time schedule. It is usually best to solicit qualification statements from a number of engineers and perhaps interview several of them before making a selection. Once a qualified engineer is selected, the scope of services and fee can be negotiated. If a reasonable fee cannot be agreed upon, negotiations will terminate and discussions can begin with another qualified engineer. It is best, however, if design costs become a factor only after a well qualified professional has been identified.

1.3 Contractor's Role and Selection

The contractor's primary role is to construct the dam and the appurtenant works in accordance with the plans and specifications. It is the contractor's responsibility to notify the engineer of any changes in the site conditions exposed during construction that vary from those shown on the drawings, in the specifications, or in any documents on site investigations. The contractor is responsible to see that the construction is conducted in a safe manner, that all state, federal and local regulations are adhered to during construction, and that the construction site is secure. The contractor is not responsible for the design of the

dam or modifications to the design made by the engineer. The contractor is responsible for all construction activities including the quality of workmanship used to construct the dam.

Selection of a qualified contractor is very important. The owner, in consultation with the engineer, should pre-qualify potential bidders. Requests for bids or quotes should be requested from contractors on the pre-qualified list. Items to be considered in the pre-qualification process vary. As a minimum, they should include previous experience in constructing dams comparable in size to the project, a history of satisfactory construction performance, adequate manpower and equipment to complete the project in a reasonable time frame, sufficient financial resources, a history of paying subcontractors, familiarity with local conditions, and a past record of displaying a cooperative attitude. Request and contact references.

The owner should select the best-qualified contractor who responds to the request for bids with a reasonable price for the work. A private owner is not required to select the lowest bidder; a governmental owner may, however, be bound by its enabling statutes to select the lowest bidder. An unusually low bid should be viewed with skepticism. It may be that the contractor has idle resources that are available to do the job, or it may be an indication that the contractor has forgotten something, is inexperienced, or follows a practice of bidding low then negotiating costly change orders during the project.

Bonding of the selected contractor should be included in the contract documents. The contractor should be required to obtain both performance and payment bonds. Payment bond references should be contacted. The contractor should warrant the work against defects for a period of at least one year after completion of the work.

1.4 Project Concept

Prior to constructing a new dam, or modifying an existing dam, certain engineering tasks are typically required to investigate, plan, analyze, and design the project. In many cases environmental, legal, real estate, utility, archaeological, historical, cultural, and other considerations related to a project are investigated and incorporated into project analysis and design. The determination of critical site information during earlier stages of the dam project may have a significant impact upon later stages of the project.

Phased design and construction is a process that should be seriously considered when difficult site conditions are encountered. Dividing a dam project into phases provides all parties with more time to make a reasonable determination of the anticipated scope and costs of the associated investigation, planning, analysis, and design work to be provided in each specific phase. Upon completion and review of each phase, the Project Engineer is better informed and prepared to advise the owner regarding tasks which will be necessary for the next phase. Estimates for construction quantities and costs are continually refined after each phase of the project as more accurate information concerning site conditions and suitable design alternatives becomes available.

Phased design and construction provides intermediate opportunities to discuss information and conditions determined during each project phase with regulatory agencies and stakeholders. Critical input concerning acceptable design methods and procedures can be obtained for application in subsequent phases.

Because the construction of a dam involves a significant financial investment, a primary advantage of phased design and construction is the opportunity it affords an owner to consult with the Project Engineer concerning the overall project and financial direction. Since dam projects are typically complex and very site specific, construction techniques and the scope of work may need to be changed to accommodate site conditions.

Actual project phases may vary and some overlap may occur. Depending on the length of time required to complete each phase, previous data may become obsolete and may need to be updated. Following are typical phases of a dam project through construction:

1.4.1 Reconnaissance Study – This is normally the initial phase of a dam project and involves the following tasks: site inspection of suitable locations for a new dam (or the evaluation of site conditions at an existing dam); discussion of the project goals and objectives with the owner; review of property ownership issues; investigation of available information and previous studies of existing dams; determination of general watershed characteristics, which include geologic conditions, soil conditions, preliminary hydrologic factors, possible access locations, potential downstream effects, and the hazard classification of the dam; evaluation of the potential for future downstream development that might increase the hazard classification during the life of the structure; determination of archaeological or historical limitations; determination of local, state, and federal regulatory jurisdictions; preliminary discussions of the project with regulatory personnel; initial discussions of the project with technical professionals in other disciplines and environmental professionals; and if possible, initial discussion of the project with a suitable contractor(s).

A site reconnaissance can disclose a number of surface features that may provide an indication of the subsurface conditions that exist at the site. These observations involve such items as the extent of alluvial depositions, topography, rock outcroppings, karst features, mining, and vegetative cover. A review of published data, including the geology and general soil conditions of the site, will provide significant additional information. Depending on the complexity of the project, other preliminary evaluation techniques may be considered. This information assists the owner and the design engineer in establishing the best preliminary conceptual design for the project, and provides valuable information concerning those areas where more detailed geotechnical evaluations should be concentrated.

1.4.2 Feasibility Study - Based on the preliminary discussions and the information obtained during the reconnaissance study, a preliminary estimate of anticipated engineering costs, mitigation costs, and possible construction costs is determined. This information provides the owner with an initial opportunity to determine whether the

project is financially feasible prior to further expenditures. It is extremely important to remember that preliminary estimates developed during this phase of the project are based on incomplete information and therefore represent only rough estimates of the possible magnitude of the project. These preliminary estimates are not intended to be applied or construed as final project costs.

1.4.3 Preliminary Engineering - During this phase of the project, limited information is obtained through field surveys, geotechnical field testing, and laboratory testing. Studies are undertaken to develop suitable alternatives, including initial estimates of quantities and costs. The Project Engineer assembles a team of qualified technical professionals, based on the project requirements. Suitable topographic maps may be developed from field survey data, a geotechnical report is published, hydrology and hydraulic analysis are conducted, and an environmental reconnaissance is performed. Other studies (water yield, sediment storage, mine tailings storage, etc.) may be performed depending on the scope of the project.

Upon completion of development of suitable alternatives, the Project Engineer presents the results of the preliminary engineering phase, including recommended alternatives to build or improve the dam, to the owner.

1.4.4 Design Phase – After an alternative is selected by the owner, the Project Engineer oversees the final design and preparation of the engineering report, construction plans and technical specifications.

Additional field survey information, geotechnical testing and analysis, environmental reconnaissance, and other technical studies may be required.

Upon completion of the construction plans and specifications, quantity estimates and costs are determined.

1.4.5 Permit Phase - Permit applications for all Local, State, and Federal regulatory agencies having jurisdiction over the project are completed, submitted, and public notice is provided.

1.4.6 Construction Bid Phase – When applicable, construction bid documents are prepared by the Project Engineer's professional team, which provide rules and guidelines for the construction bid process. The construction plans and technical specifications are included as part of the bid documents. Pre-qualification requirements for bidders are established. Requests for bids are distributed to suitable contractors. After receipt of bids, the owner, with the advice of the Project Engineer, selects the best-qualified contractor providing a reasonable price.

1.4.7 Construction Phase - After receiving all permits and approvals, acquiring all necessary property control (property ownership, easements and right-of-ways), and selecting a contractor, construction scheduling and construction activities begin.

Field survey services are used to stake and verify construction locations, alignments, elevations, and grades.

The Project Engineer should be retained to provide construction management services and monitor the construction of the dam. Material testing should be conducted throughout construction to verify that specifications are met. The Project Engineer or a member of the technical team involved in analysis and design should be available for inspection, observation and consultation during all construction activities, especially the excavation of the core trench, the installation of conduits through the dam, the installation of internal drains, and the placement of embankment fill. Because the most dangerous time in the life of a dam is first filling of the reservoir, the Project Engineer should be involved in monitoring this critical phase of the project.

Upon completion of construction activities, the Project Engineer prepares as-built drawings which note any changes or deviations from the approved design/ construction plans and submits the as-builts to the Division of Water.

1.5 IDNR Permit

These Guidelines supplement the Technical Review information in Chapter 5 of the 1996 Indiana Department of Natural Resources Permit Manual. The guidelines provide property owners and their design consultants with general information related to the technical permit requirements for dams in Indiana.

Items related to the completion of the Construction in a Floodway Permit application, environmental issues, and easements are addressed in IDNR's 1996 Permit Manual and should be followed when preparing a permit application.

Prior IDNR approval (permit) should be obtained by anyone desiring to construct or significantly modify (work that is not routine maintenance) a dam before work begins, if the dam meets any one of the following criteria:

- The drainage area above the dam is one (1) square mile or greater.
- The height of the dam, measured from the natural streambed below the crest of the dam to the lowest point on the crest, is equal to or greater than 20 feet.
- The volume of water impounded by the dam at the emergency spillway elevation, is 100 acre-feet or more.

If a permit is required for the proposed project, it will be necessary for the property owner to obtain the services of a registered professional engineer experienced in dam design, construction, repair and maintenance to take responsibility as the Project Engineer.

In order to expedite the permit process, the Project Engineer should meet with the Division of Water staff to discuss details of the project before work commences on the plans,

specifications, and engineering report. It is important that all survey, hydrology/hydraulic, geotechnical, structural and mechanical engineering evaluations are complete and accurate prior to submitting an application for a permit. It has been the staff's experience that when incomplete technical information is submitted with the application, the permit process is delayed months and in some cases years.

1.6 Emergency Action Pans

1.6.1 An Emergency Action Plan (EAP) is a formal plan that identifies potential emergency conditions at a dam and outlines the procedures to follow to minimize property damage and loss of life. All high hazard dams should have an EAP (see Appendix B for an outline).

1.6.2 An EAP is needed to preplan the actions taken by the dam owner, State Emergency Management Agency (SEMA) personnel, and local emergency officials during an emergency. This preplanning will help provide for timely notification, warning, and evacuation in the event of an emergency.

1.7 Enforcement Actions

Indiana Code 14-27-7, requires owners to keep their dam in a state of repair and operating condition required by the exercise of prudence, due regard for life or property, and the application of sound and accepted engineering principles. Routine maintenance and compliance with the conditions of the permit are required. A sample owner's inspection checklist is included in Appendix B.

The Division of Water inspects existing dams to determine their condition and continued compliance with state laws, regulations, and policies.

Occasionally, an owner will choose not to maintain the dam or will resist complying with the Indiana Code provisions for constructing and operating a safe dam. Depending on the seriousness of the situation, the Division of Water has several processes for bringing the dam into compliance ranging from certified letters to appropriate litigation. Fines can be issued and the dam can be breached at the owner's expense.

Field Survey

Section 2
FIELD SURVEY

2.1 Introduction

Collection of accurate field survey information is critical to determine existing site conditions, prepare suitable designs, and successfully construct a dam. Accurate field survey information is required for many aspects of a dam project. Listed below are some of the common, acceptable survey principles that are used by professionals practicing in the dam safety field.

2.1.1 Accuracy

The field survey information necessary for designing dams and spillways, developing construction plans, and verifying construction activities is typically required to be accurate, both horizontally and vertically to a minimum of 0.1 foot, except for preliminary and reconnaissance surveys, where horizontal accuracy of one foot may be acceptable. In certain situations, additional accuracy to a minimum of ±0.01 feet may be necessary.

Although less accurate (nearest foot) site information can be used in preliminary stages of the project to determine alternatives and quantity estimates, the Project Engineer should assess the approximate accuracy of this information to make sure reasonable estimates of locations, alignments, grades, and quantities are obtained.

2.1.2 Datum

Temporary benchmarks (TBM) should be established at the dam and tied to an NGVD vertical datum. TBM's can be used to obtain reliable survey data to design, construct and monitor the performance of the dam throughout the project life. Use of established datums connects the dam to other surveys and maps in the area, and enables the Project Engineer to use information from other sources.

Vertical control (elevations) is typically established on the National Geodetic Vertical Datum of 1929 (NGVD'29) or the North American Vertical Datum of 1988 (NAVD'88). Assumed datums may be suitable for minor improvements or repairs.

Horizontal control is important to verify property boundaries and determine the extent of the reservoir at both normal and maximum pool. Control stations for horizontal control should be established on the North American Datum of 1927 (NAD'27) or the North American Datum of 1983 (NAD'83) using Indiana State Plane Coordinates in U.S. Survey Coordinates (feet) or Universal Transverse Mercator (UTM) coordinates (meters). If a sufficient number of permanent survey markers are placed at a site, an assumed datum may be appropriate to monitor the long term performance of a dam.

2.1.3 Property Boundary

The Project Engineer should determine the project boundary and property boundary for the site. This information should be shown on the plans as well as any easements for property that may be inundated by the reservoir during the design flood.

2.2 Topographic Mapping

Development of accurate topographic mapping is desirable in the initial stages of a dam project in order to establish existing locations, alignments, and grades. The topographic information should provide reasonable accuracy for the determination of alternatives and preliminary estimates of quantities. Development of suitable contour information for proposed or existing impoundment areas is especially important in determining stage-storage relationships for the hydrologic/hydraulic analysis.

Due to the extensive areas involved in large dam projects, application of aerial photogrammetry is usually an appropriate and economic alternative for the development of suitable topographic mapping and site layout information. Field surveys are required to establish the coordinate locations and elevations of specified ground control points prior to development of the topographic mapping by aerial photogrammetry. These temporary monuments establish the necessary horizontal and vertical control to develop a topographic map of the site. It is important to note that topographic information developed from photogrammetry is typically accurate to only one half the contour interval of the topographic mapping. For example, elevation information derived from a photogrammetrically compiled map with a contour interval of 2 feet has an accuracy of ±1 foot.

Adjacent property boundaries, utilities, and other important geographical features are determined from appropriate sources and located to the accuracy required on the project site mapping. If appropriate, accurate locations and descriptions of sensitive environmental areas and archaeological resources should be delineated on the project site mapping.

A hydrographic survey of the bed of the lake at an existing dam may be needed to determine storage for a sediment or water supply study.

2.3 Field Survey for Geotechnical Testing

Field survey information is typically required in conjunction with geotechnical testing to precisely locate test borings and provide accurate cross-sections of existing dams at specified locations for stability analysis.

2.4 Field Survey for Hydrology and Hydraulics Analysis

Field survey information required for the hydrology and hydraulics analysis includes the determination of spillway control elevations and structural details for spillways at both new and existing dams. These details include the type of structure, location, size, alignment, inlet

and outlet elevations, length, outlet type, and other requested structure characteristics to determine losses in both open channels and closed conduits. Accurate determination of an existing lake pool elevation is important to help establish the stage-storage relationship for reservoir routing calculations.

Profiles and cross-sections of natural and man-made channels into which existing or proposed spillway structures will drain are typically required to determine potential backwater effects at spillway structures, the need for channel armor protection, and the design of energy dissipation devices.

For existing dams that have lake drawdown structures, inlet and outlet invert elevations, the length, diameter, and material of the pipe and the size and description of all valves, should be determined.

Finally, for both existing and proposed dams, information about downstream structures (i.e. culverts, bridges, dams, levees, placed fill, etc.) that may restrict flows and result in backwater effects at spillway structures should be determined. It is important that the datum used at any other structure be the same datum that is used at the dam.

2.5 Field Survey for Preparation of Final Designs and Construction Plans

Prior to the preparation of final designs and construction plans for a new dam or improvements to an existing dam, extensive field survey information is required to accurately define the physical characteristics of the project site. Field survey cross-sections should be obtained at intervals along the centerline of a proposed or existing dam and at appropriate intervals along the length of emergency spillways.

2.6 Construction Survey

Prior to the actual construction of the dam, a construction survey is necessary to stake actual locations, alignments, and grades of structures shown on the construction plan. During construction, additional field surveys may be required to verify information on the construction plans and to determine accurate construction quantities. It is recommended that the bottom of the core trench, internal drains, pipes through the embankment, and buried structures be surveyed before backfilling occurs.

2.7 Post Construction Survey

An as-built survey is typically performed after the completion of all construction activity to determine if the structure was built according to the plans. In some instances, the as-built survey data is used to perform hydraulic, hydrologic and geotechnical computations to verify that the dam meets minimum safety requirements.

On some dams, typically only large high-hazard dams, annual or other periodic surveys are conducted to monitor movement of the embankment and appurtenant structures.

Geotechnical and Geological Considerations

Section 3

GEOTECHNICAL AND GEOLOGICAL CONSIDERATIONS

3.1 Introduction

The identification of the site characteristics, engineering properties of the materials used to construct the dam, and geologic conditions beneath the embankment are essential to the design of a safe dam.

The geotechnical and geologic guidelines that follow are predicated on a "typical" project, generally involving a small or medium sized dam at a site with few geological challenges. It should be understood that each and every project is unique, and the geotechnical requirements may be modified accordingly. The type and quantity of field and laboratory tests conducted and the types and numbers of analyses performed will be influenced by the hazard classification and project function. A limited geotechnical investigation may be allowed on small, low-hazard dams while a comprehensive investigation is recommended for large, high-hazard dams. Unauthorized dams will require a geotechnical investigation and the same geotechnical computations as a new dam.

Structures in heterogeneous geologic settings, such as solutioned limestone or lakebed sediments may require extensive geotechnical studies. Subsurface conditions can change dramatically across a valley. Larger dams and dams with very long crest lengths may necessitate additional geotechnical investigations to properly assess the subsurface conditions.

Geotechnical evaluations for the rehabilitation of existing dams should consider the seriousness of the deficiencies. For major rehabilitation projects such as repairing breached dams, increasing the height of a dam, permanently raising the normal pool elevation of the reservoir, repairing embankment slides, modifying excessively steep slopes, and constructing control structures for extensive uncontrolled seepage and piping, the geotechnical evaluations should essentially be the same as that utilized for a new dam. The evaluation should be modified, as necessary, to target the major deficiency(s) identified. Limited geotechnical evaluations are typically acceptable for minor rehabilitation projects such as minor seepage, unsuitable vegetation and minor slope reconfiguration.

3.2 Literature and Initial Review

The development of the subsurface exploratory program should begin with a literature review of existing geologic and geotechnical maps, reports, and other records that might provide technical background information on special conditions at the site and the surrounding area**.** The project details will dictate the extent of the literature search that would be beneficial in the development of the subsurface exploration program. Listed below are some sources of information that may prove helpful.

3.2.1 Geologic Maps and other geologic information

State geologic mapping will provide an indication of the geologic setting of the site. Local, detailed geologic mapping and pertinent information may be available in or near the project area. The Indiana Geological Survey (IGS) located in Bloomington has a wealth of information on the geology of the state and trained professionals that can assist in the interpretation of this information. General information about the IGS can be obtained from the web site "http://adamite.igs. indiana.edu/index.htm".

3.2.2 Soil Surveys

All Indiana counties have existing soil surveys that contain information on the surficial soils. These are particularly useful in the preliminary phase of planning a subsurface exploration program. Almost all counties have a Natural Resources Conservation Service office staffed with technical professionals that can address general soil conditions of the site.

3.2.3 USGS Topographic Quadrangle Maps

Topographic maps provide a general characterization of the surface features of the area under investigation and the drainage patterns which may influence site selection. U.S.G.S. 7 ½ minute topographic maps are available for the entire state. More detailed topographic mapping may be available for certain local areas.

3.2.4 Other Sources of information

- Aerial Photographs
- Well Records
- Technical publications pertaining to the area
- Technical records or inspection reports on existing dams near the site
- Special maps (abandon coalmines, underground caves, etc.)

3.3 Site Reconnaissance

A thorough reconnaissance of the entire site and adjacent areas by the Project Engineer and the geotechnical engineer or engineering geologist is considered to be essential for both new dams and major modifications to existing dams. Typically, a reconnaissance is performed prior to implementing the exploration program to determine the best methods to employ. Additional site reconnaissance may be conducted during or after the field program to help interpret the data being obtained. Vegetative cover, rock outcroppings, and small topographic features (that may not be discerned from the literature review alone) provide useful input.

The primary emphasis of the site reconnaissance is the area within the embankment footprint and areas immediately upstream and downstream. These would include the creek bottom, flood plain, abutments, and any potential open channel spillway alignments within the abutments or areas removed from the dam site. In certain instances, the reconnaissance may include the entire reservoir footprint. It is very important for the reconnaissance team to include the land owner in the site reconnaissance to help identify potential borrow sources and locations of unusual geologic conditions such as rock outcroppings, caves, and springs. A downstream inspection is recommended to better identify the hazard classification.

3.4 Geologic Mapping

Site-specific geologic mapping may be warranted in some instances. This would be particularly applicable to large dams, and those located in unique geologic settings. The applicability of such a method (prior to the subsurface exploration program) is directly related to the amount of rock outcropping that may be identified during the site reconnaissance. In the absence of outcroppings, geologic mapping may be of limited use. Where shallow rock exists, that is not otherwise exposed, test trenches may be appropriate to expose these materials for direct observation.

3.5 Subsurface Exploratory Program

The objective of a successful subsurface exploration program is to strategically obtain samples and pertinent information for an engineering evaluation of all the materials that will affect the performance of the dam and appurtenant works. The Project Engineer should balance the use of in-situ exploratory procedures with the option of obtaining both disturbed and undisturbed samples for laboratory testing. On large dam projects, strength and permeability tests are usually performed on undisturbed foundation samples and remolded samples of borrow material. For small, low hazard dams, laboratory identification tests of bagged samples can be used to obtain assumed shear strength and permeability parameters. The use of conservative shear strength parameters may result in an over-designed structure, thus the Project Engineer must balance the cost of exploration with the cost of over-designing and over-building the dam. Using assumed shear strength parameters may be a reasonable approach for small, low hazard dams, but should not be used for large dams. The use of a haphazard approach to subsurface exploration wastes money and can lead to the design and construction of a potentially unsafe dam where failure may result.

3.5.1 Test Borings

Test borings are typically placed within the footprint of the dam and appurtenant structures. Boring locations on existing dams should target the specific deficiencies identified while considering accessibility to the site. For existing dams with minor deficiencies where sufficient documentation concerning the design, construction, and performance of the dam is available, the need for borings may be minimal.

3.5.1.1 Centerline of the Dam - The number of test borings along the centerline of the dam should be based on the needs of the design. Past experience indicates that three borings along the centerline of small dams with a short crest length is adequate.

3.5.1.2 Embankment Toe - Borings at the upstream and downstream toe should be considered for most dams to delineate the soil stratigraphy in the valley.

3.5.1.3 Conduit and Internal Drain Locations - Additional borings may need to be placed beneath proposed conduit and drain locations to identify subsurface conditions within these specific areas. These borings can provide information to evaluate highly compressible soil layers, weak foundation soils, permeable anisotropic soils, and high ground water conditions.

3.5.1.4 Open Channel Spillways - Open channel spillways in the abutments are typically evaluated with borings, if significant depth of excavation is anticipated. These borings should at least penetrate the depths of excavation and identify the properties of the materials at the base of the channel.

3.5.1.5 Depths and Samples - Boring depths within the embankment footprint area will generally mirror the height of the embankment above each individual boring, with a minimum depth of 15 feet typical. Disturbed samples obtained by Standard Penetration Testing, or other suitable methods, are normally made on 2.5-foot intervals unless there is evidence that the material is relatively homogeneous in which case 5.0-foot intervals may be appropriate.

3.5.2 Test Pits

Test pits excavated with a backhoe can provide useful information in certain portions of the site. Several excavations often allow a more thorough assessment of the upper stratigraphy, and can provide indications of potential difficulties that may be encountered during construction. In situations where the dam is a small, low hazard structure and sound, tight rock is near the surface, test pits that may significantly reduce the quantity of borings. Otherwise the following should be considered:

3.5.2.1 Flood plain - Alluvial deposition is typically complex. Soil test borings alone often do not clearly represent the conditions encountered within flood plain areas. Test pits can provide a better indication of subsurface variability, depths of organic material, past seismic activity, and difficulties that may be encountered relative to groundwater inflow.

3.5.2.2 Shallow Rock - Test pits may be used to supplement the evaluation of general areas where shallow rock is encountered. This helps discern if the refusal materials are fairly continuous rock and whether the rock surface is uniform. This may be particularly useful at sites with karst geology.

3.5.2.3 Open Channel Spillways - Test pits may be an inexpensive means of evaluating areas where the depths of excavation anticipated for channel spillways are minimal.

3.5.3 Rock Coring

Some rock coring is recommended within the footprint of the dam if refusal is encountered at depths less than about half the originally planned boring depth, with appropriate consideration of the geology of the site.

3.5.3.1 Depths - The amount of rock core to be obtained in each hole depends on a number of factors including the size of the dam, geologic setting, and rock quality. Typically, a minimum of 10 feet of rock should be cored at each location.

3.5.3.2 Packer Tests - Packer permeability tests may be performed in conjunction with the rock coring where there is an indication the rock mass is jointed, solutioned, or has significant discontinuities. The Packer Test will assist the geotechnical engineer in determining the hydraulic conductivity of the rock mass (see section 3.7).

3.5.4 Preliminary Instrumentation for Piezometric Levels

The subsurface exploratory program may include the installation of observation wells or piezometers to establish the groundwater conditions within the footprint of a proposed dam or assess seepage-related deficiencies in an existing dam.

Strategically placed piezometers can provide valuable information on conditions in existing dams. For new dams, the installation of piezometers allows the geotechnical engineer to monitor pore pressures during first filling of the reservoir and throughout the life of the structure. This data can be used for analyses and for long term monitoring of dams. See Section 3.10 and Geotechnical Addendum/Instrumentation in Appendix C for further discussion.

3.5.5 Test Samples

3.5.5.1 Disturbed Samples - Split-spoon samples from borings and samples from test pits should be obtained for classification and correlation.

3.5.5.2 Undisturbed samples - A sufficient number of relatively undisturbed samples should be obtained to evaluate foundation materials, especially at large dams. A sufficient number of samples are needed to accurately characterize the differing types of materials present in the valley and abutments. Strength, compression, and permeability tests on undisturbed samples produce data that

is helpful in evaluating the stability of the dam and determining the expected behavior of the materials left in place to support the dam.

3.5.5.3 Bulk Samples - Disturbed bulk samples from test pits or auger cuttings are typically collected, particularly for explorations made in open channel spillway areas and potential borrow areas.

3.5.6 Other Exploration Techniques

Several other exploration techniques may be considered in special situations to address specific areas of concern. Examples include pressuremeter testing or cone penetrometer soundings, particularly in soft foundation materials that may be left in place to support the dam. Geophysical exploration techniques may also be appropriate in some instances.

3.6 Borrow Study

The ultimate purpose of a borrow study is to identify sufficient quantities of acceptable borrow materials that can be used in the construction of the dam. This can be accomplished by estimating the quantity of material needed in the dam and conducting adequate explorations and laboratory analyses to determine the soil profiles in the borrow areas.

3.6.1 Locations

It is important to locate the borrow areas far enough away from the dam so that any excavation below the top of dam elevation does not jeopardize the integrity or the performance of the structure. There are many site and project specifics that will dictate this distance. For small to medium sized dams situated on a geologically "good" site, the location of any borrow area that will be below the dam crest elevation should be kept 200 feet or more from the dam.

3.6.1.1 Open Channel Spillways - For projects involving the excavation of open channel spillways in the abutment areas, it is recommended that these materials be evaluated for use in the construction of the dam. See Sections 3.5.1.4 and 3.5.2.3.

3.6.1.2 Reservoir Area - Any portion of the reservoir area that will be excavated for borrow material should be investigated. Under no circumstances should bedrock be uncovered and left exposed in a borrow area that is within the reservoir boundary.

3.6.2 Exploratory Techniques

The exploration of potential borrow sites should be sufficient to characterize the usable soil deposits(s) both from a geological and engineering perspective. The study

should demonstrate homogeneity relative to the deposit(s) under consideration. Exploratory holes are typically placed on approximately 500-foot centers on a rough grid system at all practical locations.

3.6.2.1 Test Pits - Test pits are the preferred exploration technique for the evaluation of borrow sources where the potential depths of excavation are limited, or where the occurrence of suitable material is near the surface. Soil stratigraphy can be determined in more detail, and the variability and inclusion of unsuitable materials may be more readily observed with test pits. Discreet sampling of specific soil layers and combined sampling of two soils in the vertical profile can easily be done using this technique.

3.6.2.2 Borings - Auger borings are typically required where greater excavation depths are planned.

3.6.3 Sampling

Small grab samples of foundation, abutment, and borrow materials are useful for general classification purposes. Sealed samples of this type can be used to determine in-situ moisture contents. Bulk samples are required on all materials that may be used as embankment fill. Sufficient quantities of bulk material are obtained based on the types of laboratory tests to be performed.

3.7 In-Situ/Field Testing

In-situ testing, or field testing, may be considered in the evaluation of foundation conditions for new dams and in the evaluation of conditions within and beneath existing dams. Typical conditions that may warrant in-situ testing include soft compressible foundation materials that cannot be sampled routinely for laboratory testing, evaluation of seepage through foundations and existing embankments, evaluation of the continuity and integrity of foundation rock, and the determination of excavation quantities and methods.

The utilization of field test methods will depend on the size and length of the dam, the type and extent of foundation materials encountered, and the economic feasibility of a particular method over another. In-situ methods may be used to supplement more common exploration techniques such as soil test borings. Some geologic settings and embankment conditions may necessitate the use of one or more of these methods (see Appendix C - Geotechnical Addendum - Insitu/Field Testing).

3.8 Laboratory Testing

The laboratory testing program typically consists of soil classification and may also include a determination of shear strength parameters, permeability, and compressibility properties of soils. Appropriate in-situ tests may be considered for foundation materials. Laboratory testing of remodeled samples of potential embankment materials is typically needed to

determine the strength of the material. Depending on the size and hazard classification of the dam, a relatively extensive testing program may be required to characterize all of the material types in the foundation and the embankment**.** It may be necessary to perform duplicate tests on significant soil material types to verify a typical value of the material being tested.

3.8.1 Characterization Testing

This type of testing is typically performed to provide an indication of the engineering characteristics of the materials that will be used to construct the dam. These tests also provide identification of the different types of materials involved so that more extensive testing can be targeted to specific material groups.

3.8.1.1 Classification Tests - General classification tests, suitable for classifying soils by the United Soil Classification System (USCS), include gradation tests (sieve and hydrometer, as required) and Atterberg Limits tests.

3.8.1.2 Compaction Tests - Proctor compaction tests, and associated natural moisture content tests are needed to establish the basis for quality control during construction and to provide samples for strength testing. Standard Proctor compaction tests are typically utilized.

3.8.2 Strength Testing

Strength testing will normally be required to determine the shear strength parameters for the stability evaluation of both new and existing dams. Tests are typically performed on relatively undisturbed samples of foundation materials and existing embankment materials. Remolded samples of potential borrow materials are compacted to the minimum value allowed in the technical specifications and tested to determine the shear strength of the material that will be used to construct the new embankment. The state encourages engineers to perform triaxial tests on foundation and embankment soils for significant and high hazard dams. For small, low hazard dams, estimated shear strength parameters may be selected from published data in the Bureau of Reclamation's *Design of Small Dams* for the embankment and foundation material. Estimates should be based on the results of soil classification tests (Atterberg Limits, Sieve Analysis, and Hydrometer Analysis).

3.8.2.1 Triaxial Shear - Laboratory strength parameters are typically evaluated using consolidated undrained (CU) triaxial shear strength tests with pore pressure measurements. The CU test provides both total and effective strength parameters.

3.8.2.2 Direct Shear - Direct shear tests may be considered in certain instances. However, these tests are less accurate than triaxial tests and are becoming less common in the determination of strength parameters for earth dam stability computations.

3.8.2.3 Unconfined Compression - Unconfined compression tests can provide a general indication of undrained shear strength of clayey soils.

3.8.3 Consolidation Testing

Where settlement is an issue, an adequate number of consolidation tests on undisturbed foundation samples are needed to establish the settlement characteristics. Consolidation tests may also be performed on samples from proposed borrow areas that are remolded to provide reliable settlement and deformation data on each soil type proposed for the embankment.

3.8.4 Permeability Testing

Depending on the dam size and the embankment and foundation characteristics, permeability tests may need to be performed on undisturbed samples from the foundation of new and existing dams. When seepage is a concern in an existing dam, permeability tests of undisturbed embankment materials may be necessary. For new dams, remolded samples of proposed borrow materials may require permeability testing. These tests are typically performed on saturated samples to establish hydraulic conductivity characteristics of the various soil types involved. Both falling and constant head tests can be performed.

3.9 Geotechnical Analyses

Appropriate geotechnical analyses are performed to determine the geometry of the dam, the size and location of internal drains, the location of conduits within the embankment, and the location of appurtenant structures. The accuracy of these analyses depends on the validity of the parameters and assumptions developed in the preceding sections. Additional field and laboratory work may be necessary to improve the accuracy of the geotechnical models that are used by the engineer. Critical sections of the embankment should be evaluated for all expected loading conditions that could occur during the life of the dam. The intent of the geotechnical analyses is to design a safe and satisfactorily functioning structure at the lowest feasible cost.

The geotechnical design typically includes the following:

1. Provisions for monitoring the performance of the dam and maintaining the structure to assure satisfactory performance throughout its design life.

2. Evaluation of the stability of the structure during construction, at the end of construction, and during steady seepage conditions.

3. Evaluation of the stability of the dam and appurtenant structures during and after seismic events.

4. Evaluation of the stability of the dam and appurtenant structures during a rapid drawdown of the reservoir.

5. Ability of the embankment, internal drains, and appurtenant structures to experience minor consolidation settlements without adverse affects.

6. Monitoring, collection, and control of seepage through the embankment, foundation and abutments.

3.9.1 Stability Analysis

The purpose of a slope stability analysis is to determine a factor of safety for the embankment which is defined as the ratio of resisting forces (gravity forces and soil shear strength) to driving forces (gravity forces and shear stresses) along the critical potential failure surface.

For existing dams, the primary purpose of the stability analysis is to determine if the embankment is stable under various loading conditions. A stability analysis can be used to evaluate a slope failure that has occurred, design modifications to improve the stability of the embankment, or evaluate proposed changes to the height of the dam or the reservoir elevation. Loading conditions are typically limited to steady seepage-full pool, steady seepage-maximum pool, rapid drawdown, and seismic events.

For new dams, the purpose of the stability analysis is to design an embankment that will meet minimum factors of safety for a variety of loading conditions. These include loading during construction and at the end-of-construction. During the placement of fill, the construction schedule and any external loading should be considered in the analysis of the embankment. The end of construction condition is typically only of concern when rapid fill placement occurs on very soft foundations and undrained conditions occur. The steady state stability of the downstream slope should be analyzed under two loading conditions: the reservoir at the normal pool elevation after development of the steady state phreatic surface and the reservoir at the maximum pool elevation. Where drawdown facilities exist, the stability of the upstream slope is analyzed under rapid drawdown conditions. In limited instances, rapid drawdown due to submergence of the downstream toe may be a consideration. In high seismic zones, a seismic stability analysis should be performed for the downstream slope using an appropriate factor of gravity (i.e. 0.15g) for the design acceleration.

For the end-of-construction condition, the shear strengths of the foundation and dam fill are typically evaluated using total stress conditions (undrained shear strength) where the fill is placed rapidly upon the foundation materials and excess pore pressures have not dissipated. Where the foundation materials are very fine grained

and the build-up of excess pore pressure could be detrimental, piezometers should be installed in the foundation to monitor the pore pressure during construction.

For steady state conditions, the stability analysis should be performed under the assumption that the phreatic surface has been developed. The phreatic surface will begin at the "normal" pool elevation of the upstream face and extend to either the internal drainage system or the downstream slope of the dam, as determined through use of constructed flow nets or finite element seepage analysis. Drained shear strength parameters should be used to evaluate the dam under steady seepage conditions.

Drawdown pipes are encouraged for all dams, especially high hazard dams. Valves should be placed at the upstream end of the pipe to prevent the pipe from being pressurized when it is not in use. Rapid drawdown could occur if the reservoir is lowered at a rapid enough rate to prevent dissipation of the pore pressures at the upstream face of the dam. For dams built of cohesive soils, excess pore pressures may result if the drawdown exceeds 1 foot per week. This could cause an upstream slope failure that could damage the embankment and ultimately lead to the breaching of the dam. A rapid drawdown stability analysis is performed using drained shear strength parameters for the embankment. The reservoir is assumed to be at the invert elevation of the drawdown pipe and embankment pore pressures are computed with the reservoir at normal pool.

After completion of the static analyses, each of the loading considerations should be analyzed considering the appropriate seismic ground acceleration forces. Typically a pseudo-static analysis of only the downstream slope at steady state seepage conditions is performed.

Stability analysis for earth embankments should consider both slip circle methods such as Bishop, Spencer, Morganstern-Price, or Janbu's, and when appropriate, sliding wedge analyses. There are numerous computer programs which are accepted by IDNR’s Division of Water for the performance of stability analyses. The geotechnical engineer is responsible for verifying that the computer stability analyses are correct.

3.9.2 Seepage Analysis

Water will seep through all earth embankments over a period of time. Therefore, it is imperative that this seepage be recognized, monitored, and controlled. A seepage analysis may be necessary to determine pore pressures within the embankment, assess the effectiveness of seepage control options, provide quantitative data for the design of seepage control structures, and predict seepage behavior of the embankment and foundation. The analyses can assist in locating piezometers for use in monitoring seepage through the embankment and foundation.

After the phreatic surface has developed, the permeability of the embankment and foundation materials will determine the seepage flow rate. If the rate is excessive, seepage reduction and seepage collection techniques may be needed. The quantity of seepage flow, the hydraulic gradient through the dam, and the long-term effects of the exit gradient on embankment performance are of particular interest to the geotechnical engineer. Seepage reduction techniques such as cut-off keyways, slurry walls, clay core zones, and grout curtains should be considered. The seepage analysis can be used to select the most effective type of internal drainage system for the dam and foundation.

Permeability data is typically obtained from appropriate laboratory and field tests. The seepage analysis should be performed on the maximum dam cross-section upon completion of the field and laboratory testing. Either a graphical flow net analysis or a more sophisticated numerical finite element model can be used.

Analytical models will aid the geotechnical engineer in determining critical seepage areas within the dam and appurtenant structures. These include areas of excess pore pressure and high gradients. The analysis should consider the proposed drainage system to allow accurate modeling of the phreatic surface, and exit gradients at the toe of the dam. Such analysis will aid in determining if special seepage devices, such as relief wells, will be required in the final design.

It is imperative that the geotechnical engineer be aware of the implications of the seepage analysis. It is always advisable to perform an independent check of any computer calculations to verify that the results are reasonable and within tolerable limits for the structure.

3.9.3 Settlement Analysis

Both the new embankment and the foundation soils will consolidate beneath the weight of the embankment materials. The amount and rate of settlement will depend on the consolidation characteristics of the underlying soils and the rate of pore pressure dissipation. Settlement of the embankment can result in loss of freeboard, depressions on the dam crest, differential settlement along conduits which penetrate the dam, and in extreme cases, transverse cracks that can lead to failure of the dam. Excessive settlement can cause misalignment of conduits, separation of joints, and possible conduit failure which results in leaking and possible soil piping (internal erosion of embankment soils).

It may be necessary to analyze settlement to determine foundation treatment and camber, for the embankment and appurtenant structures. Laboratory consolidation tests should be performed to determine the consolidation and drainage characteristics of the embankment and foundation materials. The geotechnical engineer should consider performing a one-dimensional settlement analysis, which considers the variable loadings across the dam footprint to determine areas of critical movement. If

differential settlement and cracking of the embankment is possible, the geotechnical engineer should consider chimney drains, settlement accommodation along conduits, and joint extensibility for any jointed conduits. The effects of the calculated vertical movements on both the embankment and the appurtenant structures should be carefully considered in the design.

3.10 Instrumentation

Various instrumentation devices are typically required in the construction of large, high-hazard dams, and may be necessary on existing dam rehabilitation projects. Instrumentation can be installed to monitor the performance of the dam during construction, during initial reservoir filling, and during the life of the structure. Foundation and embankment performance may be monitored with piezometers, settlement devices, inclinometers, and seepage measuring devices. Other less common instrumentation may be considered for unusual conditions. Any instrumentation selected should target specific items to be evaluated, establish critical thresholds that suggest the need for a specific action, and establish the details of the monitoring program (see Appendix C - Geotechnical Addendum Instrumentation).

3.11 Geotechnical Report

Once the field exploration, laboratory testing program, and geotechnical analyses have been completed, a final report outlining these items as well as the geotechnical aspects of construction should be prepared. A wide range of report formats is possible. However, the following items should generally be included.

3.11.1 Introduction

A general statement of the purpose of the geotechnical study.

3.11.2 Project Information

A detailed description of the project being evaluated should be documented as part of the report. This is particularly useful if the design changes significantly from the time the geotechnical study was performed to the completion of the design documents.

3.11.3 Exploration Procedures

This section should include a description of the field and laboratory testing procedures utilized in the study.

3.11.4 Site Description

A brief description of the surface features of the project area is helpful. This includes

the project location, surface topography, vegetative cover, and identifiable surface features. The site description essentially summarizes the site reconnaissance observations.

3.11.5 Subsurface Conditions

A brief summary of the subsurface conditions identified by the field exploration program should be included. This summary generally identifies the major types of materials encountered and provides correlations between borings based on the data obtained. This section of the report identifies information gleaned from the desktop study and any geologic field mapping of the site. The intent of this section is to relate the identified subsurface conditions to the known geologic conditions at in the site, and set the stage for addressing any special or unusual conditions in the conclusions and recommendations section(s) of the report.

3.11.6 Findings

This section summarizes the results of the stability, seepage, and settlement evaluations. The results should be placed in this section or intertwined with other sections of the report. By summarizing the evaluations that were performed, the basis for the design, construction conclusions, and recommendations are established.

3.11.7 Conclusions and Recommendations

This section of the report is the most critical and should identify all of the geotechnically related design and construction items that will impact, and be incorporated into, the design contract documents. Design and construction related conclusions and recommendations might be separated or combined. Any areas of uncertainty, such as items that can only be resolved by further evaluation during the actual construction process, should be clearly identified in this section. The following items should be addressed in this significant portion of the geotechnical report.

3.11.7.1 General Assessment - A brief summary of the more significant conclusions and recommendations is included, identifying unusual or critical items that should be addressed in the design and construction.

3.11.7.2 Site and Subgrade Preparation - Recommendations concerning clearing, stripping, and grubbing of the embankment footprint area, spillway locations, and potential borrow areas should be included. All disturbance and excavation limits should be based on safety considerations. Typically, the area beyond the toe of the dam is cleared to minimize root invasion.

3.11.7.3 Foundation Preparation - Recommendations concerning undercutting and replacement of unsuitable materials should be included in this section.

Special foundation preparation techniques are included to deal with partial undercutting of alluvial soils and the preparation of exposed rock foundations.

3.11.7.4 Groundwater and Dewatering - Dewatering requirements to construct the project should be identified. Specific areas that will likely require dewatering, and the extent to which groundwater lowering is needed, should be addressed. General information on the anticipated types of dewatering systems that would be appropriate should be presented.

3.11.7.5 Surface Water Diversion - A general discussion of the need to route surface flows from the drainage basin around and through the construction work area should be identified.

3.11.7.6 Seepage Considerations - The seepage evaluations should include estimates of potential seepage quantities, as well as any seepage reduction and seepage collection techniques needed. Seepage reduction techniques such as cutoff/keyways, slurry walls, clay core zones and grout curtains should be identified. Internal drainage system recommendations should be made for any foundation and embankment drains that are needed. Details concerning gradations of drainage aggregates, filter requirements, the need for special items such as relief wells, and locations and minimum dimensions for drainage components should be addressed.

3.11.7.7 Embankment Geometry - The maximum recommended slope inclination should be specified based on the results of the stability evaluation. The need for toe berms, wave berms, and minimum crest widths should be discussed as well as drainage considerations for the surface of the embankment. Any requirements for zoning within the embankment should be included, specifically addressing material properties that are considered appropriate for each zone within the dam.

3.11.7.8 Earthwork Recommendations - This section of the report should include the material types and quantities identified in potential borrow areas. It should specify minimum compaction requirements and moisture control for all fill material placed during construction. Borrow site management should be addressed. Details concerning the placement procedures for the earthwork operations to assure adequate bonding between lifts, control of overly wet, dry or frozen materials, cross slopes, and management of the fill pad should be provided. Minimum testing recommendations for the earthwork should be included.

3.11.7.9 Settlement - Estimates of settlement, particularly at critical structure locations, should be provided if compressible foundation conditions exist. In conjunction with the settlement assessment, anticipated settlement along

conduits and the associated joint extensibility for any jointed conduits should be described. The potential for excessive differential settlement should be discussed as well as any special foundation preparation techniques or design requirements, such as internal drainage systems and chimney drains. Typically, the settlement estimated at the base of the dam, as well as the settlement within the fill material should be provided. The need to compensate for any potential settlement, including cambering of the crest, special construction sequencing and surcharging requirements should be addressed.

3.11.7.10 Principal Spillway/Conduits - Any special embedding requirements for conduits that will penetrate the dam should be addressed. This would include concrete cradle requirements, filter collars, the need for camber in the pipe to accommodate settlement, and special backfill requirements adjacent to conduits. Allowable bearing pressures for outlet structures should be provided along with any special foundation preparation techniques appropriate for these areas.

3.11.7.11 Emergency/Open Channel Spillways - Items related to the excavation of any open channel spillways in the abutment areas should be addressed. The erodability index of materials exposed at the proposed finish grade should be determined for use in erosion calculations. The suitability of using excavated materials in the embankment, groundwater considerations, and the potential for difficult excavation should be considered. Armored spillway channels in abutment areas or on the embankment should provide details concerning seepage reduction and underdrainage system requirements.

3.11.7.12 Erosion Control - The need for shoreline wave protection, vegetative cover, berms, and protection of critical areas from surface runoff should be considered. Recommendations for positive erosion protection techniques such as riprap should include the bedding requirements for these materials.

3.11.7.13 Other Considerations - Any special requirements for items such as slurry walls, foundation grouting, and special consideration of the geology in which the site is located should be addressed in the geotechnical report. In essence, any geotechnical issues, which may impact the subsequent design and construction of the project, should be considered.

3.11.8 Instrumentation

Minimum instrumentation requirements should be included in this section. These recommendations should include types of instrumentation, locations, and the general approach to be used in monitoring and reporting the data.

3.11.9 Construction Monitoring

The report should address requirements related to the geotechnical evaluation and construction materials testing that will be required during construction. This includes the level of experience of the individuals responsible for testing and monitoring, general testing requirements, and identification of the specific areas that require monitoring. For large, high hazard dams, full-time monitoring of all phases of the construction is required.

3.11.10 Appendices

3.11.10.1 Supporting Data - All of the field and laboratory test results should be included as appendix items. Exploration location plans, subsurface profiles, boring records, laboratory test results, and any special details should be included.

3.11.10.2 Analyses - The actual calculations required for stability, seepage and settlement, as well as any other specific geotechnical calculations performed as part of the basis for the geotechnical study, should be included. This may be as an appendix item to the geotechnical report or may be submitted as a separate document along with the geotechnical study.

Hydrology
and
Hydraulics

Section 4
HYDROLOGY AND HYDRAULICS

4.1 Introduction

A spillway system must be capable of safely passing the runoff from the design storm event without the embankment overtopping and failing. The magnitude of the design storm depends on the hazard classification. A hydrologic analysis of the watershed and a hydraulic evaluation of the spillways are required to design an appropriate spillway system and determine the minimum crest elevation of the embankment.

The hydrologic analysis involves the computation of the runoff hydrograph. The hydraulic evaluation includes reservoir routing and the computation of elevation-discharge data for both the open channel and closed conduit spillways. Although this differentiation is not universal in civil engineering, it will be used in these guidelines.

Spillway design is an iterative process that involves routing the runoff hydrograph through the reservoir and a trial spillway system. The objective of this process is to design a spillway system that will safely pass the runoff from the design storm without overtopping the dam. Other objectives include designing a spillway system that is economical, dependable, and can be constructed with locally available materials.

The information in this section discusses some of the basic elements of a hydrologic and hydraulic analysis that the Project Engineer will find useful in designing or evaluating a spillway system for a dam. The methods referred to in this section are not exhaustive. Specific analytical methods should be determined on a case-by-case basis. Pre-design meetings between the engineer and the Division of Water are encouraged.

4.2 Hydrology

The design of a new spillway system and the evaluation of an existing spillway require the engineer to compute a runoff hydrograph. Parameters used in the computation of a runoff hydrograph include the watershed area, total rainfall, rainfall distribution (hyetograph), time of concentration, initial abstraction, and infiltration characteristics of the watershed.

4.2.1 Methodology

The runoff hydrograph, elevation-discharge data for the spillway system, and an appropriate reservoir storage-indication method of flood routing are used to perform an overtopping analysis of the dam. Flood routing is necessary to evaluate the adequacy of existing spillways and design new spillway systems. The overtopping analysis involves four steps: computing the runoff hydrograph, determining the elevation-discharge relationship for the spillway system (using the methods in Section 4.3), determining the elevation-storage relationship for the reservoir, and routing the runoff hydrograph through the reservoir and spillway(s). When designing

a new spillway, iterations continue until the engineer determines an acceptable top-of-dam elevation and adequate size for both the principal and emergency spillways. Because of the iterative nature of the computations, engineers frequently utilize computer programs to perform hydrologic simulations. Acceptable computer programs include the United States Department of Agriculture (NRCS) DAMS2, SITES, and TR-20 software and the United States Army Corps of Engineers (COE) HEC-1 and HEC-HMS software.

4.2.2 Hazard Classification

The hazard classification of a dam is determined by evaluating the area that would be affected by inundation in the event the dam fails with the reservoir at the emergency spillway crest elevation or the dam crest elevation, in the absence of an emergency spillway. A correlation between the amount of inundation and the hazard classification is summarized in Appendix A. In many cases, the hazard classification of a dam can be determined by a review of current topographic maps and a visual inspection of the downstream floodplain for a distance commensurate with the size of the reservoir. If a breach analysis is required, the methodology described in Section 4.10 should be used.

Over time, development occurs in the area downstream of a dam. In fact, a manmade lake sometimes encourages downstream development. It is therefore prudent for the Project Engineer to consider designing the spillway for a higher hazard classification, when appropriate. This can help the owner avoid major dam and spillway modifications at a later date when the downstream development occurs, the hazard classification increases, and costs for upgrading the dam and spillway system are higher.

4.2.3 Design Storm Events

After the hazard classification of the dam has been determined, the appropriate design storm is selected using the criteria in Table 1.

If the time of concentration (Tc) is less than 6 hours, the 6-hour Probable Maximum Precipitation (PMP) should be used to analyze the spillway system. If the Tc exceeds 6 hours, the design storm duration is increased to a time equal to or greater than the Tc. This increases the PMP depth to account for the longer storm duration. All season 6-hour, 10 square mile PMP isohyetals and 24-hour, 10 square mile PMP isohyetals for the state can be found in Appendix D and in the latest edition of the Indiana Department of Natural Resources (IDNR) - Division of Water Publication "Rainfall Frequency for Indiana." The definition of the PMP rainfall event and its computation are discussed in the Department of Commerce Hydrometeorological Report (HMR) No. 52. If the watershed is greater than 10 square miles, the PMP depth may be reduced using procedures outlined in Hydrometeorological Report (HMR) No. 51.

Table 1: Design Storm Event for Spillway Design and Analysis

Dam's Hazard Classification	Design Storm Event	Remarks
High	100% PMP	For existing dams, a smaller design storm between 50% & 100% PMP may be justified through an elaborate Incremental Hazard Evaluation procedure described in TADS module "Evaluation of Hydrologic Adequacy".[1]
Significant	50% PMP	
Low	100-Year to 50% PMP	The spillway design storm requirements may vary from the 100-Year storm (for in-channel, low head dams which will be completely inundated by the 100-year storm event) to the 50% PMP (for normal situations, where the downstream hazard is likely to increase from low to significant in the future). A smaller percentage of PMP may be accepted by the Division of Water on a case by case basis, if the consequences of dam failure can be demonstrated to be negligible or assurance in the form of a deed restriction, covenant, etc. is provided to the Division of Water prohibiting new development within the dam breach inundation zone.

NOTE: [1] Information regarding this publication may be obtained from the Division of Water . The owner and engineer should recognize that dam construction typically results in higher risks. If an Incremental Hazard Evaluation procedure is utilized, the owner should periodically evaluate the downstream area to determine if this evaluation is accurate as new development takes place. The owner may eventually be required to modify the dam and spillway to safely pass the runoff from the 100% PMP, if such analysis indicates that the earlier results are no longer valid due to new development occurring downstream.

The 6-hour PMP hyetograph is derived using the NRCS Type B distribution while the 24-hour PMP hyetograph is derived using the NRCS Type II distribution. Both distributions are shown in Appendix D. Other rainfall distributions may be used to develop the design hyetograph. The Project Engineer is encouraged to meet with the Division of Water staff to discuss the use of other methods.

4.2.4 Watershed Area

Watersheds should be delineated on USGS 7½ minute topographic maps in accordance with recognized USGS delineations in the booklet, “Drainage Areas of Indiana Streams” to determine the size, shape and relief of the area contributing runoff to the reservoir. Watersheds are divided into sub-watersheds when appropriate

(see http://in.water.usgs.gov/cdfactsheet/index.shtml) for use in delineating watershed boundaries. The engineer should consider dividing the watershed into sub-watersheds when the area above the dam is greater than 2000 acres or the sub-watersheds have significantly differing characteristics such as slope, land use, soil types, or shape.

4.2.5 Time of Concentration

There are numerous methods that can be used to compute the time of concentration. The size, shape, and geomorphology of the watershed are key factors that should be examined in detail before selecting a method. The surface runoff path should be divided into subreaches depending upon type of flow (sheet-overland, concentrated, gully, storm sewer, culver, ditch, stream, or channel), land cover, and slope. The kinematic wave method may be applied to calculate travel times from the point of entry into the lake, through the reservoir, and to the spillway outlet. Travel time calculations for each subreach should be provided and the total travel time indicated. Parameter limitations of each method should be examined before a method is selected. The following are a list of methods frequently used to compute the time of concentration:

- NRCS TR-55 Method (computes Tc directly by dividing the watershed into flow segments for both overland and channel flow; travel times for each segment are summed from the most hydraulically remote point in the watershed to the reservoir)
- NRCS Upland Method
- Kinematic Wave Method (computes Tc directly by dividing the watershed into flow segments for both overland and channel flow; travel times for each segment are summed from the most hydraulically remote point in the watershed to the spillway outlet)

Other Tc methods are acceptable. Documentation for the method used to determine the Tc should be included in the engineering report and should include the equation(s) and the design methodology (see Section 4.11).

4.2.6 Rainfall Losses

Initial abstraction and infiltration are deducted from the total rainfall to derive the runoff hydrograph. In the absence of site-specific data, lumped parameter models such as the NRCS Runoff Curve Number Method (*National Engineering Handbook*, Section 4, *Technical Release 5*, or *Engineering Field Handbook*, Chapter 2) can be used. The NRCS Runoff Curve Number Method is a methodology that determines losses and initial abstraction on the basis of soil types and land use. As a minimum, curve numbers should be determined for antecedent moisture condition (AMC) II. The engineer should consider projected land use changes in the computation of the curve number. Design documentation will include soil types, land use, maps, and the

methodology used in calculating the curve number (see Section 4.11). The COE HEC-1 and HEC-HMS programs include other loss rate methods that are acceptable.

4.2.7 Hydrographs

Because smaller watersheds in Indiana are ungaged, the use of synthetic unit hydrographs is an accepted procedure for the computation of runoff hydrographs. Synthetic unit hydrographs are based on the assumption that watersheds within a homogeneous region have similar rainfall-runoff characteristics. The NRCS dimensionless unit hydrograph is typically used and is valid for watersheds up to 50 square miles in size. Larger watersheds can be divided into sub-watersheds less than 20 square miles in size to use the NRCS method. Clark's unit hydrograph, which considers the storage effects of the watershed, and Snyder's unit hydrograph, which considers the physical geometry of the watershed, are useful for analyzing larger watersheds. Snyder's method is valid for watersheds ranging in size from 10 square miles to 10,000 square miles. Other synthetic unit hydrographs may be acceptable but should be coordinated in advance with the Division of Water.

4.2.8 Channel Routing

Large heterogeneous watersheds are frequently delineated into sub-watersheds and stream networks. Runoff hydrographs are derived for each sub-watershed and channel routed through the stream network to the reservoir. The Modified Puls Method and the Muskingum-Cunge Method are typically used to perform the channel routing. The Muskingum-Cunge Method requires knowledge of the physical characteristics of the channel, such as the reach length, cross sections and slope to compute the routing coefficients. Both methods may be used with the HEC-1 or HEC-HMS programs to derive the runoff hydrograph for the watershed.

4.3 Hydraulics

Hydraulic calculations are performed to determine the elevation-discharge characteristics of closed conduit and open channel spillways. Principles of fluid mechanics allow the engineer to analyze weir, orifice and full pipe flow in closed conduit systems, which may include inlet structures, outlet structures, gates, and valves. Open channels are typically analyzed under steady, nonuniform flow conditions to determine the location of the control section and the water surface profile. Transitions from gradually varied flow to rapidly varied flow frequently occur in open channels and the analysis should evaluate the effect of side channel entrances, ogee sections, bridges, geometric transitions, and energy dissipation structures.

4.3.1 Spillways

The design of spillways for a dam project requires consideration of numerous parameters. Among these parameters are the type, size, and location of primary and emergency spillways and the need for inlet and outlet structures. The topography and

soil conditions at a site are important considerations in the design of spillway systems. The need for energy dissipation, erosion control, debris protection measures, and maintenance procedures should be evaluated.

Typically, a dam will have at least two spillway structures, a principal (or primary) spillway and an emergency (or auxiliary) spillway. The combined capacities of the spillways should be able to safely pass the runoff from the design storm without overtopping the dam. The emergency spillway should be an engineered open channel to prevent blockage during the design flood.

Due to the high maintenance costs and the erosion potential of grassed open channel spillways, it is desirable to minimize the frequency of use of the emergency spillway. A typical approach is to design the spillway system so that the emergency spillway only operates for rainfall events greater than the 100-year event. For significant and low hazard structures, the emergency spillway should only operate for rainfall events greater than the 50-year storm.

The emergency spillway (regardless of the type) should be properly protected against erosion in order to provide structural resistance to up-lift, cavitation, vibration, and erosion. Sufficient erosion protection should be provided to prevent the uncontrolled release of reservoir storage below the emergency spillway elevation during the design flood.

4.3.1.1 Principal Spillway

The principal (or primary) spillway controls the normal pool elevation of the lake and should safely handle outflow from the lake under various conditions including freeze/thaw and ice buildup. The principal spillway usually consists of an inlet structure, a closed conduit, and an outlet structure. Ease of access for timely maintenance is especially critical. Principal spillways are frequently located within the embankment although they may be situated in natural ground. Some types of principal spillways include:

- Culvert(s)
- Drop Structures
- Gated Structures
- Labyrinth Weirs
- Morning Glory Inlets
- Ogee Weirs
- Standard Covered Risers

Public safety should be considered in the design of principal spillway inlets and outlets. Barriers should be placed on riser openings and signs posted near inlet structures to warn the public of the hazard posed by spillways.

4.3.1.2 Emergency Spillway

The emergency (or auxiliary) spillway provides additional discharge capacity as the lake level rises to prevent the dam from overtopping during the design storm. The emergency spillway also provides an alternative for safe discharge should the primary spillway become inoperable or blocked.

The outlet slope of the emergency spillway should be greater than the critical slope to cause critical depth (a hydraulic control section) to occur at the spillway crest. Backwater computations should be submitted for a wide range of discharges in order to establish a rating curve and show the depth-discharge characteristics for the entire length of the spillway. Regardless of the spillway slope, it is advisable to compute a water surface profile for the design discharge using the Corps of Engineers HEC-RAS or HEC-2 programs to estimate the maximum velocities in the channel and determine the height of erosion protection required in the spillway.

The emergency spillway is typically an open channel. It should be located in natural ground away from the dam so that during the operation of the spillway, the dam will not be endangered. When this is not feasible, adequate armor protection should be placed on the dam to allow a portion of it to act as an emergency spillway during the design storm. Emergency spillways in natural ground are typically vegetated but may need additional protection if operated frequently or if design flow velocities are excessive. Listed below are types of acceptable armor protection for emergency spillway channels:

- Articulated Blocks
- Concrete Paving
- Gabion Baskets (underlain with a properly designed filter)
- Engineered Riprap

Early coordination with the Division of Water is required when an emergency spillway will be located on the embankment.

4.3.2 Spillway Rating Curves

A rating curve (plot of elevation versus discharge) should be developed for each primary and emergency spillway structure. The rating curves should be combined into an overall rating curve for the reservoir. The engineer should evaluate how the different spillway structures will affect the overall outflow capacity and the ability of the spillway system to safely pass runoff from the design storm.

Design documentation should include the equations used to calculate each of the spillway rating curves and the design methodology. The rating curves should be

provided in tabular and graphical format (elevation-discharge tables) for each of the spillway structures and combination of all structures.

Maximum design flow velocities for the principal and emergency spillways should be computed when designing structures, outlets, and channels. An evaluation of the maximum velocities is necessary to determine if stilling basins or other outlet protection is required. The design of suitable energy dissipation measures is an important consideration for each spillway structure

4.3.2.1 Downstream Channel Conditions

Channel conditions downstream of the dam can greatly affect the discharge capacity and stability of the dam and should be considered in the overall design. In situations where there are restrictions in flow capacity downstream of the dam (due to a roadway culvert, bridge, lake, levee, or a narrow valley cross-section), the restrictions should be evaluated to determine if tailwater conditions exist at the dam and if the tailwater will reduce the capacity of the spillways.

Typical stilling basin and plunge pool energy dissipation designs require that the tailwater elevation for the channel downstream of these structures be known.

The methodology and data required for determining tailwater conditions at spillway outlets can vary depending upon the characteristics of each downstream restriction. Appropriate field data should be obtained for each downstream restriction, in order to accurately determine the resulting tailwater effects. Corps of Engineers programs HEC-RAS and HEC-2 are typically used to calculate backwater profiles for determining tailwater effects. Other methods or software may be acceptable with prior approval from the Division of Water

4.3.3 Force and Energy Considerations

The operation of spillway structures involves the discharge of significant flows for an extended period of time. In the event the forces and energy resulting from flow through the spillway structure are not considered in the selection and design of spillway structures, damage or failure of the structure may occur. This could impact the overall safety and integrity of the dam.

Structural analysis is necessary to determine the effect of momentum forces on the spillway structures during the design storm. The results of the analysis are used to design the structures to withstand these forces. Analysis and design to provide adequate energy dissipation at each spillway outlet is also necessary. Listed below are some types of energy dissipators.

4.3.3.1 Conduit Spillway Energy Dissipators

- Cantilever Plunge Pool
- Impact Basin
- Riprap Basin
- Stilling Basin (with blocks and end sill)
- Chute Blocks

4.3.3.2 Concrete Chute Spillway Energy Dissipators

- Deflector Buckets
- Hydraulic Jump Basin
- Stilling Basin

Earthen emergency spillways are subject to erosion and possible failure during the design storm. If the failure of an earthen emergency spillway could affect the safety or integrity of the dam, or pose a hazard to downstream residents and structures, spillway attack calculations should be provided. These calculations predict the likelihood that an earthen spillway will fail during the design storm based on soil resistance and bulk length. Field and laboratory data should be obtained to perform the spillway attack calculations so that the spillway can be designed to perform safely. The NRCS SITES computer program may be used to assess the erodibility of an earth spillway.

Structural analysis and geotechnical evaluations regarding spillways should be incorporated into the structural design section of the engineering report and submitted with the permit application.

4.4 Reservoir Routing Procedures

The elevation-storage characteristics of the reservoir should be determined from a hydrographic survey of the reservoir, USGS topographic maps, or maps derived from aerial photography. The elevation-storage data should be submitted in both graphical and tabular format.

After the runoff hydrograph, the elevation-storage curve, and the combined spillway-rating curve have been derived, the engineer can perform reservoir routing computations. Reservoir routing refers to the iterative process of balancing inflow volume, outflow volume, and available storage volume for incremental time periods over the duration of the design storm event in order to assess performance characteristics of the reservoir. The Modified Puls reservoir routing method is typically used to route the runoff hydrograph from the watershed through the reservoir and spillway system. Alternatives for various configurations of the dam and spillway system should be evaluated to design a cost effective principal and emergency spillway that will be dependable and safe.

4.5 Freeboard Calculations

All spillway systems must safely pass the design storm without overtopping the dam. The characteristics of the reservoir should be evaluated to determine if freeboard is required. Freeboard is defined as the distance between the maximum elevation of the reservoir during the design storm and the minimum elevation of the dam crest. In certain situations, the length and orientation of the reservoir may increase the height of waves during the design storm. These waves could overtop the dam. The engineer should determine the effects of wave action when appropriate.

On rare occasions, a dam may be designed to allow overtopping to occur during the design storm. Because of the complexity and risk involved in designing a dam to withstand overtopping, the Project Engineer should meet with the Division of Water staff early in the preliminary engineering phase to discuss specific design requirements.

4.6 Structural/Mechanical

Spillway structures, gates, valves, and appurtenant works should be designed to operate efficiently and safely handle all expected flows (normal & infrequent) and loading conditions from the dam. Spillway structures should be designed to allow maintenance and repairs to be accomplished throughout the expected life of the dam.

4.7 Filling Schedule for Reservoirs

In some cases, it may be necessary to fill the reservoir in stages to allow time for the embankment and foundation materials to adjust to the increased hydrostatic loads resulting from the reservoir. A schedule for filling the reservoir should be developed, based on the embankment and foundation performance, as determined by properly installed instrumentation and visual inspections. The following is a typical schedule for filling the reservoir:

- First 1/3 of the pool level – fill rate unrestricted
- Second 1/3 of pool level - no more than 2 feet per week
- Final 1/3 of pool level - no more than 1 foot per week

4.8 Drawdown Time

All dams should have an adequately designed drawdown structure to allow maintenance and accommodate the requirements of the Operation Plan and the Emergency Action Plan. The dam owner should consider the affects of downstream flooding during reservoir drawdown operations

Rapid drawdown situations affect the stability of the embankment and should be considered when designing the dam and lowering the pool. The rate of safe drawdown and the capacity

of the drawdown pipe should be computed by the engineer and documented in both the Operation Plan and the Emergency Action Plan.

4.9 Spillway Materials

Proper selection and design of materials for a spillway system are as important as the capacity. Metal, concrete, riprap, geosynthetics, and high-density polymers are some of the materials available for spillway structures. The anticipated loads, required operations, expected performance, life cost, and the spillway environment should be considered in the selection of spillway materials.

Materials for pipe spillways should be selected carefully. Pipe spillways are designed for pressure flow. Corrugated metal pipe (CMP) joints are not designed to be watertight in high-pressure applications and are not recommended for use in spillway systems. Welded steel pipe is acceptable in low-head applications but cathodic protection should be provided to delay the onset of corrosion. Because of construction issues, past failures, and the lack of long-term performance documentation in spillway applications, the use of polyvinyl chloride (PVC) and high-density polyethylene (HDPE) pipes are not recommended for spillway pipes. Reinforced concrete pipe (RCP) is very durable and is typically used in pipe spillways. Bell and spigot joints with rubber o-ring gaskets provide a watertight joint in most RCP applications. The use of anti-seep collars and/or seepage control diaphragms should be included in the design and construction of conduit spillways through dams.

4.10 Hazard Evaluation and Dam Break Analyses

Properly designed, constructed, and operated dams can be expected to attenuate downstream discharges during flood events. However, failure of a dam during normal conditions or during a flood event can create a potential hazard far greater than that which existed without the dam. The consequences of dam failure should be fully evaluated and analyzed in order to properly identify and define the extent of the potential "hazard zone". The results of these analyses should be used in determining the hazard classification of the dam and developing the Emergency Action Plan procedures.

4.10.1 Dam Break Analysis Methods

The degree of study required to define the impacts of potential dam failures is site specific and will vary depending upon the type and height of dam, size of reservoir, and downstream conditions. In some cases, detailed studies referred to as, "dam break" or "dam breach" analyses, will be required to determine the anticipated downstream hazard zone.

The generally accepted procedure for dam break analysis involves application of unsteady flow and dynamic routing methods. The following computer programs apply this procedure:

- DAMBRK (National Weather Service)
- FLOODWAV (National Weather Service: combines the DAMBRK model with the DWOPER model)

The Corps of Engineers HEC-1 hydrologic model may also be used to perform a dam break analysis to determine downstream inundation areas. The HEC-1 dam break simulation assumes that the reservoir pool remains level while water is released through an incrementally changing triangular, rectangular, or trapezoidal breach in the dam. The HEC-1 model can be used with a river routing scheme to delineate downstream flood zones or in conjunction with the COE HEC-RAS or HEC-2 models to simulate steady, nonuniform flow conditions in the downstream channel and floodplain. When the COE models are used, the hydrologic methods are assumed to be appropriate for the dynamic flood wave. Under most conditions, these assumptions will be approximately true and will provide results that are sufficiently accurate for the determination of the downstream hazard zone. Appropriate care is recommended in interpreting the results of a dam break analysis based on these assumptions. If a higher order of accuracy is necessary, the National Weather Service unsteady flow models should be applied.

4.10.2 Dam Break Analysis Parameters

The accepted methods for determining dam break analysis scenarios require the user to select the dam failure parameters under a variety of failure modes. Table 2 provides typical values for these parameters. The parameters include the size, shape, and time of formation of the dam breach.

The conditions during which the simulated dam breach occurs is a critical component of the analysis. A "sunny day" breach analysis implies that the dam fails as a result of structural, geotechnical or mechanical failure, not as a result of overtopping of the dam. However, it is advisable, when performing a sunny day breach analyses, to assume (at a minimum) that the reservoir pool elevation is at the emergency spillway operating elevation. In the event that the reservoir does not have an emergency spillway or other open channel spillway outflow, the reservoir elevation should be considered to be at the minimum dam crest elevation.

Simulation of a dam break during the design storm is also advisable. This analysis should be considered in situations where there is the potential that the spillway system capacity could be significantly reduced as a result of blockage, operating failure, or some other condition. This dam break scenario assumes that the failure will occur as soon as the reservoir elevation exceeds the minimum dam crest elevation. Careful consideration should be given to the amount of inflow, the reservoir elevation at failure, and the downstream water elevation. If a recent storm event has occurred, downstream conditions may still be fully saturated or at a flood level.

When analyzing a sunny-day breach or a dam break during the design storm event, the flood storage provided by downstream dams may be considered by the engineer if these dams are approved by the state and regularly inspected. If a downstream dam is not approved by the Division of Water or if an approved downstream dam is found to overtop, the water stored by the dam is assumed to be released and included in the analysis.

Table 2: Suggested Breach Parameters for Indiana

Type of Dam	Avg. Breach Width BR (feet)	Breach Side Slope Z	Time to Failure TFH (Hours)
Arch	W	Vertical or Slope of Valley Walls	0.1
Masonry; Gravity	Monolith Width	Vertical	0.1 to 0.3
Rockfill	HD	---	---
Timber Crib	HD	Vertical	0.1
Slag; Refuse	80% of W	1.0 to 2.0	0.1 to 1.0
Earthen "non-engineered"	2HD to 5HD	0.0 to 1.0	0.1
Earthen "engineered"	0.5HD to 5HD	0.0 to 1.0	0.5 to 1.0

Definitions:

BR	Average Width of Breach
HD	Height of Dam
TFH	Time of Full Formation of the Breach
W	Crest Length
Z	Horizontal Component of Side Slope of Breach

4.11 Documentation

The hydrologic and hydraulic design and analysis of a dam consists of extensive technical work. The engineering report should clearly document the programs, assumptions, parameters, equations, tables, graphs, methodology, engineering judgement, results, and recommendations that were used in the evaluation process. When computer programs are used to perform hydrologic and hydraulic computations, copies of the data files should be submitted in electronic format (floppy disk or CD). The engineering report should be submitted with the permit application to facilitate the review and approval process.

Drawings
and
Specifications

Section 5
DRAWINGS AND SPECIFICATIONS

5.1 Introduction

Every proposed dam or dam repair project requires a set of complete drawings (also referred to as plans) and specifications tailored to the project.

The drawings and specifications are based on the results of the technical evaluations (hydrologic/hydraulic, geotechnical, geologic, structural, etc.) described in the previous sections and recommendations in the engineering report. This section lists items which typically are included in a set of drawings and specifications submitted to the Division of Water. This is not intended to be an all-inclusive list, nor will all of these items be required for every project. This list is limited to aspects of the dam and appurtenant structures. Other items such as an erosion control plan and a plan addressing archeological and cultural resources may need to be submitted for review by others. Some of the items in this section may be combined for clarity or simplicity.

Selected plan sheets for an example dam have been included in Appendix E to illustrate the level of detail and completeness required for small to medium size dams. In Appendix F is a list of the Common Pitfalls that render plans and specifications incomplete.

5.2 Construction Drawings Guidelines

It is recommended that drawings be submitted on 24” X 36” sheets.

5.2.1 Title Sheet

- 5.2.1.1 Location map with North arrow and scale
- 5.2.1.2 List of drawings
- 5.2.1.3 Twenty-four (24) hour contact and phone number
- 5.2.1.4 Owner's name, address, and phone number
- 5.2.1.5 Engineer's name, address, and phone number
- 5.2.1.6 Engineer's professional seal
- 5.2.1.7 Legend & Information

5.2.2 Regional Plan

- 5.2.2.1 Regional features that the contractor should be aware of during construction (i.e. drainage area, upstream dams, etc.)
- 5.2.2.2 Location of proposed lake and dam
- 5.2.2.3 Downstream hazards (buildings, road, etc.) potentially impacted by dam breach

5.2.3 Vicinity Plan

5.2.3.1 Excavation within the area upstream from the toe of the dam should be based on safety considerations. The Project Engineer usually determines the limits of excavation.
5.2.3.2 Disturbance limits
5.2.3.3 Existing topography
- source (aerial, ground survey, data source)

5.2.3.4 Existing features
5.2.3.5 Borrow/spoil areas
5.2.3.6 Property/easement limits and owners/easement holders
5.2.3.7 North arrow and scale
5.2.3.8 Demolition

5.2.4 Site Plan

5.2.4.1 Site grading
5.2.4.2 Existing topography
- source (i.e. aerial, ground-run, data source)
- contour interval 2-5 ft suggested.

5.2.4.3 Existing features
5.2.4.4 Borrow/spoil areas
5.2.4.5 Disturbance limits
- should be based on safety considerations.

5.2.4.6 Property/easement limits and owners/easement holders
5.2.4.7 Proposed structures, spillways and features
5.2.4.8 Demolition
5.2.4.9 North arrow and scale
5.2.4.10 Geotechnical exploration locations
5.2.4.11 Survey control points

5.2.5 Profiles and Sections

5.2.5.1 Dam centerline profile
- subsurface soils/rock borings
- crest profile (showing compensation for settlement)
- seepage collection and drainage features

5.2.5.2 Dam cross sections
- foundation preparation
- embankment zoning
- upstream and downstream slopes
- seepage collection and drainage features
- cut off trench
- roadway on crest

5.2.5.3 Emergency spillway profile
- typical section
- cross sections
- training berm profile

5.2.5.4 Principal spillway profile
- conduit camber
- anti-seep collar
- seepage control diaphragm

5.2.5.5 Seepage reduction
- clay blanket
- keyway
- slurry wall
- grout curtain
- other relevant items

5.2.6 Seepage Collection

5.2.6.1 Drain Types
- chimney drains
- blanket drains
- trench drains
- toe drains
- foundation drains
- filter collar drains
- rock toes
- other

5.2.6.2 Drain Plans

5.2.6.3 Drain Profiles and Sections

5.2.6.4 Drain Details
- outlet headwalls
- cleanouts
- collection pipe
- animal guards

5.2.7 Instrumentation Plan

5.2.7.1 Settlement plate locations

5.2.7.2 Piezometer locations

5.2.7.3 Instrumentation details (as needed)

5.2.7.4 Installation details (as needed)

5.2.8 Structural Plans

5.2.8.1 General Plans

5.2.8.2 Structural sections and details

5.2.8.3 Waterstop details

5.2.8.4 Concrete joint details and locations

5.2.8.5 Trash rack details
5.2.8.6 Spillway slab
- underdrains
- anti-cavitation details

5.2.8.7 Outlet pipe and concrete cradle details
- filter collar

5.2.8.8 Intake structure details
5.2.8.9 Retaining wall
- foundation
- wall drain

5.2.8.10 Lake drawdown pipe

5.2.9 Miscellaneous Details

5.2.9.1 Shoreline wave protection
5.2.9.2 Internal drainage outlet
5.2.9.3 Plunge pool details
5.2.9.4 Rip-rap details
- limits
- thickness
- type
- bedding
- geotextile

5.2.9.5 Gates & Valves
5.2.9.6 Pavement Details

5.3 Construction Specification Guidelines

5.3.1 Site Preparation

5.3.1.1 Reservoir clearing
5.3.1.2 Clearing and grubbing
5.3.1.3 Waste disposal
5.3.1.4 Stripping
5.3.1.5 Demolition

5.3.2 Dewatering and Diversion

5.3.2.1 Diversion of water
5.3.2.2 Removal of water

5.3.3. Earthwork

5.3.3.1 Undercutting
5.3.3.2 Excavation

5.3.3.3 Rock removal
5.3.3.4 Borrow area development
5.3.3.5 Fill material placement
- Compaction

5.3.3.6 Backfilling
5.3.3.7 Rock fill

5.3.4 Foundation Treatment

5.3.4.1 Drilling and pressure grouting
5.3.4.2 Slurry trench
5.3.4.3 Keyways
5.3.4.4 Treatment of rock surface
5.3.4.5 Rock anchors

5.3.5 Conduits

5.3.5.1 Reinforced concrete pressure pipe
5.3.5.2 Reinforced concrete pipe
5.3.5.3 Steel pipe
5.3.5.4 Ductile iron pipe
5.3.5.5 PVC siphon pipe
5.3.5.6 HDPE pipe

5.3.6 Seepage Collection Systems

5.3.6.1 Toe drains
5.3.6.2 Blanket drains
5.3.6.3 Chimney drains
5.3.6.4 Trench drains
5.3.6.5 Foundation drains
5.3.6.6 Filter collars
5.3.6.7 PVC drain pipe
5.3.6.8 Aggregates
5.3.6.9 Geotextiles

5.3.7 Erosion Protection

5.3.7.1 Rip-rap
5.3.7.2 Geotextiles
5.3.7.3 Other
5.3.7.4 Articulated block

5.3.8 Grassing and Vegetation

5.3.8.1 Soil preparation
5.3.8.2 Seeding
5.3.8.3 Mulching

5.3.9 Fencing

5.3.9.1 Fence
5.3.9.2 Gates

5.3.10 Instrumentation

5.3.11 Concrete

5.3.11.1 Formwork
5.3.11.2 Reinforcement
5.3.11.3 Accessories
5.3.11.4 Cast-in-place concrete
5.3.11.5 Precast concrete
5.3.11.6 Roller compacted concrete
5.3.11.7 Waterstops
5.3.11.8 Joint material

5.3.12 Metals

5.3.12.1 Trash rack
5.3.12.2 Structural steel
5.3.12.3 Miscellaneous metals
5.3.12.4 Anchor bolts
5.3.12.5 Handrails

5.3.13 Equipment

5.3.13.1 Sluice gate
5.3.13.2 Valves
5.3.13.3 Weirs
5.3.13.4 Other

Construction Monitoring

Section 6
CONSTRUCTION MONITORING

6.1 Introduction

The best embankment and spillway design can turn out to be a failure without proper construction monitoring. It is critical that the Project Engineer adequately monitor the construction of the dam and the initial filling of the reservoir. It is also important to monitor the performance of the dam following the completion of construction.

6.1.1 Construction Versus Post Construction

The monitoring program for the construction of a new dam, or the remediation of an existing dam, includes both the actual construction work and the initial reservoir filling (refilling). This section of the guidelines deals primarily with the actual construction period.

6.1.2 Project Engineer and other Technical Professionals

The Project Engineer should work closely with the owner and remain involved with the project during construction. As the owner's representative, the Project Engineer should make regular visits to the site. For large projects, the Project Engineer may designate a field engineer to remain on site and monitor all construction work. In most instances, a geotechnical engineer will be actively involved with the project for the design firm, or as a subconsultant to the design firm. The geotechnical engineer will perform many of the construction monitoring activities. A senior geotechnical technician may be assigned to deal with many of the routine aspects of construction such as monitoring clearing and grubbing activities, monitoring foundation preparation, and performing compaction testing, concrete testing, and gradation tests of the filter and drain material. In addition, other engineering disciplines may be involved in project management and structural evaluations.

6.1.3 Level of Involvement

For large projects, the construction operations should be monitored on a full-time basis. The appropriate design engineer should monitor the construction work that will remain part of the completed project. Many of the construction activities require meeting not only minimum performance requirements, but also observing the details of the actual construction. For example, monitoring the earthwork requires more than density testing which provides only an indication of the degree of compaction and the in place moisture content of the fill material. It is important to monitor the placement of the materials in the dam to make sure lift surfaces are properly prepared and material is placed in the zones depicted on the design plans. This can only be determined by full-time observation of the construction activities.

6.1.4 Need for Technical Professional Involvement

Design activities continue through the construction phase. Interpretations of subsurface data, constructability issues, and modifications necessitated by the contractor's experience and equipment mandate that representatives of the design team remain involved throughout the construction process. These individuals are most familiar with the design assumptions and are in the best position to recommend appropriate modifications, if needed.

6.1.5 Adherence to Plans and Specifications

The primary function of the construction monitoring team is to verify that the contractor complies with the approved plans and specifications.

6.1.6 Design Changes/Field Conditions

Situations occasionally occur where the design will need to be altered due to unforeseen field conditions. The Project Engineer can help facilitate a quick resolution to these situations. Changes that are significant will need to be reviewed and approved by the Division of Water prior to the change being implemented. Minor modifications should be reported and documented on the as-built drawings.

6.1.7 Certification

Almost all permits on dams include a condition that requires the applicant to submit as-built plans certified by a professional engineer. The Project Engineer needs to be closely involved in the construction activities to be able to provide such a certification.

6.2 Routine Construction Monitoring Reports

The following is a brief listing of several of the aspects of construction monitoring that typically need to be performed. This should not be considered an all-inclusive list and should be amended or expanded to account for the particular dam being built. Ideally, all aspects of the construction phase should be monitored and reported.

6.2.1 Clearing and Grubbing

The Project Engineer should evaluate the site after the contractor has completed the clearing and grubbing operations to determine that adequate procedures have been followed to allow for subsequent construction. This monitoring should be reported in a daily inspection report.

6.2.2 Subgrade

The Project Engineer should monitor the subgrade and foundation preparation for the dam. This involves items such as stripping, undercutting of unsuitable material (particularly flood plain undercutting), and keyway/cutoff construction. The conditions observed, including items such as depths of excavation and quantities should be documented in the daily field reports. The geotechnical engineer should approve all subgrade areas before fill placement occurs.

6.2.3 Drains

The Project Engineer should monitor all aspects of the internal drain system construction. The internal drainage system may include a number of components such as foundation drains, blanket drains, chimney drains, and collections systems. Since these systems are filtered either with natural materials or synthetic materials, the monitoring should assure that all filters completely enclose more pervious materials, and that the drains extend into the desired material for the proper control of the phreatic surface. Field adjustments to the drain construction are common and should be documented in daily monitoring reports.

6.2.4 Outlet Works

The Project Engineer should monitor the construction of spillway and drawdown pipes, and their associated intake and outlet structures. Intake control structures typically require assessment of allowable bearing capacity and adequate subgrade preparation. Outlet structures commonly incorporate some underdrainage. Conduit alignments may include concrete anti-seepage cradles, as well as filtered seepage collars. The engineer should monitor the configuration of excavations for conduits, and closely assess all backfilling procedures adjacent to this critical area of the dam. Density tests and concrete tests should be conducted and reported. The geotechnical engineer should approve all subgrades for cradles and structures for subsequent construction.

6.2.5 Earthwork

The geotechnical engineer or a qualified representative should monitor all aspects of the earthwork operations on a full time basis. Routine density testing and moisture control should be reported. In addition, the construction techniques utilized by the contractor should be reported and evaluated to assure conformance with the project specifications. The engineer's representatives should verify that all materials placed in the embankment are suitable for their intended use and that proper lift treatment is performed by the contractor to assure adequate bonding of the individual lifts. The engineer's representatives will determine if moisture adjustments are needed at the fill pad prior to fill placement. This may include either wetting or drying the borrow material to achieve suitable moisture content. The engineer's representatives should

assure that the contractor is using appropriate equipment in the grading activities. Reporting would typically include daily inspection reports summarizing the grading activities and the individual density test report.

6.2.6 Instrumentation

The details of the instrumentation program are outlined in Appendix C. Instrumentation may be placed during the construction process or at the completion of the general embankment construction. In many instances, instrumentation will include devices that are intended to be read during the construction process. For example, settlement plates or devices placed at the base of the dam are typically read throughout the construction process. The engineer should observe the installation of all instrumentation, and evaluate data collected during construction. The data should be compared to design projections to determine if any modifications or further assessments are needed.

6.2.7 Construction Photographs

It is considered good practice to take photographs or video recordings of critical aspects of the construction. These may be in the form of regularly scheduled photographs of the work progress, or specific photographs of certain aspects of the construction. The intent is to obtain a permanent record should any difficulties arise during initial reservoir filling or during subsequent operation of the dam. Photographs should be adequately labeled and dated, and are typically maintained in the design engineer's file. In certain instances, copies should be provided to the Division of Water to document unusual situations.

6.3 Special Construction Monitoring Reports

There may be situations where special construction monitoring is needed and the collection and presentation of information is required. Guidelines are presented in Appendix G. In applying these guidelines, the Project Engineer should use good judgement and elaborate upon them as required by the particular geologic/foundation setting and engineering requirements. These guidelines are not intended to be exhaustive and include all items contained in a special report. However, they do provide guidance to formulate a data acquisition program for planning and documenting specialized work.

6.4 Post Construction Monitoring

The purpose of the post construction monitoring program is to provide information regarding the behavior of the constructed or rehabilitated dam. This information is used in conjunction with as-built drawings and construction photographs to evaluate the performance of the newly constructed dam and to compare to historical data for an existing dam. The recorded data is compared to design assumptions for the dam in order to monitor lake filling and provide a means for future monitoring, operations, and maintenance.

6.4.1 As-Built Drawings

A set of as-built drawings should be submitted to the Division of Water following completion of construction and within the time limits specified in the permit. The as-built drawings should include, as a minimum, the following:

6.4.1.1 Approved Modifications - All previously approved design and construction modifications should be incorporated into the final document.

6.4.1.2 Monitoring Program - A monitoring and instrumentation program should be described if one is required.

6.4.1.3 Acceptance Criteria - A list of critical design assumptions and expected behaviors that need to be validated initially and long term should be included.

6.4.1.4 Instrumentation Locations - The location of all post construction monitoring instrumentation should be shown on the as-built site plan.

6.4.1.5 Certification - A written certification from the Project Engineer that the dam was constructed as shown on the as-built plans.

6.4.2 Lake Level

After approval by the Project Engineer, the reservoir drawdown valve may be closed and the process of filling the lake may commence. Adherence to the reservoir-filling schedule should be controlled by operation of the outlet works in order to maintain the differential rise in Lake Level and maintain flow (see Section 4.7). In the event that sudden changes occur which may be indicative of a potential dam failure, the lake level should be lowered and the Division of Water notified immediately. Otherwise, after the lake reaches the normal operating level, the approved maintenance, inspection and operation plan should be initiated.

6.4.3 Physical Condition of Dam

Areas of potential weakness and their effects on dam stability should be identified. Visual observations should be made in conjunction with instrumentation monitoring to adequately assess the safety of the dam. Initial surveillance of the dam's performance should be conducted by the Project Engineer to confirm design assumptions and to evaluate performance. Many unusual or abnormal conditions can be identified by a walking tour of the dam crest, slopes, toe, and abutments. Long-term inspection, operation, and maintenance will be the responsibility of the dam owner.

6.4.4 Instrumentation Readings

Readings that are commonly monitored at a dam site include headwater and tailwater levels, porewater and uplift pressures, crack or joint movement, structural movement, deformation, seepage flow rates, stress and strain of structural members, temperature, and seismic loads. A monitoring and instrumentation program that assigns responsibility to the engineer for data collection, reduction, presentation, and transmittal to Division of Water staff may need to be developed and documented. The program should include the reasons for installation, frequency of monitoring, threshold ranges of instruments, installation logs, calibration data, and initial readings.

All data should be compared with design assumptions for the expected behavior of the dam. If no unusual behavior or evidence of problems is detected, the readings should be maintained for future reference. Threshold readings that indicate the development of potentially hazardous conditions should be established. Action should be taken if the data deviates from expected behavior or approaches the threshold readings, depending on the nature of the potential hazard. Possible actions include:

- Performing detailed visual inspection
- Repeating measurements to confirm behavior
- Notifying the owner's engineer and the Division of Water
- Increasing frequency of measurements
- Designing and constructing remedial measures
- Installing additional instrumentation
- Operating the reservoir at a lower level
- Implementing emergency measures

6.4.5 Photographs

Photographs or videos are useful in documenting the initial site investigation, subsurface excavation, construction, and as-built conditions. They are helpful for providing a historical perspective in evaluating whether or not there has been any change from previous conditions. Photographs and videos should be maintained for future reference in the event remedial or emergency action is required.

Appendix A
Hazard Classification

Revised - February 2010

Rule 3 - Hazard Classification

312 IAC 10.5-3-1 Consideration of hazard classification

Authority: IC 14-27-7.5-8

Affected: IC 14-27-7.5

Sec. 1 (a) The division shall assign whether a dam is classified as:

(1) high hazard;

(2) significant hazard; or

(3) low hazard;

based on best information available.

(b) In making the determination of assignment under subsection (a), the division shall apply existing U.S. Army Corps of Engineers Phase 1 reports and other appropriate documentation.

(c) The division may also consider observations of the dam and the vicinity of the dam, including the risk posed to human life and property if the dam fails.

(1) If an uncontrolled release of the structure's contents due to a failure of the structure may result in any of the following, the dam shall be considered high hazard:

(A) The loss of human life.

(B) Serious damage to:

(i) homes;

(ii) industrial and commercial buildings; or

(iii) public utilities.

(C) Interruption of service for more than one (1) day on any of the following:

(i) A county road, state two-lane highway, or U.S. highway serving as the only access to a community.

(ii) A multilane divided state or U.S. highway, including an interstate highway.

(D) Interruption of service for more than one (1) day on an operating railroad.

(E) Interruption of service to an interstate or intrastate utility, power or communication line serving a town, community, or significant military and commercial facility, in which disruption of power and communication would adversely affect the economy, safety, and general well-being of the area for more than one (1) day.

(2) If an uncontrolled release of the structure's contents due to a failure of the structure may result in any of the following, the dam shall be considered significant hazard:

(A) Damage to isolated homes.

(B) Interruption of service for not more than one (1) day on any of the following:

(i) A county road, state two-lane highway, or U.S. highway serving as the only access to a community.

(ii) A multilane divided state or U.S. highway, including an interstate highway.

(C) Interruption of service for not more than one (1) day on an operating railroad.

(D) Damage to important utilities where service would be interrupted for not more than one (1) day, but either of the following may occur:

(i) Buried lines can be exposed by erosion.

(ii) Towers, poles, and aboveground lines can be damaged by undermining or debris loading.

(3) If an uncontrolled release of the structure's contents due to a failure of the structure does not result in any of the items given in subdivision (1) or (2) and damage is limited to either farm buildings, agricultural land, or local roads, the dam shall be classified as low hazard.

(d) The division may modify an assignment of hazard classification, made previously under this article, if changes in the downstream development affect the potential for loss of human life and property. (Natural Resources Commission; 312 IAC 10.5-3-1; filed Jan 26, 2007, 10:45 a.m.: 20070221-IR-312060092FRA)

312 IAC 10.5-3-2 Reconsideration of hazard classification

Authority: IC 14-27-7.5-8

Affected: IC 14-27-7.5

Sec. 2 (a) This section establishes a process by which a dam owner or another affected person may request reconsideration of a determination of hazard classification made under section 1 of this rule.

(b) The dam owner or other affected person may submit any technical information or reports that were not previously available to the division.

(c) The dam owner's or other affected person's professional engineer may develop and submit a maximum breach inundation area and current damage evaluation assessing the downstream area affected by a dam breach.

(1) If the maximum breach inundation area and current damage evaluation predicts any of the following, the dam shall be classified as high hazard:

(A) Flood depths greater than one (1) foot in any occupied quarters.

(B) Loss of human life may occur.

(C) Interruption of service for more than one (1) day on any of the following:

(i) A county road, state two-lane highway, or U.S. highway serving as the only access to a community.

(ii) A multilane divided state or U.S. highway, including an interstate highway.

(D) Interruption of service for more than one (1) day on an operating railroad.

(E) Damage to any occupied quarters where the flow velocity at the building compromises the integrity of the structure for human occupation.

(F) Interruption of service to an interstate or intrastate, utility, power or communication line serving a town, community, or significant military and commercial facility, in which disruption of power and communication would adversely affect the economy, safety, and general well-being of the area for more than one (1) day.

(2) If the maximum breach inundation area and current damage evaluation predicts any of the following, the dam shall be classified as significant hazard:

(A) Interruption of service for not more than one (1) day on any of the following:

(i) A county road, state two-lane highway, or U.S. highway serving as the only access to a community.

(ii) A multilane divided state or U.S. highway, including an interstate highway.

(B) Interruption of service for not more than one (1) day on an operating railroad.

(C) Damage to any occupied quarters that would not render the structure unusable.

(D) Damage to important utilities where service would be interrupted for not more than one (1) day, but either of the following may occur:

(i) Buried lines can be exposed by erosion.

(ii) Towers, poles, and aboveground lines can be damaged by undermining or debris loading.

(3) If the maximum breach inundation area and current damage evaluation results predict none of the items in subdivision (1) or (2) and damage is limited to farm buildings, agricultural land, or local roads, the dam shall be classified as low hazard.

(Natural Resources Commission; 312 IAC 10.5-3-2; filed Jan 26, 2007, 10:45 a.m.: 20070221-IR-312060092FRA)

The complete text of the IAC section should be reviewed. Up to date regulation can be found at the following URL:

http://www.in.gov/dnr/water/

Appendix B
Emergency Action Plan Outline

This outline has been replaced.
Please refer to the:
"Indiana Dam Safety Inspection Manual"
Part 4 – Emergency Preparedness.

http://www.in.gov/dnr/water/

Also:
Refer to Appendix A –
"Emergency Action Plan templates"
located in Part 4 of the "Manual"

Appendix C
Geotechnical Addendum-Insitu/Field Testing

A. Geotechnical Addendum - Insitu/Field Testing

1. Field Permeability Tests

Field permeability tests are generally considered to be more representative of the hydraulic conductivity of foundation materials and existing embankment materials than are laboratory permeability tests. The field testing techniques may be the only practical means of establishing foundation permeability for certain material types.

Foundation Soil - The in-situ permeability of potential foundation materials may be determined by performing field permeability tests. Selected zones of the foundation profile including alluvial materials, which may be allowed to remain in place, residual foundation soils, and partially weathered rock, are conducive to this technique. The monitoring wells that may have been installed to better establish the ambient groundwater conditions typically can be used for the field permeability test. Bailing or slug tests are typical. Pumping tests or inflow tests may be appropriate where higher permeabilities exist. Monitoring wells should be carefully constructed to assure that the zone of material desired for testing has been isolated within the screened sections of the well by appropriate seals such as bentonite and grout. The field testing technique is generally considered to provide the horizontal permeability values directly, without the need for adjusting vertical laboratory permeability test results. In addition, a broader cross-section of the subsurface profile can be tested by this technique. Care should be exercised in higher permeability situations to assure that the values being measured do not represent the actual well materials involved in the well construction. These field techniques are typically only applicable to zones of material below existing groundwater levels. Therefore, laboratory-testing techniques are generally required for materials above the groundwater level so that saturation of the material can be established prior to testing.

Existing Embankment Fill Materials - Techniques utilized for the foundation soils can be considered for determining permeability values of existing dam embankment fill materials. This procedure is generally only applicable to the materials that exist below the currently established phreatic surface through the dam. Therefore, the existing reservoir would need to be impounded at the time of testing. This technique is generally not applicable where the lake has been temporarily drained.

Foundation Rock - Packer permeability tests are typically performed to determine the hydraulic conductivity of foundation rock. Either single or double packers are commonly employed to help isolate specific zones within the foundation rock profile. In most instances, fractures and discontinuities within the rock control the hydraulic conductivity of the material. However, the test results are commonly expressed as an equivalent permeability over the length of the test section. Relatively short test sections may be employed to help isolate higher permeability zones. As with the monitoring well type permeability tests, care should be exercised to assure that the hydraulic conductivity values being determined do not represent the hydraulic limitations of the packer test equipment.

2. Other Field Tests

Strength Testing - Various field testing techniques may be considered where soft or low consistency foundation materials exist that cannot be accurately modeled by Standard Penetration Testing or undisturbed sampling. The vane shear test is commonly employed in very soft cohesive deposits. Pressuremeter or dilatometer testing may be considered for a broad range of material types and consistencies. Cone penetrometer soundings may also be considered. To some extent, these field testing techniques have evolved as preferable in certain locations and certain geologic settings. These techniques normally would only be considered where direct support of a new embankment on very weak materials is being considered, or to supplement laboratory testing in materials that are difficult to sample.

Geophysical Methods - A variety of geophysical testing techniques are available and may be considered in certain applications. These approaches would typically be applicable to a very limited number of dam projects due to the specialized nature. The most common technique is the shallow seismic refraction survey, which can be useful in profiling difficult excavation materials. The seismic refraction survey would likely have most applicability in a dam study to generally screen potential borrow areas, since this technique can be negatively impacted by existing groundwater conditions. This typically provides a relatively low cost and expedient technique that generally does not require an invasive approach similar to test pits or borings.

Other Tests - Other field testing techniques may be considered for certain specialized applications. One possible test that would fit into this category would be tracer dye testing. This is used principally to determine the flow direction and rate of flow in karst geology.

B. Geotechnical Addendum - Instrumentation

1. Piezometric Levels

The monitoring of piezometric levels may be an important consideration for specific zones within the foundation of a dam during construction and fill placement, and to evaluate the development of the phreatic surface within the embankment during and subsequent to initial reservoir filling.

Locations - Piezometric levels may require monitoring within specific zones of embankment foundations, particularly where extensive low consistency fine grained materials exist or where there are concerns over the development of high pore pressures during embankment construction (end-of-construction stability). In such instances, the monitoring device will typically measure piezometric levels at specific locations. It is typically desirable to measure piezometric levels within the completed embankment as the reservoir fills and steady-state seepage conditions develop. Devices for this purpose typically require a broad vertical zone be monitored as the piezometric levels rise within the embankment. Piezometer locations in the foundation should be concentrated in the flood plain portion of the embankment footprint. Piezometric levels within the embankment will require devices placed at both edges of the crest, at or slightly beyond the downstream toe of the dam, and potentially within the downstream slope, particularly if berms are utilized on taller structures. These devices should be aligned to allow the phreatic surface development to be plotted. Multiple stations

of such instrumentation may be needed on longer embankments.

Observation Wells - Observation wells and open (Casagrande) piezometers may be considered for many applications. These are typically well suited to monitoring the performance of foundations outside the embankment footprint during construction and within the embankment during initial reservoir filling. Short-screened sections are typically utilized for foundation monitoring. Longer screened sections can be utilized to monitor the unconfined phreatic surface within the embankment during initial filling. The observation wells are usually installed within the embankment after the fill is topped out.

Remote Reading Piezometers - These types of piezometers are well suited to monitoring foundation conditions during and subsequent to construction. Both pneumatic and electric vibrating wire type piezometers have been utilized for this purpose. They may be installed in the foundation of a dam prior to embankment construction, with tubing and wires placed in a manner that does not obstruct the subsequent construction. Remote readout locations outside the embankment footprint are typically utilized.

2. Settlement

The settlement performance of a dam and foundation is typically a consideration during and immediately following embankment construction. A typical scenario is a relatively thick compressible zone in the foundation of the proposed dam and settlement estimates performed during design indicate that significant settlements may occur.

Location - The settlement devices should target more compressible foundation zones, particularly in the vicinity of structures such as conduits. This would normally dictate a location within the flood plain area of the dam footprint. The settlement devices are often concentrated along the centerline; however, they may be placed in other areas.

Settlement Plates - Conventional settlement plates with riser pipes are the simplest forms of settlement monitoring device for the foundation. These are generally placed after foundation preparation is completed and immediately prior to commencement of embankment construction. Accurate elevations are obtained periodically during construction. These elevations should be referenced to the project datum. Additional readings are required immediately prior to and subsequent to adding additional sections of riser rod. These devices will create an obstruction to the earthmoving equipment during construction.

Remote Reading Settlement Transducers - Both pneumatic and electric vibrating wire settlement transducers may be considered. These are typically placed at strategic locations with the cables and tubing routed outside the embankment footprint to a stationary readout location. Such devices lessen the obstructions that exist during earthwork, but may not be as reliable.

Surface Monuments - Surface-monitoring points for settlement measurement should be installed immediately after topping out the embankment. These would be placed along the crest of the dam, and be adequately protected.

3. Seepage

The monitoring of seepage quantities during initial reservoir filling, and throughout the subsequent life of the structure, provides useful information on the performance of the dam. This monitoring is typically facilitated by measuring the outflows from the internal drainage system components.

Piped Outlets - Piped internal drainage system components are common. The outlet location should be protected through the use of headwalls, riprap, etc. The exposed portions of the piping system should be durable, and include animal guards. Pipes should also be placed to allow routine measurement of flow. This typically requires that the invert of the pipe be placed at least a foot above the local subgrade level.

Relief Wells - Relief wells into the foundation are utilized on certain projects, particularly for gravity dams. These should be placed to allow for easy monitoring of the outflows and such that they are protected from damage.

Weirs - Seepage monitoring weirs may be considered in applications where seepage outflows exit from non-point sources, such as rock toe drains. The collected seepage should be routed into a small pool upstream of the weir, and sufficient fall should be provided to allow the V-notch weir to perform as intended. Staff gauges are typically required to determine the level of the water in the pool upstream of the weir in conjunction with seepage quantity calculations.

4. Other Instrumentation

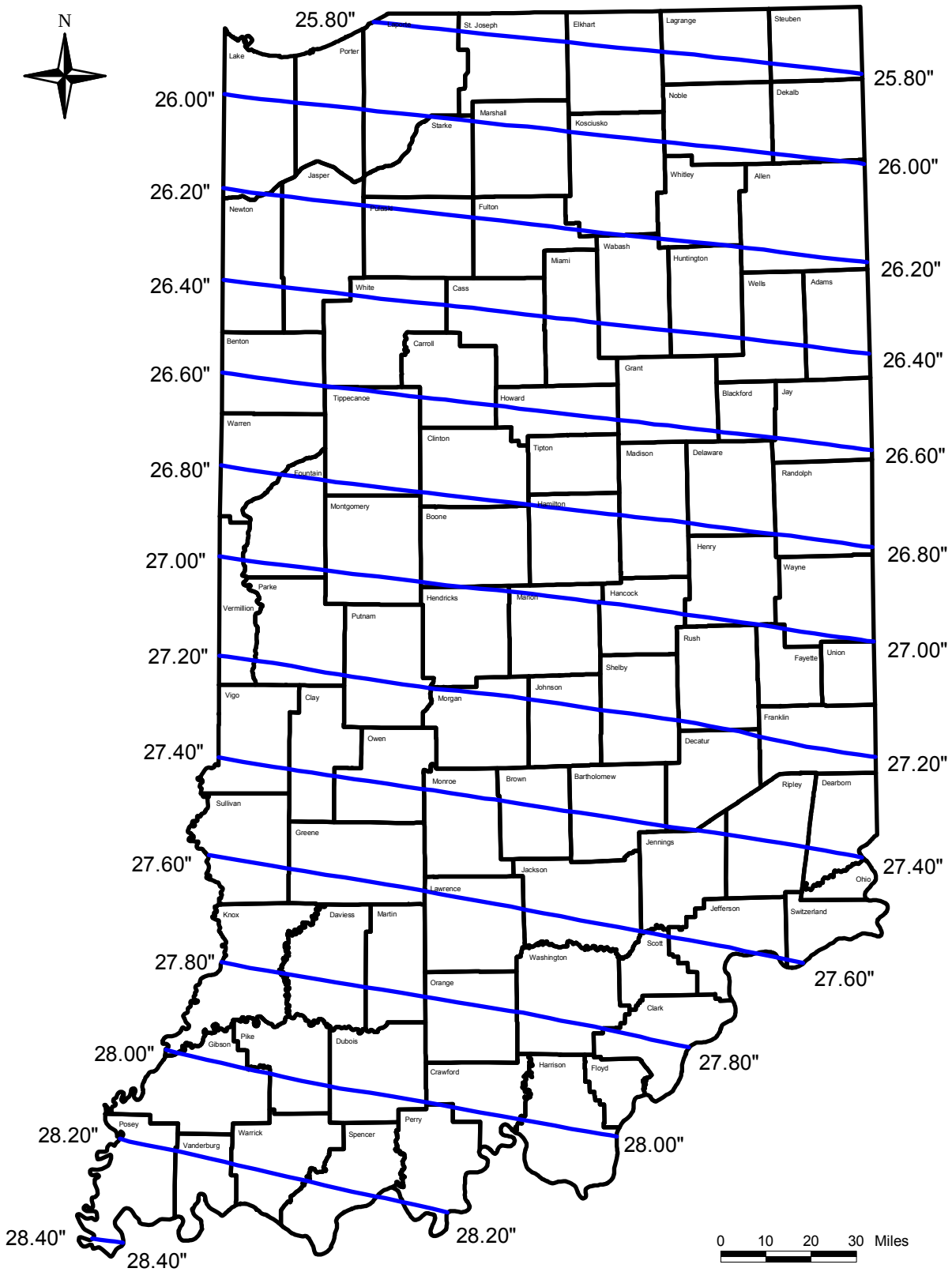
Additional types of instrumentation may be considered in certain special applications. The engineer should determine if specific project requirements dictate the need for specialized instrumentation.

Inclinometers - These devices may be installed in situations where measurement of horizontal movements is required. A fairly common application would be on an existing dam where concerns exist over slope instability.

Crack Monitoring - Crack-monitoring devices may be needed on appurtenant structures, or to evaluate movements across discontinuities of concrete gravity dam sections.

Appendix D
Rainfall Distribution &
Probable Maximum Precipitation

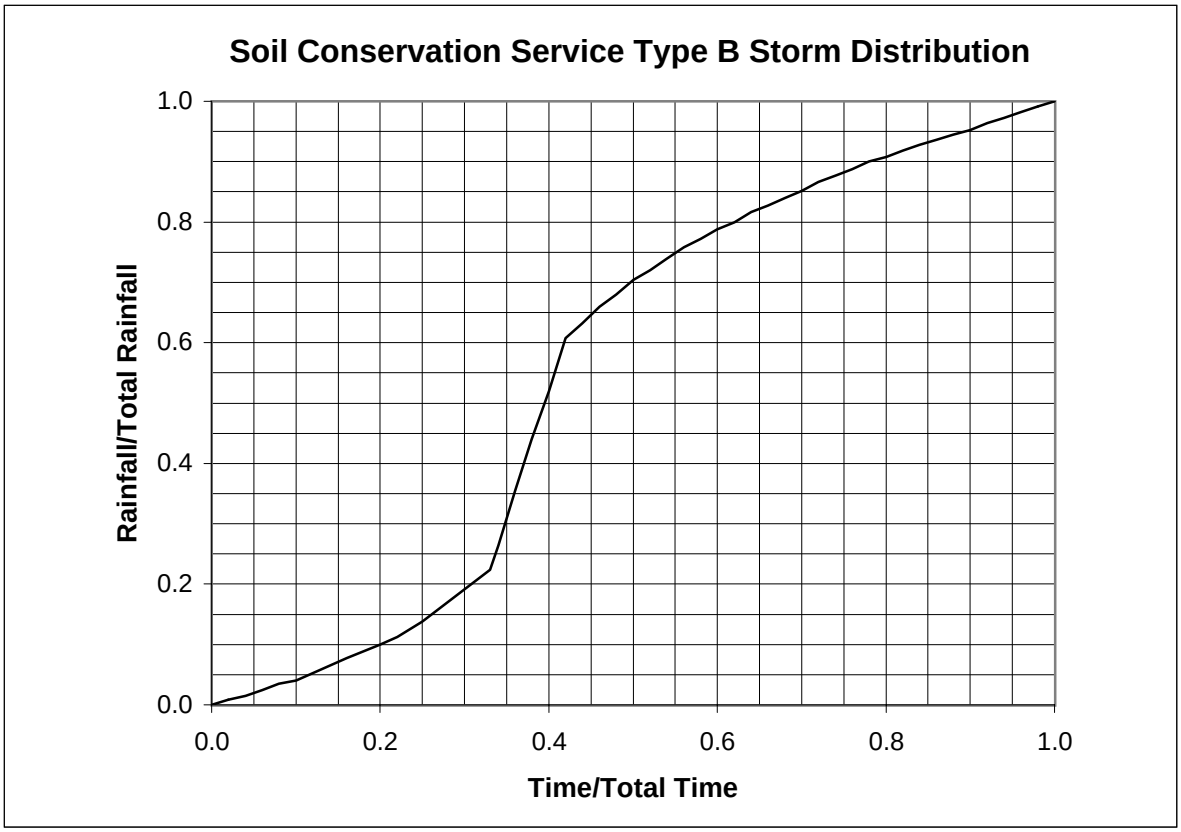
ALL SEASON 6 HOUR PMP FOR 10 SQUARE MILES



REFERENCE
HYDROMETEORLOGICAL
REPORT NO.51
NATIONAL WEATHER SERVICE

STATE OF INDIANA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER

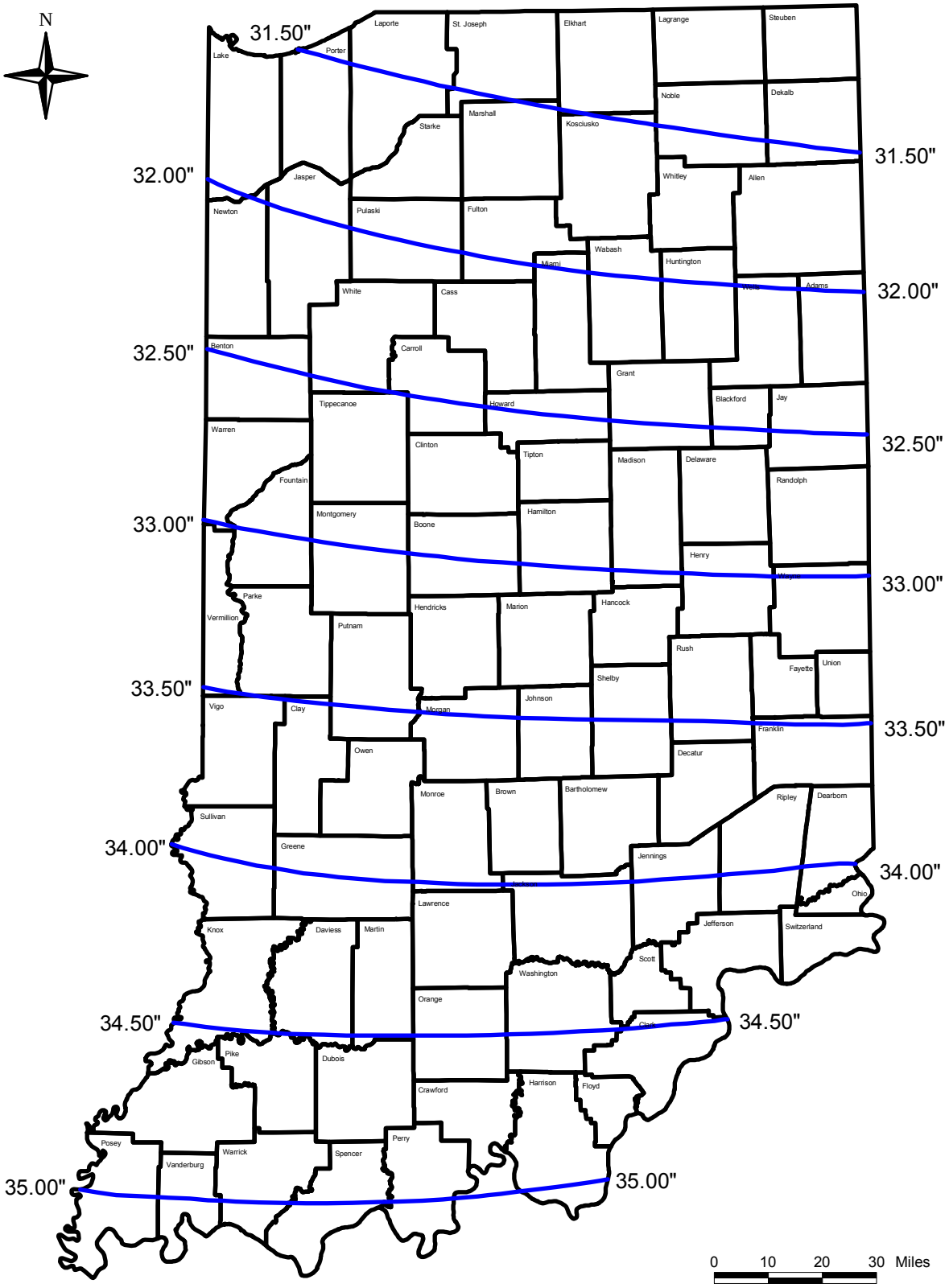
INDIANA DEPARTMENT OF NATURAL RESOURCES



Time/Total Time	Rainfall/Total Rainfall	Time/Total Time	Rainfall/Total Rainfall
0.000	0.000	0.580	0.772
0.020	0.008	0.600	0.788
0.040	0.015	0.620	0.800
0.060	0.024	0.640	0.817
0.080	0.035	0.660	0.827
0.100	0.040	0.680	0.840
0.160	0.077	0.700	0.852
0.200	0.100	0.720	0.866
0.220	0.112	0.740	0.877
0.250	0.138	0.760	0.888
0.330	0.224	0.780	0.900
0.340	0.264	0.800	0.908
0.360	0.354	0.820	0.918
0.380	0.440	0.840	0.928
0.400	0.520	0.860	0.936
0.420	0.608	0.880	0.945
0.440	0.632	0.900	0.952
0.460	0.660	0.920	0.964
0.480	0.680	0.940	0.972
0.500	0.704	0.960	0.982
0.520	0.720	0.980	0.992
0.540	0.739	1.000	1.000
0.560	0.758		

Figure 1. NRCS Type B Rainfall Distribution

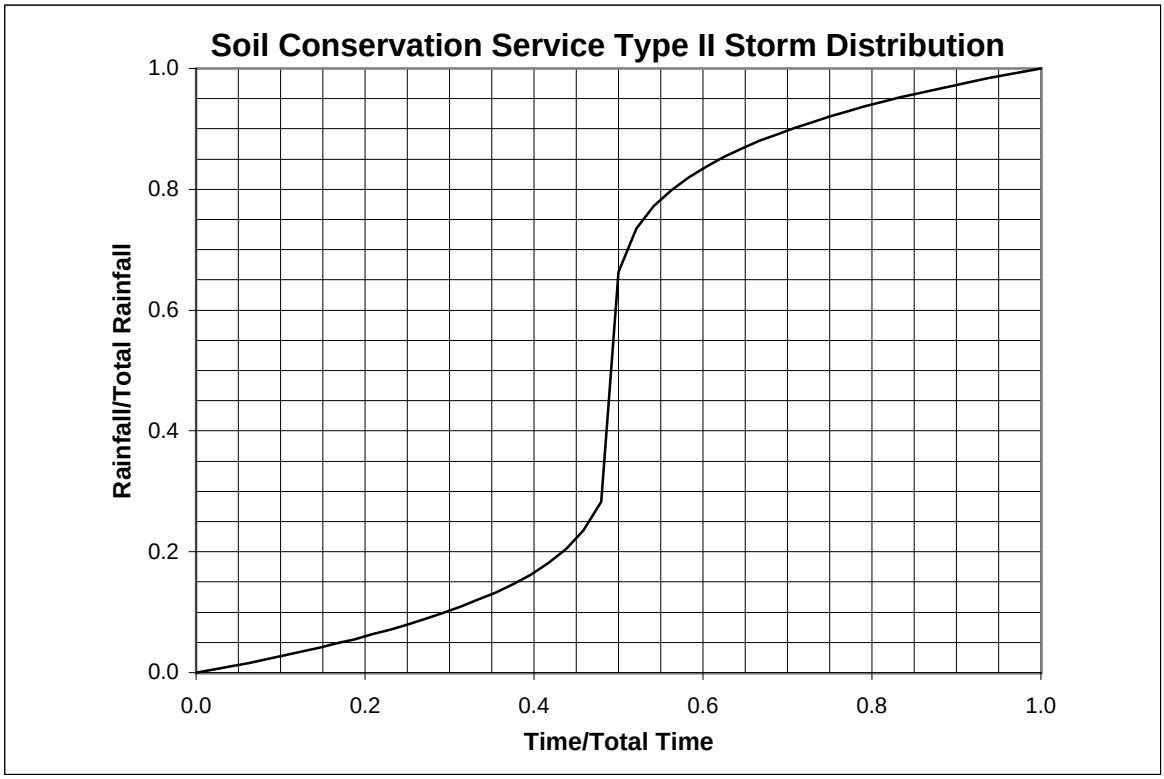
ALL SEASON 24 HOUR PMP FOR 10 SQUARE MILES



REFERENCE
HYDROMETEORLOGICAL
REPORT NO.51
NATIONAL WEATHER SERVICE

STATE OF INDIANA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER

INDIANA DEPARTMENT OF NATURAL RESOURCES

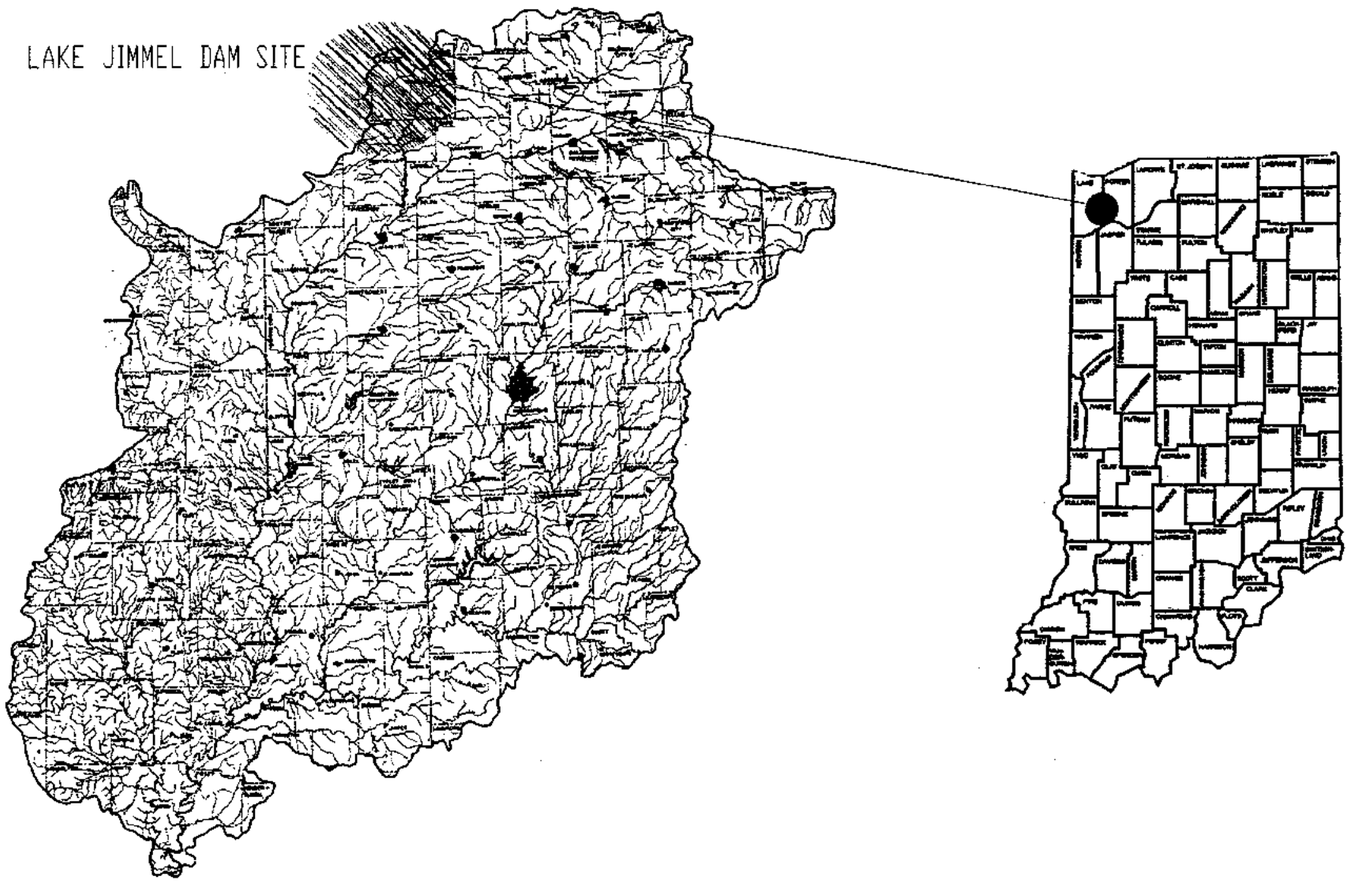


Time/Total Time	Rainfall/Total Rainfall	Time/Total Time	Rainfall/Total Rainfall
0.000	0.0000	0.521	0.7351
0.021	0.0053	0.542	0.7724
0.042	0.0108	0.563	0.7989
0.063	0.0164	0.583	0.8197
0.083	0.0223	0.604	0.8380
0.104	0.0284	0.625	0.8538
0.125	0.0347	0.646	0.8676
0.146	0.0414	0.667	0.8801
0.167	0.0483	0.688	0.8914
0.188	0.0555	0.708	0.9019
0.208	0.0632	0.729	0.9115
0.229	0.0712	0.750	0.9206
0.250	0.0797	0.771	0.9291
0.271	0.0887	0.792	0.9371
0.292	0.0984	0.813	0.9446
0.313	0.1089	0.833	0.9519
0.333	0.1203	0.854	0.9588
0.354	0.1328	0.875	0.9653
0.375	0.1467	0.896	0.9717
0.396	0.1625	0.917	0.9777
0.417	0.1808	0.938	0.9836
0.438	0.2042	0.958	0.9892
0.458	0.2351	0.979	0.9947
0.479	0.2833	1.000	1.0000
0.500	0.6632		

Figure 2. NRCS Type II Rainfall Distribution

Appendix E
Selected Plan Sheets for Illustration Purposes

CONSTRUCTION PLANS
LAKE JIMMEL DAM



SUPERB ENGINEERING, INC.
444 WATERSHED DRIVE
OUTLET, INDIANA

INDEX OF DRAWINGS

TITLE	SHEET NO.
COVERSHEET	1
LEGEND AND INFORMATION	2
SITE MAP SHOWING BORING LOCATIONS	3
VALLEY PROFILE	4
SITE PLAN	5
HYDRAULIC DATA AND CURVES	6
PROFILES AND SOIL BORING LOGS	7
TYPICAL CROSS SECTIONS	8
EMERGENCY SPILLWAY DETAILS	9
SEDIMENT BASIN DETAILS	10
DETAILS OF FOUNDATION DRAIN	11
SEEPAGE CONTROL DIAPHRAGM DETAILS	12
PRINCIPAL SPILLWAY LAYOUT	13
DETAILS OF 12' DIA. DRAWDOWN KNIFE GATE	14
DETAILS OF R/C INLET TRASH RACK	15

NOTE: OTHER SHEETS MAY BE NECESSARY TO PROVIDE DETAILS FOR THE PRINCIPAL SPILLWAY INLET STRUCTURE, OUTLET STRUCTURE, AND ANTI-SEEP COLLARS.

REVISIONS		
DESCRIPTION	DATE	APPROVED

ENGINEER'S SIGNATURE
DATE, AND SEAL

THE APPROVAL SIGNATURES APPEARING IN THE TITLE BLOCK ON THIS SHEET CONSTITUTE APPROVAL OF ALL DRAWINGS LISTED IN THE INDEX

PREPARED BY: _____

REVIEWED BY: _____

QUALITY ASSURANCE: _____

PROJECT ENGINEER: _____

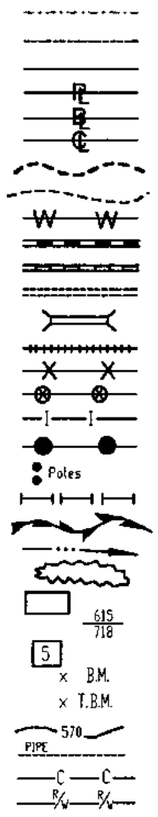
APPROVED BY: _____

DATE: _____

NOTE: THIS IS A SAMPLE SET OF PLANS-NOT FOR CONSTRUCTION

LEGEND

County Line
Township Line
Section Line
Property Line
Base Line
Centerline of Improvements
Watershed Boundary
Sub-Watershed Boundary
Approximate Limit of Work Area
Paved Road
Improved Road
Private or Field Road
Bridge
Railroad
Fence, Existing
Fence, to be Removed
Fence, to be Constructed
Power Line (location of pole)
High Voltage Transmission Line (location of pole)
Pipe Line or Buried Cable
Diversion
Stream, Flow line
Woodland Boundary
Building
Section Corner
Section Center
Bench Mark, Permanent
Bench Mark, Temporary
Contours
Foundation Trench Drain
Clearing and/or Grubbing Boundary
Right of Way Boundary



GEOLOGIC INFORMATION LEGEND

Unified classification by Visual-Manual Procedure in the field (ASTM D-2488), except where indicated by *.
Unified classification based on laboratory analysis of selected samples (ASTM D 2487)

UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOLS

COARSE-GRAINED SOILS

GW-Well graded gravels, gravel-sand mixtures little or no fines
GP-Poorly graded gravels, gravel-sand mixtures, little or no fines.
GM-Silty gravels, gravel-sand-silt mixtures
GC-Clayey gravels, gravel-sand-clay mixtures.
SW-Well graded sands, gravelly sands, little or no fines
SP-Poorly graded sands, gravelly sands, little or no fines
SM-Silty sands, sand-silt mixtures
SC-Clayey sands, sand-caly mixtures

FINE-GRAINED SOILS

ML-Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
CL-Inorganic clays of low to medium plasticity, gravelly, sandy, silty or lean clays
OL-Organic silts and silty clays of low plasticity.
MH-Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
CH-Inorganic clays of high plasticity, fat clays.
OH-Organic clays of medium to high plasticity, organic silts.
PT-Peat and other highly organic soils.

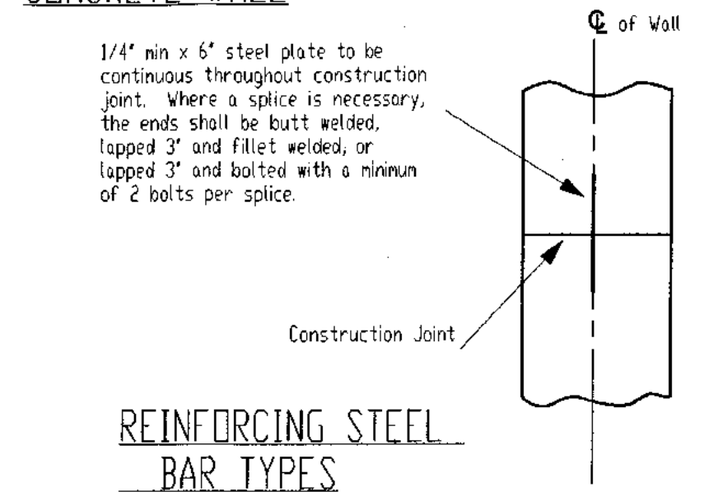
CONSOLIDATED MATERIAL

Cng-Conglomerate
Ss-Sandstone
Sh-Shale
Sist-Siltstone
Ma-Marl
Ls-Limestone
Dol-Dolomite
Co-Coal
Gyp-Gypsum
Cht-Chert

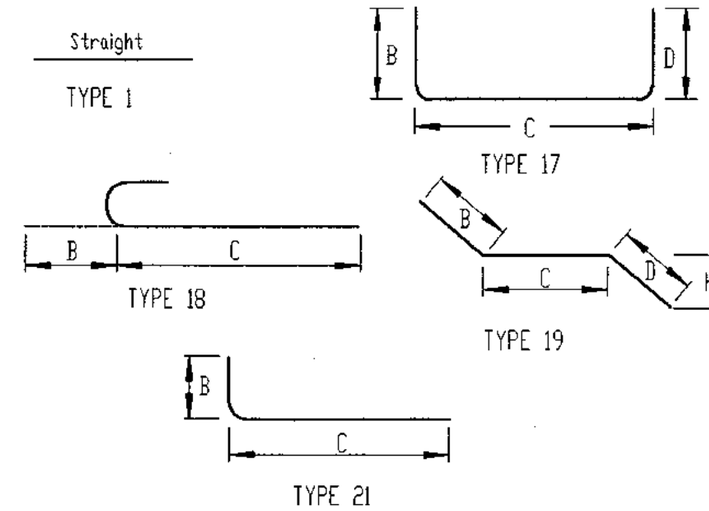
OTHER SYMBOLS

Drill hole logged only
Drill hole samples
Dip and Strike
Pit or trench logged only
Pit or trench samples
Ground water level

DETAIL OF CONSTRUCTION JOINT FOR CONCRETE WALL



REINFORCING STEEL BAR TYPES



Notes:
1. Steel bending shall meet requirements in ACI Standard 315
2. Steel will be 2" from either inside or soutside face respectively.
3. Steel will be 3" from bottom of apron.

GENERAL NOTES

North Arrow is Magnetic North
Elevations of pipes refer to invert elevations
Cross sections shown as looking downstream
Chamfer all exposed concrete edges 3/4"

DEFINITION OF TERMS

S-Grade of channel in feet of drop per foot of length
b-Bottom width of channel in feet
SS-Side Slope, horizontal to vertical
T-Top width of dike, levee or fill in feet
FH-Fill height of dike in feet (vertical distance from bottom of channel to top of dike)
NTS-Not to Scale

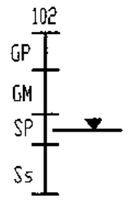
EARTHWORK SYMBOLS

Class of fill — A B C
Excavation-Common — EC
Excavation-Rock — ER
Channel Excavation-Common — CEC

TEST HOLE NUMBERING SYSTEM

Centerline of Dam	1-99
Borrow area	101-199
Emergency Spillway	201-299
Centerline of outlet structure	301-399
Stream Channel	401-499
Drain Line	501-599
Correlation holes	601-699
Other	701-799

SAMPLE PLOT

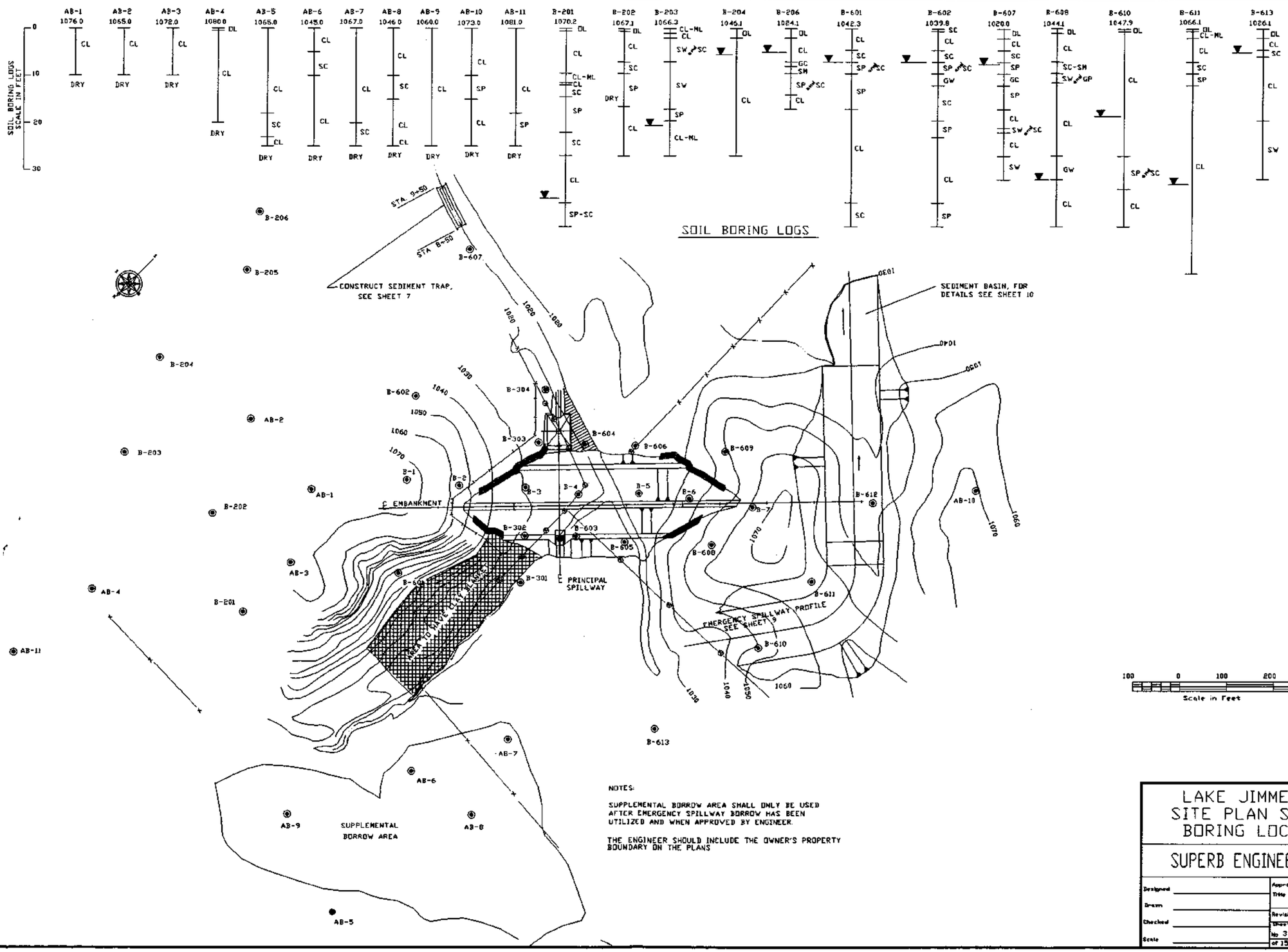


Notes:
1. Geologic investigation made in July, 2000 by Hardrock Exploration, Inc.
2. Ground water levels are as noted at the time of the investigation.
3. Records of the site investigation and geotechnical testing report may be reviewed by prospective bidders by contacting the office issuing the invitation.

LAKE JIMMEL DAM
LEGEND AND INFORMATION

SUPERB ENGINEERING, INC

Designed	Approved By
Drawn	Title
Checked	Revisions
Scale	Sheet No. 2 of 15
	Drawing No.



NOTES:

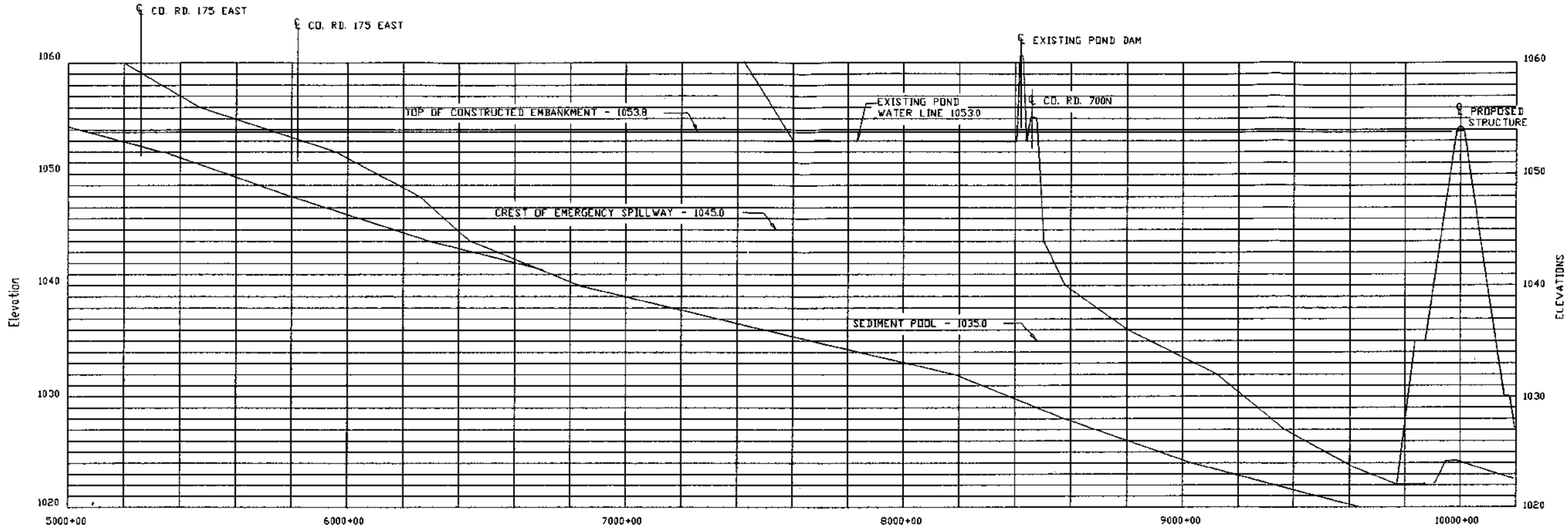
SUPPLEMENTAL BORROW AREA SHALL ONLY BE USED AFTER EMERGENCY SPILLWAY BORROW HAS BEEN UTILIZED AND WHEN APPROVED BY ENGINEER.

THE ENGINEER SHOULD INCLUDE THE OWNER'S PROPERTY BOUNDARY ON THE PLANS

LAKE JIMMEL DAM
SITE PLAN SHOWING BORING LOCATIONS

SUPERB ENGINEERING, INC

Designed	Approved By
Drawn	Title
Checked	Revisions
Scale	Sheet No. 3 of 15
	Drawing No.



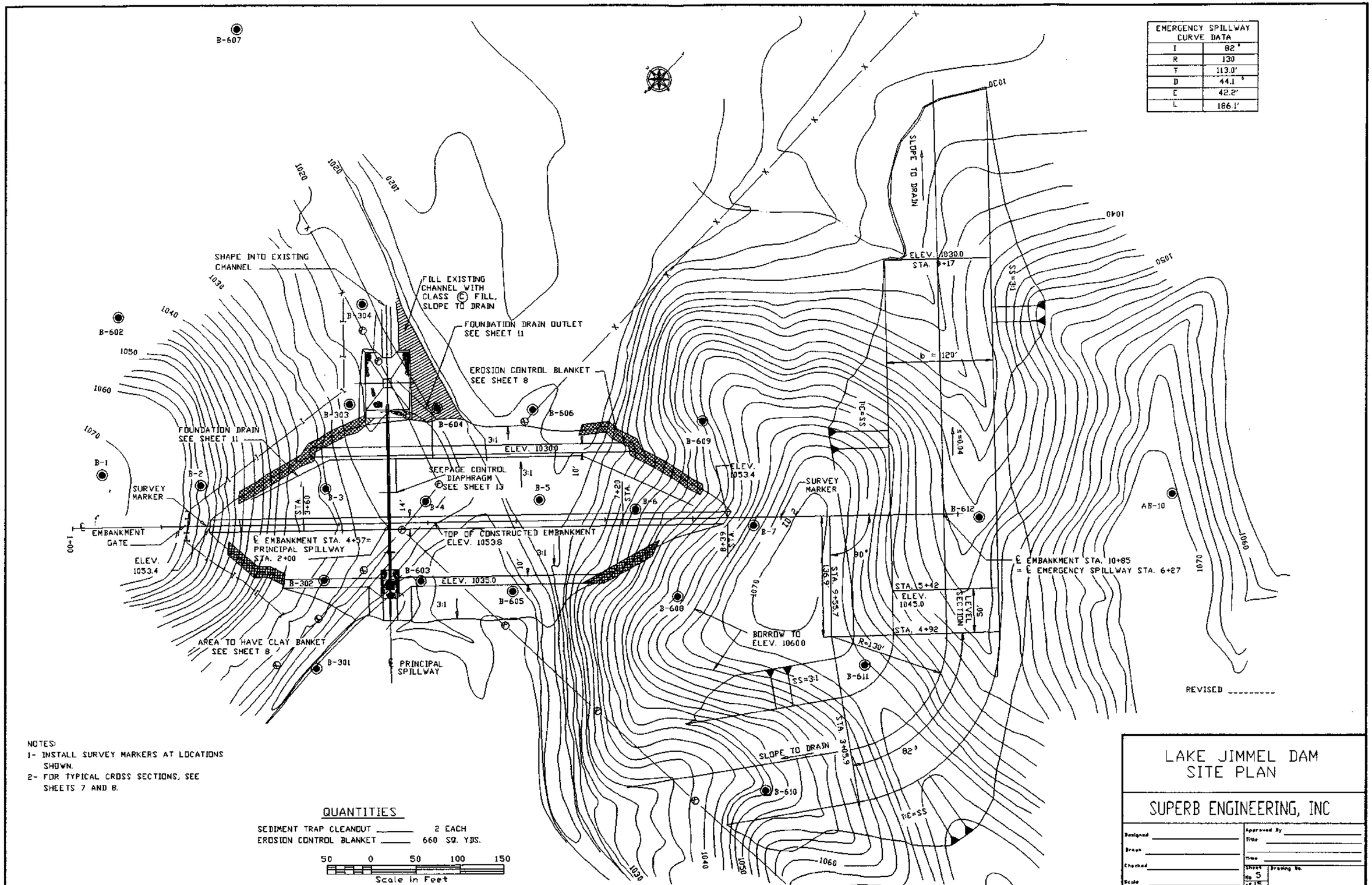
PROFILE ALONG CENTERLINE OF VALLEY

NOTE: UPSTREAM OBSTRUCTIONS SHOULD BE CONSIDERED IN THE DESIGN OF THE DAM AND RESERVOIR. OBSTRUCTIONS MAY INCLUDE BRIDGES, CULVERTS, DAMS, BUILDINGS, AND ADJACENT PROPERTY

LAKE JIMMEL DAM
VALLEY PROFILE

SUPERB ENGINEERING, INC

Designed
Drawn
Checked
Scale
Approved By
Title
Revision
Sheet No. 4 of 15
Drawing No.



EMERGENCY SPILLWAY CURVE DATA	
I	82°
R	130
T	113.0'
D	44.1°
E	42.2'
L	186.1'

REVISED _____

NOTES:
1- INSTALL SURVEY MARKERS AT LOCATIONS SHOWN.
2- FOR TYPICAL CROSS SECTIONS, SEE SHEETS 7 AND 8.

QUANTITIES

SEDIMENT TRAP CLEANOUT _____ 2 EACH
EROSION CONTROL BLANKET _____ 660 SQ. YDS.

50 0 50 100 150
Scale in Feet

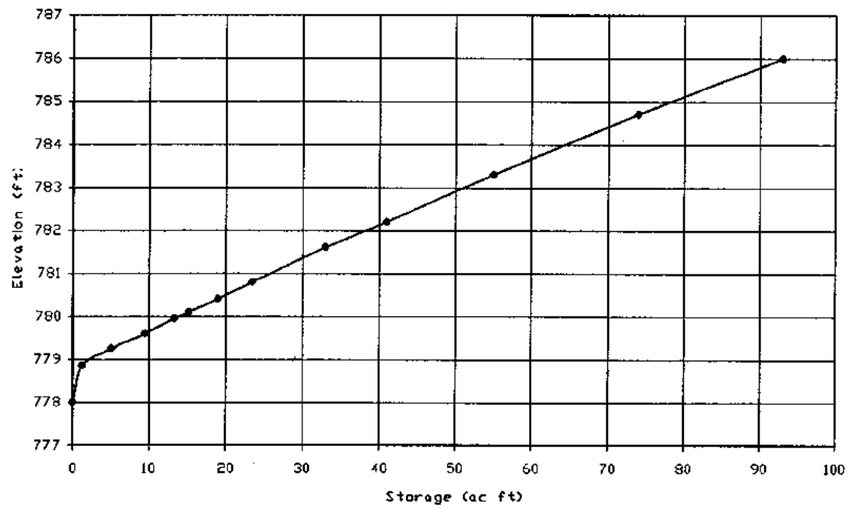
LAKE JIMMEL DAM
SITE PLAN

SUPERB ENGINEERING, INC

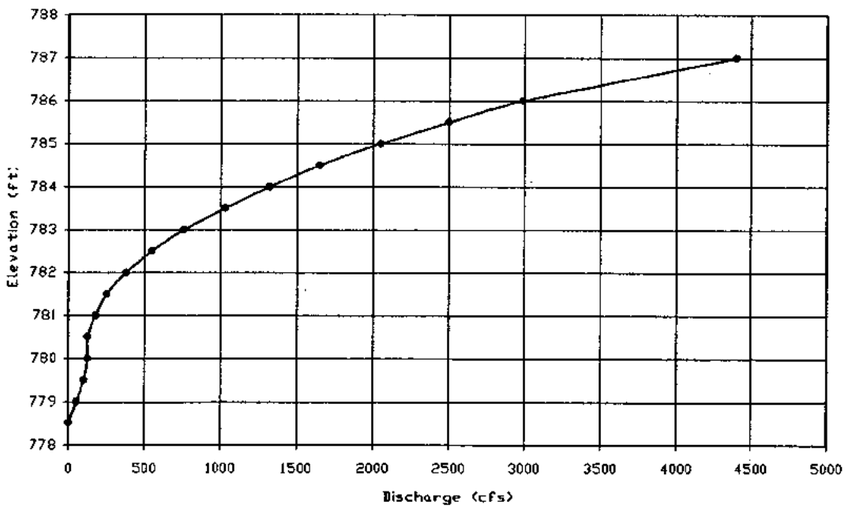
Designed _____ Approved By _____
Drawn _____ Title _____
Checked _____ Title _____
Scale _____ Sheet No 5 of 15 Drawing No.

HYDRAULIC DATA AND CURVES

LAKE JIMMEL DAM STAGE-STORAGE



LAKE JIMMEL DAM RATING CURVE



PHYSICAL DATA

Hazard Classification _____
Drainage Area (sq mi) _____
Time of Concentration, Tc (hrs) _____
Runoff Curve Number _____
(AMC II Conditions) _____

STRUCTURAL DATA

Principal Spillway
- Material _____
- Length _____
- Size _____
- Height _____
- Width _____
- Crest Elev/Area _____
- Weir Length _____

Emergency Spillway
- Material _____
- Base Width _____
- Side Slope _____
- Crest Elev/Area/Stor _____
- Shape _____
- 'n' value _____
- Length/Slope of Spillway _____
- Armoring _____

Top of Dam
- Elev _____
- Area _____
- Storage _____
- Freeboard _____
- Length of Dam _____
- Channel Outlet Elev _____

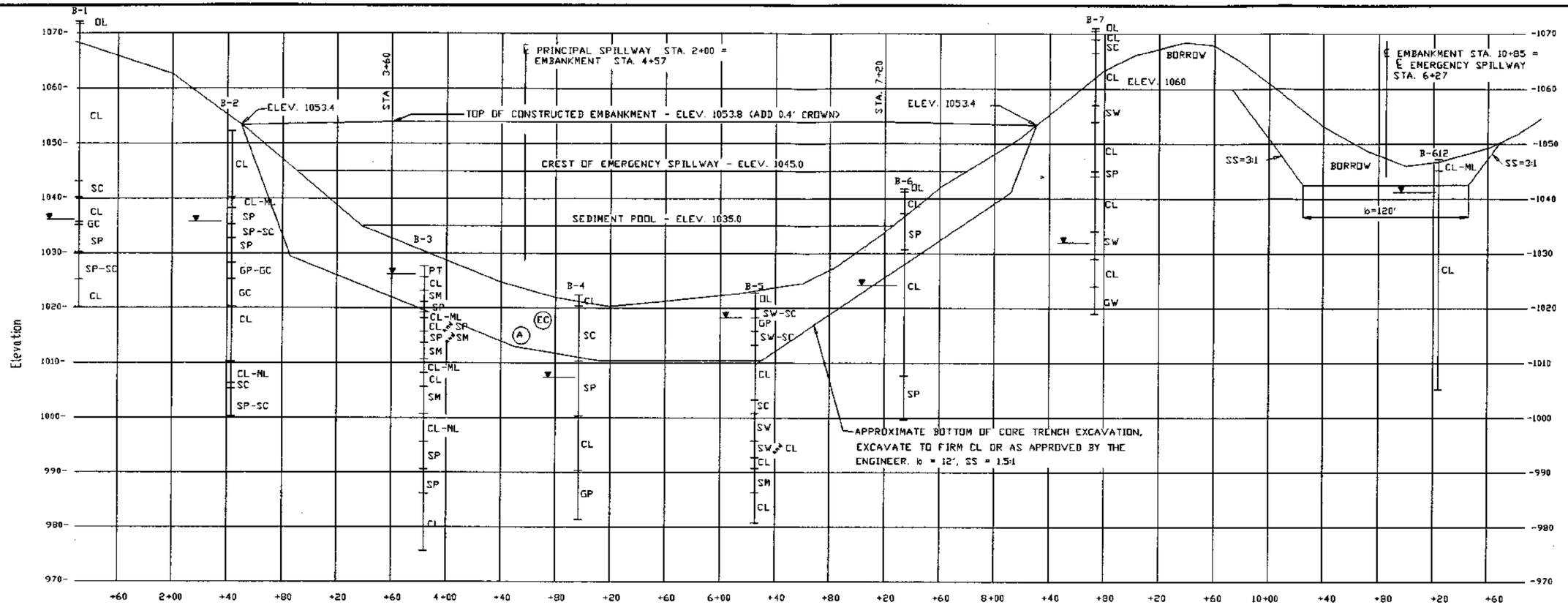
HYDROLOGIC/HYDRAULIC DATA

DESCRIPTION (UNITS)	VALUE
BASIN HYDROLOGY	
Rainfall (in)	
Duration (hrs)	
%PMP or -yr Frequency	
Runoff (in)	
Runoff (acre ft)	
Peak inflow (cfs)	
PRINCIPAL SPILLWAY	
Max. Discharge (cfs)	
Max velocity-at Opening (fps)	
Max velocity-exit channel (fps)	
BREACH ANALYSIS	
Shape of Breach	
Width (ft)	
Sideslope	
Time to Failure (hrs)	
Immediate Downstream Elev (ft)	

LAKE JIMMEL DAM
HYDRAULIC DATA
AND CURVES

SUPERB ENGINEERING, INC

Designed _____ Approved By _____
Drawn _____ Title _____
Checked _____ Revision _____
Scale _____ Sheet No. 6 of 15 Drawing No.

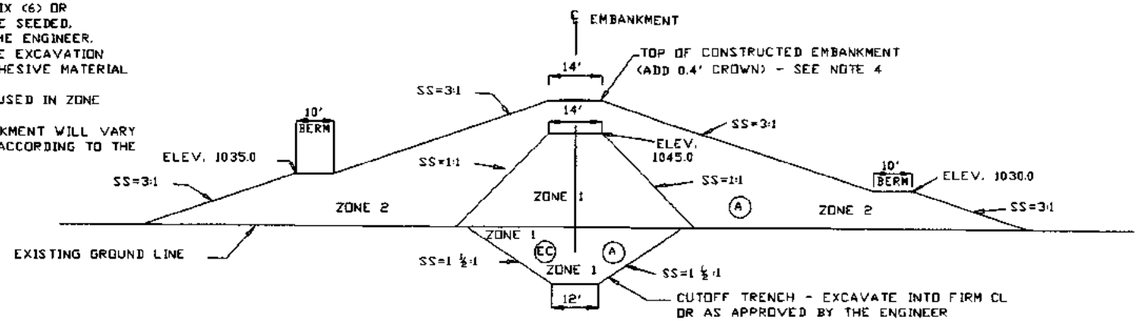


LAKE JIMMEL DAM PROFILES AND SOIL BORING LOGS

SUPERB ENGINEERING, INC

Designed	Approved By
Drawn	Title
Checked	Revision
Scale	Sheet No. 7 of 15
	Drawing No.

NOTES:
1 - TOPSOIL SHALL BE PLACED IN THE OUTSIDE SIX (6) OR MORE INCHES OF THE EMBANKMENT AREA TO BE SEEDED. IN HORIZONTAL LIFTS, WHERE DIRECTED BY THE ENGINEER.
2 - BACKFILL FOR CUTOFF TRENCH AND STRUCTURE EXCAVATION SHALL CONSIST OF THE MOST IMPERVIOUS, COHESIVE MATERIAL AVAILABLE.
3 - NON-PLASTIC SP & SW MATERIALS SHALL BE USED IN ZONE 2 AREAS.
4 - ELEVATIONS FOR TOP OF CONSTRUCTED EMBANKMENT WILL VARY ALONG THE CENTERLINE OF THE EMBANKMENT ACCORDING TO THE PROFILE SHOWN ON SHEET 7.

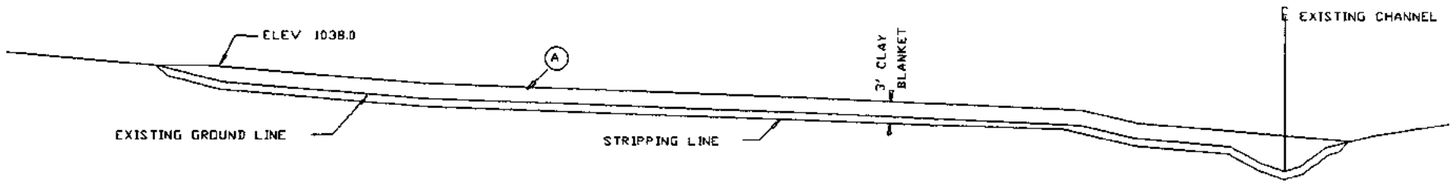


SECTION ON CENTERLINE

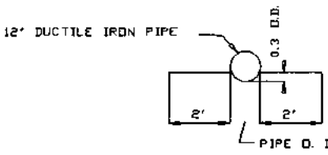
TYPICAL FILL MATERIAL MOISTURE DENSITY RELATIONSHIP

SOURCE OF MATERIAL				LABORATORY TEST INFORMATION		PLACEMENT REQUIREMENT
LOCATION BORING NUMBER	APPROXIMATE DEPTH(FT.) FROM	TO	UNIFIED SOIL CLASSIFICATION	DRY DENSITY (MAXIMUM)	MOISTURE % (OPTIMUM)	EMBANKMENT SECTION
AB-10A	0	10	CL	130.2	10.6	ALL
AB-10B	15	25	CL	133.8	7.8	ALL
AB-5	0	18	CL	121.4	13.9	ALL
AB-8	10	15	SP	140.3	5.8	2
B-611	10	12	SP	*	*	2

* NON PLASTIC SP & SW MATERIALS SHALL BE COMPACTED TO A DRY DENSITY OF 125 LBS./CU. FT. MINIMUM.



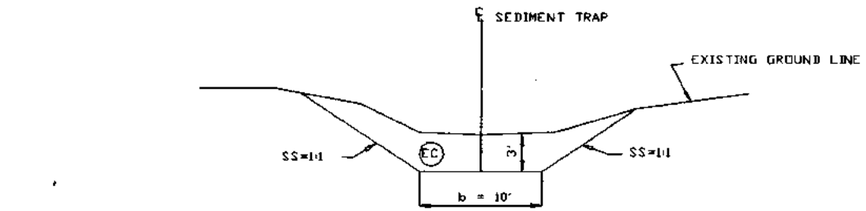
TYPICAL CROSS SECTION OF CLAY BLANKET AREA



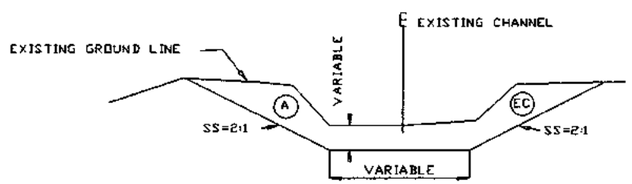
TYPICAL CROSS SECTION OF DUCTILE IRON PIPE PLACEMENT

RIPRAP GRADATION

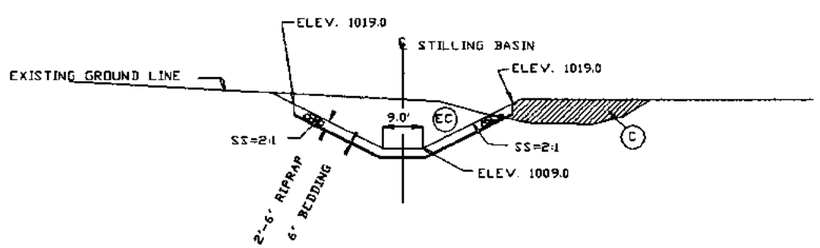
AT LEAST 50% BY WEIGHT SHALL CONSIST OF PIECES LARGER THAN 12 INCHES. THE MAXIMUM SIZE SHALL BE 18 INCHES AND NOT MORE THAN 15% OF THE PIECES BY WEIGHT SHALL BE LESS THAN 4 INCHES.



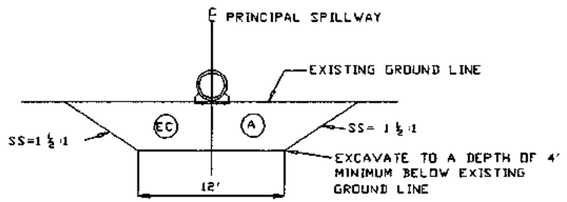
TYPICAL CROSS SECTION OF SEDIMENT TRAP



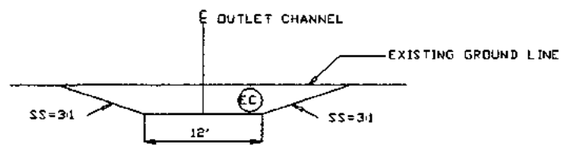
TYPICAL CROSS SECTION OF STREAM CHANNEL CLEANOUT



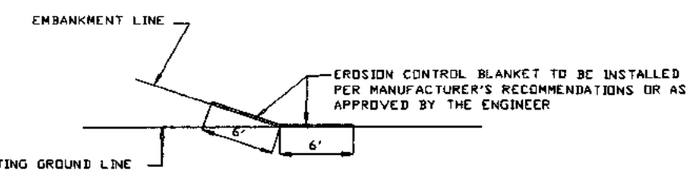
TYPICAL CROSS SECTION OF STILLING BASIN



TYPICAL CROSS SECTION OF STRUCTURE EXCAVATION



TYPICAL CROSS SECTION OF OUTLET CHANNEL



TYPICAL CROSS SECTION OF EROSION CONTROL BLANKET PLACEMENT

RIPRAP BEDDING GRADATION

RIPRAP BEDDING SHALL BE INDIANA STATE HIGHWAY COARSE AGGREGATE SIZE NO 5 OR EQUIVALENT.

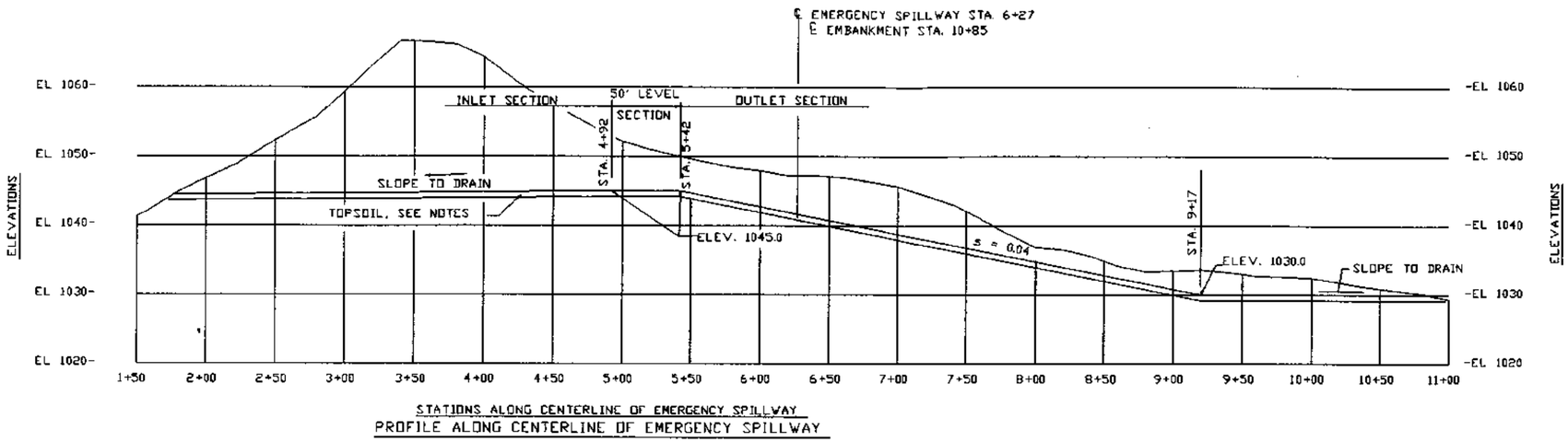
QUANTITIES

EXCAVATION - COMMON:		
CUTOFF TRENCH	4,370	CU. YDS
STRUCTURE EXCAVATION	380	CU. YDS.
STREAM CHANNEL CLEANOUT	590	CU. YDS.
OUTLET CHANNEL AND SEDIMENT TRAP	150	CU. YDS.
STILLING BASIN	2,007	CU. YDS.
TOTAL	7,497	CU. YDS.
EARTH FILL - CLASS A:		CU. YDS.
EMBANKMENT	52,250	CU. YDS.
CLAY BLANKET	5,550	CU. YDS.
CUTOFF TRENCH BACKFILL	4,370	CU. YDS.
STRUCTURE EXCAVATION BACKFILL	380	CU. YDS.
STREAM CHANNEL BACKFILL	590	CU. YDS.
TOTAL	63,140	CU. YDS.
RIPRAP	643	TONS
RIPRAP BEDDING	114	CU. YDS.

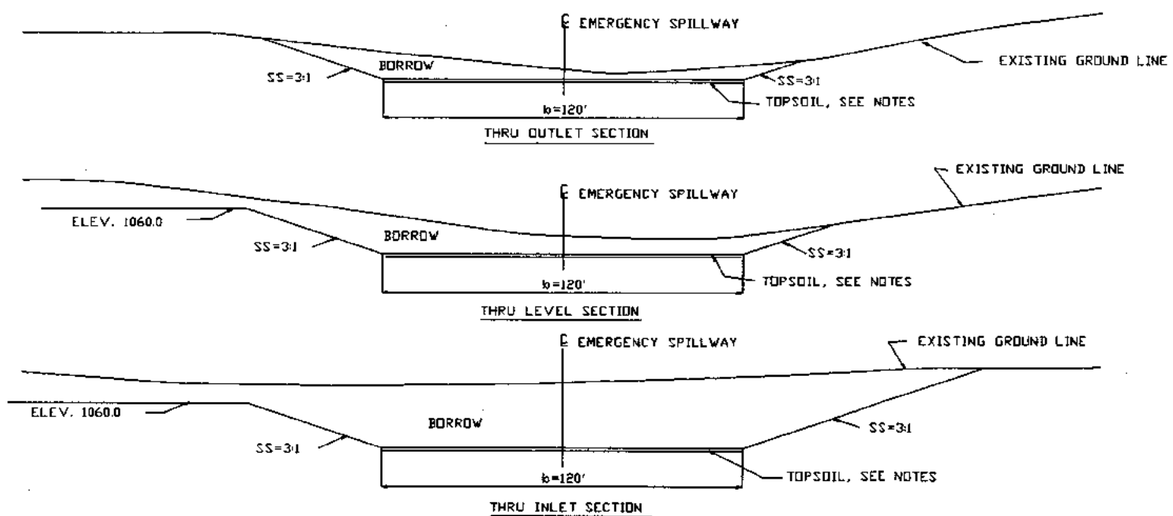
LAKE JIMMEL DAM TYPICAL CROSS SECTIONS

SUPERB ENGINEERING, INC

Designed
Drawn
Checked
Scale NOT TO SCALE
Approved By
Title
Revised
Sheet No 8 of 15
Drawing No.



PROFILE ALONG CENTERLINE OF EMERGENCY SPILLWAY



TYPICAL CROSS SECTIONS

NOT TO SCALE

NOTES:
1- PLACE TOPSOIL IN EMERGENCY SPILLWAY BOTTOM, 1 FOOT MIN THICKNESS. AREAS WHERE SP AND SW MATERIALS ARE ENCOUNTERED WILL BE EXCAVATED TO A DEPTH OF 2 FEET AND BACKFILLED WITH COMPACTED FILL MATERIAL.
2- THE REMAINING AVAILABLE TOPSOIL SHALL BE SPREAD ON THE EMERGENCY SPILLWAY, WHERE DIRECTED BY THE ENGINEER.

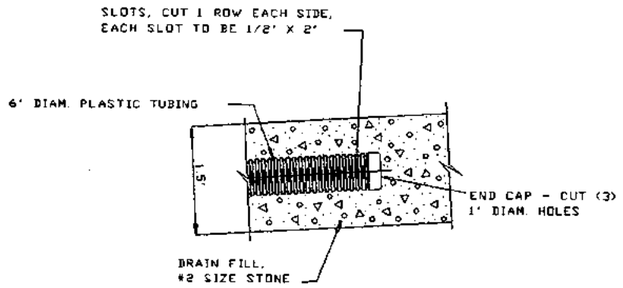
QUANTITIES

BORROW - EMERGENCY SPILLWAY	48,475	CU. YDS.
TOPSOIL SPREADING - EMERGENCY SPILLWAY	11,920	SQ. YDS

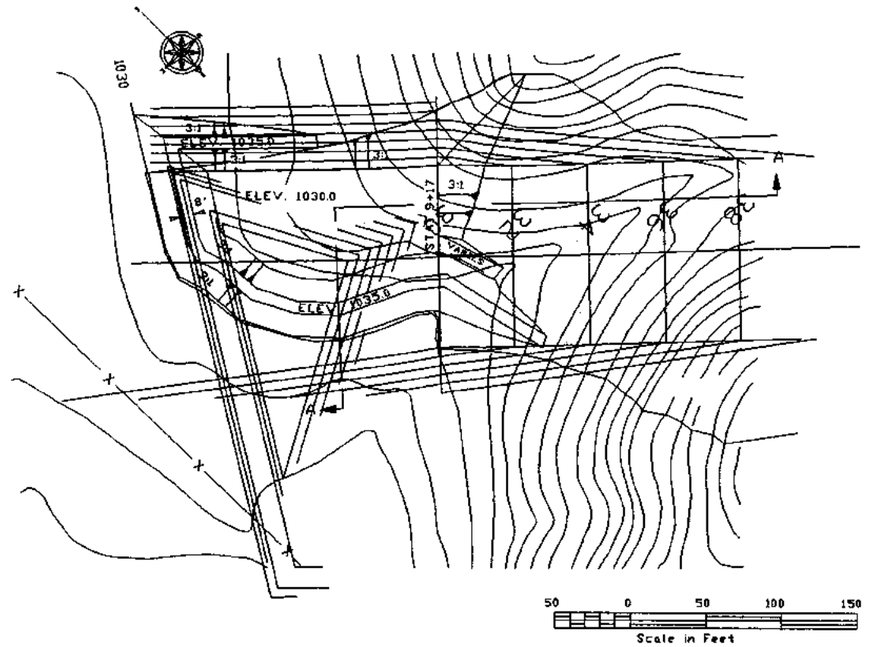
LAKE JIMMEL DAM EMERGENCY SPILLWAY DETAILS

SUPERB ENGINEERING, INC

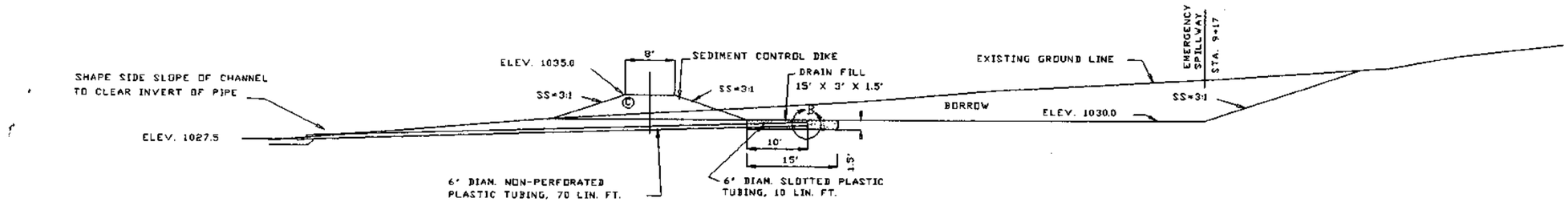
Designed
Drawn
Checked
Scale
Approved By
Title
Revision
Sheet No. 9 of 15
Drawing No.



DETAIL 'B'
NOT TO SCALE



SEDIMENT BASIN LOCATION



SECTION A-A
NOT TO SCALE

QUANTITIES

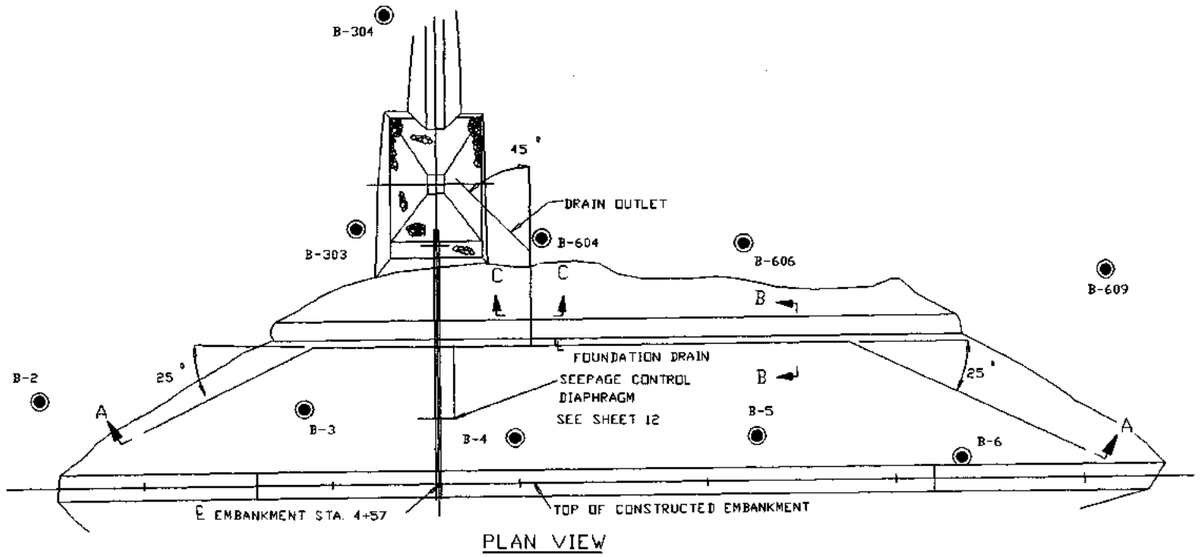
SEDIMENT CONTROL BASIN _____ SUM JOB
DRAIN FILL _____ 3 CU. YDS.

NOTES:
1- NEAR THE COMPLETION OF THE EARTH FILL OPERATIONS, WHEN DIRECTED BY THE ENGINEER, THE SEDIMENT CONTROL DIKE SHALL BE REMOVED AND USED AS BORROW.
2- THE TUBING SHALL BE REMOVED FROM THE SITE.

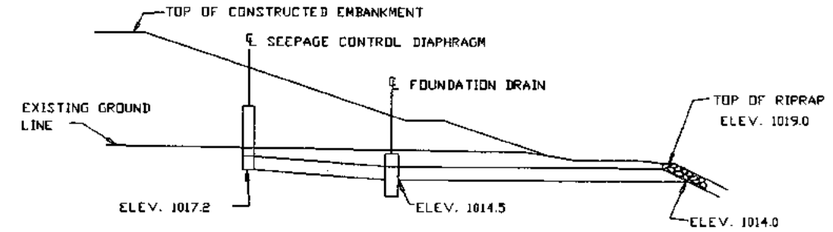
LAKE JIMMEL DAM SEDIMENT BASIN DETAILS

SUPERB ENGINEERING, INC

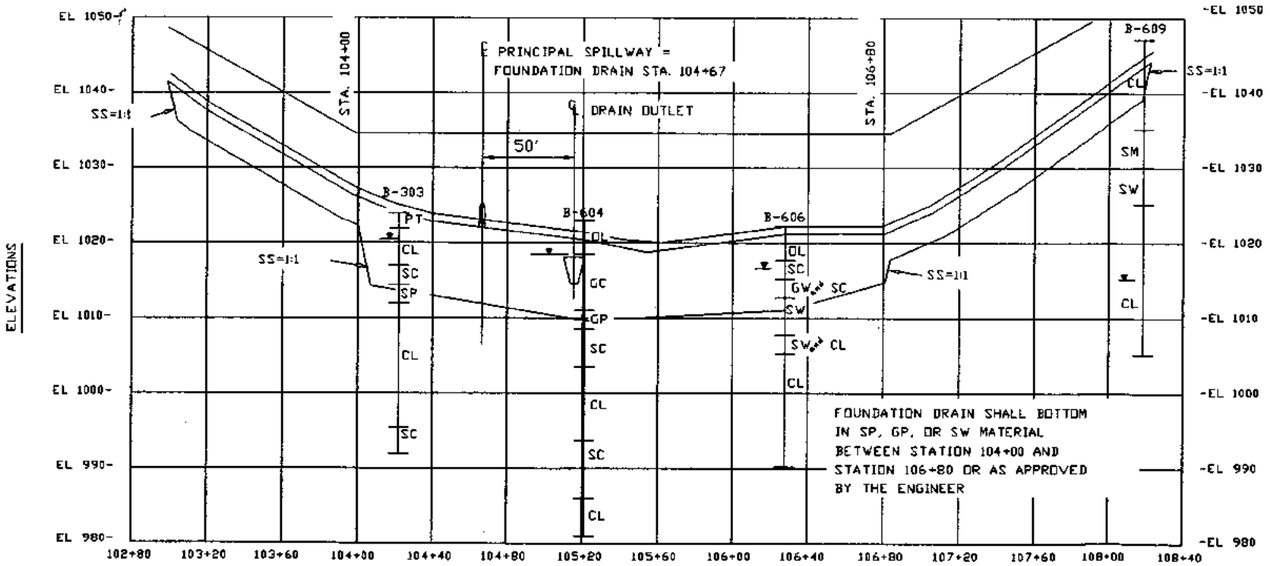
Designed
Drawn
Checked
Scale NOT TO SCALE
Approved By
Title
Revision
Sheet No. 10 of 15
Drawing No.



PLAN VIEW



DRAIN OUTLET PROFILE



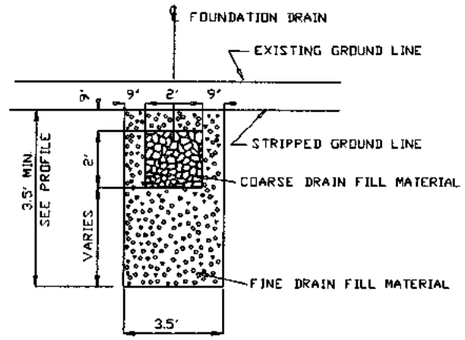
SECTION A-A

DRAIN FILL MATERIAL

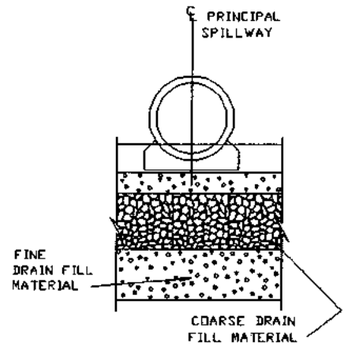
STANDARD SIEVE SIZE	COARSE % PASSING	AS-BUILT % PASSING	FINE % PASSING	AS-BUILT % PASSING
3	100			
1 1/2	85 - 100			
3/4	60 - 85			
1/2	30 - 60			
3/8	10 - 35		100	
#4	0 - 10		95 - 100	
#8	0 - 5		80 - 100	
#16	-		50 - 85	
#30	-		25 - 60	
#50	-		5 - 30	
#100	-		0 - 10	
#200	-		0 - 3	

COARSE DRAIN FILL REQUIREMENTS MAY BE MET BY USE OF INDIANA HIGHWAY COARSE AGGREGATE SIZE #5 .

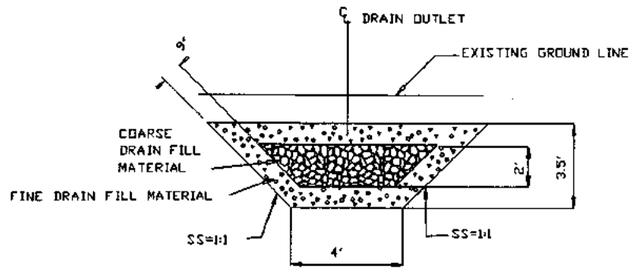
FINE DRAIN FILL REQUIREMENTS MAY BE MET BY USE OF INDIANA HIGHWAY FINE AGGREGATE SIZE #23.



SECTION B-B



DETAILS OF DRAIN FILL AT PRINCIPAL SPILLWAY



SECTION C-C

CROSS SECTION CONFIGURATION MAY BE INVERTED AT CONTRACTOR'S OPTION.

QUANTITIES

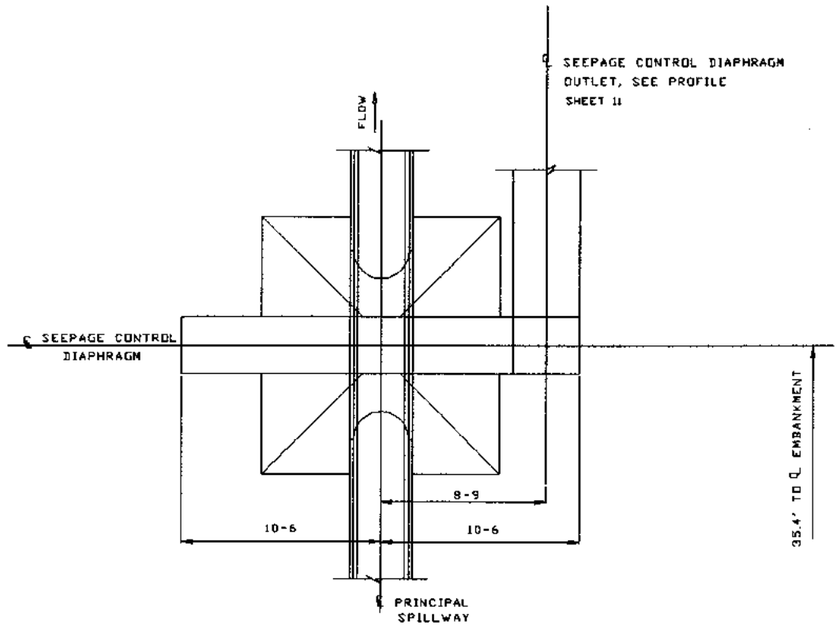
COARSE DRAIN FILL MATERIAL ____ 42.0 CU. YDS.

FINE DRAIN FILL MATERIAL ____ 430.0 CU. YDS.

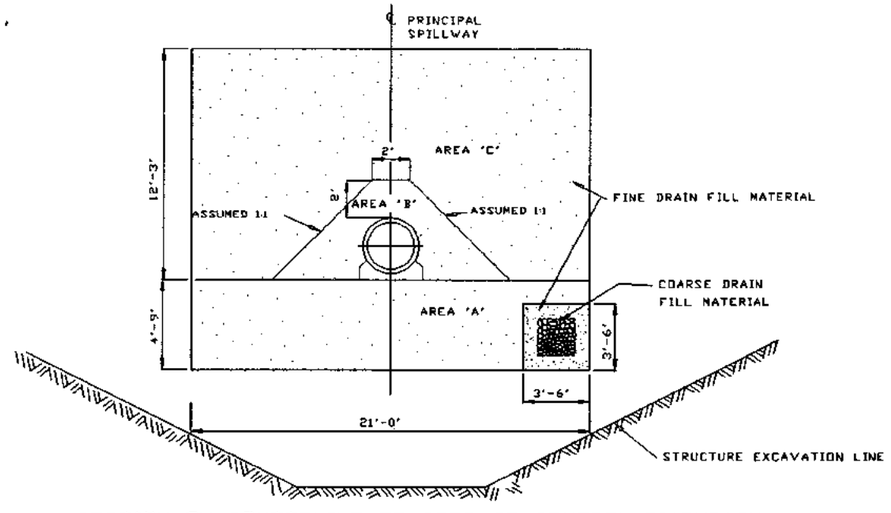
LAKE JIMMEL DAM DETAILS OF FOUNDATION DRAIN

SUPERB ENGINEERING, INC

Designed
Drawn
Checked
Scale NOT TO SCALE
Approved By
Title
Revision
Sheet No. 11 of 15
Drawing No.



PLAN



SECTION ON CENTERLINE OF SEEPAGE CONTROL DIAPHRAGM

SUGGESTED SEQUENCE FOR INSTALLATION OF SEEPAGE CONTROL DIAPHRAGM

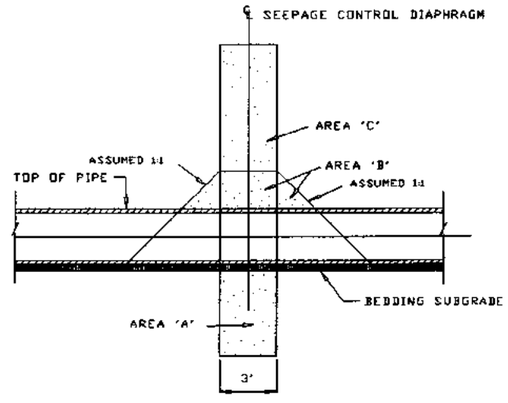
1-PLACE DRAIN FILL IN OUTLET.
2-PLACE DRAIN FILL IN AREA 'A' BELOW BEDDING SUBGRADE.
3-PLACE PIPE AND BEDDING.
4-PLACE DRAIN FILL IN AREA 'B' OVER PIPE AND BEDDING.
5-PLACE COMPACTED EARTH FILL OVER AREA 'A' AND AREA 'B'.
6-EXCAVATE TRENCH TO CONTACT CLEAN DRAIN FILL IN AREA 'A' AND AREA 'B', THEN PLACE AREA 'C'

NOTES:
1- AREA 'A' AND 'C' MAY BE DONE IN LIFTS, THICKNESS AT CONTRACTOR'S OPTION.
2- THE DRAIN FILL SHALL BE WATER FLOODED IN ACCORDANCE WITH SPECIFICATION 24.

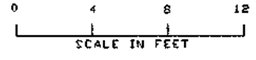
NOTE:
FOR FINE AND COARSE DRAIN FILL GRADATIONS, SEE SHEET 11.

QUANTITIES

FINE DRAIN FILL MATERIAL _____ 45.0 CU. YDS.



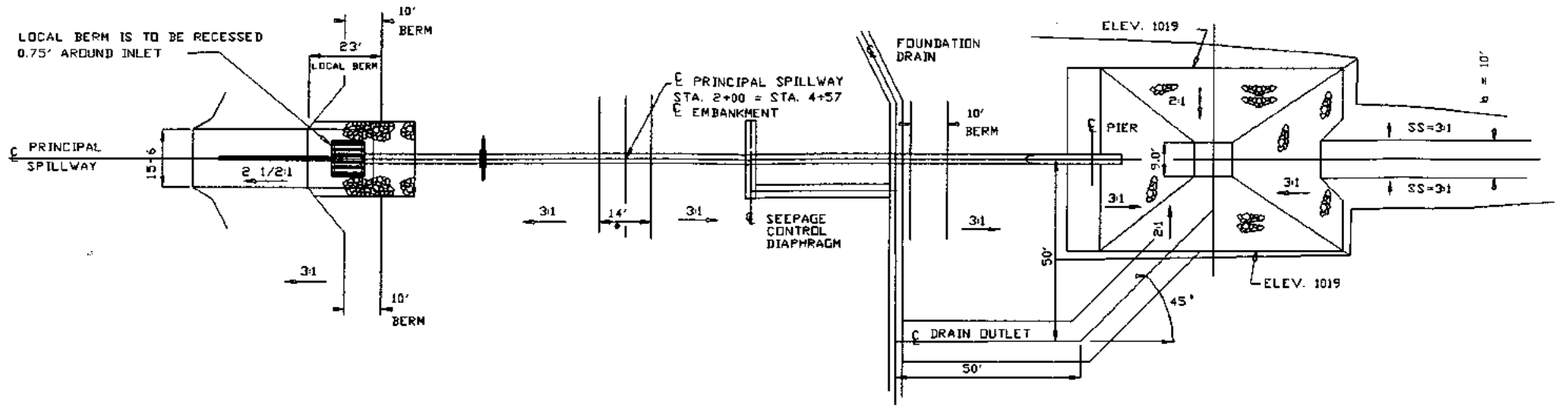
SECTION ON CENTERLINE OF PRINCIPAL SPILLWAY



LAKE JIMMEL DAM SEEPAGE CONTROL DIAPHRAGM DETAILS

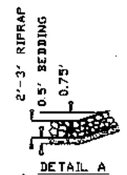
SUPERB ENGINEERING, INC

Designed	Approved by
Drawn	Title
Checked	Revision
Scale	Sheet No. 12 of 15 — Drawing No.

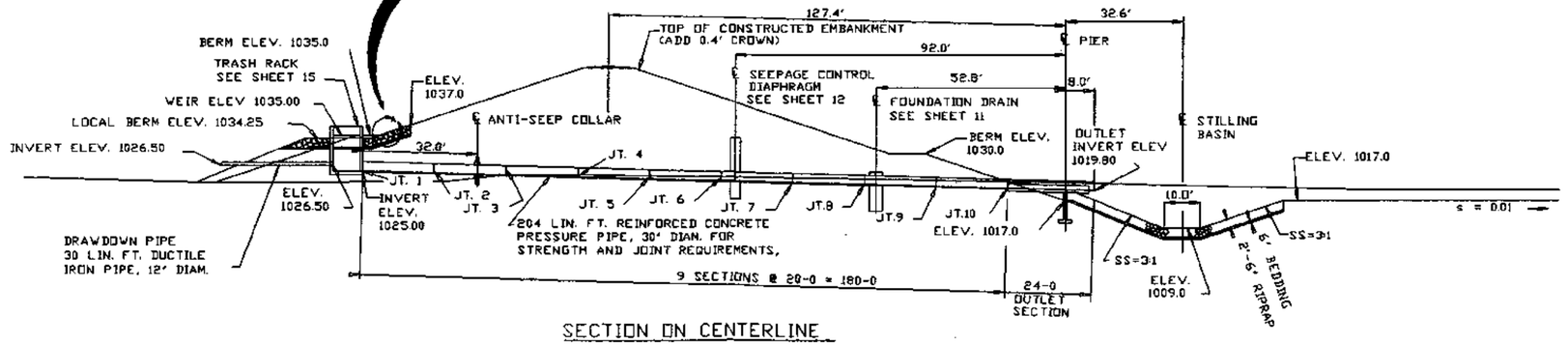


PLAN

NOTES:
1- STRUCTURE IS SYMMETRICAL ABOUT THE CENTERLINE, UNLESS SHOWN.
2-CAMBER CONDUIT IN ACCORDANCE WITH ELEVATIONS SHOWN.
3- EXCEPT AS PROVIDED FOR THE PIPE OUTLET, SHORTER PIPE LENGTHS MAY BE USED IN LIEU OF THOSE SHOWN WITH A MINIMUM PIPE LENGTH OF 8 FEET, USING APPROPRIATE JOINT EXTENSIBILITY. REVISED CAMBER ELEVATIONS WILL BE FURNISHED BY THE ENGINEER IF LENGTHS OTHER THAN THOSE SHOWN ON THE DRAWINGS ARE USED.



DETAIL A



SECTION ON CENTERLINE

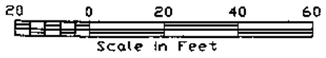
PIPE JOINT TABLE

JOINT LOCATION	INVERT ELEVATION	BEFORE BACKFILL DATE ____		EMBANKMENT IN PLACE DATE ____	
		INVERT ELEVATION	JOINT GAP	INVERT ELEVATION	JOINT GAP
JT. 1	1025.00				
JT. 2	1024.89				
JT. 3	1024.65				
JT. 4	1024.27				
JT. 5	1023.76				
JT. 6	1023.20				
JT. 7	1022.58				
JT. 8	1021.91				
JT. 9	1021.19				
JT. 10	1020.41				
OUTLET	1019.80				

QUANTITIES

PIPE CONDUIT - REINFORCED CONCRETE PRESSURE PIPE, 30" DIAM.
INCLUDING CONCRETE BEDDING _____ 204 LIN. FT.

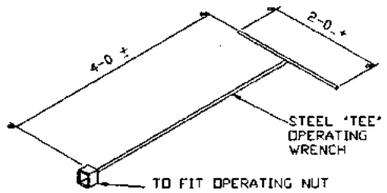
DRAWDOWN PIPE - DUCTILE IRON PIPE, 12" DIAM. INCLUDING
FITTINGS _____ 30 LIN. FT.



LAKE JIMMEL DAM
PRINCIPAL SPILLWAY
LAYOUT

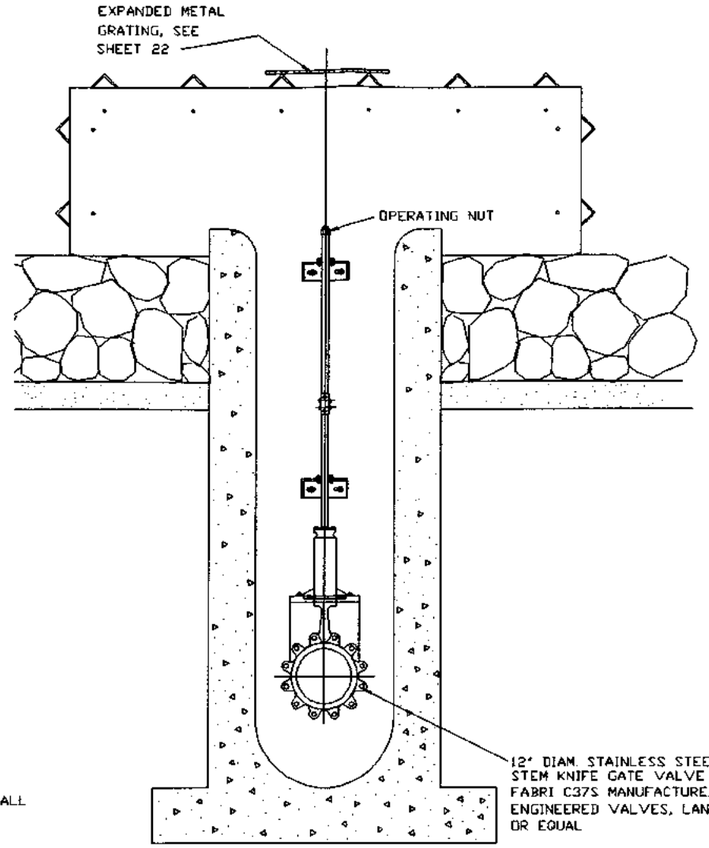
SUPERB ENGINEERING, INC

Designed _____ Approved By _____
Drawn _____ Title _____
Checked _____ Revision _____
Scale _____ Sheet No. 13 of 15 Drawing No.

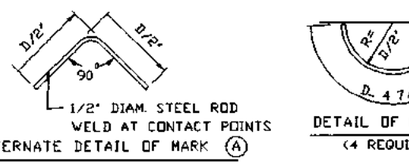


DETAIL OF OPERATING WRENCH
(1 REQUIRED)

SECTION ON CENTERLINE



ENDWALL ELEVATION

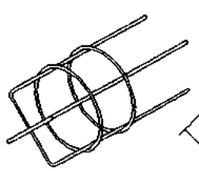


ALTERNATE DETAIL OF MARK (A)
(4 REQUIRED)

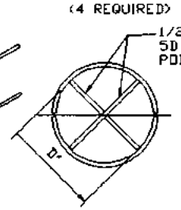
DETAIL OF MARK (A)
(4 REQUIRED)

QUANTITIES

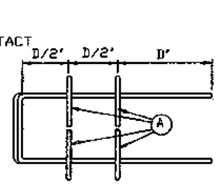
KNIFE GATE VALVE, 12" DIAM. _____ SUM JOB



ISOMETRIC



UPSTREAM ELEVATION

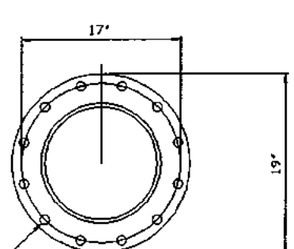


SIDE ELEVATION

DETAILS OF TRASH GUARD
(TO BE SHOP FABRICATED AND GALVANIZED)

QUANTITIES

METAL WORK _____ PART SUM JOB



NOTE:
FLANGE ON PIPE SHALL HAVE 1" DIAM. BOLT HOLES.

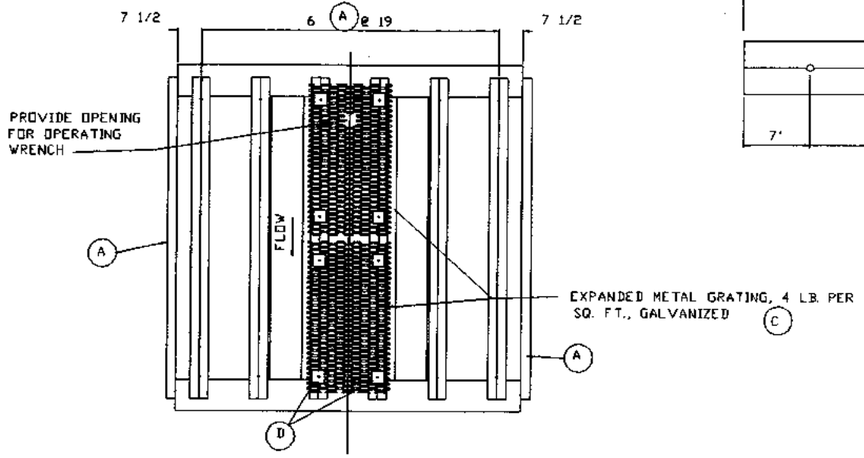
12 BOLT HOLES, TAPPED FOR 7/8" DIAM. BOLTS

FLANGE DETAILS
(FLANGE THICKNESS = 1.25+0.12)

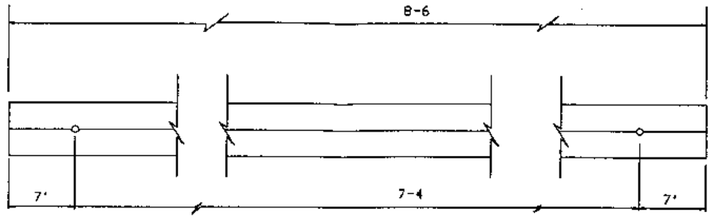
LAKE JIMMEL DAM
DETAILS OF 12" DIAMETER DRAWDOWN KNIFE GATE

SUPERB ENGINEERING, INC

Designed	Approved By
Drawn	Title
Checked	Revision
Scale NOT TO SCALE	Sheet No. 14 of 15 — Drawing No.



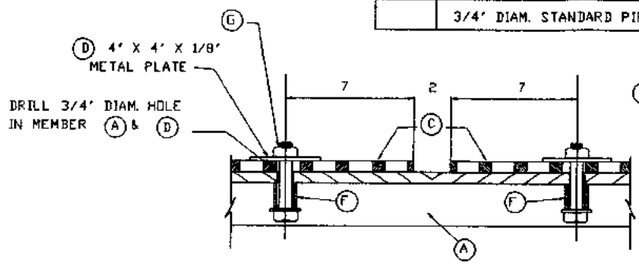
PLAN - TOP



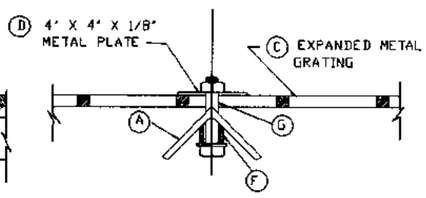
DETAIL OF ANGLE

MATERIAL LIST

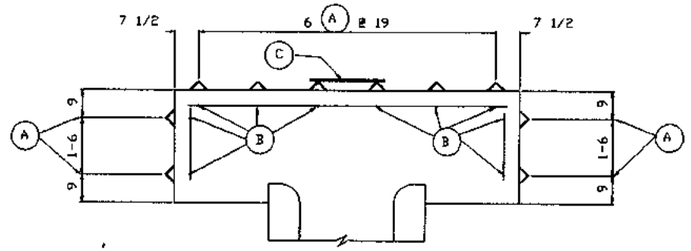
MARK	ITEM	QUANTITY
A	ANGLE 4"X4"X3/8", 8'-6" LONG (GALVANIZED)	10
B	5/8" GALVANIZED ROD (SEE DETAIL OF ANCHORAGE FOR ANGLE)	20
C	EXPANDED METAL GRATING, 4 LB. PER SQ. FT., GALVANIZED 2'-0" X 4'-0"	2
D	4" X 4" X 1/8" METAL PLATE, DRILLED AND GALVANIZED	8
E	FORMED SPACER, GALVANIZED	16
F	FORMED SPACER, GALVANIZED	4
G	5/8" DIAM. BOLTS, GALVANIZED, LENGTH = 4" MIN.	4
	5/8" DIAM. NUTS AND WASHERS, GALVANIZED	40
	3/4" DIAM. STANDARD PIPE SLEEVE, 10' LONG, GALVANIZED	20



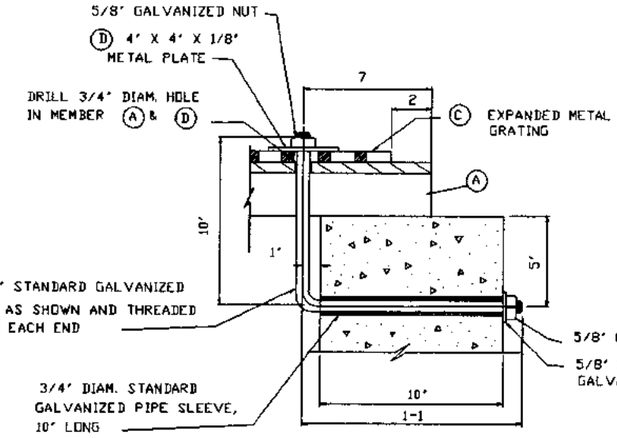
SECTION VIEW



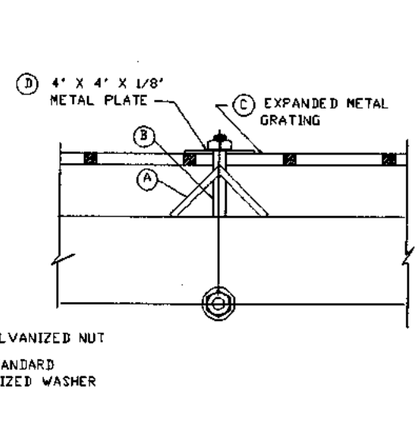
END VIEW



ENDWALL ELEVATION



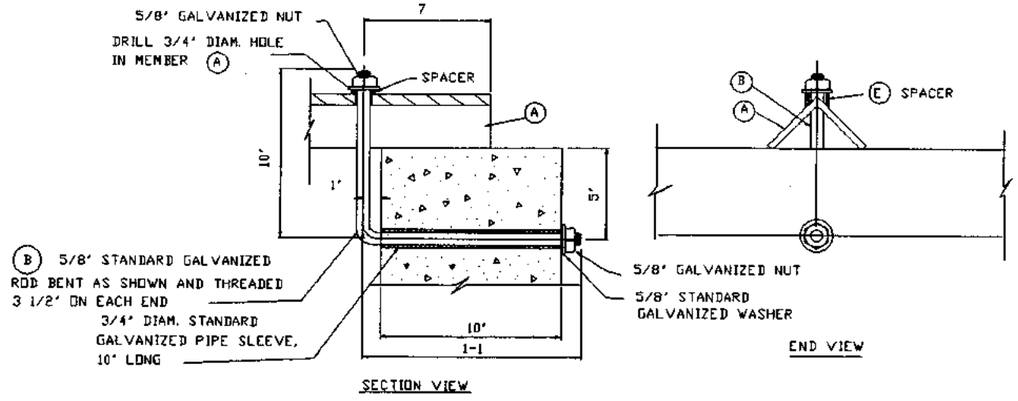
SECTION VIEW



END VIEW

DETAIL OF ANCHORAGE FOR ANGLES

(ANGLES WITH GRATING)



SECTION VIEW

END VIEW

DETAIL OF ANCHORAGE FOR ANGLES

(ANGLES WITH SPACERS)

QUANTITIES

METAL WORK _____ PART SUM JOB

LAKE JIMMEL DAM
DETAILS OF R/C INLET TRASH RACK

SUPERB ENGINEERING, INC

Designed		Approved By	
Drawn		Title	
Checked		Revision	
Scale	NOT TO SCALE	Sheet No. 15 of 15	Drawing No.

PARTIAL LIST OF SPECIFICATION ITEMS FOR EXAMPLE DAM

Title

CLEARING
CLEARING AND GRUBBING
STRUCTURE REMOVAL
POLLUTION CONTROL
SEEDING AND MULCHING FOR PROTECTIVE COVER
MOBILIZATION
WATER FOR CONSTRUCTION
REMOVAL OF WATER
EXCAVATION
EARTH FILL
DRAINFILL
SALVAGING AND SPREADING TOPSOIL
PORTLAND CEMENT CONCRETE
STEEL REINFORCEMENT
REINFORCED CONCRETE PRESSURE PIPE SPILLWAY CONDUITS
DUCTILE-IRON PIPE CONDUITS
LOOSE ROCK RIPRAP
WATER CONTROL GATES
METAL FABRICATION AND INSTALLATION
FARM FIELD FENCES
GEOTEXTILE
AGGREGATE FOR PORTLAND CEMENT CONCRETE
ROCK FOR RIP RAP
PORTLAND CEMENT
AIR-ENTRAINING ADMIXTURES
WATER-REDUCING AND SET-RETARDING ADMIXTURES
CURING COMPOUND (FOR CONCRETE)
PREFORMED EXPANSION JOINT FILLER
SEALING COMPOUND FOR JOINTS IN CONCRETE AND CONCRETE PIPE
STEEL REINFORCEMENT (FOR CONCRETE)
REINFORCED CONCRETE PRESSURE PIPE
DUCTILE-IRON PIPE AND FITTINGS
METAL
GALVANIZING

Appendix F
Common Pitfalls

Common Pitfalls

The following is a listing of shortcomings that have been noted during the application and design review process. These are offered as an aid to ensure consideration has been given to all aspects of the design. Every item will not apply to each project.

- Not incorporating the geotechnical findings and recommendations into the plans and specifications.
- Not allowing the geotechnical contractor to review the final plans & specifications before submission
- Not providing a low level outlet for emptying the reservoir.
- Not providing a low level outlet large enough to drain the reservoir in a timely fashion.
- Not encasing or cradling the outlet pipe in concrete through the dam embankment (i.e. not eliminating the seepage path along the pipe).
- Pressurizing the outlet pipe by regulating the flow at the downstream end.
- Insufficient energy dissipation in the spillway
- Inadequate joints details for the concrete spillway slabs.
- Incompatible materials in the filter drains.
- Inadequate provision for differential settlement.
- Insufficient drainage and filters to control seepage through the dam and foundation.
- Inadequate shaping and preparation of the foundation for placement of fill materials.
- Not sloping the crest towards the upstream slope.
- Earthen spillways activating prior to the 50-year storm.
- Improper usage of filter fabric.
- Use of filter fabric for separation of coarse and fine aggregate.
- No animal guards on the toe drains.
- Not providing protection for any exposed PVC from UV radiation and vandalism.
- Improper conduit selection.
- Allowing blasting to take place in the vicinity of the dam without appropriate precautions.
- Not grouting abandoned boreholes used to evaluate existing dam that is currently impounding water.
- Not addressing instrumentation needs for monitoring during filling and normal operation, and other monitoring such as settlement during the construction process.
- Not providing adequate drop and/or projection of drain outlet pipes to allow for collection of seepage flows during monitoring and normal operation.
- Not addressing the need to ensure bonding between lifts of fill.
- Lack of adequate earthwork moisture control.
- Not providing berms on the downstream slope at appropriate intervals.
- No erosion protection at the abutment contacts (groins).
- Not providing for clearing 50 feet beyond the downstream toe of the dam.
- Not providing cleanouts on the interval drainage system.
- Not addressing seepage along the spillway conduits.
- Inadequate freeboard.
- Not addressing seismic stability issues including the riser structure.
- Not addressing the impact of utilities in the vicinity of dam.

- Using inadequate vegetation on the dam.
- Inadequate or no trash rack.
- Inadequate consideration of the impact of excavation within reservoir pool with respect to seepage control.
- Not evaluating the proposed dam over abandon coal mine areas.
- Not providing adequate erosion control prior to the establishment of a gravel ground cover.
- Not submitting as-built plans to the Division of Water.
- Allowing discharge from the emergency spillway to erode the toe of the downstream slope.
- Lack of consistency between plan sheets and supporting technical data (i.e. elevation and slope discrepancies).

Appendix G
Special Construction Monitoring Reports

A. Special Construction Monitoring Reports

1. Pressure Testing of Conduits

All conduits through the embankment should be pressure tested in accordance with the applicable ASTM and/or ANSI/AWWA Specification. A continuous record should be kept of all such tests and the information submitted for review should contain the following data:

Equipment - Equipment to perform the test.

Pressure and Duration - Specified testing pressure and minimum test periods.

Acceptance Criteria - Acceptable leakage criteria for test.

Records - A copy of the continuous record of the test and any re-tests.

2. Laboratory Material Certification

All drain and filter materials obtained from an off-site source should be regularly checked for compliance with the project specifications. Documentation should be provided that the materials supplied for placement in the dam meet the required gradation limits. Such documentation should include a certified copy of the suppliers' gradation tests. Synthetic filter material should be clearly marked for identification and include the manufacturer's certification number actually shipped to the job site.

3. Grouting

Evidence should be submitted that an acceptable grout curtain was constructed within the foundation of the proposed dam structure. To satisfy these requirements the report should contain the following information:

Drilling Equipment - Equipment that was used to drill the exploratory and grout holes.

Grout Equipment - Equipment that was used to mix the ingredients of the grout and pump the slurry down the holes.

Laboratory Equipment - Laboratory equipment that was used for on-site control tests.

Grout Mix Criteria - Specified performance values/properties of grout mix (es).

Trial Mixes - The results of any tests and trials that were made on a variety of grout mixes prior to the main grouting operation.

Design Mixes - The grout design mix(es).

Water Testing - The results of all water pressure tests in exploratory or grout holes.

Field Test Results - The results of all field tests conducted on each of the grout mixes during the grouting program with identification of non-compliant results and remedial action. Field tests should include, but not be limited to, sedimentation, slurry density, Marsh Funnel viscosity and unconfined compressive strength.

Profile - A longitudinal profile of the grout curtain showing drilling depths and grout takes for each stage of the grout holes.

4. Slurry Wall

Evidence should be submitted that a relatively impervious slurry trench cutoff was successfully installed within the foundation of the proposed dam. To satisfy these requirements, the report should contain the following information.

Excavation Equipment - Equipment that was used for construction of the working platform and for trenching.

Slurry Equipment - Equipment that was used for mixing the slurry.

Backfill Equipment - Equipment that was used for mixing and placing the backfill.

Test Equipment - Equipment that was used for the control tests.

Backfill Mix Design - Slurry backfill mix design.

Acceptance Criteria - Specified performance values/properties of slurry and backfill mix.

Field Test Results - Results of control tests, with identification of non-compliance results and remedial actions. Control tests on the slurry should include, but not be limited to, pH, unit weight, filtrate loss and viscosity. Control tests on the backfill shall include, but not be limited to, permeability, Atterburg Limits, slump, percentage passing the No. 200 sieve, water content, bentonite content and unit weight.

Profile - A longitudinal profile of the slurry wall showing excavation depths, materials excavated and backfill placed.

5. Blast Monitoring

It is assumed that all blasting operations should be conducted in strict accordance with existing ordinances and regulations. To ensure that no appreciable vibration was transmitted to existing structures or facilities a monitoring report should be prepared for each blasting event. This report should include, as a minimum, the following information:

Preblast Inspections - Documentation of any preblast observations.

Monitoring Equipment - List of equipment used to monitor the blast.

Time and Location - Date, time and location of blast.

Monitoring Locations - List of structures/facilities monitored.

Acceptance Criteria - Allowable vibration parameters.

Monitoring Records - Seismograph records and interpretation.

Post Blast Inspections - Documentation of any post blast observations.

Appendix H
Correction Form

Guidelines for Dams
Amendment Form

Name: _____

Address: _____

Phone and fax numbers: _____

The following sections, discussions, etc...should be included in these guidelines (provide as much detail as possible). _____
_____
_____
_____

In reading the guidelines, I have noted the following errors (please indicate section as well as page number). _____
_____
_____
_____
_____

This form can be produced as needed. Please mail your completed form to:

Division of Water
402 W. Washington Street
Room W264
Indianapolis, IN 46204
Attn: Dam and Levee Safety Section
Phone 1-877-928-3755

You can also fax the complete form to us at (317) 233-4579.

Go

Information Maintained by the Office of Code Revision Indiana Legislative Services Agency

IC 14-27-7

Chapter 7. Dams, Dikes, and Levees; Regulation

IC 14-27-7-1

"Owner" defined

Sec. 1. As used in this chapter, "owner" means an individual, a firm, a partnership, a copartnership, a lessee, an association, a corporation, an executor, an administrator, a trustee, the state, an agency of the state, a municipal corporation, a political subdivision of the state, a legal entity, a drainage district, a levee district, a conservancy district, any other district established by law, or any other person who has a right, a title, or an interest in or to the property upon which the levee, dike, or floodwall and appurtenant works is located.

As added by P.L.1-1995, SEC.20. Amended by P.L.148-2002, SEC.6.

IC 14-27-7-2

Maintenance and repair

Sec. 2. The owner of a levee, dike, or floodwall and appurtenant works shall maintain and keep the structures and appurtenant works in the state of repair and operating condition required by the following:

(1) The exercise of prudence.

(2) Due regard for life or property.

(3) The application of sound and accepted engineering principles.

As added by P.L.1-1995, SEC.20. Amended by P.L.148-2002, SEC.7.

IC 14-27-7-3

Powers and duties of department

Sec. 3. The department:

(1) has, on behalf of the state, jurisdiction and supervision over the maintenance and repair of levees, dikes, floodwalls, and appurtenant works in, on, or along the rivers and streams of Indiana;

(2) shall exercise care to see that the dikes, floodwalls, levees, and appurtenances are maintained in a good and sufficient state of repair and operating condition to fully perform the intended purpose;

(3) may adopt rules under IC 4-22-2 for maintenance and operation that are necessary for the purposes of this chapter; and

(4) may vary the standards for maintenance and operation, giving due consideration to the following:

(A) The type and location of the dike, floodwall, levee, or appurtenance.

(B) The hazards to which the dike, floodwall, levee, or appurtenance is or may be exposed.

(C) The peril to life or property if the dike, floodwall, levee, or appurtenance fails to perform the structure's function.

As added by P.L.1-1995, SEC.20. Amended by P.L.148-2002, SEC.8.

IC 14-27-7-4

Engineering inspections

Sec. 4. (a) The department shall make an engineering inspection of all levees, dikes, and floodwalls and appurtenant works:

(1) at least one (1) time every three (3) years or at more frequent intervals if the exigencies of the

case require; or

(2) upon the written request of an affected person or agency.

(b) The department shall place in the files of the department a report of each inspection conducted under subsection (a).

(c) This chapter does not apply to the following:

(1) A levee, dike, or floodwall that meets both of the following conditions:

(A) Is under a single private ownership.

(B) Provides protection only to land or other property under the single private ownership.

(2) A dike, floodwall, or levee that is regulated under the federal Mine Safety and Health Act of 1977, unless the dike, floodwall, or levee is proposed to be retained as a permanent structure after bond release.

As added by P.L.1-1995, SEC.20. Amended by P.L.75-1998, SEC.4; P.L.148-2002, SEC.9.

IC 14-27-7-5

Notice of violation

Sec. 5. If the department finds that a dike, floodwall, levee, or appurtenance is:

(1) not sufficiently strong;

(2) not maintained in a good and sufficient state of repair or operating condition; or

(3) unsafe and dangerous to life or property;

the department shall issue a notice of violation to the owner of the dike, floodwall, levee, or appurtenance under IC 14-25.5-2.

As added by P.L.1-1995, SEC.20. Amended by P.L.148-2002, SEC.10; P.L.71-2004, SEC.11.

IC 14-27-7-6

Emergency measures to protect life and property

Sec. 6. (a) If at any time the condition of a levee, a dike, a floodwall, or an appurtenance becomes so dangerous to the safety of life and property that, in the opinion of the department there is not sufficient time for the issuance and enforcement of a notice of violation for the maintenance, alteration, repair, reconstruction, change in construction or location, or removal of the dike, floodwall, levee, or appurtenance in the manner provided in this chapter, the department may immediately take the measures that are essential to provide emergency protection to life and property.

(b) The department may recover the cost of the emergency measures from the owner by appropriate legal action.

As added by P.L.1-1995, SEC.20. Amended by P.L.148-2002, SEC.11.

IC 14-27-7-7

Violations

Sec. 7. An owner who knowingly fails to effect the maintenance, alteration, repair, reconstruction, change in construction or location, or removal within the time limit set forth in the notice of violation of the department under:

(1) section 5 of this chapter; or

(2) IC 13-2-20-4 (before its repeal);

commits a Class B infraction. Every day of failure constitutes a separate infraction.

As added by P.L.1-1995, SEC.20. Amended by P.L.148-2002, SEC.12; P.L.71-2004, SEC.12.

IC 14-27-7-8

Right of entry upon premises

Sec. 8. The department and the department's agents, engineers, and other employees may, for the purposes of determining the department's jurisdiction and performing the engineering inspections provided in section 4 of this chapter, enter upon any land or water in Indiana without liability for

trespass. The owner of a levee, dike, or floodwall and appurtenant works shall do the following:

(1) Cooperate with the department and the department's agents, engineers, and other employees in the conduct of the inspections.

(2) Facilitate access to the dike, floodwall, levee, or appurtenance.

(3) Furnish upon request the plans, specifications, operating and maintenance data, or other information that is pertinent to the dike, floodwall, levee, or appurtenance.

As added by P.L.1-1995, SEC.20. Amended by P.L.148-2002, SEC.13.

IC 14-27-7-9

Exemption of department from liability

Sec. 9. This chapter does not create a liability for damages against the department or the department's officers, agents, and employees caused by or arising out of any of the following:

(1) The construction, maintenance, operation, or failure of a levee, dike, or floodwall and appurtenant works.

(2) The issuance and enforcement of a notice of violation or a rule issued by the department to carry out the department's duties.

As added by P.L.1-1995, SEC.20. Amended by P.L.148-2002, SEC.14.

567—72.3(455B) Dams. The following criteria shall apply to dams which exceed the thresholds in 567—71.3(455B).

72.3(1) *General criteria for all regulated dams.*

a. Required findings. The department will approve the construction, operation or maintenance of a dam or modification of a dam or appurtenant structure only after finding that the project is designed in accordance with accepted engineering practice and methods and in a manner consistent with the applicable criteria and guidelines in department Bulletin No. 16, "Design Criteria and Guidelines for Iowa Dams," December 1990.

b. Anticipation of changed circumstances. In applying the approval criteria in subrule 72.3(1), paragraph *"a,"* consideration shall be given to both existing conditions and potential future conditions which can reasonably be anticipated at the time the application is reviewed.

c. Landowner notification. The department staff engineering review of the plans and specifications for a dam project shall determine whether there are lands upstream, downstream, or adjacent to the impoundment whose use apparently would be potentially adversely affected by maintenance of the dam and appurtenant structures, spillway discharges, temporary ponding of floodwater behind the dam, or failure of the dam. It is the applicant's responsibility to submit sufficient information with the application and on request to enable the staff to accurately identify the owners and occupants of affected lands. The staff shall notify all known affected owners and occupants that the project may affect use of land in which they have an interest and advise them of their opportunity to be heard on the application. The project shall not be approved unless it appears that notice reasonably calculated to advise all owners and occupants has been given and that they have had an opportunity to be heard.

72.3(2) *Dams other than low head dams.* The following criteria shall apply to all dams other than low head dams:

a. Assignment of hazard class. Dams shall be assigned a hazard class based on the potential consequences of failure. Anticipated future land and impoundment use shall be considered in the determination of hazard class. The criteria in this subrule shall be used to determine hazard class regardless of the methodology used in engineering design of a dam. The hazard class shall determine the design requirements of the structure as outlined in department Bulletin No. 16. The hazard class shall be evaluated using the following criteria:

(1) *Low hazard.* A structure shall be classified as low hazard if located in an area where damages from a failure would be limited to loss of the dam, loss of livestock, damages to farm outbuildings, agricultural lands, and lesser used roads, and where loss of human life is considered unlikely.

(2) *Moderate hazard.* A structure shall be classified as moderate hazard if located in an area where failure may damage isolated homes or cabins, industrial or commercial buildings, moderately traveled roads or railroads, interrupt major utility services, but without substantial risk of loss of human life. In addition, structures where the dam and its impoundment are of themselves of public importance, such as dams associated with public water supply systems, industrial water supply or public recreation, or which are an integral feature of a private development complex, shall be considered moderate hazard for design and regulatory purposes unless a higher hazard class is warranted by downstream conditions.

(3) *High hazard.* A structure shall be classified as high hazard if located in an area where failure may create a serious threat of loss of human life or result in serious damage to residential, industrial or commercial areas, important public utilities, public buildings, or major transportation facilities.

(4) *Multiple dams.* Where failure of a dam could contribute to failure of a downstream dam or dams, the minimum hazard class of the dam shall not be less than that of any such downstream structure.

b. Lands, easements, and rights-of-way. An application for approval of a dam project shall include information showing the nature and extent of lands, easements, and rights-of-way which the applicant has acquired or proposes to acquire to satisfy the following criteria:

(1) Ownership or perpetual easements shall be obtained for the area to be occupied by the dam embankment, spillways, and appurtenant structures, and the permanent or maximum normal pool;

(2) Ownership or easements shall be obtained for temporary flooding of areas which would be inundated by the flood pool up to the top of dam elevation and for spillway discharge areas;

(3) Easements covering areas affected by temporary flooding or spillway discharges shall include provisions prohibiting the erection and usage of structures for human habitation or commercial purposes without prior approval by the agency;

(4) In locating the site of a dam and in obtaining easements and rights-of-way, the applicant shall consider the impacts which anticipated changes in land use downstream of a dam or adjacent to the impoundment could have on the hazard class of the dam, the operation of the dam, and the potential liability of the dam owner;

(5) The applicant may be required to acquire control over lands downstream from the dam as necessary to prevent downstream development which would affect the hazard class of the dam.

c. Other approvals required. The applicant shall comply with all applicable provisions of 567—Chapters 51, 52 and 73 concerning water storage permits, operating permits, and inspections.

d. Additional requirements for major dam structures. Dams which are major dam structures as defined in 567—Chapter 70 must satisfy additional criteria set forth in Chapter VI of department Bulletin No. 16.

72.3(3) *Low head dams.* The following criteria shall apply to low head dams:

a. The location and design of a low head dam shall not adversely affect the fisheries or recreational use of the stream.

b. The pool created by a low head dam shall not adversely affect drainage on lands not owned or under easements by the applicant.

c. The structure shall be hydraulically designed to submerge before bankfull stage is reached in the stream channel in order that increased or premature overbank flooding does not occur. Where this cannot be reasonably accomplished in order for the structure to fulfill its intended purpose, the applicant shall demonstrate that any increased flooding will affect only lands owned or controlled by the applicant.

d. For projects which include significant appurtenant structures or works outside the stream channel, the combined effect of the total project shall not create more than 1 foot of backwater during floods which exceed the flow capacity of the channel, unless the proper lands, easements, or rights-of-way are obtained.

e. The structure shall be capable of withstanding the effects of normal and flood flows across its crest and against the abutments, and adjacent channel or bank areas shall be protected against erosion as needed.

72.3(4) *Operating plan.* For any dam with movable structures which must operate or be operated during times of flood or to provide minimum downstream flow, or where the impoundment level is raised or lowered on a regular basis, an operating plan must be submitted for approval. The plan shall be in accordance with department Bulletin No. 16 and rules in 567—Chapter 73.

72.3(5) *Encroachment on a confinement feeding operation structure.* A dam shall not be constructed or modified so that the ordinary high water of the lake, pond or reservoir created by the dam is closer than the following distances from a confinement feeding operation structure unless a secondary containment barrier according to 567—subrule 65.15(17) is in place. Measurement shall be from the closest point of the confinement feeding operation structure to the water edge of the lake, pond or reservoir for a pool level at the elevation of the crest of the emergency spillway or at the top of dam elevation should the dam not have an emergency spillway.

a. Minimum separation between a water source other than a major water source and a confinement feeding operation structure is 500 feet.

b. Minimum separation between a major water source and a confinement feeding operation structure is 1,000 feet or such distance that the structure is not located on land that would be inundated by Q100, whichever is greater.

This rule is intended to implement Iowa Code sections 455B.262, 455B.264, 455B.270, 455B.275 and 455B.277.

E.14. Iowa



IOWA DEPARTMENT OF NATURAL RESOURCES

Technical Bulletin No. 16

DESIGN CRITERIA AND GUIDELINES FOR IOWA DAMS

December, 1990

IOWA DEPARTMENT OF NATURAL RESOURCES

TECHNICAL BULLETIN NUMBER 16

FLOODPLAIN MANAGEMENT PROGRAM
DESIGN CRITERIA AND GUIDELINES FOR IOWA DAMS*

CONTENTS

Chapter	Title	Page
I	Introduction	2
II	Hazard Classification	2
III	Design Floods	3
IV	Hydraulic and Structural Criteria and Guidelines for Spillways	5
V	Embankments	7
VI	Special Requirements for Major Dam Structures	8
VII	Specifications	9
VIII	Dam Breach Wave Analysis	9
IX	Operating Plan	10
X	Lands, Easements, Rights-of-Way	11
XI	Hydrologic and Hydraulic Design References	11

* Adopted by reference 567—72.3(1)”a”, Iowa Administrative Code

CHAPTER I
INTRODUCTION

The purpose of this bulletin is to set forth technical design criteria and guidelines that the Department of Natural Resources will use in reviewing applications to obtain a permit for construction, operation and maintenance or modification of a dam. Other requirements which must be met in order to secure such a permit are outlined in the Iowa Administrative Code under agency number 567. Several chapters of the department's administrative rules in 567 Iowa Administrative Code concern the construction, operation and maintenance of dams as follows:

Chapter 70 contains definitions of terms used in other chapters.

Chapters 50, 51 and 52 concern water permits which must be obtained to authorize storage of water in surface impoundments.

Chapter 71 explains when approval is required in order to construct, modify, operate and maintain dams.

Chapter 72 lists criteria for approval of dam projects.

Chapter 73 concerns operational procedures for dams, fluctuation of water levels in impoundments, abandonment and removal of dams, inspections of dam sites and dams, and designation of unsafe dams. Chapter 73 applies to all dams whose dimensions or effects exceed the regulatory thresholds in Chapter 71.

Copies of the department's administrative rules may be obtained from the Records Center, Department of Natural Resources, Wallace State Office Building, Des Moines, Iowa 50319, upon request.

The above-described rules should be consulted when planning to construct or modify a dam, change the operation or use of a dam, or abandon or remove a dam. This bulletin is part of the above-described rules and is intended for use in conjunction with them. The chapters entitled "Hazard Classifications" and "Lands, Easements, Rights-of-Way" are substantively identical to rules published in the Iowa Administrative Code. These non-technical criteria are repeated in this bulletin for the convenience of the user.

Minimum requirements in this bulletin are labeled as "guidelines" or "criteria" depending on the frequency with which they are likely to be relevant to the safety of a particular type of structure. The distinction between criteria and guidelines is not intended to be rigid. When the applicability of a criterion or guideline to a particular project is not clear to the design engineer, the engineer should consult the department. Any permit issued by the department must explain the reasons for waiving conformity with a criterion or guideline determined to be applicable to the type of structure proposed.

Adoption and Amendment of Bulletin #16. This bulletin has been adopted as part of the department's administrative rules. Pursuant to Section 17A.6(3), Code of Iowa, this bulletin is not published in the Iowa Administrative Code but copies will be made available to the public upon request at no more than the cost of reproduction.

This bulletin may be amended from time to time by rulemaking proceedings. Amended editions of this bulletin will be identified in Chapter 72 of the department's rules by reference to the year and month that the new, superseding edition becomes effective. The user should obtain a copy of current departmental rules as published in the Iowa Administrative Code and compare the edition date on the cover page of this bulletin with the edition date identified in the rules.

CHAPTER II
HAZARD CLASSIFICATION[1]

Dams shall be assigned a hazard class based on the potential consequences of failure. Anticipated future land and impoundment use shall be considered in the determination of hazard class. The criteria in this chapter shall be used to determine hazard class regardless of the methodology used in engineering design of a dam. The hazard class shall determine the design requirements of the structure as outlined in this bulletin. The hazard class shall be evaluated using the following criteria.

A) Low Hazard. Structures located in areas where damages from a failure would be limited to loss of the dam, loss of livestock, damages to farm out-buildings, agricultural lands, and lesser used roads, and where loss of human life is considered unlikely.

B) Moderate Hazard. Structures located in areas where failure may damage isolated homes or cabins, industrial or commercial buildings, moderately traveled roads or railroads, interrupt

[1] This chapter is substantively identical to 567—72.3(2)"a", Iowa Administrative Code.

major utility services, but without substantial risk of loss of human life.

In addition, structures where the dam and its impoundment are of themselves of public importance, such as dams associated with public water supply systems, industrial water supply or public recreation, or which are an integral feature of a private development complex, shall be considered moderate hazard for design and regulatory purposes unless a higher hazard class is warranted by downstream conditions.

C) High Hazard. Structures located in areas where failure may create a serious threat of loss of human life or result in serious damage to residential, industrial or commercial areas, important public utilities, public buildings, or major transportation facilities.

D) Multiple Dams. Where failure of a dam could contribute to failure of a downstream dam or dams, the minimum hazard class of the dam shall not be less than that of any such downstream structure.

CHAPTER III
DESIGN FLOODS

A dam will be required to safely accommodate or pass certain minimum flood events. Routings of the flood hydrograph through the impoundment should begin at an elevation no lower than the normal operating level. The magnitude or frequency of the required flood discharges will vary with the hazard classification, size, and drainage area of the project.

A) Freeboard Design Flood

The specified freeboard design flood represents the greatest flood the dam must be designed to accommodate. The flood must be passed without overtopping of the dam and endangering its safety or the dam must be designed to withstand such overflow. Some erosion damage in earth emergency spillways will be tolerated, provided the safety of the dam would not be compromised.

For dams with emergency spillways, the top of dam elevation after settlement shall not be less than the highest peak pool elevation reached during the freeboard design flood. For dams without an emergency spillway, the top of dam elevation shall be two feet higher than the peak flood elevation expected to occur during passage of the freeboard design flood, unless it is specifically designed to withstand the overflow.

In the following circumstances, the indicated freeboard design flood will be used:

1) All high hazard dams: the probable maximum flood (PMF).

2) All moderate hazard dams, and low hazard dams classified as major structures: one-half (0.5) of the probable maximum flood (a flood hydrograph produced by multiplying the ordinates of the PMF hydrograph by a factor of 0.5).

3) Low hazard dams not classified as major structures:

a. Where the height of the emergency spillway crest* measured above the elevation of the channel bottom at the centerline of the dam (in feet) multiplied by the total storage volume (in acre-feet) to the emergency spillway crest elevation* is between 3,000 and 30,000, the flood shall correspond to the rainfall calculated from the following formula developed by the USDA Soil Conservation Service.

Rainfall = P100 + 0.12 (PMP – P100)

b. Where the height of the emergency spillway crest* measured above

the elevation of the channel bottom at the centerline of the dam (in feet) multiplied by the total storage volume (in acre-feet) to the emergency spillway crest elevation* is less than 3,000, the flood shall be that resulting from the 50-year, 24-hour precipitation.

B) Principal Spillway Design Floods and Discharge Capacity

The principal spillway is normally a concrete or metal conduit or structure which conveys water through or around the dam. Its size and discharge capacity are governed primarily by the following factors: the need to control flood discharges downstream from the dam, and the need to limit both the depth to which floodwaters are impounded and the length of time for which they are impounded. Related to these factors is the need to limit the frequency of operation of emergency spillways.

Except where special considerations must be addressed, the criteria listed below shall apply to the design of principal spillways. The design floods indicated must be passed by the principal spillway without need for operation of an emergency spillway.

1) Design Floods
   a. High hazard dams – the 100-year flood.
   b. Moderate hazard dams – the 50-year flood.
   c. Low hazard dams with drainage areas of 250 acres or more – the 25-year flood.
   d. Low hazard dams with drainage areas less than 250 acres – the 10-year flood.

2) The spillway discharge capacity shall be sufficient to evacuate at least 80% of the volume of water temporarily stored during the principal spillway design flood within 10 days. Where this cannot be accomplished, the emergency spillway and freeboard design flood routings shall be made beginning with the impoundment level at the 10-day drawdown elevation.

3) For dams with emergency spillways of structural concrete or which are excavated into sound rock, a higher frequency of use, and therefore a lower principal spillway design flood, may be permitted if flood control or dam safety would not be adversely affected.

*For dams without emergency spillways, the storage volume and height shall be determined by measuring to the top of dam elevation.

C) Rainfall Depth and Distribution

Precipitation values for various frequency storm events: 10, 25, 50, 100-year and PMP are contained in the Iowa Department of Agriculture and Land Stewardship publication, Climatology of Iowa Series #2, Revised, Iowa Rainfall Frequencies by Paul Waite. Ten-day rainfall amounts are contained in the National Weather Service publication, Technical Paper No. 49.

Some acceptable methods of distributing the rainfall in Iowa are found in the U.S.D.A. Soil Conservation Service publication, TR-60, Earth Dams and Reservoirs; and the Illinois State Water Survey publication, Time Distribution of Rainfall In Heavy Storms by F. A. Huff.

D) Rainfall Losses

Conservative loss rates (interception, infiltration, etc.) and antecedent moisture conditions should be used in computing rainfall excess. Also, when applicable, snowmelt runoff rates should be estimated.

The Soil Conservation Service (SCS) weighted curve number method is acceptable for determining rainfall

losses and is explained in National Engineering Handbook Section 4 Hydrology, SCS, 1972.

E) Storm Duration

Criteria and guidelines for developing design storms from rainfall events are as follows:

1) The critical duration storm or the storm which results in the highest water level in the impoundment, shall be used in determining the freeboard design flood for a high hazard dam.

2) Six hour storms are recommended for determining the freeboard design flood for dams designated in paragraphs A (2) and A (3)"a" of this chapter except where the time of concentration exceeds six hours. The 24-hour storm is recommended for dams designated in paragraph A (3)"b" of this chapter.

3) Twenty-four hour (24-hour) or 10-day storms are recommended for developing principal spillway design floods.

CHAPTER IV
HYDRAULIC AND STRUCTURAL CRITERIA AND GUIDELINES FOR SPILLWAYS

The following criteria and guidelines are design considerations which will be used by the department to insure that spillway structures are capable of functioning safely and efficiently and of resisting the forces to which they may be exposed during the life of the structure.

A) Spillways should be designed to operate safely for the life of the structure and at the discharges and pressures which would be experienced under all normal or flood flow conditions including the freeboard design flood.

B) Anti-seepage collars or other means of piping and seepage control (e.g., drainage diaphragms), anti-vortex devices, trash racks or other inlet debris control measures, and outlet stilling basins should be provided for all conduits unless evidence can be presented establishing they are not necessary.

C) For dams where a conduit is proposed to serve as the principal spillway, suggested minimum sizes of the principal spillway conduit for the indicated type of structure are as follows:

1) High hazard dams and moderate dams classed as major structures – 36-inch inside diameter.

2) Moderate hazard dams not classed as major structures and low hazard dams, which are classed as major structures – 24 inch inside diameter.

3) Low hazard dams not classed as major structures but which have drainage areas of 250 acres or more – 18-inch inside diameter.

4) Low hazard dams with drainage areas under 250 acres – 12-inch inside diameter.

These minimum sizes are applicable to dams with emergency spillways or which are designed for overtopping only. For dams without emergency spillways, substantially larger conduit sizes with special provisions against plugging will normally be required.

D) Drop inlets (risers) should have an inlet cross-sectional area at least 1.5 times that of the conduit and should be constructed of comparable materials.

E) Conduits and risers should be of sufficient strength and have adequate joints to withstand all anticipated

external and internal pressures without damage or leakage, with provisions made for vertical settlement. Conduits should be cambered where significant settlement of the overlying embankment is anticipated. Articulated or bell joints should be provided as necessary to accommodate the maximum elongation estimated to occur during the life of the structure. Risers must be designed to counteract buoyant forces.

F) Corrugated metal pipe conduits and risers should be close riveted with watertight connecting bands and should be fiber bonded, asphalt coated, or given equivalent protection. Cathodic protection shall be provided in corrosive soils. Corrugated metal pipe (CMP) conduits are not recommended for high hazard dams, moderate hazard dams classed as major structures, or where the height of earth fill over the conduit exceeds 25 feet.

G) Concrete conduit and drop inlet (riser) design using precast pipe sections should specify reinforced concrete pressure pipe.

H) Open concrete spillways, concrete box conduits, and concrete flumes or chutes should have longitudinal curbs or raised joints which will prevent contact by normal flows with the construction joint between the floor and wall slabs. Seepage barriers, drainage blankets and drains should be installed where needed to maintain hydraulic flow integrity through the structure and to accommodate anticipated settlement or elongation in the longitudinal or transverse directions.

I) Emergency spillways should be capable of safely conveying excess flood flows around or through the dam. They should not operate except at floods greater than the principal spillway design flood.

J) Earth emergency spillways should be subject to the following minimum requirements at the control section:

1) Minimum bottom width – 10 feet.

2) On major structures, minimum depth – 3 feet. On other structures, minimum depth – 2 feet. (Elevation of top of dam minus elevation of emergency spillway crest.)

3) The profile through the emergency spillway should be horizontal for at least 30 feet through the crest control section.

4) Exit channel slopes should not be less than 1% or greater than 10%, but should provide for maintaining critical depth control at the crest.

K) For dams where substantial erosion in the emergency spillway would pose the risk of a dam failure, the flow velocities during the freeboard design flood should be non-erosive. Where such erosion would pose no substantial risk of failure, the flow velocities should be non-erosive at the discharge which occurs when flow through the control section is at 30% of the maximum depth. On vegetated spillways, the non-erosive velocity should be determined assuming the vegetation is well established.

L) Emergency spillways should be constructed in undisturbed soil wherever possible. Where no viable alternative is available, they may be constructed on fill as a ramp spillway.

M) Smooth transitions in horizontal and vertical alignment should be provided at and between the inlet, the control at the crest and the outlet sections of emergency spillways.

N) All spillways should discharge a safe distance from the toe of the dam, and the inlets and outlets should be so located and aligned as to minimize risk of erosion damage to the dam or of damage to downstream buildings, roads, dams or other structures.

O) An adequate energy dissipation structure (stilling basin) or an alternative acceptable method should be incorporated at the outlet of all structural spillways. On major structures, uplift analysis and arching requirements should be considered.

CHAPTER V
EMBANKMENTS

The earth embankment of a dam should be designed and built according to the following criteria and guidelines.

A) Foreslopes and Backslopes. Embankments should be built of suitable materials and with stable slopes. Foreslopes should not be steeper than 3:1 (horizontal to vertical) in till or loess soils below the permanent water level. Above the permanent water level, foreslopes should not be steeper than 2.5:1 in till soil or 3:1 in loess soil. Backslopes should not be steeper than 2.5:1 in till soils or 3:1 in loess soils. Steeper foreslopes or backslopes may be used if justified by soil tests and stability analysis.

B) Settlement Allowance. A minimum vertical settlement allowance of five percent of the depth of fill should be provided unless a lesser amount is justified by soil tests.

C) Top Width. The minimum embankment top width should be 14 feet for dams 25 feet high or higher. As a rule of thumb, the top width could be reduced by two feet for every five feet of reduction in the height of the dam to a minimum width of eight feet. The top width of dams with roads across the crest should be consistent with normal roadway design practices, including roadway and shoulders.

D) Core Trench. Core trenches should be located approximately along the centerline (axis) of the earth fill. It should be continuous across the base of the fill extending into and up the side slopes of the dam abutments to normal reservoir level. The core trench should be excavated to a minimum depth of five feet or until a suitable base material is reached. The base width should be that which will accommodate excavating equipment, but not less than eight feet. The side slopes of the core trench should not be steeper than 1:1, regardless of depth or width of base. Impervious material shall be used in backfilling the core trench.

E) Wave Erosion Protection. On the upstream face of the dam, a horizontal bench or berm at least 10 feet wide usually should be provided at the normal pool elevation to limit damage from wave erosion. On larger impoundments, riprap or other physical means of protection should be considered whether or not the berm is provided.

F) Site Preparation. All vegetation, sod, stumps, and large roots should be removed from the embankment site, and the ground surface scarified to provide bond with the earth fill. Overhanging banks, pits, or holes should be sloped and graded so slopes do not exceed 1:1, and any other sharp discontinuities in the ground surface shall be smoothed. Special consideration should be given to the removal of sandy or mucky deposits unless otherwise provided for in the design.

In till soils, topsoil should be saved and placed as a surface layer over the finished embankment to provide an adequate seed base in establishing vegetation.

G) Fill. Fill material should be clean earth containing no appreciable amounts of vegetation, large rock, frozen material or other foreign substances. Fill should not be placed on a frozen foundation or in freezing weather.

Moisture content of the fill should be sufficient to assure adequate compaction. A moisture content slightly higher than optimum is recommended. An above optimum moisture content is desirable from the standpoint of providing a more plastic embankment capable of resisting greater differential settlement without experiencing

potentially hazardous cracking. Unless otherwise specified after soil testing, fill should be placed in horizontal lifts not exceeding eight inches extending over the entire fill area and compacted by not less than four overlapping passes by sheepsfoot or rubber tired rollers. Smooth steel rollers or passes by caterpillar tracks are not considered adequate for compaction of earth-fill dams. The surface of the fill should be scarified or roughened if sufficient time elapses between lifts for a crust to develop.

Backfill adjacent to spillway structures and anti-seep collars should be carefully placed and compacted by hand equipment. Heavy equipment shall not pass over conduit structures until two feet of compacted earth cover is in place.

H) Drains. Internal seepage control drains are recommended for all dams and are normally required on major structures unless soils investigation finds they are not needed. Drains should be capable of preventing saturation of the downstream portion of the embankment by intercepting any seepage through the fill or the foundation and any seepage along structural spillways or conduits.

If springs are encountered during site preparation, drains should be provided to allow a controlled outlet.

I) Seeding. As soon as possible after earth fill for the embankment is completed, the embankment and any other exposed areas should be seeded. Mulch or other means of erosion control can be placed as part of seeding and maintained until vegetation is established. Grass or vegetative species selected for use should be appropriate for the soils and conditions expected at the site. Crown vetch is generally not acceptable for dam embankments or emergency spillways.

J) Riprap. Riprap shall be designed for its expected use and anticipated water velocities. All riprap should be placed on a properly designed bedding unless the gradation of the underlying base material is such that it will not infiltrate through the riprap, or an acceptable filter fabric is used.

K) Groins. Where the embankment foreslopes and backslopes intersect the natural or modified abutment slopes, appropriate groin design and erosion control recommendations should be provided.

Embankments composed of concrete, rock, or other materials, as associated with gravity, rockfill and arch dams, designed in accordance with standards by the U.S. Army Corps of Engineers, U.S.D.A. Soil Conservation Service, or the U.S. Bureau of Reclamation are generally acceptable. These types of dams are not normally constructed in Iowa.

CHAPTER VI
SPECIAL REQUIREMENTS FOR MAJOR DAM STRUCTURES

Because of the size, public importance, or potential hazard of a major dam structure, a higher level of investigation, design and assurance of proper construction is needed. A major dam structure is defined as a dam meeting any of the following criteria.

1. Any high hazard dam.

2. Any moderate hazard dam with a permanent storage exceeding one hundred (100) acre-feet or a total of permanent and temporary storage exceeding two hundred fifty (250) acre-feet at the top of the dam elevation.

3. Any dam, including low hazard dams, where the height of the emergency spillway crest measured above the elevation of the channel bottom at the centerline of the dam (in feet) multiplied by the total storage volume (in acre-feet) to the emergency spillway crest elevation exceeds 30,000. For dams without emergency spillways, these measurements shall be taken to the top of dam elevation.

As a condition of permit approval, the following items will be required for major dam structures.

A) A soils and foundation investigation shall be made which includes the evaluation of slope stability requirements, anticipated vertical

settlement and horizontal elongation, seepage and under-seepage potential, whether cathodic protection is needed for metal pipes, and proper construction practices for the soil types and conditions encountered. Stability evaluation shall include end of construction, steady state seepage and sudden drawdown conditions.

B) Anticipated sedimentation rates and their impact on the life and usefulness of the impoundment shall be investigated. Sediment storage shall be provided in the volume necessary for continuation of design uses of the impoundment throughout its design life.

C) A gated low level outlet shall be provided which is capable of draining at least 50 percent of the permanent storage behind the dam within a reasonable length of time. The pipe conduits shall be designed so that negative pressures will not occur at any point along the system.

D) In order to assess the degree of threat to life and property located downstream of the dam, a dam breach analysis may be required. The analysis will be made to determine the most adverse failure condition and the resulting peak outflows and water surface elevations downstream of the dam following failure of the dam during the freeboard design storm.

E) Construction shall be inspected by an engineer registered under Chapter 114 of the Code of Iowa or by a trained inspector under the supervision of the engineer. The engineer shall prepare and certify as-built plans after completion and a report detailing any unusual circumstances encountered during construction and submit them to the Department of Natural Resources, ATTN: Flood Plains.

F) The applicant, as a condition of the permit, shall submit an annual maintenance and inspection report. The report shall describe maintenance work done since the previous annual report, describe any deficiencies observed in the dam or appurtenant structures, detail the remedial measures necessary and the method and time the applicant proposes to correct the deficiencies found. If there is a change in the land use downstream of the dam, this change should be noted on the annual maintenance and inspection report. The applicant may also be required to provide additional inspections and reports by an engineer or other qualified personnel.

CHAPTER VII
SPECIFICATIONS

When detailed project specifications are prepared, they should include the following information.

A) The general provisions which specify the rights, duties, and responsibilities of the owner, applicant, applicant's engineer, and builder or contractor, and the prescribed order of the work.

B) The technical provisions which describe approved work methods, equipment, materials and desired end results.

C) Special provisions as may be required which describe those technical details that are not usually contained in standard technical provisions.

CHAPTER VIII
DAM BREACH ANALYSIS

A) In some cases, it will be necessary to evaluate the consequences of a dam failure to verify hazard classification or adequacy of design. A special case of dam breach analysis will involve failure or improper operation of flood control gates or other structures.

B) Where such evaluations are made by the department's staff, the necessary data will be obtained from topographic maps or other available information. If that information is not adequate, the applicant may be required to obtain additional downstream survey data.

C) Prediction of the downstream consequences of a hypothetical dam breach requires several component steps: development of the impoundment inflow hydrograph; routing the hydrograph through the impoundment; selecting failure conditions for the structure; calculating the outflow hydrograph from the failed structure; and modeling movement of the flood wave downstream to determine travel time, inundated areas, maximum water surface elevations, etc.

D) The criteria, methodology, and computer programs developed by the U.S. Corps of Engineers, the National Weather Service, the U.S.D.A. Soil Conservation Service, and the U.S. Geological Survey for simulating a hypothetical dam failure are, in general, acceptable.

CHAPTER IX
OPERATING PLAN

For any dam with gates or other moveable structures which must operate or be operated during times of flood or to provide a minimum downstream release rate, a written operating plan shall be prepared. Development of such a plan is considered part of the design process. The following shall be addressed in preparation of the operating plan.

A) Responsibility

No operating plan can be expected to work properly unless it can be assured the necessary personnel will be present to operate the equipment, or, in the case of automatic equipment, to monitor it and insure it is functioning properly.

The plan shall identify who is responsible for operating and monitoring the equipment and provide means to assure the necessary personnel are present when needed.

B) Operating Circumstances

The circumstances under which operation must occur shall be clearly defined, and a means provided to insure that operating personnel are present when necessary.

C) Method of Operation

The means and methods by which operation is to be conducted shall be clearly defined. Included shall be such items as rates and sequences for opening or closure of gates, pool level vs. gate setting tables, etc., as required.

The operating plan shall allow for safe passage of all floods up to and including the freeboard design flood. Flood discharges through the dam greater than the design peak flood inflows into the impoundment shall not be permitted. In design and analysis, due consideration shall be given to the potential impacts of the operating procedure on both downstream and poolside lands.

The plan should also address low flow situations and should specify a minimum release rate and how it will be provided and maintained.

Consideration shall also be given to and allowance made for the possible failure of or malfunctioning of the equipment.

D) Discharge Measurement

A means shall be provided to determine the discharge through the control structures, especially where operation is to maintain a minimum downstream flow. Control setting vs. discharge tables, streamflow gages or other means of obtaining discharge readings shall be provided. The settings of control structures shall be easily read.

CHAPTER X
LANDS, EASEMENTS, RIGHTS-OF-WAY*

The determination of lands, easements, and rights-of-way required for the construction, operation and maintenance of a dam project are considered part of the design process. An application for approval of a dam project shall include information showing the nature and extent of lands, easements, and rights-of-way, which the applicant has acquired or proposes to acquire for the project. Acquisition of lands, easements or rights-of-way for construction, operation, and maintenance of a dam project shall be consistent with the following criteria.

A) Ownership or perpetual easements shall be obtained for the area to be occupied by the dam embankment, spillways and appurtenant structures, and the permanent or maximum normal pool.

B) Ownership or easements shall be obtained for temporary flooding of areas which would be inundated by the flood pool up to the top of dam elevation and for spillway discharge areas.

C) Easements covering areas affected by temporary flooding or spillway discharges shall include provisions prohibiting the erection and usage of structures for human habitation or commercial purposes without prior approval by the Department of Natural Resources.

D) In locating the site of a dam and in obtaining easements and rights-of-way, consideration should be given to the impacts which changes in land use downstream of a dam and adjacent to the impoundment could have on the hazard class of the dam, the operation of the dam, and the potential liability of the dam owner.

E) The applicant may be required to acquire control over lands downstream from the dam as necessary to prevent downstream development which would affect the hazard class of the dam.

*This chapter is substantively identical to 567—72.3(2)”b”, Iowa Administrative Code.

CHAPTER XI
HYDROLOGIC AND HYDRAULIC DESIGN REFERENCES

General

Handbook of Applied Hydrology by Ven Te Chow, McGraw-Hill Book Company, 1964.

Handbook of Applied Hydraulics by David and Sorensen, McGraw-Hill Book Company, 1969.

Handbook of Hydraulics by King and Brater, McGraw-Hill Book Company, 1963.

Water Resources Engineering by Linsley and Franzini, McGraw-Hill Book Company, 1963.

U.S. Department of Interior, Bureau of Reclamation

Design of Arch Dams, 1977.

Design of Gravity Dams, 1976.

Design of Small Canal Structures, 1974; Revised Reprint, 1978.

Design of Small Dams, 2nd Edition, 1973; Revised Reprint, 1977.

Discharge Coefficients for Irregular Overfall Spillways, Engineering Monograph No. 9, 1952.

Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering Monograph No. 25, 1978.

Unitgraph Procedures, 1965.

Interim Guidelines for Preparing Inundation Maps for Areas Downstream of Bureau of Reclamation Dams.

Corps of Engineers

Engineering Manuals (EM):

EM 1110-2-1411 Standard Project Flood Determinations.

EM 1110-2-1602 Hydraulic Design of Reservoir Outlet Structures.

EM 1110-2-1603 Hydraulic Design of Spillways.

EM 1110-2-1908 Instrumentation of Earth and Rockfill Dams.

EM 1110-2-2200 Gravity Dam Design.

EM 1110-2-2300 Earth and Rockfill Dams General Design and Construction Considerations.

EM 1110-2-50 Low Level Discharge Facilities for Drawdown of Impoundments.

EM 1110-2-1450 Hydrologic Frequency Estimates.

ETL 1110-2-221 Wave Runup and Wind Setup on Reservoir Embankments.

Mining Enforcement and Safety Administration

Engineering and Design Manual, Coal Refuse Disposal Facilities, 1975.

Soil Conservation Service

National Engineering Handbook:

Section 4 – Hydrology

Section 5 – Hydraulics

Section 11 – Drop Spillways

TR-39 Hydraulics of Broad-Crested Spillway

TR-48 Computer Program for Project Formulation-Structure Site Analysis "DAMS-2"

TR-49 Criteria for the Hydraulic Design of Impact Basins

TR-52 A Guide for Design and Layout of Earth Emergency Spillways

TR-55 Urban Hydrology for Small Watersheds

TR-59 Hydraulic Design of Riprap Gradient Control Structures

TR-60 Earth Dams and Reservoirs

TR-61 Computer Program for Water Surface Profiles

TR-66 Simplified Dam Breach Routing Procedure

DN-8 Entrance Head Losses in Drop-Inlet Spillways

SMN-1 Tentative Guides for Determining the Gradation of Filter Materials

National Weather Service

Technical Paper No. 40 – Rainfall Frequency Atlas of the United States (for Duration from 30 minutes to 24 hours and Return Periods from 1 to 100 years), 1961.

Technical Paper No. 49 – Two to Ten Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States, 1964.

Hydrometeorological Report No. 51 – Probable Maximum Precipitation Estimates, United States East of the 105th Meridian, June 1978.

DAMBRK: NWS Dam-Break Flood Forecasting Model, November 1979.

Illinois State Water Supply

Precipitation Relations for Use in Dam Safety Project by Floyd Huff, 1980.

Time Distribution of Rainfall in Heavy Storms by Floyd Huff, 1967.

Iowa Department of Agriculture and Land Stewardship

Climatology of Iowa Series #2, Revised, Iowa Rainfall Frequencies by Paul Waite, 1988.

Climatology of Iowa Series No. 3 – Iowa's Greatest 24-Hour Precipitation and Related Storm Data by Paul Waite and Paul Jaeger, 1981.

United States Geological Survey

Bulletin No. 7 – Drainage Areas of Iowa Streams by O.J. Larimer, Reprinted, March 1974.

Bulletin No. 12 – Floods in Iowa, A Comparative Study of Regional Flood Frequency Methods by Oscar G. Lara, 1974.

Water Resources Investigation Report 87-4132 – Method for Estimating The Magnitude and Frequency of Floods at Ungaged Sites on Unregulated Rural Stream In Iowa, by Oscar G. Lara, 1987.

Federal Highway Administration

Hydraulic Engineering Circulars:

HEC No. 10 – Capacity Charts for the Hydraulic Design of Highway Culverts, November 1972.

HEC No. 11 – Use of Riprap for Bank Protection, June 1967.

HEC No. 13 – Hydraulic Design of Improved Inlets for Culverts, August 1972.

HEC No. 14 – Hydraulic Design of Energy Dissipator for Culverts and Channels, December 1975.

HEC No. 15 – Design of Stable Channels with Flexible Linings, October 1975

Hydraulic Design Series No. 1 – Hydraulics of Bridge Waterways, 2nd Edition, 1970.

Hydraulic Design Series No. 3 – Design Charts for Open Channel Flow, 1973.

Hydraulic Design Series No. 4 – Design of Roadside Drainage Channels, 1965.

Hydraulic Design Series No. 5 – Design of Highway Culverts, September 1985.

Agricultural Research Service

The SAF Stilling Basin, 1959.
Hydraulics of Closed Conduit Spillways, Parts I – XVII.

567—71.3(455B) Dams. Approval by the department for construction, operation, or maintenance of a dam in the floodway or flood plain of any water source shall be required when the dimensions and effects of such dam exceed the thresholds established by this rule. EXCEPTION: Public road embankments with culverts which impound water only in temporary storage are exempt from the requirements of this rule and shall be reviewed under rules 567—71.1(455B) and 567—72.1(455B). Approval required by this rule shall be coordinated with approval for storage of water required by 567—Chapter 51. Approval by the department shall be required in the following instances:

71.3(1) *Rural areas.* In rural areas:

a. Any dam designed to provide a sum of permanent and temporary storage exceeding 50 acre-feet at the top of dam elevation, or 25 acre-feet if the dam does not have an emergency spillway, and which has a height of 5 feet or more.

b. Any dam designed to provide permanent storage in excess of 18 acre-feet and which has a height of 5 feet or more.

c. Any dam across a stream draining more than 10 square miles.

d. Any dam located within 1 mile of an incorporated municipality, if the dam has a height of 10 feet or more, stores 10 acre-feet or more at the top of dam elevation, and is situated such that the discharge from the dam will flow through the incorporated area.

71.3(2) *Urban areas.* Any dam which exceeds the thresholds in 71.3(1)*"a," "b"* or *"d."*

71.3(3) *Low head dams.* Any low head dam on a stream draining 2 or more square miles in an urban area, or 10 or more square miles in a rural area.

71.3(4) *Modifications to existing dams.* Modification or alteration of any dam or appurtenant structure beyond the scope of ordinary maintenance or repair, or any change in operating procedures, if the dimensions or effects of the dam exceed the applicable thresholds in this rule. Changes in the spillway height or dimensions of the dam or spillway are examples of modifications for which approval is required.

71.3(5) *Mill dams.* Rescinded IAB 2/20/91, effective 3/27/91.

71.3(6) *Maintenance of preexisting dams.* Approval shall be required to maintain a preexisting dam as described in 567—Chapter 73 only if the department determines that the dam poses a significant threat to the well-being of the public or environment and should therefore be removed or repaired and safely maintained. Preexisting dams are subject to the water, air and waste management dam safety inspection program as set forth in 567—Chapter 73.

This rule is intended to implement Iowa Code sections 455B.262, 455B.264, 455B.267, 455B.275 and 455B.277.

E.15. Kansas



Agency 5
Kansas Department of Agriculture—Division of Water Resources

Articles

5-24. Northwest Kansas Groundwater Management District No. 4.
5-40. Design of Earth Dams.
5-42. Design of Stream Obstructions.
5-44. Floodplain Management.

Article 24.—NORTHWEST KANSAS GROUNDWATER MANAGEMENT DISTRICT NO. 4

5-24-10. Exemptions for up to 15 acre-feet of groundwater. (a) In any area of the district that is subject to safe yield criteria and is not closed by specific regulation or intensive groundwater use control area order by the chief engineer to new nondomestic, nontemporary permits and term permits for five or fewer years, each application to appropriate groundwater shall be exempt from meeting the safe yield criteria if all the following conditions are met:

(1) The maximum annual quantity of water proposed in the application is 15 acre-feet or less.

(2) The well spacing criteria of K.A.R. 5-24-3 have been met.

(3) An existing water right from the same source of water supply that has a point of diversion located within two miles of the proposed point of diversion has its authorized annual quantity reduced as described in subsection (b).

(4) All issues relating to the possible abandonment of the offsetting water right are resolved by the chief engineer before determining the annual quantity of offset water that is available from the existing water right.

(5) The approval of the application does not authorize an additional quantity of water out of an existing authorized well with a nondomestic permit or water right that would result in a total combined annual quantity of water authorized from that well in excess of 15 acre-feet.

(6) The approval of the application does not authorize an additional quantity of water to be used on a currently authorized nondomestic place of use.

(b) If the water right to be used as the offset for the new appropriation is a water right authorized for irrigation use, the authorized quantity of water needed to offset the new appropriation of not more than 15 acre-feet of water shall be calculated as follows:

(1) Step one.

(A) Multiply the net irrigation requirement for the 50 percent chance rainfall for the county of origin, as specified in K.A.R. 5-5-12, times the maximum number of acres legally irrigated in any one calendar year during the perfection period. For vested rights, the acreage used shall be the maximum acreage legally irrigated in any one calendar year before June 28, 1945.

(B) The calculation made in paragraph (b)(1)(A) shall result in the maximum annual quantity of water that could be changed to another type of beneficial use if the entire water right were changed pursuant to K.A.R. 5-5-9(a)(1).

(2) Step two.

(A) Divide the annual quantity of water desired to be changed to the new beneficial use by the maximum annual quantity of water that could be changed if the entire water right were changed to the new use.

(B) The calculation made in paragraph (b)(2)(A) shall result in the percentage of the entire reduced water right that will be changed to the new use. The remaining percentage of the current water right may be retained by the irrigation water right owner.

(3) Step three.

(A) Multiply the remaining percentage calculated in paragraph (b)(2)(B) times the total currently authorized quantity. The resulting product

shall be the annual quantity of water that can be retained by the irrigation water right owner.

(B) The portion of the authorized annual quantity of water not retained by the irrigator as described in paragraph (b)(3)(A) shall be permanently reduced from the authorized annual quantity of the offsetting water right and used to offset the new appropriation.

(c) If the water right to be used as the offset for the new appropriation is an existing water right authorized for nonirrigation use, the total net consumptive use of the offsetting water right after the change and the new appropriation shall not exceed the net consumptive use of the offsetting water right before the change.

(d) The place of use authorized by the offsetting water right shall be reduced in proportion to the reduction in the maximum annual quantity of water as determined in paragraph (b)(1)(B). If the owner of the irrigation water right desires to retain more authorized acres, the directions specified in K.A.R. 5-5-11(b)(2)(B)(ii) shall be followed to determine whether the irrigator may retain more acres in the authorized place of use.

(e) After the use of not more than 15 acre-feet has been approved pursuant to this regulation, no application for change for that water right shall be approved for any quantity of water that would authorize the water to be diverted from a currently authorized point of diversion or to be used on a currently authorized place of use. (Authorized by K.S.A. 82a-706a and K.S.A. 2005 Supp. 82a-1028; implementing K.S.A. 2005 Supp. 82a-1028; effective Jan. 10, 2003; amended Dec. 8, 2006.)

Article 40.—DESIGN OF EARTH DAMS

5-40-1. Definitions. As used in K.S.A. 82a-301 through 82a-305a and amendments thereto, in the regulations adopted pursuant to these statutes, and by the chief engineer in administering K.S.A. 82a-301 through 82a-305a and amendments thereto, the following terms shall have the meanings ascribed to them in this regulation, unless the context clearly requires otherwise:

(a) "Application" means the formal document and any required supporting information that are submitted to the chief engineer and request a permit, pursuant to K.S.A. 82a-301 through 82a-305a, and amendments thereto.

(b) "Appurtenant works" means the primary spillway and other conduits through a dam, the valves, the auxiliary spillway, the service spillway, the stilling basin, any constructed outlet channel, all dikes and berms designed and constructed to protect the dam, the drains, and all other features constructed to protect or operate a dam.

(c) "As-built drawings" means the drawings showing a permitted project and all appurtenant works as the project and works were actually built. This term shall include the following:

(1) All deviations from the plans that were approved by the chief engineer;

(2) the location and design of any instruments and monitoring equipment that were installed at the site;

(3) the location and elevation of any benchmarks; and

(4) a certification that the permitted project was constructed as shown on the as-built drawings.

(d) "Authorized representative" means any employee of the chief engineer designated by the chief engineer to perform duties and functions on behalf of the chief engineer.

(e) "Auxiliary spillway" means an open channel that is constructed over or around an embankment for the purpose of conveying safely past the dam the flows that are greater than the primary spillway design discharge and that can be stored in the detention storage. This term is also known as an emergency spillway.

(f) "Benchmark" means a reference point or object of known elevation and location that is not expected to move horizontally or vertically during the life of the project.

(g) "Borrow area" means land, usually located near the dam, from which earth used to construct the embankment will be excavated.

(h) "Breach analysis" means an engineering analysis to determine the areas that would be inundated if a dam failed.

(i) "Channel change" means any project that alters the course, current, or cross section of any stream.

(j) "Chief engineer" means the chief engineer, division of water resources of the Kansas department of agriculture.

(k) "Control section" means the immediate downstream end of the level section of an open-channel earthen spillway. The elevation of the control section is the elevation of the open-channel spillway crest.

(l) "Cutoff collar" means a projecting flange built or installed completely around the outside of a pipe to lengthen the path of seepage along the outer surface of the pipe.

(m) "Cutoff trench" means an excavation under a dam to be later filled with impervious material to prevent or reduce the seepage of water through the foundation of a dam.

(n) "Design discharge" means the maximum rate of flow, expressed in cubic feet per second, released from a dam's spillways for the design storm.

(o) "Design storm" means the precipitation event specified in K.A.R. 5-40-22 that is the minimum precipitation event required to be used to design a particular dam.

(p) "Detention storage" means the volume in the reservoir between the lowest uncontrolled spillway, not including any low-flow augmentation works, and the crest of the auxiliary spillway.

(q) "Detention storm" means the storm described in K.A.R. 5-40-23.

(r) "Easily erodible soils" means soils with a high content of fine sand or silt and with little or no cohesion or plasticity, including fine sand, silt, sandy loam, and silty loam.

(s) "Effective height" means the difference in elevation between the crest of an auxiliary spillway or service spillway and the lowest point of the downstream toe of a dam. If the dam does not have an auxiliary or service spillway, the effective height means the difference in elevation between the top of the dam and the lowest point of the downstream toe of the dam.

(t) "Effective storage" means the volume of storage space in a reservoir below the crest of the auxiliary spillway or service spillway and above the elevation of the downstream toe of the dam at its lowest point. Effective storage shall not be reduced by accounting for accumulated sediment.

(u) "Embankment" means the earthen-fill portion of the dam.

(v) "Emergency action plan" means a formal document that identifies potential emergency conditions at a dam and specifies preplanned actions to be followed to minimize property damage and loss of life if the dam fails.

(w) "Erosion-resistant soils" means cohesive soils with a high clay content and high plasticity, including silty clay, sandy clay, and clay.

(x) "Freeboard" means the vertical distance between the maximum water surface elevation attained during the design storm and the top of the dam.

(y) "General plan" means a plan adopted by a watershed district, drainage district, or similar entity required by statute to be approved by the chief engineer, including any of the plans formulated under K.S.A. 24-901 and K.S.A. 24-1213, and amendments thereto.

(z) "Hazard" means the property or people that could be damaged or endangered by the failure of a dam, including people or property that might be inundated. This term shall include a public or industrial water supply stored in the reservoir created by the dam that would be released if the dam failed.

(aa) "High-impact dams" means all of the following classes of dams:

(1) Size class 4, hazard class A dams;

(2) size classes 3 and 4, hazard class B dams; and

(3) all hazard class C dams, using the definitions of hazard class and size class in K.A.R. 5-40-20 and K.A.R. 5-40-21.

(bb) "Hydraulically most distant point in the watershed" means the point in a watershed from which a raindrop falling at that point takes the longest time to reach the dam.

(cc) "Impervious material" means material that allows a relatively low rate of water movement through its cross section.

(dd) "Inspection year" means the period on and after May 1 of one year through April 30 of the following year. The inspection year shall be named for the calendar year in which the inspection year ends.

(ee) "Inundation area" means the area below a dam that will be inundated with water as determined by conducting a breach analysis meeting the requirements specified in K.A.R. 5-40-24.

(ff) "Invert" means the lowest point on the inside of the outlet of a conduit.

(gg) "Low-flow augmentation works" means any uncontrolled conduit, orifice, or other appurtenant works that slowly release water from storage in a reservoir, or bypass low flow through a reservoir.

(hh) "Low-impact dams" means all of the following classes of dams:

(1) Size classes 1, 2, and 3, hazard class A dams; and

(2) size classes 1 and 2, hazard class B dams, using the definitions of hazard class and size class in K.A.R. 5-40-20 and K.A.R. 5-40-21.

(ii) "Maintenance" means the actions or upkeep performed on a dam or its appurtenances to compensate for wear and tear on the dam and appurtenances and to preserve the dam and appurtenances so that the dam and appurtenances

function properly until they are removed, including woody vegetation control; grass seeding; burrowing animal control; repair of minor erosion, cracks, animal burrows, and minor settling; care of pipes, piezometers, drains, valves, gates, and other mechanical devices; replenishment of riprap; and removal of debris from spillways.

(jj) "Modification" means any change in a dam or its appurtenances that involves a change to or significant disturbance of the embankment, an alteration of the flow characteristics of a spillway, a change in the storage capacity or freeboard, or any other significant alteration in the functioning of the dam.

(kk) "Navigable stream" means any of the following:

(1) The Arkansas river;

(2) the Missouri river; or

(3) the Kansas river.

(ll) "One percent-chance storm" means a rainfall event that has a one percent chance of being equaled or exceeded one or more times in a year.

(mm) "Owner of a dam" means the owner or owners of the land upon which a dam and appurtenant works are constructed unless an easement authorizes another person or entity to construct and maintain a dam on that easement. With such an easement, the holder of the easement shall be considered to be the owner of the dam.

(nn) "Perennial stream" means a stream, or part of a stream, that flows continuously during all of the calendar year, except during an extreme drought.

(oo) "Permanent pool" means the storage space in a reservoir below the elevation of the lowest uncontrolled spillway, not including any low-flow augmentation works. This term is also known as the "normal pool."

(pp) "Permit" means the consent or other formal document issued by the chief engineer that authorizes the construction, repair, or modification of a dam, channel change, or stream obstruction, and its operation and maintenance.

(qq) "PMP" means the probable maximum precipitation that can occur in a precipitation event as prescribed by K.A.R. 5-40-31.

(rr) "Prejurisdictional dam" means any of the following:

(1) A dam constructed before May 28, 1929;

(2) a dam constructed by an agency or political subdivision of state government, other than a county, city, town, or township, before April 11, 1978; or

(3) a dam constructed before July 1, 2002 that is 25 or more feet in height and impounds less than 30 acre-feet of water at the top of the dam.

(ss) "Primary spillway" means the uncontrolled outlet device through a dam that provides the initial outlet for storm flows, usually consisting of either of the following:

(1) A riser structure in combination with an outlet conduit; or

(2) a canopy or hooded inlet structure in combination with an outlet conduit.

This term is also known as a "principal spillway."

(tt) "Rainfall excess" means that part of the rain in a given storm that falls at intensities exceeding the infiltration capacity of the land and that is the volume of the rain available for direct runoff.

(uu) "Reservoir" means the area upstream from a dam that contains, or can contain, impounded water.

(vv) "Repair" means any action, other than maintenance, taken to restore a dam and its appurtenant works to their original permitted condition.

(ww) "Service spillway" means an open-channel spillway constructed over or around a dam embankment to convey safely past the dam all flows entering the reservoir that cannot be stored in the reservoir behind a dam that does not have a primary spillway.

(xx) "Size factor" means the effective height of the dam, expressed in feet, multiplied by the effective storage of the reservoir, expressed in acre-feet.

(yy) "Stilling basin" means an open structure or excavation at the outlet of a spillway that dissipates the energy of fast-moving water being discharged from the spillway to protect the streambed below a dam from erosion.

(zz) "Stream" means any watercourse that has a well-defined bed and well-defined banks and that has a watershed above the point marking the site of the project that exceeds the following number of acres in the zones specified:

(1) Zone three: 640 acres for all geographic points within any county west of a line formed by the adjoining eastern boundaries of Phillips, Rooks, Ellis, Rush, Pawnee, Edwards, Kiowa, and Comanche counties;

(2) zone two: 320 acres for all geographic points within any county located east of zone three and west of a line formed by the adjoining eastern boundaries of Republic, Cloud, Ottawa, Saline,

McPherson, Reno, Kingman, and Harper counties; and

(3) zone one: 240 acres for all geographic points within any county located east of zone two.

The flow of a stream is not necessarily continuous and can occur only briefly after a rain in the watershed. If the site of the project has been altered so that a determination of whether the well-defined bed and banks did exist is not possible, it shall be presumed that the bed and banks did exist if the watershed acreage criteria specified in this subsection have been met, unless the owner of the project conclusively demonstrates that the well-defined bed and banks did not exist when the project site was in its natural state and had not been altered by human activity.

(aaa) "Stream obstruction" means any project or structure that is wholly or partially placed or constructed in a stream and that does not meet the definition of a dam in K.S.A. 82a-301 and amendments thereto.

(bbb) "Time of concentration" means the time required for runoff to flow from the hydraulically most distant point in the watershed to the watershed outlet once the soil has become saturated and minor depressions have been filled.

(ccc) "Trash rack" means a protective device installed on the inlet of a primary spillway to prevent trash and other debris from obstructing the primary spillway without obstructing the flow of water.

(ddd) "Watershed" means all of the area draining toward a selected point on a stream.

(eee) "Wing dike" means an earthen or rock structure below the toe of a dam that is constructed to protect the embankment from erosion.

(fff) "Zone," in an earthen dam, means a segment of earthen fill containing similar materials.

(ggg) "Zoned fill" means an embankment divided into two or more zones to make the best use of available materials. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 1, 1983; amended May 1, 1987; amended, T-5-12-30-91, Dec. 30, 1991; amended Feb. 17, 1992; amended Sept. 22, 2000; amended May 18, 2007.)

5-40-2. Dams; plans and specifications. The plans required by K.S.A. 82a-302, and amendments thereto, to construct, repair, or modify a dam shall include sufficient views to show all features in three dimensions and in sufficient detail to instruct a competent contractor to construct, repair, or modify the dam by viewing the plans and specifications. All plans with multiple pages shall include an index describing the location of required views within the plans. The views and maps specified in this regulation shall be shown. Specific details shall be listed under the view that is typically most appropriate, but they may be displayed on another view to improve the legibility of the plans if sufficient detail is provided in the plans to describe each feature in three dimensions. The required plans shall include the following:

(a) Plan views of the dam and dam site, which shall include both abutments of the dam, the area downstream to the point where the auxiliary spillway or service spillway flows enter the receiving channel, and the area upstream of the upstream toe of the dam to where the borrow area will be permitted. All elevations shown on plans shall be referenced to the same datum as the benchmarks described on the plans. The following details shall be shown, if applicable:

(1) The location of the axis of the dam, showing stationing and top width limits;

(2) the toe of the upstream and downstream slopes;

(3) the location of the centerline and the limits of each open-channel spillway;

(4) the location of the primary spillway and any stilling basin;

(5) the location of each berm;

(6) the location of slope protection;

(7) the location of borings, test holes, and test pits;

(8) the location of intakes, outlets, valves, and valve wells;

(9) the location, description, and elevation of each benchmark;

(10) the location, description, and details of all foundation drains;

(11) the location and limits of each borrow area; and

(12) the location and topography of the area where the auxiliary spillway discharge returns to the receiving stream;

(b) a map of the drainage pattern above and below the dam site drawn to an appropriate scale. The map shall show the following:

(1) The location of the watercourse across which the dam is to be built and the point where the centerline of the dam crosses the centerline of the stream specified in latitude and longitude,

or in feet north and west of the southeast corner of the section;

(2) the location of the dam and the outline of the reservoir;

(3) the boundary of the watershed, shown by a line enclosing the entire area that will drain into the reservoir;

(4) section lines, with sections properly identified; and

(5) the size of the drainage area in acres or square miles;

(c) a topographic map of the dam site and reservoir area, which shall be shown to a scale that provides sufficient detail to clearly show the required features and to locate them in the field, but in no case is less than 1 to 3,600. The elevation of each contour shall be clearly noted on the map. The following details shall be shown:

(1) The location of the dam; and

(2) the following topography:

(A) The contours at two-foot intervals. For dams more than 20 feet in height, contours may be spaced at greater intervals, but the interval shall not exceed four feet;

(B) the contour equivalent to the elevation of the lowest uncontrolled spillway inlet, not including any low-flow augmentation works;

(C) the contour equivalent to the maximum water surface reached during the design storm;

(D) the contour equivalent to the elevation of the top of the dam;

(E) construction ingress and egress routes to the dam and reservoir;

(F) the name and address of each person owning any of the following:

(i) The land on which the dam and its appurtenances, including the auxiliary spillway or service spillway, down to the location where the spillway discharges back to the receiving stream, will be constructed;

(ii) ingress and egress routes to the dam and reservoir;

(iii) the reservoir site up to the top of the dam elevation; and

(iv) the borrow areas if they are located outside the reservoir site;

(G) if the reservoir area is divided between more than one landowner, the property lines, which shall be shown on the topographic map of the reservoir;

(H) roads, railroads, pipeline crossings, and any other prominent features in the vicinity;

(I) the boundary line for each easement; and

(J) the limits of each borrow area;

(d) the cross-section view of the valley at the dam site, which shall be shown along the centerline of the dam with the same stationing as that used on the plan view. The following shall be shown:

(1) The elevation to which the top of the dam is to be maintained and the elevation to which the dam is to be initially constructed in order to provide an adequate settlement allowance;

(2) the location and elevation of the auxiliary spillway or service spillway at the centerline of the dam;

(3) the original surface of the ground, including the streambed, up to the elevation of the top of the dam;

(4) the proposed elevations of the bottom of the cutoff trench; and

(5) the location of all test holes and the materials encountered in the test holes;

(e) a cross-section view perpendicular to the centerline of the dam at the lowest point on the downstream toe extending to the limits of the fill being placed. If the cross section is variable, a typical section shall be shown for each reach of similar cross section with a proper description of the reach by stationing. Additional typical cross sections along the centerline of the primary spillway and the centerline of any other outlets shall be shown. Cross sections of the dam shall include the following:

(1) The elevations of the shoulders and centerline of the dam and the width of the top of the dam;

(2) the elevation of the top of any berm, the elevation of the outside shoulder of any berm, and the top width of any berm;

(3) the slopes of upstream and downstream faces of the dam;

(4) the elevation, location, and type of slope protection;

(5) the zones of the embankment;

(6) the dimensions to which the dam is to be constructed to provide an adequate allowance for settlement;

(7) the elevation, location, and dimensions of the planned cutoff trench; and

(8) the elevation of the downstream toe of the dam at its lowest point;

(f) the following information concerning each open-channel spillway:

(1) A plan view showing the location and sta-

tioning along the centerline of the spillway, together with the location of the control section;

(2) cross sections showing side slopes and dimensions of the spillway, and the original surface of the ground up to the point where the spillway sides intersect the original ground surface;

(3) a profile along the centerline of the spillway, extending from the point upstream where the profile of the spillway intersects natural ground through the control section to the streambed below the dam. The stationing on the profile shall correspond to that on the plan view. The station and elevation of the breaks in the grade of the spillway shall be shown. This profile shall show the existing ground elevation, proposed grade of the bottom of the spillway, elevation of slope protection on the side slopes, and geologic logs of the borings required in the auxiliary spillway or service spillway by K.A.R. 5-40-40, superimposed on the profile through which the spillway is excavated; and

(4) the data necessary to stake out any curves;

(g) the following information concerning the primary spillway:

(1) The profile along the centerline of the spillway, extending from the intake to the outlet, showing the size, dimensions, and locations of seepage control features. This profile shall show existing ground elevations and the proposed grade of the spillway;

(2) the plan, profile, and cross-section views of the stilling basin, primary spillway supports, and other features;

(3) the geologic logs of the borings done in the vicinity of the primary spillway shall be superimposed on the profile;

(4) the location and type of all bedding materials;

(5) a table of pipe grades for all concrete pipes; and

(6) conduit joint details;

(h) the number of acres enclosed by each contour within the reservoir area and the total storage capacity of the reservoir in acre-feet at the elevation of each contour, which shall be determined and tabulated on the plan. The data shall be compiled for all contours in the reservoir up to the elevation of the top of the dam. Computations of capacity shall be based on the natural topography of the reservoir basin but may include the volume of any excavation in the reservoir made during construction of the dam;

(i) a curve or table showing the discharge capacities, in cubic feet per second, of all spillways through a range of surface water elevations from the lowest spillway inlet elevation to the top of the dam elevation, which shall be developed and shown on the plans or in the design report;

(j) the following information, which shall be shown on the plans in plan view, profile, and cross section:

(1) Drain details, including foundation drains;

(2) permanent erosion control protection, including riprap; and

(3) details of stilling basins, outlets, and other appurtenant structures; and

(k) the following information, which shall be shown on either the plans or the specifications:

(1) A table of gradation for each drain; and

(2) a table of gradation of the bedding of the riprap. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 1, 1983; amended May 1, 1985; amended May 1, 1987; amended May 18, 2007.)

5-40-2a. Benchmarks. (a) At least two permanent benchmarks shall be installed for future reference at each dam. Each benchmark shall be located according to the following criteria:

(1) In an area where the benchmark will not be disturbed, destroyed, or inundated after the dam is complete; and

(2) along the centerline of the dam on either end of the dam, if practical, and in undisturbed soil.

(b) On high-impact dams, each permanent benchmark shall also meet the following criteria:

(1) Be installed in a hole that meets the following criteria:

(A) Is 12 inches in diameter; and

(B) is at least 42 inches deep or is drilled to bedrock, whichever is less;

(2) be constructed of one or more steel reinforcing bars at least ⅜ inch in diameter and 36 inches in length or the length of the depth of the hole, whichever is less. The reinforcing bar or bars shall be placed in the hole and the hole backfilled with concrete rounded off flush with the ground;

(3) be capped by a metal survey marker; and

(4) be either marked by a witness post or survey marker sign or tied to at least two objects in the vicinity by distance and bearing.

(c) On low-impact dams, each permanent benchmark shall also meet the following minimum requirements:

(1) Be constructed of a reinforcing bar that is 36 inches long, one-half inch in diameter, and driven flush with the surface of the ground;

(2) be installed at a location protected from grazing animals and vehicular traffic; and

(3) be either marked by a witness post or survey marker sign or tied to at least two objects in the vicinity by distance and bearing.

(d)(1) The elevation and horizontal location of each permanent benchmark shall be shown on the as-built drawings or the construction inspection report. The location of each permanent benchmark shall be described in reference to centerline stationing and offset from the centerline. The elevation of each permanent benchmark for all of the following classes of dams shall be referenced to the national geodetic vertical datum of 1988, or other acceptable national vertical datum, to a tolerance of plus or minus 0.5 foot:

(A) Class size two, hazard classes B and C;

(B) class size three dams; and

(C) class size four dams.

(2) The elevation of each benchmark for class sizes one and two, hazard class A dams may be referenced to an assumed datum.

(e) Horizontal control shall be referenced to the Kansas state plane coordinate system as set forth in K.S.A. 58-20a01 et seq., and amendments thereto. The location of each benchmark shall be shown on the as-built drawings or the notice of completion by using either of the following:

(1) The plane coordinate values consisting of a northing and an easting from the appropriate monumented point according to K.S.A. 58-20a03, and amendments thereto; or

(2) the feet distances north or south, and east or west, from the nearest or most convenient section corner. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-2b. Design reports. (a) The application for each permit to construct, repair, or modify a dam shall be accompanied by a design report prepared by the engineer who designed the new dam or the repair or modification of an existing dam. The design report shall document every major design element of the dam, the conditions that must be addressed in the construction of the project, and the manner in which those conditions will be addressed. The design report shall document the design process, including references to each design method and computer program utilized in the design, and shall include the following:

(1) The design of any slope protection for the embankment and the auxiliary or service spillway. If no slope protection is provided, the report shall provide justification for not having slope protection;

(2) documentation of the determination of the hazard class;

(3) a report of the geotechnical investigation, including the results of the testing required in K.A.R. 5-40-40 through K.A.R. 5-40-42, and all boring logs not shown on the plans;

(4) documentation of the embankment design based upon the geotechnical investigation;

(5) documentation of the hydrological evaluation, including the determination of the composite curve number and drainage area;

(6) if a proposed dam is part of a general plan, the report shall evaluate whether the proposed dam conforms to the general plan;

(7) the design of the foundations, including the proposed depth of the cutoff trench;

(8) the design of the drains, including size, material gradation, interface with soil, and outlets;

(9) the design of the pipe bedding, including documentation that the loading and deflection conditions are met;

(10) the stilling basin design;

(11) documentation of the flood routing or routings;

(12) the gradation of the material in the diaphragm and the design of the diaphragm; and

(13) any other relevant information required by the chief engineer.

(b) In addition to those items required in subsection (a), the design report for each high-impact dam shall include the following:

(1) The auxiliary spillway or service spillway analysis required by K.A.R. 5-40-56(c), if applicable, or K.A.R. 5-40-57(a);

(2) a slope stability analysis; and

(3) an embankment settlement analysis. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-3. Specifications. (a) Each applicant shall submit specifications with the application for a permit to construct a dam. The specifications shall address every major element in the construction of the dam and the materials used to construct the dam. The specifications shall be clear,

legible, and sufficiently detailed to ensure that the dam and appurtenant works will be properly constructed and shall meet the requirements of sound engineering principles and commonly accepted engineering practices. The specifications shall state the minimum quality of materials and workmanship that is acceptable and the required materials tests and testing frequency. The specifications shall cover the following:

(1) The excavation procedures;

(2) the placement and compaction of earthen fill;

(3) the dewatering process;

(4) concrete and reinforcing steel requirements and placement;

(5) the materials for and placement of all conduits;

(6) the materials for and placement of permanent erosion control measures;

(7) drains and seepage control, including aggregate requirements; and

(8) seeding and fencing.

The specifications shall also include an index. The specifications may be submitted electronically in a form and manner prescribed by the chief engineer.

(b) A copy of the plans and specifications that have been approved by the chief engineer shall be accessible at the construction site at all times during construction. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 1, 1983; amended May 1, 1987; amended May 18, 2007.)

5-40-4. Preparer of maps, plans, profiles, reports, and specifications. In addition to the requirements of the Kansas state board of technical professions, the requirements in this regulation shall apply. (a) Each map, plan, profile, report, and specification submitted to the chief engineer for approval shall be prepared by, or under the supervision of, a person who is competent in the design and construction of channel changes or stream obstructions, as appropriate.

(b) Maps, plans, profiles, reports, and specifications for any dam shall be prepared by, or under the supervision of, a licensed professional engineer who is competent in the design and construction of dams.

(c) Maps, plans, profiles, reports, and specifications for any channel change or stream obstruction project on a navigable stream or a stream having a mean annual flow of 100 cubic feet per second or more at the proposed location of the project shall be prepared by a licensed professional engineer who is competent in the design of that type of project.

(d) No provision of this regulation, and no decision made by the chief engineer pursuant to this regulation, shall alter the responsibilities or duties of any licensee of the Kansas state board of technical professions to comply with that board's requirements. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 1, 1983; amended May 1, 1986; amended May 1, 1987; amended Sept. 22, 2000; amended May 18, 2007.)

5-40-5. Determining the capacity of a reservoir. (a) The capacity of each proposed reservoir shall be determined as specified in K.A.R. 5-40-2(h).

(b) The capacity of each existing reservoir shall be determined by using the procedure specified in K.A.R. 5-40-2(h) for contours above the water surface. The engineer determining the reservoir capacity shall demonstrate the validity of the method that the engineer selects to extrapolate the data for contours below the water surface. The capacity of an existing reservoir shall not be reduced by including the accumulated sediment. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-301 and 82a-303a; effective May 1, 1983; amended May 18, 2007.)

5-40-5a. Determining the height of a dam or barrier. To determine the height of a dam or barrier pursuant to K.S.A. 82a-301(b) and amendments thereto, that measurement shall be made as follows: (a) The height of a dam or barrier that extends across the natural bed of a stream or watercourse shall be the vertical distance measured from the bed of the stream or watercourse at the downstream toe of the dam or barrier to the lowest elevation on the top of the dam or barrier, excluding any open-channel spillway and any anomalous low points.

(b) The height of a dam or barrier that does not extend across the natural bed of a stream or watercourse shall be the vertical distance measured from the lowest elevation of the outside limit of the dam or barrier to the lowest elevation on the top of the dam or barrier, excluding any open-channel spillway and any anomalous low points.

(c) The height of a proposed barrier or dam shall be measured from the planned top of the

dam, excluding any allowance for settlement. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-301 and 82a-303a; effective May 18, 2007.)

5-40-8. Acceptable application. (a) To be acceptable for filing, each application for a permit to construct, modify, or repair a dam, other stream obstruction, or channel change shall be accompanied by the statutorily required filing fee and shall contain all of the following:

(1) One copy of the completed application on a form prescribed by the chief engineer and signed by the applicant;

(2) two copies of the maps, plans, specifications, and profiles for a proposed or existing dam that meet the requirements of these regulations or one copy of the maps, plans, specifications, and profiles for any other stream obstruction or channel change that meet the requirements of these regulations; and

(3) for a proposed or existing dam, one copy of the design report that meets the requirements of these regulations.

(b) If the applicant fails to meet the requirements of subsection (a), the applicant shall be notified by the chief engineer of the deficiencies in writing and given 60 days from the time the notice is postmarked to submit the required items. If the required items are not submitted within 30 days after the chief engineer's notice is postmarked, a reminder letter shall be sent to applicant again requesting the required items.

(c) Any applicant may submit a request for an extension of time to provide a complete application. The applicant shall submit the request for extension of time before the deadline to submit the items. The request shall also include a justification for the extension of time and an estimate of the time needed to submit the required items.

(d) If the required items are not submitted within 60 days after the chief engineer's notification of deficiency, or within any authorized extension of time, the application shall be dismissed and the application fee forfeited.

(e) If the dismissed application was for the construction, repair, or modification of an existing illegal, unpermitted dam, the removal of the dam shall be ordered by the chief engineer.

(f) If an application is dismissed pursuant to this regulation, within 30 days of the date of dismissal the applicant may apply to have the application reinstated. The application may be reinstated by the chief engineer for good cause shown by the applicant. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-301, 82a-302, and 82a-303a and K.S.A. 82a-303c; effective May 1, 1983; amended May 18, 2007.)

5-40-9. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-302; effective May 1, 1983; amended May 1, 1985; amended May 1, 1986; revoked May 18, 2007.)

5-40-10. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-302; effective May 1, 1984; amended May 1, 1985; amended May 1, 1986; revoked May 18, 2007.)

5-40-11. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-302 and 82a-303; effective Sept. 22, 2000; revoked May 18, 2007.)

5-40-12. As-built drawings. (a) Each permit shall be conditioned by the chief engineer to require as-built drawings for each category listed in subsection (b) to be submitted within 90 days of the completion of the dam, repairs, or modifications, or any extension of time authorized by the chief engineer for good cause. The drawings shall be prepared by a person qualified to prepare the original plans and specifications pursuant to K.A.R. 5-40-4.

(b) As-built drawings shall be submitted for each of the following categories:

(1) All high-impact dams;

(2) any dam, if required by the chief engineer as a condition of the permit to build, repair, or modify the dam; and

(3) any dam, if required by the chief engineer as the result of an approval of a change in the approved plans requested by the applicant during construction.

(c) The as-built drawings shall show all the features of the structure included in the approved plans as those features were constructed. A legibly marked-up copy of the approved plans shall be acceptable as as-built drawings.

(d) A profile of the bottom of the cutoff trench as constructed shall be shown on the as-built drawings. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 82a-303 and 82a-303a; effective May 1, 1987; amended May 18, 2007.)

5-40-13. (Authorized by K.S.A. 82a-303a;

implementing K.S.A. 82a-303; effective May 1, 1987; revoked May 18, 2007.)

5-40-20. Hazard classes of dams. (a) The hazard classes of dams shall be determined from the following based on the location of the dam, the hazards found within the inundation area, and the impact of a failure of a dam:

(1) A "hazard class A dam" shall mean a dam located in an area where failure could damage only farm or other uninhabited buildings, agricultural or undeveloped land including hiking trails, or traffic on low-volume roads that meet the requirements for hazard class A dams as specified in subsections (b) and (c).

(2) A "hazard class B dam" shall mean a dam located in an area where failure could endanger a few lives, damage an isolated home, damage traffic on moderate-volume roads that meet the requirements for hazard class B dams as specified in subsections (b) and (c), damage low-volume railroad tracks, interrupt the use or service of a utility serving a small number of customers, or inundate recreation facilities, including campground areas intermittently used for sleeping and serving a relatively small number of persons.

(3) A "hazard class C dam" shall mean a dam located in an area where failure could result in any of the following:

(A) Extensive loss of life;

(B) damage to more than one home;

(C) damage to industrial or commercial facilities;

(D) interruption of a public utility serving a large number of customers;

(E) damage to traffic on high-volume roads that meet the requirements for hazard class C dams as specified in subsections (b) and (c) or a high-volume railroad line;

(F) inundation of a frequently used recreation facility serving a relatively large number of persons; or

(G) two or more individual hazards described in hazard class B.

(b) If there is a road across any part of the embankment or a spillway, including the auxiliary spillway or service spillway channel down to the receiving stream, the daily vehicular traffic shall be considered in determining the hazard classification, in addition to the criteria specified in subsection (a). The hazard classifications specified in this subsection shall be used if these classifications are more stringent than the hazard classifications required by subsection (a).

Hazard class	Vehicles per day
A	0 through 100
B	101 through 500
C	more than 500

(c) If any road in the inundation area does not meet the criteria of subsection (b), the daily vehicular traffic shall be considered in determining the hazard classification, in addition to the criteria specified in subsection (a). The hazard classifications specified in this subsection shall be used if these classifications are more stringent than the hazard classifications otherwise required by subsection (a).

Hazard class	Vehicles per day
A	0 through 500
B	501 through 1,500
C	more than 1,500

(Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-303a and 82a-303b; effective May 18, 2007.)

5-40-21. Class sizes of dams. (a) Each dam that the chief engineer has authority to regulate pursuant to K.S.A. 82a-301 et seq., and amendments thereto, with an effective height of less than 25 feet and an effective storage of less than 50 acre-feet shall be considered to be a class size 1 dam. The class size of all other dams shall be determined from the following table:

Class size	Size factor
2	less than 3,000
3	3,000 through 30,000
4	more than 30,000

(b) Each existing permitted dam and each dam for which an application was submitted before the effective date of this regulation shall continue to have the effective height measured from the flow line of the stream at the centerline of the dam. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-303a and 82a-303b; effective May 18, 2007.)

5-40-22. Design requirements for construction of a dam. Each dam constructed shall meet or exceed the design requirements specified in the table in this regulation. The minimum top of the dam elevation shall be the maximum water surface elevation determined by routing the design storm specified in the following table, using

the methodology specified in K.A.R. 5-40-30 through K.A.R. 5-40-33, through the reservoir and the dam's spillways, plus the minimum freeboard shown in the following table. The minimum floor width of the open-channel spillway shall be the minimum floor width shown in the following table.

Dam size class	Hazard class	Precipitation for design storm	Minimum freeboard in feet	Minimum floor width of open-channel spillway in feet
1	A	2% chance	1	20
	B	0.25 PMP	2	
	C	0.40 PMP	3	
2	A	1% chance	2	30
	B	0.25 PMP	2	
	C	0.40 PMP	3	
3	A	1% chance	3	40
	B	0.30 PMP	3	
	C	0.40 PMP	3	
4	A	0.25 PMP	3	40
	B	0.30 PMP	3	
	C	0.40 PMP	3	

(Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-23. Detention storage. (a) To determine the minimum required detention storage, the applicant shall show that the computed runoff from the detention storm can be stored in the reservoir and discharged through the primary spillway without any flow being discharged through the auxiliary spillway. The elevation of the auxiliary spillway control section shall be set so that the computed runoff from the detention storm specified in the following table and determined from the procedures in K.A.R. 5-40-30 through K.A.R. 5-40-33 does not result in discharge through the auxiliary spillway.

Hazard class	Size	Purpose	Minimum detention storm
A	1, 2	Flood control	4% chance
A	3	Flood control	4% chance
A	4	Flood control	2% chance
B	All	Flood control	2% chance
C	All	Flood control	2% chance
A	1, 2	All uses other than flood control	50% chance
A	3	All uses other than flood control	50% chance
A	4	All uses other than flood control	20% chance
B	All	All uses other than flood control	20% chance
C	All	All uses other than flood control	20% chance

Each dam that has flood control as a purpose shall meet the detention storm requirements for a flood control structure. A dam that is not constructed for flood control purposes and whose auxiliary spillway meets the requirements for a service spillway in K.A.R. 5-40-57 shall not be required to meet any minimum detention storm requirement in the table in this subsection.

(b) Each dam shall have a primary spillway and an auxiliary spillway, unless a service spillway meeting the requirements of K.A.R. 5-40-57 is provided. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-24. Dam breach analysis. A dam breach analysis shall be conducted on each proposed dam as specified in this regulation. If a dam breach analysis is required for an existing dam, the analysis shall be conducted in the same manner as that specified in this regulation for a proposed dam. (a) To determine the appropriate water surface elevation in the reservoir when the breach begins, the breach analysis shall route the appropriate design duration one percent-chance storm determined by K.A.R. 5-40-31 through the reservoir. The routing shall begin by assuming that the water surface elevation is at the elevation of the lowest uncontrolled spillway inlet, not including any low-flow augmentation works. The antecedent moisture condition (AMC) used to determine the runoff shall be determined according to K.A.R. 5-40-32. The minimum water surface elevation used to begin the breach analysis shall be the greater of the following:

(1) The water surface elevation determined by routing the required design duration one percent-chance storm through the reservoir; or

(2) the elevation of the crest of the auxiliary spillway.

Routing the storm through the reservoir may account for the discharge of the primary spillway and any open-channel spillways. If the dam does not have an open-channel spillway, the water sur-

face elevation used shall be the elevation of the top of the dam or the elevation resulting from using PMP as the runoff event, whichever is lower.

(b) The breach discharge shall be determined by using the peak breach discharge criteria section on pages 1-1 through 1-2 in "earth dams and reservoirs," TR-60, dated July 2005, published by the conservation engineering division of the natural resources conservation service, and hereby adopted by reference, unless the applicant receives written approval of the chief engineer to use a model that is more appropriate for a particular dam. The breach discharge hydrograph shall be determined by methods in NRCS TR-66, third edition, "simplified dam-breach routing procedure," dated September 1985, which is hereby adopted by reference, including the appendices. If another model is used, the following breach modeling assumptions shall be used, unless the applicant demonstrates to the chief engineer that more appropriate assumptions should be used:

(1) The parameters shall support the assumption of a rapidly developing breach that is either an overtopping failure or a spillway failure caused by intense, localized erosion beginning at the downstream end of the auxiliary spillway or service spillway and working its way upstream.

(2) If the breach model has breach width as a variable, the minimum bottom width of the breach shall be twice the height of the dam. If there is a well-defined physical floodplain, the height of the dam may be measured from the top of the low bank of the stream to the top of the dam for the purpose of determining the minimum breach width.

(3) If the side slopes of the breach are a parameter of the model, vertical side slopes shall be used.

(4) If the breach model has breach time as a variable, the maximum breach time shall be one minute per foot of height of the dam.

(c) The breach discharge shall be routed downstream using a hydraulic flow model in accordance with sound engineering principles and commonly accepted engineering practices. An unsteady state hydraulic flow model shall be used if it is necessary to model existing hydraulic structures in the inundation area. In all other instances, a steady state hydraulic flow model may be used.

(d) The inundation area analyzed shall meet both of the following requirements:

(1) Be from the downstream toe of the dam and the control section of any open-channel section of any open-channel spillway, downstream to the point where the crest of the breach wave intersects the flood level of the peak discharge of the one percent-chance storm, assuming that the dam was not in place; and

(2) be analyzed to the point at which there are no more hazards downstream.

The peak discharge of the one percent-chance storm may be determined by any of the methods provided in K.A.R. 5-42-5 or the appropriate published flood insurance study for the stream receiving the discharge from the breach of the dam.

(e) If there is more than one dam on a stream, it shall be assumed that the most upstream dam is breached first and that the peak flow of that breach arrives at the next downstream dam at the same time the peak water surface elevation from the inflow of the one percent-chance storm from the uncontrolled portion of the lower dam's drainage area occurs. An appropriate model may be used to demonstrate when the peaks will occur for an entire system of dams, in which case the water surface elevation modeled shall be used.

(f) If there are dams on separate tributaries above the dam being analyzed, the modeling assumption specified in subsection (e) shall be applied only to the tributary that has the upstream dam whose breach results in the greatest computed breach discharge at the dam being analyzed.

(g) If digital elevation data is used in the analysis of the breach, the data used shall have a root mean square error of 2.5 meters or less.

(h) Cross sections for modeling purposes shall be taken at appropriate locations, but in no case shall the intervals be less than 2,640 feet measured along the floodplain of the watercourse. Cross sections shall be generally perpendicular to the direction of flow and the contour lines that the cross sections intersect. Cross sections may be broken into several connected segments as needed to meet the requirements of this subsection.

(i) Each bridge and any other hydraulic structure that has a significant hydraulic effect shall be included in the analysis.

(j)(1) The applicant shall submit a contour map of the valley with contour intervals of 10 feet or less and a scale of not less than 1:24,000, which shall show the following:

(A) The inundation area determined from the breach;

(B) the location of each existing hazard; and

(C) each cross section entered in the hydraulic flow model with a label identifying the cross section.

(2) The following items shall be shown on the contour map or on separate documentation:

(A) The elevation of each existing hazard;

(B) the water surface elevation at each existing hazard;

(C) the elevation of the streambed at the point nearest each existing hazard; and

(D) a tabular report including the following information for each cross section:

(i) The label identifying each cross section shown on the map;

(ii) the elevation of the maximum water surface attained during the breach;

(iii) the peak discharge; and

(iv) the computed width of the water surface.

(3) If there are more than 10 hazards in any 2,640-foot reach in the flood inundation area, the information required in paragraph (j)(2) may be noted only for the hazard in that reach that is closest to the maximum water surface elevation measured vertically and the hazard in that reach that is farthest from the maximum water surface elevation measured vertically.

(k) The applicant shall submit one copy of each data file used to perform each analysis in electronic form along with identification of the computer programs used to perform the analysis and any model documentation needed for the chief engineer to review the analysis. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-26. Request to issue or reconsider hazard class determination. (a)(1) If an owner or applicant does not agree with the hazard classification determined for a dam, the owner or applicant may file a request for reconsideration of the hazard class determination.

(2) Each request for reconsideration shall be submitted in writing and shall indicate the following:

(A) The owner's or applicant's proposed hazard classification;

(B) the basis of that proposal; and

(C) an explanation of why the owner or applicant believes that the determination of the hazard classification by the chief engineer is incorrect. The request shall also contain documentation and analysis that support the request.

(3) Each request for reconsideration shall be filed with the chief engineer within 15 days after the owner or applicant is served with written notice of the hazard classification by the office of the chief engineer or within any extension of time authorized by the chief engineer in writing.

(b) Each request for reconsideration shall be reviewed by the chief engineer, and a final written determination of the hazard classification shall be made by the chief engineer.

(c) If the chief engineer has not issued a written notice of the hazard classification, the owner or applicant may request a written notice after the owner or applicant has been informed verbally of the proposed hazard classification by the chief engineer. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-303a and 82a-303b; effective May 18, 2007.)

5-40-30. Time of concentration. (a) Except as specified in subsections (b) and (c), the time of concentration (T_c) shall be determined by using one of the methods specified in chapter 15, "travel time, time of concentration and lag," in the natural resources conservation service (NRCS) national engineering handbook, part 630, dated August 1972, which is hereby adopted by reference.

(b) For drainage areas of not more than three square miles, the time of concentration (T_c) may be determined by use of the Kirpich formula, which is as follows:

$$T_c = \left(\frac{11.9L^3}{H} \right)^{0.385}$$

Where

T_c = the time of concentration, in hours

L = the longest distance that water has to travel in the drainage basin, in miles

H = the maximum elevation difference in the drainage basin, in feet.

(c) In addition to the methods specified in subsections (a) and (b), the applicant may determine T_c based on sound engineering principles and commonly accepted engineering practices if the applicant obtains the prior written consent of the chief engineer. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-31. Design duration rainfall depth. (a) If the time of concentration is six hours or less, a duration of six hours shall be used for all design

storms. The appropriate six-hour storm depth, in inches, shall be selected from the following table.

County	Probability of occurrence in any year					
	50%	**20%**	**4%**	**2%**	**1%**	**PMP**
Allen	2.7	3.5	4.8	5.4	6.1	28.0
Anderson	2.7	3.5	4.8	5.3	6.0	27.8
Atchison	2.6	3.4	4.5	5.1	5.7	27.2
Barber	2.4	3.2	4.4	5.0	5.7	27.3
Barton	2.3	3.0	4.1	4.8	5.3	26.6
Bourbon	2.7	3.5	4.8	5.4	6.0	28.1
Brown	2.5	3.2	4.4	5.0	5.6	27.0
Butler	2.6	3.4	4.7	5.3	6.0	27.7
Chase	2.6	3.4	4.6	5.2	5.9	27.5
Chautauqua	2.7	3.5	4.9	5.5	6.2	28.3
Cherokee	2.8	3.6	5.0	5.5	6.2	28.5
Cheyenne	1.8	2.4	3.4	3.8	4.3	24.7
Clark	2.2	3.0	4.1	4.7	5.3	26.7
Clay	2.5	3.2	4.3	5.0	5.5	26.8
Cloud	2.4	3.1	4.2	4.8	5.4	26.6
Coffey	2.7	3.5	4.7	5.3	6.0	27.8
Comanche	2.3	3.1	4.2	4.9	5.5	27.0
Cowley	2.6	3.4	4.8	5.4	6.1	28.0
Crawford	2.8	3.6	4.9	5.4	6.1	28.3
Decatur	1.9	2.6	3.6	4.2	4.6	25.3
Dickinson	2.5	3.2	4.4	5.1	5.6	27.1
Doniphan	2.5	3.2	4.5	5.0	5.6	27.0
Douglas	2.6	3.4	4.6	5.2	5.8	27.5
Edwards	2.2	2.9	4.1	4.7	5.3	26.7
Elk	2.7	3.5	4.8	5.4	6.1	28.1
Ellis	2.1	2.9	3.9	4.6	5.0	26.2
Ellsworth	2.3	3.1	4.2	4.9	5.4	26.7
Finney	2.0	2.6	3.8	4.3	4.8	26.8
Ford	2.1	2.8	4.0	4.6	5.1	26.4
Franklin	2.7	3.5	4.7	5.2	5.9	25.8
Geary	2.5	3.2	4.4	5.1	5.7	27.1
Gove	2.0	2.6	3.7	4.3	4.7	25.7
Graham	2.0	2.7	3.8	4.4	4.8	25.8
Grant	1.9	2.6	3.7	4.2	4.7	25.6
Gray	2.0	2.7	3.9	4.4	4.9	26.1
Greeley	1.8	2.5	3.4	3.9	4.4	25.0
Greenwood	2.7	3.5	4.8	5.3	6.1	27.8
Hamilton	1.8	2.5	3.5	4.0	4.5	25.2
Harper	2.5	3.3	4.5	5.2	5.9	27.5
Harvey	2.5	3.3	4.5	5.1	5.8	27.4
Haskell	2.0	2.7	3.8	4.3	4.8	25.9
Hodgeman	2.1	2.8	3.9	4.5	5.0	26.3
Jackson	2.6	3.4	4.5	5.1	5.7	27.2
Jefferson	2.6	3.4	4.6	5.1	5.8	27.3
Jewell	2.3	2.9	4.0	4.7	5.1	26.3
Johnson	2.6	3.4	4.6	5.2	5.8	27.5
Kearny	1.9	2.6	3.6	4.1	4.6	25.5
Kingman	2.4	3.2	4.4	5.1	5.7	27.3
Kiowa	2.2	2.9	4.2	4.8	5.4	26.7
Labette	2.8	3.6	5.0	5.5	6.2	28.4
Lane	2.0	2.7	3.7	4.3	4.8	25.8
Leavenworth	2.6	3.4	4.6	5.1	5.8	27.4
Lincoln	2.3	3.0	4.2	4.8	5.3	26.6
Linn	2.7	3.5	4.8	5.3	6.0	27.9
Logan	1.9	2.5	3.6	4.1	4.6	25.3
Lyon	2.6	3.4	4.6	5.2	6.0	27.5
Marion	2.5	3.3	4.5	5.2	5.8	27.3
Marshall	2.5	3.2	4.3	4.9	5.5	26.8
McPherson	2.5	3.2	4.4	5.1	5.7	27.1
Meade	2.1	2.8	4.0	4.6	5.1	26.3
Miami	2.7	3.5	4.7	5.2	5.9	27.7
Mitchell	2.3	3.0	4.1	4.7	5.2	26.4
Montgomery	2.8	3.5	5.0	5.5	6.2	28.3
Morris	2.6	3.4	4.5	5.1	5.8	27.3
Morton	1.9	2.5	3.6	4.1	4.6	25.4
Nemaha	2.5	3.2	4.4	5.0	5.6	26.9
Neosho	2.7	3.5	4.9	5.5	6.1	28.2
Ness	2.1	2.8	3.9	4.5	4.9	26.1
Norton	2.0	2.6	3.7	4.3	4.7	25.6
Osage	2.6	3.4	4.6	5.2	5.9	27.5
Osborne	2.2	2.9	4.0	4.6	5.1	26.2
Ottawa	2.4	3.1	4.3	4.9	5.4	26.8
Pawnee	2.2	2.9	4.1	4.7	5.2	26.6
Phillips	2.1	2.8	3.8	4.4	4.9	25.8
Pottawatomie	2.5	3.2	4.4	5.0	5.6	27.0
Pratt	2.3	3.1	4.3	4.9	5.5	27.0
Rawlins	1.9	2.5	3.5	4.0	4.5	25.0
Reno	2.4	3.2	4.4	5.0	5.7	27.2
Republic	2.3	3.0	4.1	4.8	5.3	26.4
Rice	2.4	3.1	4.3	4.9	5.5	26.9
Riley	2.5	3.2	4.4	5.0	5.6	27.0
Rooks	2.1	2.8	3.9	4.5	4.9	26.0
Rush	2.2	2.9	4.0	4.6	5.1	26.4
Russell	2.2	2.9	4.1	4.7	5.2	26.5
Saline	2.4	3.1	4.3	5.0	5.5	26.9
Scott	1.9	2.6	3.6	4.2	4.7	25.5
Sedgwick	2.5	3.3	4.6	5.2	5.9	27.5
Seward	2.0	2.7	3.8	4.4	4.9	26.0
Shawnee	2.6	3.4	4.6	5.1	5.8	27.4
Sheridan	2.0	2.6	3.7	4.2	4.7	25.5
Sherman	1.8	2.4	3.4	3.9	4.4	24.8
Smith	2.2	2.9	3.9	4.6	5.0	26.1
Stafford	2.3	3.0	4.2	4.9	5.4	26.9
Stanton	1.9	2.5	3.6	4.1	4.5	25.3
Stevens	1.9	2.6	3.7	4.3	4.7	25.8
Sumner	2.6	3.4	4.7	5.3	6.0	27.8

County	Probability of occurrence in any year					
	50%	20%	4%	2%	1%	PMP
Thomas	1.9	2.5	3.5	4.1	4.5	25.2
Trego	2.0	2.7	3.8	4.4	4.9	25.9
Wabaunsee	2.6	3.4	4.5	5.1	5.8	27.3
Wallace	1.8	2.4	3.4	3.9	4.4	24.9
Washington	2.4	3.1	4.2	4.9	5.4	26.6
Wichita	1.9	2.5	3.5	4.1	4.5	25.3
Wilson	2.7	3.5	4.9	5.4	6.1	28.1
Woodson	2.7	3.5	4.8	5.4	6.1	28.0
Wyandotte	2.6	3.4	4.6	5.1	5.8	27.4

(b) If the time of concentration of the watershed, or any subwatershed being used to develop the inflow hydrograph, is more than six hours, the ratio for the time equal to or greater than the computed time of concentration shall be selected from the following table. Linear interpolation shall be acceptable. That ratio shall be multiplied by the depth of the six-hour rainfall in the table in subsection (a). The resulting depth is the design duration rainfall depth.

Relative increase in rainfall amount for storm durations over six hours

Time (hours)	100-year ratio	PMP ratio
6	1.000	1.000
6.5	1.019	1.013
7	1.035	1.025
7.5	1.051	1.037
8	1.066	1.048
8.5	1.081	1.058
9	1.094	1.068
9.5	1.108	1.078
10	1.120	1.087
10.5	1.132	1.096
11	1.144	1.104
11.5	1.155	1.112
12	1.166	1.120
13	1.187	1.134
14	1.207	1.148
15	1.225	1.161
16	1.243	1.173
17	1.259	1.185
18	1.275	1.196
20	1.305	1.217
22	1.333	1.236
24	1.359	1.254

(c) If the drainage area exceeds 10 square miles, the rainfall depth obtained from the table in subsection (a) may be reduced by the ratio shown in the table in this subsection. The ratio for the zone in which the dam is located and a drainage area less than or equal to the actual drainage area above the dam shall be selected. The use of linear interpolation shall be acceptable. That ratio shall be multiplied by the depth of rainfall from the table in subsection (a). The result is the design duration rainfall depth. The ratios in subsection (b) and this subsection may be used together, if subsections (b) and (c) both apply.

Drainage area (sq. mi.)	Reduction ratio		
	Zone 1	Zone 2	Zone 3
10	1.00	1.00	1.00
12	0.99	0.99	0.98
15	0.97	0.95	0.93
17	0.96	0.94	0.91
20	0.94	0.91	0.88
22	0.93	0.90	0.86
25	0.92	0.88	0.83
27	0.92	0.87	0.82
30	0.91	0.86	0.80
35	0.90	0.84	0.77
40	0.88	0.82	0.75
45	0.87	0.80	0.72
50	0.86	0.78	0.70
60	0.84	0.75	0.65
70	0.82	0.72	0.62
80	0.80	0.70	0.59
90	0.79	0.68	0.57
100	0.78	0.67	0.55

Zone 1, zone 2, and zone 3 shall have the meanings specified in K.A.R. 5-40-1 under the definition of a "stream." (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-32. Determination of rainfall excess. (a) Rainfall excess shall be determined by using the natural resource conservation service (NRCS) runoff curve number method.

(b) The antecedent moisture condition (AMC) to be used when determining the curve number for the design storm shall be one of the following:

(1) For zone one, the curve number determined using AMC III;

(2) for zone two, the curve number determined by averaging the AMC II and AMC III curve numbers; or

(3) for zone three, the curve number determined using AMC II.

Zone one, zone two, and zone three shall have

the meanings specified in K.A.R. 5-40-1 under the definition of a "stream."

(c) If the drainage basin is in two zones, the curve number may be weighted based on the drainage area within each zone.

(d) AMC II shall be used in determining the rainfall-runoff relationship used to compute the required detention storage. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-33. Hydrographs. The rainfall excess determined in K.A.R. 5-40-32 shall be used to determine the time-discharge relationship of inflow to the reservoir for the detention storm and design storm using the techniques described in chapter 16, "hydrographs," in the natural resource conservation service (NRCS) national engineering handbook, part 630, dated March 2007, which is hereby adopted by reference. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-40. Geotechnical investigation of all dams. (a) Each applicant shall ensure that a sufficient geotechnical investigation is performed on the proposed site for each dam to design the dam in accordance with the regulations of the chief engineer and with sound engineering principles and commonly accepted engineering practices. The materials under the proposed dam, open-channel spillway, and borrow area shall be investigated before design and submission of the application for a permit to construct a dam. If unusual or unexpected foundation conditions are encountered in the investigations required in this regulation, additional geotechnical investigation and soil mechanics testing shall be performed as necessary to design and construct the dam in accordance with the regulations of the chief engineer and with sound engineering principles and commonly accepted engineering practices.

(b) The geotechnical investigation specified in these regulations shall be designed by a licensed professional competent in geotechnical investigation and analysis for dams.

(c) The geotechnical information specified in these regulations shall be included in the engineering design report and submitted with the proposed construction plans. The report shall contain a general description of the geotechnical investigation, including the method used for sampling.

(d) The soils sampled in all of the geotechnical investigations shall be classified by using field classification methods and the uniform soil classification system.

(e) The dam design shall make appropriate accommodations for the geology discovered in the investigation.

(f)(1) The foundation of the dam shall be investigated to a depth of not less than one-half the height of the dam at the location of the test hole plus five feet.

(2) If unweathered bedrock is encountered before reaching the sampling depth required in paragraph (f)(1), the sampling shall be done to the unweathered bedrock.

(g) The static water level in each test hole shall be recorded.

(h) A sufficient number of test holes shall be made in each open-channel spillway to determine the stability of the spillway crest and the outlet channel down to the streambed elevation.

(i) A sufficient number of test holes in the borrow area shall be made to determine the amount of suitable material available and to classify the soil to be used in the embankment. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-41. Geotechnical investigation of a low-impact dam. (a) In addition to meeting the requirements of K.A.R. 5-40-40, each low-impact dam shall have a sufficient number of properly placed test holes to be representative of the geology under the proposed dam embankment, with an average of at least one test hole each 200 feet along the centerline of the dam and at least three test holes.

(b) Except as specified in subsection (d) and K.A.R. 5-40-74, each existing unpermitted, illegal dam shall have the same level of geotechnical investigation as that required for a proposed new dam, except that testing the borrow area shall not be required, before a permit will be issued. In addition, the condition of the following shall be determined:

(1) All conduits passing through the embankment;

(2) the embankment in the vicinity of the conduits; and

(3) the rest of the embankment, including any slides, seeps, saturated areas, sloughs, and other visible anomalies in the embankment.

(c) If there are any signs of instability in the embankment, the stability of the slope of the ex-

isting embankment shall be analyzed according to the requirements of K.A.R. 5-40-46(c).

(d) An existing unpermitted, illegal low-hazard dam that is class size 1, 2, or 3, for which a qualified professional has conducted an inspection and submitted to the chief engineer a report of that investigation demonstrating that a geotechnical investigation is not necessary to protect the public safety and property, shall not be required to have the geotechnical investigation required by subsection (b). (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-42. Geotechnical investigation of a high-impact dam. (a) In addition to meeting the requirements of K.A.R. 5-40-40, each proposed high-impact dam shall have at least the following number of geotechnical test holes:

(1) A sufficient number of properly placed test holes to be representative of the geology under the proposed dam embankment, with an average of at least one test hole every 100 feet along and as close to the centerline of the dam as practical and a minimum of three test holes; and

(2) a test hole as close as practical to the anticipated location of the following:

(A) The base of the drop inlet; and

(B) the support of the outlet pipe.

(b) At least one representative sample of undisturbed soil shall be tested to determine shear strength parameters, permeability, and compressability.

(c) The geotechnical investigation shall determine the following for at least one representative sample:

(1) Atterberg limits;

(2) the settlement characteristics of the proposed embankment materials and the foundation of the dam;

(3) the Proctor compaction curves of soils;

(4) gradation tests of foundation materials, especially where drain systems could be located; and

(5) any other properties necessary to design a dam to meet the requirements of the regulations of the chief engineer, sound engineering principles, and commonly accepted engineering practices.

(d) Each existing unpermitted, illegal dam shall have the same level of geotechnical investigation as that required for a proposed dam, except that testing the borrow area shall not be required, before a permit may be issued. In addition, the following properties shall be determined:

(1) The condition of all conduits passing through the embankment and the condition of the embankment in the vicinity of the conduits;

(2) the in situ density of the existing embankment and its foundation;

(3) the condition of the embankment, including any slides, seeps, saturated areas, sloughs, and other visible anomalies in the embankment; and

(4) a slope stability analysis of the existing embankment, which shall be performed according to the requirements of K.A.R. 5-40-46. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-43. Cutoff trench. (a) Each dam shall have a cutoff trench. The cutoff trench shall meet all of the following requirements:

(1) Have side slopes no steeper than one horizontal unit to one vertical unit;

(2) have a bottom width of 10 or more feet as necessary to meet the compaction requirements of K.A.R. 5-40-44;

(3) be constructed to the depth justified in the design report based on the findings in the geotechnical report, unless observations by the inspecting engineer during construction justify a different depth;

(4) be backfilled with the most impervious material available at the site. If no impervious material is available at the site, then this material shall be procured off-site;

(5) be backfilled with material that is contiguous to and homogeneous with the most impervious zone within the dam, if the dam is designed as a zoned fill;

(6) be constructed in lifts that shall not exceed nine inches for each lift; and

(7) be constructed of a material that has been brought to acceptable moisture content.

(b) The material placed in the cutoff trench shall be placed according to the same specifications as those required for the embankment in K.A.R. 5-40-44. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-44. Embankment. (a) The minimum top width of an embankment shall be determined from the following table:

Height of dam (in feet)	Minimum top width (in feet)
less than 20	10
20 through 24.9	12
25 through 39.9	14
40 or greater	15

(b) The top of the dam shall be sloped toward the reservoir, unless special measures are taken to adequately control erosion on the downstream side of the dam.

(c) The height of each lift in the embankment and cutoff trench shall be no more than nine inches, unless the dam is designed as a zoned fill. If the dam is designed as a zoned fill, the lifts outside the cutoff trench and most impermeable zone may be larger if geotechnical data is provided that shows that adequate compaction can be achieved using lifts in excess of nine inches.

(d) The material in each low-impact embankment and cutoff trench shall be brought to a moisture content that can be compacted in accordance with this subsection. Each application for a low-impact dam shall contain specifications requiring adequate compaction. The minimum compaction required shall be achieved by one of the following:

(1) Using a sheepsfoot roller until the feet cease to push into the fill material and start to walk across the compacted surface;

(2) using the controlled movement of rubber-tired earth-moving equipment so that every point on the surface of each lift is traversed by not less than one tread track of the equipment; or

(3) using another method that achieves the compaction required by this subsection.

(e) Each high-impact dam shall include the following in its specifications for earth placement in the embankment and cutoff trench:

(1) The minimum and maximum allowable levels of soil moisture;

(2) the compaction standards;

(3) a provision for testing the soils placed during construction; and

(4) a means to ensure that the compaction standards approved by the chief engineer are met during construction.

(f) In addition to the requirements of subsections (d) and (e), the specifications for hand-compacted fill around each conduit in the embankment shall meet the following requirements:

(1) Set a maximum lift of one-third the diameter of the outside of the conduit. However, no lift shall exceed four inches; and

(2) specify a minimum distance around the conduit for hand compaction. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-45. Allowance for settlement of an earthen dam. (a) A detailed soil mechanics investigation report shall be submitted as part of the design report for each high-impact dam. An appropriate allowance for settlement shall be made based on the results in the soil mechanics report.

(b) If a detailed soil mechanics investigation report is not submitted for a low-impact dam, at least five percent of the height of the dam shall be allowed for settlement of the embankment.

(c) An allowance for settlement on each dam may be made by steepening the side slopes during construction and adding to the height of the embankment as needed to increase the height of the dam. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-46. Side slopes of an earthen dam. (a) The side slopes of each earthen dam shall be designed and constructed to be stable and easily maintained.

(b) A slope stability analysis shall be required on each high-impact dam.

(c) If a slope stability analysis is required, the minimum factor of safety shall be based on the steady-state seepage load condition with the water level at the elevation of the lowest open-channel spillway or other uncontrolled spillway with a trash rack that meets the requirements of K.A.R. 5-40-51, as shown in the following table:

Class size	Hazard class	Factor of safety
4	A	1.4
3, 4	B	1.5
1, 2, 3, 4	C	1.5

(d) Each dam whose face is subject to prevailing winds shall be given additional protection from erosion caused by wave action, which may include a flatter side slope, the use of riprap, or the use of grass or vegetation adapted to fluctuating water levels. The design of any slope protection for the embankment and the auxiliary spillway or service spillway shall be shown on the plans. If no slope protection is provided, regardless of the orientation of the dam, the design report shall provide justification for not having slope protection.

(e) The steepest allowable design side slope shall be three horizontal units to one vertical unit on the upstream side of the dam, and two and

one-half horizontal units to one vertical unit on the downstream slope of the dam. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-50. Pipes. (a) Each pipe under or through an embankment shall meet the following requirements:

(1) Be capable of withstanding the external load without buckling, cracking, being damaged, or being deformed. The minimum internal diameter of the pipe shall not be reduced by more than the pipe manufacturer's stated allowable, long-term pipe deflection limit and in no case by more than five percent;

(2) be designed to adequately resist flotation;

(3) be impervious to water, with watertight joints and seams;

(4) except for drawdown pipes, be installed with sufficient slope to provide adequate drainage, with a minimum average slope of one percent after settlement. No pipe shall have an adverse grade through any section of pipe;

(5) if the pipe is installed in conjunction with a riser on a high-impact dam, be placed to insure that the requirements of paragraph (a)(4) are met and that all pipe sections are properly aligned after settlement of the foundation and consolidation of the embankment;

(6) have the discharge end extended a sufficient distance beyond the downstream toe of the dam to avoid erosion to the dam;

(7) be adequately supported at the discharge end to prevent deflection when the pipe is flowing full; and

(8) if the pipe is a primary spillway, be sized to evacuate 95 percent of the detention storage in 14 or fewer days.

(b) Steel cylinder-reinforced concrete pipe shall be acceptable for use in any dam if the design computations, plans, and specifications related to the placement of the pipe meet the minimum requirements of the manufacturer.

(c) In applying the provisions of subsections (c), (e), and (f), the depth of fill over the top of each pipe shall be measured from the top of the embankment after settlement has occurred. Reinforced concrete pipe shall be acceptable for use in a low-impact dam if less than 30 feet of fill will be placed over the pipe and if the design computations, plans, and specifications related to the placement of the pipe meet the minimum requirements of the manufacturer.

(d) Each metal pipe shall be coated with a protective coating adequate to prevent corrosion for the planned life of the dam, or the design report shall include an estimate of the expected life of the pipe, the expected life of the dam, and a plan for replacement of the pipe when it no longer functions as designed.

(e) Corrugated metal pipe shall be acceptable for use in any hazard class A or B dam if no more than 25 feet of fill is placed over the pipe.

(f)(1) Polyvinyl chloride pipe shall be acceptable for use in any dam if the maximum fill over the pipe does not exceed the depth specified in the following table:

Standard dimension ratio (SDR)	Maximum fill over top of pipe (feet)
SDR 17 and thicker	35
SDR 18	31
SDR 21	23
SDR 25	18
SDR 26	16
SDR 28	14

A pipe with walls thinner than SDR 28 shall not be used.

(2) Polyvinyl chloride pipe shall not be placed in high-plasticity soils.

(3) Each portion of polyvinyl chloride pipe that will be exposed to sunlight shall be protected as recommended by the manufacturer of the pipe or shall be encased in a protective material.

(g) Pipe materials other than those described in subsections (b) through (f) may be used if the applicant demonstrates that all of the following criteria are met:

(1) The pipe material, accounting for any protective measures that will be taken, has a minimum expected life of 25 years if exposed to sunlight or buried in soil with the same characteristics of the soil to be used to construct the dam.

(2) All of the pipe manufacturer's design recommendations are met by the plans and specifications for the dam and are documented in the design report.

(3) All of the pipe manufacturer's recommendations for bedding, supporting, and installing the pipe are included in the specifications for construction of the dam, except those specifications that are demonstrated in the design report to be inapplicable in the construction of the proposed dam.

(4) The design report includes an estimate of

the life of the pipe, the life of the dam, and a plan to replace the pipe when it no longer functions as designed if the design life of the pipe is less than that of the dam.

(5) The design report demonstrates that the proposed placement and use of the pipe will meet the requirements of sound engineering principles and commonly accepted engineering practices.

(h) If the estimated life of a pipe is less than the estimated life of the dam, the permit shall contain the condition that the pipe shall be replaced when the pipe no longer functions properly. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-51. Acceptable trash racks for primary spillways. (a) Except as specified in subsection (c), each new or modified primary spillway permitted on or after the effective date of this regulation shall be equipped with an acceptable trash rack, as specified in subsection (b).

(b) "Acceptable trash rack" shall mean a trash rack designed and constructed to prevent debris from clogging the inlet of the primary spillway or the primary spillway conduit. Each acceptable trash rack shall be constructed of material of sufficient strength to withstand the impact of the material that could strike the inlet.

(c)(1) Each primary spillway in a dam permitted before the effective date of this regulation shall be equipped with the acceptable trash rack required by the permit and approval of design. If no trash rack was required by the permit and approval of design, no trash rack shall be required unless the primary spillway fails to function properly.

(2) If the applicant demonstrates that there is not sufficient woody vegetation or other debris in the drainage area to justify the installation of an acceptable trash rack, the requirement to have an acceptable trash rack may be waived.

(d) If a fish screen is installed, the screen shall not impair the functioning of the primary spillway. If a fish screen is proposed, the design report shall demonstrate that the screen is designed in accordance with the standards of subsection (b) and will not impair the functioning of the primary spillway. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-52. Stilling basins. (a) For each new dam, for each primary spillway conduit replacement, and for each existing dam for which the chief engineer determines that it is necessary to protect the integrity of the embankment, each primary spillway conduit with a cross-sectional area in excess of 1.75 square feet shall discharge into one of the following:

(1) A constructed stilling basin below the downstream toe of the dam; or

(2) any other constructed works designed to dissipate energy and prevent erosion.

(b) If a stilling basin is required or constructed, the stilling basin shall be designed to dissipate the energy of the water exiting the conduit so that the stilling basin discharges water to the receiving channel without causing excessive erosion and the stilling basin itself is not damaged by full conduit flow.

(c) The invert of the outlet conduit that discharges into a stilling basin shall be located at least one foot above the tailwater elevation in the stilling basin when water is flowing through the primary spillway at the maximum rate of discharge during the design storm. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-53. Drawdown pipes. (a) Except as specified in subsection (b), each dam shall be equipped with a drawdown pipe that meets the requirements for a pipe as specified in K.A.R. 5-40-50. A valve or gate shall be installed in the pipe so that the controls are accessible and damage from freezing is prevented. Drawdown pipes may be incorporated into the primary spillway.

(b) The installation of a drawdown pipe shall not be required for a low-impact dam if the chief engineer determines that both of the following criteria are met:

(1) The failure to install a drawdown pipe will not prejudicially and unreasonably affect the public interest and the public safety.

(2) The drawdown pipe is not necessary to administer water rights.

(c) Each drawdown pipe shall have the capacity to evacuate 90 percent of the volume of the permanent pool in 14 or fewer days assuming no inflow into the reservoir, but in no case shall the drawdown pipe have an internal diameter of less than four inches. The inlet of the drawdown pipe shall be constructed to reduce the likelihood of plugging. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-54. Control of seepage along a conduit. (a) Each conduit through any portion of a dam below the elevation of the permanent pool shall be constructed to protect the dam from seepage along the conduit by means of cutoff collars or a drainage diaphragm. Cutoff collars may be used only on hazard class A dams that are class sizes one and two.

(b) Each drainage diaphragm shall meet all of the following design criteria:

(1) Be installed so that the largest face is perpendicular to the conduit;

(2) be sized as follows:

(A) If the conduit is circular, the diaphragm shall extend a minimum of two feet or three times the outside diameter of the conduit, whichever is greater, from the outside surface of the conduit horizontally and vertically upward. The diaphragm shall extend vertically downward a minimum of two feet from the outside surface of the conduit;

(B) if the conduit is rectangular, the diaphragm shall extend minimum of two feet or three times the vertical dimension of the conduit, whichever is greater, from the outside surface of the conduit horizontally and vertically upward. The diaphragm shall extend vertically downward a minimum of two feet from the outside surface of the conduit;

(C) a drainage diaphragm shall not be required to penetrate unweathered bedrock; and

(D) the diaphragm shall not be required to extend vertically upward to an elevation higher than the crest of the auxiliary spillway;

(3) have a dimension parallel to the conduit that is at least three feet thick;

(4) except as specified in subsection (d), be located downstream of the centerline of the dam, downstream of the cutoff trench, and far enough upstream of the toe so that there is a minimum of two feet of fill, measured perpendicular to the surface of the embankment, over the top of the diaphragm after settlement of the embankment; and

(5) have an outlet that provides positive drainage of the diaphragm to the stilling basin or other point below the downstream toe of the dam. The flow line of the outlet shall be no lower than one-half foot above the elevation of the outlet of the stilling basin.

(c) Except as specified in subsection (d), each cutoff collar shall meet all of the following design criteria:

(1) Be constructed of the same or similar material as that of the conduit;

(2) be attached to the conduit with a watertight seal;

(3) be of sufficient size and number to increase the length of the seepage path by at least 15 percent;

(4) be spaced at intervals of at least twice the vertical dimension of the largest collar being used;

(5) be located along the conduit in that portion of the dam that will be saturated;

(6) project a minimum of two feet beyond the outside wall of the conduit; and

(7) be located no closer than two feet from any conduit joint.

(d) If cutoff collars or a drainage diaphragm is located in a zoned fill, the location shall be justified in the design report and established in accordance with sound engineering principles and commonly accepted engineering practices.

(e) If another drain included in the design meets the requirements for a diaphragm in subsection (b), that other drain may be considered to be the diaphragm required by subsection (a).

(f) If the applicant desires to use any other type of seepage control, the applicant shall demonstrate to the chief engineer that the proposed type of seepage control protects the dam from seepage along the conduit and meets the requirements of sound engineering principles and commonly accepted engineering practices. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-55. Earthen auxiliary spillways. Each earthen auxiliary spillway shall meet all of the following requirements: (a) If the design discharge from the auxiliary spillway is directed so that the discharge impinges on the downstream toe of the dam, a wing dike shall be designed and constructed to direct spillway flows away from the downstream toe of the dam.

(b) If the auxiliary spillway is located on the embankment of the dam, adequate armor protection, including articulated blocks, concrete paving, gabion baskets underlain with properly designed bedding, or engineered riprap, shall be placed on the portion of the dam where the auxiliary spillway is located.

(c) The side slopes shall be no steeper than three horizontal units to one vertical unit, unless

the spillway is constructed through competent sandstone or limestone.

(d) There shall be at least a 30-foot level section immediately upstream of the control section. Immediately downstream of the control section, the slope of the spillway outlet shall be sufficient to ensure that flows at and above 50 percent of the design storm discharge will flow at a supercritical velocity.

(e) The auxiliary spillway shall be a minimum of three feet deep, as measured from the elevation of the control section to the design top of the dam.

(f) The entrance channel from the reservoir to the level section shall provide a smooth transition that prevents turbulent flow.

(g) The outlet channel shall convey flow to the receiving stream channel with a minimum of erosion.

(h) If a fish screen is installed, the screen shall not impair the functioning of the auxiliary spillway. If a fish screen is proposed, the design report shall demonstrate that the screen will not impair the functioning of the auxiliary spillway. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-56. Maximum design velocity for an auxiliary spillway. (a) The maximum velocity in feet per second during the design storm for water flowing in a vegetated earthen auxiliary spillway shall be determined from the following table:

	Slope of the exit channel			
Vegetation	**Erosion-resistant soils**		**Easily erodible soils**	
	0% to 5%	**5% to 10%**	**0% to 5%**	**5% to 10%**
Bermuda grass and Bahia grass	8	7	6	5
buffalo grass, Kentucky blue grass, smooth brome grass, tall fescue, and reed canary grass	7	6	5	4
sod-forming grass-legume mixtures	5	4	4	3
weeping love grass, yellow bluestem, and native grass mixtures	3.5	3.5	2.5	2.5

(b) The maximum design velocities specified in subsection (a) may be increased by not more than 10 percent if the design frequency of use of the auxiliary spillway is not more than two percent. The maximum design velocities may be increased by not more than 25 percent if the design frequency of use of the auxiliary spillway is not more than one percent.

(c) For exit channel slopes greater than 10 percent, the applicant shall provide analyses showing both of the following:

(1) There is no more than 0.5 foot of erosion depth within 20 feet of the control section for the one-percent chance storm.

(2) The auxiliary spillway does not fail by breaching during the spillway stability design event indicated in the following table:

Hazard class	Size class	Spillway stability design event
A	1, 2, or 3	0.3 PMP
A	4	0.4 PMP
B	1, 2, 3, or 4	0.5 PMP
C	1, 2, 3, or 4	PMP

(d) The provisions of paragraphs (c)(1) and (2) may be used for slopes of 10 percent or less in lieu of the maximum values specified in the table in subsection (a).

(e) The maximum allowable design velocity for water flowing over the following types of materials shall be determined from the following table:

Material	Maximum velocity allowed in feet per second
stratified rock	8.0
sound rock	13.0

(f) Channel lining materials not reliant on vegetation, including concrete, riprap, and grouted riprap, may be used if the applicant demonstrates that the lining will not fail during the spillway stability design event specified in paragraph (c)(2). (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-57. Service spillway design. (a) If a dam will have a service spillway, the spillway shall be designed and constructed with a lining material that meets the following requirements:

(1) Covers the channel floor and walls up to the

depth of flow required to bypass the flows of the storm specified as the detention requirement in K.A.R. 5-40-23(a), at a minimum; and

(2) will not fail during the spillway stability design event specified in K.A.R. 5-40-56(c)(2).

(b) Each design report required by K.A.R. 5-40-2b shall include all hydraulic, structural, and geotechnical design information necessary to show that the criteria in subsection (a) are met.

(c) If a fish screen is installed, the screen shall not impair the functioning of the service spillway. If a fish screen is proposed, the design report shall demonstrate that the screen will not impair the functioning of the service spillway. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-70. Construction notification to the chief engineer. Each holder of a permit to construct, or an approval to repair or modify a dam, shall notify the chief engineer at least 48 hours before any of the following stages of construction and shall obtain the approval of the chief engineer before proceeding with each of these stages of construction: (a) Starting construction;

(b) placing backfill in the cutoff trench;

(c) placing backfill around the primary spillway conduit or any other conduit that extends through the dam embankment and exits the downstream slope; and

(d) starting any stage of construction not specified in this regulation for which the permit requires that the chief engineer shall be notified. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-301a and 82a-303a; effective May 18, 2007.)

5-40-71. Inspection during dam construction, repair, and modification. (a) Except as specified in subsection (d), each high-impact dam shall be inspected by an engineer competent in the design of dams, or that engineer's authorized representative, at all times during any construction activity.

(b) Each low-impact dam shall be inspected by an engineer qualified in the design of dams, or that engineer's authorized representative, whenever any of the following conditions is met:

(1) Backfill is being placed in the cutoff trench of a dam.

(2) Conduits and their appurtenances are being placed.

(3) Backfill is being placed around a conduit.

(4) Drain material and outlets are being installed.

(5) Concrete forms and reinforcing steel are being placed.

(6) Concrete is being placed.

(7) Any other stage of construction required by the permit, approved plans, or approved specifications to be inspected occurs.

(c) Before the start of construction, the permit holder shall provide the chief engineer in writing with the name, address, and telephone number of the engineer responsible for the inspection.

(d) The inspecting engineer, or the engineer's authorized representative, shall not be required to be present during any of the following construction activities for a high-impact dam:

(1) The clearing and grubbing of the construction site;

(2) the removal of structures from the reservoir area other than the removal of a dam;

(3) the installation of pollution-control measures, unless required by other authorities;

(4) seeding;

(5) mulching; and

(6) the construction of a fence.

(e) If the inspecting engineer, or the engineer's authorized representative, observes construction activity that is not in compliance with the approved permit, plans, or specifications and the contractor fails to correct the item or items that are not in compliance with the approved permit, plans, or specifications after being notified by the inspector, the inspector shall notify the chief engineer of the noncompliant activity. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-301a and 82a-303a; effective May 18, 2007.)

5-40-72. Construction inspection reports. The engineer responsible for the inspection required by K.A.R. 5-40-71 shall, within 30 days of the completion of the construction, repair, or modification of the dam and its appurtenances, submit to the chief engineer an inspection report containing the following items: (a) A notice of completion showing the date on which construction, repair, or modification of the dam and its appurtenances was completed;

(b) a statement indicating one of the following:

(1) The dam and its appurtenances were constructed, repaired, or modified substantially in accordance with the permit and the approved plans and specifications; or

(2) the completed work varied from the permit and the approved plans and specifications. A description of each variation shall be provided;

(c) a final survey of the completed dam and its appurtenances, including the following:

(1) A profile of the top of the dam;

(2) a profile of the centerline of the auxiliary spillway or service spillway;

(3) a cross section at the control section of the auxiliary spillway or service spillway;

(4) a cross section of the dam at its deepest point;

(5) a cross section of the dam at the primary spillway if that section is not near the deepest section of the dam;

(6) the locations and elevations of the inlet and the outlet of the primary spillway;

(7) the location and elevation of each drain outlet; and

(8) the final elevation and coordinates of each permanent benchmark; and

(d) a summary or a copy of the daily inspection logs if required by the permit. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-301a and 82a-303a; effective May 18, 2007.)

5-40-73. Emergency action plan. (a) The owner of each hazard class B dam shall create an emergency action plan (EAP) on a form prescribed by the chief engineer. The owner shall keep the original EAP and submit a copy of the EAP to the chief engineer. The EAP shall address each of the following:

(1) A description of the dam, including the location of the dam and the access roads;

(2) the name, address, and telephone number of the person responsible for notifying local authorities of an emergency;

(3) a map or written description of the area that could be inundated by the type of breach described in K.A.R. 5-40-24;

(4) a list of persons who should be notified in case of an emergency, including the telephone numbers of those persons and their responsibilities; and

(5) the names, addresses, and telephone numbers of each owner of the dam and its appurtenances and those persons responsible for the operation and maintenance of the dam.

(b) Except as specified in subsection (d), the owner of a hazard class C dam shall create and maintain an emergency action plan that meets the recommendations of the "federal guidelines for dam safety: emergency action planning for dam owners," prepared by the interagency committee on dam safety and published by the federal emergency management agency, dated October 1998 and reprinted January 2004, which is hereby adopted by reference. The owner shall submit a copy of the EAP to the chief engineer.

(c) The owner of any dam for which an EAP is required under these regulations shall annually review the EAP to determine if it is still accurate and applicable to the current condition of the dam and current downstream conditions, including the following:

(1) The contact names and related information;

(2) the breach inundation map or a description of the inundation area; and

(3) emergency procedures.

If any material changes are made when updating the EAP, a copy of the revised EAP shall be submitted to the chief engineer.

(d) Any owner of a hazard class C dam may request that the chief engineer allow the owner to submit an EAP that meets only the requirements of subsection (a) in lieu of meeting the requirements of subsection (b). To make this request, the owner shall submit written justification of why an EAP meeting the requirements of subsection (a) is sufficient to protect the public safety. If the chief engineer approves the request, the chief engineer shall reserve the right to later impose the requirements of subsection (b) if downstream conditions change, the condition of the dam deteriorates, or the EAP does not adequately protect the public safety.

(e) The owner of a hazard class B dam shall submit the required EAP within 180 days of written notification by the chief engineer of the requirement.

(f) The owner of a hazard class C dam shall submit the required EAP within 180 days of written notification by the chief engineer that an EAP is required and that an adequate EAP is not on file in the chief engineer's office. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-73a. Discovery of an existing illegal, unpermitted dam. (a) Except when it is necessary to take additional actions to protect the public safety, when the chief engineer becomes aware of an existing illegal, unpermitted dam, the

following actions shall be taken by the chief engineer:

(1) Determine the hazard classification and condition of the dam;

(2) notify the owner of the dam of the following, in writing:

(A) The fact that the dam is illegal and unpermitted;

(B) the hazard classification of the dam;

(C) the fact that if the owner desires to keep the dam in existence, the owner shall submit a complete application for a permit for the dam pursuant to K.S.A. 82a-301 and K.S.A. 82a-302, and amendments thereto, within 120 days of the date of the chief engineer's notification;

(D) the condition that the application to obtain a permit for the dam shall meet the requirements of K.A.R. 5-40-8 and K.A.R. 5-40-74;

(E) the fact that failure to apply for a permit within 120 days shall result in the issuance of an order by the chief engineer requiring the owner to submit plans to breach or completely remove the dam; and

(F) the fact that the dam is subject to the provisions of this regulation.

(b)(1) If the owner submits an application for a permit within the time specified in paragraph (a)(2)(C), or within any extension of time authorized by the chief engineer in writing, the application shall meet the requirements of K.A.R. 5-40-8 and K.A.R. 5-40-74.

(2) If the owner fails to submit an application for a permit within the time specified in paragraph (a)(2)(C), or within any extension of time authorized by the chief engineer, an order requiring the owner to perform the following shall be issued by the chief engineer:

(A) Submit plans to breach or completely remove the dam; and

(B) bypass inflows and release water from storage so that no more than 15 acre-feet of water is kept in storage in the reservoir while the application for a permit to breach or completely remove the dam is being processed. The application for a permit shall contain all of the information required by K.A.R. 5-40-8 and any other information necessary to properly and safely design and complete the breach or removal. The application shall be submitted within 120 days of the date of the order, or within any extension of time authorized by the chief engineer. The owner shall be required to complete the breach or removal as permitted by the chief engineer within one year of the approval of a permit by the chief engineer, or any extension of time authorized by the chief engineer in writing.

(c) If the chief engineer dismisses an application for an existing illegal, unpermitted dam for any reason, the dismissal of the application shall be accompanied with an order requiring the dam to be breached or removed as provided in paragraph (b)(2).

(d) The order described in paragraph (b)(2) shall be filed by the chief engineer with the register of deeds for the county in which the dam is located.

(e) Each existing illegal, unpermitted dam of which the chief engineer becomes aware, either before or after the adoption of this regulation, shall be subject to this regulation. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-301, 82a-302, and 82a-303a; effective May 18, 2007.)

5-40-74. Design criteria for an existing illegal, unpermitted dam. (a) Except as specified in subsection (b), the design criteria specified in this subsection (a) shall be met to obtain a permit from the chief engineer pursuant to K.S.A. 82a-301 et seq., and amendments thereto, for an existing illegal, unpermitted hazard class A dam constructed before May 1, 1984 that has not been modified on or after May 1, 1984. The applicant shall have an engineer who is qualified in dam design and construction conduct an inspection of the dam and prepare a report that includes all of the following:

(1) The date of the inspection and a list of the members of the inspection team;

(2) color photographs documenting the condition of the dam's appurtenances and embankment and any observed deficiencies in the appurtenances and embankment;

(3) a plan view sketch of the dam and its immediate vicinity showing the location from which each photograph was taken and the direction in which it was taken;

(4) a description of the physical condition of the dam and its appurtenances, a list of the deficiencies that were observed, and a description of the severity of each observed deficiency. All deficiencies that may threaten the structural integrity of the dam shall be shown; and

(5) a survey of the dam, documented by a plan view of the dam and cross section drawings, including the following:

(A) Cross sections of the embankment every 200 feet, with each cross section starting from the upstream toe of the dam or the water surface on the upstream side to the toe of the dam on the downstream side of the dam;

(B) a profile of each open-channel spillway from the water surface on the upstream side of the dam to the point where spillway flows enter the receiving stream;

(C) a cross section of each open-channel spillway every 200 feet and at each control section, with a minimum of two cross sections;

(D) the elevation of each primary spillway inlet and outlet;

(E) the elevation of the flow line of the outlet channel; and

(F) the dimensions, locations, and descriptions of materials, workmanship, condition, apparent purpose for, and any other relevant information about all visible appurtenances in sufficient detail to represent the appurtenances in three dimensions;

(6) the dimensions and location of each deficiency noted as required in paragraph (a)(4);

(7) the estimated rate and color of discharge from drain outlets and any seeps;

(8) a determination of the hazard classification of the dam as specified in K.A.R. 5-40-24;

(9)(A) A description of the drawdown valve, if any;

(B) specification of whether the valve was operated during the inspection; and

(C) if the valve could not be operated, an explanation of why it could not be operated;

(10) the name, mailing address, and telephone number of the engineer who conducted the inspection;

(11) the name, mailing address, and telephone number of each current owner of the dam; and

(12) any other information relevant to the safety and integrity of the dam, including any items requested by the chief engineer before the inspection.

(b) If the applicant provides construction plans prepared before construction that show how the dam was to be constructed or modified and that reflect the actual dimensions of the dam as it exists, those plans may be substituted for the survey required in paragraph (a)(5).

(c) If the chief engineer determines from the inspection report that the dam does not pose a threat to public safety or public or private property and that the condition of the dam is sound, an after-the-fact permit may be issued by the chief engineer pursuant to K.S.A. 82a-301 et seq., and amendments thereto.

(d)(1) In order for an existing illegal, unpermitted hazard class A dam constructed or modified on or after May 1, 1984 or an existing illegal, unpermitted hazard class B or C dam to receive a permit from the chief engineer pursuant to K.S.A. 82a-301 et seq. and amendments thereto, the applicant shall demonstrate that the dam meets all of the applicable statutory and regulatory requirements in effect when the application for the permit is filed. The applicant shall provide a survey meeting the requirements of paragraph (a)(5) and a design report that meets the requirements of K.A.R. 5-40-2b. If plans are available that show how the dam was constructed or modified and those plans reflect the actual dimensions of the dam as it exists when the application is filed, the plans may be substituted for the required survey. If a geologic investigation was conducted before construction of the dam and the results of that investigation are available, that investigation may be substituted for the investigation and report required by K.A.R. 5-40-40 through K.A.R. 5-40-42.

(2) If the applicant cannot determine that the chief engineer's requirements for the following design or actual construction properties were met without significantly disturbing the embankment but the applicant demonstrates that the dam was built in a manner appropriate to the standards in effect when the dam was constructed, then a permit may be issued if the chief engineer determines that the dam does not pose a hazard to public safety:

(A) The location, dimensions, and composition of the backfill materials to fill the cutoff trench;

(B) the location, dimensions, and construction of cutoff collars, drains, or other seepage control;

(C) the allowance for settlement of an earthen dam;

(D) specification of whether the primary spillway pipe was tested;

(E) the specifications used; and

(F) documentation of any construction inspections. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-301a, 82a-302, and 82a-303a; effective May 18, 2007.)

5-40-75. Maintenance of dams. Each owner of a dam that the chief engineer has authority to regulate pursuant to K.S.A. 82a-301 et seq., and amendments thereto, shall operate and

maintain the dam in a manner that protects the public safety, complies with the terms of any permit of the chief engineer, and ensures the integrity of the dam. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-301a and 82a-303a; effective May 18, 2007.)

5-40-76. Repair or modification of a permitted or prejurisdictional dam. (a) The repair or modification of a permitted or prejurisdictional dam shall meet the requirements of both of the following:

(1) The statutes and the regulations in effect when the application for repair or modification is filed; and

(2) any additional criteria specified by the chief engineer that are necessary to ensure the integrity of the dam and its appurtenances.

(b) At the time of the repair or modification, the applicant shall bring the dam and all of its appurtenances into conformance with the requirements of the statutes and regulations in effect at the time of the application for repair or modification, unless both of the following conditions are met:

(1) The applicant demonstrates that bringing any feature of the dam and its appurtenances into compliance is not feasible or is unduly burdensome.

(2) The chief engineer determines that failing to bring any feature of the dam into compliance with one or more requirements applicable to that feature will not significantly affect the public safety.

(c) Each application to repair or modify a dam or its appurtenances shall include a design report on the repair or modification, including a section describing the condition of the dam at the time of the application. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-77. Easements for dams. (a) Each applicant that applies for a permit to construct a dam, modify a dam in a manner that will raise the top of the dam, or modify the dam in any other way that will increase the backwater effect of the dam or the flow of water from the dam to the receiving stream shall demonstrate either of the following to the chief engineer:

(1) The applicant owns the site of the dam and appurtenant works, the land that will be inundated, and the land over which discharge from the dam's spillways will flow.

(2) The applicant has easements or other legal authority to perform the following for the design life of the dam:

(A) Construct and maintain the dam;

(B) inundate all of the land upstream from the dam to the top of the dam elevation; and

(C) discharge water from the spillways to a stream channel and the associated floodplain adequate to convey the discharge from the design storm.

(b) For permitted dams for which a modification is proposed, an easement or other legal authority shall be required only for the effects caused by the modification. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302, K.S.A. 82a-303, and K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

5-40-90. Requirements for a dam safety inspection report. Each dam safety inspection report required by K.S.A. 82a-303b, and amendments thereto, shall document the observations made during the inspection and the engineer's opinion of the condition of the dam and shall include all of the following:

(a) An executive summary briefly describing the overall condition of the dam as found during the inspection;

(b) the date of the inspection and a list of the members of the inspection team;

(c) color photographs documenting the condition of the dam appurtenances and embankment and any observed deficiencies in the appurtenances and embankment;

(d) a plan view sketch of the dam and the vicinity, showing the location where each photograph was taken and the direction in which the photograph was taken;

(e) a description of the physical condition of the dam and its appurtenances, a list of any deficiencies that were observed, and a plan view sketch of the dam and its appurtenances showing the location of those deficiencies. The deficiencies that shall be shown shall include those that meet any of the following conditions:

(1) Violate the permit or approved plans or any approved modifications of the permit or approved plans;

(2) threaten the structural integrity of the dam; or

(3) threaten the safety of people or property above or below the dam;

(f) survey and other documenting data if the

engineer observes any changes from previously documented conditions in the dam or its appurtenances that could jeopardize the integrity of the dam, including any changes in the profile or cross section of the dam, profile, or cross section of any open-channel spillway, and areas of settlement or erosion;

(g) a description of the severity of each observed deficiency and the engineer's opinion about the urgency of remedying each deficiency;

(h) a summary of the engineer's review of the adequacy of the emergency action plan, including a review of any updates since the last inspection;

(i) the estimated rate and color of discharge from drain outlets and any seeps;

(j) a statement indicating whether the engineer agrees or disagrees with the hazard classification of the dam, including the reasons why the engineer agrees or disagrees with that classification;

(k) a map drawn to a scale of 1:24,000 or larger showing the location of any hazards added, removed, or not previously shown downstream of the dam, in addition to those identified in previous reports, that would require a modification of the emergency action plan or might change the hazard classification of the dam;

(l) any significant changes in the capacity of the reservoir;

(m) any significant changes in the capacity of any spillway;

(n) a statement indicating whether there have been any significant changes in the watershed and an estimate of the impact of those changes on the design hydrology;

(o) the name, mailing address, and telephone number of the engineer;

(p) the name, mailing address, and telephone number of each current owner of the dam;

(q) observations or readings from all instrumentation required by the permit, the approved plans, the approved specifications, or the chief engineer;

(r)(1) A description of the drawdown valve, if any; and

(2) specification of whether the drawdown valve was operated during the inspection and, if the valve could not be operated, an explanation of why it could not be operated; and

(s) any other information relevant to the safety of the dam, including any items requested by the chief engineer before the inspection. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-303a and 82a-303b; effective May 18, 2007.)

5-40-91. Schedule for inspection of hazard class C dams. Each hazard class C dam shall be inspected every third inspection year after the inspection year in which the initial inspection was completed. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-303a and 82a-303b; effective May 18, 2007.)

5-40-92. Schedule for inspection of hazard class B dams. Each hazard class B dam shall be inspected every fifth inspection year after its initial inspection. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-303a and 82a-303b; effective May 18, 2007.)

5-40-93. Schedule for inspection of dams. The initial and follow-up dam safety inspections required by K.S.A. 82a-303b, and amendments thereto, for any dam completed on or after July 1, 2002, shall be conducted and a report shall be filed with the chief engineer in accordance with the following schedule: (a) Each permitted hazard class C dam shall be inspected in the third inspection year after the inspection year in which the dam is completed and every third inspection year thereafter.

(b) Each permitted hazard class B dam shall be inspected in the fifth inspection year after the inspection year in which the dam is completed and every fifth inspection year thereafter.

(c) Each unpermitted class B or class C hazard dam completed on or after July 1, 2002, shall be inspected in accordance with a schedule approved by the chief engineer as necessary to protect the public safety.

(d) Each dam that had its hazard class increased by the chief engineer on or after July 1, 2002, shall initially be inspected by the chief engineer in the inspection year in which the hazard class is increased.

(e) If the dam was reclassified as a hazard class B dam, the dam shall be inspected every fifth inspection year after the inspection year in which the hazard class was changed.

(f) If the dam was reclassified as a hazard C dam, the dam shall be inspected every third inspection year after the inspection year in which the hazard class was changed. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-303a and 82a-303b; effective May 18, 2007.)

5-40-94. Revision of schedule of inspections. For good cause shown, including a change

in hazard class or repair or modification of a dam, the dam safety inspection schedule may be revised by the chief engineer and a new inspection cycle may be started. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-303a and 82a-303b; effective May 18, 2007.)

5-40-100. Request to be included on the list of independent engineers qualified to review applications. (a) Each licensed professional engineer who desires to be placed on the list of licensed professional engineers approved to review applications for the permit required by K.S.A. 82a-301 et seq., and amendments thereto, shall submit a request to the chief engineer on a form prescribed by the chief engineer.

(b) Any engineer may request approval in one or more of the following areas:

(1) Dam design;

(2) channel design; and

(3) the design of stream obstructions other than dams.

(c) A team of persons may be qualified to be a reviewer for a project. The qualifications of each team member shall be submitted, and one person shall be designated as the supervising reviewer. The supervising reviewer shall meet the minimum requirements for an individual reviewer. The other members of the review team shall not be required to meet the minimum requirements for an individual reviewer. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-101. Information to be submitted with a request to be a reviewer. (a) Each engineer who wants to be included on the list of licensed professional engineers approved to review applications under the obstructions in streams act, as authorized by K.S.A. 82a-302, and amendments thereto, shall submit that request on a form prescribed by the chief engineer and shall designate each area of review for which the engineer or a team of engineers desires to be approved.

(b) All of the following information shall be included on each request for each area in which the engineer seeks to be approved:

(1) The type and license number of each current license from the Kansas state board of technical professions;

(2) relevant education, including graduate and postgraduate schools attended, degrees received, and professional development work; and

(3) work experience in the requested area of expertise, including the following:

(A) The number of years of experience as an engineering intern;

(B) the number of years of experience as an engineer; and

(C) the approximate number of projects for which the engineer met the following criteria:

(i) Was responsible for the project;

(ii) performed substantive design tasks;

(iii) had quality assurance, quality control, or project review responsibilities; and

(iv) performed construction supervision or inspection; and

(D) the project name, the location, a brief description of the project, and a brief description of the engineer's responsibilities for one or two projects for which the engineer met the following criteria:

(i) Had responsible charge or performed significant portions of the design; or

(ii) provided quality control, quality assurance, project review, construction supervision, or construction inspection duties. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-102. Minimum requirements to be an individual reviewer. To be an individual reviewer, each person shall meet both of the following qualifications: (a) Have a current professional engineer's license from the Kansas state board of technical professions; and

(b) have a minimum of five years of relevant work experience in the area for which approval is sought. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-103. Conflict of interest. A reviewer shall not be eligible to review any of the following: (a) Any project in which the reviewer has participated in the project's design in any way;

(b) any project designed by any other employee of the reviewer's current employer; or

(c) any other project for which the reviewer has a conflict of interest with the owner of the dam, the designer of the dam, or the state of Kansas. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-104. Notification of approval or disapproval to be a reviewer. Within 60 days of the receipt in the office of the chief engineer of a completed request pursuant to K.A.R. 5-40-101, the requester shall be notified by the chief engineer of whether that individual has been approved in each requested area. If the chief engineer has not approved the request for each area of review requested, the requester shall be notified by the chief engineer of the reason or reasons that each request has been denied. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-105. Procedure for independent review of an application to construct a dam or other water obstruction. (a) When an applicant provides a copy of that individual's application to an approved reviewer pursuant to K.S.A. 82a-302 and amendments thereto, the applicant shall also submit the following to the chief engineer:

(1) The original application;

(2) all documentation required for an acceptable application as specified in K.A.R. 5-40-8;

(3) the statutorily required filing fee; and

(4) the name, address, and telephone number of the reviewer.

(b) The review required by the water projects environmental coordination act, K.S.A. 82a-325 et seq. and amendments thereto, shall be initiated by the chief engineer after the chief engineer receives the application.

(c) Within 37 days after the review specified in subsection (b) is initiated by the chief engineer, any comments received from the environmental review agencies shall be sent by the chief engineer to the reviewer. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

5-40-106. Report of findings of independent reviewer. (a) When a reviewer completes the review of an application pursuant to K.S.A. 82a-302 and amendments thereto, the reviewer shall submit a report of that review to the chief engineer. The report shall be properly sealed by the reviewing engineer as directed by the Kansas state board of technical professions.

(b) Each complete report shall include the following:

(1) An opinion as to whether the application meets the requirements of K.S.A. 82a-301 et seq., and amendments thereto, the regulations that implement these statutes, sound engineering principles, and commonly accepted engineering practices;

(2) the basis for that opinion, including any analyses that were performed, and the supporting data;

(3) an evaluation of the comments from the environmental review agencies that were furnished to the reviewer by the chief engineer and a recommendation about how to address all adverse comments;

(4) a recommendation about whether any request by the applicant to waive one or more regulations should be approved and the basis for approving or denying the waiver; and

(5) a recommendation about whether the chief engineer should approve or deny the permit and any conditions that the chief engineer should impose on the permit.

(c) The recommendations shall not be binding on the chief engineer. The chief engineer shall maintain the final authority to approve or deny all applications. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-302 and 82a-303a; effective May 18, 2007.)

Article 42.—DESIGN OF STREAM OBSTRUCTIONS

5-42-1. Stream obstructions; plans and specifications. (a) The plans required for a permit for a stream obstruction pursuant to K.S.A. 82a-301, and amendments thereto, shall include the following:

(1) A general location map or aerial photograph showing the stream, location of the proposed obstruction, sufficient detail to locate the proposed construction site, section lines, a bar scale, a north arrow, property lines with the names and addresses of adjoining landowners and any other landowners whose land may be hydraulically affected by the proposed stream obstruction, drainage area, and any other prominent features;

(2) a detailed plan view fully describing the obstruction and the site;

(3) the following topographical information, which shall be provided from streambed elevation to the limits specified in subsection (b):

(A) A profile of the streambed and both banks;

(B) a contour map with a contour interval of no more than two feet; or

(C) cross sections perpendicular to the stream

and at intervals of no more than five times the width of the channel;

(4) an elevation view showing the obstruction on a cross section of the stream and the valley up to the post project design flood elevation at the site;

(5) at least one permanent benchmark shall be conveniently located for use after construction. The location, description, and elevation of the permanent benchmark to which all elevations are referred shall be shown on the plans. Reference to the national geodetic vertical datum of 1988, or other acceptable national vertical datum, to a tolerance of plus or minus one-half foot shall be required for all stream obstructions on perennial streams and all other streams where base flood elevations have been determined and are shown on flood insurance rate maps. An assumed project datum shall be acceptable on all other stream obstruction projects;

(6) details of the manner in which the obstruction is to be tied into the bed and banks of the streams;

(7) the land for which easements or rights-of-way are to be acquired if the proposed obstruction affects land other than that owned by the applicant; and

(8) unless it is clear that the impact of the proposed project will be contained within the channel or limited to property under the control of the applicant, a hydraulic analysis determining the preproject and postproject water surface elevations for the 50 percent-chance flood and the one percent-chance flood shall be prepared and submitted to the chief engineer.

(b)(1) If it is clear that the impact of the proposed stream obstruction will be contained within the channel or limited to property under the control of the applicant, the topographical information upstream of the stream obstruction required in paragraph (a)(3) shall be required to either of the following, whichever is lower:

(A) The elevation of the highest point on the proposed obstruction; or

(B) the elevation of the one percent-chance flood water surface.

The applicant shall not be required to show topographical information for any property not under the control of the applicant.

(2) If it is not clear that the impact of the proposed project will be contained within the channel or limited to property under the control of the applicant, the topographical information upstream of the stream obstruction required in paragraph (a)(3) shall be provided from streambed elevation up to the elevation of the one percent-chance flood water surface upstream of the stream obstruction.

(3) The topographical information required in paragraph (a)(3) and subsection (b) shall be provided downstream of each proposed stream obstruction for a distance equal to five times the width of the channel at the proposed site of the stream obstruction or 50 feet downstream from the toe of the stream obstruction, whichever is greater.

(c) Each application for a permit to construct a stream obstruction shall include the following specifications:

(1) Each major element in the construction of the obstruction;

(2) the minimum quality of workmanship that is acceptable to construct the obstruction;

(3) the minimum quality of materials that is acceptable to construct the obstruction; and

(4) the materials proposed to be used to construct the obstruction.

(d) The specifications shall meet the following requirements:

(1) Be clear, legible, and shown in sufficient detail to assure that the work can be properly constructed; and

(2) be shown on the plans, in the design report, or on a separate document.

(e) If the Kansas department of transportation (KDOT) standard construction specifications meet all of the requirements of this regulation and are to be enforced during construction, referencing those specifications on the plans shall be sufficient to comply with this regulation.

(f) If the standard construction specifications of a city or county in Kansas meet the following requirements, then referencing those specifications on the plans shall be sufficient to comply with this regulation:

(1) Meet all the requirements of this regulation;

(2) are to be enforced during construction; and

(3)(A) Have been provided to the chief engineer; or

(B) are readily available at no cost from the city or county that utilizes the specifications. (Authorized by K.S.A. 2006 Supp. 82a-303a; implementing K.S.A. 2006 Supp. 82a-301, 82a-302, and 82a-303a; effective May 1, 1987; amended, T-5-12-30-91, Dec. 30, 1991; amended April 27, 1992; amended May 18, 2007.)

5-42-5. Determining the peak discharge of a one percent-chance storm. In determining the flow magnitude of a design storm, the applicant shall use one of the following methods. (a) For drainage areas of less than 640 acres, use of the rational formula shall be acceptable.

The rational formula is Q = CIA

Where C = the runoff coefficient

I = the intensity of rainfall, in inches per hour

A = the drainage area, in acres.

(b) For any drainage area, the flow magnitude of a design storm may be determined by using one of the methods in the following:

(1) "Estimation of peak streamflows for unregulated rural streams in Kansas," water-resources investigations report 00-4079, published by the United States geological survey in 2000, which is hereby adopted by reference;

(2) "urban hydrology for small watersheds," technical release 55, published by the natural resources conservation service and dated June 1986, which is hereby adopted by reference; and

(3) "computer program for project formulation," technical release 20, published by the natural resources conservation service, United States department of agriculture, and dated October 2004, which is hereby adopted by reference.

(c) For streams for which sufficient stream gaging data is available, the applicant may use sound engineering principles and commonly accepted engineering practices to estimate the peak one percent-chance discharge from the gage record.

(d) A method other than the methods specified in subsections (a), (b), and (c) may be used to determine the one percent-chance storm discharge if the method meets both of the following criteria:

(1) The method is based on sound engineering principles and commonly accepted engineering practices.

(2) The method has been previously approved, in writing, by the chief engineer. (Authorized by and implementing K.S.A. 2006 Supp. 82a-303a; effective May 18, 2007.)

Article 44.—FLOODPLAIN MANAGEMENT

5-44-7. Certification of elevations. Any elevation required to be certified to meet the requirements of this article of regulations may be certified by either a licensed land surveyor or a licensed professional engineer. (Authorized by and implementing K.S.A. 2006 Supp. 12-766; effective May 18, 2007.)

Agency 5

Kansas Department of Agriculture—Division of Water Resources

Articles

5-1. Definitions.
5-2. Vested Rights.
5-3. Appropriation Rights.
5-4. Distribution of Water Between Users.
5-5. Change in the Place of Use, the Point of Diversion or the Use Made of Water Under an Existing Water Right.
5-6. Storage of Water.
5-7. Abandonment and Termination.
5-8. Certification of Water Rights.
5-9. Temporary Permits.
5-10. Water Appropriation.
5-11. Assurance Districts.
5-12. Aquifer Storage and Recovery.
5-13. Sand and Gravel Pit Operations.
5-14. Enforcement and Appeals.
5-15. Minimum Desirable Streamflows.
5-16. Flex Account.
5-17. Water Banking.
5-18 to 5-20. Reserved.
5-21. Western Kansas Groundwater Management District No. 1.
5-22. Equus Beds Groundwater Management District No. 2.
5-23. Southwest Kansas Groundwater Management District No. 3.
5-24. Northwest Kansas Groundwater Management District No. 4.
5-25. Big Bend Groundwater Management District No. 5.
5-26 to 5-29. Reserved.
5-30. Dams.
5-31 to 5-39. Reserved.
5-40. Design of Earth Dams.
5-41. Design of Channel Changes.
5-42. Design of Stream Obstructions.
5-43. Sand Dredging Permits.
5-44. Floodplain Management.
5-45. Design of Levees.
5-46. General Permits.
5-47 to 5-49. Reserved.
5-50. Water Transfers.

Article 1.—DEFINITIONS

5-1-1. Definitions. As used in these regulations and the Kansas water appropriation act, and by the division of water resources in the administration of the Kansas water appropriation act, unless the context clearly requires otherwise, the following words and phrases shall have the meanings ascribed to them in this regulation.

(a) "Above-baseflow stage" means streamflow that is in response to a significant runoff event during which period the water level elevation of the stream is greater than the elevation of the adjacent water table.

(b) "Acceptable quality surface water" means surface water that will not degrade the quality of the groundwater source into which it is discharged.

(c) "Application" means the formal document submitted on the form prescribed by the chief engineer for a permit to appropriate water for beneficial use and filed in the office of the chief engineer as provided by K.S.A. 82a-708a and 82a-709, and amendments thereto.

(d) "Approval of application" means a permit to proceed with construction of diversion works and the diversion and use of water in accordance with the terms and conditions set forth in the permit. Approval of application shall not constitute any permit that may be required by other state laws.

(e) "Aquifer storage" means the act of storing water in the unsaturated portion of an aquifer by artificial recharge for subsequent diversion and beneficial use.

(f) "Aquifer storage and recovery system" means the physical infrastructure that meets the following conditions:

(1) Is constructed and operated for artificial recharge, storage, and recovery of source water; and

(2) consists of apparatus for diversion, treatment, recharge, storage, extraction, and distribution.

(g) "Artificial recharge" means the use of source water to artificially replenish the water supply in an aquifer.

(h) "Authorized representative" means any staff employee designated by the chief engineer to perform duties and functions on behalf of the chief engineer.

(i) "Bank storage" means water absorbed by and temporarily stored in the banks and bed of a stream during above-baseflow stage.

(j) "Bank storage well" means a well used to divert or withdraw water from bank storage.

(k) "Basin storage area" means the portion of the aquifer's unsaturated zone used for aquifer storage that has defined horizontal boundaries and is delimited by the highest and lowest index water level elevations.

(l) "Basin storage loss" means that portion of artificial recharge naturally flowing or discharging from the basin storage area.

(m) "Basin term permit" means a term permit to appropriate surface water from a stream within a specific drainage basin, or a portion of it, for a reasonable quantity of water, not to exceed a maximum of 100 acre-feet per calendar year, for use in either of the following:

(1) Drilling oil and gas wells; or

(2) construction projects within the specified basin.

(n) "Battery of wells" means two or more wells connected to a common pump by a manifold, or not more than four wells in the same local source of supply within a 300-foot-radius circle that are being operated by pumps not to exceed a total maximum rate of diversion of 800 gallons per minute and that supply water to a common distribution system.

(o) "Beneficial uses of water" are the following:

(1) Domestic uses;

(2) stockwatering;

(3) municipal uses;

(4) irrigation;

(5) industrial uses;

(6) recreational uses;

(7) waterpower;

(8) artificial recharge;

(9) hydraulic dredging;

(10) contamination remediation;

(11) dewatering;

(12) fire protection;

(13) thermal exchange; and

(14) sediment control in a reservoir.

(p) "Complete and accurate water use report" means a water use report that the water right owner has filed pursuant to K.S.A. 82a-732, and amendments thereto, that provided all of the information required on the form prescribed by the chief engineer, including the following:

(1) The quantity of water diverted during the calendar year;

(2) if the diversion of water was required to be metered during the calendar year for which the

report is being filed, the information required by K.A.R. 5-3-5e;

(3) if the water was used for irrigation purposes, the number of acres that were irrigated; and

(4) if the water was diverted from a sand and gravel pit operation, the size of the surface area of the pit in acres at the end of the calendar year for which the report was filed.

(q) "Completed substantially as shown on aerial photograph, topographic map, or plat," as used to define the authorized point of diversion, means within 300 feet of the location as shown on the aerial photograph, topographic map, or plat accompanying the application.

(r) "Confined Dakota aquifer system" means that portion of the Dakota aquifer system overlain by Graneros shale.

(s) "Conjunctive use" means the safe-yield management and operation of an aquifer in coordination with a surface water system to enhance the use of the total water supply availability in accordance with the provisions of the water appropriation act.

(t) "Contamination remediation" means the diversion of water by a state agency, or under a written agreement or order of an appropriate state agency, for the purpose of improving the water quality.

(u) "Dakota aquifer system" shall include the Dakota formation, the Kiowa formation, the Cheyenne sandstone, and, where hydraulically connected, the Morrison formation.

(v) "Dakota aquifer system well" means a well or proposed well screened in whole or in part in the Dakota aquifer system.

(w) "Dam" means any artificial barrier, together with all appurtenant works, that does or could impound water.

(x) "Dewatering" means the removal of surface water or groundwater to achieve either of the following:

(1) Facilitate the construction of a building, pipeline, or other facility; or

(2) protect a building, levee, mining activity, or other facility.

(y) "Direct diversion of surface water" means the diversion of surface water directly from a stream by means of a pump, headgate, siphon, or similar installation, for application to beneficial use without storing it behind a dam, levee, or similar type of structure.

(z) "Diversion" means the act of bringing water under control by means of a well, pump, dam, or other device for delivery and distribution for the proposed use.

(aa) "Diversion works" means any well, pump, power unit, power source, dam, and any other devices necessary to bring water under control for delivery to a distribution system by which the water will be distributed to the proposed use and any other equipment required as a condition of the permit, including a check valve, water level measurement tube, meter, or other measuring device.

(bb) "Division" means the division of water resources of the Kansas department of agriculture.

(cc) "Dry hydrant" means a permanent, unpressurized intake pipe used to remove water from a pond, stream, reservoir, or other surface water supply by means of suction or vacuum supplied by a fire truck or other portable pumping device.

(dd) "Field inspection" means that for the purpose of issuing a certificate of appropriation pursuant to K.S.A. 82a-714 and amendments thereto, the chief engineer conducts a test of the rate of diversion of the diversion works under the normal and maximum conditions that the diversion works actually applied water to beneficial use during the perfection period. The chief engineer also collects all other information necessary to prepare a certificate, including the following:

(1) A description of the location and size of the place where water was actually applied to beneficial use during the perfection period in accordance with the terms, conditions, and limitations of the approval of application;

(2) information on the quantity and rate of water that was applied to the authorized use during the perfection period; and

(3) the actual location of the point or points of diversion from which water was diverted in accordance with the terms, conditions, and limitations of the approval of application.

(ee) "Fire protection" means the use of water for fire protection by a fire department for public protection in general.

(ff) "Fish farming" means the controlled cultivation and harvest of aquatic animals.

(gg) "Flow-straightening vanes" means vanes, or other device installed at the upstream throat of a measuring chamber for the purpose of aligning all velocity components of flow parallel with the flow in the measuring chamber at the water flowmeter sensor location.

(hh) "Full irrigation" means the application of water to crops during the growing season. Full irrigation shall include water for preirrigation.

(ii) "Groundwater" means water below the surface of the earth.

(jj) "Growing season" means the average frost-free period of the year.

(kk) "Household purposes" means the use of water by a person for cooking, cleaning, washing, bathing, human consumption, rest room facilities, fire protection, and other uses normally associated with the operation of a household.

(1) "Fire protection" shall be considered to be use of water for "household purposes" if either of the following conditions is met:

(A) Water is available from a "dry hydrant" that has been installed on a pond located within 1,000 feet of the residence.

(B) Water can be pumped from a well located within 1,000 feet of the residence for fire protection.

(2) Household purposes shall also include the replacement of the potential net evaporation from a domestic pond of up to ½ acre in surface area if both of the following conditions are met:

(A) The pond is utilized for aesthetic purposes as an integral part of the landscaping of a house.

(B) Any portion of the pond is located within 300 feet of the closest edge of the house.

(3) The maximum reasonable annual quantity of groundwater that may be pumped into a pond to be withdrawn later for domestic fire protection shall not exceed 0.06 acre-feet plus the average annual potential net evaporation for a pond at that location in the state having a surface area of 0.2 of an acre.

(4) Household purposes shall also include the use of 1½ acre-feet of water or less per calendar year by an industrial user, restaurant, hotel, motel, church, camp, correctional facility, educational institution, or similar entity for household purposes.

(ll) "Hydraulic dredging" means the removal of saturated aggregate from a stream channel, pit, or quarry by means of hydraulic suction and the pumping of the aggregate and water mixture as a slurry to a location where at least 95% of the water returns directly to the source of supply.

(mm) "Immediate vicinity," as used in specifying the place of use for a water right in which the water is authorized to be used for municipal purposes, means within 2,640 feet of the corporate limits of the municipality, rural water district, or other entity.

(nn) "In compliance" means that a water flowmeter does not meet any of the criteria of K.A.R. 5-1-9 for being out of compliance.

(oo) "Index water level" means water level elevations established spatially throughout a basin storage area to be used to represent the maximum volume of a basin storage area, and storage available for recovery based upon accounting methodology, and conditions of the permit.

(pp) "Indirect use" means the total of the seepage loss and the average annual potential net evaporation loss from the surface of water originally impounded in a reservoir for beneficial use.

(qq) "Industrial use" means the use of water in connection with the manufacture, production, transport, or storage of products, or the use of water in connection with providing commercial services, including water used in connection with steam electric power plants, greenhouses, fish farms, poultry operations that are not incidental to the operation of a traditional farmstead pursuant to K.S.A. 82a-701(c) and amendments thereto, secondary and tertiary oil recovery, air conditioning, heat pumps, equipment cooling, and all uses of water associated with the removal of aggregate for commercial purposes except the following:

(1) The evaporation caused by exposing the groundwater table or increasing the surface area of a stream, lake, pit, or quarry by excavation or dredging, unless the evaporation has a substantially adverse impact on the area groundwater supply; and

(2) hydraulic dredging.

(rr) "Irrigation use" means the use of water for the following:

(1) The growing of crops;

(2) the watering of gardens, orchards, and lawns exceeding two acres in area; and

(3) the watering of golf courses, parks, cemeteries, athletic fields, racetrack grounds, and similar facilities.

(ss) "Measuring chamber" means a cylindrical chamber in which a water flowmeter is installed that is calibrated to match the measuring element of the water flowmeter and the nominal size of the pipe in which it is installed.

(tt) "Municipal use" means the various uses made of water delivered through a common distribution system operated by any of the following:

(1) A municipality;

(2) a rural water district;

(3) a water district;

(4) a public wholesale water supply district;

(5) any person or entity serving 10 or more hookups for residences or mobile homes; or

(6) any other similar entity distributing water to other water users for various purposes.

Municipal use shall also include the use of water by restaurants, hotels, motels, churches, camps, correctional facilities, educational institutions, and similar entities using water that does not qualify as a domestic use.

(uu) "Nonvolatile memory" means the ability of a water flowmeter to retain the values stored in the mechanical or electronic memory if all power, including backup battery power, is removed.

(vv) "Normal operating range" means the range of flow rates for which the water flowmeter will meet the accuracy requirements of K.A.R. 5-1-4 (a), as certified by the water flowmeter manufacturer.

(ww) "Off-season irrigation" means the application of water to land for the purpose of storing moisture in the soil for future use by a crop that will not be irrigated during the growing season.

(xx) "Operator," as used in the regulation of sand and gravel pits, means any person who engages in mining sand or gravel, or both.

(yy) "Perfect" means the actions taken by a water user to develop an approval of application into a water right. These actions shall consist of the completion of the diversion works and the actual application of water to the authorized beneficial use in accordance with the terms, conditions, and limitations of the approval of application.

(zz) "Point of diversion" means the point at which water is diverted or withdrawn from a source of water supply.

(aaa) "Point of diversion for storage of surface water in a reservoir created by a dam" means the point at which the longitudinal axis of the dam crosses the centerline of the stream impounded by the reservoir.

(bbb) "Potential annual runoff" means the mean annual runoff for the watershed of the reservoir.

(ccc) "Preirrigation" means the application of water to the land for a crop before planting to ensure adequate moisture for early plant growth.

(ddd) "Primary well" means a well for which a standby well is available.

(eee) "Prior right" means a vested right, an appropriation right with earlier priority, or a permit with earlier priority than that of a subsequent appropriation right or permit.

(fff) "Proven reserves" means extractable sand and gravel deposits for which good estimates of the quantity and quality have been made by various means, including core drilling.

(ggg) "Recharge" means the natural infiltration of surface water or rainfall into an aquifer from its catchment area.

(hhh) "Recharge credit" means the quantity of water that is stored in the basin storage area and that is available for subsequent appropriation for beneficial use by the operator of the aquifer storage and recovery system.

(iii) "Recreation storage" means the storage and use of water within the reservoir for recreational use as defined in this regulation. Water stored for recreation use in a reservoir shall be considered to be an indirect use of water.

(jjj) "Recreational use" means a use of water in accordance with a water right that provides entertainment, enjoyment, relaxation, and fish and wildlife benefits.

(kkk) "Rediversion of water" means releasing or withdrawing water that had been previously impounded behind a dam, levee, or similar type of structure, by use of a pump, outlet tube, headgate, or similar type of device, and the application of the water directly to beneficial use.

(lll) "Register" means an integral or remote device that displays the quantity of water passing the water flowmeter sensor and is part of the water flowmeter.

(mmm) "Reservoir" means the area upstream from a dam that contains, or will contain, impounded water.

(nnn) "Reservoir capacity" means the volume of water that can be stored below the lower of either of the following:

(1) The elevation of the principal spillway tube; or

(2) the lowest uncontrolled spillway in the reservoir.

(ooo) "Reservoir having a total water volume of less than 15 acre-feet," as used in K.S.A. 82a-728 and amendments thereto, means a reservoir having a capacity of 15 acre-feet or less as measured at the principal spillway tube or the lowest uncontrolled spillway, whichever is lower.

(ppp) "Safe yield" means the long-term sustainable yield of the source of supply, including hydraulically connected surface water or groundwater.

(qqq) "Sand and gravel pit operation" means a project that meets the following conditions:

(1) Excavates overburden for mining sand or

gravel, or both, exposing the underlying groundwater table to evaporation; and

(2) has a perimeter equal to or greater than its depth.

(rrr) "Sediment control in a reservoir" means a beneficial use of water that meets both of the following criteria:

(1) The water is stored in a reservoir that has no other authorized type of beneficial use, except domestic use.

(2) The water is stored only in the part of the reservoir designed and constructed for the storage of sediment.

(sss) "Source water" means water used for artificial recharge that meets the following conditions:

(1) Is available for appropriation for beneficial use;

(2) is above base-flow stage in the stream;

(3) is not needed to satisfy minimum desirable streamflow requirements; and

(4) will not degrade the ambient groundwater quality in the basin storage area.

(ttt) "Specialty crop" means a crop other than a normal Kansas field crop. This term shall include turf grass, trees, vegetables, ornamentals, and other similar crops.

(uuu) "Standby well" means a well that can withdraw water from the same source of supply as the primary well and that is used only when water is temporarily unavailable from the primary well or wells authorized to be used on the same place of use because of mechanical failure, maintenance, or power failure. A standby well may also be used for fire protection or a similar type of emergency.

(vvv) "Static water level" means the depth below land surface at which the top of the groundwater is found when not affected by recent pumping.

(www) (1) "Stockwatering" means the watering of livestock and other uses of water directly related to either of the following:

(A) The operation of a feedlot with the capacity to confine 1,000 or more head of cattle; or

(B) any other confined livestock operation or dairy that would divert 15 or more acre-feet of water per calendar year.

(2) Stockwatering shall not include the irrigation of feed grains or other crops.

(3) For the purposes of this subsection, a group of feedlots or other confined feeding operations shall be considered to be one feedlot or confined feeding operation if both of these conditions are met:

(A) There are common feeding or other physical facilities.

(B) The group of facilities is under common management.

(xxx) "Straight pipe" means a straight length of pipe free of all internal obstructions, including size changes, valves, cooling coils, injection ports, sand or foreign material, and any other condition that would cause a disturbance of the internal velocity profile in the pipe. Internal obstructions shall not include properly designed, constructed, and installed straightening vanes and inspection ports.

(yyy) "Stream channel aquifer" means unconsolidated water-bearing deposits in river valleys, flood plains, and terraces that are separate and distinct from any other aquifer and capable of yielding water in sufficient quantities for beneficial use.

(zzz) "Surface water" means water in creeks, rivers, or other watercourses, and in reservoirs, lakes, and ponds.

(aaaa) "Term permit" means a permit to appropriate water issued for a specified period of time. At the end of the specified time, or any authorized extension of it, the permit shall be automatically dismissed, and any priority it may have had shall be forfeited.

(bbbb) "The production and return of saltwater in connection with the operation of oil and gas wells in accordance with the written approval granted therefor by the Kansas corporation commission pursuant to K.S.A. 55-901, and amendments thereto" means only that saltwater actually produced during the primary production of oil and gas wells and shall not include the following:

(1) Saltwater used in the drilling of an oil and gas well; and

(2) saltwater injected into an enhanced recovery injection well, unless that saltwater was produced in the primary production of the oil and gas well, separated from the oil and gas, and then subsequently reinjected.

(cccc) "Thermal exchange" means the use of water for climate control in a nondomestic building and in a manner that is essentially nonconsumptive to the source of supply.

(dddd) "Totalizer" means the mechanical or electronic portion of the register that displays the total quantity of water that has passed the water flowmeter sensor.

(eeee) "Unconfined Dakota aquifer system" means that portion of the Dakota aquifer system not overlain by Graneros shale.

(ffff) "Unconsolidated regional aquifer" means a body of mostly unconsolidated and heterogeneous water-bearing deposits that are hydraulically and geologically contiguous, and are capable of yielding water in sufficient quantities for beneficial use.

(gggg) "Waste of water" means any act or omission that causes any of the following:

(1) The diversion or withdrawal of water from a source of supply that is not used or reapplied to a beneficial use on or in connection with the place of use authorized by a vested right, an appropriation right, or an approval of application for a permit to appropriate water for beneficial use;

(2) the unreasonable deterioration of the quality of water in any source of supply, thereby causing impairment of a person's right to the use of water;

(3) the escaping and draining of water intended for irrigation use from the authorized place of use; or

(4) the application of water to an authorized beneficial use in excess of the needs for this use.

(hhhh) "Waterpower use" means the use of falling water for hydroelectric or hydromechanical power.

(iiii) "Water balance" means the method of determining the amount of water in storage in a basin storage area by accounting for inflow to, outflow from, and changes in storage in that basin storage area.

(jjjj) "Water flowmeter" means the combination of a flow-sensing device, measuring chamber, integral or remote display device or register, and any connecting parts required to make a working assemblage to measure, record, and allow determination of flow rate and total quantity of water flowing past the water flowmeter sensor.

(kkkk) "Water storage device" means a reservoir, elevated water tank, pressurized water tank, including a bladder tank, or other container into which water is pumped and stored before beneficial use.

(llll) "Water use correspondent" means a person designated in writing, on a form prescribed by the chief engineer, by one of the owners of a water right to file the water use reports required by K.S.A. 82a-732 and amendments thereto, on behalf of the owner or owners of that water right. (Authorized by and implementing K.S.A. 82a-706a; modified, L. 1978, ch. 460, May 1, 1978; amended May 1, 1980; amended May 1, 1981; amended May 1, 1983; amended May 1, 1986; amended Dec. 3, 1990; amended May 31, 1994; amended Sept. 22, 2000; amended Oct. 24, 2003.)

5-1-2. Standby well. In order for a well to qualify as a standby well:

(a) The well shall be maintained in operable condition and be capable of being hooked to a power source within a reasonable amount of time to allow the well to function effectively as a standby well.

(b) Both the primary well or wells and the standby well or wells shall be required to be metered by order of the chief engineer or as a condition of the water right or permit.

(c) The standby well shall be located close enough to the primary well so that both wells withdraw water from the same local source of supply.

(d) The standby well shall be authorized to divert the same rate and quantity as the primary well or wells. A limitation clause shall be placed on any water right or permit authorizing a standby well or wells limiting the standby well to no more than the rate and quantity authorized for the primary well or wells. With the limitation clause or clauses in effect, the standby well or wells shall not be counted in any safe yield, allowable appropriation, depletion or similar type of analysis. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706; effective May 31, 1994.)

5-1-3. Permitting requirements of the Kansas water appropriation act. An individual engaged in the drilling of water well test holes, seismic test holes, stratigraphic test holes, observation wells, and water quality sampling wells, shall not be required to have an approval of application pursuant to the Kansas water appropriation act if water will not be diverted for beneficial use. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-701(f), 82a-703, 82a-705, and K.S.A. 1999 Supp. 82a-711; effective Sept. 22, 2000.)

5-1-4. Water flowmeter specifications. Each water flowmeter required by the chief engineer, or required pursuant to a regulation adopted by the chief engineer, on or after the effective date of this regulation shall meet the following minimum requirements:

(a)(1) The water flowmeter has been certified by the manufacturer to register neither less than 98

percent nor more than 102 percent of the actual volume of water passing the water flowmeter when installed according to the manufacturer's instructions. This requirement shall be met throughout the water flowmeter's normal operating range without further adjustment or calibration.

(2) The manufacturer has certified to the chief engineer that it has an effective quality assurance program, including wet testing a random sample of production line water flowmeters with water flowmeter test equipment. The minimum number of samples to be tested shall be determined using a confidence interval of 90 percent, an expected compliance of 95 percent, and an acceptable error of two percent. The minimum number of samples of each model that shall be tested shall be calculated by multiplying 1,300 times the annual production of that model of water flowmeter divided by Q. Q equals four times the annual production of that water flowmeter plus 1,300.

(3) The manufacturer has certified that the water flowmeter test equipment described in paragraph (a)(2) has been tested annually and found accurate by standards traceable to the national institute of standards and technology (NIST). Documentation of the testing required in paragraphs (a)(1) and (2) shall be maintained by the manufacturer for a period of at least five years and shall be made available to the chief engineer upon request during normal business hours.

(b) The water flowmeter shall be designed and constructed so that it will meet the following criteria:

(1) Maintain the accuracy required by the chief engineer in K.A.R. 5-1-4(a) and K.A.R. 5-1-9(a);

(2) be protected by the following:

(A) A seal installed by the manufacturer or an authorized representative of the manufacturer; or

(B) a way that makes it impossible to alter the totalizer reading without breaking the seal or obtaining the authorization of the manufacturer, an authorized representative of the manufacturer, or the chief engineer;

(3) clearly indicate the direction of water flow;

(4) clearly indicate the serial number of the water flowmeter;

(5) have a weatherproof register that is sealed from all water sources;

(6) have a register that is readable at all times, whether the system is operating or not;

(7) be able to be sealed by an authorized representative of the chief engineer to prevent unauthorized manipulation of, tampering with, or removal of the water flowmeter;

(8) be equipped with a manufacturer-approved measuring chamber through which all water flows. Except for positive displacement water flowmeters, full-bore electromagnetic water flowmeters, and multijet water flowmeters, flow-straightening vanes shall be installed at the upstream throat of the water flowmeter chamber. The flow-straightening vanes shall meet either of the following criteria:

(A) Be designed and installed by the manufacturer, or an authorized representative of the manufacturer; or

(B) consist of at least three vanes that meet the following conditions:

(i) Are longer, when placed parallel to the length of the pipe, than the inside diameter of the pipe;

(ii) are equally spaced radially on the inner periphery of the pipe; and

(iii) are wider in diametrical distance than one-fourth of the inside diameter of the pipe;

(9) be equipped with an inspection port if the straightening vanes are not designed, constructed, and installed by the manufacturer or an authorized representative of the manufacturer. The port shall be of sufficient size and placement to allow determination of the following:

(A) The proper installation of the flow-straightening vanes; and

(B) the inside diameter of the pipe in which the water flowmeter sensor is installed;

(10) remain operable without need for recalibration to maintain accuracy throughout the operating life of the water flowmeter; and

(11) have a totalizer that meets the following criteria:

(A) Is continuously updated to read directly only in acre-feet, acre-inches, or gallons;

(B) has sufficient capacity, without cycling past zero more than once each year, to record the quantity of water diverted in any one calendar year;

(C) reads in units small enough to discriminate the annual water use to within the nearest 0.1 percent of the total annual permitted quantity of water;

(D) has a dial or counter that can be timed with a stopwatch over not more than a 10-minute period to accurately determine the rate of flow under normal operating conditions; and

(E) has a nonvolatile memory.

(c) Each water flowmeter that is required to be installed by the chief engineer, or that was required to be installed as a condition of either an approval of application or an order of the chief engineer, or pursuant to a regulation adopted by the chief engineer before the effective date of this regulation, shall meet the following minimum specifications:

(1) Each water flowmeter shall be of the proper size, pressure rating, and style, and shall have a normal operating range sufficient to accurately measure the water flow passing the water flowmeter under normal operating conditions.

(2) Each water flowmeter shall meet the accuracy requirements of K.A.R. 5-1-9(a). If the water flowmeter does not meet the accuracy requirements of K.A.R. 5-1-9(a), then the water flowmeter shall meet either of the following criteria:

(A) Be repaired so that it can meet the accuracy requirements of K.A.R. 5-1-9(a); or

(B) be replaced with a water flowmeter complying with all of the requirements of K.A.R. 5-1-4 and installed in a manner that meets the requirements of K.A.R. 5-1-6. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 82a-706c; effective Sept. 22, 2000; amended Oct. 24, 2003.)

5-1-5. Variances from water flowmeter specifications. (a) A variance from the chief engineer's water flowmeter specifications may be granted by the chief engineer if the water right owner furnishes detailed specifications of a proposed water flowmeter and demonstrates to the chief engineer all the following:

(1) A water flowmeter meeting the specifications of K.A.R. 5-1-4 will not satisfactorily serve the water user's needs.

(2) The proposed water flowmeter will meet the accuracy requirements of K.A.R. 5-1- 4(a) and (b).

(3) The proposed water flowmeter will provide a reliable and accurate water use record for that point of diversion.

(b) Variances shall be granted only on a site-by-site, case-by-case basis. No general variances shall be granted for any brand or model of water flowmeter, except as set forth in subsection (c).

(c) A limited variance shall be granted by the chief engineer for a period of up to three years to allow that specific brand and model of a water flowmeter to be tested in the field and to serve as a water flowmeter required by the chief engineer if all of the following conditions are met:

(1) The manufacturer demonstrates to the chief engineer that a particular model and brand of water flowmeter utilizes new technology, does not meet one or more of the requirements of K.A.R. 5-1-4, and is likely to be as reliable, or more reliable, than water flowmeters currently meeting all of the requirements of K.A.R. 5-1-4.

(2) The manufacturer agrees to install not more than 50, nor less than 10, water flowmeters to test the new technology.

(3) The manufacturer agrees to collect data for at least one year that is sufficient to allow the chief engineer to determine whether that brand and model of water flowmeter meets the reliability and accuracy specifications of K.A.R. 5-1-4. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706c; effective Sept. 22, 2000.)

5-1-6. Water flowmeter installation specifications. (a) Each water flowmeter required by the chief engineer to be installed or required pursuant to a regulation adopted by the chief engineer, on or after the effective date of these regulations shall meet the following minimum water flowmeter installation specifications:

(1) Each water flowmeter shall be installed in a manner that meets the following criteria:

(A) Meets or exceeds the instructions of the manufacturer; and

(B) except for a multijet and a positive displacement water flowmeter, is installed so that there are at least five pipe diameters of straight pipe upstream and at least two pipe diameters of straight pipe downstream of the sensor portion of the water flowmeter, regardless of the manufacturer's installation specifications.

(2) Each water flowmeter shall be sized and installed so that full pipe flow will be maintained through the water flowmeter and so that water velocity in the measuring chamber will be within the normal operating range of the water flowmeter at all times while water is being diverted.

(3) If a water flowmeter is located downstream of a water storage device, there shall be at least seven diameters of straight pipe upstream of the water storage device where a water flowmeter may be installed for a field test by the chief engineer.

(4) Each water flowmeter shall be installed at a location at which the flowmeter measures all water diverted from the source of supply and does

not measure water or other discharge, including tailwater and sewage effluent.

(b) Each water flowmeter that is required by the chief engineer to be installed, or that was required to be installed as a condition of either an approval of application or an order of the chief engineer, or pursuant to a regulation adopted by the chief engineer, before the effective date of these regulations, shall meet the following minimum installation specifications:

(1) Each water flowmeter shall be installed in a manner that meets or exceeds the instructions of the manufacturer and, except for a multijet and a positive displacement water flowmeter, shall be installed so that there are at least five pipe diameters of straight pipe upstream and at least two pipe diameters of straight pipe downstream of the sensor portion of the water flowmeter, regardless of the manufacturer's installation specifications.

(2) Each water flowmeter shall be sized and installed so that full pipe flow will be maintained through the water flowmeter and so that water velocity in the measuring chamber will be within the normal operating range of the water flowmeter at all times while the water is being diverted.

(3) Each water flowmeter shall be installed at a location at which the flowmeter measures all water diverted from the source of supply and does not measure water or other discharge, including tailwater and sewage effluent. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 82a-706c; effective Sept. 22, 2000; amended Oct. 24, 2003.)

5-1-7. Requirement to install a water flowmeter or other suitable water-measuring device. (a) All nondomestic, nontemporary wells and pump sites operated under the authority of an approval of application issued on or after the effective date of this regulation shall be equipped with a water flowmeter that meets or exceeds the specifications of the chief engineer effective at the time the application is approved by the chief engineer.

(b)(1) All nondomestic, nontemporary gravity diversions of water, including irrigation ditches, operating under the authority of an approval of application issued on or after the effective date of this regulation shall be equipped with a continuous recording gauge, or other suitable water-measuring device located at or near the headgate. Before installation, the water right owner shall submit plans and specifications for the proposed gauge, or other suitable water-measuring device, to the chief engineer and shall receive approval in writing from the chief engineer before installing the gauge or other suitable water-measuring device.

(2) The gauge or other suitable water-measuring device shall meet the following criteria:

(A) Register not less than 94% and not more than 106% of the actual volume of water passing the device under normal operating conditions when compared to a field test made by, or approved by, the chief engineer;

(B) be installed in accordance with the installation requirements of the chief engineer; and

(C) be maintained in a satisfactory operating condition any time water can reasonably be expected to be diverted.

(c) An approval of a nondomestic application for change in place of use, the point of diversion, or the use made of the water, or any combination of these, shall require the owner of the well or pump site to install a water flowmeter on all points of diversion authorized by the water right or approval of application, unless any of the following conditions is met:

(1) The applicant demonstrates to the chief engineer that the application to change the place of use meets the requirements of K.A.R. 5-5-11(e).

(2) The applicant demonstrates to the chief engineer both of the following:

(A) Installation of a water flowmeter meeting these specifications is not physically feasible.

(B) The applicant agrees to implement a reasonable, objective alternative of measuring the quantity of water diverted that is acceptable to the chief engineer.

(3) The water is being diverted from multiple points of diversion authorized by one water right that does not limit the maximum annual quantity and maximum rate of diversion by point of diversion, and all of the water flows to a common point where a water flowmeter meeting the requirements of K.A.R. 5-1-4 and K.A.R. 5-1-6 measures all of the water pumped from all of the points of diversion authorized by that water right.

(4) An application for change in point of diversion only is filed to change the point of diversion of only one well, when more than one well is authorized by the approval of application or water right that authorizes the well for which a change in point of diversion is sought. In this case, only the well that is being relocated shall be required to have a water flowmeter.

(d) Except as set forth in subsection (c), if an approval of an application for change requires the installation of a water flowmeter, the requirement to install a water flowmeter shall also be placed on all other water rights and approvals authorizing diversion of water from the same point of diversion.

(e) If any water right or approval of application has a condition requiring development, adoption, and implementation of a water conservation plan pursuant to K.S.A. 82a-733 and amendments thereto, a water flowmeter or suitable water-measuring device shall be installed on each authorized point of diversion in compliance with these regulations.

(f) The owner of a water right, including a domestic water right, or an approval of application shall also be required by the chief engineer to install a water flowmeter or other suitable water-measurement device that complies with these regulations on each authorized point of diversion if it is necessary for the chief engineer to effectively administer water rights to prevent impairment, to protect minimum desirable stream flows, to conserve water, or to otherwise carry out the duties of the chief engineer as set forth in the Kansas water appropriation act, K.S.A. 82a-701 et seq., and amendments thereto.

(g) Except as set forth in subsection (c), if a water flowmeter is required by the chief engineer, each point of diversion authorized by the approval of application or water right shall be required to have a separate meter. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706c; effective Sept. 22, 2000.)

5-1-8. Water flowmeter maintenance. If a water right owner is required by the chief engineer to install a water flowmeter, the water right owner shall maintain the water flowmeter in compliance, as defined by K.A.R. 5-1-1, whenever diversion of water can reasonably be expected to occur. If at any time the required water flowmeter fails to function properly, the owner shall promptly initiate action to repair or replace the meter, or to correct any problems with the installation. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706c; effective Sept. 22, 2000.)

5-1-9. Criteria to determine when a water flowmeter is out of compliance. A water flowmeter shall be considered to be out of compliance if any of the following criteria is met: (a) The water flowmeter registers less than 94 percent or more than 106 percent of the actual volume of flow water passing the water flowmeter. If necessary, this determination may be made by a field test conducted by, or approved by, the chief engineer.

(b) The seal placed on the totalizer by the manufacturer or the manufacturer's authorized representative has been broken, or the totalizer value has been reset or altered without the authorization of the manufacturer, an authorized representative of the manufacturer, or the chief engineer.

(c) A seal placed on the water flowmeter or totalizer by the chief engineer has been broken.

(d) The water flowmeter register is not clearly visible or is unreadable for any reason.

(e) There is not full pipe flow through the water flowmeter.

(f) Flow-straightening vanes have not been properly designed, manufactured, and installed.

(g) The water flowmeter is not calibrated for the nominal size of the pipe in which it is installed.

(h) The water flowmeter is not installed in accordance with the manufacturer's installation specifications. However, five diameters of straight pipe above the water flowmeter sensor and two diameters below the water flowmeter sensor shall be the minimum spacing, regardless of the manufacturer's installation specifications.

(i) A water flowmeter is installed at a location at which the flowmeter does not measure all of the water diverted from the source of supply. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 82a-706c; effective Sept. 22, 2000; amended Oct. 24, 2003.)

5-1-10. Duties of water right owner when a water flowmeter is out of compliance. (a) A water right owner, or the water right owner's authorized designee, shall promptly notify the chief engineer if any water flowmeter required by the chief engineer is out of compliance.

(b) Within 30 days after the date on which the out-of-compliance water flowmeter has been repaired or replaced, the water right owner or the water right owner's authorized designee shall notify the chief engineer in writing of the following information:

(1) The date the water flowmeter became out of compliance;

(2) the water flowmeter reading at the time the water flowmeter became out of compliance;

(3) if the water flowmeter was replaced, the following information:

(A) The brand, model, size, and serial number of the new water flowmeter;

(B) the units in which the new water flowmeter reads;

(C) the reading of the new water flowmeter at the time of installation; and

(D) the location of the new water flowmeter on the diversion works or delivery system;

(4) if the water flowmeter was repaired, the water flowmeter reading immediately before the repair and the reading of the water flowmeter at the time it was reinstalled or the repair was completed on site;

(5) the date the repair or replacement was completed; and

(6) the amount of water diverted while the water flowmeter was out of compliance.

(c) If the water right owner does not maintain a record of diversions of water that is sufficient to reasonably estimate the quantity of water diverted while the water flowmeter was out of compliance, it shall be assumed, for the sole purposes of enforcement of the terms, conditions, and limitations of the approval of application or water right, and priority administration of water rights among water users, that the diversion works were operated continuously at the tested rate of diversion during the entire period the water flowmeter was out of compliance. If the rate of diversion has not been tested by the chief engineer, then it shall be assumed that the diversion works were operated continuously at the authorized rate of diversion during the entire time the water flowmeter was out of compliance. The assumption set forth in this subsection shall not apply to the determination of the annual quantity of water diverted for the purpose of perfecting a water right.

(d) If the water right owner is required by the chief engineer to repair or replace an inoperable water flowmeter, it shall be the duty of the water right owner to ensure that the repaired or replaced water flowmeter is in compliance with K.A.R. 5-1-4 and K.A.R. 5-1-6. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706c; effective Sept. 22, 2000.)

5-1-11. Water flowmeter testing by a nonagency person. If a water right owner desires to have a water flowmeter flow rate test done by a nonagency person for any reason, a person may be approved by the chief engineer to perform a water flowmeter flow rate test if the person demonstrates to the chief engineer both of the following:

(a) The person has the training, skills, and experience necessary to properly conduct the test.

(b) The person has the appropriate water flowmeter to do the test, and the water flowmeter has been tested for accuracy with water flowmeter test equipment that has been found to be accurate using standards traceable to the national institute of standards and technology (NIST). The equipment shall have been tested and found to be accurate within 12 months of performing the water flowmeter test. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706c; effective Sept. 22, 2000.)

5-1-12. List of water flowmeters certified by the manufacturer to meet the specifications of the chief engineer. (a) A list of all makes and models of water flowmeters that have been certified by the water flowmeter manufacturer to meet the specifications of the chief engineer shall be maintained by the chief engineer. This list shall be made available by the chief engineer to the public upon request.

(b) A water flowmeter shall be placed on the list only if the manufacturer has submitted to the chief engineer all of the following information for each water flowmeter model:

(1) The water flowmeter manufacturer's name, address, contact person's name, and telephone number;

(2) the water flowmeter model name or number;

(3) proof that a random sample of water flowmeters of each model has been tested in accordance with the requirements of K.A.R. 5-1-4(a);

(4) the last date that the water flowmeter test equipment was tested and found to be accurate by standards traceable to the national institute of standards and technology (NIST);

(5) verification that the water flowmeter is designed and constructed so that accuracy will be maintained over the life of the water flowmeter;

(6) verification that the water flowmeter serial number and direction of flow are clearly indicated on the water flowmeter;

(7) verification that the register is weatherproof and sealed from all water sources;

(8) verification that the totalizer will read only in acre-feet, acre-inches, or gallons;

(9) the number of active digits in the totalizer;

(10) verification that the memory is nonvolatile;

(11) verification that the totalizer cannot be reset without breaking the manufacturer's seal or obtaining the authorization of the manufacturer, an authorized representative of the manufacturer, or the chief engineer;

(12) verification that the water flowmeter and register are constructed in such a manner that they can be sealed by the chief engineer;

(13) a description of the measuring chamber provided for each water flowmeter model;

(14) specifications of the flow-straightening vanes installed in the measuring chamber;

(15) the spacing recommendations for each water flowmeter model in terms of pipe diameters of straight pipe required upstream and downstream of the water flowmeter sensor; and

(16) the normal operating range of the water flowmeter.

(c) A brand or model of a water flowmeter shall be removed from the list of water flowmeters specified in subsection (a) of this regulation if it has been demonstrated to the chief engineer that the brand or model of water flowmeter does not reliably and consistently meet the accuracy standards of K.A.R. 5-1-9(a). (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 82a-706c; effective Sept. 22, 2000; amended Oct. 24, 2003.)

Article 2.—VESTED RIGHTS

5-2-1 and 5-2-2. Not in active use.

Editor's Note:

Proposed regulations 5-2-1 and 5-2-2 were rejected by the legislature, see L. 1978, ch. 460.

5-2-3. Battery of wells. Except as set forth in subsection (c), if a permit to appropriate water did not authorize a battery of wells, as defined in K.A.R. 5-1-1, before the effective date of this regulation, an application for change filed pursuant to K.S.A. 82a-708b, and amendments thereto, to add one or more wells to the authorized well to create a battery of wells shall not be approved unless all of the following criteria in either subsection (a) or (b) are met at the time that the application for change is filed:

(a) (1) The time to construct the diversion works has not expired.

(2) The proposed battery will meet the definition of a battery of wells as defined in K.A.R. 5-1-1.

(b) (1) The time to construct the diversion works has expired.

(2) A new application to appropriate water filed to appropriate water at the geocenter of the proposed battery of wells would meet the safe yield, allowable appropriation, or similar type of regulation, for a well filed at that location.

(3) The proposed battery of wells meets the definition of a battery of wells as defined in K.A.R. 5-1-1.

(c) Subsections (a) and (b) shall not apply to an application to change the point of diversion filed to add one or more wells to the authorized well to create a battery of wells if the proposed battery of wells is located within the boundary of a groundwater management district for which the chief engineer has adopted a specific regulation applicable to batteries of wells within that district. (Authorized by and implementing K.S.A. 82a-706a; effective Sept. 22, 2000.)

Article 3.—APPROPRIATION RIGHTS

5-3-1. Application acceptable for filing. (a) To be acceptable for filing, an application for an approval of application shall be accompanied by the statutorily required filing fee, except for an application for domestic use, and shall contain all of the following:

(1) The name and mailing address of each applicant;

(2) the signature of each applicant or each authorized representative;

(3) the proposed source of water supply;

(4) the proposed authorized place of use; and

(5) either a description of the location of the proposed point of diversion or a request for a 60-day period of time in which to establish the proposed point of diversion within a specifically described, nominal legal quarter section of land.

(b) When an application is received in the office of the chief engineer and assigned a number, the maximum quantity of water per calendar year and the maximum rate of diversion shall not be increased. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 82a-709; modified, L. 1978, ch. 460, May 1, 1978; amended May 1, 1980; amended Oct. 24, 2003.)

5-3-1a. Application for a basin term permit. An application for a basin term permit shall be filed on a form prescribed by the chief engineer. The term requested shall not exceed one year. A basin term permit may be extended in one-year increments if all of the following conditions are met:

(a) The request for extension is filed before the end of the current term in a manner acceptable to the chief engineer.

(b) The applicant has complied with the terms, conditions, and limitations of the basin term permit during the previous calendar year.

(c) Granting the requested extension will not cause impairment of each approval of application and water right with an earlier priority.

(d) The applicant shows good cause why the extension should be granted.

The total time authorized by a basin term permit shall not exceed five calendar years. Basin term permits shall not be transferable. At the end of the specified term, the permit shall be dismissed, and any priority it may have had shall be forfeited. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-712; effective Sept. 22, 2000.)

5-3-1b. Complete new application. (a) A new application to appropriate water for beneficial use shall be considered to be a "complete application" for the purposes of K.S.A. 82a-708a, and amendments thereto, if the application completely and accurately meets all the requirements specified in this regulation and the following criteria:

(1) The requirements specified in K.S.A. 82a-708a, and amendments thereto;

(2) the requirements specified in K.S.A. 82a-709, and amendments thereto;

(3) the requirements specified in K.S.A. 82a-710, and amendments thereto;

(4) any water conservation plans required by the chief engineer pursuant to K.S.A. 82a-733, and amendments thereto;

(5) the requirements of K.S.A. 82a-301 through K.S.A. 82a-305a, and amendments thereto, if the proposed point of diversion, or rediversion, is a dam or stream obstruction;

(6) the requirements specified in K.A.R. 5-3-1;

(7) the requirements specified in K.A.R. 5-3-4; and

(8) the requirements specified in K.A.R. 5-3-4d.

(b) If minimum desirable streamflow (MDS) requirements have been set for the proposed source of water supply, the application shall contain a statement signed by the applicant acknowledging that the MDS requirements apply to the proposed source of water supply and that the diversions of water authorized by this approval of application could be regulated at times to protect MDS.

(c) If the applicant is requesting a waiver or exemption of a regulation pursuant to K.S.A. 82a-1904, and amendments thereto, the applicant shall submit a written request for the waiver or exemption, and documentation to support the waiver or exemption.

(d) If the proposed point of diversion is located within the boundaries of a groundwater management district, a final recommendation or analysis of the availability of water has been received from the groundwater management district within the time limit set by the chief engineer concerning the approval, denial, or modification of the application.

(e) If a substantive question has been raised concerning whether approval of the application could cause impairment of senior water rights or prejudicially and unreasonably affect the public interest, the applicant shall submit sufficient information to resolve that question.

(f) If any actions are required to be taken by the applicant on other approvals of applications or water rights owned by the applicant in order to make the new application approvable, including dismissals, reductions in water rights in accordance with K.A.R. 5-7-5, and applications for change, all necessary forms shall be completed and filed with the chief engineer.

(g) The applicant shall submit all information and data necessary to demonstrate that the application complies with the applicable regulations adopted by the chief engineer. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a, K.S.A. 2002 Supp. 82a-708a, K.S.A. 82a-709, K.S.A. 82a-710, K.S.A. 2002 Supp. 82a-711, K.S.A. 82a-733, and K.S.A. 2002 Supp. 82a-1904; effective Oct. 24, 2003.)

5-3-2. Priorities. (a) Upon receipt in the office of the chief engineer of an acceptable application for permit to appropriate water for beneficial use, accompanied by the statutory application fee, a stamp showing the date and time of receipt shall be placed on the application form. The date and time of receipt of the application for any use, other than domestic, shall establish the priority of whatever appropriation right that may be subsequently perfected pursuant to the application; (b) The date and time of the receipt of an application for permit to appropriate water for domestic use or the date of the first use of water for such purpose, whichever is earlier, shall establish

the priority of the appropriation right for domestic use. When the first use of water is earlier in time than the filing date of an application, the applicant shall furnish affidavits from disinterested parties to substantiate the date that water was first used from the appropriate water supply for domestic purposes. (Authorized by K.S.A. 82a-706a; modified, L. 1978, ch. 460, May 1, 1978.)

5-3-3. Storage of water for domestic use. Any person entitled to use water for beneficial purposes may collect and store the same so long as such collection, storage, use and times of use thereafter are consistent with reasonable storage and conservation practices. A reasonable quantity of water stored for domestic use shall be considered to be that quantity sufficient to satisfy the domestic use for the current year and two succeeding years. (Authorized by K.S.A. 82a-706a; modified, L. 1978, ch. 460, May 1, 1978.)

5-3-3a. Legal access. If the chief engineer is aware, or becomes aware, that the applicant does not have legal access to either the point of diversion or the place of use, before an application for any of the following can be approved by the chief engineer, the applicant shall demonstrate that the applicant has legal access to the proposed point of diversion and the proposed place of use before the approval of the application: (a) An approval of application;

(b) a change in place of use;

(c) a change in point of diversion; or

(d) any combination of subsections (a), (b), and (c). (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-708a; effective Oct. 24, 2003.)

5-3-4. Application contents. (a) Each application for permit to appropriate water for beneficial use shall contain all the information requested for the proposed uses as set forth in the prescribed application form and such other information as may be required for a proper understanding of the proposed appropriation.

(b) Each application shall be accompanied by an aerial photograph or a detailed plat preferably to a scale of one (1) inch equals one thousand three hundred and twenty (1,320) feet, or a U.S. geological survey topographic map, scale 1:24,000. Information that shall be plotted on the plat, photograph, or topographic map is as follows:

(1) The section corners.

(2) The center of the section, identified by the section number, township and range.

(3) The location of the point of diversion—well location, stream bank pump site, dam location or location of other works for diversion of water—indicated by an appropriate symbol.

(4) The location of the place of use identified by crosshatching or by some other appropriate method.

(5) The location of all other water wells of every kind within one-half (½) mile of the well(s) covered by the proposed appropriation, each of which shall be identified as to its use and the name and mailing address of the owner, if the proposed appropriation is for use of groundwater.

(6) The name and mailing address of the owner(s) of each tract of land adjacent to the stream for a distance of one-half (½) mile upstream and one-half (½) mile downstream from the property lines of the land owned or controlled by the applicant, if the proposed appropriation is for the use of surface water.

(7) The locations of proposed or existing dams, dikes, reservoirs, canals, pipelines, power houses and other structures for the purpose of storing, conveying or using water.

(8) A north arrow and scale.

The information shown on the photograph or plat shall be legible. Black line prints may be submitted in lieu of the original drawing if a plat is submitted.

(c) Separate applications shall be filed for surface water and groundwater.

(d) If the source of supply is groundwater, a separate application shall be filed for each proposed well or battery of wells, except that up to four (4) wells within a circle with a quarter (¼) mile radius in the same local source of supply which do not exceed a maximum diversion rate of twenty (20) gallons per minute per well and which are operated by means of submersible pumps may be included in a single application. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-709; modified, L. 1978, ch. 460, May 1, 1978; amended May 1, 1980; amended May 1, 1981.)

5-3-4a. Hearing prior to approval of application. A hearing may be held before the chief engineer, or a person designated by the chief engineer, on an application to appropriate water for beneficial use prior to approval, when the chief engineer finds it to be in the public interest to hold a hearing, or a hearing has been requested

by a person who shows to the satisfaction of the chief engineer that approval of the application may cause impairment of senior water rights or permits. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1993 Supp. 82a-711; effective May 1, 1980; amended May 31, 1994.)

5-3-4b. Deadlines for return of documents. (a) If the chief engineer allows a person a specific number of days to return or submit a document or other information, the time period shall be computed as prescribed in K.S.A. 60-206(a) and (e), and amendments thereto.

(b) If a person is given until a specific date to return or submit a document or other information, the document or information shall be deemed to be timely filed if it is received in the office of the chief engineer no later than the third working day following the specified date. Working days shall be all days except Saturdays, Sundays, and legal holidays designated by the United States congress, the Kansas legislature, or the governor of Kansas. Half holidays shall be counted as working days.

(c) Any document that is postmarked by the United States postal service with a legible date on or before the deadline set by the division for returning the document shall be accepted by the division as being timely filed, regardless of when it is received. In the case of United States registered mail, the date of registration shall be deemed to be the postmark date. The term "United States postal service," as used in this subsection, shall include a private delivery service available to the general public that routinely records, in the regular course of business, the date the item is given to the service for delivery. The date the item is given to the service for delivery shall be deemed to be the postmark date. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-710; effective May 1, 1980; amended Sept. 22, 2000.)

5-3-4c. Retaining new applications. (a) A new application to appropriate water for beneficial use shall be held by the chief engineer in accordance with the terms of subsection (b) if the application meets both of the following conditions:

(1) The application is in proper form and has been completely processed, but cannot be approved because it does not currently comply with one or more statutory or regulatory requirements, including spacing, safe yield, and allowable appropriation regulations.

(2) There is good cause to believe that, if the application were held for a reasonable period of time, it may be approvable in the future because of actions currently pending on other permits and water rights in the area, including issuance of certificates, dismissals of applications, and declarations of abandonment.

(b) Upon demonstration by the applicant to the chief engineer that the application apparently could be approved within a reasonable time, not to exceed 365 days from the date the request to retain the application was received by the chief engineer, if the pending actions take place, the applicant's pending new application may be held by the chief engineer for a period not to exceed 365 days.

(c) If the application still cannot be approved at the end of the time set forth in section (b), the application shall be dismissed by the chief engineer and the priority of the application forfeited.

(d) If any prior applications to appropriate water or prior applications to change the point of diversion from the same source of supply are not complete and if the approval or denial of these applications could affect the approval of the proposed new application or application to change a water right, then the 150-day period specified in K.S.A. 82a-708a, and amendments thereto, shall begin to run only after all these prior applications have been processed. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-705, K.S.A 82a-706a, K.S.A. 2002 Supp. 82a-708a, and K.S.A. 82a-710; effective Sept. 22, 2000; amended Oct. 24, 2003.)

5-3-4d. Stratigraphic log requirements. (a) Except as set forth in subsection (b), each applicant who files either of the following applications shall submit to the chief engineer a stratigraphic log for a test hole located within 300 feet of the proposed new or replacement well:

(1) A new application to appropriate groundwater, except for domestic use, a temporary permit, or a term permit for fewer than five years; or

(2) an application to change the point of diversion to relocate a well.

This stratigraphic log shall contain geologic and any other information sufficient to allow the chief engineer to understand the lithology and to classify the groundwater source formation or formations from which the proposed well will be withdrawing water.

(b) (1) If an application is filed for a new well, the stratigraphic log shall not be required if the

chief engineer has sufficient information to understand the lithology and determine the groundwater source formation or formations from which the proposed well will be withdrawing water.

(2) If an application is filed for a change in point of diversion, the stratigraphic log shall not be required if the chief engineer has sufficient information to understand the lithology and determine the groundwater source formation or formations from which the original well withdrew water and the replacement well will withdraw water.

(c) Each applicant to construct a new well or to change the point of diversion to a newly constructed well who submitted a stratigraphic log to the chief engineer pursuant to subsection (a) above shall not be required to submit to the chief engineer a copy of the stratigraphic log of the completed well as required by the Kansas department of health and environment under the authority of K.S.A. 82a-1212 and amendments thereto. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a, K.S.A. 82a-709, and K.S.A. 82a-710; effective Sept. 22, 2000; amended Oct. 24, 2003.)

5-3-4e. Groundwater source formation codes. The Kansas department of agriculture, division of water resources' document titled "groundwater source formation codes," dated June 24, 2004, is hereby adopted by reference. The groundwater source formation codes used by the chief engineer in administering the Kansas water appropriation act shall be the codes specified in this document. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-709; effective Sept. 22, 2000; amended, T-5-8-23-04, Aug. 23, 2004; amended Nov. 29, 2004.)

5-3-5. Approval of application. The approval of an application on the prescribed form shall constitute a permit to proceed with the construction of authorized diversion works and the diversion and use of water.

The applicant shall be notified of the approval of the application by transmitting to him or her the original document setting forth the terms, conditions, and limitations of the permit which has been duly dated and signed by the chief engineer or his or her authorized representative. A copy of the approval of application and permit to proceed shall be maintained in the office of the chief engineer or the appropriate field office. (Authorized by K.S.A. 82a-706a; modified, L. 1978, ch. 460, May 1, 1978.)

5-3-5a. Authorization for the use of water for emergency purposes. The chief engineer, or a person designated by the chief engineer, may authorize the use of water for emergency purposes. The emergency approval shall be subject to the terms, conditions and limitations specified by the chief engineer and may be granted when determined to be in the public interest or when needed to protect the quality of a water supply, to provide fire protection, or to provide an alternate point of diversion or source of supply when the principal source of supply or point of diversion is unavailable due to conditions beyond the control of the applicant. (Authorized by K.S.A. 82a-706a, 82a-711; effective May 1, 1980.)

5-3-5b. Approval of application for water for the development of underground storage in mineralized formations. In any case where it is not technologically and economically feasible to utilize poorer quality water for the development of underground storage in mineralized formations and fresh water must be used, the chief engineer shall require the construction of surface brine storage facilities to the extent economically and technologically feasible in an amount not to exceed forty percent (40%) of underground storage capacity of the applicant. This regulation does not exempt a person from complying with the requirements of other state and federal agencies relative to the construction of surface brine storage facilities. (Authorized by K.S.A. 82a-706a, 82a-707(d); effective May 1, 1980.)

5-3-5c. Check valves. (a) All diversion works not subject to regulation under the Kansas chemigation safety law, K.S.A. 2-3301 et seq. and amendments thereto, into which any type of chemical or other foreign substances will be injected into the water pumped from the diversion works shall be equipped with an in-line, automatic, quick-closing check valve capable of preventing pollution of the source of the water supply.

(b) Each check valve required by the chief engineer shall be constructed and installed in accordance with the requirements specified in K.A.R. 5-6-13a.

(c) Each check valve and all required components shall be maintained in an operating condition that prevents backflow into the source of water supply whenever a foreign substance could reasonably be expected to be introduced into the water system. (Authorized by K.S.A. 82a-706a;

implementing K.S.A. 82a-706, K.S.A. 82a-706a, K.S.A. 82a-712; effective May 1, 1980; amended May 1, 1981; amended Oct. 24, 2003.)

5-3-5d. Persons required to install a water level measurement tube. Every well with an authorized maximum rate of diversion of 100 or more gallons per minute drilled after the effective date of this regulation, except those wells authorized under a temporary permit, a domestic right, or a term permit for five or fewer years, shall have a tube installed in accordance with specifications adopted by the chief engineer. This tube shall be suitable for making water level measurements and shall be maintained in a satisfactory condition. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706c; effective May 1, 1980; amended Sept. 22, 2000.)

5-3-5e. Meters and other water-measuring devices; reporting readings; maintenance, and replacement. (a) For the purpose of this regulation, "meter" shall mean a water flowmeter or other water-measuring device.

(b) Whenever the installation of a meter is required by the chief engineer as a condition of a water right or permit, by written order of the chief engineer, or by requirement of a groundwater management district, the water right owner shall report all information required on the form prescribed by the chief engineer pursuant to K.S.A. 82a-732, and amendments thereto, including the following:

(1) The beginning and ending readings of the meter each calendar year;

(2) the units in which the meter registers; and

(3) the quantity of water diverted during the calendar year in the same units in which the meter registers.

(c) Whenever a totalizing hour meter has been required by the chief engineer or a groundwater management district, the water right owner shall report all information required on the form prescribed by the chief engineer pursuant to K.S.A. 82a-732, and amendments thereto, including the following:

(1) The beginning and ending readings of the meter each calendar year;

(2) the units in which the meter registers; and

(3) the rate of diversion at which water is pumped in gallons per minute. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-732; effective May 31, 1994; amended Sept. 22, 2000.)

5-3-5g. Designation of a water use correspondent. If the owner or owners of an approval of application or a water right desire to delegate the authority to receive and submit the annual water use reports as prescribed by K.S.A. 82a-732, and amendments thereto, to another person, an owner of the approval of application or the water right shall sign and submit a form prescribed by the chief engineer designating the person responsible to receive and submit the required annual water use report. However, the water right owner or owners shall remain, in all cases, the person or persons legally responsible for filing the water use reports required by K.S.A. 82a-732, and amendments thereto. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-732; effective Sept. 22, 2000.)

5-3-5h. Water conservation plans. Each water conservation plan shall be submitted on a form prescribed by the chief engineer. The plan shall also contain the name, address, and telephone number of the designer of the water conservation plan. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-733; effective Sept. 22, 2000.)

5-3-5i. Time limit to implement a water conservation plan. (a) The time to fully implement the water conservation plan shall be limited by the chief engineer to a reasonable specific date, which may be extended for good cause shown by the applicant.

(b) A municipal or industrial water user shall be given at least one full calendar year after the conservation plan is approved by the chief engineer to fully implement the water conservation plan.

(c) A user of water for irrigation shall be given at least one full growing season after the conservation plan is approved by the chief engineer to fully implement the approved water conservation plan. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-733; effective Sept. 22, 2000.)

5-3-5j. Maintenance of a water conservation plan. Once implemented, the applicant shall continue to satisfactorily maintain each component of the water conservation plan. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-733; effective Sept. 22, 2000.)

5-3-5k. Review of a water conservation plan. The right to review the water conservation plan to determine if it is consistent with current guidelines adopted and maintained pursuant to

K.S.A. 74-2608, and amendments thereto, shall be reserved by the chief engineer. If the review determines that the water conservation plan is materially different from those guidelines, then the owner of the water right or approval of application may be ordered by the chief engineer to amend the water conservation plan to make it consistent with the current guidelines for conservation plans and practices adopted and maintained pursuant to K.S.A. 74-2608, and amendments thereto. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-733; effective Sept. 22, 2000.)

5-3-5*l*. Changes in a water conservation plan. If a person required to implement a water conservation plan desires to make a material change in the plan, that person shall submit a request to make the change to the chief engineer on a form prescribed by the chief engineer. Any material change in an approved water conservation plan shall require the prior written approval of the chief engineer. Any proposed change in a water conservation plan shall be subject to the same type of review as that required for the original water conservation plan. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-733; effective Sept. 22, 2000.)

5-3-5m. Limited power of attorney. If all of the owners of an approval of application or water right desire to authorize any other person to take any type, or types, of official action on behalf of the approval of application or water right, all of the owners of the approval of application or water right shall meet the following requirements:

(a) A limited power of attorney shall be submitted to the chief engineer.

(b) The limited power of attorney shall be signed and acknowledged by all of the owners of the approval of application or water right and filed pursuant to the provisions of K.S.A. 58-601, and amendments thereto. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 82a-701 et seq.; effective Sept. 22, 2000.)

5-3-5n. Authorized place of use. (a) Except as set forth in subsection (b), each approval of application, or an approval of an application for change filed in accordance with K.S.A. 82a-708b, and amendments thereto, shall describe the authorized place of use as either of the following:

(1) Land not authorized for beneficial use of water by any other water right or approval of application; or

(2) exactly the same land authorized for beneficial use of water by one or more prior approvals of applications or water rights.

(b) The requirement in subsection (a) shall not apply to applications that propose to partially overlap the authorized place of use with any of the following:

(1) A municipality;

(2) an irrigation district;

(3) an irrigation ditch company;

(4) a rural water district;

(5) another authorized place of use that cannot all be physically served by all of the water rights and approvals of applications;

(6) an authorized place of use that is owned by different landowners who do not operate together; or

(7) the owner or owners of the water rights and approvals of applications demonstrate both of the following to the chief engineer:

(A) It is not practical or desirable to have a complete overlap.

(B) Allowing an incomplete overlap of authorized places of use will not prejudicially and unreasonably affect the public interest. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-709; effective Sept. 22, 2000.)

5-3-5o. Amending water use reports. (a) Except as specified in this subsection, each annual water use report submitted to the chief engineer pursuant to K.S.A. 82a-732, and amendments thereto, shall be considered the official report of water use information filed in the office of the chief engineer. Each person who files a request to correct a water use report shall ensure that the water use report is corrected in accordance with all of the following procedures, in order for the corrected report to be considered the official report:

(1) A written request to correct the report is submitted to the chief engineer on a form prescribed by the chief engineer.

(2) Each requested change in the water use report is documented by independent, verifiable supporting information, including fuel records, power records, crop production records, county appraiser records, natural resource conservation service records, crop insurance records, other similar types of records, and any combination of these records. The independent, verifiable supporting information may be supported by an affidavit from one or more competent, disinterested

persons who have actual personal knowledge of the facts.

(3) The written request, including the supporting documentation, is verified upon oath or affirmation to be accurate and complete to the best knowledge of the person filing the request.

(4) The person filing the request to change a water use report sustains the burden to show the following:

(A) How the water use report on file in the office of the chief engineer is erroneous or incomplete; and

(B) that the proposed changes are the most complete and accurate water use information available.

(b) The right to perform the following shall be reserved by the chief engineer:

(1) Contest the accuracy and completeness of any water use report filed with the chief engineer, or corrected in accordance with this regulation, to show that the water use report is inaccurate, incomplete, false, or fraudulent; and

(2) make a determination of the actual water use based on the best available information. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 82a-732; effective Aug. 13, 2004.)

5-3-6. Forfeiture, revocation and dismissal. Failure of the applicant or his or her successors to comply with the provisions of the approval of application and permit to proceed and its terms, conditions and limitations without good cause shall result in the forfeiture of the priority date, revocation of the permit and dismissal of the application. (Authorized by K.S.A. 82a-706a; modified, L. 1978, ch. 460, May 1, 1978.)

5-3-6a. Sealing pumps. If the chief engineer, or any of his or her duly authorized representatives, has reasonable cause to believe that any person has failed to obey an order of the chief engineer to cease and desist from operating a pump or other diversion device, the chief engineer or his or her duly authorized representative shall place a seal, or chain and padlock, on the pump or device in such a manner as to render the pump or other diversion device inoperable.

If the seal, or chain and padlock, is broken without the written permission of the chief engineer, this shall create a rebuttable presumption that the pump had been unlawfully operated in violation of the order of the chief engineer and that the water right holder has been acting in violation of the conditions of his or her permit to appropriate water for beneficial use.

The suspected violator shall be informed in writing of the creation of this presumption at the time the seal, or chain and padlock, is installed on the pump or other diversion device. (Authorized by K.S.A. 82a-706a, 82a-706b; effective May 1, 1980.)

5-3-7. Request for extension of time. (a) For applications filed after May 1, 1978, any request for extension of time either for completion of diversion works or for perfecting the appropriation shall be submitted to the chief engineer before the expiration of the time allowed for completing the diversion works or perfecting the appropriation. The request shall be signed by the holder of the approval of application and permit to proceed, by the owner of the land to be irrigated, by an authorized official of a municipality, corporation or partnership, or by any other person that has a recognized interest in the appropriation. Failure to request an extension of time to perfect the appropriation within the time allowed shall limit the water appropriation right to the extent perfected in accordance with the terms, conditions, and limitations set forth in the approval of application.

(b) The request for an extension of time either for completion of diversion works or for perfecting the appropriation shall be accompanied by the statutorily required filing fee and shall include the following information:

(1) The application number;

(2) the date by which the diversion works will be completed or the appropriation will be perfected;

(3) the progress that has been made toward completing the diversion works or perfecting the appropriation;

(4) if for irrigation, the number of acres of land to which water has been applied during one calendar year;

(5) the reason why the diversion works have not been completed or the appropriation has not been perfected; and

(6) the plans for completing the diversion works or perfecting the appropriation. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-714(e); modified, L. 1978, ch. 460, May 1, 1978; amended Oct. 24, 2003.)

5-3-8. Certificate of appropriation. Upon

determination that the appropriation diversion works have been completed and an appropriation right perfected in conformity with an approved application and plans, the chief engineer shall issue a certificate of appropriation setting forth the extent to which the appropriation right was perfected. No appropriation shall be determined for a quantity of water or a diversion rate in excess of that set forth in the approval of application and permit to proceed or in excess of that found to have been actually applied to the approved beneficial use or for any quantity of water found to have been wasted during the calendar year of record used as the basis for perfecting the appropriation right. (Authorized by K.S.A. 82a-706a; modified, L. 1978, ch. 460, May 1, 1978.)

5-3-9. Public interest. (a) In accordance with K.S.A. 82a-711(b)(5), as amended, in ascertaining whether a proposed use will prejudicially and unreasonably affect the public interest, the chief engineer shall also take into consideration the quantity, rate and availability of water necessary to:

(1) satisfy senior domestic water rights from the stream;

(2) protect senior water rights from being impaired by the unreasonable concentration of naturally occurring contaminants; and

(3) over the long term reasonably recharge the alluvium or other aquifers hydraulically connected to the stream.

(b) Unless otherwise provided by regulation, it shall be considered to be in the public interest that only the safe yield of any source of water supply, including hydraulically connected sources of water supply, shall be appropriated. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1993 Supp. 82a-711; effective Nov. 28, 1994.)

5-3-10. Availability of water for appropriation - safe yield. (a) Except as set forth in subsection (b) and K.A.R. 5-3-16 and K.A.R. 5-3-17, the approval of any new application to appropriate groundwater or surface water for beneficial use, except for domestic use, temporary use and term permits for five years or less, shall not cause the safe yield of the source of water supply to be exceeded, neither shall it otherwise prejudicially and unreasonably affect the public interest. The approval of term permits shall not allow impairment nor prejudicially and unreasonably affect the public interest.

(b) This regulation shall not apply to an application which proposes:

(1) to divert water from a source of water supply subject to a different safe yield, allowable appropriation, depletion or other similar type of criteria adopted by rule and regulation of the chief engineer or intensive groundwater use control area order of the chief engineer issued pursuant to K.S.A. 82a-1036 et seq., or

(2) to use water in a manner so that there is no significant net consumptive use of the local source of supply either in quantity or availability of water for use by other appropriators.

(c) If a total quantity of water that is available for appropriation in any basin, subbasin, stream reach or other hydrologic unit has been determined by the chief engineer prior to the date that application is filed, the total quantity of water authorized by vested rights, prior appropriations, requests by prior unapproved applications and the proposed appropriation shall be determined by the chief engineer.

(1) If the total quantity of water authorized and requested by applications with earlier filing dates is less than or equal to the total annual quantity of water determined to be available for appropriation, or if no total quantity of water available was determined by the chief engineer prior to the date the application was filed, the following procedures shall be used by the chief engineer to further evaluate the applications:

(A) K.A.R. 5-3-11 shall be used to evaluate an application to appropriate groundwater from an unconfined aquifer;

(B) K.A.R. 5-3-14 shall be used to evaluate an application to appropriate groundwater from a confined aquifer; or

(C) K.A.R. 5-3-15 shall be used to evaluate an application to appropriate surface water.

(2) If the total quantity of water authorized and requested exceeds the limit determined by the chief engineer pursuant to this subsection, the application shall be denied or considered only for the quantity available. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1993 Supp. 82a-711; effective Nov. 28, 1994.)

5-3-11. Availability of water for appropriation-safe yield; unconfined groundwater aquifers. (a) Each application to appropriate groundwater from an unconfined aquifer shall be processed in accordance with this regulation.

(b) To determine the safe yield available for ap-

propriation from an unconfined aquifer at a specific location, the following procedure shall be used by the chief engineer:

(1) The amount of calculated recharge occurring within the area of consideration shall be determined by the chief engineer.

(2) That amount shall be multiplied by the percent of calculated recharge determined by the chief engineer to be available nondomestic groundwater and surface water for appropriation.

(3) The total quantity of water authorized and requested in the same area of consideration shall be subtracted from the number derived from paragraph (b)(2) above. If a water right or permit authorizes more than one point of diversion and not all of them are within the area of consideration, the authorized quantity shall be divided equally between or among all the points of diversion, unless information is available to more accurately distribute the authorized quantity between or among the multiple points of diversion.

(c) (1) If the quantity of water remaining is sufficient to satisfy the proposed application, then the safe yield criteria shall be deemed to have been met, unless there are other relevant factors that need to be taken into account in order to protect the public interest. The application shall then be processed according to other criteria in effect in that area.

(2) If there is sufficient water available to reasonably satisfy part of the request, then the application shall be approved for the quantity available if the remaining quantity is reasonable for the proposed use and the application meets the other applicable criteria in that area.

(3) If no water is available to satisfy the proposed application, then the application shall be denied by the chief engineer.

(d)(1) In making a safe yield calculation, unless the context clearly requires otherwise, the following words and phrases shall have the meanings ascribed to them:

(A) "Circle" means a circle with a two-mile radius, with the proposed point of diversion as the center.

(B) "Area of consideration" means the portion of the two-mile circle located within the limits of the unconfined aquifer expressed in acres, including any area of the circle located within the boundaries of a groundwater management district. The area of consideration shall not include any portion of the circle located outside the state of Kansas.

(C) "Total quantity of water" means the total combined authorized annual quantities under all groundwater rights and approvals of applications, and requested by pending applications with a senior priority in that unconfined aquifer except for domestic use, temporary permits, and term permits for five or fewer years with priority dates senior to the proposed application and with points of diversion located within the area of consideration.

(D) "Calculated recharge" means that portion of the average annual precipitation that becomes recharge to the unconfined aquifer, calculated using the data shown on water resources investigations report 87-4230, plate no. 4, dated 1987, prepared by the United States geological survey, hereby adopted by reference, interpolated to the nearest tenth of an inch, unless better or more specific recharge data for the area of consideration, basin, or aquifer is supplied by the applicant or is already available to the chief engineer.

(2) The calculated recharge in the Kansas river alluvium shall be determined by taking 25% of the average annual rainfall in the area of consideration as taken from figure 2, United States geological survey water resources investigation report 92-4137, dated 1993, hereby adopted by reference, interpolated to the nearest 0.1 of an inch.

(3) For each application to appropriate groundwater from an unconfined aquifer filed on or after the effective date of this regulation, the percentages of calculated recharge that shall be considered to be available for appropriation shall be determined using the following table:

Percent of Calculated Recharge Available for Appropriation	River Basin
(A) 100% plus the recharge from the Missouri River available to the well, as calculated by a Jenkins or similar stream-depletion technique.	Missouri
(B) 100%	Arkansas River below Hutchinson*
	Big Blue River **
	Black Vermillion River **
	Delaware River **
	Little Arkansas River below GMD No. 2 *
	Little Blue River **
	Little Osage River **
	Lower Republican River Basin outside the effective alluvium and the Belleville formation that does not contribute significant baseflow to a stream**

Percent of Calculated Recharge Available for Appropriation	River Basin
	Marais des Cygnes River **
	Mill Creek **
	Marmaton River **
	Nemaha River **
	Pottawatomie Creek **
	Smoky Hill River below its confluence with the Saline River **
	Spring River *
	Stranger Creek **
	Sugar Creek **
	Vermillion Creek **
	Wakarusa River **
	Walnut River *
	Any hydrologic unit that does not contribute significant baseflow to a stream.
(C) 75%	Any hydrologic units in the following river basins that contribute significant baseflow to a stream:
	Arkansas River above Hutchinson*
	Caney River *
	Cottonwood River *
	Cow Creek outside the boundaries of GMD No. 2 and GMD No. 5*
	Elk River *
	Fall River *
	Kansas River **
	Little Arkansas River above GMD No. 2 *
	Lower Republican River Basin outside the effective alluvium and the Belleville formation that contributes significant baseflow to a stream. **
	Neosho River *
	Ninnescah River *
	Saline River **
	Salt Creek **
	Smoky Hill above its confluence with the Saline River **
	Solomon River **
	South Fork Ninnescah River (except Smoots Creek) *
	Upper Republican Basin outside areas closed to new appropriations as set forth in paragraph (d)(5) of this regulation. **
	Verdigris River *
	Any other basin in Kansas not specifically identified
(D) 50%	Any hydrologic units in the following river basins that contribute significant baseflow to a stream:
	Bluff Creek-Chikaskia River *
	Bluff Creek-Cimarron River *
	Chikaskia River *
	Cimarron River outside GMD No. 3 *
	Medicine Lodge River *
	North Fork Ninnescah River *
	Rattlesnake Creek *
	Salt Fork Arkansas River *
	Sandy Creek *
	South Fork Ninnescah River (Smoots Creek only) *

* Located in Arkansas River Basin
** Located in Kansas River Basin

(4) The total quantity of water and the percent of calculated recharge originally available to be appropriated for nondomestic groundwater and surface water use in all or part of the following basins, subbasins, stream reaches, and other hydrologic units identified in electronic data file unitbsn.e00, dated July 30, 1997, prepared by the division of water resources, Kansas department of agriculture and hereby adopted by reference for the purpose of defining the boundaries of the hydrologic units, shall be determined using the following table:

South-Central Kansas Designated Unit Areas

Map Label	Effective Date	Area (acres)	Recharge Rate (in/yr)	Recharge Quantity (Ac-ft/yr)	Percentage of Recharge to Appropriate	Original Quantities Available (Ac-ft/yr)	General Location (Twp.-Range)	Abbreviation for Portion of Basin or Basins
1	November 28, 1994	32204	1.8	4831	100%	4831	29-12w	Chikaskia
2	November 28, 1994	41426	1.8	6214	100%	6214	30-11w	Chikaskia
3	November 28, 1994	55524	1.8	8329	50%	4164	29-10w	Chikaskia
4	November 28, 1994	43603	1.8	6540	50%	3270	30-10w	Chikaskia
5	November 28, 1994	46828	2.0	7805	50%	3902	31-05w	Chikaskia
6	November 28, 1994	46895	2.5	9770	50%	4885	33-03w	Chikaskia
7	November 28, 1994	37378	3.0	9344	50%	4672	34-02w	Chikaskia

Map Label	Effective Date	Area (acres)	Recharge Rate (in/yr)	Recharge Quantity (Ac-ft/yr)	Percentage of Recharge to Appropriate	Original Quantities Available (Ac-ft/yr)	General Location (Twp.-Range)	Abbreviation for Portion of Basin or Basins
8	November 28, 1994	42210	3.0	10553	50%	5276	33-01w	Chikaskia
9	November 28, 1994	15145	2.0	2524	100%	2524	30-08w	Chikaskia
10	November 28, 1994	6855	2.0	1143	100%	1143	31-06w	Chikaskia
11	November 28, 1994	2824	2.0	471	100%	471	31-06w	Chikaskia
12	November 28, 1994	8548	2.0	1425	100%	1425	31-05w	Chikaskia
13	November 28, 1994	12165	2.0	2027	50%	1014	31-07w	Chikaskia
14	November 28, 1994	27213	2.0	4535	50%	2268	32-05w	Chikaskia
15	November 28, 1994	21101	1.5	2638	50%	1319	31-15w	Medicine Lodge
16	November 28, 1994	7489	1.5	936	50%	468	32-11w	Medicine Lodge
17	November 28, 1994	20516	1.5	2564	50%	1282	33-11w	Medicine Lodge
18	November 28, 1994	34426	1.5	4303	50%	2152	29-19w	Rattlesnake
19	November 28, 1994	25566	1.5	3196	50%	1598	29-18w	Medicine Lodge
20	November 28, 1994	56730	1.8	8509	100%	8509	29-14w	Medicine Lodge
21	November 28, 1994	41800	1.8	6270	50%	3135	30-12w	Medicine Lodge
22	November 28, 1994	15825	1.2	1582	50%	791	30-17w	Medicine Lodge
23	November 28, 1994	59864	1.5	7483	50%	3742	29-16w	Medicine Lodge
24	November 28, 1994	37658	1.5	4707	100%	4707	29-15w	Medicine Lodge
25	November 28, 1994	102144	1.9	16173	75%	12130	28-09w	SF Ninnescah
26	November 28, 1994	10638	2.0	1773	75%	1330	28-07w	SF Ninnescah
27*	Revision	84047	2.0	14008	50%	7004	26-07w	SF Ninnescah
28	November 28, 1994	5196	2.2	953	75%	714	28-04w	SF Ninnescah
29	November 28, 1994	73816	1.9	11688	100%	11688	28-07w	Chik/SFNin/Nin
30	November 28, 1994	38651	2.0	6442	100%	6442	30-05w	Chik/SFNin/Nin/Ark
31	November 28, 1994	5572	2.3	1068	100%	1068	31-04w	Chik/Ark
32	November 28, 1994	21937	2.0	3656	100%	3656	27-07w	SF Ninnescah
33	November 28, 1994	40646	2.5	8468	75%	6351	23-08w	Arkansas
34	November 28, 1994	41974	2.3	8045	75%	6034	24-08w	NF Ninnescah
35	November 28, 1994	3917	2.0	653	75%	490	26-08w	NF Ninnescah
36	November 28, 1994	12106	2.0	2018	75%	1513	27-10w	NF Ninnescah
37	November 28, 1994	8135	2.0	1356	75%	1017	26-08w	NF Ninnescah
38*	Revision	34550	1.2	3455	50%	1728	32-20w	Bluff Creek (Cim)
39	November 28, 1994	21875	1.2	2188	50%	1094	33-20w	Bluff Creek (Cim)
40	November 28, 1994	11466	1.2	1147	50%	573	33-20w	Bluff Creek (Cim)
41	November 28, 1994	8565	1.6	1142	50%	571	34-17w	Salt Fork Arkansas
42	November 28, 1994	3746	1.6	499	50%	250	33-15w	Salt Fork Arkansas
43	November 28, 1994	9763	1.6	1302	50%	651	34-15w	Salt Fork Arkansas
44	November 28, 1994	33060	1.8	4959	100%	4959	31-10w	Sandy Cr
45	November 28, 1994	3922	1.8	588	100%	588	33-09w	Sandy Cr
46	November 28, 1994	26959	1.8	4044	50%	2022	32-10w	Sandy Cr
47	November 28, 1994	41296	1.8	6194	50%	3097	34-09w	Sandy Cr
48	November 28, 1994	36364	1.9	5758	50%	2879	31-08w	Bluff Creek (Chik)
49	November 28, 1994	45511	2.0	7585	50%	3793	32-07w	Bluff Creek (Chik)
50	November 28, 1994	23546	2.3	4513	50%	2257	34-06w	Bluff Creek (Chik)
51	November 28, 1994	25608	2.7	5762	50%	2881	35-03w	Bluff Creek (Chik)
52	November 28, 1994	4460	1.9	706	100%	706	32-09w	Sandy Cr
53	November 28, 1994	17083	2.0	2847	100%	2847	33-08w	Sandy Cr/Bluf (Chik)
54	November 28, 1994	3845	2.0	641	50%	320	32-08w	Sandy Cr/Bluf (Chik)
55	July 5, 1996	3582	1.2	358	50%	179	35-18w	Cimarron
56	July 5, 1996	10967	1.2	1097	50%	548	35-19w	Cimarron
57	July 5, 1996	37387	1.2	3739	50%	1869	34-20w	Cimarron
58	July 5, 1996	3379	1.3	366	50%	183	33-21w	Cimarron
59	July 5, 1996	5885	1.3	638	50%	319	35-22w	Cimarron
60	July 5, 1996	14854	1.3	1609	50%	805	33-22w	Cimarron
61	July 5, 1996	34080	1.3	3692	50%	1846	34-22w	Cimarron
62	July 5, 1996	25419	1.3	2754	50%	1377	31-17w	Salt Fork
63	July 5, 1996	29813	1.3	3230	15%	484	32-17w	Salt Fork

Map Label	Effective Date	Area (acres)	Recharge Rate (in/yr)	Recharge Quantity (Ac-ft/yr)	Percentage of Recharge to Appropriate	Original Quantities Available (Ac-ft/yr)	General Location (Twp.-Range)	Abbreviation for Portion of Basin or Basins
64	July 5, 1996	90035	1.3	9754	50%	4877	31-18w	Salt Fork
65	July 5, 1996	35931	1.3	3893	50%	1946	31-19w	Bluff Creek
66	July 5, 1996	100983	1.3	10940	50%	5470	30-20w	Bluff-Rattlesnake
67	July 5, 1996	111132	1.2	11113	50%	5557	30-24w	Bluff-Crooked
68	July 5, 1996	12188	1.2	1219	50%	609	31-23w	Cimarron
69	July 5, 1996	5518	1.2	552	50%	276	31-24w	Cimarron
70	July 5, 1996	32689	1.2	3269	50%	1634	32-25w	Cimarron
71	July 5, 1996	94734	1.3	10263	50%	5131	32-26w	Cim-Crooked
72	July 5, 1996	44833	1.3	4857	50%	2428	33-27w	Cim-Crooked
73	July 5, 1996	50088	1.3	5426	50%	2713	34-27w	Cim-Crooked
74	July 5, 1996	25210	1.3	2731	50%	1366	35-27w	Cim-Crooked
75	July 5, 1996	103816	1.3	11247	50%	5623	34-24w	Cim-Crooked
76	July 5, 1996	23296	1.2	2330	50%	1165	30-22w	Bluff-Rattlesnake
77	July 5, 1996	27666	1.2	2767	50%	1383	32-15w	Salt-Medicine
78	July 5, 1996	5261	1.2	526	100%	526	35-13w	Salt Fork
79	July 5, 1996	8249	1.8	1237	50%	619	31-12w	Medicine

* Revision is effective the date of this regulation.

(5) The following hydrologic units, which have been determined by the chief engineer to be fully appropriated based on the safe yield criteria, shall be closed to further new surface water and groundwater appropriations except for domestic use, temporary permits, and term permits for five years or less:

(A) Big Creek, its tributaries and their valley alluviums, and any other aquifer that has a substantial hydraulic connection to an alluvium;

(B) Beaver Creek and Little Beaver Creek, their tributaries and their alluviums, and any other aquifer that has a substantial hydraulic connection to an alluvium;

(C) North Fork Solomon River, its tributaries and their alluviums, and any other aquifer that has a substantial hydraulic connection to an alluvium;

(D) Prairie Dog Creek, its tributaries and their alluviums, and any other aquifer that has a substantial hydraulic connection to an alluvium;

(E) Sappa Creek, its tributaries and their alluviums, and any other aquifer that has a substantial hydraulic connection to an alluvium;

(F) South Fork of the Solomon River, its tributaries and their alluviums above Glen Elder Dam, and any other aquifer that has a substantial hydraulic connection to an alluvium; and

(G) Walnut Creek, its tributaries and their alluviums, and other hydraulically connected aquifers outside the boundaries of the intensive groundwater use control area created by order of the chief engineer shall be those set forth below:

Section	Township	Range	County
28 through 33	18S	23W	Barton
4 through 10 and 14 through 36	18S	14W	Barton
1 through 36	18S	25W	Barton
3 through 11 and 14 through 23	29S	13W	Barton
1 through 6, 9 through 15, and 22 through 24	29S	14W	Barton
1	19S	15W	Barton
31 through 35	17S	16W	Rush
19 through 36	17S	17W	Rush
19 through 36	17S	18W	Rush
23 through 26 and 31 through 36	17S	19W	Rush
35 and 36	17S	20W	Rush
1 through 36	18S	16W	Rush
1 through 36	18S	17W	Rush
1 through 36	18S	18W	Rush
1 through 36	18S	19W	Rush
1 through 36	18S	20W	Rush
3 through 6	19S	16W	Rush
1 through 6	19S	17W	Rush
1, 2, 11, and 12	19S	20W	Rush
32 through 34	17S	25W	Ness
1 through 36	18S	21W	Ness
1 through 4 and 7 through 36	18S	22W	Ness
19, 25 through 36	18S	23W	Ness
23 through 27, 35, and 36	18S	24W	Ness
1 through 5, 10 through 13, 24, 33, and 34	28S	25W	Ness
4 through 9	19S	21W	Ness
1 through 12, 17 and 18	19S	22W	Ness
1 through 23	19S	23W	Ness
1, 2, and 7 through 29	19S	24W	Ness
1 through 3 and 11 through 13	19S	25W	Ness

(6) "Technical guidelines for determining the availability of groundwater for appropriation in the Lower Republican River Basin and Belleville Formation and the availability of surface water for appropriation in the Lower Republican River Basin," adopted by the chief engineer, division of water resources, Kansas department of agriculture, on October 1, 1999, is hereby adopted by reference as determining the availability of groundwater for appropriation in the lower Republican River basin and Belleville formation and the availability of surface water for appropriation in the lower Republican River basin.

(7) (A) All applications for a permit to appropriate groundwater from the area described in paragraph (7) (B) for any beneficial use, except for domestic use, temporary permits, and short-term permits for five or fewer years, shall be accepted for filing and given a file number, if acceptable for filing. The application shall be returned by the chief engineer, and the reason that the application will be denied shall be specified by the chief engineer. The applicant shall be given 30 days to show cause why the application should not be denied. If the applicant does not show good cause, the application shall be dismissed.

(B) The area is described as sections 17, 18, 19, 20, township 7 south, range 6 west, and sections 13, 14, township 7 south, range 7 west, all in Mitchell County, Kansas.

(C) All applications for permits to appropriate groundwater from sections 29 and 30 in township 7 south, range 6 west, and sections 12, 15, 16, 21, 22, 23, 24, 25, 26, and 27 in township 7 south, range 7 west, all in Mitchell County, Kansas, for any beneficial use, except for domestic use, temporary permits, and term permits for five or fewer years, shall be processed based on the criteria set forth below in paragraph (7) (D).

(D) No new wells shall be allowed in the area described in paragraph (7) (C) above if the proposed well would produce one foot or more of additional drawdown at any existing well in that area and if the proposed well was pumped continuously for 45 days (1,080 hours) at the rate requested on the application. This analysis shall be done by using the Theis equation, with a coefficient of transmissivity of 71,000 gallons per day per foot (gpd/ft) and a coefficient of storage of 0.02.

(E) Any application for a change in the point of diversion filed for a well located in the areas described in paragraphs (7) (B) and (C) above shall be limited to a move of no more than 100 feet, unless the applicant can show the chief engineer that the proposed move will not prejudicially and unreasonably affect the public interest, will not impair existing water rights, and otherwise complies with the provisions of K.S.A. 82a-708b, and amendments thereto. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-711; effective Nov. 28, 1994; amended Sept. 22, 2000.)

5-3-12. (Authorized by K.S.A. 82a-701(g), 82a-706a; effective May 1, 1980; revoked May 1, 1987.)

5-3-13. Dewatering of construction sites. The chief engineer shall limit the time in which water may be withdrawn for dewatering purposes. Any water right that may be perfected by the dewatering project shall be deemed abandoned and terminated upon the completion of the dewatering project. Any extension of time in which to complete the project must be requested in writing by the applicant prior to the expiration date on the permit. (Authorized by K.S.A. 82a-706a, 82a-712; effective May 1, 1980.)

5-3-14. Availability of water for appropriation - safe yield; confined groundwater aquifers. (a) Each application to appropriate water from a confined aquifer shall be processed on a case by case basis so that the safe yield of the source of water supply is not exceeded.

(b) Until a specific regulation is adopted by the chief engineer for the confined source of water supply, the analysis shall be made using the best information reasonably available to the chief engineer. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1993 Supp. 82a-711; effective Nov. 28, 1994.)

5-3-15. Availability of water for appropriation - safe yield; surface water. (a) Each application filed to directly divert the natural flow of the Kansas river, the Missouri river, the Big Blue river, the Spring river, or their tributaries, shall:

(1) be processed in accordance with K.A.R. 5-3-9; and

(2) meet all other requirements for the approval of a new application.

(b) The water right owner shall be required by the chief engineer to meet minimum desirable streamflows (MDS), assurance district target flows (assurance target flows) and division of wa-

ter resources (DWR) target flows where applicable.

(c) Each application filed to directly divert the natural flow from any stream or tributary in the state of Kansas, except those streams listed in paragraph (a) of this regulation, shall have the following conditions of approval.

(1) If MDS or assurance target flows or DWR target flows have been set for that stream, and MDS administration has been requested by the Kansas water office, diversion of natural flow shall only be permitted if MDS, assurance target flows or DWR target flows, if applicable, are being met at the gage or gages immediately below the proposed point of diversion.

(2) Diversion of natural flow shall not take place unless there is water available to satisfy all demands by senior water rights and permits.

(3) The streamflow shall not be stopped at the first riffle below the point of diversion while diversion is taking place under the authority of that water right or permit.

(4) During the period October 1 through June 30, the verbal or written permission of the chief engineer, or an authorized representative of the chief engineer, shall be obtained in order to divert water each time the applicant desires to divert water.

(5) The applicant shall be required to demonstrate that the direct diversion of streamflow is not necessary during the period July 1 through September 30 each calendar year because of lack of need; the availability of adequate water storage or alternative water supplies; or other similar reasons.

(6) During the period July 1 through September 30 each calendar year, no direct diversions of water shall be permitted unless written permission is obtained from the chief engineer or the chief engineer's authorized representative.

(d) Each application filed by a member of an operational assurance district for that stream shall be processed taking into consideration the provisions of the assurance district contract.

(e) Each application filed for a point of diversion which might divert water released from storage pursuant to an agreement between the state of Kansas and the federal government shall be processed taking into consideration the provisions of that agreement.

(f) Each application filed to divert the natural flow of any stream subject to a more specific regulation adopted by the chief engineer or an intensive groundwater use control area order issued by the chief engineer, for a basin or portion thereof, shall be processed in accordance with the provisions of that regulation or order. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1993 Supp. 82a-711; effective Nov. 28, 1994.)

5-3-16. Safe yield; exemptions for up to 15 acre-feet of groundwater. In any area of the state outside a groundwater management district that is subject to safe yield criteria and is not closed by regulation or intensive groundwater use control area order by the chief engineer to new nondomestic, nontemporary permits and term permits for five or fewer years, applications to appropriate groundwater shall be exempt from meeting the safe yield criteria if the chief engineer finds that all of the following conditions are met:

(a) The sum of the annual quantity requested by the proposed appropriation and the total annual quantities authorized by prior permits allowed because of an exemption pursuant to this regulation does not exceed 15 acre-feet in a ½-mile-radius circle surrounding the proposed point of diversion.

(b) Well spacing criteria in the area have been met.

(c) The approval of the application does not authorize an additional quantity of water out of an existing authorized well with a nondomestic permit or water right, which would result in a total combined annual quantity of water authorized from that well in excess of 15 acre-feet.

(d) All other criteria for processing a new application to appropriate water at that location have been met. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-711; effective Nov. 28, 1994; amended Sept. 22, 2000.)

5-3-16a. Closed areas; exemptions for up to five acre-feet of groundwater. In any area of the state that is outside a groundwater management district and an intensive groundwater use control area (IGUCA) and that is closed to new appropriations of groundwater by regulation except for domestic use, temporary permits, and term permits for five or fewer years, applications to appropriate groundwater shall be exempt from meeting the safe yield criteria and the regulation closing the area to new appropriations if the chief engineer finds that all of the following criteria are met: (a) The sum of the annual quantity of water requested by the proposed appropriation and the total annual quantities of water au-

thorized by prior approvals of applications allowed because of an exemption pursuant to this regulation does not exceed five acre-feet in a two-mile-radius circle surrounding the proposed point of diversion.

(b) The annual quantity of water requested is reasonable for the proposed beneficial use of water.

(c) All other criteria for processing a new application to appropriate water at that location, including well spacing criteria, have been met.

(d) The approval of the application does not authorize an additional quantity of water out of an existing well that would result in a total combined annual quantity of water authorized from that well in excess of five acre-feet per calendar year.

(e) The proposed beneficial use of water will significantly benefit the public interest and help maximize economic development. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a, K.S.A. 2002 Supp. 82a-711, and K.S.A. 2002 Supp. 82a-1904; effective Oct. 24, 2003.)

5-3-17. Safe yield; miscellaneous exemptions. In any area of the state which is subject to safe yield criteria, and outside a groundwater management district or an intensive groundwater use control area closed to new non-domestic, non-temporary uses, each application to appropriate groundwater for a beneficial use shall be exempt from meeting the safe yield criteria if the chief engineer finds that:

(a) the proposed use has occurred continuously since prior to the effective date of this regulation;

(b) the proposed use could have reasonably been classified by the division of water resources as a domestic use at the time the use began; and

(c) all other requirements in effect for the approval of a new application to appropriate water at that location have been met. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1993 Supp. 82a-711; effective Nov. 28, 1994.)

5-3-18. Applicant's opportunity to submit additional information. (a) If at any stage of processing an application, it is determined by the chief engineer that an application does not meet the safe yield criteria, the applicant shall be notified by the chief engineer in writing prior to denial of the application that the safe yield requirements have not been met and the reason for the proposed denial. In this written notice, the chief engineer shall allow the applicant 15 days to request time in which to submit additional information to show why the application should be approved.

(b) Within 15 days the applicant shall either submit the additional information or file a written request for a reasonable amount of time to submit an engineering report or similar type of hydrologic analysis to show that approval of the application will not cause the safe yield of the source of water supply to be exceeded.

(c) If the applicant fails to timely show to the satisfaction of the chief engineer that the application can be approved, then the application shall be denied by the chief engineer. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1993 Supp. 82a-711; effective Nov. 28, 1994.)

5-3-19. Maximum reasonable annual quantity of water for irrigation use. (a) For applications filed before the effective date of this regulation, the maximum annual quantity of water reasonably necessary to irrigate crops shall be determined as follows:

(1) In that area of Kansas located between the eastern border of Kansas and the western border of range 6 east, the maximum reasonable annual quantity of water shall not exceed one acre-foot of water per acre irrigated.

(2) In that area of Kansas located between the eastern border of range 5 east and the western border of range 20 west, the maximum reasonable annual quantity of water shall not exceed 1½ acre-feet of water per acre irrigated.

(3) In that area of Kansas located between the eastern border of range 21 west and the western border of Kansas, the maximum reasonable annual quantity of water shall not exceed two acre-feet of water per acre irrigated.

(b) On and after the effective date of this regulation, the maximum annual quantity of water reasonably necessary to irrigate crops shall be determined by multiplying the number of irrigated acres by the county value found on the map adopted by reference in K.A.R. 5-3-24. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a, K.S.A. 82a-707(e), and K.S.A. 2002 Supp. 82a-711; effective Sept. 22, 2000; amended Oct. 24, 2003.)

5-3-20. Maximum reasonable annual quantity of water approvable for a new appropriation of water for irrigation use. (a) The maximum reasonable annual quantity of water that may be approved for use on irrigated land for

applications filed before the effective date of this regulation shall be limited to the following:

(1) The quantity of water available for appropriation as determined by the safe yield, allowable appropriation or similar type of limitation adopted by regulation of the chief engineer for the area in which the proposed point of diversion will be located;

(2) the quantity of water reasonably physically available from the source of water supply based on the physical characteristics of the source of water supply and the proposed diversion works; and

(3) the quantity of water reasonably necessary to irrigate crops in the region of the state where the proposed place of use is located as set forth in K.A.R. 5-3-19(a). The authorized quantity shall be determined by multiplying the number of acres approved to be irrigated by the quantity per acre set forth in K.A.R. 5-3-19(a).

(b) The maximum reasonable annual quantity of water that may be approved for use on irrigated land for applications filed on or after the effective date of this regulation shall be limited to the following:

(1) The quantity of water available for appropriation as determined by the safe yield, allowable appropriation or similar type of limitation adopted by regulation of the chief engineer for the area in which the proposed point of diversion will be located;

(2) the quantity of water reasonably physically available from the source of water supply based on the physical characteristics of the source of water supply and the proposed diversion works; and

(3) the quantity of water reasonably necessary to irrigate crops in the region of the state where the proposed place of use is located as set forth in K.A.R. 5-3-19(b).

(c) The quantity specified in subsection (a) or (b) may be exceeded only if the applicant demonstrates both of the following to the chief engineer:

(1) Because of specialty crops or other unusual conditions, the quantity specified in K.A.R. 5-3-19 is insufficient.

(2) The requested quantity is reasonable for the intended irrigation use, is not wasteful, and will not otherwise prejudicially and unreasonably affect the public interest. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-707(e), K.S.A. 1999 Supp. 82a-711, and K.S.A. 82a- 712; effective Sept. 22, 2000.)

5-3-21. Perfection of a water right for irrigation use. (a) For applications with a priority date before the effective date of this regulation, the maximum reasonable annual quantity of water that may be perfected for irrigation use shall not exceed the following:

(1) The maximum annual quantity of water actually applied to beneficial use in any one calendar year in accordance with the terms, conditions, and limitations of the approval of application during the perfection period; and

(2) the quantity of water reasonably necessary to irrigate crops in the region of the state where the place of use is located as set forth in K.A.R. 5-3-19(a). The reasonable quantity shall be determined by multiplying the number of acres actually irrigated during the year of record by the quantity per acre as set forth in K.A.R. 5-3-19(a).

(b) For applications with a priority date on or after the effective date of this regulation, the maximum reasonable annual quantity of water that may be perfected for irrigation use shall not exceed the following:

(1) The maximum annual quantity of water actually applied to beneficial use in any one calendar year in accordance with the terms, conditions, and limitations of the approval of application during the perfection period; and

(2) the quantity of water reasonably necessary to irrigate crops in the region of the state where the place of use is located as set forth in K.A.R. 5-3-19(b). The reasonable quantity shall be determined by multiplying the number of acres actually irrigated during the year of record by the quantity per acre set as forth in K.A.R. 5-3-19(b).

(c) The quantity specified in subsection (a) or (b) may be exceeded only if the water right owner demonstrates both of the following to the chief engineer:

(1) Because of specialty crops or other unusual conditions, the quantity specified in K.A.R. 5-3-19 was insufficient.

(2) A greater quantity was reasonable for the intended irrigation use, was not wasteful, and did not otherwise prejudicially and unreasonably affect the public interest. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-707(e) and K.S.A. 1999 Supp. 82a-714; effective Sept. 22, 2000.)

5-3-22. Maximum reasonable quantity of water for livestock and poultry. (a) The following quantities shall be deemed the maximum

quantity of water reasonable for nondomestic livestock and poultry water use:

Livestock/ poultry	Drinking water (gallons per head per day)	Additional quantities for servicing/flushing (gallons per head per day)
Cattle, beef	15	0 (open lot) 100 [confined building capacity (cbc)]
Cattle, dairy	35	100 (cbc)
Swine		
finishing	5	15 (cbc)
nursery	1	4 (cbc)
sow and litter	8	35 (cbc)
gestating sow	6	25 (cbc)
Sheep	2	0 (open lot) 15 (cbc)
Horses	12	0 (open lot) 100 (cbc)
Poultry		
chickens (100	9	200 (cbc)
layers)	30	400 (cbc)
turkeys (100)		

(b) The maximum reasonable quantity of water that may be approved for nondomestic livestock and poultry use for applications approved on or after the effective date of this regulation shall be limited as set forth in subsection (a) above. The quantities set forth in subsection (a) may be exceeded only if the applicant demonstrates both of the following to the chief engineer:

(1) The requested quantity is reasonable for the intended use.

(2) This quantity is not wasteful and will not otherwise prejudicially and unreasonably affect the public interest.

(c) For all other types of nondomestic livestock, poultry, birds, and animals, the maximum quantity of water approved for beneficial use shall be reasonable.

(d) The maximum reasonable quantity of water that may be perfected for nondomestic livestock or poultry use shall not exceed the quantities set forth in subsections (a), (b) and (c) above, unless the water right owner demonstrates both of the following to the chief engineer:

(1) A larger quantity of water was actually applied to beneficial use within the terms, conditions, and limitations of the permit within the perfection period.

(2) The quantity used was not wasted. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-707(e), K.S.A. 1999 Supp. 82a-711, K.S.A. 82a-712, and K.S.A. 1999 Supp. 82a-714; effective Sept. 22, 2000.)

5-3-23. Maximum reasonable annual quantity approvable for irrigation use for an application for change in place of use and a request to reduce a water right. (a) Except as provided in subsections (c), (d), and (e), for water rights with a priority date before the effective date of this regulation, the maximum reasonable annual quantity of water that may be approved for either of the following shall be that quantity of water reasonably necessary to irrigate crops in the region of the state where the proposed place of use is located as set forth in K.A.R. 5-3-19(a):

(1) An application for change in place of use for irrigation filed pursuant to K.A.R. 82a-708b and amendments thereto; or

(2) a request to reduce the authorized place of use for irrigation for a water right filed pursuant to K.A.R. 5-7-5.

(b) Except as provided in subsections (c), (d), and (e), for water rights with a priority date on or after the effective date of this regulation, the maximum reasonable annual quantity of water that may be approved for either of the following shall be that quantity of water reasonably necessary to irrigate crops in the region of the state where the proposed place of use is located as set forth in K.A.R. 5-3-19(b):

(1) An application for change in place of use for irrigation filed pursuant to K.A.R. 82a-708b and amendments thereto; or

(2) a request to reduce the authorized place of use for a water right filed pursuant to K.A.R. 5-7-5.

(c) The maximum reasonable quantities approvable in subsections (a) and (b) above shall not exceed either of the following:

(1) The applicable quantity set forth in either subsection (a) or (b) above; or

(2) the maximum quantity of acre-feet per acre authorized by the vested water right or certificate of appropriation, whichever is greater. The maximum authorized quantity of acre-feet per acre shall be calculated by dividing the maximum annual quantity of water authorized at the time the application for change or request to reduce is filed by the number of acres authorized at the time the application for change is filed.

(d) The quantities set forth above in subsections (a), (b), and (c) above may be exceeded only if the

applicant demonstrates both of the following to the chief engineer:

(1) Because of specialty crops or other unusual conditions, the quantity specified in K.A.R. 5-3-19(a) is insufficient.

(2) The requested quantity is reasonable for the intended irrigation use, is not wasteful, and will not otherwise prejudicially and unreasonably affect the public interest.

(e) The maximum annual quantity of water approved pursuant to this regulation shall not exceed the maximum annual quantity of water authorized by the water right at the time the change application is approved. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-707(e) and K.S.A. 1999 Supp. 82a-708b; effective Sept. 22, 2000.)

5-3-24. Reasonable quantity for irrigation use. The Kansas department of agriculture, division of water resources' map titled "reasonable quantities for irrigation use in Kansas, by county," dated October 21, 1999, is hereby adopted by reference. (Authorized by K.S.A. 82a- 706a; implementing K.S.A. 82a-707(e), K.S.A. 1999 Supp. 82a-711, and K.S.A. 1999 Supp. 82a-714; effective Sept. 22, 2000.)

5-3-25. Conditions on permits and certificates. (a) All terms, conditions, and limitations placed on an approval of application by the chief engineer pursuant to the provisions of K.S.A. 82a-712, and amendments thereto, shall remain in full force and effect until expressly modified or removed by the chief engineer.

(b) Unless the terms and conditions are expressly modified or removed by the subsequent approval, certification, or other order of the chief engineer, none of the following shall modify or remove any of the terms, conditions, and limitations placed on the original approval of applications or water right:

(1) The approval of an application to change the place of use, the point of diversion, or the use made of water under the authority of K.S.A. 82a-708b and amendments thereto;

(2) the issuance of a certificate of appropriation pursuant to K.S.A. 82a-714 and amendments thereto; or

(3) the issuance of any other findings and order relative to the approval of application or water right. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-708b, K.S.A. 1999 Supp. 82a-711, K.S.A. 82a-712, and K.S.A. 1999 Supp. 82a-714; effective Sept. 22, 2000.)

5-3-26. Closed townships in Pawnee and Buckner drainage basins in Pawnee, Hodgeman, Ness, and Finney counties. (a) Except as specified in subsection (c), the following townships in the Pawnee and Buckner drainage basins shall be closed to new appropriations of water:

(1) T 20 S:

(A) R 19 W through R 26 W;

(B) R 18 W, section 7 and sections 17 through 36; and

(C) R 17 W, section 31;

(2) T 21 S:

(A) R 30 W, sections 1 through 4, 9 through 16, 21 through 28, and 33 through 36;

(B) R 21 W through R 29 W;

(C) R 20 W and R 19 W, sections 1 through 6; and

(D) R 18 W, sections 1 through 24;

(3) T 22 S:

(A) R 30 W, sections 1 through 4, 9 through 16, 21 through 28, and 33 through 36;

(B) R 21 W through R 29 W;

(C) R 19 W and R 20 W, sections 13 through 36;

(D) R 18 W, sections 20 through 36; and

(E) R 17 W, sections 20, 21, and 30;

(4) T 23 S:

(A) R 22 W through R 26 W;

(B) R 21 W, sections 1 through 24, and 27 through 32;

(C) R 20 W, sections 1 through 18;

(D) R 19 W, sections 1 through 12 and 14 through 18; and

(E) R 18 W, sections 3 through 10; and

(5) T 24 S:

(A) R 23 W through R 26 W;

(B) R 22 W, sections 1 through 23 and 26 through 35; and

(C) R 21 W, sections 5, 6, and 7.

(b) Except as specified in subsection (c), all new applications that propose a point of diversion in any of the areas described in subsection (a) that are pending approval on the effective date of this regulation shall be dismissed.

(c) The closure of the townships listed in subsection (a) to new appropriations of water shall not apply to the following types of wells:

(1) Wells for domestic use;

(2) wells authorized by temporary permits; and

(3) wells authorized by term permits of fewer than five years.

This regulation shall be effective on and after October 25, 2002. (Authorized by K.S.A. 82a-

706a; implementing K.S.A. 2001 Supp. 82a-711 and K.S.A. 82a-721; effective Sept. 22, 2000; amended, T-5-6-27-02, June 27, 2002; amended Oct. 25, 2002.)

5-3-27. Equus Beds special groundwater quality area. (a) A special groundwater quality area located within the boundaries of the Equus Beds groundwater management district no. 2 shall be hereby established in the following area consisting of approximately 36 square miles in northwest Harvey County, south-central McPherson County, and northeast Reno County, Kansas:

(1) Sections 3 through 10, 15 through 22, and 27 through 34, of township 22 south, range 3 west, Harvey County;

(2) sections 31 through 34, township 21 south, range 3 west, and section 36, township 21 south, range 4 west, McPherson County; and

(3) sections 1, 12, 13, 25, 26, and 36, township 22 south, range 4 west, Reno County, Kansas.

(b) Each application for a new appropriation of groundwater, a newly constructed well, or a change in the point of diversion for a well within the area shall be reviewed by the chief engineer to determine the effect of the proposed appropriation or well on the movement of saltwater pollution in the area.

(c) A test well log shall accompany each type of application described in subsection (b) within the area described in subsection (a) above and shall include the following information:

(1) Depth to bedrock;

(2) a water quality analysis of water taken from the bottom 20 feet of the aquifer, including sodium and chloride concentrations; and

(3) a water quality analysis of water taken within the top 20 feet of the aquifer, including specific conductance and chloride concentrations.

(d) If the chief engineer can not determine whether the proposed application will affect the movement of saltwater pollution in the area in a manner that is adverse to the public interest or that will cause impairment to other water rights by causing an unreasonable deterioration of the water quality, then the applicant shall submit any information the chief engineer needs to make that determination. The information shall be submitted within a reasonable time period specified by the chief engineer.

(e) The chief engineer shall submit the proposed application to the board of the Equus Beds groundwater management district no. 2 for its review and recommendation. The board shall have 30 days to review the application and provide its recommendation to the chief engineer. The recommendation of the board shall be considered by the chief engineer in making a decision as to whether the application can be approved as filed or modified.

(f) The application shall be dismissed and its priority forfeited if either of the following conditions is met:

(1) The chief engineer determines that approval of the application will affect the movement of saltwater pollution in the area in a manner that will prejudicially and unreasonably affect the public interest or that will cause impairment to other water rights by causing an unreasonable deterioration of the water quality because of saltwater pollution.

(2) The applicant fails to submit the information requested by the chief engineer within the time specified.

(g) The application shall be approved if both of the following conditions are met:

(1) The chief engineer determines that the approval of the application, as filed or modified, will not affect the movement of saltwater pollution in the area in a manner that is adverse to the public interest and will not cause impairment to other water rights by causing an unreasonable deterioration of the water quality because of saltwater pollution.

(2) The application meets all other statutory and regulatory criteria.

(h) In addition to reporting the information normally required in the water use reports required by K.S.A. 82a-732, and amendments thereto, each owner of a water right or approval of application shall also report the depth to the static water level in each well, in a manner acceptable to the chief engineer.

(i) All groundwater diversion works permitted in the Equus Beds special groundwater quality area shall be equipped with a water flowmeter that meets the specifications adopted by the chief engineer, except for domestic wells, temporary wells, and wells authorized by term permits for fewer than five years. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706c, K.S.A. 82a-709, K.S.A. 82a-710, K.S.A. 1999 Supp. 82a-711, and K.S.A. 82a-732; effective Sept. 22, 2000.)

5-3-28. Lyons special groundwater quality area. (a) A special groundwater quality area

all in Rice County, Kansas, and partially located within the boundaries of the Big Bend groundwater management district no. 5 shall be hereby established in the following described area consisting of approximately 37 square miles in central Rice County, Kansas:

(1) Sections 33, 34, and 35 of township 19 south, range 8 west;

(2) sections 1-4, 9-16, 21-25, township 20 south, range 8 west;

(3) sections 7, 17-21, 27-34, township 20 south, range 7 west; and

(4) sections 3-5, township 21 south, range 7 west.

(b) Each application for a new appropriation of groundwater, a newly constructed well, or a change in point of diversion for a well proposed to be located within the area shall be reviewed by the chief engineer to determine whether the proposed appropriation will have any adverse effect on the movement and remediation of saltwater pollution south and east of Lyons, Kansas.

(c) A test well log shall accompany each type of application filed for a point of diversion described in subsection (b) that is proposed to be located within the area described in subsection (a), and shall include the following information:

(1) Depth to bedrock;

(2) a water quality analysis of water taken from the bottom 20 feet of the aquifer, including analysis of sodium and chloride concentrations; and

(3) a water quality analysis of water taken within the top 20 feet of the aquifer, including analysis of sodium and chloride concentrations.

(d) If the chief engineer can not determine whether the proposed application will affect the movement and cleanup of saltwater pollution south and east of Lyons in a manner that is adverse to the public interest or that will cause impairment to other water rights by causing an unreasonable deterioration of the water quality, then the applicant shall submit any information the chief engineer needs to make that determination. The information shall be submitted within a reasonable time period specified by the chief engineer.

(e) If the proposed point of diversion is located within the district, the proposed application shall be submitted by the chief engineer to the board of the district for review and recommendation. The board shall have 30 days to review the application and submit its recommendation to the chief engineer. The recommendation of the board shall be considered by the chief engineer in making a decision as to whether the application can be approved as filed or modified.

(f) The application shall be dismissed and its priority forfeited if either of the following conditions is met:

(1) The chief engineer determines that approval of the application will affect the movement and cleanup of saltwater pollution south and east of Lyons in a manner that prejudicially and unreasonably affects the public interest or that will cause impairment to other water rights by causing an unreasonable deterioration of the water quality because of saltwater pollution.

(2) The applicant fails to submit the information requested by the chief engineer within the time specified.

(g) The application shall be approved if both of the following conditions are met:

(1) The chief engineer determines that the approval of the application, as filed or modified, will not affect the movement and cleanup of saltwater pollution south and east of Lyons in a manner that would prejudicially and unreasonably affect the public interest and will not cause impairment to other water rights by causing an unreasonable deterioration of the water quality because of saltwater pollution.

(2) The application meets all other applicable statutory and regulatory criteria. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706c, K.S.A. 82a-709, K.S.A. 82a-710, K.S.A. 1999 Supp. 82a-711, and K.S.A. 82a-732; effective Sept. 22, 2000.)

5-3-29. Ozark and Springfield plateau aquifers. (a) Except as specified in subsections (b) and (c), the Ozark aquifer and the Springfield plateau aquifer in the following townships in Cherokee, Crawford, Allen, Bourbon, Neosho, and Labette counties in Kansas shall be closed to new appropriations of water: ranges 20 east through 25 east and townships 26 south through 35 south.

(b) The closure of townships listed in subsection (a) to new appropriations of water shall not apply to the following types of wells:

(1) Wells for domestic use;

(2) wells authorized by temporary permits;

(3) wells meeting the requirements of K.A.R. 5-3-16a; and

(4) wells meeting both of the following conditions:

(A) Are authorized by a term permit of five or fewer years, which can be extended by the chief engineer not beyond December 31, 2010, and over which the chief engineer retains jurisdiction to dismiss or amend if necessary to prevent impairment of the water quantity, rate, or quality or to otherwise protect the public interest; and

(B) are used as an alternate source of water supply that is actively being planned, financed, and constructed and that will be available no later than December 31, 2010.

(c) Notwithstanding the provisions of paragraph (b)(4)(A), the term permits may be extended by the chief engineer beyond December 31, 2010 or may be converted by the chief engineer to regular permits to appropriate water, if both of the following conditions are met:

(1) A study has been completed before December 31, 2010, determining the safe yield of the Ozark aquifer and the Springfield plateau aquifer.

(2) Extending the term of the term permit or converting the term permit to a regular permit to appropriate water will not result in any of the following:

(A) Causing the safe yield to be exceeded;

(B) impairing prior permits or water rights; or

(C) prejudicially and unreasonably affecting the public interest. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-711; effective, T-5-8-23-04, Aug. 23, 2004; effective Nov. 29, 2004.)

Article 4.—DISTRIBUTION OF WATER BETWEEN USERS

5-4-1. Distribution of water between users where a prior right is being impaired. When a complaint is received that a prior right to the use of water is being impaired, the following procedure shall be followed:

1. The complaint shall be made to the chief engineer or his or her authorized representative. A complaint may be accepted verbally, in person or by telephone. No action shall be taken by the agency until the complaint is confirmed in writing.

2. An investigation of the physical conditions involved shall be made by the chief engineer or his or her authorized representative.

3. A written report of the investigation shall be prepared and a copy given to the complainant. If the investigation shows there is no basis for further action by the division the complainant shall be so advised.

4. The complainant shall make a written request to secure water to satisfy his or her prior right.

5. The chief engineer or his or her authorized representative shall give a written legal notice and directive to other water users whose use of water must be regulated to secure water to satisfy the complainant's prior rights.

The request to secure water shall be made on a prescribed form furnished for that purpose by the division of water resources. All water delivered to the user's point of diversion for his or her use at the specified rate or less shall be applied to the authorized beneficial use and count against the quantity of water specified unless the user notifies the chief engineer or his or her authorized representative that diversion and use will be discontinued for a period of time for good reason.

When the quantity of water needed has been delivered to the user's point of diversion or when the user discontinues his or her use of water, those persons who have been directed to regulate their use shall be notified that they may resume the diversion and use of water.

If the available water supply in the source should increase, the chief engineer or his or her authorized representative may allow some or all of the users regulated to resume use depending on the supply. (Authorized by K.S.A. 82a-706a; modified, L. 1978, ch. 460, May 1, 1978.)

5-4-4. Well spacing. (a) The spacing between wells shall be sufficient to prevent direct impairment between wells located in a common source of supply or hydraulically connected sources of supply and to protect the public interest. Except as set forth in subsection (b), the following guidelines shall be used to determine the spacing required between wells permitted by the chief engineer in a common source of supply, unless it is determined by the chief engineer in any specific instance that the spacing guidelines set forth in this regulation are insufficient to prevent direct impairment or are not necessary to prevent direct impairment.

(b) Whenever an applicant proposes to divert water from a source of supply in a location where there is a significant hydraulic connection between the proposed source of supply and another source or sources of supply, the chief engineer shall determine the spacing necessary to prevent impairment and to protect the public interest on a case by case basis.

(c) Except as set forth in subsection (e) below, each well that is described in an application for a permit to appropriate water for beneficial use or for a term permit, excluding any domestic or temporary well, shall meet the minimum spacing requirements set out in paragraphs (1) and (2) below.

(1) The minimum distance from the well which is the subject of the application to all other senior authorized non-domestic and non-temporary wells in the same aquifer or a hydraulically connected aquifer shall be:

(A) four miles between wells whose common source of supply is the confined Dakota aquifer system;

(B) one-half mile between wells whose common source of supply is the unconfined Dakota aquifer system; and

(C) 1320 feet for wells whose common source of supply is any other aquifer.

(2) In addition to meeting the minimum spacing requirements of paragraph (1) above, the minimum distance from the well which is the subject of the application to all domestic wells, except where the domestic well owner has given the applicant written permission to reduce the spacing interval, shall be:

(A) one-half mile for wells whose common source of supply is the confined Dakota aquifer system;

(B) 1320 feet for wells whose common source of supply is the unconfined Dakota aquifer system; and

(C) 660 feet for wells whose common source of supply is any other aquifer.

(d) Except as provided in subsection (e), the location of a well or wells on an application to change the point of diversion under an existing water right shall either:

(1) meet the spacing requirements in paragraphs (c)(1) and (c)(2) above; or

(2) not decrease the distance to other wells or authorized well locations by more than 300 feet.

(e) This regulation shall not apply if the chief engineer has adopted another regulation, or issued an order pursuant to K.S.A. 82a-1036 *et seq.*, specifying a different well spacing for the source of supply in which the proposed point of diversion is located.

(f) In the case of a battery of wells, the distance shall be measured from the geographic center of the points of diversion comprising the battery.

(g) If the proposed point of diversion does not meet the well spacing requirements in this regulation, the applicant shall be notified by the chief engineer in writing prior to dismissal that the requirements have not been met. The applicant shall then have 15 days to request time in which to submit additional information. Upon written request, the applicant shall be given a specified reasonable amount of time by the chief engineer to submit an engineering or similar type of hydrologic analysis to show that the spacing can be decreased without impairing existing rights or prejudicially and unreasonably affecting the public interest. The burden shall be on the applicant to make such a showing to the satisfaction of the chief engineer. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1993 Supp. 82a-711; effective May 31, 1994.)

5-4-5. Approval of application for additional rate only. (a) Except as set forth in subsection (c), an application for a permit to appropriate water for beneficial use that requests only an increase in the authorized rate of diversion, and no net increase in maximum annual quantity, from a specific point of diversion already authorized by another water right or approval of application shall be exempt from complying with any safe yield, allowable appropriation, or similar type of criteria adopted by the chief engineer if both of the following conditions are met:

(1) The application requests only an increase in the authorized maximum rate of diversion of 15 percent or less.

(2) There has been no significant physical enlargement of the capacity of the original diversion works to divert water. If a well has been replaced, reconstructed, and reequipped in accordance with an approval of an application for change by the chief engineer pursuant to K.S.A 82a-708b and amendments thereto in substantially the same way that the original diversion works were constructed, that type of well shall not be considered to be a significant physical enlargement of the diversion works. Conversion to a battery of wells or adding an additional well shall be considered to be a significant physical enlargement of the capacity of the diversion works.

(b) Except as set forth in subsection (c), an application to increase the rate of diversion by more than 15 percent that requests no net increase in maximum annual quantity from a specific point of diversion already authorized by another water right or approval of application shall be exempt

from complying with any safe yield, allowable appropriation, or similar type of criteria adopted by the chief engineer if the conditions in either paragraph (b)(1) or (2) are met:

(1)(A) The application was filed within the time authorized to perfect any water right authorizing that point of diversion.

(B) The application is filed to increase the authorized maximum rate of diversion to the rate the original diversion works were physically capable of diverting water under actual maximum operating conditions, or less.

(2) The appropriator demonstrates to the chief engineer that authorizing an increase in the rate of diversion meets the following criteria:

(A) Will not impair existing water rights;

(B) will not prejudicially and unreasonably affect the public interest; and

(C) will not substantially increase the consumptive use in violation of K.A.R. 5-5-3.

(c) If the chief engineer adopts a regulation pertaining to applications for additional rate only for a specific groundwater management district, or issues an order concerning that type of application pursuant to an intensive groundwater use control area (IGUCA) proceeding authorized by K.S.A. 82a-1036 et seq. and amendments thereto, the application for additional rate shall be processed by the chief engineer pursuant to the provisions of that regulation or IGUCA order. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-701(f), K.S.A. 1999 Supp. 82a-711, K.S.A. 82a-712, K.S.A. 82a-1036, K.S.A. 82a-1037, K.S.A. 1999 Supp. 82a-1038, K.S.A. 82a-1039, and K.S.A. 82a-1040; effective Sept. 22, 2000.)

5-4-8. Custodial care of the state. (a) For any groundwater or surface water right placed in the custodial care of the state, the following criteria shall be met by the chief engineer:

(1) Not reappropriate the water authorized to be diverted by a water right in the custodial care of the state;

(2) continue to include the priority, terms, limitations, authorized rate and quantity, and other conditions of the water right in any analysis or action conducted for the permitting, management, regulation, or administration of other water rights or applications to appropriate water;

(3) not declare the water right abandoned for the nonuse of water. Placement of the water right in the custodial care of the state shall be deemed to be due and sufficient cause for nonuse of a water right pursuant to K.S.A. 82a-718 and amendments thereto; and

(4) not dismiss the water right, unless the chief engineer determines that the geographic area in which the water right is located no longer meets the requirements of K.S.A. 2-1919(2), and amendments thereto, and reopens the area to new appropriations of water.

(b) A water right owner desiring to place a portion of an existing water right in the custodial care of the state shall request the division to divide the water right. Each portion of a divided water right shall be treated as a separate water right and administered accordingly. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-707(d) and K.S.A. 1999 Supp. 82a-718; effective Sept. 22, 2000.)

Article 5.—CHANGE IN THE PLACE OF USE, THE POINT OF DIVERSION OR THE USE MADE OF WATER UNDER AN EXISTING WATER RIGHT

5-5-1. Filing an application for change. (a) An application for approval to change the place of use, the point of diversion, the use made of water, or combinations thereof, filed pursuant to K.S.A. 82a-708b and amendments thereto, shall be made on a form prescribed by the chief engineer and shall include whatever information is required by the chief engineer to properly understand the proposed change in the place of use, the point of diversion, the use made of water, or any combination of these.

(b) Before the application may be accepted for filing, the application shall be signed by at least one owner of the water right, or a duly authorized agent of an owner.

(c) Except as set forth in subsection (e), before any approval of an application can be granted, all of the water right owners, including their spouses, or a duly authorized agent of the owners of the water right, shall verify upon oath or affirmation that the statements contained in the application are true and complete.

(d) If one or more owners refuse to sign the application, or a written request is filed by one or more owners to withdraw their signatures from the application before the application is approved, the application shall be dismissed.

(e) (1) An application to change the location of a groundwater point of diversion that proposes to do only the following shall be signed by at least

one owner of the approval of application or water right, or the duly authorized agent, who verifies upon oath or affirmation all of the items specified below in paragraph (e)(2):

(A) Move the location of the well 300 or fewer feet; and

(B) have the new well located on land owned by all the same owners as the owners of the original point of diversion.

(2) (A) The signer of the application for change has the authority to sign the application on behalf of all the owners.

(B) None of the ownership interests of any of the owners of the approval of application or water right will be adversely affected if the application for change is approved as filed.

(C) If the application is not approved expeditiously, there will be substantial damage to property, public health, or safety. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-708b; modified, L. 1978, ch. 460, May 1, 1978; amended Sept. 22, 2000.)

5-5-2. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-708b; effective May 1, 1980; revoked May 1, 1983.)

5-5-2a. Complete change application. (a) An application to change a water right pursuant to K.S.A. 82a-708b, and amendments thereto, shall be considered to be a "complete application," if the application completely and accurately meets all of the requirements specified in this regulation and the following criteria:

(1) The requirements specified in K.S.A. 82a-708b, and amendments thereto;

(2) any water conservation plans required by the chief engineer pursuant to K.S.A. 82a-733, and amendments thereto;

(3) the requirements specified in K.A.R. 5-5-1;

(4) the requirements specified in K.A.R. 5-5-5;

(5) the requirements specified in K.A.R. 5-3-4d;

(6) a demonstration that the proposed point of diversion meets all applicable well spacing criteria; and

(7) the requirements of K.S.A. 82a-301 through K.S.A. 82a-305a, and amendments thereto, if the proposed point of diversion, or rediversion, is a dam or stream obstruction.

(b) If the applicant is requesting a waiver or exemption of a regulation pursuant to K.S.A. 82a-1904, and amendments thereto, the applicant shall submit a written request for the waiver or exemption, and documentation to support the waiver or exemption.

(c) If the proposed point of diversion is located within the boundaries of a groundwater management district, a final recommendation or an analysis of water availability has been received from the groundwater management district within the time allowed by the chief engineer concerning the approval, denial, or modification of the application.

(d) If any questions have been raised concerning whether approval of the application could cause impairment of senior water rights or prejudicially and unreasonably affect the public interest, the applicant shall submit sufficient information to resolve those questions.

(e) If any actions are required to be taken by the applicant on other approvals of applications or water rights owned by the applicant in order to make the application for change approvable, including dismissals, division agreements, reductions in water rights in accordance with K.A.R. 5-7-5, and applications for change, all necessary forms shall be completed and filed with the chief engineer.

(f) If the application involves a change in the place of use or the use made of water, the applicant shall submit all information and data necessary to ensure that the consumptive use will not be increased substantially in violation of K.A.R. 5-5-3.

(g) If the application proposes to add one or more additional wells in accordance with the provisions of K.A.R. 5-5-16, the applicant shall submit all tests, data, and information required by that regulation.

(h) If there is an issue as to whether the water right for which the change application has been filed has been abandoned in whole or in part pursuant to K.S.A. 82a-718, and amendments thereto, the applicant shall submit whatever information is necessary to resolve all abandonment issues.

(i) Each application shall be accompanied by an aerial photograph or a detailed plat with a scale of one inch equals 1,320 feet, or a U.S. geological survey topographic map with a scale of 1:24,000. The following information shall be plotted on the plat, photograph, or topographic map:

(1) The section corners;

(2) the center of the section, identified by the section number, township, and range;

(3) the actual location of the currently author-

ized point of diversion and the location of the proposed point of diversion indicated by appropriate symbols;

(4) the location of the place of use identified by crosshatching or by some other appropriate method;

(5) the location of all other water wells of every kind within one-half mile of the well or wells to be authorized by the proposed appropriation, each of which shall be identified by its use and the name and mailing address of the owner, if the proposed appropriation is for use of groundwater;

(6) the name and mailing address of the owner or owners of each tract of land adjacent to the stream for a distance of one-half mile upstream and one-half mile downstream from the property lines of the land owned or controlled by the applicant, if the proposed appropriation is for the use of surface water;

(7) the locations of proposed or existing dams, dikes, reservoirs, canals, pipelines, power-houses, and other structures for the purpose of storing, conveying, or using water; and

(8) a north arrow and scale.

All information shown on the photograph, plat, or map shall be legible. Black line prints may be submitted in lieu of the original drawing if a plat is submitted.

(j) The applicant shall certify on the application that all water wells of any kind located within one-half mile of the requested point of diversion have been plotted on the plat, photograph, or map attached to the application.

(k) The applicant shall submit all information and data necessary to demonstrate that the application complies with the applicable regulations adopted by the chief engineer. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a, K.S.A. 2002 Supp. 82a-708b, K.S.A. 82a-709, K.S.A. 82a-710, K.S.A. 2002 Supp. 82a-711, K.S.A. 2002 Supp. 82a-718, K.S.A. 82a-733, and K.S.A. 2002 Supp. 82a-1904; effective Oct. 24, 2003.)

5-5-3. Change in consumptive use. The extent of consumptive use shall not be increased substantially after a vested right has been determined or the time allowed in which to perfect the water right has expired, including any authorized extension of time to perfect the water right. (Authorized by K.S.A. 82a-706a, 82a-708b; effective May 1, 1983.)

5-5-4. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-708b; effective May 1, 1980; revoked May 1, 1981.)

5-5-5. Signatures required on change applications. If more than one person is the owner of a water right, and an application is filed for a change in the place of use, point of diversion, use made of the water, or any combination thereof, only the signature(s) of the landowner(s) whose portion of the water right(s) is (are) involved in the change shall be required on the application. If the extent of each owners interest in the water right has not been legally determined, then all landowners holding an undetermined portion of the water right must sign the change application or the landowners must submit an agreement signed by all landowners agreeing how the water right should be divided. (Authorized by K.S.A. 82a-706a, 82a-708b; effective May 1, 1980.)

5-5-6. Failure to construct diversion works at authorized location. (a) If an application to appropriate water for beneficial use is approved by the chief engineer, the location of the point of diversion shall be limited to a specific tract of land and to within 300 feet of a point identified in distances measured in feet north and west from the southeast corner of the legal section.

(b) If the diversion works were not constructed at the location authorized for the point of diversion, but the appropriator can demonstrate to the satisfaction of the chief engineer that all of the following criteria have been met, the authorized location shall be corrected to the actual location of the point of diversion by a correctional order issued by the chief engineer:

(1) The original application was filed before January 1, 1978.

(2) The diversion works were constructed before the date the original application to appropriate water was signed.

(3) It was not discovered that the actual diversion works were not constructed at the authorized point of diversion until after the application was approved.

(4) The diversion works were constructed at a location that could have been approved at the time the original application was filed based on the criteria in effect at the time the original application was filed.

(c) An application for a change in point of diversion filed pursuant to K.S.A. 82a-708b and amendments thereto shall be approved by the

chief engineer, authorizing the actual location where the diversion works were constructed and extending the time to construct the diversion works until the end of the calendar year in which the application to change the point of diversion was approved, if the diversion works were not constructed at the authorized location, but the appropriator can demonstrate to the satisfaction of the chief engineer that all of the following criteria have been met:

(1) The original application was filed with the chief engineer before January 1, 1978.

(2) The diversion works were completed after the application was filed, but within the time authorized to construct the diversion works.

(3) The diversion works were constructed within 1,320 feet of the authorized point of diversion.

(4) The diversion works were constructed at a location that could have been approved at the time that the original application was filed based upon the criteria in effect at the time the original application was filed.

(5) The change application meets the other criteria of K.S.A. 82a-708b and amendments thereto.

If the actual point of diversion is within a groundwater management district, the application shall be sent to the groundwater management district board for review and recommendation.

(d) The point of diversion shall be authorized at the actual location by approval of a new application to appropriate water by the chief engineer if the diversion works were not constructed at the authorized location, but the appropriator can demonstrate to the chief engineer that all of the following criteria have been met:

(1) The original application was filed on or after January 1, 1978.

(2) The diversion works were subsequently completed within the time authorized to complete the diversion works.

(3) The diversion works were constructed within 1,320 feet of the authorized point of diversion.

(4) The time authorized to complete the diversion works has expired.

(5) There is no water available for a new appropriation to be approved at the location of the actual point of diversion.

(6) The application would have met all the criteria for a new application that were in effect at the time the original new application was filed.

If the actual point of diversion is within a groundwater management district, the application shall be sent to the groundwater management district board for review and recommendation. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-708b, and K.S.A. 82a-728; effective May 1, 1980; amended Sept. 22, 2000.)

5-5-7. Waste of water. Each person shall not commit a waste of water as defined in these regulations. Upon a finding by the chief engineer that waste of water has occurred, the chief engineer may suspend use of that water right until the owner shows to the satisfaction of the chief engineer that the waste of water will no longer occur. (Authorized by K.S.A. 82a-706(a); implementing K.S.A. 82a-706; effective Dec. 3, 1990.)

5-5-8. Standards for approval of an application for a change in the place of use and a change in the use made of water. (a) Each application for a change in the place of use or the use made of water which will materially injure or adversely affect water rights or permits to appropriate water with priorities senior to the date the application for change is filed shall not be approved by the chief engineer.

(b) Each approval of a change application shall be conditioned by the chief engineer with the terms, conditions and limitations the chief engineer deems necessary to protect the public interest and enforce the terms of K.A.R. 5-5-3.

(c) As used in K.A.R. 5-5-3, "consumptive use" means gross diversions minus:

(1) waste of water, as defined in K.A.R. 5-1-1(cc); and

(2) return flows to the source of water supply:

(A) through surface water runoff which is not waste; and

(B) by deep percolation.

(d) The maximum annual quantity and maximum rate of diversion of water authorized by an approval of an application for a change in the use made of water shall not exceed the maximum annual quantity or maximum rate of diversion perfected at the time the application for change in the use made of water is filed with the chief engineer. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1993 Supp. 82a-708b; effective Nov. 28 1994).

5-5-9. Criteria for the approval of an application for a change in the use made of water from irrigation to any other type of beneficial use of water. (a) The approval of a change

in the use made of water from irrigation to any other type of beneficial use shall not be approved if it will cause the net consumptive use from the local source of water supply to be greater than the net consumptive use from the same local source of water supply by the original irrigation use based on the following criteria:

(1) The maximum annual quantity of water to be allowed by the change approval shall be the net irrigation requirement (NIR) for the 50% chance rainfall for the county of origin, as set forth in K.A.R. 5-5-12, multiplied by the maximum acreage legally irrigated under the authority of the water right in any one calendar year during the perfection period. For vested rights, the acreage used shall be the maximum acreage irrigated prior to June 28, 1945; or

(2) if the applicant establishes to the satisfaction of the chief engineer the need for more flexibility in the authorized annual quantity, the application may be approved subject to the following limits.

(A) The maximum annual quantity of water to be allowed by the change approval shall be the NIR for the 80% chance rainfall for the county of origin, as set forth in K.A.R. 5-5-12, multiplied by the maximum acreage legally irrigated in any one calendar year during the perfection period. For vested rights the acreage used shall be the maximum acreage irrigated prior to June 28, 1945.

(B) The new type of beneficial use shall be further limited by a five year fixed allocation of water in which the NIR for a 50% chance rainfall for the county of origin, as set forth in K.A.R. 5-5-12, is multiplied by five times the maximum acreage lawfully irrigated in any one calendar year during the perfection period. For vested rights, the acreage used shall be the maximum acreage irrigated prior to June 28, 1945.

(C) An application for a term permit which will circumvent the five year allocation of water limit shall not be approved by the chief engineer.

(3) In determining whether the net consumptive use of water will be increased by the proposed change in the use made of water, the applicant shall be given credit by the chief engineer for any return flows from the proposed type of beneficial use which will return to the same local source of supply as the return flows from the originally authorized type of beneficial use as substantiated by the applicant to the satisfaction of the chief engineer by an engineering report or similar type of hydrologic analysis.

(4) The authorized quantity to be changed to the new type of beneficial use shall never exceed the maximum annual quantity authorized by the water right.

(5) If a water right which overlaps the authorized place of use of one or more other water rights, either in whole or in part, is being changed to a different type of beneficial use, the total net consumptive use of all water rights after the change is approved shall not exceed the total net consumptive use of all of the rights before the change is approved.

(6) The approval for a change in the use made of water shall also be limited by that quantity reasonable for the use proposed by the change in the use made of water.

(b) Upon request of the applicant, the historic net consumptive use actually made during the perfection period, or prior to June 28, 1945 in the case of vested rights, under the water right proposed to be changed shall be considered by the chief engineer, but the burden shall be on the owner to document that historic net consumptive use with an engineering study, or an equivalent documentation and analysis, and demonstrate to the satisfaction of the chief engineer that the analysis submitted by the applicant is a more accurate estimate of the historic net consumptive use than the net consumptive use calculated using the methodology set forth in paragraph (a)(1).

(c) If the methods set forth in subsection (a) produce an authorized annual quantity of water which appears to be unrealistic and could result in impairment of other water rights, the chief engineer shall make a site-specific net consumptive use analysis to determine the quantity of water which was actually beneficially consumed under the water right. The quantity approved shall be limited to the quantity determined to be reasonable by the chief engineer's analysis. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1993 Supp. 82a-708b; effective Nov. 28, 1994.)

5-5-10. Partial changes in the use made of water from irrigation to another type of beneficial use. (a) In a case where an irrigation right is to be divided and only a portion of the rate and quantity will be changed to a different use made of water, only that portion of the annual quantity of the water right being changed to a different type of beneficial use shall be reduced as necessary to prevent the net consumptive use from increasing substantially.

(b) The authorized place of use for the irrigation right shall generally be reduced in proportion to the reduction in annual quantity caused by the change. If the irrigator desires to retain more than his or her proportional allotment of acres after the change, the procedures outlined in K.A.R. 5-5-11(b)(2)(B)(ii) shall be followed to determine whether the irrigator shall be allowed to retain more acreage.

(c) The authorized rate of diversion shall be divided between the irrigation and the non-irrigation use. Any reasonable division of the rate by the parties shall be approved. The division of the maximum rate of diversion need not be proportional to the division of the quantity as long as the division of the rate of diversion is reasonable to divert each portion of the annual quantity of water after the division of the water right is made.

(d) The division of the annual quantity shall be made as follows:

(1) Step one.

(A) Multiply the net irrigation requirement (NIR) for the 50% chance rainfall for the county of origin, as set forth in K.A.R. 5-5-12, times the maximum number or acres irrigated in any one calendar year during the perfection period. For vested rights, the acreage used shall be the maximum acreage irrigated prior to June 28, 1945.

(B) This will result in the maximum quantity that could be changed to another type of beneficial use if the entire right were changed pursuant to K.A.R. 5-5-9(a)(1).

(2) Step two.

(A) Divide the annual quantity desired to be changed to the new use by the maximum quantity that could be changed if the entire right were changed.

(B) This will result in the percentage of the entire reduced right that will be changed to the new use. The remaining percentage of the current right can be retained by the irrigation water right owner.

(3) Step three.

(A) Multiply the remaining percentage times the total currently authorized quantity. This shall be the annual quantity of water which may be retained by the irrigation water right owner. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1993 Supp. 82a-708b; effective Nov. 28, 1994.)

5-5-11. Applications for change in place of use for irrigation purposes. (a) For the purpose of this regulation, "base acreage" means:

(1) the maximum number of acres actually legally irrigated in any one calendar year on or before December 31, 1994 if the perfection period expired on or before December 31, 1994 or the water right is a vested right; or

(2) if the perfection period expires after December 31, 1994, and the perfection period has not expired at the time the change application has been filed, the base acreage shall be the number of acres authorized by the permit; or

(3) if the perfection period expires after December 31, 1994, and the perfection period has expired at the time the change application was filed, the base acreage shall be the maximum acreage legally irrigated in any one calendar year during the perfection period.

(4) Any year in which any of the terms, conditions and limitations of the water right or permit were violated shall not be used to determine base acreage.

(b) An application to change the authorized place of use for irrigation purposes which would permit the applicant to exceed the base acreage by 10 acres or 10 percent, whichever is less, shall not be approved by the chief engineer because it would result in a substantial increase in net consumptive use in violation of K.A.R. 5-5-3 except when one of the six following criteria are met.

(1) Identical places of use.

(A) The change application shall be filed only for the purpose of creating an identical place of use with another water right or rights;

(B) there shall not be a net increase in authorized acres;

(C) each water right involved in the proposed identical overlap in place of use shall be certified by the chief engineer prior to processing the change application if approval of the change application would authorize an increase in base acreage; and

(D) the total quantity authorized by all existing water rights and all permits involved shall be reasonable to irrigate the land authorized after the change in place of use is approved.

(2) Necessity to install more efficient irrigation system; limited acres and quantity.

(A) The change applicant shall submit information demonstrating to the satisfaction of the chief engineer that it is necessary to increase the base acreage so that a significantly more efficient irrigation delivery system may be installed. Types of crops to be grown or tillage practices used shall

not be considered in deciding whether the proposed system is more efficient.

(B) If the chief engineer approves the application for a change in place of use pursuant to this subsection, the following limitations shall apply.

(i) The authorized quantity of water under the water right shall be limited to a 5 year fixed allocation, computed by dividing the net irrigation requirement (NIR), as set forth in K.A.R. 5-5-12, for the 50% chance rainfall for the county where the place of use is located, by an efficiency factor of 0.85, multiplying by the base acreage as determined in subsection (a) of this regulation, and then multiplying by 5. In any given year, the water right owner shall still be authorized to divert the maximum annual quantity authorized, provided that the 5 year allocation is not exceeded.

(ii) The maximum number of irrigated acres that shall be allowed under the proposed change in place of use shall be computed by multiplying the currently authorized annual quantity by 0.85 and dividing by the NIR, as set forth in K.A.R. 5-5-12, for the 80% chance rainfall for the county where the place of use is located.

(iii) The approval of the change shall be conditioned so that the use of water in excess of the five year allocation shall result in a two year suspension of all water use under that water right and a subsequent restriction of the authorized place of use to the base acreage at a location specifically set forth in the change approval.

(3) Necessity to install a more efficient irrigation system; limited quantity.

(A) The groundwater management district in which the point of diversion is located shall agree to assume monitoring responsibility to ensure compliance with the conditions of the change approval;

(B) the applicant shall submit information demonstrating to the satisfaction of the chief engineer that it is necessary to increase the base acreage so that a significantly more efficient irrigation delivery system may be installed;

(C) the applicant shall submit a feasible operation plan demonstrating to the satisfaction of the chief engineer that the amount of water available for appropriation under that water right is reasonable to irrigate the number of acres requested to be irrigated; and

(D) the water right owner shall have no recent pattern of water use significantly in excess of the maximum annual quantity of water authorized.

(E) If the chief engineer approves the application for a change in place of use pursuant to this subsection, the following limitations shall apply.

(i) The authorized quantity of water under the water right shall be limited to a 5-year fixed allocation, computed by dividing the net irrigation requirement (NIR), as set forth in K.A.R. 5-5-12, for the 50% chance rainfall for the county where the place of use is located by an efficiency factor of 0.85, multiplying by the base acreage irrigated as determined in subsection (a) of this regulation, and then multiplying by 5. In any given year, the water right owner shall still be authorized to divert the maximum annual quantity authorized, provided that the 5-year allocation is not exceeded.

(ii) The approval of the change shall be conditioned so that the use of water in excess of the five-year allocation shall result in a two-year suspension of all water use under that water right and a subsequent restriction of the authorized place of use to the base acreage at a location specifically set forth in the change approval.

(4) Rotation of the irrigated land within the authorized place of use.

(A) The point of diversion is located outside a groundwater management district or the groundwater management district in which the point of diversion is located shall agree to assume monitoring responsibility to ensure compliance with the conditions of the change approval;

(B) the water right owner shall have no recent pattern of water use significantly in excess of the maximum annual quantity of water authorized; and

(C) approval of the change application shall result in a net increase in the number of acres authorized for irrigation purposes solely for the purpose of rotation of the irrigated land within the authorized place of use.

(D) If the chief engineer approves the application for a change in place of use pursuant to this subsection, the following limitations shall apply.

(i) Approval of the change application shall be limited by the chief engineer so that the net acres physically irrigated in any one calendar year after the change approval shall not exceed the base acreage; and

(ii) the approval shall be conditioned so that the use of water on more than the maximum number of acres authorized to be irrigated in any one calendar year shall result in a two-year suspension of all water use under that water right and a subsequent restriction of the authorized place of use

to the base acreage at a location specifically set forth in the change approval.

(5) Specific groundwater management district regulation.

The application shall meet the criteria in a regulation adopted by the chief engineer pursuant to K.S.A. 82a-1028(o) and K.S.A. 82a-706a specifically for changes in place of use for irrigation purposes for the groundwater management district in which the point of diversion is located.

(6) No increase in historic net consumptive use.

The applicant shall demonstrate to the satisfaction of the chief engineer, with an engineering report or similar type of hydrologic analysis, that the historic net consumptive use will not be increased substantially if the proposed change in place of use is approved.

(c) If the chief engineer determines that the application cannot be approved as filed, the applicant shall be notified in writing by the chief engineer prior to denial that the change application requirements have not been met and the reason for the proposed denial.

(1) In this written notice the chief engineer shall allow the applicant 15 days to request time in which to submit additional information to show why the application should be approved.

(2) Upon written request, the applicant shall be given a reasonable time specified by the chief engineer to submit an engineering report or similar type of hydrologic analysis to show that approval of the change application will not substantially increase the historic net consumptive use.

(3) The applicant shall have the burden of demonstrating to the satisfaction of the chief engineer that approval of the change application will not cause the historic net consumptive use to be increased substantially.

(d) Whether or not the time to perfect the water right has expired, including any authorized extensions of time, the application for a change in place of use to change the size of the authorized place of use for irrigation purposes may be approved without the certificate of appropriation being issued except as provided in subsection (b)(1)(C) of this regulation.

(1) If a certificate of appropriation has not been issued, the increase in base acreage shall be determined based on reliable information.

(2) The types of acceptable information shall include, but not be limited to, field inspection reports or U.S. department of agriculture records.

(e) A flow meter meeting the specifications adopted by the chief engineer, and installed and maintained in a manner satisfactory to the chief engineer, shall be required by the chief engineer in all cases where there is an increase in the base acreage authorized to be irrigated by the approval of the change in the place of use, except when:

(1) the application for change in place of use is filed solely to create an identical place of use with other water rights; and

(2) the total quantity authorized by all existing water rights and all permits to appropriate water that are involved equals or exceeds the NIR, as set forth in K.A.R. 5-5-12, in that county for a 50% chance rainfall divided by an irrigation efficiency of 0.85. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1993 Supp. 82a-708b; effective Nov. 28, 1994.)

5-5-12. Net irrigation requirements (NIR). The following amounts shall be used as the net irrigation requirements (NIR).

County	50% Chance Rainfall	80% Chance Rainfall
Allen	7.1" = 0.59'	9.9" = 0.83'
Anderson	6.1" = 0.51'	9.4" = 0.78'
Atchison	7.2" = 0.60'	10.3" = 0.86'
Barber	12.6" = 1.05'	14.6" = 1.22'
Barton	12.0" = 1.00'	14.4" = 1.20'
Bourbon	6.8" = 0.57'	9.6" = 0.80'
Brown	7.1" = 0.59'	10.6" = 0.88'
Butler	9.2" = 0.77'	12.0" = 1.00'
Chase	8.7" = 0.73'	11.4" = 0.95'
Chautauqua	8.6" = 0.72'	11.4" = 0.95'
Cherokee	7.0" = 0.58'	9.9" = 0.83'
Cheyenne	13.7" = 1.14'	15.4" = 1.28'
Clark	13.7" = 1.14'	15.7" = 1.31'
Clay	9.2" = 0.77'	12.2" = 1.02'
Cloud	10.3" = 0.86'	12.7" = 1.06'
Coffey	6.8" = 0.57'	9.9" = 0.83'
Comanche	13.0" = 1.08'	15.1" = 1.26'
Cowley	9.7" = 0.81'	12.3" = 1.03'
Crawford	7.0" = 0.58'	9.8" = 0.82'
Decatur	12.7" = 1.06'	14.8" = 1.23'
Dickinson	9.4" = 0.78'	12.3" = 1.03'
Doniphan	7.3" = 0.61'	10.3" = 0.86'
Douglas	6.8" = 0.57'	9.8" = 0.82'
Edwards	13.0" = 1.08'	15.1" = 1.26'
Elk	8.7" = 0.73'	11.3" = 0.94'
Ellis	12.2" = 1.02'	14.6" = 1.22'
Ellsworth	11.5" = 0.96'	13.7" = 1.14'
Finney	14.5" = 1.21'	16.3" = 1.36'
Ford	13.7" = 1.14'	15.7" = 1.31'
Franklin	5.8" = 0.48'	9.1" = 0.76'
Geary	8.4" = 0.70'	11.5" = 0.96'
Gove	13.1" = 1.09'	15.3" = 1.28'
Graham	12.4" = 1.03'	14.7" = 1.23'

County	50% Chance Rainfall	80% Chance Rainfall
Grant	14.9" = 1.24'	16.7" = 1.39'
Gray	13.8" = 1.15'	16.1" = 1.34'
Greeley	14.7" = 1.23'	16.5" = 1.38'
Greenwood	8.1" = 0.68'	11.1" = 0.93'
Hamilton	15.2" = 1.27'	16.9" = 1.41'
Harper	11.7" = 0.98'	14.0" = 1.17'
Harvey	10.2" = 0.85'	12.9" = 1.08'
Haskell	14.5" = 1.21'	16.4" = 1.37'
Hodgeman	13.4" = 1.12'	15.5" = 1.29'
Jackson	7.4" = 0.62	10.5" = 0.88'
Jefferson	7.0" = 0.58'	10.1" = 0.84'
Jewell	10.6" = 0.88'	13.1" = 1.09'
Johnson	6.6" = 0.55'	9.5" = 0.79'
Kearny	14.9" = 1.24'	16.6" = 1.38'
Kingman	11.7" = 0.98'	14.0" = 1.17'
Kiowa	13.2" = 1.10'	15.1" = 1.26'
Labette	7.3" = 0.61'	10.3" = 0.86'
Lane	13.7" = 1.14'	15.7" = 1.31'
Leavenworth	7.0" = 0.58'	9.9" = 0.83'
Lincoln	11.3" = 0.94'	13.6" = 1.13'
Linn	5.6" = 0.47'	9.0" = 0.75'
Logan	13.9" = 1.16'	15.8" = 1.32'
Lyon	7.5" = 0.63'	10.5" = 0.88'
Marion	9.6" = 0.80'	12.2" = 1.02'
Marshall	8.7" = 0.73'	11.4" = 0.95'
McPherson	10.8" = 0.90'	13.1" = 1.09'
Meade	14.3" = 1.19'	16.1" = 1.34'
Miami	5.0" = 0.42'	9.0" = 0.75'
Mitchell	10.8" = 0.90'	13.3" = 1.11'
Montgomery	8.1" = 0.68'	10.9" = 0.91'
Morris	8.5" = 0.71'	11.4" = 0.95'
Morton	15.4" = 1.28'	17.1" = 1.43'
Nemaha	7.8" = 0.65'	10.9" = 0.91'
Neosho	7.1" = 0.59'	10.2" = 0.85'
Ness	13.3" = 1.11'	15.3" = 1.28'
Norton	12.3" = 1.03'	14.4" = 1.20'
Osage	7.0" = 0.58'	9.9" = 0.83'
Osborne	11.7" = 0.98'	13.8" = 1.15'
Ottawa	10.5" = 0.88'	12.9" = 1.08'
Pawnee	12.7" = 1.06'	14.9" = 1.24'
Phillips	11.7" = 0.98'	14.0" = 1.17'
Pottawatomie	8.1" = 0.68'	11.1" = 0.93'
Pratt	12.6" = 1.05'	14.6" = 1.22'
Rawlins	13.2" = 1.10'	15.1" = 1.26'
Reno	11.4" = 0.95'	13.8" = 1.15'
Republic	10.0" = 0.83'	12.6" = 1.05'
Rice	11.5" = 0.96'	13.8" = 1.15'
Riley	8.5" = 0.71'	11.4" = 0.95'
Rooks	12.0" = 1.00'	14.3" = 1.19'
Rush	12.6" = 1.05'	14.8" = 1.23'
Russell	11.3" = 0.94'	14.1" = 1.18'
Saline	10.8" = 0.90'	13.1" = 1.09'
Scott	14.0" = 1.17'	15.9" = 1.33'
Sedgwick	10.7" = 0.89'	13.1" = 1.09'
Seward	14.5" = 1.21'	16.4" = 1.37'
Shawnee	7.4" = 0.62'	10.2" = 0.85'
Sheridan	12.9" = 1.08'	15.0" = 1.25'
Sherman	14.1" = 1.18'	15.7" = 1.31'
Smith	11.4" = 0.95'	13.6" = 1.13'
Stafford	12.3" = 1.03'	14.5" = 1.21'
Stanton	15.6" = 1.30'	17.2" = 1.43'
Stevens	14.8" = 1.23'	16.8" = 1.40'
Sumner	10.3" = 0.86'	13.2" = 1.10'
Thomas	13.5" = 1.13'	15.4" = 1.28'
Trego	12.9" = 1.08'	15.0" = 1.25'
Wabaunsee	7.8" = 0.65'	10.7" = 0.89'
Wallace	14.3" = 1.19'	16.1" = 1.34'
Washington	9.2" = 0.77'	12.0" = 1.00'
Wichita	14.4" = 1.20'	16.3" = 1.36'
Wilson	8.0" = 0.67'	10.7" = 0.89'
Woodson	7.4" = 0.62'	10.4" = 0.87'
Wyandotte	7.0" = 0.58'	9.8" = 0.82'

(Authorized by K.S.A. 82a-706a; implementing K.S.A. 1993 Supp. 82a-708b; effective Nov. 28, 1994.)

5-5-13. Relocation of alluvial wells. If an authorized point of diversion is a well that has as its source of supply an alluvium in a reach of a basin that is fully appropriated or closed to new appropriations, the approval of a change in point of diversion, and any subsequent approvals of changes in points of diversion, shall not authorize the distance between the well and the centerline of the stream to be decreased by more than 10 percent since the time the source of supply became fully appropriated or was closed to new appropriations. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-708b; effective Sept. 22, 2000.)

5-5-14. Duties of owners of approvals of applications and water rights. (a) All of the owners of an approval of application or a water right shall be responsible for taking all legally required actions necessary to maintain the validity of the approval of application or water right, including the filing of statutorily required fees, reports, and applications.

(b) (1) Unless the approval of application or the water right has been severed from the authorized place of use, except as set forth in paragraph (b) (2), all of the owners of the authorized place of use shall be considered to be the owners of the approval of application or the water right.

(2) Unless the chief engineer has documentation to the contrary, an approval of application or water right for municipal use shall be considered to be owned by the entity owning and operating the water distribution system. A water right for an

irrigation district shall be considered to be owned by the irrigation district. (Authorized by and implementing K.S.A. 82a-706a; effective Sept. 22, 2000.)

5-5-16. Additional wells. (a) An application for approval to change the point of diversion to add an additional point of diversion to divert groundwater, by either constructing a new well or moving a portion of a water right to a well that has previously been authorized by the chief engineer, shall not be approved unless it meets the following requirements:

(1) The provisions of K.S.A. 82a-708b, and amendments thereto, and any applicable regulations adopted by the chief engineer shall be met.

(2) The total maximum quantity of water authorized to be diverted each calendar year by the original well or wells, and the additional well or wells, shall not exceed any of the following limits:

(A) The maximum annual quantity of water that has been perfected;

(B) the maximum annual quantity of water authorized to be diverted before approval of the change; or

(C) the maximum consumptive use during the perfection period as required by K.A.R. 5-5-3 and as specified in either paragraph (a) (2) (C) (i) or (ii):

(i) If the water right authorizes the use of water for irrigation use, the consumptive use shall be presumed to not be increased in violation of K.A.R. 5-5-3 if the maximum annual quantity requested does not exceed the quantity in acre-feet calculated by use of the following formula: multiply the maximum number of acres legally irrigated in any one year during the perfection period by the 80 percent chance net irrigation requirements (N.I.R.), as set forth in K.A.R. 5-5-12 expressed in acre-feet, and divide that number by a delivery efficiency of 0.85.

(ii) If the beneficial use authorized is not irrigation, the net consumptive use during the perfection period shall be determined using the best information available.

(3) The total maximum rate of diversion that may be authorized for the original well or wells and the additional well or wells shall not be greater than the total maximum rate of diversion that could have been diverted from the original well or wells if they were currently being replaced by new wells at substantially the originally authorized location or locations in the same local source of supply. A reasonable value for the maximum rate of diversion shall be one of the following:

(A) The total rate of diversion based on a current water flow rate test done on the point or points of diversion; or

(B) a value based on a valid hydraulic analysis submitted by the applicant showing the current capacity of the aquifer to yield water at the currently authorized point or points of diversion.

(4) A condition shall be placed on the approval of the application for change authorizing the additional well or wells that provides that, for the sole purpose of administering wells concerning direct impairment, the additional well or wells shall be considered to have the priority of the date the application was filed to add the additional well or wells.

(b) The applicant shall submit the following information:

(1) A well completion log of the currently authorized well or a stratigraphic log of a test hole located within 300 feet of the currently authorized well;

(2) the depth of the currently authorized well;

(3) the current depth to the static water level of the currently authorized well;

(4) a stratigraphic log of a test hole located within 300 feet of the proposed location of each of the proposed additional well or wells; and

(5) any additional information that the chief engineer needs to understand the nature of the proposed additional well or wells.

(c) The proposed additional well or wells shall meet one of the following conditions:

(1) Meet the well spacing requirements to all other wells with a priority earlier than the date the change application was filed; or

(2) if a hydraulic analysis shows that the approval of the proposed additional well within 300 feet of the currently authorized well location will neither impair any water rights senior to the date the application for change was filed nor prejudicially and unreasonably affect the public interest, be located within a 300-foot radius of one of the wells, or the geocenter if the currently authorized point of diversion is a battery of wells, authorized pursuant to the water right upon which the change application has been filed.

(d) Each point of diversion authorized by an approval of an application for change for an additional well shall have a specific assignment of a

maximum instantaneous rate of diversion and a maximum annual quantity of water.

(e) Each well authorized by a water right that has been changed under the provisions of this regulation shall be equipped with a separate water flowmeter that meets or exceeds the specifications for water flowmeters adopted by the chief engineer.

(f) Each approval of an additional well or wells shall have a condition that reserves jurisdiction for the chief engineer to review the approval of the additional well or wells at intervals of no fewer than five years, and not more than 10 years, to determine if the total annual quantity of water actually being withdrawn by all wells authorized by the approval of an application for change is exceeding the total annual quantity of water that could have been physically withdrawn if the additional well or wells had not been approved. If the chief engineer determines during the review that the total annual quantity being withdrawn by all the wells, including the additional wells, exceeds the total annual quantity of water that could have been physically withdrawn by the original well or wells, the total maximum annual quantity that can be withdrawn by all the wells shall be reduced by the chief engineer to the total maximum annual quantity that could have been physically withdrawn by the original well or wells. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-708b; effective Sept. 22, 2000; amended Oct. 24, 2003.)

Article 6.—STORAGE OF WATER

5-6-1. Application proposing storage, contents. Any person intending to store water may make application to the chief engineer in the same manner as any other person making application for permit to appropriate water for beneficial use. The application shall set forth the same general information as any other application for permit to appropriate water for beneficial use and, in addition, shall be accompanied by information to show:

(a) The area-capacity data of the reservoir in which the water is to be stored.

(b) The drainage area.

(c) The names and mailing addresses of the owners of lands that will be inundated by water accumulated in the reservoir.

(d) Any additional information as may be required by the chief engineer for a proper understanding of the proposed appropriation and storage of water. (Authorized by K.S.A. 82a-706a; modified, L. 1978, ch. 460, May 1, 1978.)

5-6-2. Storage of water in watershed district reservoirs. When a person makes application for permit to appropriate water for beneficial use proposing the storage of water in a watershed district reservoir, the application shall be accompanied by one of the following:

(a) A copy of an agreement or letter from the board of directors of the watershed district that states it was mutually agreed and understood at the time an easement was granted by the landowner that the landowner was to have the use of space in the sediment pool to store the water to which he or she might be entitled under the water appropriation act.

(b) A copy of a resolution by the board of directors that shows, as of a certain date, the board allocated or gave to the landowner all or a specified part of the sediment pool for the storage of water in accordance with the water appropriation act. (Authorized by K.S.A. 82a-706a; modified, L. 1978, ch. 460, May 1, 1978.)

5-6-3. Potential net evaporation. (a) The Kansas department of agriculture, division of water resources' map titled "potential net evaporation, in inches, for Kansas," dated September 6, 1996, is hereby adopted by reference for the purpose of determining potential net evaporation from a free water surface.

(b) The values on the map shall be used in all situations in which determination of potential net evaporation from a free water surface is necessary, including the following:

(1) Calculating the maximum annual quantity of water allowed to be appropriated for the storage of surface water in a reservoir;

(2) computing the annual amount of evaporation that will be caused by exposing the groundwater table;

(3) calculating the quantity of evaporation from surface water or exposed groundwater that will be used to determine annual water use; and

(4) determining the maximum annual quantity of water that is perfected pursuant to K.S.A. 82a-714 and amendments thereto.

(c) The values shown on the map shall be used unless the applicant provides, or the chief engineer has available, better or more site-specific data concerning potential net evaporation. (Authorized by K.S.A. 82a-706a; implementing K.S.A.

82a-707(e), K.S.A. 1999 Supp. 82a-711, and K.S.A. 1999 Supp. 82a-714; effective Sept. 22, 2000.)

5-6-4. Determination of potential annual runoff. (a) Unless the applicant for an approval of application supplies, or the chief engineer has available, better or more site-specific data, the potential annual runoff shall be determined using the following:

(1) A 20 percent chance of occurrence of runoff by extrapolating from the "annual yield of runoff" graph of the United States department of agriculture, natural resources conservation service, national engineering handbook series, part 650, engineering field handbook, EFM notice KS-38, dated December 12, 1991, which is adopted by reference;

(2) the soil cover complex number of the drainage basin, using the "generalized soil cover complex number" map of Kansas produced by the Kansas department of agriculture, division of water resources, dated August 1999, which is hereby adopted by reference;

(3) the normal annual precipitation in the watershed as set forth in K.A.R. 5-6-12; and

(4) the area of the watershed of the reservoir determined by using a United States geological survey 7½-minute topographic map.

(b) In computing the potential annual runoff of the watershed of the reservoir, if the quantity of water applied for, or authorized by, prior upstream surface water and groundwater applications, approvals of applications, and existing water rights within the watershed of the reservoir will significantly decrease the potential annual runoff available for appropriation in the reservoir, the impact of those rights on the potential annual runoff shall be subtracted from the total computed potential annual runoff in order to determine the potential annual runoff available. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-707(e) and K.S.A 1999 Supp. 82a-711; effective Sept. 22, 2000.)

5-6-5. Maximum reasonable annual quantity for storage of water for beneficial use in a reservoir. The maximum reasonable annual quantity of water that may be authorized for appropriation by the chief engineer for diversion and storage in a reservoir shall be limited to the maximum of either of the following:

(a) The potential annual runoff; or

(b) the total of the following:

(1) A three-year supply of water to be rediverted for all authorized beneficial uses; and

(2) a three-year supply of water for indirect use subject to the following limitations:

(A) A maximum of three years of indirect use shall be authorized for each reservoir as a whole; and

(B) If the maximum annual quantity of water requested for rediversion exceeds the reservoir capacity, the maximum annual quantity of water authorized to be diverted and stored in any one year shall not exceed the total of the following:

(i) The annual quantity of water rediverted for beneficial use;

(ii) the reservoir capacity; and

(iii) one year of indirect use from the reservoir. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-707(e), K.S.A. 1999 Supp. 82a-711, and K.S.A. 82a-712; effective Sept. 22, 2000.)

5-6-6. Initial filling and refilling of a reservoir. (a) The initial filling of a reservoir that has a capacity that exceeds the maximum annual quantity of water authorized shall be authorized by a special condition on the approval of application.

(b) Each refilling of a reservoir after the release of water for maintenance or similar reasons shall be required to be authorized by a term permit if the reservoir capacity exceeds the maximum annual quantity authorized. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-707(e), K.S.A. 1999 Supp. 82a-711, and K.S.A. 82a-712; effective Sept. 22, 2000.)

5-6-7. Determination of average annual potential net evaporation loss. The average annual potential net evaporation loss shall be determined by multiplying the surface area of the reservoir at the top of the reservoir capacity times the value for average annual potential net evaporation, as set forth in K.A.R. 5-6-3, for the township in which the point of diversion is located. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-707(e), K.S.A. 1999 Supp. 82a-711, and K.S.A. 82a-712; effective Sept. 22, 2000.)

5-6-8. Determination of average annual seepage loss from a reservoir. Average annual seepage loss from a reservoir shall be determined by the chief engineer based on relevant, credible information furnished by the applicant. If no relevant, credible information is supplied by the applicant, it shall be assumed by the chief engineer

that there is no seepage loss. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-707(e), K.S.A. 1999 Supp. 82a-711, and K.S.A. 82a-712; effective Sept. 22, 2000.)

5-6-9. Administration of surface water stored in a reservoir. Water lawfully stored within any reservoir authorized to store water for subsequent beneficial use shall not be subject to administration unless senior water right holders downstream of the reservoir make an appropriate request to have water bypassed to satisfy their senior water right within two weeks of the runoff event, or any other time frame in which inflow to the reservoir could reasonably have been expected to be available to the downstream senior water right if the reservoir had not impounded the water. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706b; effective Sept. 22, 2000.)

5-6-10. Authorized place of use for stored surface water. The approval of application shall limit the authorized place of use to the actual location where the water will be put to beneficial use. If the authorized use is for recreational use within the reservoir only, the authorized place of use shall not exceed the size and location of the surface area of the reservoir at the elevation of the top of the principal spillway. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-711 and K.S.A. 82a-712; effective Sept. 22, 2000.)

5-6-11. Reasonable rate of diversion for storage of surface water in a reservoir. Each approval of application shall limit the rate of diversion for storage of surface water in a reservoir to all natural flows not necessary to satisfy all of the following:

(a) Senior water rights;

(b) senior approvals of applications;

(c) senior water reservation rights; and

(d) senior minimum desirable stream flows pertaining to the use of water from the same source of water supply. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-712; effective Sept. 22, 2000.)

5-6-12. Average annual precipitation. (a) The Kansas department of agriculture, division of water resources' map titled "normal annual precipitation, by township, 1961-1990," dated September 29, 1999, is hereby adopted by reference for the purpose of determining average annual precipitation.

(b) The data on the map shall be used in all situations in which the determination of average annual precipitation is necessary, including calculating the maximum annual quantity of water allowed to be appropriated for the storage of surface water in a reservoir.

(c) The values shown on the map shall be used unless the applicant provides, or the chief engineer has available, better or more site-specific data concerning average annual precipitation. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-711; effective Sept. 22, 2000.)

5-6-13. Water level measurement tube specifications. (a) The Kansas department of agriculture, division of water resources' document titled "specifications for water level measurement tube," dated November 5, 1999, is hereby adopted by reference.

(b) If a water level measurement tube is required by the chief engineer to be installed, the required water level measurement tube shall be installed in accordance with the specifications for water level measurement tubes adopted by the chief engineer. These requirements are in addition to those made by the Kansas department of health and environment pursuant to the groundwater exploration and protection act, K.S.A. 82a-1201 et seq., and amendments thereto.

(c) As long as the well is permitted, the water level measurement tube shall be maintained in a satisfactory condition. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706c; effective Sept. 22, 2000.)

5-6-13a. Check valve specifications. The Kansas department of agriculture, division of water resources' document titled "check valve specifications," dated March 14, 2003, is hereby adopted by reference. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706, K.S.A. 82a-706a, and K.S.A. 82a-712; effective Oct. 24, 2003.)

5-6-14. Irrigation with effluent from a confined feeding facility lagoon. An individual who irrigates with effluent pumped from a confined feeding facility lagoon or runoff retention pit shall not be required to have an approval of application pursuant to K.S.A. 82a-701 et seq. and amendments thereto, unless there are more than 15 acre-feet of average annual runoff meeting the following criteria:

(1) Is generated from outside of the confined feeding facility;

(2) is impounded in the lagoon or runoff retention pit; and

(3) is used for irrigation purposes. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-705 and 82a-707(a); effective Sept. 22, 2000.)

5-6-15. Drainage basin boundaries. (a) The following electronic data files, all dated February 14, 2002, prepared by the division of water resources, Kansas department of agriculture, using data developed by the United States geological survey and the natural resource conservation service, are hereby adopted by reference by the chief engineer for the purpose of defining the boundaries of the 62 drainage basins in Kansas:

(1) dwrbasins.dbf;

(2) dwrbasins.sbn;

(3) dwrbasins.sbx;

(4) dwrbasins.shp; and

(5) dwrbasins.shx.

(b) The electronic data files described in subsection (a) shall be used in all situations in which determination of the basin boundaries is necessary.

(c) The boundaries shown in the electronic data files shall be used unless the applicant provides, or the chief engineer has available, better or more site-specific data concerning the actual drainage basin boundaries. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706 and K.S.A. 82a-706a; effective Sept. 22, 2000; amended Oct. 24, 2003.)

Article 7.—ABANDONMENT AND TERMINATION

5-7-1. Due and sufficient cause for nonuse. (a) Each of the following circumstances shall be considered "due and sufficient cause," as used in K.S.A. 82a-718, and amendments thereto:

(1) Adequate moisture is provided by natural precipitation for production of crops normally requiring full or partial irrigation within the region of the state in which the place of use is located.

(2) A right has been established or is in the process of being perfected for use of water from one or more preferred sources in which a supply is available currently but is likely to be depleted during periods of drought.

(3) Water is not available from the source of water supply for the authorized use at times needed.

(4) Water use is temporarily discontinued by the owner for a definite period of time to permit soil, moisture, and water conservation, as documented by any of the following:

(A) Furnishing to the chief engineer a copy of a contract showing that land that has been lawfully irrigated with a water right that has not been abandoned is enrolled in a multiyear federal or state conservation program that has been approved by the chief engineer;

(B) enrolling the water right in the water right conservation program in accordance with K.A.R. 5-7-4; or

(C) any other method acceptable to the chief engineer that can be adequately documented by the owner before the nonuse takes place.

(5) Management and conservation practices are being applied that require the use of less water than authorized. If a conservation plan has been required by the chief engineer, the management and conservation practices used shall be consistent with the conservation plan approved by the chief engineer to qualify under this subsection.

(6) The chief engineer has previously approved the placement of the point of diversion in a standby status in accordance with K.A.R. 5-1-2.

(7) Physical problems exist with the point of diversion, distribution system, place of use, or the operator. This circumstance shall constitute due and sufficient cause only for a period of time reasonable to correct the problem.

(8) Conditions exist beyond the control of the owner that prevent access to the authorized place of use or point of diversion, as long as the owner is taking reasonable affirmative action to gain access.

(9) An alternate source of water supply was not needed and was not used because the primary source of supply was adequate to supply the needs of the water right owner. The owner shall maintain the diversion works on the alternate source of supply in a condition that will allow the owner to effectively use the alternate source of supply in a timely manner.

(10) The chief engineer determines that a manifest injustice would result if the water right were deemed abandoned under the circumstances of the case.

(b) In order to constitute due and sufficient cause for nonuse of water, the reason purporting to constitute due and sufficient cause shall have in fact prevented, or made unnecessary, the authorized beneficial use of water.

(c) Each year of nonuse for which the chief engineer finds that due and sufficient cause exists shall be considered to interrupt the successive years of nonuse for which due and sufficient cause does not exist.

(d) When a verified report of the chief engineer, or the chief engineer's authorized representative, is made a matter of record at a hearing held pursuant to K.S.A. 82a-718, and amendments thereto, that establishes nonuse of a water right for five or more successive years, the water right owner shall have the burden of showing that there have not been five or more successive years of nonuse without due and sufficient cause. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-718; modified, L. 1978, ch. 460, May 1, 1978; amended May 1, 1986; amended May 31, 1994; amended Oct. 24, 2003.)

5-7-2. Waiver of hearing. The owner of a water right may waive any hearing on the questions of abandonment and termination of such right by letter to the chief engineer requesting that it be terminated and its priority forfeited. In the event of such waiver the chief engineer shall cause the termination and forfeiture of priority date to be made a matter of record in his office and shall notify the owner of the water right of his or her action by regular mail. (Authorized by K.S.A. 82a-706a; modified, L. 1978, ch. 460, May 1, 1978.)

5-7-3. (Authorized by K.S.A. 82a-706a; modified, L. 1978, ch. 460, May 1, 1978; revoked May 31, 1994.)

5-7-4. Water rights conservation program. (a) Enrollment in the water rights conservation program (WRCP) approved by the chief engineer, and continued compliance with the WRCP shall constitute due and sufficient cause for nonuse pursuant to K.S.A. 82a-718, and amendments thereto, and K.A.R. 5-7-1 during the time the water right is enrolled in the WRCP.

(b) In order to qualify for enrollment in the WRCP, the following conditions shall be met:

(1) The point of diversion shall be located in either of the following locations:

(A) In an area that is closed to new appropriations of water, except for temporary permits, term permits, and domestic use; or

(B) in some other area designated by the chief engineer as an area where it would be in the public interest to allow water rights to be placed in the WRCP. In areas within the boundaries of a groundwater management district, the recommendations of the board of the district shall be taken into consideration by the chief engineer.

(2) Each of the owners of the water right shall agree to totally suspend all water use authorized by that water right for the duration of the contract.

(3) The owner or owners of the water right shall sign a contract with the chief engineer, or the chief engineer's authorized representative, before placing the water right into the WRCP. The contract shall be binding on all successors in interest to the water right owner.

(4) Only an entire water right may be placed into the WRCP. If a portion of a water right has been abandoned, the portion that is still in good standing may be enrolled in the WRCP. If a water right is administratively divided by the chief engineer, each portion of a formally divided water right shall be considered to be an entire water right for the purpose of this regulation.

(A) If at least five successive years of nonuse have occurred before application for enrollment in the WRCP, a determination of whether or not that water right is subject to abandonment before entry into the program, including an analysis of any reasons given that might constitute due and sufficient cause for nonuse, shall be made by the chief engineer.

(B) If, after review of the information, it appears that the right has been abandoned, the statutory procedures, including the right to a hearing, shall be followed to determine whether or not it has been abandoned.

(5) Only the portion of a water right in good standing at the time of application for enrollment may be entered into the WRCP.

(c) Other obligations, responsibilities, and aspects of enrollment in the WRCP program shall include the following:

(1) Water rights shall originally be placed into the WRCP for a definite period of calendar years of no fewer than five and no more than ten. The owner of the water right may apply for renewal of the contract for a period not to exceed 10 years. Applications for renewal shall be subject to the approval of the chief engineer. In determining whether or not to approve the renewal, the following factors shall be taken into account by the chief engineer:

(A) The hydrologic conditions in the vicinity of the point of diversion;

(B) the effect of renewal on the public interest; and

(C) any other relevant information.

(2) The water right owner or operator shall not be required to maintain the diversion works or delivery system during the period of the WRCP contract. If the pump is removed from a well, the well shall be properly capped or sealed during the contract. These requirements are in addition to those made by the Kansas department of health and environment pursuant to the groundwater exploration and protection act, K.S.A. 82a-1201 et seq., and amendments thereto.

(3) A certificate determining the extent to which a water right has been perfected shall be issued by the chief engineer before entering the water right into the WRCP if all of the following conditions are met:

(A) An applicant has a permit to appropriate water for beneficial use and has perfected all, or any portion, of the water right authorized by the permit.

(B) The time in which to perfect the water right has expired, including any authorized extensions of time.

(C) A field inspection has been completed.

(4) If the time to perfect the water right, or any authorized extension of it, has not expired, enrollment in the WRCP shall be considered as suspending the time to perfect. Upon expiration of the WRCP contract pertaining to this water right, the time to perfect shall again commence, and the applicant shall be required to perfect the water right within the remainder of the time allowed to perfect, or any authorized extension of that time.

(5) Each year after authorized enrollment in the WRCP, the water use correspondent shall indicate on the water use report that no water was used because the water right was enrolled in the WRCP.

(6) If the owner breaches, or causes or allows a breach of, the WRCP contract with the chief engineer, each year of nonuse between the effective date of the contract and the date of the breach shall be counted as years of non use without due and sufficient cause for the purpose of determining whether or not the water right has been abandoned pursuant to the provisions of K.S.A. 82a-718, and amendments thereto. Before this penalty is imposed, the owner shall be given an opportunity to show either of the following:

(A) A breach of contract did not occur.

(B) A breach occurred, but either was minor or has been cured, and should not constitute grounds for imposing the penalty. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706, K.S.A. 82a-713, K.S.A. 1999 Supp. 82a-714, and K.S.A. 1999 Supp. 82a-718; effective July 1, 1994; amended Sept. 22, 2000.)

5-7-4a. Conservation reserve program. (a) Enrollment of all, or part of, the authorized place of use in the conservation reserve program (CRP) shall not be considered good cause to extend the time to construct the diversion works.

(b) If an authorized place of use has been placed into the CRP after the diversion works have been completed but before the time to perfect the water right has expired, the appropriator may request and receive an extension of time to perfect the water right for the length of time that the authorized place of use is enrolled in the CRP program, plus the length of time remaining to perfect the water right, if all of the following conditions are met:

(1) The diversion works were properly completed within the time allowed by the approval of application.

(2) The time to perfect the water right as set forth in the approval of the application has not expired at the time the request for the extension is filed.

(3) The appropriator furnishes the chief engineer with a copy of the CRP contract, including the aerial photograph designating which land has been placed into the CRP program. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-713 and K.S.A. 1999 Supp. 82a-714; effective Sept. 22, 2000.)

5-7-5. Reduction of an existing water right. (a) In order to have an approval of application or water right reduced, the water right owner may file, at any time, a request to reduce any of the following:

(1) The authorized maximum annual quantity of water;

(2) the authorized maximum rate of diversion;

(3) the authorized place of use;

(4) the authorized points of diversion;

(5) the types of beneficial use; or

(6) any combination of paragraphs (a)(1) through (a)(5).

(b) The request to reduce a water right shall be filed on a form prescribed by the chief engineer.

(c) The request to reduce shall be submitted in

proper form and shall include the following information:

(1) Except as set forth in subsection (d) below, notarized signatures of all water right owners that would be required by K.A.R. 5-5-1 to sign an application for change under K.S.A. 82a-708b and amendments thereto;

(2) a clear description of which portion or portions of the approval of application or water right are proposed to remain;

(3) a statement that all of the owners of the approval of application or water right are waiving any right they might have to a hearing concerning the dismissal or abandonment of any portion of the approval of application or water right that they are requesting to have removed; and

(4) any other information requested by the chief engineer.

(d) A request solely to reduce the authorized place of use that will not affect the approval of application or water right in any other way shall be only required to be signed only by all of the owners of the authorized place of use that is proposed to be deleted.

(e) A reasonable request to reduce an approval of application or water right that is submitted in proper form shall be approved by the chief engineer unless it will cause the impairment of existing water rights or prejudicially and unreasonably affect the public interest. If the request to reduce the water right or approval of application is to remove a point of diversion, the approval shall reduce only that maximum annual quantity of water and maximum rate of diversion associated with the authorized point of diversion that is removed.

(f) A request to reduce an existing water right shall not be considered to be an application for a change pursuant to K.S.A. 82a-708b and amendments thereto, so no application fee shall be required. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706 and 82a-721; effective Sept. 22, 2000.)

Article 8.—CERTIFICATION OF WATER RIGHTS

5-8-1. Certification of a water right. Prior to the issuance of a certificate of appropriation by the chief engineer pursuant to an application under which water has been applied to the land of more than one owner, these landowners shall be allowed an opportunity to submit to the chief engineer an agreement signed by all landowners involved recommending how the water right should be divided among them. (Authorized by K.S.A. 82a-706a, 82a-714; effective May 1, 1980.)

5-8-2. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-712, 82a-714; effective May 1, 1980; revoked May 1, 1981.)

5-8-3. Perfection; multiple water rights. (a) The total maximum annual quantity of water that can be perfected by all water rights authorized to divert water to the same authorized place of use, shall be limited to the maximum quantity of water actually physically and legally diverted and applied to beneficial use on the common authorized place of use during any one calendar year during the perfection period for the water right being certified.

(b) The junior water right shall be limited by means of a limitation clause in the certificate so that the authorized annual quantity of water for the junior water right, when combined with all senior water rights authorized to apply water to beneficial use on the common authorized place of use, does not exceed either of the following standards:

(1) The annual quantity of water reasonable for the type of beneficial use made of the water; and

(2) the total annual quantity of water legally diverted by all water rights to the common authorized place of use during any one calendar year during the perfection period of the junior water right.

(c) The limitation clause on the junior water right being certified shall not restrict the total annual quantity authorized to be diverted to the authorized place of use to less than the total annual quantity of water authorized by the senior water right or water rights for beneficial use on the common authorized place of use.

(d) The owner whose water right is being certified shall be sent a draft certificate showing the maximum rate of diversion and maximum annual quantity of water that are being proposed for the certificate. The water right owner shall be given a reasonable time period of no fewer than 30 days to comment on the draft certificate and to provide any additional information concerning the water diverted and applied to beneficial use on the authorized place of use during the perfection period in accordance with the terms, conditions, and limitations of the approval of application, and all other water rights and approvals of applications

authorized to divert water to the common authorized place of use.

(e) In certifying a water right with a priority date before the effective date of this regulation, the provisions of subsection (a) shall be followed to the extent possible. If sufficient information is not available to make the determination described in subsection (a), the best information available shall be utilized by the chief engineer to determine the quantity of water applied to the authorized place of use during any one calendar year during the perfection period under the authority of the approval of application being certified and all other water rights. The standard set forth in paragraph (b)(1) shall be applied, even if sufficient information is not available to make the determination described in subsection (a). (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-707(e), K.S.A. 82a-713, and K.S.A. 1999 Supp. 82a-714(a); effective Sept. 22, 2000.)

5-8-4. Construction of diversion works. (a) A reasonable period of time for construction of diversion works shall be not less than one full year following the approval of the application to appropriate water. If a person demonstrates that a reasonable long-term schedule for development of diversion works or other infrastructure is in the public interest, that information shall be taken into consideration by the chief engineer in determining a reasonable period of time for the construction of diversion works.

(b) For good cause shown by the applicant, a reasonable extension of time to construct the diversion works shall be allowed by the chief engineer, if the request for extension is filed pursuant to the requirements of K.A.R. 5-3-7 and is accompanied by the statutorily required filing fee.

(c) If the total time allowed to construct the diversion works has been more than 16 months and fewer than 24 months, an extension of time shall be granted by the chief engineer only if the applicant meets the following criteria:

(1) Demonstrates good cause;

(2) provides a copy of a contract with the well driller or other information substantiating the intent to proceed to complete the construction of the diversion works in an expeditious manner;

(3) files the request for extension pursuant to the requirements of K.A.R. 5-3-7; and

(4) submits the statutorily required filing fee.

(d) If the total time allowed to construct the diversion works equals or exceeds 24 months, an extension of time may be granted only if the applicant demonstrates to the chief engineer that circumstances beyond the control of the applicant necessitate the extension of time.

(e)(1) The applicant shall file a notice of completion of diversion works and the statutorily required field inspection fee with the chief engineer no later than March 1 following the deadline to construct the diversion works. The notice of completion of diversion works shall be filed on a form prescribed by the chief engineer.

(2) If a water flowmeter has been required by the chief engineer as a condition of the permit, the applicant shall also file a notice of completion of installation of a water flowmeter on a form prescribed by the chief engineer. This form shall be due at the same time that the notice of completion of diversion works form is due.

(f)(1) The applicant shall be sent a notice by the chief engineer giving the applicant 30 days to show that the diversion works were completed within the time allowed in accordance with the terms, conditions, and limitations of the approval of application and to pay the field inspection fee, if it has not already been paid, under either of the following conditions:

(A) A notice of completion of diversion works has not been completely and timely filed with the chief engineer.

(B) Information on file in the office of the chief engineer indicates that the diversion works were not properly constructed within the time allowed to construct the diversion works, including any authorized extensions of time.

(2) The permit shall be dismissed and its priority forfeited if the applicant fails to perform the following:

(A) To demonstrate that the diversion works were completed within the time allowed by the approval of application; and

(B) to pay the statutorily required field inspection fee, if it has not already been paid. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-712, K.S.A. 82a-713, and K.S.A. 1999 Supp. 82a-714; effective Sept. 22, 2000.)

5-8-6. Perfection of a water right. (a) Except for municipal use, a reasonable period of time to perfect a water right shall be no fewer than four full calendar years following the deadline for construction of the diversion works. If the time to construct the diversion works is extended, the perfection period shall be extended to no fewer than

four full calendar years beyond the final deadline to construct the diversion works, unless the owner of the approval of application objects.

(b) A reasonable time to perfect a water right for municipal use shall be no fewer than 20 full calendar years plus the remainder of the calendar year in which the application was approved. Each holder of a permit for municipal use of water shall submit a progress report to the chief engineer 10 full calendar years after the permit was issued. The report shall be submitted on a form prescribed by the chief engineer. The report shall meet the following conditions:

(1) Compare the annual water use projected in the original application with the actual annual water use for the prior 10 years; and

(2) document compliance with an approved conservation plan, if one had been required. If the 10-year review by the chief engineer shows that actual annual water use is significantly less than originally projected, the holder shall revise the estimated annual water use for the next 10 years. If it is in the public interest, the total authorized annual quantity of water for the next 10 years shall be reduced by the chief engineer to a reasonable annual quantity based on the municipal user's revised estimates of annual water use for the next 10 years. If the 10-year review indicates that a required conservation plan was not being complied with or that the conservation plan does not meet the Kansas water office's conservation guidelines for municipal users, as in effect at the time of the review, an order requiring any of the following shall be issued by the chief engineer:

(A) That the conservation plan be amended to comply with current guidelines;

(B) that the user comply with the provisions of the approved conservation plan; or

(C) both of the requirements in paragraphs (b) (2) (A) and (B).

(c) If the applicant demonstrates to the chief engineer that a longer perfection period is necessary to justify purchase or construction of infrastructure related to the diversion, treatment, or distribution of water that actually is being built, the original time to perfect a water right for municipal use or other public entity, including a utility, may be extended for a period not to exceed a total time to perfect of 40 years.

(d) For good cause shown by the applicant, a reasonable extension of time to perfect a water right shall be allowed by the chief engineer if the request for extension is filed pursuant to the terms of K.A.R. 5-3-7 and is accompanied by the statutorily required filing fee.

(e) If water use reports and other information on file in the office of the chief engineer indicate that no water was applied to the authorized beneficial use during the time allowed to perfect the water right, including any authorized extensions of time, the owner of the approval of application as shown in the records of the chief engineer shall be sent a notice by the chief engineer, giving the owner 30 days to show that water was put to beneficial use within the terms, conditions, and limitations of the permit during the perfection period. If the owner fails to demonstrate that water was so used, the permit shall be dismissed and its priority forfeited. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-707(e), K.S.A. 82a-712, K.S.A. 82a-713, and K.S.A. 1999 Supp. 82a-714; effective Sept. 22, 2000.)

5-8-7. Extensions of time to perfect a water right. (a) For all beneficial uses of water, except municipal use, the total time to perfect the water right, including extensions of time, shall not exceed 10 years after the calendar year in which the diversion works were required to be completed unless one or more of the following "extenuating circumstances" exist.

(b) "Extenuating circumstances" shall include the following:

(1) Circumstances beyond the control of the owner of the approval of application that have unduly restricted the owner's ability to perfect the water right;

(2) actions or omissions by the chief engineer that make it necessary to extend the time to perfect; and

(3) for applications with a priority before May 1, 1978, the unavailability or lack of credibility of records of water use, crops grown, and the number and location of acres actually irrigated, and other relevant information during the perfection period, but other records or information is available for a period after the perfection period and would reasonably represent the application of water to beneficial use in accordance with the terms, conditions, and limitations of the permit.

(c) The burden shall be on the owner of the approval of application to document the extenuating circumstances described in subsection (b) and justify to the chief engineer the need for the extension of time to perfect the water right.

(d)(1) Extensions of time to perfect for appli-

cations with a priority before May 1, 1978, may be granted in any reasonable increment of years. The total amount of time allowed to perfect the water right shall be reasonable.

(2) Extensions of time to perfect a water right for nonmunicipal use, with a priority on or after May 1, 1978, may be granted in any increment of time until the total time to perfect equals 10 years. After the total time allowed to perfect the water right equals 10 years, extensions of time shall be granted in one-year increments only.

(e) Extensions of the time to perfect a water right for municipal use of water that can be justified shall be extended in five-year increments or less after the original 20-year time period to perfect the water right has elapsed. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-712 and 82a-713; effective Sept. 22, 2000.)

5-8-8. Owner required to allow chief engineer to conduct timely field inspection for certification. (a) In order to allow the chief engineer to conduct a timely field inspection to certify a water right, the owner of an approval of application shall perform the following:

(1) Operate the diversion works in the same manner that they were operated when water was applied to beneficial use during the perfection period, so that an accurate rate-of-diversion test can be conducted by the chief engineer;

(2) allow the chief engineer access to the diversion works and the authorized place of use for the purpose of making the field inspection; and

(3) allow, cooperate with, and assist the chief engineer in any other ways necessary for the chief engineer to conduct the field inspection.

(b) The owner of the approval of application shall allow the field inspection to be conducted within 365 days after the chief engineer has sent the owner of the approval of application a restricted letter requesting that the chief engineer be allowed to conduct a field inspection. If the owner does not cooperate with, assist, and allow the chief engineer to conduct a field inspection, without good cause, within one year after the restricted letter is sent by the chief engineer, an order shall be issued by the chief engineer requiring the owner of the approval of application to comply with the terms of the restricted letter. The order shall also be sent by restricted mail. If the owner fails to comply with the order of the chief engineer, an action shall be brought by the chief engineer to enforce the order of the chief engineer pursuant to the act for judicial review, and civil enforcement of agency actions, K.S.A. 77-624 et seq. and amendments thereto. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-714; effective Sept. 22, 2000.)

Article 9.—TEMPORARY PERMITS

5-9-1. Application for temporary permit acceptable for filing. To be acceptable for filing, an application for temporary permit to appropriate water for beneficial use shall meet the following requirements: (a) Be made on the form prescribed by the chief engineer;

(b) be signed by the applicant or an authorized representative of the applicant;

(c) be accompanied by the statutory application fee;

(d) contain all the information requested for the proposed use as set forth in the prescribed application form; and

(e) include any other information requested by the chief engineer that is necessary to understand the application. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-727; effective May 1, 1979; amended Oct. 24, 2003.)

5-9-2. Priority. Upon receipt in the office of the chief engineer of an acceptable application for temporary permit to appropriate water, accompanied by the statutory application fee, a stamp showing the date and time of receipt shall be placed on the application form. The date and time of receipt of the application shall establish the priority to the use of the water. The priority shall terminate on the date when use of water will be discontinued as set forth in the application or any authorized extension of time thereof. (Authorized by K.S.A. 82a-727; effective May 1, 1979.)

5-9-3. Quantity. A temporary permit shall not be granted for a quantity in excess of 1,000,000 gallons except for dewatering purposes or when water is to be diverted from a source located on a construction site and used on the construction site in connection with a project that the chief engineer has approved under the authority of K.S.A. 82a-301 through 305a or K.S.A. 24-126. (Authorized by K.S.A. 82a-727b; implementing K.S.A. 82a-727; effective May 1, 1979; amended Dec. 3, 1990.)

5-9-4. Place of use limitation. A temporary permit shall not be granted for more than one

place of use. (Authorized by K.S.A. 82a-727; effective May 1, 1979.)

5-9-5. Point of diversion limitation. A temporary permit shall not be granted authorizing more than one point of diversion from any source of supply. (Authorized by K.S.A. 82a-727; effective May 1, 1979.)

5-9-6. Approval of application. The approval of an application for a temporary permit shall be by endorsement on the application by the chief engineer. The endorsement shall set forth the terms, limitations, and conditions necessary for the protection of the public interest. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-727; effective May 1, 1979; amended Oct. 24, 2003.)

5-9-7. Extension of time. For good cause shown by the applicant the chief engineer may grant an extension of time to continue the use of water under a temporary permit beyond the date authorized as shown in the approval of the application. The term of a temporary permit shall not exceed six (6) months including any authorized extension of time thereof. (Authorized by K.S.A. 82a-727; effective May 1, 1979.)

5-9-8. Ownership. A temporary permit for the appropriation of water shall not be transferable. (Authorized by K.S.A. 82a-727; effective May 1, 1979.)

5-9-9. Reserved.

5-9-10. Application fee for a temporary permit. The fee for an application for a temporary permit or extension of a temporary permit shall be twenty-five dollars ($25.00). This regulation shall be effective on and after September 1, 1982. (Authorized by and implementing K.S.A. 1982 Supp. 82a-727; effective, T-83-25, Sep. 1, 1982; effective May 1, 1983.)

5-9-11. Documentation of access to source of water supply for temporary permit. Before approval of a temporary permit, the applicant shall show that permission for access to the source of water supply has been obtained from the landowner or landowners of the property where the proposed point of diversion will be located. If permission is granted in an oil and gas lease, it shall be sufficient for the applicant to indicate this on the application for a temporary permit to appropriate water. If the water is to be obtained from land not covered by the oil and gas lease, then the permission of the landowner or landowners shall be adequately documented. (Authorized by and implementing K.S.A. 82a-727; effective Sept. 22, 2000.)

Article 10.—WATER APPROPRIATION

5-10-1. (Authorized by K.S.A. 82a-706a, K.S.A. 1982 Supp. 82a-708a; implementing K.S.A. 1982 Supp. 82a-708a; effective, T-83-25, Sep. 1, 1982; effective May 1, 1983; revoked May 1, 1988.)

5-10-2. (Authorized by K.S.A. 82a-706a, K.S.A. 1982 Supp. 82a-708a; implementing K.S.A. 1982 Supp. 82a-708a; effective, T-83-25, Sep. 1, 1982; effective May 1, 1983; revoked May 1, 1988.)

5-10-3. (Authorized by K.S.A. 82a-706a, K.S.A. 1982 Supp. 82a-708b; implementing K.S.A. 1982 Supp. 82a-708b; effective, T-83-25, Sep. 1, 1982; effective May 1, 1983; revoked May 1, 1988.)

5-10-4. Waiver or exemptions. The chief engineer may grant an exemption or waiver from any regulation adopted by the chief engineer if it is shown that the granting of such exemption or waiver will not prejudicially nor unreasonably affect the public interest and that it will not impair an existing water right. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-711, 82a-712; effective May 1, 1983.)

5-10-5. Administration of water use among vested right holders. If, during the administration of water rights, each appropriation right and approved permit to appropriate water for beneficial use has been regulated in accordance with the provisions of K.S.A. 82a-706b, the division of water resources shall administer the water available from that source of supply among the holders who have active vested rights, including vested rights for domestic purposes, on a proportional basis and in a manner which will provide, if possible, sufficient flow in the stream for vested rights for domestic purposes. The proportionment may be accomplished by a pro rata reduction in the rate or quantity that each vested right shall be allowed to divert, by setting up a rotation system or by any other equitable method. Vested rights shall be administered in this manner unless they have been adjudicated by a court of

competent jurisdiction as to priority or rotation and then the chief engineer shall administer them in accordance with the order of the court. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-704a and K.S.A. 82a-706; effective May 1, 1986.)

5-10-6. Procedure for determination of an active vested domestic water right. The existence of an active domestic vested water right shall be determined by the chief engineer as follows:

(a) Information shall be filed with the chief engineer on a form prescribed by the chief engineer concerning the dates beneficial use of water was made, and the nature and extent of the active domestic vested right.

(b) Affidavits from at least three competent disinterested persons shall be filed by the claimant on a form prescribed by the chief engineer or other reliable substantiating evidence shall be submitted to the chief engineer by the claimant documenting the dates beneficial use of water was made, and the nature and extent of the active domestic vested right.

(c) Within a reasonable time, the staff of the division of water resources shall investigate the information submitted.

(d) Notice.

(1) Written notice of the claim shall be sent by the chief engineer to all water right owners of record in the office of the chief engineer with an authorized point of diversion within one-half mile of the claimed point of diversion.

(2) In addition, one notice in a newspaper with general circulation in the county in which the point of diversion is located shall be published by the chief engineer. Such published notice shall contain:

(A) the name of the claimant;

(B) the location of the claimed point of diversion; and

(C) a declaration that it is a claim for a domestic vested right.

(3) All notices shall be given at least 14 days prior to the close of the record.

(e) A copy of the chief engineer's draft order determining the active domestic vested water right and any comments received in response to the notices shall be furnished to the claimant by the chief engineer or the chief engineer's authorized representative.

(f) The claimant shall be given thirty days from the date the chief engineer mails the draft to the claimant in which to submit additional information, request a hearing concerning the determination, or both.

(g) If a hearing is requested by the claimant in a timely manner, or the chief engineer deems it to be in the public interest to do so, a hearing shall be held by the chief engineer, or the chief engineer's authorized representative, within a reasonable time.

(h) The chief engineer shall issue the order determining whether the claimed active vested domestic right exists and, if so, determining the nature and extent of that right.

(i) The order determining the active vested domestic right shall be made a matter of record in the office of the chief engineer. In addition, a copy of the order shall be furnished to the claimant by the chief engineer, with instructions that it shall be filed with the register of deeds in the county in which the point of diversion is located.

(j) All vested domestic water rights shall be assumed to have a priority of June 28, 1945 until they have been adjudicated by a court of competent jurisdiction. Vested domestic rights shall be administered in accordance with K.A.R. 5-10-5. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-705a; effective Nov. 28, 1994.)

Article 11.—ASSURANCE DISTRICTS

5-11-1. Definitions. As used in these rules and regulations and the water assurance program act by the division of water resources in the administration of the water assurance program act, unless the context clearly requires otherwise, the following words and phrases shall have the meaning ascribed to them in this section.

(a) "Board" means the board of directors of a water assurance district.

(b) "Chief engineer" means the chief engineer of the division of water resources of the Kansas state board of agriculture. (Authorized by K.S.A. 82a-1345(e); implementing K.S.A. 82a-1334; effective May 31, 1994.)

5-11-2. Determination of benefits. (a) A water assurance district member may apply in writing to the board to be removed as a member of the district if that member is no longer receiving benefits from supplementing the stream by assurance reservoir releases because:

(1) the member no longer has a water right or permit; or

(2) the member's water right or permit has been reduced so that the member is no longer receiving benefits.

(b) The board shall forward the request to be removed as a member from the district to the chief engineer, who shall determine whether the member will be receiving benefits. The chief engineer shall forward the results of that determination to the board in writing within a reasonable time.

(1) If the chief engineer determines that the member will continue to receive benefits, the chief engineer shall notify the board and the member's application to be removed shall be dismissed by the board.

(2) If the chief engineer determines that the member will no longer be receiving benefits, the chief engineer shall notify the board and it shall be determined by the board whether the member will be removed from the district and the terms of removal. (Authorized by K.S.A. 82a-1345(e); implementing K.S.A. 82a-1334; effective May 31, 1994.)

Article 12.—AQUIFER STORAGE AND RECOVERY

5-12-1. Aquifer storage and recovery permitting. (a) An operator may store water in an aquifer storage and recovery system under a permit to appropriate water for artificial recharge if the water appropriated is source water. The requirements of article 12 of the rules and regulations adopted by the Kansas department of agriculture, division of water resources are in addition to any requirements of the Kansas department of health and environment concerning underground injection wells, including article 46 of the rules and regulations adopted by the Kansas department of health and environment.

(b) Each application for a permit to appropriate water for artificial recharge shall describe the horizontal and vertical extent of the basin storage area in which the source water will be stored.

(1) The horizontal extent shall be determined by a closed boundary within which the recharge system used to store the water will be physically located. The recharge system may include recharge pits, recharge trenches, recharge wells, or other similar systems that cause source water to enter the storage volume of the basin storage area, either by gravity flow or by injection. The basin storage area may be subdivided into smaller areas representative of the areas that may be recharged by the individual recharge systems.

(2) The vertical extent shall be defined by a minimum and a maximum index water level for the basin recharge storage area, or for each subdivided area within the basin storage area if the basin storage area is subdivided. The minimum index water level shall be the lowest water level within the basin storage area, or smaller subdivided area if the basin storage area is subdivided, that occurred within the 10 years before the filing of the application for a permit to appropriate water, or a period of time longer than 10 years demonstrated by the applicant to reflect the lowest water level. If the basin storage area is subdivided, measurements from the same year shall be used to determine the minimum index water level for each subdivision. The maximum index water level shall represent the maximum storage potential for the basin storage area.

(c) An application for a permit to appropriate water for artificial recharge shall set forth the maximum annual quantity and maximum rate of diversion of source water.

(d) (1) Each application for a permit to appropriate water for artificial recharge shall include a methodology for accounting for water stored in a basin storage area both on an annual basis and on a cumulative basis so that recharge credits can be calculated. If more than one application for a permit to appropriate water for artificial recharge relates to the same aquifer storage and recovery system, each application shall use the same methodology for accounting for water stored in the basin storage area. The accounting of the water balance of all water entering and leaving the basin storage area shall be determined by using sound engineering methods based on actual measurements, generally accepted engineering methodology, or a combination of both.

(2) Approval of any application for a permit to appropriate water for artificial recharge shall be contingent upon the chief engineer's approval of the method for accounting for the basin storage area.

(e) An applicant for recovery of water stored by the holder of a permit to appropriate water for artificial recharge to store water in a basin storage area shall obtain a permit separate from the aquifer storage permit to appropriate water for beneficial use for each well used to recover the water stored. The maximum annual quantity of water that may be appropriated for this purpose shall be

no more than the maximum cumulative recharge credits available to the operator of the aquifer storage and recovery system. These credits shall be determined by the accounting methodology approved under a permit to appropriate water for artificial recharge pertaining to the aquifer storage and recovery system. In determining whether diversion of the annual quantity impairs other water rights, the following data may be considered by the chief engineer:

(1) The maximum storage volume available in the basin storage area;

(2) the spatial distribution of recharge and withdrawal systems;

(3) the maximum rate of diversion at which the water will be withdrawn; and

(4) any other relevant information.

Recharge credits may be accumulated over more than one year, and any amount of recharge credits available may be withdrawn in accordance with the permit if the withdrawal does not impair other water rights.

(f) The approval of application, if the water to be diverted is the water artificially recharged into the basin storage area, shall be conditioned upon the following:

(1) Generally accepted engineering methodology;

(2) a maximum annual quantity that does not exceed the recharge credits; and

(3) an annual reporting that complies with K.A.R. 5-12-2. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-711 and K.S.A. 82a-712; effective Sept. 22, 2000.)

5-12-2. Aquifer storage and recovery accounting. (a) In addition to annual water use reporting requirements pursuant to K.S.A. 82a-732, and amendments thereto, on June 1 of each year the permit holder of an aquifer storage or recovery system shall report an accounting of water in the basin storage area to the chief engineer and to any groundwater management district identified in subsection (c) of this regulation. The annual report for the preceding calendar year shall account for all water entering and leaving the basin storage area and shall specifically compute the amount of recharge credits held in the basin storage area.

(b) The report shall be in the form prescribed by the chief engineer and shall address the items in the water balance for the basin storage area, which may include the following amounts:

(1) Natural and artificial recharge;

(2) groundwater inflow and outflow;

(3) evaporation and transpiration;

(4) groundwater water diversions from all nondomestic wells;

(5) infiltration from streams;

(6) groundwater discharge to streams;

(7) the calculated recharge credits; and

(8) any other information that in the opinion of the chief engineer is pertinent to the basin storage and surrounding areas.

The annual accounting shall specifically take into account the amounts of natural recharge, artificial recharge, groundwater inflow, groundwater outflow, evapotranspiration, and groundwater pumpage. Groundwater pumpage shall include recharge credits withdrawn as well as pumpage from all nondomestic wells in the basin storage area. The annual accounting shall include any additional items within a basin storage area that would be necessary to determine the amount of recharge credit available for recovery.

(c) If any part of the basin storage area is within the boundaries of a groundwater management district, the permit holder of any aquifer storage or recovery system shall furnish a copy of the annual report to the district board for comments by June 1 of each year.

(d) If a groundwater management district receives an annual report, the district may provide comments to the chief engineer if the comments are submitted to the chief engineer within 30 days of the district's receipt of the report identified in subsection (c) of this regulation.

(e) The permit holder may be required by the chief engineer to submit additional information pertinent to the system. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-711 and K.S.A. 82a-712; effective Sept. 22, 2000.)

5-12-3. Hearings. (a) A hearing shall be held by the chief engineer in the general vicinity where an applicant proposes aquifer storage and recovery before approval of any such application for aquifer storage and recovery.

(b) If any part of a proposed basin storage area is within the boundaries of a groundwater management district, the hearing required by subsection (a) of this regulation shall be held within the groundwater management district. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-711 and K.S.A. 82a-712; effective Sept. 22, 2000.)

5-12-4. Aquifer storage and recovery systems in a groundwater management district. A groundwater management district may recommend rules and regulations pertaining to monitoring and accounting requirements for that portion of the basin storage area that falls within the district's boundaries. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-711, K.S.A. 82a-712, and K.S.A. 82a-1028(o); effective Sept. 22, 2000.)

Article 13.—SAND AND GRAVEL PIT OPERATIONS

5-13-1. Notice of intent to open or expand a sand and gravel pit operation. Each operator desiring to open or expand a sand and gravel pit operation shall file a notice of intent to open or expand a sand and gravel pit operation on a form prescribed by the chief engineer before opening or expanding the sand and gravel pit operation.

The following information shall be included on the form:

(a) The legal description of the sand and gravel pit operation;

(b) the date the project began or will begin;

(c) the number of acres of the groundwater table that will be exposed by the project at the time active mining ceases;

(d) a legal description and a map showing the location of the groundwater that will be exposed at the time active mining ceases;

(e) the year the pit excavation is estimated to be completed;

(f) measures that will be used to protect the area groundwater supply from pollution; and

(g) any other pertinent information that may be required by the chief engineer to understand the nature of the proposed project and to ensure that the provisions of K.S.A. 82a-734, and amendments thereto, and any regulations promulgated thereunder, are being complied with. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-721 and K.S.A. 82a-734; effective Sept. 22, 2000.)

5-13-2. Determination of "substantially adverse impact on the area groundwater supply." (a) A sand and gravel operation shall be deemed to cause a "substantially adverse impact on the area groundwater supply," as provided in K.S.A. 82a-734 (b) and amendments thereto, if the sand and gravel pit operation is opened or expanded after the effective date of this regulation in any township that has an average annual potential net evaporation greater than 18 inches per year as determined from K.A.R. 5-6-3.

(b) In any township that has an average annual potential net evaporation of 18 or fewer inches per year, as determined from K.A.R. 5-6-3, the opening or expansion of a sand and gravel pit operation, shall be deemed to not cause a "substantially adverse impact on the area groundwater supply," as provided in K.S.A. 82a-734 and amendments thereto, unless the chief engineer can demonstrate that the project will cause one or more of the following:

(1) A direct impairment to a groundwater approval of application or water right;

(2) an unreasonable deterioration of the groundwater quality;

(3) an unreasonable raising or lowering of the static water level; or

(4) prevention of any waters of the state from moving to a person having a prior right to use these waters. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-721 and K.S.A. 82a-734; effective Sept. 22, 2000.)

5-13-3. Determination of when groundwater evaporation is a beneficial use. On and after the effective date of this regulation, whenever the opening or expansion of a sand and gravel operation is considered to cause a substantially adverse impact on the area groundwater supply pursuant to K.A.R. 5-13-2, the evaporation caused shall be considered to be a beneficial use, and the operator shall be required to receive an approval of application, or approval of an application for change, pursuant to K.S.A. 82a-701 et seq. and amendments thereto, before exposing the groundwater table to evaporation. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-711, K.S.A. 82a-721, and K.S.A. 82a-734; effective Sept. 22, 2000.)

5-13-4. Exemption. (a) To the extent that groundwater evaporation causes a substantially adverse impact to the area groundwater supply pursuant to K.A.R. 5-13-2, a new application to appropriate the groundwater evaporation caused by the project shall be exempt from meeting the safe yield, allowable appropriation, or similar types of regulations adopted by the chief engineer. This exemption shall be granted if the operator meets all of the criteria in subsection (b) because exempting the quantity of water that has been, or will be, evaporated by exposing the

groundwater table beneath the proven reserves will not prejudicially and unreasonably affect the public interest and will not impair any existing water right.

(b) Except as set forth in subsection (e), in order to qualify for this exemption, the operator shall show that on December 31, 1999, all of the following conditions were met:

(1) The operator had an active, existing sand and gravel mining operation.

(2) If required, the operator had a valid surface-mining license issued pursuant to the surface-mining land conservation and reclamation act, K.S.A. 49-601 et seq., and amendments thereto.

(3) If required, the operator had made a timely application for a hydraulic dredging permit or had received a hydraulic dredging permit issued pursuant to the Kansas water appropriation act.

(4) The operator had filed the water use reports required by, and paid any civil fines assessed by the chief engineer pursuant to K.S.A. 82a-732, and amendments thereto.

(5) The operator had paid the water protection fees required by K.S.A. 82a-954, and amendments thereto.

(6) To the extent necessary to physically operate, the operator had acquired all local permits and local zoning approvals.

(7) The operator had purchased, leased, or otherwise acquired legal control over proven sand and gravel reserves.

(8) The operator had filed an application to appropriate water or filed a notice of intent to open or expand a sand and gravel pit operation with the chief engineer when required by K.S.A. 82a-734(a), and amendments thereto.

(c) It shall be the burden of the operator to show that the operator meets the requirements of subsection (b) by filing the necessary information or documentation with the chief engineer on or before December 31, 2001. An extension of time may be granted by the chief engineer for good cause if the request for extension of time is filed by the operator with the chief engineer before December 31, 2001.

(d) To the extent that the operator meets the requirements of subsection (b) above, an application to appropriate water for evaporation of the groundwater caused by exposing the groundwater table shall be exempt from complying with safe yield, allowable appropriation, and similar types of regulations adopted by the chief engineer. This exemption shall apply to all the evaporation caused by exposing the groundwater table up to the areal extent of the proven reserves that existed on December 31, 1999.

(e) If, on the effective date of this regulation, an operator was in the process of establishing a replacement operation for an active, existing sand and gravel pit operation, an exemption shall be allowed by the chief engineer for the proposed replacement operation according to subsection (d) on terms, conditions and limitations that will neither cause impairment of existing water rights nor prejudicially and unreasonably affect the public interest if all of the following criteria are met:

(1) The proposed replacement sand and gravel operation is located outside the boundaries of all groundwater management districts and intensive groundwater use control areas.

(2) The geocenter of the proposed replacement operation is located within two miles of the geocenter of the existing, active operation.

(3) The proposed replacement operation met the provisions of paragraphs (b)(1) through (b)(6) of this regulation on December 31, 1999.

(4) The proposed replacement project meets the requirements of paragraphs (b) (7) and (8) on the effective date of this regulation. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-721, K.S.A. 1999 Supp. 82a-1904, and K.S.A. 82a-734; effective Sept. 22, 2000.)

5-13-5. Approval of pit operations that are opened or expanded after the effective date of this regulation. Except as set forth in K.A.R. 5-13-4, pit operations that are excavated or expanded after the effective date of this regulation and that have a substantial adverse impact on the area groundwater supply shall meet one of the following conditions:

(a) Receive prior approval of the chief engineer for a new permit to appropriate an annual quantity of water sufficient to offset the evaporation caused by exposing the groundwater table in a manner described in K.A.R. 5-13-7;

(b) acquire existing water rights and receive approval of the chief engineer to change the point of diversion, place of use, and the use made of water to authorize the water rights to be used for the project in a manner described in K.A.R. 5-13-7;

(c) acquire and take out of production sufficient water rights in the manner described in K.A.R. 5-13-7 to offset the net average annual evaporation caused by exposing the groundwater table; or

(d) any combination of the above. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-721 and K.S.A. 82a-734; effective Sept. 22, 2000.)

5-13-6. Determination of the maximum rate of diversion and annual quantity of water. The annual quantity of water, in acre-feet, required to be appropriated for evaporation caused by exposing the area groundwater table shall be determined by multiplying the exposed groundwater surface area of the project in acres by the potential net evaporation in inches, for Kansas, as found in K.A.R. 5-6-3, and dividing by 12. The rate of diversion shall be the natural rate of evaporation. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-721 and K.S.A. 82a-734; effective Sept. 22, 2000.)

5-13-7. Offsets for evaporation of groundwater. The net average annual quantity of groundwater evaporation shall be authorized, accounted for, or offset in one or more of the following ways:

(a) An approval of application or water right currently authorizes the use of water at that pit location.

(b) A new approval of application authorizes the use of water at that pit location.

(c) Acceptable quality surface water that is legally and physically available for groundwater recharge is authorized to be diverted into the proposed project.

(d) Both of the following conditions are met:

(1) Water is made available by acquiring all, or a portion of, an existing water right to any of the following:

(A) Use surface water or groundwater, or both, that is hydraulically connected to a stream channel aquifer in which the project is located;

(B) use groundwater from an unconsolidated regional aquifer that is within a two-mile radius of the geocenter of the project that is the same unconsolidated regional aquifer in which the project is located, or a hydraulically connected aquifer; or

(C) use groundwater from an unconsolidated regional aquifer that is within a 3.5 mile radius of the geocenter of the project and is the same unconsolidated regional aquifer in which the project is located, or a hydraulically connected aquifer, if the operator can demonstrate to the chief engineer that sufficient water rights to offset the evaporation caused by the project cannot be acquired within a two-mile radius of the geocenter of the project after making reasonable and prudent efforts to find both proven reserves and water rights.

(2) The applicant demonstrates to the chief engineer that the acquired water right, or portion of it, will no longer be exercised by any of the following:

(A) Placing it in the custodial care of the state;

(B) placing it in a perpetual trust approved by the chief engineer; or

(C) restricting its future use in some other way that the chief engineer determines to be adequate to ensure that it will no longer be exercised.

(e) Diffused surface water is diverted into the project from inside a berm surrounding the project built to prevent unacceptable quality surface water from entering the groundwater table. The average annual amount of runoff shall be determined from a map titled "figure 12. — mean annual runoff in Kansas," dated June 1982, published by the Kansas water office and hereby adopted by reference, unless the applicant demonstrates to the chief engineer, or the chief engineer has, better, more site-specific data.

(f) Any other water credit or offset that the chief engineer determines will adequately offset the groundwater evaporation caused by the pit operation. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-721 and K.S.A. 82a-734; effective Sept. 22, 2000.)

5-13-8. Offset calculations. All of the following requirements shall apply with respect to an offset water right described in K.A.R. 5-13-7(d): (a) No physical diversion of the offset water right shall be required or allowed.

(b) The project shall receive credit for 100 percent of the net consumptive use of the water right used as an offset.

(c) Credit for acquisition of an existing surface water right shall be given for an equivalent quantity of water that is legally and physically available within the terms, conditions, and limitations of the surface water right at the location of the groundwater pit. The quantity of water available at the groundwater pit from the acquired surface water right shall be calculated by taking into account the following:

(1) Stream gains;

(2) stream losses;

(3) transit losses;

(4) water supplied from intervening tributaries; and

(5) water needed to satisfy senior surface water rights to the same source of supply.

(d) Credit for acquisition of a groundwater right with a point of diversion located in the same stream channel aquifer as the groundwater pit shall be given for either of the following:

(1) A groundwater right located within a two-mile radius of the groundwater pit; or

(2) a groundwater right in the same source of water supply with a point of diversion located more than two miles up gradient of the geocenter of the groundwater pit for the quantity of water legally and physically available under that groundwater right at its original point of diversion, minus the transit loss between the original groundwater point of diversion and the geocenter of the proposed pit. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-721 and K.S.A. 82a-734; effective Sept. 22, 2000.)

5-13-9. Easements and covenants. The applicant shall provide any easements or covenants, attached to or running with the land, that are necessary to document that the offset water acquired pursuant to K.A.R. 5-13-7 will continue to be legally available to offset the evaporation of groundwater. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-721 and K.S.A. 82a-734; effective Sept. 22, 2000.)

5-13-10. Time to construct the diversion works for a sand and gravel pit operation. (a) As used in this regulation, "completion of diversion works" means that both of the following have occurred:

(1) All equipment necessary to begin to operate a sand and gravel operation, including the hydraulic dredge, has been installed.

(2) Sufficient overburden has been excavated to begin to expose the groundwater to evaporation.

(b) A reasonable time to construct the diversion works for a sand and gravel pit operation shall be not less than one full year following the approval of the application to appropriate water.

(c) For good cause shown by the applicant, a reasonable extension of time to construct the diversion works shall be allowed by the chief engineer if both of the following conditions are met:

(1) The request for extension is filed pursuant to the requirements of K.A.R. 5-3-7.

(2) The request for extension is accompanied by the statutorily required filing fee. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-712 and 82a-713; effective Sept. 22, 2000.)

5-13-11. Time to perfect a water right for evaporation of groundwater. (a) A reasonable time to perfect a water right for evaporation of groundwater caused by a sand and gravel pit operation shall be neither less than five calendar years plus the remainder of the calendar year in which the application was approved, nor more than 20 years plus the remainder of the calendar year in which the application was approved.

(b)(1) For good cause shown by the applicant, a reasonable extension of the time to perfect the water right shall be allowed by the chief engineer if both of the following conditions are met:

(A) The request is timely filed pursuant to the terms of K.A.R. 5-3-7.

(B) The request is accompanied by the statutorily required filing fee.

(2) The total time to perfect a water right shall not exceed 40 years. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-713; effective Sept. 22, 2000.)

Article 14.—ENFORCEMENT AND APPEALS

5-14-1. Enforcement. (a) Except as set forth in subsection (i), the procedure set forth below shall be followed whenever enforcement action is taken by the chief engineer after becoming aware that a person may be performing any of the following:

(1) Violating any provision of K.S.A. 82a-701 et seq., and amendments thereto;

(2) violating any provision of a regulation adopted pursuant to that act; or

(3) violating a term, condition, or limitation of an approval of application or water right.

(b) The alleged violation shall be investigated by the chief engineer.

(c) A written report of the investigation shall be prepared by the chief engineer. This report shall include any documents regarding the matter that were relied upon or prepared by the chief engineer. This report shall be made a part of the official record of the chief engineer. If an approval of application or a water right is involved, the report shall be made an official part of that file.

(d)(1) If the investigation shows that no violation has occurred or that enforcement action is not warranted, no further enforcement action shall be taken at that time.

(2) If the investigation determines that a violation has occurred, an order shall be issued by the

chief engineer. The owner or owners of the approval of application or water right, as shown in the records of the chief engineer, shall be served by delivering a copy in person or sending a copy of the order by restricted mail. The order shall specify the following:

(A) What the violation is;

(B) what actions are necessary to correct the violation;

(C) what a reasonable time is in order to correct the violation. Extensions of time to correct a violation may be granted by the chief engineer if good cause is shown by the violator or owner;

(D) that the order will become effective immediately; and

(E) that a hearing may be requested within 15 days of the issuance of the order. The request for a hearing may include a request for a stay of the order. If the person shows good cause why a stay should be granted, a stay may be granted by the chief engineer.

(e) If the violation is corrected within the time specified by the chief engineer, the violator shall notify the chief engineer. An inspection shall be conducted by the chief engineer to determine if the violation has been corrected. If the violation has been corrected, the diversion of water may continue within the terms, conditions, and limitations of the approval of application or water right.

(f) If the violation is not corrected within the time specified by the chief engineer, an order requiring that unauthorized or illegal diversion of water cease until the violation is corrected shall be issued by the chief engineer.

(g) If the violator ceases diversion of water and then corrects the violation, the violator shall notify the chief engineer when the violation is corrected. The diversion works and the authorized place of use, as appropriate, shall be inspected by the chief engineer to determine if the violation has been corrected. If the chief engineer determines that the violation has been corrected, the order prohibiting diversion of water shall be rescinded by the chief engineer as soon as possible. When the owner or violator receives notice from the chief engineer that the order prohibiting the diversion of water has been rescinded, the diversion of water may recommence.

(h) (1) Any of the actions listed in paragraph (h) (2) may be taken by the chief engineer if the violator performs any of the following acts and fails to cease the diversion of water as ordered by the chief engineer:

(A) Violates any provision of K.S.A. 82a-701 et seq., and amendments thereto;

(B) violates any provision of a regulation adopted pursuant to that act; or

(C) violates a term, condition, or limitation of an approval of application or a water right.

(2) If the violator performs any act listed in paragraph (h)(1), any of the following actions may be taken by the chief engineer:

(A) Bring an action to enforce the orders of the chief engineer pursuant to the act for judicial review and civil enforcement of agency actions, K.S.A. 77-624 et seq., and amendments thereto;

(B) request the attorney general to bring an action in the name of the state of Kansas;

(C) request that criminal proceedings be brought pursuant to K.S.A. 82a-728, and amendments thereto;

(D) enter into a consent order with the violator specifying the remedial actions that shall be taken by the violator;

(E) take any other legally permissible enforcement action; or

(F) any combination of the above actions.

(i) The provisions of this regulation shall not apply to any actions taken by the chief engineer pursuant to K.S.A. 82a-706b, and amendments thereto, to enforce water right priorities and to prevent direct impairment by either of the following:

(1) Junior water rights; or

(2) illegal diversions of water.

(j) After the violator has been issued an order as specified in subsection (f), the violator may request an administrative hearing before the chief engineer in accordance with the provisions of K.A.R. 5-14-2. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706, 82a-706b, 82a-706d, and 82a-728; effective Sept. 22, 2000.)

5-14-2. Request for conference hearing. (a) Each written request for a hearing of an order issued by the chief engineer according to K.A.R. 5-14-1 shall be served on the chief engineer within 15 days of the issuance of the order. The request for a hearing may include a request for a stay of the order. If the requester demonstrates good cause for a stay to the chief engineer, a stay of the order may be granted by the chief engineer.

(b) If a request for a hearing is not served on the chief engineer within 15 days after the order

is issued by the chief engineer, the order shall become a final agency action as defined by K.S.A. 77-607, and amendments thereto.

(c) If a request for a hearing is filed with the chief engineer within 15 days of the issuance of an order, a conference adjudicative hearing shall be held by the chief engineer.

(d) A conference hearing shall be an informal proceeding conducted according to the following criteria:

(1) The hearing officer shall regulate the course of a conference proceeding.

(2) Only parties may testify and present written exhibits.

(3) Only parties may offer comments on the issues.

(4) The hearing officer may conduct all or part of the hearing by telephone, or other electronic means, if each participant in the hearing has the opportunity to participate in the entire proceeding while it is taking place.

(5) The hearing shall be recorded at the agency's expense.

(6) Any party, at the party's expense and subject to any reasonable conditions that the chief engineer may establish, may cause a person other than the chief engineer to prepare a transcript from the chief engineer's recording or cause additional recordings to be made during the hearing.

(e) After the conference adjudicative hearing, or completion of a full adjudicative hearing if the conference hearing was converted to a full hearing, a final agency action, as defined by K.S.A. 77-607, and amendments thereto, shall be issued by the chief engineer. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706 and K.S.A. 82a-706b; effective Sept. 22, 2000.)

5-14-3. Administrative appeal to the secretary of agriculture. (a) Except as set forth in subsection (f), a summary order shall be issued by the chief engineer in accordance with the provisions of K.S.A. 77-537 through 77-542, and amendments thereto, for the following types of actions:

(1) Approval or rejection of an application to change the place of use, the point of diversion, the use made of water, or any combination, filed pursuant to K.S.A. 82a-708b, and amendments thereto;

(2) approval of an application as filed, approval of a smaller maximum annual quantity of water than requested, approval with conditions necessary to protect the public interest, or disapproval of an application to appropriate water for beneficial use filed pursuant to K.S.A. 82a-711, and amendments thereto; and

(3) abandonment and termination of a water right pursuant to K.S.A. 82a-718, and amendments thereto.

(b) If a request for a hearing is not filed with the chief engineer within 15 days after issuance of the summary order by the chief engineer, the order shall become final.

(c) If a request for a hearing is filed with the chief engineer within 15 days, a conference adjudicative hearing shall be held by the chief engineer in accordance with the provisions of K.S.A. 77-533 through K.S.A. 77-535, and amendments thereto.

(d) After the conference adjudicative hearing, an initial order shall be issued by the chief engineer in accordance with the provisions of K.S.A. 77-526, and amendments thereto.

(e) A petition for review of the initial order shall be filed with the secretary of agriculture in accordance with the provisions of K.S.A. 77-527, and amendments thereto, within 15 days of the issuance of the initial order by the chief engineer.

(f) A hearing may be held by the chief engineer in accordance with K.A.R. 5-3-4a before processing a new application to appropriate water if the chief engineer determines that one of the following conditions exists:

(1) It is in the public interest.

(2) A person demonstrates to the chief engineer that approval of the application may cause impairment of senior approvals of applications or water rights.

If the chief engineer holds a hearing before processing a new application to appropriate water, an initial order shall be issued by the chief engineer. A petition for review of the initial order shall be filed in accordance with the provisions of subsection (e) of this regulation. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-708b, K.S.A. 82a-709, K.S.A. 1999 Supp. 82a-711, K.S.A. 1999 Supp. 82a-718, K.S.A. 1999 Supp. 82a-1038, and K.S.A. 1999 Supp. 82a-1901; effective Sept. 22, 2000.)

5-14-4. Appeal of the failure of the chief engineer to timely issue a certificate of appropriation. (a) The time period specified in K.S.A. 82a-714(c), and amendments thereto, shall begin when the time authorized to perfect the wa-

ter right, including any authorized extensions of time, expires.

(b) If the chief engineer fails to issue a certificate of appropriation within the time limit specified by K.S.A. 82a-714(c) and amendments thereto, the water right owner may file a request for review with the secretary of agriculture pursuant to K.S.A. 82a-1901, and amendments thereto, within 15 days of the expiration of the time period specified in K.S.A. 82a-714(c) and amendments thereto. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-714 and K.S.A. 1999 Supp. 82a-1901; effective Sept. 22, 2000.)

5-14-5. Conditions of a request for a conference hearing. (a) Any request for a conference hearing before the chief engineer shall meet the following conditions:

(1) Be in writing and be served on the chief engineer within 15 days of the issuance of the summary order;

(2) clearly admit, deny, or explain each of the findings of facts and conclusions of law in the summary order;

(3) identify any facts and conclusions of law that the person disputes and intends to place at issue; and

(4) state any other defenses and the bases for those defenses.

(b) If the person states that the person has no knowledge of a particular factual allegation, that allegation shall be deemed denied in the request. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706 and K.S.A. 82a-706b; effective Sept. 22, 2000.)

5-14-6. Informal settlement. At any time during the proceedings conducted under K.A.R. 5-14-2, K.A.R. 5-14-3, or K.A.R. 5-14-4, the alleged violator may request a settlement conference. The request shall be in writing and shall be served on the chief engineer on behalf of the alleged violator. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 1999 Supp. 82a-1901; effective Sept. 22, 2000.)

5-14-7. Conversion of a conference hearing. (a) At any point during a conference hearing being conducted according to K.A.R. 5-14-2, the conference hearing may be converted by the chief engineer to a full adjudicative hearing to be heard by the chief engineer.

(b) The conversion of a conference hearing to a full adjudicative hearing may be effected only upon providing notice to all parties to the original proceedings.

(c) The record of the conference hearing may be used in the full adjudicative hearing.

(d) After a conference hearing is converted to a full adjudicative hearing, the hearing officer shall perform the following:

(1) Give any additional notice to parties or other persons necessary to satisfy the requirements of a full adjudicative hearing; and

(2) conduct any additional proceedings necessary to satisfy the requirements of a full adjudicative hearing.

(e) If the conference hearing is converted to a full adjudicative hearing, the full adjudicative hearing shall be conducted according to the following criteria:

(1) The hearing officer shall regulate the course of the proceedings.

(2) The parties may testify and present exhibits.

(3) The hearing officer may allow nonparties an opportunity to present oral or written statements and exhibits.

(4) All testimony shall be given under oath.

(5) To the extent necessary for full disclosure of all relevant facts and issues, the hearing officer shall afford to all parties the opportunity to respond, present evidence and arguments, conduct cross-examination, and submit rebuttal evidence.

(6) The hearing officer may conduct all or part of the hearing by telephone or other electronic means, if each party in the hearing has an opportunity to participate in the entire proceeding while it is taking place.

(7) The hearing shall be recorded at the agency's expense.

(8) Any party, at that party's expense and subject to any reasonable conditions that the state agency may establish, may cause a person other than the state agency to prepare a transcript from the state agency's recording or cause additional recordings to be made during the hearing. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706 and 82a-706b; effective Sept. 22, 2000.)

5-14-10. Civil penalties; suspension or modification of water rights. (a) In addition to any other authorized enforcement procedures, if the chief engineer finds that any of the violations specified in K.S.A. 82a-737, and amendments thereto, have occurred, a written order shall be issued by the chief engineer stating the following:

(1) The nature of the violation;

(2) the factual basis for the violation;

(3) the civil penalty, suspension, modification of a water right or use of water, or any combination of these, to be imposed; and

(4) the appropriate procedure for appeal pursuant to K.S.A. 82a-1901, and amendments thereto.

(b) The categories of offenses specified in subsections (c), (d), and (e) shall be applied when assessing the civil penalty for each violation. Each day on which the violation continues to occur may constitute a separate offense.

(c)(1) Each category 1 offense shall result in a civil penalty of $100.

(2) Category 1 offenses shall include the following:

(A) A threat to divert water without authorization from the chief engineer;

(B) irrigating an unauthorized place of use that is 10 acres or less;

(C) diversion of water at a rate in excess of the authorized rate of diversion, but less than 115 percent of the authorized rate of diversion;

(D) maintaining a water flowmeter or other water-measuring device required by the chief engineer that is out of compliance as specified by K.A.R. 5-1-9; and

(E) violation of any other condition on a water right or approval of application not specified anywhere else in this regulation.

(d)(1) Each category 2 offense shall result in a civil penalty of $500.

(2) Category 2 offenses shall include the following:

(A) Diverting water from an unauthorized point of diversion of water;

(B) irrigating an unauthorized place of use that is more than 10 acres;

(C) failure to properly implement a conservation plan required by the chief engineer;

(D) committing a waste of water;

(E) diversion of water at a rate that equals or exceeds 115 percent of the authorized rate of diversion;

(F) failure to install a water flowmeter or other acceptable water-measuring device;

(G) failure to promptly provide complete and accurate water use or other data, information, or records requested by the chief engineer, except the annual water use reports required by K.S.A. 82a-732, and amendments thereto;

(H) diversion of water in excess of the authorized quantity of water; and

(I) applying water to an unauthorized type of beneficial use.

(e)(1) Each category 3 offense shall result in a civil penalty of $1,000.

(2) Category 3 offenses shall include the following:

(A) Tampering with a water flowmeter or other acceptable water-measuring device;

(B) causing a water flowmeter or other acceptable water-measuring device to show an incorrect reading by any method, including any of the following:

(i) Altering the propeller;

(ii) reversing the water flowmeter; or

(iii) running the water flowmeter in reverse by any means;

(C) failing to timely install or removing a required water flowmeter or other acceptable water-measuring device;

(D) falsifying water use or other data required by the chief engineer;

(E) denying authorized personnel of the chief engineer access as required by K.S.A. 82a-706b, and amendments thereto;

(F) violating a cease and desist order issued by the chief engineer; and

(G) violating an order of the chief engineer issued pursuant to K.S.A. 82a-706b and amendments thereto.

(f) The civil penalties specified in paragraph (c)(1) may be increased if the chief engineer finds that aggravating circumstances exist. The civil penalties specified in paragraph (d)(1) may be increased or decreased if the chief engineer finds that aggravating or extenuating circumstances exist. The civil penalties specified in paragraph (e)(1) may be decreased if the chief engineer finds that extenuating circumstances exist. Extenuating circumstances and aggravating circumstances shall include the following:

(1) Prior violations;

(2) intentional noncompliance or gross negligence; and

(3) failure to correct the violation upon discovery or notification by the chief engineer.

(g) In addition to the assessment of a civil penalty or any other penalty provided for by law, any water right may be modified or suspended by the chief engineer upon the issuance of a written order finding a violation as established in subsection (a). Except as otherwise specified by regulation,

violation of either a multiyear annual allocation or a condition limiting the net acres that may be irrigated in any one calendar year pursuant to an approval to allow annual rotation of the authorized place of use for irrigation shall result in the following:

(1) A two-year suspension of all water use authorized by the water right, any term permit, and any water right upon which the multiyear allocation or rotation was based;

(2) a subsequent restriction of the authorized place of use to the base acreage at a location specifically set forth in the change approval; and

(3) after any suspension has expired, a reversion to all conditions in effect on the water right before approval of the change application authorizing the multiyear allocation or rotation.

In all other cases, the term of the suspension or modification shall be determined by the chief engineer based upon the circumstances set forth in subsection (f).

(h) Any person aggrieved by an order of the chief engineer may request a review pursuant to K.S.A. 82a-1901, and amendments thereto, and after exhaustion of administrative remedies, may appeal to the district court in the manner provided by the act for judicial review and civil enforcement of agency actions. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a, K.S.A. 2002 Supp. 82a-737, and K.S.A. 2002 Supp. 82a-1901; effective Oct. 24, 2003.)

5-14-11. Civil fines; water use reporting. (a) Each owner of a water right or approval of application who fails to perform either of the following shall be assessed a civil penalty of $250 for each water right or approval of application that is not timely filed or that is materially incomplete or inaccurate:

(1) Timely submit an annual water use report pursuant to K.S.A. 82a-732, and amendments thereto; or

(2) submit a complete and accurate water use report as required by K.S.A. 82a-732, and amendments thereto.

(b) If the owner submits both the complete and accurate water use report and payment of the civil penalty after March 1 but before June 1, the civil penalty per water right or approval of application shall be reduced to $50 for each water right or approval of application. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 82a-732; effective Oct. 24, 2003.)

Article 15.—MINIMUM DESIRABLE STREAMFLOWS

5-15-1. Administration of minimum desirable streamflow. (a) Except as specified in subsection (d), if the streamflow at a minimum desirable streamflow (MDS) gaging station falls below the streamflow established in K.S.A. 82a-703c, and amendments thereto, for a period of seven consecutive days, a determination of whether the following conditions have been met shall be made by the chief engineer:

(1) The actual daily average streamflow at the gage has been less than the streamflow trigger value set by K.A.R. 5-15-4.

(2) If an alluvial aquifer has a significant effect on streamflow, the static groundwater level in the alluvial aquifer above the gage is insufficient to maintain MDS in the stream.

(b) Whenever the chief engineer determines that MDS administration should occur according to subsection (d) or because the conditions specified in paragraphs (a)(1) and (2) have both been met, water rights and approvals of applications with a priority after April 12, 1984 shall be administered in order of priority as necessary to protect the appropriate minimum desirable streamflow specified in K.S.A. 82a-703c, and amendments thereto. Owners of record in the office of the chief engineer of water rights and approvals of applications that are being administered shall be notified by the chief engineer that water rights and approvals of applications are being administered to protect MDS. This notification shall be made by certified mail, personal notice, or other verifiable means.

(c) After administration to protect MDS has begun, no person that has received notice according to subsection (b) may divert water under the authority of a water right or approval of application with a priority after April 12, 1984, unless one of the following conditions is met:

(1) The owner of the water right or approval of application has entered into an annual MDS consent order with the chief engineer in accordance with the provisions of K.A.R. 5-15-2 and is diverting water in accordance with the terms of that MDS consent order.

(2) The chief engineer has determined, in accordance with the provisions of K.A.R. 5-15-3, that administration of water rights and approvals of applications with a priority after April 12, 1984 is no longer necessary to protect MDS and has notified the owners by certified mail, personal notice, or other verifiable means that diversions may continue in accordance with the terms, conditions, and limitations of the water right or approval of application.

(d) If the streamflow at an MDS gaging station falls below the level established in K.S.A. 82a-703c, and amendments thereto, for a period of seven consecutive days and no streamflow trigger value has been set for an MDS gaging station in K.A.R. 5-15-4, a determination of whether and when MDS administration will begin and how it should occur shall be made by the chief engineer, based on the following factors:

(1) The general hydrologic conditions affecting streamflow in the stream reach;

(2) the magnitude and duration of recent streamflows;

(3) the extent to which groundwater contributes to streamflow;

(4) the effects of drought on streamflow;

(5) the existence and effect of relevant water management agreements;

(6) the magnitude of the effect that the administration of water rights with priorities junior to the MDS values would have on the streamflow; and

(7) the effect of reservoir operations.

This regulation shall be effective on and after August 27, 2002. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-703a, 82a-703b, and 82a-703c; effective, T-5-4-29-02, April 29, 2002; effective Aug. 27, 2002.)

5-15-2. Minimum desirable streamflow consent orders. (a) An annual minimum desirable streamflow (MDS) consent order according to K.A.R. 5-15-1(c)(1) may be entered into by the chief engineer and the owner of the water right or approval of application to divert surface water. This consent order shall contain the following provisions:

(1) Whenever the chief engineer has determined that the administration of water rights and approvals of applications to divert surface water with a priority after April 12, 1984 is necessary to protect the minimum desirable streamflow set by K.S.A. 82a-703c, and amendments thereto, water shall not be diverted under the authority of these water rights or approval of applications unless the owner has been notified by the chief engineer by certified mail, personal notice, or other verifiable means that either of the following conditions has been met:

(A)(i) The chief engineer has determined that the average daily streamflow has been, or is likely to be, at or above the temporary surface water diversion threshold for a period of time specified in K.A.R. 5-15-4 or set by the chief engineer according to K.A.R. 5-15-1(d); and

(ii) the chief engineer has determined that water is available to be diverted during that time period under the priority of water rights or approval of applications with a priority after April 12, 1984 without impairing senior water rights or senior water reservation rights.

(B) The chief engineer has determined that it is no longer necessary to administer water rights and approval of applications to protect the minimum desirable streamflow set by K.S.A. 82a-703c, and amendments thereto.

(2) The owner of the water right or approval of application shall properly install and maintain a water flowmeter on all points of diversion authorized by the water rights or approval of applications in accordance with regulations adopted by the chief engineer.

(3) The water right owner agrees that failure to abide by either of the following will result in the suspension of the water right or approval of application pursuant to K.S.A. 82a-737, and amendments thereto, for the remainder of the calendar year, and any other enforcement actions that may be authorized by law:

(A) The terms of the MDS consent order; or

(B) the terms, conditions, and limitations of the water right or approval of application.

(4) The water right owner agrees to comply with any other provisions that the chief engineer determines are necessary to prevent impairment, protect MDS values, and protect the public interest.

(b) If the chief engineer determines that hydrologic conditions indicate that some groundwater will be available to be pumped in the basin during the next water-use season or year by water rights or approval of applications with a priority after April 12, 1984, the owner of the water right or approval of application may enter into an an-

nual MDS consent order pursuant to K.A.R. 5-15-1(c)(1) to divert groundwater, upon approval of the chief engineer. This consent order shall contain the following provisions:

(1) Whenever the chief engineer has determined that the administration of water rights and approval of applications to divert groundwater with a priority after April 12, 1984 is necessary to protect minimum desirable streamflows set by K.S.A. 82a-703c, and amendments thereto, groundwater shall not be diverted under the authority of the water right or approval of application unless the owner has been notified by the chief engineer by certified mail, personal notice, or other verifiable means that one of the following conditions has been met:

(A) During MDS administration during that calendar year, the owner is authorized to divert, pursuant to the owner's water right or approval of application, a quantity of water not to exceed that quantity of water set forth in K.A.R. 5-15-4 as the well pumping allowance.

(B) The chief engineer has determined that it is no longer necessary to administer water rights and approvals of applications to protect the minimum desirable streamflows set by K.S.A. 82a-703c, and amendments thereto.

(2) The owner of the water right or approval of application shall properly install and maintain a water flowmeter on all points of diversion authorized by the water right or approval of application in accordance with regulations adopted by the chief engineer.

(3) The total quantity of water authorized to be diverted under the water right or approval of application during a calendar year shall not exceed the annual quantity of water authorized.

(4) The water right owner agrees that failure to abide by either of the following will result in the suspension of the water right or approval of application for the remainder of the calendar year, and any other enforcement actions that may be authorized by law:

(A) The terms of the MDS consent order; or

(B) the terms, conditions, and limitations of the water right or approval of application.

(5) The water right owner agrees to comply with any other provisions that the chief engineer determines are necessary to prevent impairment, protect MDS values, and protect the public interest.

This regulation shall be effective on and after August 27, 2002. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-703a, 82a-703b, and 82a-703c, and K.S.A. 2001 Supp. 82a-737; effective, T-5-4-29-02, April 29, 2002; effective Aug. 27, 2002.)

5-15-3. Cessation of minimum desirable streamflow administration. (a) Except as specified in subsection (c), whenever the chief engineer determines that both of the conditions specified in subsection (b) have been met, the administration of water rights and approvals of applications with a priority after April 12, 1984 to protect minimum desirable streamflows pursuant to K.S.A. 82a-703c, and amendments thereto, shall be declared by the chief engineer to be no longer necessary. The owners of those water rights and approvals of applications shall be notified by the chief engineer by certified mail, personal notice, or other verifiable means that the owners may recommence diverting water in accordance with the terms, conditions, and limitations of their water rights or approvals of applications.

(b)(1) The streamflows at the minimum desirable streamflow (MDS) gage have exceeded the streamflows established by K.S.A. 82a-703c, and amendments thereto, for a period of 14 consecutive days.

(2) If a significant alluvial aquifer exists, the average static water level in the alluvial aquifer has recovered sufficiently to maintain MDS in the stream.

(c) Whenever the chief engineer determines that hydrologic conditions indicate that MDS values have been met or exceeded and are likely to be maintained for the foreseeable future, MDS administration may be declared by the chief engineer to be no longer necessary even if both of the conditions of subsection (b) have not been met.

This regulation shall be effective on and after August 27, 2002. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-703a, 82a-703b, and 82a-703c; effective, T-5-4-29-02, April 29, 2002; effective Aug. 27, 2002.)

5-15-4. Standards for minimum desirable streamflow. The streamflow trigger values, temporary surface water diversion thresholds, and well pumping allowances set forth in the following table shall be used whenever appropriate in these regulations.

MDS gaging station	streamflow trigger value	temporary surface water diversion threshold	well pumping allowance
Republican River Concordia	150 percent of the daily average MDS value* for the 60 preceding days	115 percent of MDS value* for a period of at least five days	32 percent of the maximum annual quantity of water that has not been diverted under the authority of that water right or approval of application, at the time MDS administration begins
Republican River Clay Center	150 percent of the daily average MDS value* for the 60 preceding days	100 percent of MDS value* for a period of at least five days	32 percent of the maximum annual quantity of water that has not been diverted under the authority of that water right or approval of application, at the time MDS administration begins

* "MDS value" means the minimum desirable streamflow value established by K.S.A. 82a-703c, and amendments thereto.

This regulation shall be effective on and after August 27, 2002. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-703a, 82a-703b, and 82a-703c; effective, T-5-4-29-02, April 29, 2002; effective Aug. 27, 2002.)

Article 16.—FLEX ACCOUNT

5-16-1. Definitions. As used in this article of regulations, in the Kansas water appropriation act, and by the chief engineer in the administration of the Kansas water appropriation act, unless the context clearly requires otherwise, the following words and phrases shall have the meanings ascribed to them in this regulation. (a) "Base amount" and "BA" mean the quantity of water deposited in a flex account.

(b) "Base average usage factor" and "BAUF" mean the percentage of the "base average usage," as this term is defined in K.S.A. 82a-736 and amendments thereto, that is multiplied by five as a part of the calculations set out by K.A.R. 5-16-5 to determine the quantity of water that may be deposited into a flex account. The BAUF shall not exceed the maximum of 90% established by K.S.A. 82a-736 and amendments thereto.

(c) "Base water right" means a vested or certified water right or rights for which the owner applies to the chief engineer to establish a flex account pursuant to K.S.A. 82a-736, and amendments thereto.

(d) "BAU" means the "base average usage" as defined in K.S.A. 82a-736, and amendments thereto.

(e) "Good standing," only as that term is used in K.S.A. 82a-736, and amendments thereto, in reference to base water rights, means a base water right that meets the following conditions:

(1) Has been lawfully exercised within the 11-year time period specified in K.A.R. 5-16-5;

(2) has had all required water use reports filed and any civil fines assessed for failure to timely file a complete and accurate water use report paid; and

(3) has had no period of nonuse with a duration of five or more consecutive years since January 1, 1990, except for enrollment in the water right conservation program according to K.A.R. 5-7-4, enrollment in the federal conservation reserve program, or enrollment in another multiyear federal or state conservation program.

(f) "Significant water conservation measures" means actual physical changes in a water distribution system or management practices that improve water use efficiency, including the following:

(1) Conversion from flood irrigation to center pivot irrigation with a nozzle package designed to improve water use efficiency;

(2) irrigation scheduling;

(3) conversion to subsurface drip irrigation; and

(4) removal of an end gun, resulting in a significant reduction in the number of irrigated acres. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 2004 Supp. 82a-736, as amended by L. 2005, ch. 142, sec. 3; effective Oct. 11, 2002; amended Jan. 6, 2006.)

5-16-2. Fee to establish flex account and apply for term permit. The filing fee for establishing a flex account and applying for a five-year term permit to exercise the flex account shall be $400. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 2001 Supp. 82a-708a(d), as amended by L. 2002, Ch. 181, § 21; effective Oct. 11, 2002.)

5-16-3. Establishing a flex account. (a) A flex account shall be established by filing an application for a flex account and a term permit on a form prescribed by the chief engineer. The five-year period shall begin on January 1 of the next calendar year for which the application has been timely filed, unless expressly authorized by the chief engineer to begin the following January 1. The application shall also show the location of all wells located within one-half mile of the proposed point of diversion, and the names, addresses, and telephone numbers of the owners of those wells. Except as set forth in subsection (e), a separate application shall be filed for each water right and each point of diversion for which the owner desires to establish a flex account. Each application shall be accompanied by the filing fee specified in K.A.R. 5-16-2.

(b) Before any application to establish a flex account and a term permit will be accepted for filing, the application shall be signed by at least one owner of the water right, or a duly authorized agent of an owner of the water right.

(c) Before the flex account can be established or the term permit approved, all of the water rights owners, or a duly authorized agent of the owners, shall verify upon oath or affirmation that the statements contained in the application are true and complete.

(d) If one or more owners refuse to sign the application or if a written request is filed by one or more of the owners to withdraw their signatures from the application before the application is approved, the application shall be dismissed.

(e) A single application to establish a flex account and apply for a term permit may be filed in the following situations:

(1) Multiple water rights authorize the diversion of water from a single point of diversion that diverts water to an identical place of use for a single type of use.

(2) Multiple points of diversion are authorized by the chief engineer to divert water through a single water flowmeter before going to an identical place of use.

(f) The flex account shall not be established, and the term permit to exercise the flex account shall not be valid until both have been approved by the chief engineer. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 2001 Supp. 82a-736; effective Oct. 11, 2002.)

5-16-4. Conditions on the term permit. (a) The place of use authorized by a term permit shall be identical to the place or places of use authorized by the base water right or rights.

(b) The type of use authorized by a term permit shall be limited to one of the types of use authorized by the base water right or rights.

(c) The rate of diversion authorized by a term permit shall not exceed the maximum instantaneous rate of diversion authorized by the base water right or rights. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 2001 Supp. 82a-736; effective Oct. 11, 2002.)

5-16-5. Maximum annual quantity of water authorized by term permit. (a) Except as set forth in subsections (b) through (e), the maximum quantity of water deposited in a flex account and authorized to be diverted in five consecutive calendar years under the authority of a term permit shall be determined in accordance with K.S.A. 82a-736, and amendments thereto, by means of these calculations:

(1) Adding the total actual, legal annual water use of the base water right or rights for the period of calendar years 1992 through 2002;

(2) dividing that total quantity of water by 11;

(3) multiplying that quantity by the BAUF; and

(4) multiplying that quantity by five.

(b) If significant water conservation measures were implemented under the base water rights at any time during the period of calendar years 1992 through 2002, the average annual quantity of water actually used may be calculated using the five consecutive calendar years immediately preceding the implementation of significant water conservation measures, but these five calendar years shall not begin before calendar year 1987. The five-year allocation under the term permit shall be determined by means of these calculations:

(1) Adding the total actual, legal annual water use of the base water right or rights for the five consecutive calendar years;

(2) dividing that total quantity of water by five;

(3) multiplying that quantity by the BAUF; and

(4) multiplying that quantity by five.

(c) If water use records for a base water right are inadequate to accurately determine actual water use during any calendar year during the period used to determine the base average usage, then that year shall be counted as having no water use.

(d) No flex account shall be allowed if the flex account is inconsistent with the provisions of any intensive groundwater use control area created

pursuant to K.S.A. 82a-1036 through K.S.A. 82a-1040, and amendments thereto.

(e) If water was authorized to be diverted for less than the entire period used to determine the base average usage, the five-year allocation shall be determined by means of these calculations:

(1) Adding the total actual, legal annual water use of the base water right or rights for the entire period used to determine the base average usage;

(2) dividing the total quantity by the number of years, or parts thereof, that water was authorized to be diverted by the chief engineer;

(3) multiplying that quantity by the BAUF; and

(4) multiplying that quantity by five.

Water rights that authorized use of water for less than two calendar years during the period used to determine the base average usage shall not be eligible for a flex account. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 2004 Supp. 82a-736, as amended by L. 2005, ch. 142, sec. 3; effective Oct. 11, 2002; amended Jan. 6, 2006.)

5-16-6. Flex accounts and term permits. (a) The duration of the flex account and term permit shall be five consecutive calendar years.

(b) There shall be no extension of a flex account or a term permit beyond the period of five consecutive calendar years originally authorized.

(c) There shall be no carryover of unused quantities of water from one flex account or term permit to another flex account or term permit.

(d) Only one flex account shall be in force for a point of diversion or a water right at any time.

(e) A water flowmeter meeting the requirements of the chief engineer shall be installed on each point of diversion authorized by the term permit. If an existing water flowmeter had been required on or after September 22, 2000 or if there is no existing water flowmeter, the water flowmeter shall meet the requirements of the chief engineer in effect at the time the term permit is approved. If a water flowmeter was installed before September 22, 2000, the water flowmeter shall meet the requirements of K.A.R. 5-1-6(b).

(f) Only an entire water right, or a portion of a water right that has been formally divided, may be deposited in a flex account.

(g) All water diverted pursuant to a term permit and the base water rights associated with the term permit shall be counted against the quantity of water deposited in the flex account. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 2001 Supp. 82a- 736; effective Oct. 11, 2002.)

5-16-7. Conditions under which a base water right may be exercised. Each term permit approved by the chief engineer according to this article shall include the condition that if the term permit can no longer be exercised because of an order issued by the chief engineer, including an intensive groundwater use control area order, a minimum desirable streamflow order, or an order to administer water rights to prevent impairment, then any base water right may be exercised to the extent that all of the following conditions are met:

(a) The base water right is in priority.

(b) The annual quantity of water authorized by the base water right has not been diverted during that calendar year.

(c) The five-year allocation authorized by the term permit has not been used.

(d) The use of water under the base water right does not impair water rights senior to the base water right. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706a and K.S.A. 2001 Supp. 82a-736; effective Oct. 11, 2002.)

Article 17.—WATER BANKING

5-17-1. Definitions for water banking. As used in these water banking regulations, in the Kansas water banking act, K.S.A. 82a-761 et seq. and amendments thereto, and by the chief engineer in the administration of this act, unless the context clearly requires otherwise, the following words and phrases shall have the meanings ascribed to them in this regulation:

(a) "Bankable water right" means a water right, or portion of a water right, that meets the requirements of the following:

(1) K.S.A. 82a-764, and amendments thereto; and

(2) the water bank charter.

In calculating the portion of a water right that is bankable, credit shall be given for any water conservation practices implemented according to this regulation. The bankable portion of linked water rights shall be determined on a case-by-case basis. For a surface water right that has water available from a water assurance district, the quantity of water available from the water assurance district may be considered when determining how much of the water right is bankable.

(b) "Good standing," only for the purposes of

the Kansas water banking act and regulations, means a water right, or portion of a water right, that meets all of the following criteria:

(1) Except as set forth in paragraph (b)(2), the water right, or portion of a water right, has been lawfully put to beneficial use within the past five years.

(2) For a water right that has been enrolled in the water right conservation program (WRCP) or a water right whose authorized place of use has been enrolled in the conservation reserve program (CRP), the water right has been put to lawful beneficial use within the five-calendar-year period before enrollment in the program. A water right that is currently enrolled in the WRCP shall not be deposited in a water bank. If the authorized place of use is currently enrolled in the CRP, the water right shall not be deposited in a water bank, unless the authorized place of use has been changed to a place of use that is not enrolled in the CRP and water has actually been applied to beneficial use on the newly authorized place of use for at least one calendar year.

(3) All of the following conditions regarding the water right are met:

(A) In the five calendar years before the water right is deposited or placed in a safe deposit account, there has not been a conviction associated with that water right pursuant to K.S.A. 82a-728, and amendments thereto.

(B) No civil penalty has been assessed pursuant to K.S.A. 82a-737, and amendments thereto, against anyone for violations relating to the water right.

(C) The water right has not been suspended pursuant to K.S.A. 82a-737, and amendments thereto.

(D) No order of the chief engineer relating to the water right has been disobeyed.

(E) The applicant who is applying to deposit the water right into, or lease water from, a water bank or to withdraw water from a safe deposit account has a history of compliance with contracts with the water bank and term permits used to withdraw water from a water bank or from a safe deposit account.

(c) "Long-term rolling average," only for the purposes of the Kansas water banking act, means a five-year running average of the net consumptive use of all the participating rights. This average shall be calculated by adding together the average net consumptive use for each participating right in a hydrologic unit.

The average shall first be computed after the water bank has been in operation for three years. For each year after the third year, another year's data shall be added until five years of data are available. After the water bank has been in operation for five years or more, the last five years of data shall be used to calculate the average. The resulting number shall then be compared against the average annual net consumptive use of participating rights in that hydrologic unit for the representative past period.

(d) "Net consumptive use" means the gross diversion of water for beneficial use, minus the following:

(1) Waste of water, as defined in K.A.R. 5-1-1; and

(2) return flows to the source of water supply through surface water that is not waste and by deep percolation.

For irrigation use, only as used in the water banking act and regulations, net consumptive use shall be calculated as 85 percent of the actual legal gross diversions in any one calendar year or calculated using some other methodology approved by the chief engineer as complying with standard engineering practices. Net consumptive use for all other types of water use shall be calculated in accordance with a methodology approved by the chief engineer as complying with standard engineering practices.

The average annual net consumptive use for the representative past period shall be calculated by first calculating the average annual net consumptive use for each participating right for the representative past period and then adding those averages together. If a participating right did not legally divert water during any year in the representative past period or was not authorized to divert water, that year shall be counted as zero in computing the average annual consumptive use for that water right for the representative past period.

(e) "Participating rights" means all of the water rights in a hydrologic unit that are under contract to be deposited in a water bank or safe deposit account.

(f) "Representative past period" means a period of at least 10 consecutive years occurring entirely before the date on which the water bank is chartered and having a reasonable balance of years with above-normal and below-normal precipitation. For a water right not permitted during the entire representative past period, for the sole pur-

pose of determining the portion of that water right that is bankable pursuant to K.S.A. 82a-765(b)(9) and amendments thereto, the water bank may select a different representative past period, but the bankable portion of each water right shall be the lesser of either of the following:

(1) The annual quantity of water perfected; or

(2) the average percentage of water rights determined to be bankable, for all water rights in that hydrologic unit that were permitted for the representative past period occurring entirely before the date on which the bank was chartered.

(g) "Severely depleted groundwater aquifer" means an aquifer that meets any of the following criteria:

(1) The chief engineer has declared the aquifer to be an aquifer in need of recovery pursuant to K.S.A. 2-1919, and amendments thereto.

(2) The average static water level decline in the hydrologic unit, based on a representative sample of wells distributed throughout the hydrologic unit, in the 20 calendar years immediately preceding the calendar year in which the water bank was chartered is substantially greater than the average annual variability in the static water level in the hydrologic unit.

(3) The average yield of the groundwater aquifer is not sufficient to meet the 50 percent chance net irrigation requirements (N.I.R.) for crops typically grown in the hydrologic unit using methods of irrigation typically used in that hydrologic unit.

(h) "Severely depleted stream course" means a stream reach that has been declared by the chief engineer to be a stream reach in need of stream recovery pursuant to K.S.A. 2-1919, and amendments thereto.

(i) "Water conservation practices" means actual physical changes in a water distribution system or management practices that were made to improve water use efficiency during the representative past period, including the following:

(1) Conversion from flood irrigation to center pivot irrigation with a nozzle package designed to improve water use efficiency;

(2) irrigation scheduling;

(3) conversion to subsurface drip irrigation; and

(4) removal of an end gun, resulting in a reduction in the number of irrigated acres.

The applicant shall have the burden of documenting the implementation of water conservation practices that could have altered the results of the calculation of the portion of the water right that is bankable, to the detriment of the applicant. (Authorized by and implementing K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-2. Application to deposit a water right into a water bank or withdraw a deposit. (a) Each water right owner proposing to deposit all or a portion of a water right into a water bank shall complete an application on a form prescribed by the water bank and approved by the chief engineer. The application shall be filed with the water bank on or before December 31 of the year preceding the first calendar year in which the deposit will be made. A water right, or a portion of a water right, may be deposited only in increments of full calendar years. The application shall contain the following information concerning the water right, or portion of the water right, that is proposed to be deposited:

(1) The file number of the water right to be deposited;

(2) if the water right is a vested right or an appropriation right that has been certified by the chief engineer, specification of that status;

(3) the hydrologic unit from which the water right is authorized to withdraw water;

(4) the calendar years during which the water right will be on deposit. This period shall not exceed five years; and

(5) any CRP contracts that were in effect for any part of the representative past period.

(b) A water right may be withdrawn from deposit only if both of the following conditions are met:

(1) The water right has not been leased in whole or part.

(2) An application to withdraw the water right from deposit is made before July 1 of the calendar year for which the deposit has been made. Withdrawal of a water right during one calendar year also shall withdraw the water right from deposit in any subsequent years for which the water right may have been deposited. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-763, K.S.A. 2003 Supp. 82a-764, and K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-3. Contract for deposit of a water right. (a) Each water right owner that has an application approved for the deposit of all or a portion of a water right into a water bank and that desires to deposit all or a portion of the water right into the water bank shall enter into a contract with

the water bank that includes the following provisions and information:

(1) The file number of the water right to be deposited;

(2) the hydrologic unit from which the water is authorized to be withdrawn;

(3) the calendar years during which the water right will be on deposit, which shall not exceed five years;

(4) the quantity of water to be deposited;

(5) the terms of payment for the deposit;

(6) if a portion of a water right is deposited, an agreement that the quantity of water pumped under the portion of the water right that is not deposited shall not exceed the difference between the bankable portion of the water right and the amount deposited; and

(7) an acknowledgment of the specific fines or suspension penalties that will be imposed for violation of the contract.

(b) The water bank shall notify the chief engineer of each water right deposit before the deposit is leased. This notice shall include a determination of the annual quantity of water that is bankable for each water right and the portion of the bankable quantity of the water right that has been deposited. If an entire water right is deposited, no water may be pumped under that water right, except under the authority of a lease from a water bank and a term permit issued by the chief engineer to exercise that lease. If a portion of a water right is deposited, the annual quantity of water pumped under the portion of the water right that is not deposited shall not exceed the difference between the bankable portion of the water right and the amount deposited. An order may be issued by the chief engineer after the deposit notifying the owner of the annual quantity of water, if any, that may be diverted under the original water right to prevent the net consumptive use of the water right from being increased. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-763 and K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-4. Application to lease water. (a) Each person proposing to lease water from a water bank shall complete an application for a contract to lease water on a form prescribed by the water bank and approved by the chief engineer and an application for a term permit. The application for the contract shall be filed with the water bank. The application for a term permit shall be filed with the chief engineer. Each application shall include the following information concerning the water proposed to be leased:

(1) The quantity of water to be leased;

(2) the proposed maximum rate of diversion;

(3) the calendar years during which water is proposed to be leased, which shall not exceed the length of the water bank charter plus three calendar years;

(4) the location of the proposed point of diversion, including the hydrologic unit;

(5) the proposed place of use;

(6) the proposed use made of water;

(7) the water flowmeter reading from the proposed point of diversion, if the water will be diverted from an existing point of diversion, at the time the application is filed;

(8) the file numbers of the other water rights and approvals of applications that authorize use of water from the proposed point of diversion; and

(9) if the proposed use is for irrigation, the number of acres that will be irrigated and the number of acres of each type of crop that will be grown.

(b) Any water bank may enter into a lease extending beyond the length of the water bank charter only if both of the following conditions are met:

(1) The water bank charter has a procedure approved by the chief engineer that sets forth how the leases will be administered if the water bank is dissolved.

(2) The bank charter assigns the responsibility and cost of administering the leases after the water bank is dissolved to a responsible person or entity.

(c) Any applicant whose application meets all the criteria in subsections (a) and (b) may enter into a contract to lease water from the water bank if sufficient water rights have been deposited in the same hydrologic unit where the point of diversion and the place of use are proposed to be located to cover the lease. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-763 and K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-5. Contract to lease water. Any person who has an application approved by the water bank for the lease of water from the water bank may enter into a contract with the water bank to lease water. The contract shall be entered into before a term permit can be issued by the chief en-

gineer and shall include the following information and provisions:

(a) The quantity of water to be leased;

(b) the maximum rate of diversion at which the leased water will be diverted;

(c) the calendar years during which water will be leased, which shall not exceed the length of the water bank charter plus three calendar years;

(d) the location of the point of diversion where the leased water will be diverted, including the hydrologic unit;

(e) the use made of the water to be leased;

(f) the place of use of the water to be leased. The place of use shall be identical to a place of use authorized by an existing water right or approval of application, or shall be an entirely new place of use;

(g) the terms of payment for the lease of water;

(h) the penalties for breach of the lease, including those set forth in K.A.R. 5-17-13; and

(i) a provision that if the term permit is not obtained by a certain date or the term permit is dismissed for any reason, the contract shall not be exercised. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-763 and K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-6. Conditions on the term permit to exercise a contract to lease water. (a) A contract to lease water may be exercised only if the chief engineer approves an application for a term permit to divert the leased water.

(b) The following conditions shall be imposed by the chief engineer on the term permit authorizing the use of water leased from a water bank:

(1) The maximum reasonable quantity of water that may be diverted per calendar year, as set forth in K.A.R. 5-17-17, and the maximum quantity of water that may be diverted during the term of the permit;

(2) the maximum rate of diversion;

(3) the term of the permit, which shall not exceed the length of the water bank charter plus three calendar years;

(4) the authorized point of diversion;

(5) the authorized place of use;

(6) the authorized use made of the leased water;

(7) a provision that the diversion shall not cause the impairment of any existing water rights;

(8) a provision that the diversion shall not cause an increase in depletion to any severely depleted groundwater aquifer or severely depleted stream course;

(9) a provision that the leased water shall be diverted from, and used within, the same hydrologic unit where the water rights were deposited; and

(10) a provision that any violation of a term permit used to exercise a lease shall make the permittee subject to the penalty provisions of K.A.R. 5-17-13. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-763 and K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-7. Contract to deposit water in a safe deposit account. (a) Each person proposing to deposit water into a safe deposit account shall enter into a contract with the water bank on a form prescribed by the water bank and approved by the chief engineer. The contract shall include the following information and provisions and any other provision needed to ensure that the deposit complies with the provisions of the Kansas water banking act and regulations:

(1) The term of the contract, which shall be for a specific number of calendar years and shall not exceed the length of the water bank charter plus three years;

(2) the proposed deposit of water, which shall be from a water right that is bankable;

(3) the water right from which water is being deposited. The water right shall be in good standing and shall be vested or certified;

(4) the hydrologic unit from which water is being deposited;

(5) the terms of payment for the deposit and a provision that any fees paid are not refundable if the water user voids the contract, or causes it to be void, for any reason;

(6) the location of the point of diversion authorized by the water right that is proposed to be deposited;

(7) the water right file numbers of any linked water rights that are proposed to be deposited; and

(8) a provision that the contract shall be entered into by December 31 of the year preceding the first year for which the owner desires to make a deposit in the safe deposit account.

(b) The amount of water that may be deposited in any year shall not exceed 25 percent of the quantity of unused water from the preceding year.

(c) At the end of the term of the contract to

deposit water in a safe deposit account, including any extensions of time, all water in the account shall be forfeited.

(d) There shall not be multiple safe deposit accounts for any point of diversion.

(e) The term of a safe deposit account may be extended by the chief engineer upon request of the owner for a period not to exceed the length of the water bank charter plus three calendar years. Any water bank may extend a safe deposit account beyond the length of the water bank charter only if both of the following conditions are met:

(1) The water bank charter has a procedure approved by the chief engineer that sets forth how the safe deposit accounts will be administered if the water bank is dissolved.

(2) The bank charter assigns the responsibility and costs of administering the accounts after the water bank is dissolved to a responsible person or entity. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-763 and K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-8. Depositing water in a safe deposit account. (a) Each calendar year in which water is deposited, the depositor shall file a deposit slip, on a form prescribed by the water bank and approved by the chief engineer, with the water bank indicating the quantity of water that was unused and the quantity of water that the depositor proposes to deposit.

(b) Water shall be deposited in an existing safe deposit account no later than March 1 of the year following the calendar year in which the water was not used.

(c) When the deposit is made, the depositor shall furnish the water bank with the following information:

(1) The water flowmeter readings at the beginning and end of the calendar year in which the water was not used under the water right; and

(2) the quantity of water proposed to be deposited.

(d) The water bank shall accept for deposit the quantity of water that meets the provisions of the water bank charter and the Kansas water banking act and regulations. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-763 and K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-9. Term permit to use water that was deposited in a safe deposit account. (a) Before approval of a term permit to use water deposited in a safe deposit account, the water bank shall certify to the chief engineer the quantity of water that is in the safe deposit account.

(b) Before any water that has been deposited into a safe deposit account may be used, the applicant shall apply for a term permit, submit the appropriate filing fee, and receive approval from the chief engineer. Each term permit shall contain the following conditions:

(1) The maximum rate of diversion of water;

(2) the maximum quantity of water that may be diverted the remainder of that calendar year, which shall not exceed the quantity of water certified by the water bank to be in the safe deposit account;

(3) the length of the term permit, which shall not exceed December 31 of the year in which the term permit was issued by the chief engineer. No extensions of time shall be granted for this type of term permit;

(4) a provision that the use of water under the term permit shall not impair any existing water rights;

(5) a provision that the use of water under the term permit shall not cause an increase in the depletion of a severely depleted groundwater aquifer or severely depleted stream course; and

(6) a provision that violation of any of the terms of the term permit shall subject the owner to the penalty provisions of K.A.R. 5-17-13. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-763 and K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-10. Water bank charter proposal. (a) Each proposed water bank charter submitted to the chief engineer shall contain all of the following:

(1) Information showing that the proposed operations and policies of the water bank are consistent with the Kansas water banking act, the Kansas water appropriation act and regulations, the Kansas state water plan, the policies of any groundwater management district that is located within the boundaries of the proposed water bank, and the water assurance district operation agreements of any water assurance district located within the boundaries of the proposed water bank;

(2) information that demonstrates that there is sufficient participation to make the water bank's

operations practical and feasible, including economically;

(3) a petition declaring an intent to establish a water bank that is signed by at least five percent of the water right owners within the water bank's proposed boundaries;

(4) the names of at least five members of the proposed governing body of the water bank, their addresses, and the public and private interests that each represents;

(5) the proposed boundaries of the water bank, including information showing that the boundaries of the proposed water bank do not overlap the boundaries of another water bank;

(6) for groundwater banks, an enumeration of all the hydrologic units and sources of water supply within the water bank boundaries, including alluviums, terrace deposits, and regional aquifers, both confined and unconfined, that have similar aquifer properties. The aquifer properties shall include the saturated thickness and water level changes over the representative past period;

(7) for a water bank that includes surface water, a list of the streams and their tributaries that are to comprise the water bank and a methodology to limit the leasing of surface water so that it does not impair senior surface water rights and minimum desirable streamflow;

(8) the designation of a representative past period;

(9) a comprehensive method to account for the following:

(A) The amount of water deposited and the length of the contracts for deposit;

(B) the amount of water leased from the water bank and the length of the lease contracts; and

(C) the identification of the hydrologic units from which deposits and leases are being made;

(10) for a water bank that includes the use of groundwater, a proposed plan to ensure that the net amount of water consumed by the deposited water rights will be at least 10 percent less than the average net amount of water consumed by the deposited water rights for the representative past period. The proposed plan shall require the comparison of the average annual net consumption for the deposited water rights for the five-year period after a water bank is chartered or rechartered with the average net consumptive use for the deposited water rights for the representative past period;

(11) a list of any severely depleted groundwater aquifers or severely depleted stream courses;

(12) a plan to ensure that there will be no increase in the depletion of severely depleted groundwater aquifers or severely depleted stream courses;

(13) a method for determining the water rights that are bankable and the portion that is bankable;

(14) a procedure for dissolution of the water bank;

(15) for a bank using groundwater, a methodology for ensuring that the total quantity of groundwater leased each year does not exceed 90 percent of the average annual quantity collectively diverted pursuant to all deposited water rights or portions of water rights from each hydrologic unit for the representative past period;

(16) for a water bank that authorizes safe deposit accounts, a methodology to ensure that the users of safe deposit accounts will not increase the consumption of groundwater; and

(17) for a water bank that authorizes safe deposit accounts, a provision setting the maximum percentage of unused water from the previous year that may be deposited in a safe deposit account.

(b) After the body wishing to charter the water bank submits the proposed water bank charter to the chief engineer, it shall be circulated by the chief engineer to any groundwater management districts and water assurance districts located within the boundaries of the proposed water banks and to the Kansas water office for comments as to whether the proposed water bank charter complies with the provisions of K.S.A. 82a-765, and amendments thereto. Comments regarding the proposed water bank charter shall be due within 30 days after comments are requested by the chief engineer, unless an extension of time is requested within the time allowed and granted by the chief engineer for good cause shown. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-765 and K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-11. Annual reports of water banks. Each water bank shall file an accounting report with the chief engineer each calendar year containing the following information: (a) The file numbers of the water rights, or portion of the water rights, deposited in the water bank;

(b) the annual quantity of water authorized for diversion for each water right deposited and a determination of the bankable quantity of water associated with each deposited water right;

(c) the term of each deposit;

(d) the hydrologic unit from which each water right was deposited;

(e) the file number of each term permit authorizing a lease of water;

(f) the term of the lease;

(g) the annual quantity of water that has been leased from each hydrologic unit;

(h) the hydrologic units where the leased water was diverted;

(i) the net year-end balance of water deposited versus water leased in each hydrologic unit within the water bank's boundaries;

(j) the annual quantity of water deposited into safe deposit accounts;

(k) the annual quantity of water used from safe deposit accounts;

(l) the hydrologic unit in which water was deposited in a safe deposit account;

(m) the total year-end balance of water remaining in safe deposit accounts after the 10 percent year-end reduction for all individual accounts;

(n) the total quantity of water diverted during the last three calendar years, by type of use;

(o) the total number of acres irrigated and the number of acres of each crop grown during the last three calendar years;

(p) any contracts that were breached, the nature of the breaches, and the enforcement actions taken by the water bank; and

(q) the average annual quantity of water diverted during the representative past period of each water right that has been deposited in the water bank. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-766 and K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-12. Water use reports. (a) Each owner of a water right authorized for irrigation use that deposits a water right in a water bank or deposits water in a safe deposit account, and each person that leases water for irrigation use and any linked water rights, shall file the water use report required by K.S.A. 82a-732, and amendments thereto, on or before December 1 of the year for which water use is being reported.

(b) Each owner of a water right authorized for non-irrigation use that deposits a water right in a water bank or deposits water in a safe deposit account, and each person that leases water for non-irrigation use and any linked water rights, shall file the water use report required by K.S.A. 82a-732, and amendments thereto, on or before January 10 of the year following the year for which water use is being reported.

(c) The failure of a water right owner to submit a complete and accurate water use report, including water flowmeter readings, as required by this regulation shall result in civil fines in the amounts set forth in K.A.R. 5-14-11.

(d) If a water use report is inadequate to accurately determine the actual water use during any calendar year, then that year shall be counted as having had no water use for the purpose of determining the extent to which a water right is bankable pursuant to K.S.A. 82a-764, and amendments thereto, unless the water use report is corrected as set forth in K.A.R. 5-3-5o. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-766 and K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-13. Enforcement. If any person violates any of the following, enforcement action may be taken by the chief engineer as specified in K.A.R. 5-14-1 and K.A.R. 5-14-10:

(a) A term, condition, or limitation of a term permit issued to authorize the diversion of leased water;

(b) a term, condition, or limitation of a term permit issued to withdraw water from a safe deposit account;

(c) a term, condition, or limitation of a water right that has been deposited in the water bank or a safe deposit account;

(d) any order of the chief engineer concerning the deposit or lease of a water right; or

(e) any order or condition placed on the use of the remainder of a water right that was partially deposited in the water bank or a safe deposit account. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-769 and K.S.A. 2003 Supp. 82a-770; effective Aug. 13, 2004.)

5-17-14. Water flowmeters. (a) The following points of diversion shall meet the requirements specified in subsection (b):

(1) Within a groundwater bank, all non-domestic, non-temporary wells within the boundaries of the water bank;

(2) within a surface water bank, all non-domestic, non-temporary surface water points of diversion within the boundaries of the water bank; and

(3) within a groundwater and surface water bank, all non-domestic, non-temporary points of diversion within boundaries of the water bank.

(b) While a water bank is operating, each of the points of diversion described in subsection (a) shall meet one of the following requirements:

(1) Be equipped with a water flowmeter meeting the requirements of K.A.R. 5-1-4 through K.A.R. 5-1-12;

(2) be sealed by the chief engineer; or

(3) be approved by the chief engineer as having another objectively verifiable means of determining that water has not been pumped, including capping the well, removal of the pump, or removal of a permanent power source.

(c) If a water flowmeter does not function properly whenever water is being diverted, it shall be assumed, for the purpose of determining compliance with the water right and the term permit issued to withdraw leased water or water deposited in a safe deposit account, that the diversion works have been operated continuously at the tested rate of diversion since the last time the waterflow meter was confirmed by the chief engineer or a groundwater management district to have been operating properly. If the diversion works have not been tested by the chief engineer or a groundwater management district, it shall be assumed that the diversion works have been operated continuously at the authorized rate of diversion during the entire time the water flowmeter was out of compliance. Either of the assumptions specified in this subsection may be rebutted if the water right owner submits objective documentation of the actual quantity of water diverted while the water flowmeter was out of compliance. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-766 and K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-15. Private sale or lease of water right facilitated by a water bank. If a water bank provides services to facilitate the sale or lease of water rights, the owner of the water rights that are bought, sold, or leased between private parties shall be required to comply with all applicable statutes and regulations, including any regulation of the chief engineer limiting the distance that a point of diversion may be moved. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-763 and K.S.A. 2003 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-16. Priority of use of water rights and permits. (a) If multiple water rights or permits authorize the use of water from a single point of diversion, the water shall be considered to be used in the order of priority with the earliest priority first.

(b) If the water used exceeds the total quantity of water authorized by the water rights and permits described in subsection (a) that authorize water use from that point of diversion, all water rights and permits under which the water was lawfully diverted shall be deemed to be violated unless this presumption is rebutted by one or more of the water right owners. (Authorized by K.S.A. 2003 Supp. 82a-769; implementing K.S.A. 2003 Supp. 82a-769 and K.S.A. 2003 Supp. 82a-770; effective Aug. 13, 2004.)

5-17-17. Waste of leased water and safe deposit account water. For using leased water or water withdrawn from a safe deposit account, the quantity not considered to be waste for irrigation use shall be 150 percent of the value specified in K.A.R. 5-3-24 for the county where the point of diversion is located. (Authorized by K.S.A. 2002 Supp. 82a-769; implementing K.S.A. 2002 Supp. 82a-763 and K.S.A. 2002 Supp. 82a-769; effective Aug. 13, 2004.)

5-17-18. Reimbursable and non-reimbursable costs. (a) The following costs incurred by the chief engineer for assistance and services to implement the Kansas water banking act shall be reimbursable by a water bank:

(1) The cost of reviewing and approving a proposed water bank charter;

(2) the cost of determining the extent to which a water right is bankable and in good standing;

(3) the cost of reviewing an annual report filed by a water bank and conducting the analysis necessary to determine if the water bank has complied with the terms of the Kansas water banking act;

(4) extra costs incurred to require water use reports to be filed earlier than March 1, the tracking of that information, and reporting that information to a water bank;

(5) increased costs incurred to provide other water use and water right information to water banks or water bank customers;

(6) the costs to monitor and enforce the provisions of the Kansas water banking act;

(7) the costs of meetings and other discussions with water bank officials and employees;

(8) the cost of enforcement of terms, conditions, and limitations of term permits issued to

allow withdrawal of leased water and water from safe deposit accounts;

(9) if additional enforcement of water rights and permits is requested by a water bank, enforcement costs that would not have been incurred by the chief engineer in the ordinary course of business against all water rights diverting water from within the boundaries of the water bank to prevent overpumping; and

(10) the cost incurred if a water bank or a water bank customer requests the chief engineer to hold an abandonment hearing necessary to determine whether a water right is bankable that would not have been done in the ordinary course of business by the chief engineer at that time.

(b) The following costs incurred by the chief engineer for assistance and services to implement the Kansas water banking act shall not be reimbursable by a water bank:

(1) The cost of issuing a term permit to allow diversion of leased water;

(2) the cost of issuing a term permit to allow withdrawal of water from a safe deposit account;

(3) enforcement costs that the chief engineer would have incurred in the ordinary course of business to take action against all water rights diverting water from within the boundaries of the water bank to prevent overpumping; and

(4) the cost of adopting regulations to implement the act. (Authorized by K.S.A. 2002 Supp. 82a-769; implementing K.S.A. 2002 Supp. 82a-769 and K.S.A. 2002 Supp. 82a-771; effective Aug. 13, 2004.)

Articles 18 to 20.—RESERVED

Article 21.—WESTERN KANSAS GROUNDWATER MANAGEMENT DISTRICT NO. 1

5-21-1. Definitions. As used in these rules and regulations, the following words and phrases shall have the meaning ascribed to them in this section.

(a) "Aquifer" means a geologic water-bearing formation that will yield considerable quantities of water to wells and springs.

(b) "Board" means the board of directors constituting the governing body of the western Kansas groundwater management district no. 1.

(c) "Chief engineer" means the chief engineer of the division of water resources of the Kansas state board of agriculture.

(d) "District" means the western Kansas groundwater management district no. 1.

(e) "Authorized representative of the board" means an individual designated by the board to perform duties and functions on its behalf.

(f) "Groundwater" means water below the surface of the earth.

(g) "Substantially" means within 300 feet of the approved location, but in no case closer to other wells than the minimum spacing requirements allow.

(h) "Tailwater" means that portion of the irrigation water applied which appears as run-off from the authorized place of use.

(i) "Tailwater re-use system" means a facility to collect, store and transport irrigation tailwater for reapplication to the authorized place of use.

(j) "Unconsolidated aquifer" means unconsolidated deposits that will yield water in a sufficient quantity to supply pumping wells and springs.

(k) "Waste of water" means any act or omission which causes:

(1) groundwater to be diverted or withdrawn from a source of supply and not used, managed or reapplied to a beneficial use on or in connection with land authorized as the place of use by a vested right, an appropriation right or an approved application for permit to appropriate water for beneficial use;

(2) the unreasonable deterioration of the quality of water in any source of supply thereby causing impairment of a person's right to the use of water;

(3) groundwater intended for irrigation use to escape and drain from the authorized place of use; or

(4) groundwater to be applied to an authorized beneficial use in excess of the needs for such use.

(l) "Well" means any excavation that is drilled, cored, bored, washed, driven, dug or otherwise constructed when the intended use of such excavation is for the acquisition, diversion, or artificial recharge of groundwater. (Authorized by K.S.A. 82a-1028(o); effective May 1, 1979; amended May 23, 1994.)

5-21-2. Tailwater control and waste. No water user shall allow water which is pumped or diverted from any aquifer to leave the land under the water user's direct supervision and control. If the water is re-used, the user shall apply the water consistent with the approved application to appropriate water for beneficial use, vested right, or

appropriation right. All water users shall construct and operate the water distribution systems in a manner as to prevent waste of water, and shall do everything necessary and proper to preserve the quality of the groundwater resources within the district. (Authorized by K.S.A. 1978 Supp. 82a-1028(o); effective May 1, 1979.)

5-21-3. Well spacing requirements. (a) Each well location described in an application for a permit to appropriate water for a beneficial use, other than domestic use, which proposes the diversion or withdrawal of water from the Ogallala formation shall be spaced a minimum of 2640 feet from all other non-domestic wells in the Ogallala aquifer.

(b) (1) Each well location described in an application to appropriate water for a beneficial use, other than domestic use, which proposes the diversion or withdrawal of water from the Dakota aquifer shall be spaced a minimum of two thousand six hundred forty (2,640) feet from any other well constructed into the same Dakota aquifer.

(2) Each Dakota well shall be sealed off between the Dakota aquifer and any other aquifers in such a manner as to prevent migration of water to or from the Dakota aquifer and any other aquifers.

(c) Each well included in an application to appropriate water for a beneficial use, other than domestic use, which proposes the diversion or withdrawal of water shall be a minimum of 1,320 feet away from a domestic well constructed into the same aquifer unless the applicant has received written permission from the neighboring well owner or the domestic wells are owned by the applicant.

(d) The location of a well or wells on an application for approval to change the point of diversion under an existing water right shall be no more than 1,320 feet from the originally authorized point of diversion and shall:

(1) not decrease the distance to other wells or authorized well locations by more than 300 feet; or

(2) meet the minimum well spacing requirements in this regulation.

(e) A new well shall be drilled in a location substantially as shown on the approved application and the accompanying map, plat, or aerial photograph.

(f) Exceptions to this well spacing regulation may be granted on an individual basis by recommendation of the board in conjunction with the approval of the chief engineer. The applicant may be required by the board to submit information as it deems necessary in order to make the determination. (Authorized by K.S.A. 82a-1028(o); effective May 1, 1979; amended May 23, 1994.)

5-21-4. Safe yield. (a) Except as set forth in subsection (c), the district shall be closed to further new appropriations of water in all areas where the total saturated thickness of the unconsolidated aquifer, commonly known as the Ogallala, meets either of these criteria:

(1) Has been depleted by 15 percent or more since 1950, as determined according to K.A.R. 5-21-8; or

(2) is less than 40 feet thick, as determined according to K.A.R. 5-21-9.

(b) In the rest of the district, the approval of each application for a permit to appropriate water for a beneficial use, except as set forth in subsection (c), from the Ogallala aquifer, and the approval of each application for a change in the point of diversion if the diversion works have not been completed under the original approved application, shall be subject to the following criteria:

(1) The proposed appropriation, when added to the vested rights, prior appropriation rights, and earlier priority applications, shall not exceed the allowable safe yield amount for the area included within a two-mile-radius circle, which is approximately 8,042 acres, of the proposed well.

(2) For the purpose of analysis, all vested rights, certificates, permits, and prior unapproved applications shall be considered to be fully exercised, and all limitation clauses listed on permits to appropriate water and certificates shall be considered to be in force.

(3) In the case of an application for change in the point of diversion referred to in subsection (b), each application and water right with a priority earlier than the priority established by the filing of the application for change shall be included in the analysis.

(4) The allowable annual safe yield amount shall be calculated using the following formula:

$$Q = \frac{AR}{12}$$

Q = the allowable annual safe yield amount in acre-feet per year

A = area of consideration, within a two-mile-radius circle, approximately 8,042 acres

R = average annual recharge of 0.5 inches per year

(5) If part of the radial area is located outside the district boundary, it shall be included in the depletion analysis only if the chief engineer determines that hydraulically connected groundwater exists in that portion of the area outside the district. A part of the area of consideration lying outside the state of Kansas shall not be included in the analysis.

(6) If wells authorized under a vested right, a certified water right, or a permit to appropriate water are divided by the circumference of the radial area, the authorized quantity of water shall be assigned to each well. If specific quantities are not authorized for each well, a proportional amount shall be assigned to each well.

(c) This regulation shall not apply to the following:

(1) Domestic use;

(2) temporary permits; and

(3) a new application filed to appropriate groundwater in any area of the district not closed by regulation or intensive groundwater use control area order by the chief engineer to new nondomestic, nontemporary permits and term permits for five or fewer years, meeting all of the following criteria:

(A) The sum of the annual quantity requested by the proposed appropriation and the total annual quantities authorized by prior permits allowed because of an exemption pursuant to this subsection does not exceed 15 acre-feet in a ½-mile-radius circle surrounding the proposed point of diversion.

(B) Well spacing criteria in the area have been met.

(C) The approval of the application does not authorize an additional quantity of water out of an existing authorized well with a nondomestic permit or water right that would result in a total combined annual quantity of water authorized from that well in excess of 15 acre-feet.

(D) All other criteria for approving a new application to appropriate water at that location have been met.

(d) Exceptions to this regulation may be granted on an individual basis by recommendation by the board in conjunction with the approval of the chief engineer. The applicant may be required by the board to submit information necessary in order to make the determination. (Authorized by K.S.A. 82a-706a and K.S.A. 82a-1028(o); implementing K.S.A. 82a-1028(n); effective May 23, 1994; amended Sept. 22, 2000.)

5-21-5. Battery of wells. Within the boundaries of the district, an application for change of point of diversion from one well to a battery of wells shall not be approved unless the application meets the following criteria:

(a) The proposed points of diversion constitute a "battery of wells" as defined in K.A.R. 5-1-1.

(b) If the application for change has been filed pursuant to an appropriation right, the certificate shall be issued before approval of the application for change.

(c) The maximum annual quantity and maximum instantaneous diversion rate approved shall not exceed the maximum annual quantity and the maximum instantaneous diversion rate actually used during any of the three consecutive full calendar years before the application.

(d) The application meets the criteria for the approval of a new application. However, the wells comprising the battery of wells shall not be required to meet the well spacing requirements of K.A.R. 5-21-3 in relationship to each other. (Authorized by K.S.A. 82a-706a and K.S.A. 82a-1028(o); implementing K.S.A. 82a-1028(n); effective Sept. 22, 2000.)

5-21-6. Water-measuring devices. (a) Except as specified in subsections (b) and (e), each well authorized after the effective date of this regulation within the boundaries of the district shall be equipped with a water flowmeter that is installed and maintained in accordance with the specifications in K.A.R. 5-1-4 through 5-1-12. Each water right owner shall maintain the water flowmeter so that the flowmeter functions properly whenever the diversion of water can reasonably be expected to occur. If the water flowmeter fails to function properly, the owner shall promptly initiate action to repair or replace the meter, or to correct any problems with the installation.

(b) If the owner of the water right demonstrates to the board that the installation of a water flowmeter meeting the requirements of subsection (a) is not feasible, the installation of an hour meter in lieu of a water flowmeter may be approved by the board. Installation of a water flowmeter shall be considered to be not feasible if all of the following conditions are met:

(1) The diversion works and the delivery sys-

tem are both in existence before the order of the board to install a water-measuring device.

(2) The owner enters into a written agreement with the district providing that the owner will perform the following:

(A) Notify the district whenever the diversion works or the delivery system is modified; and

(B) install a water flowmeter when the diversion works or delivery system is modified, unless a waiver is granted by the board.

(3) Either of the following conditions is met:

(A) The normal operating rate of diversion is less than 200 gallons per minute.

(B) The diameter of the existing pipe is too large for the normal operating flow rate so that full pipe flow cannot be maintained through a water flowmeter.

(c) Each well location authorized before the effective date of this regulation and located within the boundaries of the district shall be equipped with a water-measuring device that was acceptable at the time the water-measuring device was required. Waivers or exemptions to the installation of a water flowmeter granted by the district before the effective date of this regulation shall be considered to be effective until one of the following occurs:

(1) The well is redrilled.

(2) The delivery system is modified.

(3) The water-measuring device is no longer functioning properly and is not promptly repaired.

(4) The district or the chief engineer orders that the well be equipped with a water flowmeter.

(d) An hour meter installation shall be deemed acceptable if all of the following requirements are met:

(1) The hour meter shall be enclosed in a weatherproof box and installed on a stand or post separate from, but adjacent to, the pumping plant base.

(2) The wiring from the pumping plant to the hour meter shall be at least 16 gauge and shall be enclosed in a conduit.

(3) All electrical connections shall be firmly attached.

(e) The following types of water use shall be exempt from the requirements of this regulation:

(1) Domestic use; and

(2) temporary use. (Authorized by K.S.A. 82a-706a and K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5; implementing K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5 and K.S.A. 2001 Supp. 82a-1903, as amended by L. 2002, Ch. 137, § 7; effective Jan. 24, 2003.)

5-21-7. Change in the use made of water from irrigation use to any other type of beneficial use. A change in the use made of water from irrigation use to any other type of beneficial use shall not be approved if any of the following conditions is met: (a) The application for change does not meet the requirements of K.A.R. 5-5-9.

(b) The rate of diversion applied for exceeds the rate of diversion as determined by a test of the normal operating rate of diversion conducted within 1,095 days before the date the application for change was filed.

(c) The maximum annual quantity of water applied for is in excess of any of the following:

(1) The maximum annual quantity of water determined for a vested right;

(2) the maximum annual quantity of water certified; or

(3) the average annual quantity of water actually used in the preceding 10 calendar years, excluding those years in which the water right was enrolled in the water right conservation program, the conservation reserve program, or any other multiyear water conservation program approved by the chief engineer. (Authorized by K.S.A. 82a-706a and K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5; implementing K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5 and K.S.A. 2001 Supp. 82a-1903, as amended by L. 2002, Ch. 137, § 7; effective Jan. 24, 2003.)

5-21-8. Percent change of saturated thickness. The map titled "percent change in saturated thickness of the High Plains aquifer, west central Kansas, 1950 to average 1997-1999" and designated as the Kansas geological survey open file report 2000-15B, dated July 25, 2000, is hereby adopted by reference. (Authorized by K.S.A. 82a-706a and K.S.A. 82a-1028(o); implementing K.S.A. 82a-1028(n); effective Sept. 22, 2000.)

5-21-9. Saturated thickness. The map titled "saturated thickness of unconsolidated aquifer, west central Kansas average 1997-1999" and designated as the Kansas geological survey open file report 2000-15A, dated July 25, 2000, is hereby adopted by reference. (Authorized by K.S.A. 82a-706a and K.S.A. 82a-1028(o); implementing K.S.A. 82a-1028(n); effective Sept. 22, 2000.)

Article 22.—EQUUS BEDS GROUNDWATER MANAGEMENT DISTRICT NO. 2

5-22-1. Definitions. As used in article 22 of these regulations, by the Equus Beds groundwater management district no. 2 in the implementation of the groundwater management district act and by the division of water resources in the administration of the Kansas water appropriation act, the following terms shall have the meanings ascribed to them in this regulation, unless the context clearly requires otherwise.

(a) "Above-baseflow stage" means streamflow that is in response to a significant runoff event during which period the water-level elevation of the stream is greater than the elevation of the adjacent water table.

(b) "Aquifer" means any geologic formation capable of yielding water in sufficient quantities that it can be diverted for beneficial use.

(c) "Aquifer storage" means the act of storing water in the unsaturated portion of an aquifer by artificial recharge for subsequent diversion and beneficial use.

(d) "Aquifer storage and recovery system" means a physical infrastructure that meets the following conditions:

(1) Is constructed and operated for artificial recharge, storage, and recovery of source water; and

(2) consists of apparatus for diversion, treatment, recharge, storage, extraction, and distribution.

(e) "Area of consideration" means the two-mile-radius circle whose center is the location of the proposed point of diversion. The area of consideration equals 8,042 acres minus the area of the circle that meets the following conditions:

(1) Is outside the district boundary;

(2) is inside an intensive groundwater use control area with a declining water table; and

(3) is in an area where the bedrock is not overlain by an aquifer.

(f) "Artificial recharge" means the use of source water to artificially replenish the water supply in an aquifer.

(g) "Bank storage" means water absorbed by and temporarily stored in the banks and bed of a stream during above-baseflow stage.

(h) "Bank storage well" means a well used to divert or withdraw water from bank storage.

(i) "Baseflow" means groundwater that seeps, flows, or is otherwise naturally discharged from an aquifer into a stream.

(j) "Baseflow allocation" means the annual quantity of water assigned to a baseflow node expressed in acre-feet per calendar year. The natural discharge to the stream shall be assumed to be equivalent to the rate of flow in the stream that is equaled or exceeded 90 percent of the time.

(k) "Baseflow node" means an artificial point located in the channel of a watercourse for the purpose of allocating a proportional amount of the baseflow.

(l) "Basin storage area" means the portion of the aquifer's unsaturated zone used for aquifer storage that has defined horizontal boundaries and is delimited by the highest and lowest index water levels.

(m) "Basin storage loss" means that portion of artificial recharge naturally flowing or discharging from the basin storage area.

(n) "Battery of wells" means either of the following:

(1) A group of two or more wells that meets the following conditions:

(A) Withdraws water from the same local source of supply;

(B) is connected to a common pump by a manifold or piping; and

(C) supplies water to a common distribution system; or

(2) a group of not more than four wells that meets the following conditions:

(A) Withdraws water from the same local source of supply;

(B) is located within a 300-foot-radius circle of the geographic center of the battery of wells;

(C) supplies water to a common distribution system;

(D) does not exceed a combined capacity of 800 gallons per minute; and

(E) has an individual pump installed in each well with a maximum capacity of 400 gallons per minute.

A battery of wells shall be considered to be one point of diversion.

(o) "Board" means the board of directors constituting the governing body of the Equus Beds groundwater management district no. 2.

(p) "Completed substantially as shown on aerial photograph, topographic map, or plat" means within 300 feet of the location as shown on the aerial photograph, topographic map, or plat accompanying the application.

(q) "Confined aquifer" means either of the following:

(1) An aquifer overlain and underlain by impermeable layers; or

(2) an aquifer in which the groundwater is under pressure greater than atmospheric pressure and will rise in a well above the elevation at which groundwater is first encountered.

(r) "Conjunctive use" means the management of the aquifer to achieve safe yield and the operation of the aquifer in coordination with a surface water system to enhance the use of the total water supply availability, in accordance with the provisions of the Kansas water appropriation act.

(s) "Consumptive use" means gross diversion minus the following:

(1) Waste of water; and

(2) return flows to the source of water supply by at least one of the following:

(A) Through the surface water runoff that is not waste; and

(B) by deep percolation.

(t) "District" means the Equus Beds groundwater management district no. 2.

(u) "Free-water surface" means water that is exposed to the atmosphere, including lakes, ponds, and pits that intercept the water table.

(v) "Geographic center" means either of the following:

(1) The arithmetic mean of the northing and westing coordinates or measurements for each well in a battery of wells; or

(2) the apparent center of a groundwater pit.

(w) "Groundwater" means water below the surface of the earth.

(x) "Groundwater pit" means an excavation in the earth that meets all of the following criteria:

(1) Exposes the current or historic groundwater table;

(2) has caused, or will likely cause, annual evaporation of groundwater; and

(3) has a perimeter equal to or greater than the depth of the excavation.

(y) "Index water level" means water-level elevations established spatially throughout a basin storage area to be used to represent the maximum volume of a basin storage area and the volume of stored water available for recovery, based upon accounting methodology and the conditions of the permit.

(z) "Non-consumptive use" means the beneficial use of water in which essentially all of the water diverted from the source of supply is returned to the source of supply.

(aa) "Person" means a natural person, a partnership, an organization, a corporation, a municipality, and any agency of the state or federal government.

(bb) "Point of diversion" means the point at which water is diverted or withdrawn from a source of water supply.

(cc) "Primary well" means a well equipped with a flowmeter for which a standby well is available.

(dd) "Recharge" means the natural infiltration of surface water or rainfall into an aquifer from its catchment area.

(ee) "Recharge credit" means the quantity of water that is stored in a basin storage area and that is available for subsequent appropriation for beneficial use by the operator of the aquifer storage and recovery system.

(ff) "Safe yield" means the total quantity of groundwater meeting the following conditions:

(1) Can be artificially withdrawn from an aquifer; and

(2) naturally discharges to a stream without exceeding the aquifer recharge value for the area of consideration and without impairing the water rights diverting from the aquifer.

(gg) "Standby well" means a well that meets the following conditions:

(1) Is used to provide water for any of the following:

(A) Fire protection;

(B) emergency purposes; or

(C) any period during which the primary well has mechanical failure, maintenance, or power failure;

(2) is maintained in good operating condition;

(3) withdraws water from the same source of supply as the primary well;

(4) is located within 300 feet of the primary well;

(5) is limited to the same rate and quantity authorized by the primary well's appropriation or vested right;

(6) is equipped with a flowmeter; and

(7) is operated only when water is temporarily unavailable from the primary well or wells, except when water is needed for fire protection or a similar type of emergency.

(hh) "Stream" means any watercourse that has a well-defined bed and well-defined banks, and that flows continuously during the calendar year, except during periods of drought.

(ii) "Surface water" means water in creeks, rivers, or other watercourses, and in reservoirs, lakes, and ponds. This term shall not include water in groundwater pits.

(jj) "Thermal exchange" means the use of water for climate control in a nondomestic building and in a manner that is essentially nonconsumptive to the source of supply.

(kk) "Unconfined aquifer" means an aquifer with a water table at atmospheric pressure.

(ll) "Waste of water" means any act or omission that causes any of the following:

(1) The diversion or withdrawal of water from a source of supply that is not used or reapplied to a beneficial use on or in connection with the place of use authorized by a vested right, an appropriation right, or an approval of application for a permit to appropriate water for beneficial use;

(2) the unreasonable deterioration of the quality of water in any source of supply, thereby causing impairment of a person's right to the use of water;

(3) the escaping and draining of water intended for irrigation use from the authorized place of use; or

(4) the application of water to an authorized beneficial use in excess of the needs for this use.

(mm) "Water balance" means the method of determining the amount of water in storage in a basin storage area by accounting for inflow to, outflow from, and changes in storage in that basin storage area.

(nn) "Water table" means the top or surface of an unconfined or confined aquifer at which the pore water pressure is atmospheric.

(oo) "Well" means any excavation that is drilled, cored, bored, washed, driven, dug, or otherwise constructed if the intended use of the excavation is for the acquisition, diversion, or artificial recharge of groundwater. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective May 1, 1979; amended Oct. 15, 1990; amended March 7, 1994; amended Nov. 12, 2004.)

5-22-2. Well spacing requirements. (a) Except as specified in subsections (d) and (e), the minimum spacing of all nondomestic and nontemporary wells described in an application for permit to appropriate water for beneficial use, an application for a term permit, or application to change the point of diversion shall be the following:

(1) 1,320 feet from all nondomestic wells, groundwater pits, and baseflow nodes; and

(2) 660 feet from all domestic wells.

(b) The minimum spacing interval from the geographic center of a battery of wells to each nondomestic well, groundwater pit, and baseflow node shall be 1,620 feet. The minimum spacing interval from the geographic center of a battery of wells to each domestic well shall be 960 feet.

(c) The minimum spacing interval from the edge of a groundwater pit to each nondomestic well, the edge of any other groundwater pit, and baseflow node shall be 1,320 feet and 330 feet to a domestic well.

(d)(1) In the areas described in the following table, the requirements specified in paragraphs (2), (3), and (4) of this subsection shall apply:

Township	Range	Section	County
23 South	6 West	31, 32 and 33	Reno
23 South	7 West	31 through 36	Reno
24 South	6 West	4 through 9, and 13 through 36	Reno
24 South	7 West	1 through 36	Reno
25 South	5 West	30 and 31	Reno
25 South	6 West	1 through 36	Reno
25 South	7 West	1 through 36	Reno
26 South	5 West	6, 7, and 8; 17 through 21; and 27 through 35	Reno
26 South	6 West	1 through 36	Reno
26 South	7 West	1 through 36	Reno

(2) The minimum spacing of all nondomestic and nontemporary wells with an authorized rate of diversion of 401 gallons per minute or more, as described in an application for permit to appropriate water for beneficial use, term permit, or application to change the point of diversion, shall be the following:

(A) 2,640 feet from all other nondomestic wells, groundwater pits, and baseflow nodes; and

(B) 660 feet from all domestic wells.

(3) The minimum spacing of a battery of wells with a total authorized rate of diversion of 401 gallons per minute or more, as described in an application for permit to appropriate water for beneficial use, term permit, or application to change the point of diversion shall be the following:

(A) 2,940 feet from all nondomestic wells, groundwater pits, and baseflow nodes; and

(B) 960 feet from all domestic wells.

(4) The minimum spacing interval from the

edge of a groundwater pit to each nondomestic well, the edge of any other groundwater pit, and baseflow node shall be 1,320 feet. The minimum spacing interval from the edge of a groundwater pit to a domestic well shall be 330 feet.

(e) The following types of wells shall not be subject to this well-spacing regulation:

(1) A standby well;

(2) a bank storage well;

(3) a well authorized pursuant to the approval of an application to change the point of diversion that meets both of the following conditions:

(A) The number of wells comprising the point of diversion remains unchanged; and

(B) each point of diversion is proposed to be relocated 300 feet or less from the currently authorized location;

(4) the minimum spacing interval of nondomestic wells to domestic wells, if the domestic well owner has granted written permission to reduce the spacing interval; and

(5) the minimum spacing interval of groundwater pits to nondomestic, nontemporary, or domestic wells, if the well owner has granted written permission to reduce the spacing interval. (Authorized by and implementing K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5; effective May 1, 1979; amended Oct. 15, 1990; amended March 7, 1994; amended Jan. 10, 2003.)

5-22-3. Waste of water. It shall be a violation of these rules and regulations for any person, private corporation, public corporation, municipality, company, institution, township, county, state agency or federal agency to waste water as defined in these regulations. (Authorized by K.S.A. 1978 Supp. 82a-1028(o); effective May 1, 1979.)

5-22-4. Metering. (a) Each water flowmeter, gauge, or other measuring device required by the district shall meet the minimum specifications adopted by the chief engineer by regulation.

(b) The owner of the water right or approval of application shall perform the following:

(1) Ensure that the water flowmeter is properly installed in accordance with the specifications adopted by the chief engineer by regulation;

(2) maintain the water flowmeter in satisfactory working condition whenever the diversion works can reasonably be expected to operate; and

(3) ensure that the water flowmeter measures all of the discharge from the diversion works and does not measure any other discharge, including tailwater and sewage lagoon effluent. (Authorized by and implementing K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5; effective May 1, 1979; amended Oct. 15, 1990; amended Jan. 10, 2003.)

5-22-4a. Water flowmeter requirement. Each nondomestic, nontemporary well meeting any of the following conditions shall be equipped with a water flowmeter that meets or exceeds the requirements of K.A.R. 5-22-4:

(a) A well operated under the authority of an approval of application issued on or after September 1, 1987;

(b) a well operated under the approval of an application for change in the place of use, the point of diversion, or the use made of the water, or any combination of these, filed after September 1, 1987;

(c) a well that meets the standards for being a standby well as set forth in K.A.R. 5-22-1;

(d) a well for which a certificate of appropriation was issued on or after July 1, 1995; or

(e) a well for which the board determines it is necessary to have a water flowmeter to ensure any of the following:

(1) The accuracy of reported water use;

(2) compliance with the terms, conditions, and limitations of the water right, approval of application, or approval of change; or

(3) nonimpairment of other water rights. (Authorized by and implementing K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5; effective Jan. 10, 2003.)

5-22-4b. Water flowmeter maintenance. (a) If a water flowmeter required by the district is ever out of compliance, the owner shall promptly repair or replace the water flowmeter, or correct any problems with the installation.

(b) A water flowmeter shall be considered to be out of compliance if any of the following conditions is met:

(1) The water flowmeter registers less than 94 percent or more than 106 percent of the actual volume of water passing the water flowmeter. If necessary, this determination may be made by a field test conducted or approved by the chief engineer.

(2) The seal placed on the totalizer by the manufacturer or the manufacturer's authorized representative has been broken, or the totalizer value has been reset or altered without the authoriza-

tion of the manufacturer, an authorized representative of the manufacturer, or the chief engineer.

(3) A seal placed on the water flowmeter or totalizer by the chief engineer has been broken.

(4) The water flowmeter register is not clearly visible or is unreadable for any reason.

(5) There is not full pipe flow through the water flowmeter.

(6) The flow-straightening vanes have not been properly designed, manufactured, and installed.

(7) The water flowmeter is not calibrated for the nominal size of the pipe in which the flowmeter is installed.

(8) The water flowmeter is not installed in accordance with the manufacturer's installation specifications. However, five diameters of straight pipe above the water flowmeter sensor and two diameters below the water flowmeter sensor shall be deemed the minimum required spacing, regardless of the manufacturer's installation specifications.

(9) A water flowmeter is installed at a location where the flowmeter does not measure all of the water diverted from the source of supply. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective Nov. 12, 2004.)

5-22-4c. Water flowmeter testing by a nondistrict person. If a water right owner desires to have a water flowmeter flow rate test performed by a person other than district staff to comply with any requirement of the district, that person may be approved by the board to perform a water flowmeter flow rate test if the person demonstrates to the district both of the following: (a) The person has the training, skills, and experience necessary to properly conduct the test.

(b) The person has the appropriate water flowmeter to perform the test, and the water flowmeter has been tested for accuracy with water flowmeter test equipment that has been found to be accurate using standards traceable to the national institute of standards and technology (NIST). The equipment shall have been tested and found to be accurate within 12 months of performing the water flowmeter test. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective Nov. 12, 2004.)

5-22-4d. Water flowmeter installation procedures. (a) If installation of a water flowmeter is required by the board, the owner of the approval of application or the water right shall be notified of the requirement in writing.

(b) A water flowmeter shall be installed on a new or replacement point of diversion within 30 days after the point of diversion is operational, or before the diversion of water, whichever occurs first.

(c) A water flowmeter shall be installed on an existing point of diversion within 30 days of the issuance of the water flowmeter order by the district, or before the diversion of water, whichever occurs first.

(d) An extension of time to install the water flowmeter may be granted by the board if a request for an extension of time is filed with the district before the expiration of the time to install the water flowmeter and one of the following conditions is met:

(1) The water right owner has a contract with a vendor to install a water flowmeter, but the vendor cannot complete the installation within the time allowed.

(2) Weather, site conditions, or other conditions beyond the control of the owner prevent the water flowmeter from being installed within the time allowed.

(3) The owner demonstrates any other reason constituting good cause why the water flowmeter cannot be installed within the time allowed and that granting of an extension of time will not be adverse to the public interest.

(e) The water right owner shall notify the district within 30 days after the required water flowmeter is installed. The notification shall be submitted on a form prescribed by the district.

(f) An inspection of the water flowmeter installation may be made by the district to determine if the water flowmeter has been properly installed in accordance with the requirements of K.A.R. 5-22-4, K.A.R. 5-22-4a, and K.A.R. 5-22-4b.

(g) If an inspection is made by the district, the owner shall be notified by the district of the results of the inspection in writing. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective Nov. 12, 2004.)

5-22-5. (Authorized by K.S.A. 82a-1028(o); implementing K.S.A. 82a-1028(n); effective May 1, 1980; amended Oct. 15, 1990; revoked Jan. 10, 2003.)

5-22-6. Noncompliance; penalties; appeal procedures. (a) Any person may file with the board a written or verbal complaint that some-

one is allegedly violating any regulation of the district, any provision of the Kansas water appropriation act, or a term, condition, or limitation of an approval of application or a water right.

(b) The alleged violation shall be investigated by the district staff.

(c) A written report of the investigation shall be prepared by the district staff.

(d) If the investigation determines that a violation of a regulation of the district has occurred, an order shall be issued by the board or its designee. The order shall specify the following:

(1) What the violation of the regulation is;

(2) what actions are necessary to correct the violation;

(3) what a reasonable time is for correcting the violation. Extensions of time to correct a violation may be granted by the board if good cause is shown by the violator or owner;

(4) that the order will become effective immediately; and

(5) that a hearing may be requested within 15 days of the issuance of the order. The request for a hearing may include a request for a stay of the order. If the person shows good cause why a stay should be granted, a stay may be granted by the board.

(e) The owner or owners of the approval of application or water right, as shown in the records of the district, shall initially be notified of the violation verbally, in writing, or by other means. Regardless of the means of initial notification, a copy of the order shall also be served by delivering a copy of the order in person or by restricted mail.

(f) The record of the complaint, the investigation, and the notice of violation shall be made a part of the official records of the district.

(g) If the violation is corrected by the deadline specified by the board, the violator shall notify the district staff. An inspection shall be conducted by the district staff to determine if the violation has been corrected. If the violation has been corrected, the diversion of water may continue within the terms, conditions, and limitations of the approval of application or water right.

(h) If the violation is not corrected by the deadline specified by the board, an order requiring that unauthorized or illegal diversion of water cease until the violation is corrected shall be issued by the district.

(i) If the violator ceases diversion of water and then corrects the violation, the violator shall notify the district when the violation is corrected. The diversion works and the authorized place of use, as appropriate, shall be inspected by the district staff to determine whether the violation has been corrected. If the board determines that the violation has been corrected, the order prohibiting the diversion of water shall be rescinded by the board. When the owner or violator receives notice from the district that the order prohibiting the diversion of water has been rescinded, the diversion of water may recommence.

(j) If the violator performs any act described in subsection (a), any of the following actions may be taken by the board:

(1) If applicable, bring an injunctive action to enforce the order of the district;

(2) if applicable, request enforcement assistance from the chief engineer;

(3) if applicable, request that criminal proceedings be brought pursuant to K.S.A. 82a-728, and amendments thereto;

(4) if applicable, request that the county attorney or district attorney initiate injunctive remedies pursuant to K.S.A. 68-184, and amendments thereto, to prevent the occurrence of a nuisance;

(5) enter into a consent order with the violator specifying the remedial actions that shall be taken by the violator;

(6) require the installation of a water flowmeter;

(7) take any other legally permissible enforcement action; or

(8) any combination of the actions specified in paragraphs (j)(1) through (7).

(k) After the violator has been issued an order as specified in subsection (d), the violator, or anyone whose legal rights, duties, privileges, immunities, or other legal interests could be affected by the order, may appeal the order to the board. The appeal shall be filed within 15 days of the issuance of the order.

(l) The appeal petition shall state the basis for the appeal and shall be accompanied by documentation supporting the appeal.

(m) During the appeal, any relevant information or data may be considered by the board, including relevant data and information submitted by any person whose legal rights, duties, privileges, immunities, or other legal interests could be affected by the order.

(n) After consideration of the appeal, one of the following actions shall be taken by the board:

(1) Remand the matter to the district staff with instructions for additional investigation; or

(2) notify the violator and the chief engineer of

the board's final decision. The violator and all other parties shall be notified of the board's decision by certified mail.

(o)(1) Within 15 days after the service of the board's decision on the violator and any other affected party, the violator or any other affected party may file with the board a written request for reconsideration, which shall state the specific grounds for the request for reconsideration. The petition for reconsideration shall be deemed denied if not acted on by the board within 30 days.

(2) If the request for reconsideration is granted by the board, an administrative hearing shall be held by the board within 30 days of the date on which the request is filed with the board. After the hearing, the board may affirm, reverse all or part of, or modify the order of the board. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective May 1, 1980; amended Dec. 10, 2004.)

5-22-7. Safe yield. (a) Except as set forth in subsection (b), the approval of each application for a change in the point of diversion, term permit, and permit to appropriate water for beneficial use shall be subject to the following requirements:

(1) The sum of prior appropriations, including the proposed application, vested rights, appropriation rights, term permits and earlier priority applications and baseflow nodes, shall not exceed the allowable safe-yield amount for the area of consideration. The non-consumptive use of groundwater previously authorized by the chief engineer shall be excluded from the sum of prior appropriations.

(2) The quantity authorized on all prior permits, certificates, and vested rights, the quantity requested on prior applications, and the quantities allocated to baseflow nodes shall be used to calculate the sum of prior appropriations and baseflow allocations.

(3) All conditions and limitation clauses listed on all prior appropriations and applications in the area of consideration shall be considered in effect.

(4) The baseflow allocation for baseflow nodes shall be calculated using the formula Qa = T/N where:

(A) Qa is the baseflow allocation per baseflow node in acre-feet per year;

(B) T is the total baseflow allocation for a reach of a stream in acre-feet per calendar year. T is the average of the 12 calendar months' daily flow values in cubic feet per second that were equaled or exceeded 90 percent of the time during a specifically designated hydrologically significant period of record, times a factor of 724; and

(C) N is the number of baseflow nodes established on a stream or reach of a stream. Nodes are located at the upstream end of the watercourse reach and thereafter at the intersection of the channel of a watercourse and an arc of a 1,320 foot-radius circle whose center is located on the previously established baseflow node.

(5) The allowable safe-yield amount shall be calculated using the formula $S = A \times K$ where:

(A) S is the allowable safe-yield amount in acre-feet per year;

(B) A is the area of consideration; and

(C) K is an aquifer recharge value in feet. Everywhere in the district, except in McPherson county, K is equal to 0.5 feet per year. In McPherson county, K is a constant equaling 0.25 feet per year. K is calculated by multiplying the recharge percentage, which is 10 percent in McPherson county and 20 percent for the rest of the district, times the average annual precipitation of 2.5 feet per year.

(6) When evaluating an application for a change in the point of diversion, each application with a priority earlier than the priority established by the filing of the application of change shall be included in the safe-yield analysis.

(7) If the perimeter of the area under consideration intersects a group of wells authorized under prior applications, permits, certificates, or vested rights, a reasonable quantity of water shall be assigned to each well based upon the best available information.

(b) The following shall not be subject to this regulation:

(1) An application to appropriate groundwater in an area not closed by regulation or intensive groundwater use control area order by the chief engineer to new non-domestic, non-temporary permits and term permits for five or fewer years, if all of the following conditions are met:

(A) The annual quantity of water requested in the application does not exceed 15 acre-feet;

(B) the sum of the annual quantity of water requested in the application and the total annual quantities of water authorized by prior approvals of applications allowed because of an exemption pursuant to this regulation does not exceed 45 acre-feet in a two-mile-radius circle surrounding the proposed point of diversion;

(C) the approval of the application does not au-

thorize an additional quantity of water out of an existing authorized point of diversion with a nondomestic approval of application or water right that would then authorize a total combined annual quantity of water from that point of diversion in excess of 15 acre-feet;

(D) the application complies with the well spacing criteria in K.A.R. 5-22-2; and

(E) the application complies with all other applicable regulations in effect when the application is filed;

(2) an application for a non-consumptive use of groundwater;

(3) an application for change in point of diversion, if the diversion works were completed:

(A) 300 feet or less from the originally authorized point of diversion;

(B) within 150 feet of the location approved by the chief engineer; and

(C) a notice of completion was timely filed with the chief engineer under the original approval of application;

(4) an application requesting only an additional rate of diversion on an existing well, if the approval of the application:

(A) Is limited to the maximum annual quantity of water authorized by a prior certified, vested, or appropriation right; and

(B) contains both of the following conditions:

(i) The approved application for additional rate shall be dismissed if the prior certified, vested, or appropriation right is dismissed and terminated; and

(ii) the approved or certified maximum annual quantity of water shall be reduced in an amount equal to any subsequent reduction in the maximum annual quantity of water authorized by the prior certified, vested, or appropriation right;

(5) an application for a standby well;

(6) an application for a bank storage well only to the extent that the bank storage well is withdrawing bank storage water; and

(7) an application for an aquifer storage and recovery well. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective May 1, 1983; amended Oct. 15, 1990; amended March 7, 1994; amended Nov. 12, 2004.)

5-22-8. Change applications. (a) Except as set forth in subsection (d), the approval of each application for a change in point of diversion for a vested right, appropriation right, permit, term permit, or an application to appropriate groundwater shall be subject to the following requirements:

(1) The maximum distance a replacement well can be located from the originally authorized location shall be 2,640 feet.

(2) A replacement well located more than 300 feet from the currently authorized location shall comply with the provisions of K.A.R. 5-22-2.

(3) An application for a change in point of diversion shall be accompanied by either a completed abandoned-well or inactive-well agreement if the original well will no longer be authorized by any other vested right, appropriation right, approval of application, or term permit and the well has not been properly physically adapted for, and actually used for, domestic use. The completed agreement shall be submitted by the applicant with the application for a change in point of diversion on a form prescribed by the district.

(4) Each point of diversion described in the application shall be equipped with a water flowmeter that meets or exceeds the criteria of K.A.R. 5-22-4, K.A.R. 5-22-4a, K.A.R. 5-22-4b, and K.A.R. 5-22-4d.

(b) The approval of each application for a change in place of use or the use made of water for a vested right, appropriation right, approval of application, and term permit shall have a condition that a water flowmeter that meets or exceeds the requirements of K.A.R. 5-22-4, K.A.R. 5-22-4a, K.A.R. 5-22-4b, and K.A.R. 5-22-4d be installed on each point of diversion described in the application.

(c) Except as specified in subsection (d), each approval of application for a change in place of use for irrigation purposes shall be subject to the following requirements:

(1) If the time to perfect the water right has expired, the water right shall be certified before the change application may be approved.

(2) The approval of the application for change in place of use shall not authorize an increase in the size of the authorized place of use in excess of the limits specified in K.A.R. 5-5-11(b).

(d) An application for change in place of use for irrigation purposes filed only for the purpose of creating an identical place of use with another water right or rights shall not be subject to subsection (c) if all of the following conditions are met:

(1) There is not a net increase in the number of authorized acres.

(2) Each water right involved in the proposed

identical overlap in place of use is certified by the chief engineer before processing the change application if approval of the change application would authorize an increase in base acreage as defined in K.A.R. 5-5-11(a).

(3) The total quantity authorized by all existing water rights and all permits involved is reasonable to irrigate the land authorized after the change in place of use is approved. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective Oct. 15, 1990; amended March 7, 1994; amended Nov. 12, 2004.)

5-22-9. Exceptions. Each recommendation timely submitted by the district concerning an exemption from, or waiver to, a regulation adopted by the chief engineer shall be considered by the chief engineer. An exception to these regulations may be granted by the chief engineer if the applicant demonstrates that the exception will neither impair a use under an existing right nor prejudicially affect the public interest. (Authorized by K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective Oct. 15, 1990; amended Nov. 12, 2004.)

5-22-10. Aquifer storage and recovery system: data reporting requirements. (a) Each person operating an aquifer storage and recovery system of which all or part of is within the boundaries of the district shall file an annual report with the district no later than June 1 for the previous calendar year. The report shall contain the water balance in the basin storage area and, in addition to the information required by K.A.R. 5-12-2, information about the following, as specified:

(1) Source water:

(A) The type;

(B) the quantity of water available;

(C) the quantity of water surface water and bank storage water diverted;

(D) the basin storage loss; and

(E) the chemical, physical, radiological, and biological quality for each type of source water diverted;

(2) aquifer storage:

(A) The artificial recharge techniques used;

(B) the quantity of source water recharged by each technique used;

(C) the total quantity of source water stored in the basin storage area; and

(D) the chemical, physical, radiological, and biological quality for each type of water stored;

(3) recovery of stored water:

(A) A monthly and annual summary of recharge credits withdrawn from each recovery well; and

(B) the chemical, physical, radiological, and biological quality of the water recovered; and

(4) hydrologic conditions:

(A) The quarterly index water levels;

(B) the key groundwater quality parameters;

(C) the monthly and annual precipitation quantities;

(D) the annual groundwater withdrawals from all wells except domestic wells;

(E) the annual streamflow, including baseflows and above-baseflow stage;

(F) a summary of the conjunctive use amounts; and

(G) the water supply and demand forecast for the next three years.

(b) The operator of the aquifer storage and recovery system shall furnish the district with whatever analyses, data, and other supporting documentation are necessary to understand and verify the report.

(c) The board shall review the report and submit its findings and recommendations to the chief engineer regarding the report no later than September 1 of the calendar year in which the report is required to be filed. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective Dec. 10, 2004.)

5-22-12. Application processing requirements and procedures. (a) Except as provided in subsection (c), each application for any of the following shall be subject to the requirements and procedures in subsection (b):

(1) Appropriate water for beneficial use;

(2) change the point of diversion, the use made of water, the place of use, or any combination of these; or

(3) obtain a term permit.

(b)(1) Before final action is taken on an application, a copy of the application shall be submitted by the chief engineer to the district for review and recommendation.

(2) The district staff shall conduct a review of the proposed application. The district staff's recommendation to the chief engineer shall be consistent with the provisions of the Kansas water appropriation act, the groundwater management district act, and the regulations adopted by the chief engineer pursuant to those acts.

(3) Within 15 working days after the date the

chief engineer submits the application to the district for review, or any extension of time approved by the chief engineer, the district staff shall submit to the chief engineer its findings and recommendation for approval, denial, or modification of the application and shall specify the basis for the recommendation. At the same time the district submits its recommendation to the chief engineer, the recommendation shall also be served on the applicant and any other parties to the proceedings.

(4) A district staff's findings and recommendation concerning an application may be appealed to the board by the applicant or anyone whose legal rights, duties, privileges, immunities, or other legal interests may be affected by approval, denial, or modification of the application.

(5) The petition for review by the board shall be filed by the party appealing the recommendation with the board within 30 days after the date of the letter sending the findings and recommendations by the staff of the district to the applicant or other party. The petition shall state the basis for the appeal and shall be accompanied by documentation supporting the appeal.

(6) During the appeal, any relevant information or data may be considered by the board, including relevant data and information submitted by a person whose legal rights, duties, privileges, immunities, or other legal interests may be affected by approval, denial, or modification of the application.

(7) After consideration of the appeal, one of the following actions shall be taken by the board:

(A) Remanding the matter to the district staff with instructions for additional investigation; or

(B) notifying the applicant and the chief engineer of the board's final recommendation. The applicant and all other parties shall be notified of the board's decision by certified mail.

(8) Within 15 days after the service of the board's decision on the applicant and any other party, the applicant or any other party may file with the board a written request for reconsideration, which shall state the specific grounds for the request for reconsideration. The petition for reconsideration shall be deemed denied if not acted on by the board within 30 days.

(c) The following shall not be subject to this regulation:

(1) The domestic use of water;

(2) an application for a temporary permit; and

(3) an application to change the point of diversion if both of the following conditions are met:

(A) The point of diversion is proposed to be moved less than 300 feet; and

(B) the point of diversion is not a battery. (Authorized by and implementing K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5; effective Jan. 10, 2003.)

5-22-13. Potential net evaporation. (a) The map titled "annual potential net evaporation in inches for Equus Beds groundwater management district no. 2 (annual average evaporation minus annual normal precipitation)," prepared by the district and dated June 11, 2002, is hereby adopted by reference for the purpose of determining potential net evaporation from a free-water surface within the district.

(b) The values on the map shall be used in all situations in which the determination of potential net evaporation from a free-water surface is necessary, including the following:

(1) Computing the annual amount of evaporation that will be caused by exposing the groundwater table;

(2) calculating the quantity of surface water that is reasonably expected to be replaced with groundwater pumped under an approval of application or water right;

(3) calculating the average annual evaporation from groundwater that will be used to determine annual water use; and

(4) determining the maximum annual quantity of water that is perfected pursuant to K.S.A. 82a-714, and amendments thereto.

(c) The values shown on the map shall be used unless the applicant provides, or the chief engineer or the district has available, better or more site-specific data concerning potential net evaporation. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective Dec. 10, 2004.)

5-22-14. Maximum reasonable quantity for beneficial use. (a) The maximum annual quantity of water deemed reasonable for irrigation use shall be the following:

(1) 1.3 acre-feet per acre in Harvey, McPherson, and Sedgwick counties; and

(2) 1.4 acre-feet per acre in Reno county.

(b) The following quantities shall be used to determine the maximum annual quantity of water deemed reasonable for nondomestic livestock and poultry use:

Livestock or poultry	Drinking water (gallons per day)	Units
Cattle, beef	15	per head
Cattle, dairy	35	per head
Swine finishing nursery sow and litter gestating sow	 5 1 8 6	per head
Sheep	2	per head
Horses	12	per head
Poultry chickens turkeys	 9 30	 100 layers 100 turkeys
Calves (750 pounds or less)	10	per head
Goats	9	per head

(c) The maximum reasonable quantity of water that may be approved for nondomestic livestock and poultry use for applications approved on or after the effective date of this regulation shall be limited as specified in subsection (b), unless the applicant demonstrates with adequate supporting information that the quantity of water and rate of diversion requested meet the following conditions:

(1) Are reasonable for the intended use;

(2) are not wasteful; and

(3) will not otherwise prejudicially and unreasonably affect the public interest.

(d) For all other types of nondomestic livestock, poultry, birds, and animals, the maximum quantity of water approved for beneficial use shall be reasonable. The applicant shall justify the quantity of water requested with information on peer water use, the historical measured usage, a professional recommendation, or any other relevant information.

(e) Each applicant who seeks to appropriate water for industrial use shall submit information to demonstrate that the annual quantity of water requested is reasonable for that particular type of industrial use. The information submitted shall include the quantity of water reasonable for that type of industrial use based on current industry standards and a use of technology that is economically and technically feasible for that industry at that location.

(f) Unless the applicant demonstrates a projected deviation from actual population trends, a reasonable annual quantity of water for municipal use shall not exceed the lessor of either of the following:

(1) 200 gallons per capita per day; or

(2) 110 percent of the last three years' average per capita per day usage, excluding industries that use over 200,000 gallons per year, times 365 days per year, times the projected population for the twentieth year after the application is filed, plus reasonable projected water use for industries that use over 200,000 gallons per year. Population projections shall be made using one of the following:

(A) Accepted statistical methods using historic population trends for the applicant; or

(B) data from the U.S. census bureau, Kansas water office population projections, or the Kansas census bureau. Projected deviations from historic population trends shall be justified by the applicant.

(g) The maximum annual quantity of water deemed reasonable to be provided from a well to a pond, lake, or reservoir that does not expose the current or historical water table shall be calculated using the formula $Q_c = [(E+S)/12] \times A_{sw} + F$ where:

(1) Q_c is the maximum quantity of water use in acre-feet;

(2) E is the potential net evaporation in inches per year;

(3) S is the seepage loss based on soil and subsoil in inches per year;

(4) A_{sw} is the surface area of the pond in acres as measured at the elevation of the lowest uncontrolled spillway; and

(5) F is the quantity of water in acre-feet necessary to fill the pond initially.

(h) The maximum annual quantity of water deemed reasonable to replace the evaporation from a groundwater pit shall be calculated using the formula $Q_c = (E/12) \times A_{wt}$ where:

(1) Q_c is the maximum annual quantity of evaporation of groundwater from the pit in acre-feet;

(2) E is the potential net evaporation in inches per year; and

(3) A_{wt} is the area of the water table exposed in the groundwater pit expressed in acres. (Authorized by and implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective Dec. 10, 2004.)

5-22-15. Limitations on the use of fresh groundwater. (a) Fresh groundwater shall not be used for any of the following purposes, unless the

applicant demonstrates before approval of the application that the use of other waters is not technologically or economically feasible:

(1) The enhanced recovery of oil or gas;

(2) solution mining;

(3) the construction of storage caverns in subsurface salt deposits;

(4) the displacement and extraction of hydrocarbons from subsurface storage;

(5) any use that is not a beneficial use, as defined in K.A.R. 5-1-1; and

(6) any use that is not in the public interest.

(b) "Other waters" shall include the following:

(1) Water having a chloride content of more than 500 milligrams per liter (mg/l);

(2) water that is otherwise contaminated so that it is not drinkable;

(3) renewable surface water; and

(4) water that is being reclaimed, recycled, or reused. (Authorized by K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; implementing K.S.A. 82a-706a, K.S.A. 2003 Supp. 82a-711, and K.S.A. 2003 Supp. 82a-1028; effective Dec. 10, 2004.)

5-22-17. Bank storage wells. (a) Each applicant for one or more bank storage wells shall demonstrate all of the following:

(1) The hydraulic connection from the streambed and banks to each bank storage well screen is sufficient to transmit bank storage water from the bed and banks of the stream to each bank storage well screen at a rate sufficient to sustain the authorized rate of diversion of the well or wells.

(2) Within seven days after the pumping of all bank storage wells has ceased, the water level in each bank storage well, or a monitoring well located within 100 feet of that bank storage well, will recover to an elevation equal to or greater than the water level elevation immediately before the bank storage well began to pump, adjusted for any regional groundwater level changes not caused by the pumping of the bank storage well.

(3) The naturally occurring and artificially induced rate of infiltration from the bed and banks of the stream when bank storage is occurring will be sufficient to meet the following conditions:

(A) Equal or exceed the authorized rate of diversion of all of the bank storage wells;

(B) prevent impairment caused by all bank storage wells; and

(C) prevent groundwater mining caused by all bank storage wells.

(b) If an application for a bank storage well is approved by the chief engineer, the applicant shall install one or more water-level measurement tubes at locations that will allow adequate monitoring of groundwater quality and groundwater levels within the area where the annual cone of depression of the bank storage well or wells could be greater than 0.5 feet. Each water-level measurement tube shall be constructed and maintained in accordance with K.A.R. 5-6-13. (Authorized by K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2003 Supp. 82a-1028; effective Nov. 12, 2004.)

Article 23.—SOUTHWEST KANSAS GROUNDWATER MANAGEMENT DISTRICT NO. 3

5-23-1. Definitions. As used in these regulations, by the southwest Kansas groundwater management district in the implementation of the groundwater management district act, and by the division of water resources in the administration of the Kansas water appropriation act and the groundwater management district act, unless the context clearly requires otherwise, the following words and phrases shall have the meanings ascribed to them in this regulation. (a) "Confined aquifer" means an aquifer overlain and underlain by impermeable layers. Groundwater in a confined aquifer is normally under pressure greater than atmospheric pressure.

(b) "High plains aquifer" means the aquifer comprised of the undifferentiated Pleistocene-age deposits, Quaternary loess, alluvium, dune sand, the Ogallala formation, and deeper aquifers that are in vertical or horizontal hydraulic contact with the Ogallala formation.

(c) "Hydraulic contact" means the absence of an impermeable layer between aquifers.

(d) "Theis analysis" means the Theis non-equilibrium equation analysis described in pp. 108-113 in "ground water and wells: a reference book for the water-well industry," published in 1966 by Edward E. Johnson, Inc. The pages specified in this subsection are hereby adopted by reference.

(e) "Unconfined aquifer" means an aquifer in which the groundwater is exposed to the atmosphere through openings in the overlying materials. The upper surface of an unconfined aquifer is the water table.

(f) "Well" means any artificial excavation that is

drilled, cored, bored, washed, driven, dug, or otherwise constructed when the intended use of the excavation is for the acquisition, diversion, or artificial recharge of groundwater. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028(o); implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1981; amended May 1, 1985; amended Sept. 22, 2000; amended Feb. 27, 2004.)

5-23-2. Tailwater control and waste. No water user shall allow waste of water. If the water is re-used, the user shall apply the water consistent with the approved application to appropriate water for beneficial use, vested right or appropriation right. All water users shall construct and operate the water distribution systems in a manner as to prevent the waste of water, and shall do everything necessary and proper to preserve the quality of the groundwater resources within the district. (Authorized by K.S.A. 1980 Supp. 82a-1028(o); implementing K.S.A. 1980 Supp. 82a-1028(n); effective May 1, 1981.)

5-23-3. Minimum well spacing requirements: high plains aquifer. (a) (1) The minimum horizontal distance between each proposed nontemporary, nondomestic well and all other senior nontemporary, nondomestic wells diverting water from the high plains aquifer shall be determined from the following schedule.

Quantity per well (acre-feet per year)	Minimum well spacing requirement
15 or less	660 feet
16 - 200	1,300 feet
201 - 300	1,600 feet
301 - 400	1,900 feet
401 - 500	2,100 feet
more than 500	2,300 feet

(2) The minimum well spacing requirement shall be based on the maximum annual quantity of water. The required well spacing shall be the greater of either of the following:

(A) The minimum spacing for the total authorized and requested quantity of water for the proposed well; or

(B) the total authorized and requested annual quantity of water for the nontemporary, nondomestic well against which the spacing is being measured that is senior to the date on which the application was filed. If the quantity of water applied for includes a fraction of an acre-foot, the quantity of water shall be rounded down to the next whole number of acre-feet for the purpose of applying the table in this subsection.

(b) The location of a well or wells on an application for approval to change the point of diversion under an existing water right shall be no more than 2,640 feet from the currently authorized and completed point of diversion.

(c) A well shall be exempt from the minimum well spacing requirements of this regulation if the well meets either of the following conditions:

(1) The well is being replaced within 300 feet of the currently authorized point of diversion.

(2) The proposed replacement well location improves the spacing to all other wells for which the spacing requirement was not met on the date on which the application for a change in point of diversion was filed and continues to meet requirements for spacing to all wells for which the spacing requirement was met at the time the application for change in point of diversion was filed.

(d) No application for approval to change the point of diversion under an approved application for which the original well has not been drilled shall be approved if the location of the proposed point of diversion decreases the distance from the approved location to any other existing wells to less than the spacing requirement for new applications.

(e) Each nondomestic, nontemporary well shall be located a minimum of 660 feet from all domestic wells with a priority earlier than the date on which the change application was filed, unless all of the following conditions are met:

(1) The domestic well is owned by the applicant.

(2) The applicant signs a written request to waive the requirements for spacing to the domestic well.

(3) The applicant submits information documenting the location and depth of the domestic well and any other information necessary for the chief engineer to determine whether the domestic well is likely to be impaired.

(4) A Theis analysis or other hydraulic analysis shows that the domestic well is not likely to be impaired by the proposed well.

(f) In the case of a battery of wells, as defined in K.A.R. 5-1-1, the minimum horizontal distance shall be measured from the geographic center of the wells comprising the battery.

(g) The total annual quantity per well shall be the sum of all of the quantities authorized or requested by any water rights, permits, or applica-

tions requesting or authorizing that well as a point of diversion. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a, K.S.A. 2002 Supp. 82a-711, K.S.A. 2002 Supp. 82a-708b, and K.S.A. 82a-1028; effective May 1, 1981; amended May 1, 1985; amended Aug. 28, 1989; amended Sept. 30, 1991; amended Sept. 22, 2000; amended Feb. 27, 2004.)

5-23-3a. Minimum well spacing requirements: confined aquifers. (a)(1) The minimum horizontal distance between each proposed nontemporary, nondomestic well and all other senior nontemporary, nondomestic wells diverting water from a confined aquifer shall be determined from the following schedule.

Quantity per well (acre-feet per year)	Minimum well spacing requirement	Required distance from hydraulic contact point
15 or less	660 feet	2,640 feet
16 to 25	2,300 feet	1 mile
26 to 100	5,280 feet	2 miles
More than 100	10,560 feet	5 miles

(2) The minimum well spacing requirement shall be based on the authorized maximum annual quantity of water. The well spacing requirement shall be the greater of either of the following:

(A) The minimum spacing for the total authorized and requested annual quantity of water of the proposed well; or

(B) the total authorized and requested quantity of water for nontemporary, nondomestic well against which spacing is being measured that is senior to the date on which the application was filed.

The total annual quantity of water per well shall be the sum of all of the quantities authorized or requested by any water rights, approvals of applications, or applications requesting or authorizing that well as a point of diversion.

If the quantity of water applied for includes a fraction of an acre-foot, the quantity of water shall be rounded down to the next whole number of acre-feet for the purpose of applying the table in this subsection.

(b) In the case of a battery of wells, as defined in K.A.R. 5-1-1, the minimum horizontal distance shall be measured from the geographic center of the wells comprising the battery.

(c) A well penetrating both a confined and unconfined aquifer shall be constructed to prevent the vertical migration of water between the aquifers. A well diverting water from the Dakota aquifer system shall be constructed to prevent the vertical migration of water between the Dakota aquifer system and all other freshwater aquifers.

(d) The location of a well or wells on an application for approval to change the point of diversion under an existing water right shall be no more than 2,640 feet from the currently authorized and completed point of diversion.

(e) A well shall be exempt from the minimum well spacing requirements of this regulation if the well meets either of the following conditions:

(1) The well is being replaced within 300 feet of the currently authorized point of diversion.

(2) The proposed replacement well location improves the spacing to all other wells for which the spacing requirement was not met on the date on which the application for a change in point of diversion was filed and continues to meet requirements for spacing to all wells for which the spacing requirement was met at the time the application for change in point of diversion was filed.

(f) No application for approval to change the point of diversion under an approval of application for which the original well has not been drilled shall be approved if the location of the proposed point of diversion decreases the distance from the approved location to any other existing wells to less than the spacing requirements for a new application.

(g) Each nondomestic, nontemporary well shall be located a minimum of 1,320 feet from all domestic wells in the same or a hydraulically connected aquifer with a priority earlier than the date on which the change application was filed, unless all of the following conditions are met:

(1) The domestic well is owned by the applicant.

(2) The applicant signs a written request to waive the requirements for spacing to the domestic well.

(3) The applicant submits information documenting the location and depth of the domestic well and any other information necessary for the chief engineer to determine whether the domestic well is likely to be impaired.

(4) A Theis analysis or other hydraulic analysis shows that the domestic well is not likely to be impaired by the proposed well.

(h) The minimum horizontal distance between a nontemporary, nondomestic well withdrawing water from a confined aquifer and a well withdrawing water from an unconfined aquifer shall

be 660 feet. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a, K.S.A. 2002 Supp. 82a-711, K.S.A. 2002 Supp. 82a-708b, and K.S.A. 2002 Supp. 82a-1028; effective Sept. 22, 2000; amended Feb. 27, 2004.)

5-23-4. Safe yield: high plains aquifer. (a) Except as set forth in subsection (b), the approval of all applications for a permit to appropriate water from the high plains aquifer, and the approval of all applications for a change in the point of diversion if the diversion works have not been completed under the original approved application, shall be processed in accordance with K.A.R. 5-3-9, K.A.R. 5-3-10, and K.A.R. 5-3-11. For the purpose of applying K.A.R. 5-3-11 (d)(3) within the boundaries of the district, the percentages of the calculated recharge that shall be considered to be available for appropriation shall be determined using the following table:

Percent of Calculated Recharge Available for Appropriation	River Basin
(A) 75 %	Arkansas
(B) 75 %	Cimarron River
(C) 75 %	Crooked Creek
(D) 75 %	North Fork Cimaron River

(b) This regulation shall not apply to the following:

(1) Wells for domestic use;

(2) wells authorized by temporary permits;

(3) wells authorized by term permits of fewer than five years;

(4) an application to appropriate 15 acre-feet of water or less if all of the following conditions are met:

(A) The safe yield has been exceeded, but the sum of the annual quantity requested by the proposed appropriation and the total quantities authorized by prior permits because of this exemption does not exceed 15 acre-feet in a circle with a radius of ½ mile surrounding the proposed point of diversion.

(B) Well spacing criteria have been met.

(C) Approval of the application will not authorize an additional quantity of water out of an existing well authorized by a nondomestic approval of application or water right, which would result in a total combined annual quantity of water authorized from that well in excess of 15 acre-feet.

(D) All other criteria for processing a new application have been met.

(c) Each application filed to request a well within the area described in subsection (e) shall include a driller's log, an electric log, and a laboratory analysis from a state-certified laboratory of the chloride concentrations in samples taken from whatever depths are necessary to determine the vertical location where the chloride concentrations exceed 250 milligrams per liter (mg/l). The samples shall be taken from a well located within a 300-foot radius of the proposed well. A state-certified laboratory analysis shall be used to determine the vertical location of the chloride concentrations exceeding 250 mg/l.

(d) Each well constructed in the area described in subsection (e) shall be constructed in a manner that prevents the movement of water containing 250 mg/l of chlorides beyond its naturally occurring condition.

(e) The level of chlorides may exceed 250 mg/l in the following areas:

(1) The west ½ of townships 33, 34, and 35 south, range 28 west in Meade County, Kansas;

(2) the east ½ of township 33 south, range 29 west in Meade County, Kansas;

(3) all of townships 34 and 35 south, ranges 29 and 30 west in Meade County, Kansas; and

(4) all of townships 34 and 35 south, ranges 31 and 32 west and the east ½ of townships 34 and 35 south, range 33 west in Seward County, Kansas. (Authorized by K.S.A. 82a-706a and 82a-1028; implementing K.S.A. 82a-706a, K.S.A. 2002 Supp. 82a-711, and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1981; amended May 1, 1986; amended Aug. 28, 1989; amended Sept. 22, 2000; amended Nov. 21, 2003.)

5-23-4a. Criteria for closing townships to new appropriations. (a) Entire townships shall be closed to further appropriation of water for beneficial use from the high plains aquifer if at least one of the following conditions exists:

(1) The entire township is fully appropriated.

(A) A township shall be considered to be fully appropriated if the aquifer within the township would be depleted by 40 percent or more in 25 years if current vested rights and appropriations are fully exercised and all limitation clauses listed on permits to appropriate water and certificates are in force.

(B) Aquifer depletion shall be calculated using the allowable annual appropriation formula de-

scribed in subsection (b) with the area of consideration equal to the number of acres within sections of land containing saturated thickness within the township.

(2) The average saturated thickness of the aquifer within the township is 50 feet or less, as set forth in K.A.R. 5-23-15.

(3) The aquifer has been depleted by 20 percent or more since 1950. Depletion since 1950 shall be determined from maps or data, or both, recommended by the board and adopted by the chief engineer by regulation.

(4) Groundwater pumping has lowered the water level of the high plains aquifer, which has diminished the baseflow from the aquifer to the stream and impaired senior domestic surface water rights and other senior surface water rights.

(5) Groundwater pumping in an area has lowered the water level of the freshwater to the point that the issuance of additional approvals of applications will induce water in excess of 250 milligrams per liter chlorides to mix with overlying freshwater, causing contamination of the overlying freshwater.

(b) Except for the types of wells listed in subsection (c), the proposed appropriation, when added to the vested rights, prior appropriation rights, and earlier priority applications, shall not exceed, in 25 years, a calculated rate of depletion of 40 percent of the saturated thickness underlying the area of consideration. For the purpose of analysis, all vested rights, appropriation rights, approvals of applications, and prior unapproved applications shall be considered to be fully exercised, and all limitation clauses on approvals of application and certificates shall be considered to be in force. The allowable annual appropriation shall be calculated using the following formula:

$$\text{Allowable Aquifer Yield} = \frac{0.40AMS}{25} + \frac{AR}{12}$$

Allowable aquifer yield = the amount of water, measured in acre-feet, available annually for appropriation from a proposed point of diversion (well).

A = the "area of consideration" shall be equal to the number of acres within sections containing saturated thickness within the township and within the district.

M = the number of feet of average saturated thickness of the high plains aquifer within the township as set forth in K.A.R. 5-23-15.

S = the storage coefficient or a specific yield of 15 percent.

R = average annual recharge and return flow, which shall be one inch per year.

(c) The calculation specified in subsection (b) shall not include the following types of wells:

(1) Wells for domestic use;

(2) wells authorized by temporary permits; and

(3) wells authorized by term permits of fewer than five years. (Authorized by K.S.A. 82a-706a and 82a-1028(o); implementing K.S.A. 82a-1028(n); effective Sept. 30, 1991; amended Sept. 22, 2000; amended Nov. 21, 2003.)

5-23-4b. Township closures. (a) The following townships have been determined to meet the criteria in K.A.R. 5-23-4a for closing a township to new appropriations of water from the high plains aquifer; therefore, no new appropriations of water shall be allowed from the high plains aquifer in the following townships, except as described in subsection (b):

County	Township	Range	County	Township	Range
Finney	21	30	Ford	26	21
Finney	21	31	Ford	26	22
Finney	21	32	Ford	26	23
Finney	21	33	Ford	26	24
Finney	21	34	Ford	26	25
Finney	22	30	Ford	26	26
Finney	22	31	Ford	27	21
Finney	22	32	Ford	27	22
Finney	22	33	Ford	27	23
Finney	22	34	Ford	27	24
Finney	23	27	Ford	27	25
Finney	23	28	Ford	27	26
Finney	23	29	Ford	28	21
Finney	23	30	Ford	28	22
Finney	23	31	Ford	28	23
Finney	23	32	Ford	28	24
Finney	23	33	Ford	28	25
Finney	23	34	Ford	28	26
Finney	24	31	Ford	29	21
Finney	24	32	Ford	29	22
Finney	24	33	Ford	29	23
Finney	24	34	Ford	29	24
Finney	25	31	Ford	29	25
Finney	25	32	Ford	29	26
Finney	25	33	Grant	27	35
Finney	25	34	Grant	27	36
Finney	26	31	Grant	27	37
Finney	26	32	Grant	27	38
Finney	26	33	Grant	28	35
Finney	26	34	Grant	28	36
Ford	25	21	Grant	28	37
Ford	25	22	Grant	28	38
Ford	25	23	Grant	29	35
Ford	25	24	Grant	29	36
Ford	25	25	Grant	29	37
Ford	25	26	Grant	29	38

County	Township	Range
Grant	30	35
Grant	30	36
Grant	30	37
Grant	30	38
Gray	24	27
Gray	24	28
Gray	24	29
Gray	24	30
Gray	25	27
Gray	25	28
Gray	25	29
Gray	25	30
Gray	26	27
Gray	26	28
Gray	26	29
Gray	26	30
Gray	27	27
Gray	27	28
Gray	27	29
Gray	27	30
Gray	28	27
Gray	28	28
Gray	28	29
Gray	28	30
Gray	29	27
Gray	29	28
Gray	29	29
Gray	29	30
Hamilton	25	42
Hamilton	25	43
Hamilton	26	39
Hamilton	26	40
Hamilton	26	41
Hamilton	26	42
Hamilton	26	43
Haskell	27	31
Haskell	27	32
Haskell	27	33
Haskell	27	34
Haskell	28	31
Haskell	28	32
Haskell	28	33
Haskell	28	34
Haskell	29	31
Haskell	29	32
Haskell	29	33
Haskell	29	34
Haskell	30	31
Haskell	30	32
Haskell	30	33
Haskell	30	34
Kearny	22	35
Kearny	22	36
Kearny	22	37
Kearny	22	38
Kearny	23	35
Kearny	23	36
Kearny	23	37
Kearny	23	38
Kearny	24	35
Kearny	24	36
Kearny	24	37
Kearny	24	38
Kearny	25	35
Kearny	25	36
Kearny	25	37
Kearny	25	38
Kearny	26	35
Kearny	26	36
Kearny	26	37
Kearny	26	38
Meade	30	26
Meade	30	27
Meade	30	28
Meade	30	29
Meade	30	30
Meade	31	26
Meade	31	27
Meade	31	28
Meade	31	29
Meade	31	30
Meade	32	28
Meade	32	29
Meade	32	30
Meade	33	28
Meade	33	29
Meade	33	30
Meade	34	28
Meade	34	29
Meade	34	30
Meade	35	28
Meade	35	29
Meade	35	30
Morton	31	39
Morton	31	40
Morton	31	41
Morton	31	42
Morton	31	43
Morton	32	39
Morton	32	40
Morton	32	41
Morton	32	42
Morton	32	43
Morton	33	41
Morton	33	42
Morton	33	43
Morton	34	42
Morton	34	43
Morton	35	39
Morton	35	40
Morton	35	41
Morton	35	42
Morton	35	43
Seward	31	31
Seward	31	32
Seward	31	33
Seward	31	34
Seward	32	31
Seward	32	32
Seward	32	33
Seward	32	34
Seward	34	31
Seward	34	32
Seward	34	33
Seward	35	31
Seward	35	32
Seward	35	33
Stanton	27	39
Stanton	27	40
Stanton	27	41
Stanton	27	42
Stanton	27	43
Stanton	28	39
Stanton	28	40
Stanton	28	41
Stanton	28	42
Stanton	28	43
Stanton	29	39
Stanton	29	40
Stanton	29	41
Stanton	29	42
Stanton	29	43
Stanton	30	39
Stanton	30	40
Stanton	30	41
Stanton	30	42
Stanton	30	43
Stevens	31	35
Stevens	31	36
Stevens	31	37
Stevens	31	38
Stevens	31	39
Stevens	32	35
Stevens	32	36
Stevens	32	39
Stevens	33	35
Stevens	33	38
Stevens	34	35
Stevens	34	38
Stevens	35	38
Stevens	35	39

(b) The closure of the townships to new appropriations of water from the high plains aquifer as listed in subsection (a) shall not apply to the following:

(1) Wells for domestic use;

(2) wells authorized by temporary permits;

(3) wells authorized by term permits of fewer than five years; and

(4) wells authorized by an application to appropriate 15 acre-feet of water or less if the following conditions are met:

(A) The allowable aquifer yield has been exceeded, but the sum of the annual quantity requested by the proposed appropriation and the total quantities authorized by prior permits because of this exemption does not exceed 15 acre-feet in a radius of ½ mile surrounding the proposed point of diversion.

(B) Well spacing criteria have been met.

(C) Approval of the application will not authorize an additional quantity of water out of an existing well authorized by a nondomestic approval of application or water right that would result in a total combined annual quantity of water authorized from that well in excess of 15 acre-feet.

(D) All other criteria for processing a new application have been met. (Authorized by K.S.A. 82a-706a and K.S.A. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective Sept. 22, 2000; amended Nov. 21, 2003.)

5-23-5. (Authorized by K.S.A. 1980 Supp. 82a-1028(o); implementing K.S.A. 1980 Supp. 82a-1028(n); effective May 1, 1981; revoked Nov. 21, 2003.)

5-23-6. Water-measuring devices. The

diversion works for each nontemporary, nondomestic well located within the boundaries of the district shall be equipped with a water flowmeter that meets or exceeds the specifications in K.A.R. 5-1-4 through 5-1-12.

(a) The owner shall perform the following:

(1) Ensure that the water flowmeter is installed according to specifications in K.A.R. 5-1-4 through 5-1-12;

(2) maintain the water flowmeter in proper working condition whenever the diversion of water for nondomestic use can reasonably be expected to occur; and

(3) promptly initiate action to repair or replace any water flowmeter that is out of compliance, and correct any problems with the installation of a water flowmeter.

(b) The owner shall notify the district, on a form prescribed by the district, within 30 days after any of the following:

(1) A new water flowmeter is installed.

(2) A water flowmeter is repaired and reinstalled.

(3) A water flowmeter is repaired without removing the water flowmeter.

(4) An improper water flowmeter installation has been corrected.

(c) An extension of time to install a water flowmeter may be granted by the district for a reasonable period of time if just cause is shown to the district. Each appeal shall be filed with the board at least 10 days before a regularly scheduled board meeting. Just cause may include any of the following:

(1) A contract has been signed by the owner and the seller to sell or install the water flowmeter, but the seller cannot complete the sale or installation before diversion of water will take place.

(2) Weather conditions prevent the water flowmeter from being installed before the diversion of water.

(3) Legal proceedings prevent the owner from installing the water flowmeter.

(4) The supply of natural gas to power the well has been cut off by the seller of the natural gas for reasons beyond the control of the owner of the water right.

(d) A water flowmeter shall not be required to be installed if any of the following criteria is met:

(1) A well is authorized to divert 15 acre-feet or less per calendar year.

(2) Two or more wells are authorized by the same water right or approval of application with one authorized annual quantity of water for all the wells, and all of the water diverted by all of the wells is measured by a single water flowmeter prior to its application to beneficial use.

(3) The well is enrolled in a multiyear federal conservation program or the water rights conservation program pursuant to K.A.R. 5-7-4.

(4) The well is registered as inactive with the Kansas department of health and environment.

(5) An affidavit is filed by the owner with the district stating that the well is not, and will not be, operated until a water flowmeter meeting the specifications in K.A.R. 5-1-4 through 5-1-12 is properly installed. Thirty days before operating the well, the owner shall file a notice with the district indicating that a water flowmeter has been installed and indicate when the owner proposes to begin the diversion of water. (Authorized by and implementing K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5; effective May 1, 1981; amended May 1, 1985; amended Jan. 10, 2003.)

5-23-7 and 5-23-8. (Authorized by K.S.A. 1980 Supp. 82a-1028(o); implementing K.S.A. 1980 Supp. 82a-1028(n); effective May 1, 1981; revoked May 1, 1985.)

5-23-9. (Authorized by K.S.A. 1980 Supp. 82a-1028(o); implementing K.S.A. 1980 Supp. 82a-1028(n); effective May 1, 1981; revoked Aug. 28, 1989.)

5-23-10. Reserved.

5-23-11. Procedures for non-compliance with rules and regulations. The district, its board or manager, any eligible voter within the district, or any person residing within the district that is at least eighteen (18) years of age, may file a written complaint with the district alleging a violation of these rules and regulations, the management program, the groundwater management district act (K.S.A. 82a-1020 *et seq.*), or the water appropriation act (K.S.A. 82a-701 *et seq.*). The written complaint shall be filed at the district office.

Within thirty (30) days following the filing of the complaint, a representative of the district designated by the board shall investigate the complaint. If the representative of the district finds that a violation has existed or presently exists, the representative shall issue a written directive to the violator stating the nature of the violation and directing the violator to come into compliance with these rules and regulations.

If the violator fails to comply with the directive, the district may: (1) Seek to enjoin the violator's use of water by suitable action in district court until such time as the violator complies; or

(2) Seek the assistance of the chief engineer and the attorney general of the state of Kansas to enjoin the violator's use of water until such time as the violator complies. (Authorized by K.S.A. 1980 Supp. 82a-1028(o); implementing K.S.A. 1980 Supp. 82a-1028(n); effective May 1, 1981.)

5-23-14. Dakota aquifer system. All evaluations in the southwest Kansas groundwater management district no. 3 involving a determination of the extent of the confined and unconfined Dakota aquifer system shall use the information shown in the Kansas geological survey open file report number 98-37, released August 1998, which is hereby adopted by reference, unless the applicant or the district provides, or the chief engineer has available, better or more site-specific data concerning the extent of the confined and unconfined Dakota aquifer system. (Authorized by K.S.A. 82a-706a and K.S.A. 82a-1028(o); implementing K.S.A. 82a-709, K.S.A. 1999 Supp. 82a-711, and K.S.A. 82a-1028(n); effective Sept. 22, 2000.)

5-23-15. Saturated thickness of the high plains aquifer. All evaluations in the southwest Kansas groundwater management district no. 3 involving a determination of the saturated thickness of the high plains aquifer shall use the information shown in the Kansas geological survey open file report number 98-52, plate B, released February 1999, which is hereby adopted by reference, unless the applicant or the district provides, or the chief engineer has available, better or more site-specific data concerning the saturated thickness of the high plains aquifer. (Authorized by K.S.A. 82a-706a and K.S.A. 82a-1028(o); implementing K.S.A. 1999 Supp. 82a-711 and K.S.A. 82a-1028(n); effective Sept. 22, 2000.)

Article 24.—NORTHWEST KANSAS GROUNDWATER MANAGEMENT DISTRICT NO. 4

5-24-1. Definitions. As used in these regulations for the northwest Kansas groundwater management district no. 4, the following words and phrases shall have the following meanings. (a) "Area of consideration" means the two-mile-radius circle whose center is the location of the proposed point of diversion. The area of consideration equals 8,042 acres minus any area of the circle that is outside the state of Kansas.

(b) "Base acreage" has the meaning specified in K.A.R. 5-5-11(a).

(c) "Battery of wells" has the meaning specified in K.A.R. 5-1-1.

(d) "Board" means the board of directors constituting the governing body of the northwest Kansas groundwater management district no. 4.

(e) "District" means the northwest Kansas groundwater management district no. 4.

(f) "Tailwater" means that portion of the applied irrigation water that becomes runoff from the authorized place of use.

(g) "Theis analysis" means the Theis non-equilibrium equation analysis described in pp. 108-113 in "ground water and wells: a reference book for the water-well industry," published by Edward E. Johnson, Inc., Saint Paul, Minnesota, in 1966. The pages specified in this subsection are hereby adopted by reference.

(h) "Usable water" means water containing not more than 10,000 milligrams per liter of total dissolved solids.

(i) "Waste of water" has the meaning specified in K.A.R. 5-1-1.

(j) "Well" means any excavation that is drilled, cored, bored, washed, driven, dug, or otherwise constructed if the intended use of the excavation is for the acquisition, diversion, or artificial recharge of groundwater. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1983; amended May 1, 1985; amended Jan. 30, 2004.)

5-24-2. Allowable withdrawals. (a) Except as set forth in subsection (b) below, each application for an approval of application and each application for a change in the point of diversion shall be subject to the following requirements:

(1) The sum of the annual quantities of water of the proposed appropriation, the vested rights, prior appropriation rights, and earlier priority applications with a point of diversion authorized or proposed within the area of consideration that withdraw water from the same source of supply as the proposed point of diversion, as a hydraulically connected source of supply, shall not exceed the calculated quantity of annual recharge received by the aquifer underlying the area of consideration. The quantity authorized on all prior

permits, certificates, and vested rights, and the quantity requested on prior applications shall be used to calculate the sum of prior appropriations.

(2) All limitation clauses listed on permits and certificates shall be considered to be in force.

(3) In the case of an application for change in the point of diversion, all applications with a priority earlier than the priority established by the filing of the application for change shall be included in the analysis.

(4) The allowable annual appropriation shall be calculated using the formula Q = AR/12, in which the following values are used:

(A) Q is the allowable annual appropriation in acre-feet per year.

(B) A is the area of consideration.

(C) R is the average annual recharge in inches per year.

(5) The value of .5 inch per year shall be used for recharge, including natural recharge and return flow from irrigation.

(6) If a portion of the area of consideration is outside the district boundary, the evaluation shall be conducted as though the entire area of consideration were within the district boundary. If the perimeter of the area of consideration intersects a group of wells authorized under prior applications, permits, certificates, or vested rights, a reasonable quantity of water shall be assigned to each well based upon the best available information.

(b) The following types of applications shall not be subject to this regulation:

(1) A nondomestic application for an approval of application if the proposed point of diversion meets the following criteria:

(A) Is to be located in an alluvial aquifer not closed to new appropriations, except for domestic use, temporary permits, and term permits for five or fewer years;

(B) meets the well spacing requirements of K.A.R. 5-24-3; and

(C) meets the safe yield requirements of K.A.R. 5-3-9, K.A.R. 5-3-10, and K.A.R. 5-3-11;

(2) a nondomestic application to appropriate water from one or more of the following sources of supply:

(A) Niobrara;

(B) Carlile;

(C) Greenhorn;

(D) Dakota;

(E) Kiowa; or

(F) the Cheyenne formations if both of the following conditions are met:

(i) The well spacing requirements of K.A.R. 5-24-3 are met; and

(ii) the proposed point of diversion is located in an area where there is a natural hydraulic connection between all of the formations from which the applicant proposes to divert water;

(3) an application for a permit to appropriate water for domestic use;

(4) an application for a term permit for five years or less;

(5) an application for a temporary permit;

(6) an application for change in point of diversion if either of the following conditions is met:

(A) The authorized well has been drilled, cased, and test-pumped; or

(B) the authorized diversion works have been completed and a notice of completion was timely filed with the chief engineer under the current water right or approval of application;

(7) an application for an approval of application filed on an existing well currently authorized by a vested right, appropriation right, or approval of application that requests a quantity of water equal to or less than the currently available quantity of water that will be conjunctively reduced from a well authorized by either a vested right or certified appropriation right meeting either of the criteria specified in paragraph (c)(1);

(8) an application for an approval of application that meets the criteria of K.A.R. 5-24-10; and

(9) an application for an additional rate of diversion only that meets the requirements of K.A.R. 5-4-5.

(c)(1) To be exempt from this regulation, each application for an approval of application filed on an existing well currently authorized by a vested right, appropriation right, or approval of application that requests a quantity of water equal to or less than the currently available quantity of water that will be conjunctively reduced from a well authorized by either a vested right or certified appropriation right shall meet either of the following criteria:

(A) Be located within 2,640 feet of the existing well that will have its authorized quantity reduced; or

(B) be located within a distance from the currently authorized well for which a Theis analysis shows a .5 foot or greater drawdown, using the following assumptions:

(i) The certified rate of diversion of the currently authorized well;

(ii) the certified annual quantity of water for the currently authorized well;

(iii) the pumping time equal to the time it takes to pump the certified annual quantity at the certified rate of diversion;

(iv) the drawdown computed at the time equal to the pumping time; and

(v) the transmissivity and storage coefficient derived either from a time drawdown aquifer pump test of the currently authorized well or from use of the well log from the currently authorized well or a well log from a test hole or well located within 300 feet of the currently authorized well, using the procedure described in pages 26-27 of the United States geological survey's water-resources investigations report 85-4198, published in 1985. The pages specified in this paragraph are hereby adopted by reference.

(2)(A) For water rights authorized for irrigation use, the currently available quantity of water shall be calculated as follows:

(i) Determine the maximum number of acres actually irrigated during the perfection period. For vested rights, use the maximum number of acres irrigated in any one calendar year before June 29, 1945; and

(ii) use the 80 percent chance rainfall net irrigation requirements (NIR) for corn as set forth in K.A.R. 5-5-12 to determine the NIR for each acre, and then divide that value by .85 to adjust for efficiency.

(B) For non-irrigation water rights, the currently available quantity of water shall not exceed the actual consumptive use during the perfection period.

(3) Each well that has a reduced or new water right pursuant to this subsection shall be equipped with a water flowmeter meeting the requirements of article one of the chief engineer's regulations.

(4) The maximum distance that a well shall be relocated under paragraph (c)(1)(B) shall be the distance computed as described in paragraph (c)(1)(B), or 3,960 feet, whichever is less.

(5) The historic consumptive use of a well meeting the requirements of paragraph (b)(7) that is accounted for in the Republican river compact, K.S.A. 82a-518 and amendments thereto, accounting as a stream depletion reaching the Republican river downstream of Trenton dam shall not be transferred to a well that would cause a depletion reaching the Republican river upstream of Trenton dam.

(6) The total net acreage authorized by the following shall not exceed the current net total authorized acreage for both wells:

(i) The approval of application;

(ii) the water right being reduced; and

(iii) the water right currently authorizing the well for which the new water right is sought. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1983; amended May 1, 1985; amended May 1, 1987; amended Aug. 19, 1991; amended Jan. 30, 2004.)

5-24-3. Well spacing. (a) Except as specified in subsection (b), the spacing between each proposed well and all other wells authorized to withdraw water from the same source of water supply shall be as follows:

(1) In the Ogallala aquifer and in alluvial aquifers not closed to new appropriations, the required minimum spacing for nondomestic, nontemporary wells shall be as follows:

(A) 0 to 175 acre-feet requested: a minimum spacing of 1,400 feet;

(B) 176 to 350 acre-feet requested: a minimum spacing of 2,000 feet;

(C) 351 to 575 acre-feet requested: a minimum spacing of 2,400 feet; and

(D) more than 575 acre-feet requested: a minimum spacing of 2,800 feet.

(2) If the quantity of water authorized or applied for includes a fraction of an acre-foot, the quantity of water shall be rounded off to the nearest acre-foot of water for the purpose of applying this regulation.

(3) Each nondomestic well shall be spaced a minimum of 800 feet from each domestic well constructed in the same aquifer unless the chief engineer determines that one of the following criteria is met:

(A)(i) The domestic well is owned by the applicant;

(ii) the applicant signs a written request to waive the spacing requirement to the domestic well;

(iii) the applicant submits information documenting the location and depth of the domestic well, and any other information necessary to determine whether the domestic well is likely to be impaired; and

(iv) a Theis analysis or other hydraulic analysis done by the chief engineer shows that the do-

mestic well is not likely to be impaired by the proposed well; or

(B)(i) The owner of the domestic well signs a written request to waive the spacing requirement to the domestic well;

(ii) the applicant submits information documenting the location and depth of the domestic well, and any other information necessary to determine whether the domestic well is likely to be impaired; and

(iii) a Theis analysis or other hydraulic analysis done by the chief engineer shows that the domestic well is not likely to be impaired by the proposed well.

(4) Each nondomestic application for additional water from an existing well already authorized by one or more water rights shall meet the minimum spacing requirements in paragraph (a)(1) for the cumulative total of all existing water rights, earlier appropriations, and the proposed appropriation for that well.

(5) For a battery of wells, the well spacing shall meet the minimum spacing in paragraph (a)(1) based on the total amount of water applied for by the battery of wells. The minimum spacing distance shall be measured from the geocenter of the proposed battery of wells.

(6) Nondomestic wells withdrawing water from a cretaceous aquifer shall be spaced a minimum of four miles from all other wells withdrawing water from a hydraulically connected cretaceous aquifer. The spacing between a nondomestic well withdrawing water from a cretaceous aquifer and a domestic well withdrawing water from the same aquifer shall be a minimum of 2,640 feet unless one of the following criteria is met:

(A)(i) The domestic well is owned by the applicant;

(ii) the applicant signs a written request to waive the spacing requirement to the domestic well;

(iii) the applicant submits information documenting the location and depth of the domestic well, and any other information necessary to determine whether the domestic well is likely to be impaired; and

(iv) a Theis analysis or other hydraulic analysis by the chief engineer shows that the domestic well is not likely to be impaired by the proposed well; or

(B)(i) The owner of the domestic well signs a written request to reduce the spacing requirement to the domestic well;

(ii) the applicant submits information documenting the location and depth of the domestic well, and any other information necessary to determine whether the domestic well is likely to be impaired; and

(iii) a Theis analysis or other hydraulic analysis done by the chief engineer shows that the domestic well is not likely to be impaired by the proposed well.

(b) The well spacing requirements of subsection (a) shall not apply to the following:

(1) Spacing to a standby well;

(2) spacing to another well if either of the following conditions is met:

(A)(i) The other well is owned by the applicant;

(ii) the owner of the other well signs a written request to reduce the spacing requirement to the other well;

(iii) the applicant submits information documenting the location and depth of the other well, and any other information necessary to determine whether the other well is likely to be impaired by the proposed well; and

(iv) a Theis analysis or other hydraulic analysis done by the chief engineer shows that the proposed well is not likely to impair the other well; or

(B)(i) The owner of the other well files a written request to waive the spacing requirement to the proposed well;

(ii) the applicant submits information documenting the location and depth of the other well, and any other information necessary to determine whether the other well is likely to be impaired by the proposed well; and

(iii) a Theis analysis or other hydraulic analysis done by the chief engineer shows that the proposed well is not likely to impair the other well;

(3) a replacement well that meets one of the following criteria:

(A) The well is being replaced within 300 feet of the currently authorized location; or

(B) both of the following conditions are met:

(i) The proposed replacement well location increases the spacing to all other wells for which the spacing requirement was not met on the date the application for a change in point of diversion was filed; and

(ii) the proposed replacement well location continues to meet the requirements for spacing to all wells for which the well spacing requirement

was met at the time the application for change in point of diversion was filed; and

(4) an additional well if the original well and the additional well are owned by the same owner or owners. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1983; amended Jan. 30, 2004.)

5-24-4. Tailwater control and waste. No person shall commit or allow a waste of water as defined in K.A.R. 5-1-1. Runoff from precipitation shall not be considered a waste of water. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1983; amended Jan. 30, 2004.)

5-24-5. Allowable appropriation—reasonable use. (a) The maximum reasonable annual quantity of water for irrigation use shall not exceed the standards adopted in K.A.R. 5-3-19, K.A.R. 5-3-20, K.A.R. 5-3-21, K.A.R. 5-3-23, and K.A.R. 5-3-24.

(b) The annual quantity of water deemed reasonable on an application for municipal use shall be determined using the following criteria:

(1) The annual quantity of water needed for residential use shall be based on a population projection for the ensuing 20 years. The projected population shall be determined by extending present population for 20 years at one and one-half percent per year increase.

(2) The total quantity of water reasonable for the residential population shall then be determined by the following:

(A) Multiplying the projected population by the current per capita use; and

(B) adding a reasonable quantity of water for the present and projected industrial use for the ensuing 20-year-period.

(3) Municipalities may purchase, condemn, or otherwise acquire existing water rights in excess of the quantities set forth in paragraphs (b) (1) and (2) and apply to the chief engineer to change a reasonable quantity of the acquired water rights for municipal use, which shall not exceed 200 percent of the quantity considered reasonable pursuant to paragraphs (b)(1) and (2).

(c) The quantities of water deemed to be reasonable for livestock and poultry shall be determined pursuant to K.A.R. 5-3-22.

(d) All applications for any other type of beneficial use shall be reviewed to determine if the annual quantity of water and rate of diversion requested are reasonable for the intended use based on the best information available. (Authorized by K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5, and K.S.A. 82a-706a; implementing K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5; effective May 1, 1983; amended Aug. 19, 1991; amended Jan. 10, 2003.)

5-24-6. Changes in points of diversion. (a) Each replacement well shall meet all of the criteria in either of the following paragraphs:

(1)(A) Be located within 2,640 feet of the currently approved well location; and

(B) meet the well spacing criteria of K.A.R. 5-24-3; or

(2)(A) Be located within a distance from the currently authorized well for which a Theis analysis shows a .5 foot or greater drawdown, using the following assumptions:

(i) The certified rate of diversion of the currently authorized well;

(ii) the certified annual quantity of water for the currently authorized well;

(iii) the pumping time equal to the time it takes to pump the certified annual quantity at the certified rate of diversion;

(iv) the drawdown computed at the time equal to the pumping time;

(v) the transmissivity and storage coefficient derived either from a time drawdown aquifer pump test of the currently authorized well or from use of the well log from the currently authorized well or a well log from a test hole or well located within 300 feet of the currently authorized well, using the procedure specified in K.A.R. 5-24-2(c)(1)(B)(v); and

(B) meet the well spacing criteria of K.A.R. 5-24-3.

(b) The maximum distance that a well may be relocated under paragraph (a)(2) shall be the distance computed as specified in paragraph (a)(2), or 3,960 feet, whichever is less. If the historic consumptive use of the well being replaced is accounted for in the Republican river compact, K.S.A. 82a-518 and amendments thereto, accounting as a stream depletion reaching the Republican river downstream of Trenton dam, that consumptive use shall not be transferred to a well that would cause a depletion reaching the Republican river upstream of Trenton dam.

(c) No change in a point of diversion application that proposes to change the authorized point

of diversion from one well to a battery of wells shall be approved unless at least one of the following conditions has been met:

(1) Water is available for appropriation pursuant to K.S.A. 5-24-2 at the geocenter of the proposed battery of wells or would be available if the current water right were dismissed.

(2) The proposed battery of wells meets the requirements of K.A.R. 5-2-3. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1983; amended May 1, 1987; amended Jan. 30, 2004.)

5-24-7. Well construction criteria. (a) Each nondomestic well that is not subject to regulation under the Kansas chemigation safety law, K.S.A. 2-3301 et seq., and amendments thereto, and that is completed after May 1, 1983 shall include the installation of a check valve that meets or exceeds specifications adopted by the chief engineer which were in effect at the time the well was completed.

(b) All wells, including domestic wells, to be completed in a cretaceous aquifer shall be constructed in a manner that prevents the cretaceous aquifer from mixing with all quaternary, tertiary, and any other cretaceous water-bearing strata that have no natural hydraulic connection between the formation or formations in which the well will be screened. (Authorized by and implementing K.S.A. 82a-1028; effective May 1, 1983; amended Jan. 10, 2003.)

5-24-8. Resource development plans. (a) A resource development plan may be required by the district to be submitted for any of the following:

(1) A new application to appropriate water for irrigation use;

(2) a nonemergency application to change the place of use or the use made of water from irrigation to another type of use that involves an actual physical change in operation; or

(3) a new application to appropriate water for nonirrigation purposes if one of the following criteria is met:

(A) The quantity of water requested is likely to be unreasonable.

(B) The proposed beneficial use is likely to be inefficient.

(C) The proposed operation is likely to result in a waste of water.

(D) The owner or operator has a recent, documented history of noncompliance with the provisions of the Kansas water appropriation act or regulations adopted pursuant to the act.

(b) Each resource development plan shall include a description of the proposed operation, including the diversion works, the distribution system, and all other matters necessary to determine whether the proposed annual quantity of water is likely to be reasonable and not wasteful.

(c)(1) The applicant shall be notified by the district whenever an applicant is required to submit a resource development plan. This notification shall include the deadline for submitting the plan. The district shall then review the plan and submit it to the chief engineer with one of the following recommendations:

(A) The application should be approved because the proposed plan meets the regulatory requirements, and those portions of the plan consistent with the conservation plan guidelines adopted by the Kansas water office should be required as a conservation plan as a condition of the approval of application.

(B) The application should be approved if certain changes are made to the plan, and the amended plan should be required as a condition of the approval of application insofar as it is consistent with the water conservation planning guidelines adopted by the Kansas water office.

(C) The plan does not meet the regulatory requirements, and the application should not be approved.

(2) Each water conservation plan required by the chief engineer shall be made a condition of the approval of application. The required water conservation plan shall be fully implemented before diversion of water occurs pursuant to that approval of application. After the plan is implemented, the owner shall maintain the plan in a satisfactory manner.

(d) In addition to meeting the requirements specified in subsection (b), for irrigation use, the resource development plan shall meet the following requirements:

(1) Include irrigation system design, tailwater control methods, well yield, and cropping patterns; and

(2) comply with design criteria meeting the following requirements:

(A) Are set forth in the national engineering handbook (NEH), part 652, irrigation guide, dated November 13, 1997, as amended through

the Kansas state supplement dated May 8, 2003, which is hereby adopted by reference; and

(B) are consistent with the "irrigation water conservation program for the state of Kansas," published by the Kansas water office in November 1993 and hereby adopted by reference.

(e) For municipal use, the plan shall comply with the "Kansas 1990 municipal water conservation plan guidelines," second edition, which is published by the Kansas water office and hereby adopted by reference.

(f) In addition to meeting the requirements specified in subsection (b), for all other types of beneficial use, the resource development plan shall include a description of the proposed use of water in sufficient detail to determine if the proposed use is reasonable and not wasteful. (Authorized by K.S.A. 2002 Supp. 82a-1028 and K.S.A. 82a-706a; implementing K.S.A. 2002 Supp. 82a-1028; effective Jan. 10, 2003; amended Jan. 30, 2004.)

5-24-9. Water flowmeters. (a) Each of the following types of wells shall be equipped with a water flowmeter meeting the water flowmeter and installation specifications in K.A.R. 5-1-4 through K.A.R. 5-1-12 at the time the well is permitted:

(1) Any nondomestic, nontemporary well permitted or drilled after May 1,1980;

(2) any nondomestic, nontemporary well actually drilled after May 1, 1980 pursuant to an approval of an application for a change in point of diversion; and

(3) any well reduced in annual quantity of water authorized in order to allow approval of another application pursuant to K.A.R. 5-24-2.

(b) In addition to meeting the requirements of this regulation, each owner shall meet the requirements specified in K.A.R. 5-3-5e. (Authorized by K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5, and K.S.A. 82a-706a; implementing K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5, and K.S.A. 2001 Supp. 82a-1903, as amended by L. 2002, Ch. 137, § 7; effective Jan. 10, 2003.)

5-24-10. Exemptions for up to 15 acre-feet of groundwater. (a) In any area of the district that is subject to safe yield criteria and is not closed by specific regulation or intensive groundwater use control area order by the chief engineer to new nondomestic, nontemporary permits and term permits for five or fewer years, applications to appropriate groundwater shall be exempt from meeting the safe yield criteria if all the following conditions are met:

(1) The sum of the annual quantity requested by the proposed appropriation and the total annual quantities authorized by prior permits allowed because of an exemption pursuant to this regulation does not exceed 15 acre-feet in a one-mile-radius circle surrounding the proposed point of diversion.

(2) Well spacing criteria have been met.

(3) The approval of the application does not authorize an additional quantity of water out of an existing authorized well with a nondomestic permit or water right that would result in a total combined annual quantity of water authorized from that well in excess of 15 acre-feet.

(4) The approval of the application does not authorize an additional quantity of water to be used on a currently authorized nondomestic place of use.

(b) After the use of up to 15 acre-feet has been approved pursuant to this regulation, no application for change shall be approved for any quantity of water that would authorize the water to be diverted from a currently authorized point of diversion or onto a currently authorized place of use. (Authorized by K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5, and K.S.A. 82a-706a; implementing K.S.A. 82a-1028, as amended by L. 2002, Ch. 137, § 5; effective Jan. 10, 2003.)

5-24-11. Investigation and enforcement. The procedure set forth in this regulation shall be followed whenever enforcement action is taken by the district after it becomes aware that a person could be violating any of the regulations adopted by the chief engineer that relate to conservation and management of groundwater within the district.

(a) If a violation is discovered by the district's staff, the enforcement procedure shall begin with the step specified in subsection (c). In all other cases, a complaint may be filed with the district either verbally or in writing. The complaint shall describe and specify the following:

(1) The nature of the alleged violation;

(2) the location of the alleged violation;

(3) the name of the complainant;

(4) the mailing address of the complainant; and

(5) any other information necessary for the staff to understand the alleged violation and assist the staff in investigating the complaint.

(b) Before the staff makes any field investiga-

tion of the complaint, the staff shall make at least one attempt to contact an owner, operator, or other responsible representative of the water right or approval of application to notify the individual that a field investigation will be made.

(c) The district's staff shall make an investigation under either of the following circumstances:

(1) A complaint has been filed with the district, and the requirement specified in subsection (b) has been met.

(2) The district's staff discovers a violation of any regulation adopted by the chief engineer relating to conservation and management of groundwater within the district.

(d) A written report of the investigation shall be prepared by the staff. This report shall include any documents relied on or prepared by the staff in investigating the complaint or internally discovered violation. The report shall become a part of the official district record concerning the investigation. If a water right or an approval of application is involved, the report shall be made a part of that file.

(e) If the investigation shows that no violation has occurred or that enforcement action is not warranted, a copy of the report shall be sent to the complainant, if the investigation was prompted by a complaint, and the water right owner. A copy shall be retained in the district office. No further enforcement action shall be taken by the district at that time.

(f)(1) If the investigation determines or confirms that a violation has occurred, the report shall contain an order issued by the district staff, which shall be sent by restricted mail to the water right owner as shown in the district records and to any other person who is known by the district to have been committing the violation. The order shall specify and include the following:

(A) A description of the violation, including the specific regulations that are being violated;

(B) the actions necessary to correct the violation;

(C) a reasonable time frame to correct the violation;

(D) a statement that extensions of time to correct any violation may be granted by the staff if good cause is shown by the water right owner or other responsible party;

(E) a statement that the order is effective immediately;

(F) a statement that if the violation is corrected within the time specified by the order, the violator is required to notify the district, and an inspection will be conducted by the staff to determine if the violation has ceased;

(G) a statement that if any party desires to appeal an order issued by the staff, an appeal to the board is required to be requested within 15 days of the issuance of the order by a water right owner or violator;

(H) a statement that the request for an appeal may also request a stay of the order. If the requestor demonstrates good cause for a stay, a stay of the order may be granted by the staff or the board; and

(I) a statement that any subsequent violations of the same nature will be handled as a continuation of the current violation, not a new violation.

(2) A copy of the report shall be sent to the complainant.

(g) If the violation is corrected within the time frame specified by the order, the violator shall notify the district, and an inspection shall be conducted by the staff to determine if the violation has ceased. If the staff investigation determines that the violation has been corrected within the time frame specified by the order and in accordance with the district order, the enforcement activity by the district shall cease.

(h) If the violation has not been corrected within the time frame specified in the order and in the manner specified in the order, one or more of the following actions may be taken by the board:

(1) Seeking an injunction to stop the violation;

(2) requesting enforcement assistance from the chief engineer; or

(3) requesting enforcement assistance from the attorney general. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective Jan. 30, 2004.)

Article 25.—BIG BEND GROUNDWATER MANAGEMENT DISTRICT NO. 5

5-25-1. Definitions. As used in these regulations for the Big Bend groundwater management district no. 5, unless the context clearly requires otherwise, the following words and phrases shall have the meaning ascribed to them in this regulation:

(a) "Aquifer" means a geologic formation capable of yielding water in a quantity sufficient to supply water to a spring or pumping well.

(b) "Baseflow" means groundwater that seeps, flows, or is otherwise naturally discharged from an aquifer into a stream.

(c) "Baseflow node" means an artificial point located in the channel of a stream for the purpose of allocating a proportional amount of the baseflow to be considered when evaluating a new application to appropriate water from a proposed point of diversion located within two miles of the node.

(d) "Baseflow node allocation" means the annual quantity of water assigned to a baseflow node expressed in acre-feet per year. The baseflow node allocation shall be based on the natural discharge to a stream, which shall be the rate of flow in the stream that is equaled or exceeded 90 percent of the time.

(e) "Bedrock aquifer" means any consolidated material and unconsolidated material that is older than the Dakota formation of the Dakota aquifer system, as defined in K.A.R. 5-1-1, and that will yield water in a quantity sufficient to supply a spring or a pumping well.

(f) "Board" means the board of directors constituting the governing body of the Big Bend groundwater management district no. 5.

(g) "Dakota aquifer" means that portion of the Cretaceous Dakota formation that is capable of yielding water in a quantity sufficient to supply water to a spring or pumping well.

(h) "District" means the Big Bend groundwater management district no. 5.

(i) "Neat cement" means one 94-pound bag of Portland cement mixed with five to six gallons of clean water.

(j) "Portland cement" means class A, type I cement.

(k) "Stream" means any watercourse, or part of a watercourse, with a well-defined bed and banks that flows continuously during the calendar year, except during a drought.

(l) "Sustainable yield" means the long-term yield of the source of supply, including hydraulically connected surface water or groundwater, allowing for the reasonable raising and lowering of the water table.

(m) "Well" means any excavation that is drilled, cored, bored, washed, driven, dug, or otherwise constructed, either by nature or by man, when the proposed use of the excavation is for the acquisition, diversion, or artificial recharge of groundwater. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1980; amended May 1, 1987; amended April 19, 1996; amended Oct. 31, 2003.)

5-25-2. Well spacing. (a) With the exception of those wells described in subsection (b), the minimum spacing of all wells described in an application to appropriate water for beneficial use, other than those wells for domestic use, shall be 1,320 feet from the following:

(1) All other non-domestic wells and proposed non-domestic wells that carry an earlier priority; and

(2) baseflow nodes.

Non-domestic wells shall be 660 feet from all existing domestic wells, except those domestic wells owned by the applicant.

(b)(1) Each replacement well drilled within 100 feet of the originally authorized point of diversion shall be exempt from the well spacing requirement of subsection (a).

(2) Each non-domestic well that proposes the withdrawal of groundwater from the Dakota aquifer or any bedrock aquifer shall be one mile from all other wells withdrawing groundwater from the same formation, including domestic wells, except those domestic wells owned by the applicant. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1980; amended April 19, 1996; amended Oct. 31, 2003.)

5-25-2a. Change in point of diversion. (a) The location of a well requested in an application to change a point of diversion shall be no more than 2,640 feet from the point of diversion currently authorized by a vested right, appropriation right, or an application to appropriate water for beneficial use. This well shall also meet the minimum spacing requirement established in K.A.R. 5-25-2. If the point of diversion was not completed at the currently authorized point of diversion, the location of a well requested in an application to change the point of diversion shall be no more than 2,640 feet from the last authorized point of diversion for which the diversion works were completed.

(b) If the current authorization for a well requires one or more observation wells to be installed in accordance with K.A.R. 5-25-10, then the approval of an application for a change in the point of diversion shall also require the installation of one or more new observation wells in accord-

ance with K.A.R. 5-25-10 if either of the following conditions exists:

(1) The well is proposed to be located 300 feet or more from the currently authorized well location.

(2) The well is proposed to be located more than 50 feet and less than 300 feet from the currently authorized well location, and the water quality analysis required pursuant to K.A.R. 5- 25-10 shows that the chloride concentration exceeds 500 milligrams per liter (mg/l) at the currently authorized well location.

(c) The number and location of test holes or observation wells required for the approval of an application to change the point of diversion from a single well to a battery pursuant to subsection (b) shall be based on the locations and the number of wells in the proposed battery. Hydrologic factors, including groundwater flow direction, lithology, and chlorides at the location, shall be considered.

(d) An approval of an application to change the point of diversion shall not authorize the proposed well to be completed in an aquifer other than the aquifer or aquifers in which the currently authorized well was authorized to be completed. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective Oct. 31, 2003.)

5-25-3. Reasonable appropriation. (a) An application for a permit to appropriate water for irrigation use shall not be recommended by the board for approval for a quantity in excess of those quantities specified in K.A.R. 5-3-19.

(b) For livestock and poultry, the maximum annual quantity of water shall be limited to those quantities specified in K.A.R. 5-3-22.

(c) For all uses of water, the quantity of water requested shall be reasonable for the proposed beneficial use, and the approval shall neither impair an existing right nor prejudicially and unreasonably affect the public interest. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706, K.S.A. 82a-706a, K.S.A. 2002 Supp. 82a-711, and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1980; amended April 19, 1996; amended Oct. 31, 2003.)

5-25-4. Sustainable yield. (a) Except as set forth in subsections (b) and (c), the district has been determined to be appropriated to the sustainable yield level, and therefore the entire district shall be closed to further new surface water and groundwater appropriations filed on or after December 17, 1998.

(b) The following types of applications shall be exempt from the closure of the district to new appropriations of water described in subsection (a):

(1) Domestic use;

(2) temporary permits;

(3) applications for a change in the point of diversion for which the diversion works have been completed under the original approved application;

(4) standby wells used for emergency purposes only;

(5) permits to appropriate 15 acre-feet of water or less per year that are exempt pursuant to K.A.R. 5-25-15;

(6) term permit applications of one year or less and those term applications meeting the requirements of K.A.R. 5-25-13;

(7) permits to appropriate water from a bedrock aquifer;

(8) permits to appropriate water from the Dakota aquifer if the applicant can show either of the following:

(A) No Pleistocene aquifer exists within 5,280 feet of the proposed well location; or

(B) there is a significant difference in hydraulic head between the Pleistocene aquifer and the Dakota aquifer; and

(9) an application that proposes to use water in a manner so that there is no significant consumptive use of the local source of supply either in quantity or availability of water for use by other appropriators.

(c)(1) For each application for a change in the point of diversion, if the diversion works have not been completed, the application shall be exempt from the closure to new appropriations set forth in subsection (a). However, the proposed appropriation, when added to the vested rights, prior appropriation rights, earlier priority applications, term permits for more than a year, and all baseflow node allocations within a two-mile-radius circle whose center is the location of the proposed well, shall not exceed 1,500 acre-feet. It shall be assumed for purposes of analysis that all prior applications, permits, certificates, and vested rights are being fully exercised and that all limitation clauses listed on permits and certificates are in force.

(2) If part of the area within the two-mile-radius

circle around the proposed well location is outside the district boundaries, the 1,500 acre-feet quantity of water referred to above in paragraph (c)(1) shall be reduced proportionately by the percentage of the circle lying outside of the district boundaries. Only the baseflow node allocations, vested rights, prior appropriations, earlier priority applications, and term permits for more than one year ascribed to wells within the portion of the circle within the district shall be considered.

(3) If all of the wells authorized under a vested right or an application are not included inside the circumference of the circle, then a reasonable quantity shall be allocated to each well based upon the best available information.

(4) Each analysis for an application for a change in the point of diversion referred to in subsection (c) shall include all applications with a priority earlier than the priority established by the filing of the application for change. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706, K.S.A. 82a-706a, K.S.A. 2002 Supp. 82a-708b, and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1980; amended May 1, 1981; amended, T-86-4, March 22, 1985; amended May 1, 1986; amended May 1, 1987; amended May 1, 1988; amended April 19, 1996; amended March 16, 2001; amended Oct. 31, 2003.)

5-25-5. Well equipment. (a) Each non-domestic well, except any well authorized by a temporary permit, shall be equipped with a water flowmeter that meets or exceeds the requirements of subsection (c).

Each non-domestic, non-temporary well not subject to regulation under the Kansas chemigation safety law, K.S.A. 2-3301 et seq. and amendments thereto, shall be equipped with an in-line, automatic, quick-closing check valve capable of preventing pollution of the source of water supply.

(b) Each check valve installed shall meet or exceed the specifications set forth in K.A.R. 5-6-13a.

(c) Each water flowmeter required by the board, or pursuant to a regulation adopted by the chief engineer, before the effective date of this regulation, shall meet or exceed applicable requirements of article 1 of the division's regulations. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1980; amended May 1, 1985; amended April 19, 1996; amended Oct. 31, 2003.)

5-25-6. Reporting water use. Each water right owner shall report to the board the readings of water meters, gauges and other measuring devices at such times as may be required by the board. (Authorized by K.S.A. 82a-706a and K.S.A. 82a-1028(o); implementing K.S.A. 82a-1028(l); effective May 1, 1980; amended April 19, 1996.)

5-25-7. Water quality tests. Each water right owner shall take water samples from the owner's wells and have water quality analyses made on those samples at the owner's expense at times specified by the board. A laboratory licensed by the Kansas department of health and environment shall conduct the water quality analyses. The type of water quality analyses conducted shall be specified by the board. The owner shall submit the results of the water quality analyses to the board. (Authorized by K.S.A. 82a-706a and K.S.A. 82a-1028(o); implementing K.S.A. 82a-1028(k); effective May 1, 1980; amended April 19, 1996.)

5-25-8. Waste of water. A person shall not commit or allow a waste of water as defined in K.A.R. 5-1-1. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1980; amended April 19, 1996; amended Oct. 31, 2003.)

5-25-9. Procedures for non-compliance with rules and regulations. (a) The district's board or manager, any eligible voter or any person 18 years or older residing within the district may file a written complaint with the district alleging a violation of these rules and regulations, the management program, the groundwater management district act or the Kansas water appropriation act, as amended. The written complaint shall be filed at the district office.

(b) Within 30 days following the filing of the complaint, a representative of the district designated by the board shall investigate the complaint. If the representative of the district finds that a violation exists or did exist, the representative shall issue a written directive to the violator to come into compliance with the applicable rules and regulations, management program and laws, within a reasonable period of time.

(c) If the violator fails to comply with the directive of the representative within a reasonable period of time as determined by the board, the district may:

(1) seek to enjoin the violator's use of water by

suitable action in district court until such time as the violator complies;

(2) seek the assistance of the chief engineer and attorney general of the state of Kansas to enjoin the violator's use of water until such time as the violator complies; or

(3) pursue other courses of action in the public interest. (Authorized by K.S.A. 82a-706a and K.S.A. 82a-1028(o); implementing K.S.A. 82a-1028(n); effective May 1, 1980; amended May 1, 1981; amended April 19, 1996.)

5-25-10. Test holes and water quality analyses. (a) Except for those types of applications described in K.A.R. 5-25-4(b), each applicant proposing to divert groundwater for non-domestic use within the district shall drill a test hole that shall meet the following requirements:

(1) Be drilled within 20 feet of the proposed well to the bottom of the aquifer;

(2) be completed as an observation well according to the following specifications:

(A) A casing made of schedule 80 PVC with a minimum outside diameter of three inches shall be used;

(B) five feet of well screen shall be installed at the base of the usable aquifer;

(C) the annular space shall be grouted with neat cement from the top of the well screen to the land surface; and

(D) centralizers shall be placed on the casing at intervals of not greater than 40 feet starting at the bottom of the casing; and

(3) be drilled under the supervision of the district.

(b) Each applicant shall have a water sample taken from within five feet of the bottom of the aquifer and shall have the water sample analyzed for chloride content by a laboratory certified by the Kansas department of health and environment. The applicant shall furnish the results of the water quality analysis and a copy of the test hole log to the district.

(c) If the analysis of the water sample taken within five feet of the bottom of the aquifer indicates that the chloride content exceeds 500 milligrams per liter (mg/l), the application to appropriate water shall be recommended for denial by the district unless both of the following conditions are met:

(1) The applicant shows that approval of the application will not cause an unreasonable deterioration of the water quality nor prejudicially and unreasonably affect the public interest.

(2) The applicant desires to proceed and is willing, at the applicant's expense, to drill and complete at least two additional observation wells at locations to be determined by the district based on the lithology and the construction of the proposed well. Both of these two additional observation wells shall be constructed according to specifications adopted by the district and in the presence of a representative of the district. The two additional observation wells shall be constructed and screened above the saltwater and freshwater interface at a depth specified by the district. If the proposed point of diversion is to be a well battery, the number and location of the test holes and observation wells required shall be determined by the district based on the best hydrogeologic information available, including groundwater flow direction, lithology, and chloride levels.

(d) If at any time the chloride concentration in either of the latter two observation wells exceeds 500 mg/l, the owner shall reduce the instantaneous rate of pumping or the annual quantity pumped, or both, as necessary to reduce the chloride concentration in both observation wells to below 500 mg/l.

(e) The permit shall be dismissed and the owner shall properly plug the well at the owner's expense if either of the following occurs:

(1) Within one year after the chloride concentrations exceed 500 mg/l in either of the two observation wells, the chloride concentrations are not reduced below 500 mg/l.

(2) Operation of the well causes impairment of any other water right, including a domestic water right. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a, and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1983; amended April 19, 1996; amended Oct. 31, 2003.)

5-25-11. Determination of well locations. If a question arises as to where a well is located, the burden of proof shall remain upon the applicant to show the actual location of the well in question. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective May 1, 1983; amended Oct. 31, 2003.)

5-25-12. Approval of application for additional rate only. Each application for a permit to appropriate water for beneficial use that re-

quests only an increase in the authorized rate of diversion, and no net increase in maximum annual quantity, from a specific point of diversion already authorized by another water right or approval of application shall be exempt from meeting the requirements of K.A.R. 5-25-4 if the application meets the requirements of K.A.R. 5-4-5. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective Oct. 31, 2003.)

5-25-13. Term permits. The approval of an application, or an extension of a term permit, for more than one year may be granted only if one of the following conditions is met:

(a) The term permit authorizes the use of contaminated water. For the purpose of this regulation, water containing chlorides in excess of 1,000 milligrams per liter (mg/l) shall be considered to be contaminated. For other types of contamination, the level of contamination at which an application may be approved in accordance with this regulation shall be based on the best information available.

(b) The term permit authorizes the use of water for aquifer remediation.

(c) The term permit authorizes hydraulic dredging.

(d) The applicant demonstrates that approval of an extension of the expiration date of a term permit for more than one year will neither impair a use under an existing water right or approval of application nor prejudicially and unreasonably affect the public interest. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective Oct. 31, 2003.)

5-25-14. Battery of wells. (a) An application for a change in point of diversion to convert one well to a battery of wells, as defined in K.A.R. 5-1-1, shall not be considered for approval unless all of the criteria in paragraph (a)(1), (2), or (3) below are met:

(1)(A) The proposed battery of wells meets the definition of a battery of wells as defined in K.A.R. 5-1-1.

(B) The time to construct the diversion works has not expired.

(C) The proposed rate of diversion does not exceed the currently authorized rate of diversion.

(2)(A) The proposed battery of wells meets the definition of a battery of wells as defined in K.A.R. 5-1-1.

(B) Water is available for appropriation at the geocenter of the proposed well battery based on the criteria set forth in K.A.R. 5-25-4(c).

(C) The proposed rate of diversion does not exceed the currently authorized rate of diversion.

(3)(A) The proposed battery of wells meets the definition of a battery of wells as defined in K.A.R. 5-1-1.

(B) A certificate of appropriation has been issued pursuant to K.S.A. 82a-714 and amendments thereto.

(C) The maximum instantaneous rate of diversion approved shall be either of the following:

(i) The maximum instantaneous rate of diversion under normal operating conditions actually used during any of the three consecutive calendar years before the date of the application for change; or

(ii) the tested rate of diversion achieved under actual operating conditions made by a tester approved by the chief engineer. The test of the rate of diversion shall be made within six months either before or after the change application is filed.

(D) The proposed rate of diversion does not exceed the currently authorized rate of diversion.

(b) In addition to meeting the requirements specified in subsection (a), the applicant shall also demonstrate that approval of the battery of wells will not impair existing water rights or approvals of applications and will not prejudicially and unreasonably affect the public interest.

(c) Each permit shall also be conditioned by the chief engineer so that the permit is subject to K.A.R. 5-25-2a (b) and (c). (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706, K.S.A. 82a-706a, K.S.A. 2002 Supp. 82a-706b, and K.S.A. 2002 Supp. 82a-1028; effective Oct. 31, 2003.)

5-25-15. Exemptions for up to 15 acre-feet of groundwater. Except as specified in subsection (b), an application to appropriate groundwater for up to 15 acre-feet of water shall be approved if all of the criteria in subsection (a) are met:

(a) (1) The sum of the annual quantity of water requested by the new application and the total annual quantities authorized by prior approvals of

applications because of an exemption pursuant to this regulation does not exceed 15 acre-feet in a ½-mile-radius circle surrounding the proposed point of diversion.

(2) The proposed well meets the well spacing criteria set forth in K.A.R. 5-25-2.

(3) The approval of application will not authorize an additional quantity of water out of an existing authorized well with a non-domestic permit or water right that would result in a total combined annual quantity of water authorized from that well in excess of 15 acre-feet.

(4) The applicant demonstrates that approval of up to 15 acre-feet of water will not impair existing water rights or approvals of applications and will not prejudicially and unreasonably affect the public interest.

(5) All other criteria for processing a new application to appropriate water have been met.

(b) Exemptions to approve a new application to appropriate water in accordance with this regulation shall not be approved if the exemption would conflict with one of the following:

(1) The provisions of an intensive groundwater use control area order issued by the chief engineer pursuant to K.S.A. 82a-1036 through K.S.A. 82a-1040, and amendments thereto; or

(2) the implementation of a water right purchase program in the Rattlesnake creek basin in both of the following:

(A) The corridor; and

(B) the number two priority area as shown in figure two of the Rattlesnake creek management plan accepted by the chief engineer on July 11, 2000.

(c) After the use of up to 15 acre-feet has been approved pursuant to this regulation, no application for change shall be approved for that quantity of water that would authorize that water to be diverted from another authorized point of diversion.

(d) An application approved as an exemption under this regulation shall not be leased or placed in a water bank so that it can be diverted at another location. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706, K.S.A. 82a-706a, K.S.A. 2002 Supp. 82a-711, and K.S.A. 2002 Supp. 82a-1028; effective Oct. 31, 2003.)

5-25-16. Water quality analyses and observation wells in the Rattlesnake creek subbasin. Groundwater rights that have points of diversion located in the Rattlesnake creek subbasin east and north of federal highways US-281 and US-50 shall be subject to the following requirements: (a) The water right owner, or the authorized representative, shall test water samples to determine, as needed, whether the water being pumped contains more than 300 milligrams of chlorides per liter. The district may require the tests to be made at a frequency not to exceed once in 365 days.

All water quality samples shall be taken in the presence of an authorized representative of the district, and one-half of the sample shall be given to the authorized representative of the district when the sample is taken. The owner shall have the water sample analyzed for chloride content by a laboratory certified by the Kansas department of health and environment. The applicant shall furnish the results of the water quality analysis to the district within 60 days after the date the sample was taken.

(b) If the analysis of the water sample taken indicates that the chloride content exceeds 300 milligrams of chlorides per liter, the owner shall be required, before any approval of a change in point of diversion, to drill an observation well to bedrock in the manner specified in K.A.R. 5-25-10(a). (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706, K.S.A. 82a-706a, K.S.A. 2002 Supp. 82a-708b, and K.S.A. 2002 Supp. 82a-1028; effective Oct. 31, 2003.)

5-25-17. Voluntary reductions of water rights in the Rattlesnake creek subbasin. Each water right owner in the Rattlesnake creek subbasin that agrees to meet, and does meet, all of the conditions specified in subsections (a) through (e) no later than March 31, 2004 on a water right for a center pivot irrigation system with a priority date on or before April 12, 1984 shall receive a credit toward any reduction required by alternative management actions implemented in accordance with the Rattlesnake creek basin management program accepted by the chief engineer on July 11, 2000. The amount of the credit shall be calculated by multiplying by 1.5 the total number of years that the water right has been voluntarily reduced in accordance with the terms of this regulation before any alternative actions are taken under this program times the quantity of water that was voluntarily reduced. Water right

owners who have taken a reduction in their water right under this regulation shall have any further reduction through the Rattlesnake creek basin management program based on the authorized amount before a voluntary reduction is made under this regulation.

(a) The owner permanently reduces the maximum number of acres actually irrigated in any one calendar year during the period 1987 through 1996 by the number of acres previously watered by the end gun and provides documentation to the chief engineer of the number and location of the acres irrigated by the end gun during the period 1987 through 1996.

(b) The owner removes the end gun from the center pivot and certifies to the chief engineer what type of end gun has been removed.

(c) The owner installs pressure regulators on the center pivot to prevent the same rate of diversion from being pumped after the end gun is removed as was pumped before the end gun was removed and certifies to the chief engineer what pressure regulators have been installed.

(d) The chief engineer permanently reduces the authorized place of use of that water right by the maximum number of acres actually irrigated in any one calendar year by the end gun during the period 1987 through 1996.

(e) The chief engineer permanently reduces the maximum annual quantity authorized by that water right by the quantity of water that is calculated by multiplying the number of acres previously watered by the end gun times the net irrigation requirements (NIR) for the 50 percent chance rainfall for the county in which the point of diversion is located, as set forth in K.A.R. 5-5-12. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective Oct. 31, 2003.)

5-25-18. Changes of well locations within the Rattlesnake creek basin. (a) Each application to change the location of a well within the Rattlesnake creek basin by more than 2,640 feet may be approved by the chief engineer if all of the following conditions are met:

(1) The source of water supply for the currently authorized well and the proposed well is the Rattlesnake creek basin as defined in K.A.R. 5-6-15.

(2) The currently authorized well is located within the corridor or the number two priority decline area as defined in figure two of the Rattlesnake creek management plan accepted by the chief engineer on July 11, 2000.

(3) The well will be moved to a location outside the corridor or the number two priority decline area as defined in figure two of the Rattlesnake creek management plan accepted by the chief engineer on July 11, 2000.

(4) The average saturated thickness in the two-mile-radius circle in which the proposed well will be located is greater than 40 feet as shown on the saturated thickness map adopted by reference in K.A.R. 5-25-19.

(5) The water level within the two-mile-radius circle surrounding the proposed well location has not declined in excess of 20 feet of the predevelopment water level as shown in Kansas geological survey bulletins numbered 65, 80, and 88.

(6) The change proposes the relocation of all the water right or a divided water right.

(7) No other well has previously been authorized by the chief engineer to be relocated within a one-mile radius of the proposed well location under the provisions of this regulation, or the applicant demonstrates that the proposed well will not impair existing water rights.

(8) The water right that is proposed to be changed is vested or certified.

(9) All other statutory and regulatory requirements for approval of a change in point of diversion that do not conflict with this regulation are met.

(b) The approval of the change in point of diversion shall be subject to the conditions specified in this subsection:

The approval of the application to change the point of diversion shall be subject to review by the chief engineer 10 years after the approval of the change application. If the water level at the new well location has declined in excess of 10 feet from the date the new well was drilled, for the sole purpose of administering wells concerning direct impairment, the new well shall be considered to have the priority of the date of the application to change the point of diversion. The owner of the well shall have the option of applying for another change in point of diversion.

(c) The quantity of water that can be approved for a change in point of diversion meeting the requirements of subsection (a) above shall be determined based on the following tables.

Points

point value for each column at right	saturated thickness at proposed well site, in feet	quantity of water authorized in two-mile-radius circle around proposed well, in acre-feet	feet of decline in two-mile-radius circle around proposed well since pre-development
1	146+	0-1,500	0-4
2	111-145	1,501-3,000	5-8
3	91-110	3,001-4,500	9-12
4	66-90	4,501-6,000	13-16
5	41- 65	6,001+	17-20

Percent of a water right that can be moved to a new location

number of points scored by proposed well	percent of water right that can be moved to new well location
3-6	100
7-9	90
10-12	80
13-15	70

(Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective Oct. 31, 2003.)

5-25-19. Saturated thickness map. (a) The following electronic data files, all dated July 10, 2002 and prepared by the district using data developed by the Kansas geological survey and the district, are hereby adopted by reference by the chief engineer:

(1) Rattlesnake basin.dbf;
(2) Rattlesnake basin.sbn;
(3) Rattlesnake basin.sbx;
(4) Rattlesnake basin.shp;
(5) Rattlesnake basin.shx; and
(6) Wln.dbf.

(b) Except as set forth in subsection (c), the electronic data files described in subsection (a) shall be used in all situations in which determination of the saturated thickness of the aquifer within the boundaries of the district is necessary.

(c) The saturated thickness shown in the electronic data files shall be used unless the applicant provides, or the chief engineer has available, better or more site-specific data concerning the actual saturated thickness of the two-mile-radius circle surrounding the well in question. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; effective Oct. 31, 2003.)

5-25-20. Recommendations by the board. (a) The following types of applications shall be submitted by the chief engineer to the district for review and recommendation:

(1) All applications to appropriate water for beneficial use, except for temporary use and domestic use; and

(2) all applications to change the point of diversion, place of use, the use made of the water, or any combination thereof, except applications to move the point of diversion less than 300 feet.

(b) The district shall conduct a review of the proposed application. Except as set forth in subsection (d), the district's recommendation to the chief engineer shall be consistent with the provisions of the Kansas water appropriation act, the groundwater management district act, and the regulations adopted by the chief engineer pursuant to those acts.

(c) Within 15 working days after the date the chief engineer submits the application to the district for review, or within any extension of time authorized by the chief engineer, the district shall submit its findings and recommendation for approval, denial, or modification of the application and shall specify the basis for the recommendation.

(d) The district may submit to the chief engineer a written recommendation of an exemption from or a waiver of a regulation. If the district submits such a recommendation, the district shall demonstrate to the chief engineer that the granting of the proposed waiver or exemption will not prejudicially and unreasonably affect the public interest and will not cause impairment of any existing water right. (Authorized by K.S.A. 82a-706a and K.S.A. 2002 Supp. 82a-1028; implementing K.S.A. 82a-706, K.S.A. 82a-706a, and K.S.A. 2002 Supp. 82a-711; effective Oct. 31, 2003.)

Articles 26 to 29.—RESERVED

Article 30.—DAMS

5-30-1. Approval of or permits for dams. The chief engineer shall not approve or grant a permit for any dam subject to the jurisdiction of the chief engineer under the authority of K.S.A. 1979 Supp. 82a-301 through 305a as amended, unless the applicant also receives prior approval

of his or her application to appropriate water for beneficial use to be diverted by means of the dam for which the approval or permit is sought, unless the sole proposed use for the water is for domestic use. (Authorized by K.S.A. 82a-706a, 82a-709; effective May 1, 1980.)

Articles 31 to 39.—RESERVED

Article 40.—DESIGN OF EARTH DAMS

5-40-1. Definitions. As used in K.S.A. 82a-301 through 82a-305a and amendments thereto, in the regulations adopted pursuant thereto, and by the division of water resources in administering K.S.A. 82a-301 through 82a-305a and amendments thereto, unless the context clearly requires otherwise, the following words and phrases shall have the meaning ascribed to them in this regulation: (a) "Application" means the formal document submitted to the chief engineer requesting a permit, in accordance with the provisions of K.S.A. 82a-301 through 82a-305a and amendments thereto, that authorizes the applicant to proceed with the construction of a proposed dam, channel change, or stream obstruction.

(b) "Authorized representative" means any staff employee designated by the chief engineer to perform duties and functions on behalf of the chief engineer.

(c) "Channel change or stream obstruction" means any project or structure, including any dam, that meets either of the following criteria:

(1) Does not extend above the higher natural bank; or

(2) alters the course, current, or cross section of any stream of the state.

(d) "Chief engineer" means the chief engineer, division of water resources of the Kansas department of agriculture.

(e) "Dam" means any artificial barrier, together with appurtenant works, that does, or may, impound water.

(f) "Freeboard" means the vertical distance between the maximum stage attained in the design storm event and the top of the structure.

(g) "Navigable stream" means the Arkansas river, the Missouri river, and the Kansas river.

(h) "Perennial stream" means a stream, or part of a stream, that flows continuously during all of the calendar year, except during an extreme drought.

(i) "Permit" means the formal document that is issued by the chief engineer to the sponsor of a project and that authorizes the sponsor to proceed with the construction of the dam, channel change, or stream obstruction.

(j) "Reservoir" means the area upstream from a dam that contains, or will contain, impounded water.

(k) "Stream" means any watercourse that has a well-defined bed and banks, and that has a watershed above the geographic point in question that exceeds the following number of acres:

(1) Zone three: 640 acres for all geographic points within any county west of a line formed by the adjoining eastern boundaries of Phillips, Rooks, Ellis, Rush, Pawnee, Edwards, Kiowa, and Comanche counties;

(2) zone two: 320 acres for all geographic points within any county located east of zone three and west of a line formed by the adjoining eastern boundaries of Republic, Cloud, Ottawa, Saline, McPherson, Reno, Kingman, and Harper counties; and

(3) zone one: 240 acres for all geographic points within any county located east of zone two. The stream need not flow continuously and may flow only briefly after a rain in the watershed. If the site of the project has been altered so that a determination of whether the well-defined bed and banks exist is not possible, it shall be presumed that they did exist if the watershed acreage criteria have been met, unless the owner of the project can conclusively demonstrate that the well-defined bed and banks did not exist before the construction of the project.

(l) "Watershed" means all of the area draining toward a selected point on a stream. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-302; effective May 1, 1983; amended May 1, 1987; amended, T-5-12-30-91, Dec. 30, 1991; amended Feb. 17, 1992; amended Sept. 22, 2000.)

5-40-2. Dams; plans and specifications. Plans for dams shall include: (a) Plan view of dam and dam site. The plan view of the dam and dam site may be shown in connection with the topographic map of the reservoir basin, providing the scale is sufficiently large to show adequate detail. A separate plan view shall be used if necessary to clearly show the features of the entire area in which the dam and spillway are to be located, and the details required below. The area covered by this view shall be on both abutments of the dam as well as a considerable distance both upstream

and downstream from the dam. All elevations shown on plans shall be referred to permanent bench marks described on the plans. The following details shall be shown:

(1) Location of the axis of the dam, showing stationing and top width limits;

(2) toe of upstream and downstream slopes;

(3) location of center line and limits of emergency spillway;

(4) location of principal spillway and any stilling basin;

(5) location of berms;

(6) location of slope protection;

(7) location of borings or test holes and test pits;

(8) location of intakes, outlets, valves and valve wells;

(9) location, description and elevation of permanent bench marks; and

(10) location, description and details of all foundation drains;

(b) Map of drainage pattern above and below the dam site. A map, to a scale no smaller than one inch to 2,000 feet, shall show the location of the watercourse across which the dam is to be built and its tributaries above the dam site. The following shall also be shown: (1) The location of the dam and the outline of the reservoir;

(2) the boundary of the watershed, shown by a line enclosing the entire area that will drain into the reservoir;

(3) section lines, with sections properly identified;

(4) size of the drainage area;

(5) the land owned by the sponsor; and

(6) roads, railroads, pipeline crossings and any other prominent features in the vicinity. The point where the axis of the dam crosses the stream shall be shown on this map by showing distances and angles from an apparent section corner or quarter corner. It shall be acceptable to utilize an aerial photograph to make this determination;

(c) Topographic map of the reservoir basin. A topographic map of the dam site and reservoir area shall be shown to the following scale:

Surface areas at top of dam	Acceptable scale
less than 30 acres	one inch to 100 feet
30 acres through 100 acres	one inch to 200 feet
more than 100 acres	one inch to 300 feet

The location of the dam shall be superimposed on this map. Topography shall be shown by contours at two foot intervals. For dams more than 20 feet in height, contours may be spaced at greater intervals, but shall not exceed five feet. In addition, contours equivalent to the elevation of the lowest uncontrolled opening (permanent pool), elevation of the crest of the emergency spillway, and elevation of the top of the dam shall be shown. The elevation of each contour shall be clearly noted on the map;

(d) Cross section of dam site and longitudinal section of dam. The cross section of the valley at the dam site shall be taken along the axis of the dam. A separate cross section view shall be used if necessary to clearly show the details required below. The details on this section shall include the following:

(1) Elevation to which the top of the dam is to be maintained and the elevation to which it is to be initially constructed in order to provide an adequate settlement allowance;

(2) elevation of the stream bed;

(3) location and elevation of the crest of the emergency spillway;

(4) location and elevation of the crest of the principal spillway;

(5) elevation of any berms;

(6) original surface of the ground;

(7) proposed elevations and dimensions of cutoff trench;

(8) location and elevation of outlet works;

(9) location of test holes showing materials encountered in the section; and

(10) location, description and elevations of all foundation drains;

(e) Cross section of dam. A cross section of the dam at the deepest point shall be shown. If the cross section is variable, a typical section shall be shown for each reach with proper description of the reach by stationing. Additional cross sections along the axis of the principal spillway and the axis of any other outlets shall be shown. Cross sections of the dam shall include the following:

(1) Elevation and width of the top of the dam;

(2) elevation and width of any berms;

(3) slopes of the upstream and downstream faces of the dam;

(4) elevation, location and type of slope protection;

(5) zones of earth embankment;

(6) dimensions to which the dam is to be constructed to provide an adequate allowance for settlement;

(7) elevation, location and dimensions of cutoff trench and core wall; and

(8) location of all foundation drains;

(f) Plan, profile, and cross section of emergency spillway. Details of the emergency spillway shall include the following:

(1) Plan view showing the location and stationing along the center line of the emergency spillway, together with the location of the control section and details of riprap or other slope and floor protection;

(2) sections showing elevations, slopes and dimensions of the spillway; and

(3) profile along the axis of the spillway, extending from the reservoir area through the control section to the stream bed below the dam. Stationing on the profile shall correspond to that on the plan view. This profile shall show the existing ground elevation, proposed grade of the bottom of the spillway, elevation of slope protection on the side slopes, and the nature of the material through which the spillway is excavated;

(g) Profile of principal spillway. Details of the principal spillway shall include the profile along the axis of the spillway, extending from the intake to the outlet, showing the size and spacing of the cutoff collars. This profile shall show existing ground elevations and the proposed grade of the spillway. Details of the stilling basin, supports and other features shall also be shown;

(h) Reservoir data. The number of acres enclosed by each contour within the reservoir basin and the total storage capacity of the reservoir in acre-feet at the elevation of each contour shall be determined and tabulated on the plan. The data shall be compiled for all contours in the reservoir up to the elevation of the top of the dam. Computations of capacity shall be based on the natural topography of the reservoir basin including the volume of any excavation in the reservoir below the emergency spillway made during construction of the dam. When the reservoir is divided between more than one landowner, the property lines shall be shown on the topographic map of the basin;

(i) Bench marks. At least two permanent bench marks shall be set for future reference conveniently located for use after construction. The bench marks shall be placed where they will not be destroyed or submerged after the reservoir fills, preferably, at a location along the axis of the dam near both dam extremities. A three or four foot length of pipe or steel driven flush with the ground in an area which is unlikely to be disturbed may be used. Wood or plastic stakes, nails, or marks in trees shall not be considered as permanent bench marks. The location and description of the bench marks shall be shown on the plans. They shall be properly referenced so that they can be easily found in the field. Elevations for size two, size three and size four structures shall be referenced to the national geodetic vertical datum of 1929 to a tolerance of plus or minus one half foot. Elevations for size one structures shall be referred to any assumed datum; and

(j) Spillway discharge capacity data. (1) A curve or table showing discharge capacity of the emergency spillway, in cubic feet per second, shall be developed and shown on the plan.

(2) A curve or table showing discharge capacity of the principal spillway, in cubic feet per second, shall be developed and shown on the plan.

(k) Each application for a permit to construct a class (c) high hazard dam shall include an emergency preparedness plan. (Authorized by K.S.A 82a-303a; implementing K.S.A. 82a-302; effective May 1, 1983; amended May 1, 1985; amended May 1, 1987.)

5-40-3. Specifications. The specifications for dams, channel changes and obstructions shall be prepared on 8½ by 11 inch sheets of a good grade of white bond paper. The specifications shall be in sufficient detail to assure that the works will be properly executed and shall comply with currently accepted engineering practices. The specifications shall include provisions for: (a) Adequate supervision during the period of construction by a person qualified to design the structure;

(b) notification of the division of water resources of the status of construction; and

(c) inspection by representatives of the division of water resources. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-302; effective May 1, 1983; amended May 1, 1987.)

5-40-4. Preparer of maps, plans, profiles, and specifications. In addition to the requirements of the Kansas board of technical professions, the requirements in this regulation shall apply. (a) Each map, plan, profile, and specification submitted to the chief engineer for approval shall be prepared by a person who is competent in the design and construction of dams, channel changes, or stream obstructions, as appropriate.

(b) Maps, plans, profiles, and specifications for any dam that meets one of the following criteria shall be prepared by a licensed professional en-

gineer who is competent in the design and construction of dams:

(1) Impounds 50 acre-feet or more at the top of the dam;

(2) is 25 feet or more in height; or

(3) is either a class (b) or class (c) hazard dam.

(c) Maps, plans, profiles, and specifications for any channel change or stream obstruction project on a navigable stream or a stream having a mean annual flow of 100 cubic feet per second or more at the proposed location of the project shall be prepared by a licensed professional engineer who is competent in the design of that type of project.

(d) No provision of this regulation, nor any decision made by the chief engineer pursuant to this regulation, shall alter the responsibilities or duties of any licensee of the Kansas board of technical professions to comply with that board's requirements. (Authorized by K.S.A. 82a- 303a; implementing K.S.A. 82a-302; effective May 1, 1983; amended May 1, 1986; amended May 1, 1987; amended Sept. 22, 2000.)

5-40-5. Determining capacity of reservoir. To determine whether a dam impounds 30 acre-feet of water, pursuant to K.S.A. 82a-304, that measurement shall be made at the lowest elevation of the top of the dam. (Authorized by K.S.A. 1982 Supp. 82a-303a; implementing K.S.A. 82a-302; effective May 1, 1983.)

5-40-6. Waiver and stricter requirements. (a) The chief engineer may waive any of the regulations adopted under articles 40, 41, 42 and 43 if it is shown to the satisfaction of the chief engineer that the waiver of the regulation will not pose a hazard to the public safety and that the waiver is in the public interest.

(b) The chief engineer may also invoke any jurisdiction granted by statute and impose stricter requirements than required by rules and regulations where such jurisdiction or additional requirements are necessary to protect the public interest, protect the public safety or prevent damage to property. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective May 1, 1983; amended May 1, 1987.)

5-40-7. Other maps, plans, profiles, data and specifications. The applicant shall also submit any other maps, plans, profiles and specifications of the dam, channel change or obstruction and any other data which the chief engineer may require. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-302; effective May 1, 1983; amended May 1, 1987.)

5-40-8. Application. The application shall be filed on the prescribed form or forms furnished by the chief engineer and shall be completed in proper form. (Authorized by K.S.A. 1982 Supp. 82a-303a; implementing K.S.A. 82a-302; effective May 1, 1983.)

5-40-9. Adoption by reference. All of "engineering guide-1" (eg-1), relating to earth dams, hazard classes, spillway requirements, detention storage requirements and rainfall data, as revised May 1, 1986, by the Kansas state board of agriculture, division of water resources, is hereby adopted by reference and shall apply to dams constructed in this state. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-302; effective May 1, 1983; amended May 1, 1985; amended May 1, 1986.)

5-40-10. Adoption by reference. All of "engineering guide-2" (eg-2), relating to administrative requirements and criteria for the design of earth dams, as revised May 1, 1986, by the Kansas state board of agriculture, division of water resources, is hereby adopted by reference and shall apply to dams constructed or modified in this state. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-302; effective May 1, 1984; amended May 1, 1985; amended May 1, 1986.)

5-40-11. Alternative requirements for approval to construct a dam. Construction or modification of a dam shall be approved by the chief engineer with any permit conditions necessary to protect life, property, and public safety if both of the following conditions are met:

(a) The applicant applies for prior written consent or a permit to build or modify a dam.

(b) The proposed dam or modification of a dam does not meet one or more of the hydrologic and engineering requirements of K.A.R. 5-40-9 and K.A.R. 5-40-10, but the applicant demonstrates to the chief engineer, based on sound hydrologic and engineering principles, that the proposed dam, or modification of a dam, will not endanger life, property, and public safety if it is constructed or modified in accordance with the submitted plans and specifications. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-302 and 82a-303; effective Sept. 22, 2000.)

5-40-12. As built drawings. Following

completion of all class (c) high hazard dams, within 90 days, or within any authorized extension of time, the applicant shall submit as built drawings prepared by a person authorized to prepare the original plans and specifications pursuant to K.A.R. 5-40-4. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective May 1, 1987.)

5-40-13. Safety inspections. Following the completion of construction of any class (c) high hazard dam, the owner shall have a dam safety inspection conducted by a licensed professional engineer and have the report submitted to the division of water resources. Inspections shall be conducted at five-year intervals, or more frequently if specifically requested by the chief engineer. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective May 1, 1987.)

5-40-14. Testing a principal spillway pipe installation in a dam; applicability. (a) For the purpose of testing the leakage rate of principal spillway pipe installation in a dam, an applicant shall conduct a static pressure test of each principal spillway installation constructed of corrugated metal pipe.

(b) A static pressure test shall be required only of a principal spillway installation made of corrugated metal pipe, unless the chief engineer determines that testing principal spillway pipe made of other materials or testing other pipes used in the construction of dams is necessary to protect public safety, life, or property. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303b; effective Sept. 22, 2000.)

5-40-15. Testing a principal spillway pipe installation in a dam; general procedures. The following general procedures shall apply to all static pressure tests required by K.A.R. 5-40-14: (a) The applicant shall conduct the test before backfilling around and over the principal spillway pipe and after laying the pipe on the grade line and connecting the pipe according to the approved plans and the manufacturer's requirements.

(b) The applicant, the applicant's representative, or the contracting officer shall make arrangements for the chief engineer, or a person designated by the chief engineer, to be present during the test.

(c) The applicant shall place a watertight plug in the downstream end of the pipe. The plug shall be sufficient to withstand a pressure of three pounds per square inch for the duration of the test. The plug shall be equipped with an acceptable means of draining the water out of the pipe after completion of the test.

(d) The applicant shall fill the pipe with water up to an elevation of 10 feet above the flow line at the pipe outlet, or up to the principal spillway inlet elevation, whichever is less, unless a different elevation is required by the test method described in K.A.R. 5-40-16(b).

(e) The applicant shall note the exact elevation of the water surface at the time the test begins. At the end of the prescribed test duration, the applicant shall measure the water surface elevation.

(f) The applicant shall use one of the test methods described in K.A.R. 5-40-16 to determine whether the water leakage rate is acceptable.

(g) If the leakage rate determined by either of the methods described in K.A.R. 5-40-16 is not acceptable, the applicant shall determine the source of the leakage and correct the leakage. After correction, the applicant shall perform another test in accordance with K.A.R. 5-40-15 and K.A.R. 5-40-16.

(h) If the leakage rate determined by either of the methods described in K.A.R. 5-40-16 is acceptable, the applicant shall drain and backfill the pipe in the manner prescribed by the approved plans and specifications. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303b; effective Sept. 22, 2000.)

5-40-16. Testing a principal spillway pipe installation in a dam; allowable leakage rate, test methods. The allowable leakage rate for a principal spillway pipe installation in a dam shall not exceed 1,000 gallons per inch diameter of pipe per mile of pipe per day. The applicant shall use one of the following test methods in determining whether the allowable leakage rate has been exceeded:

(a) The applicant shall use the following test method procedure for a drop inlet structure if the starting and ending elevation of the water is within the vertical drop structure and above the top of the barrel:

(1) Calculate the allowable leakage rate in gallons per minute for the pipe being tested based on the following formula:

The allowable leakage rate in gallons per minute = $0.000132 \times d \times l$ where:

d = diameter of the tested pipe in inches
l = length of the tested pipe in feet

If the allowable leakage rate in gallons per minute is determined to be less than one, then it shall be assumed for the purposes of the test that the allowable leakage rate in gallons per minute is one.

(2) Conduct the test for 15 minutes.

(3) If the allowable leakage rate is one gallon per minute, the applicant may use the following table to determine the allowable drop in the elevation of the water in the riser.

Nominal diameter of riser (inches)	Allowable drop (feet)
18	1.13
20	0.83
24	0.64
30	0.41
36	0.28

(4) If the measured drop in the riser exceeds the corresponding allowable drop in paragraph (a)(1) above, the allowable leakage rate has been exceeded, which shall not be acceptable. If the measured drop in the riser is less than or equal to the corresponding allowable drop in paragraph (a)(1) above, the allowable leakage rate has not been exceeded and shall be acceptable.

(b) The applicant shall use the following test method procedure for all other types of installations, including canopy inlets:

(1) If filling the pipe with water up to an elevation of 10 feet above the outlet puts water within the vertical riser below the top of the barrel, the elevation shall be reduced below the bottom of the vertical riser before the test begins.

(2) The allowable drop in elevation is a function of the allowable leakage rate, test duration, and the diameter and slope of the pipe. The allowable drop in the pipe in feet shall be calculated by use of the following formula:

$$\frac{\text{allowable rate (gallons per minute)} \times \text{test duration (minutes)} \times \text{slope (\%)}}{[\text{diameter (inches)}]^2 \times 4.08}$$

(3) The minimum test duration shall be 15 minutes. If the above formula results in an allowable drop of less than 0.1 foot in 15 minutes, the test duration shall be extended so that the allowable drop is greater than 0.1 feet.

(4) The water surface elevation drop shall be measured by means of a clear plastic tube installed in the plug at the downstream end of the principal spillway pipe. Any other means of measuring the drop in elevation shall be approved by the chief engineer in advance of the test.

(5) If the measured drop is greater than the allowable drop as calculated in paragraph (b)(2), the allowable leakage rate has been exceeded, which shall not be acceptable. If the allowable drop is less than or equal to the allowable drop as calculated in paragraph (b)(2), the allowable leakage rate has not been exceeded, which shall be acceptable. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303b; effective Sept. 22, 2000.)

Article 41.—DESIGN OF CHANNEL CHANGES

5-41-1. Channel changes; plans and specifications. Plans for a channel change shall include the following: (a) A general location map or aerial photograph, showing the present alignment of the stream, location of the proposed channel change, section lines, property lines with names and addresses of adjoining landowners, drainage area, a north arrow, a bar scale, and any other prominent features;

(b) a detailed plan view of the project with stationing shown, including as many other views as necessary to fully describe the project;

(c) a profile drawing along the centerline of the proposed new channel. This profile shall extend five times the channel width upstream and an equivalent distance downstream from each end of the new channel. The stationing shown on the plan view shall correspond to stationing on the profile drawing. This drawing shall show the present ground surface, the present stream bed, and the grade line of the proposed new channel;

(d) cross sections of the existing stream at locations immediately above and below the proposed channel change. The location of these cross sections shall be described and shown on the plans. The elevations of the top of the existing banks and bottom of the channel shall be shown;

(e) at least one permanent bench mark conveniently located for use after construction, except for grassed waterways constructed for the purpose of conveying runoff without causing erosion or flooding. The location, description, and elevation of the permanent bench mark, to which all elevations are referred, shall be shown on the plans. The designer shall reference the project bench mark to the current national geodetic vertical datum, to a tolerance of plus or minus ½ foot on all channel

changes involving perennial streams and where detailed floodplain data are available. Project datum shall be acceptable on all other channel changes; and

(f) a cross-sectional drawing of the proposed new channel, including dimensions. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-302; effective May 1, 1987; amended Sept. 22, 2000.)

5-41-2. Channel changes; water velocity. The new channel shall have a conveyance capacity equal to or greater than the old channel. The water velocity after the completion of the proposed channel change or stream obstruction shall not exceed a permissive velocity. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective May 1, 1987.)

5-41-3. Channel changes; side slopes. The side slopes of the proposed new channel shall not be steeper than one foot vertical to two feet horizontal unless the applicant submits data and analysis to show that a steeper slope will be stable. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective May 1, 1987.)

5-41-4. Channel changes; construction by erosion. New channels shall not be constructed by erosion. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective May 1, 1987.)

5-41-5. Channel changes; disposal of excavated material. (a) Material removed from the newly excavated channel shall be deposited at a location and in a form acceptable to the chief engineer. If the material is to be deposited so that it will have the effect of a levee, a separate prior written approval of the chief engineer is required pursuant to K.S.A. 24-126.

(b) Filling or plugging the original channel shall receive the prior written approval of the chief engineer. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective May 1, 1987.)

5-41-6. Channel changes; vegetative strips on new channels. On each new channel project, except a grassed waterway constructed for the purpose of conveying runoff without causing erosion or flooding, a vegetative strip shall be established and maintained for a width of 50 feet immediately adjoining the channel on each side of the stream if site conditions permit, unless an acceptable engineering design shows that a greater or lesser width of vegetative strip is preferable. The general type of vegetation shall be approved by the chief engineer. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective May 1, 1987; amended Sept. 22, 2000.)

Article 42.—DESIGN OF STREAM OBSTRUCTIONS

5-42-1. Stream obstructions; plans and specifications. Plans for a stream obstruction shall include: (a) A general location map or aerial photograph showing the stream, location of the proposed obstruction, section lines, a bar scale, a north arrow, property lines with names and addresses of adjoining landowners, and any other landowners whose land may be hydraulically affected by the proposed stream obstruction, drainage area and any other prominent features;

(b) a detailed plan view fully describing the obstruction and the site;

(c) a profile showing the present elevation of the stream bed and both banks, extending upstream to the point where the stream bed elevation is equal to or higher than the top of the obstruction and extending downstream an equivalent distance from the project site;

(d) an elevation view showing the obstruction on a cross section of the stream and the valley up to the post project design flood elevation at the site;

(e) at least one permanent benchmark shall be conveniently located for use after construction. The location, description and elevation of the permanent benchmark, to which all elevations are referred, shall be shown on the plans. Reference to the national geodetic vertical datum of 1988, or other acceptable national vertical datum, to a tolerance of plus or minus one half foot is required for all stream obstructions on perennial streams and where detailed floodplain data are available. Project datum is acceptable on all other stream obstruction projects;

(f) details of the manner in which the obstruction is to be tied into the bed and banks of the streams;

(g) the land for which easements or rights-of-way are to be acquired if the proposed obstruction affects land other than that owned by the applicant; and

(h) unless it is clear that the impacts of the proposed project will be contained within the channel or limited to property under the control of the

applicant, a hydraulic analysis determining the pre-project and post-project water surface elevations for the two-year flood and the 100-year flood shall be prepared and submitted to the chief engineer. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-302; effective May 1, 1987; amended, T-5-12-30-91, Dec. 30, 1991; amended April 27, 1992.)

5-42-2. Stream obstruction; minor. If a proposed stream obstruction will not decrease the cross sectional area of a stream channel at the location of the obstruction by more than 15 percent, the plans required by the chief engineer shall be equivalent to the type submitted to the United States corps of engineers with applications for a department of the army permit. Such obstructions shall include weirs, causeways, low-water crossings, low-head dams, intake structures, boat launching ramps, pipeline crossings, outfall structures, marinas, boat docks, jetties and revetments. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective May 1, 1987.)

5-42-3. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective May 1, 1987; amended April 27, 1992; revoked Sept. 22, 2000.)

5-42-4. Stream obstruction; temporary structure. A temporary structure shall not require a stream obstruction permit from the chief engineer pursuant to K.S.A. 82a-301 et seq. and amendments thereto if it meets all of the following criteria:

(a) The structure is temporary in nature.

(b) The structure is constructed only of temporary materials, including local streambed materials, straw or hay bales, plastic, or plywood, that are likely to wash out during a bank-full storm event.

(c) The structure is actively maintained only during the duration of the temporary beneficial use.

(d) The structure is less than two feet in height above the natural bed of the stream, and alterations to the stream and alterations to the stream bank are no more than are necessary for permitting access to the site for operation and maintenance.

(e) The structure is below the natural low bank of the stream.

(f) Any water backed up by the structure is detained solely on property under the control of the landowner that constructed the temporary structure.

(g) The structure does not materially adversely affect the public interest, public safety, or environment. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective Sept. 22, 2000.)

Article 43.—SAND DREDGING PERMITS

5-43-1. Sand dredging operation; plans and specifications. Plans for a sand dredging operation from a stream shall include: (a) A general location map or aerial photograph showing the stream, location of the proposed sand dredging operation, section lines, property lines with names and addresses of adjoining landowners, local access roads, a bar scale, a north arrow and any other prominent features;

(b) a plat of the area within which the sand plant will be operated, prepared to a scale of 200 feet per inch, or less, if necessary to show in detail the features of the stream at the location. The plat shall include at least one permanent bench mark. The survey shall also include at least two permanent horizontal control points on a baseline running generally parallel to the stream. These permanent points shall be identified with substantial markers and shall be easily visible in the field. The plat shall show the location of the natural banks on both sides of the stream, all islands, sand bars, and the direction of the stream within the channel. Where county commissioners have established bank lines along a stream in accordance with the provisions of K.S.A. 82a-307a, the location of such established bank lines shall be shown. The plat shall also show the proposed location of the tipple, boundaries of areas from which material will be removed and the area to which rejected material will be returned;

(c) cross sections of the channel, measured along lines at right angles to the general direction of the stream and plotted to a horizontal scale of not more than 200 feet per inch and an appropriate vertical scale. Typical cross sections shall be shown for unobstructed portions of the channel as well as for portions in which islands, sand bars or other obstructions may be located. The elevation of the top of both banks, the bed of the stream, and the surface of islands and bars shall be shown on the cross sections. The location of lines along which cross sections are measured shall be referred to the baseline and indicated on the plat. All elevations shall be referred to a per-

manent bench mark, which is referenced to the national geodetic vertical datum of 1929 to a tolerance of plus or minus one half foot; and

(d) a statement of plan of operation. A brief paragraph shall be included explaining the plants usual operating plans. The kind of equipment, pumping capacities, seasonal limitations and any other operational constrictions shall be included. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-302; effective May 1, 1987.)

5-43-2. Sand dredging; buffer zone. There shall be a buffer zone of not less than 500 feet between dredging operations, and between dredging operations and all bridges. There shall be a buffer zone of 300 feet between dredging operations and buried pipeline or cable crossings. There shall be a buffer zone of 200 feet between dredging operations and levees, or other features subject to damage by undercutting. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective May 1, 1987.)

5-43-3. Sand dredging; operation. In counties at locations where bank lines have been established on designated streams pursuant to K.S.A. 82a-307, materials shall be removed only between established bank lines. The chief engineer, for good cause, may allow excavation or removal of material landward from established bank lines if approval is also obtained from the board of county commissioner. On navigable streams materials shall be removed only from the channel and in such a manner so as not to degrade the banks. On all other streams, materials shall be removed only from areas and in a manner approved by the chief engineer. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective May 1, 1987.)

5-43-4. Sand dredging; operations conflicting. If more than one operator proposes to operate within a given reach of a private stream, then all conflicting applicants shall be required to submit proof of easements or other legal authority to operate. If more than one operator proposes to operate within a given reach of a navigable stream, the chief engineer shall determine which operators shall be permitted, based on the following criteria: (a) The capability of the applicant's equipment to operate within the desired area;

(b) the applicant's need for the material;

(c) the applicant's existing operation, if any;

(d) the anticipated date the applicant will begin operation;

(e) the applicant's history of operation;

(f) the anticipated plant completion date;

(g) proof of the applicant's easements and right-of-ways necessary to operate;

(h) date of application; and

(i) any other relevant factor. (Authorized by K.S.A. 82a-303a; implementing K.S.A 82a-302; effective May 1, 1987.)

5-43-5. Sand dredging; operation setback. Sand dredging operations located outside the channel of a stream shall be set back a minimum of 50 feet from the bank of the channel. There shall be a minimum slope on the sand plant side of not greater than one foot vertical to four feet horizontal. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective May 1, 1987.)

Article 44.—FLOODPLAIN MANAGEMENT

5-44-1. Floodplain management; definitions. As used in these regulations, K.S.A. 12-766, and by the division of water resources in administering K.S.A. 12-766, unless the context clearly requires otherwise, the following words and phrases shall have the meaning ascribed to them in this section: (a) "Basement" means any area of a building having its floor subgrade (below ground level) on all sides.

(b) "Chief engineer" means the chief engineer of the division of water resources, Kansas state board of agriculture.

(c) "Development" means any man-made change to real estate, including, but not limited to:

(1) buildings or other structures;

(2) mining;

(3) dredging;

(4) filling;

(5) grading;

(6) paving;

(7) excavation or drilling; or

(8) storage of equipment or materials.

(d) "Flood or flooding" means a general and temporary condition of partial or complete inundation of normally dry land from:

(1) the overflow of waters normally confined between the banks of a stream or other watercourse, or

(2) the unusual, rapid accumulation or runoff of surface waters from any source.

(e) "Regulatory floodway" means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot.

(f) "Lowest floor" means the lowest enclosed area, including a basement, of a building. An unfinished or flood resistant enclosure usable solely for parking of vehicles, building access or storage in an area other than a basement is not considered a building's lowest floor.

(g) "Permit" means a signed document from a designated community official authorizing development in a floodplain, including all necessary supporting documentation such as:

(1) the site plan;

(2) an elevation certificate; and

(3) any other necessary or applicable approvals or authorizations from local, state or federal authorities.

(h) "Structure" means a walled and roofed building, a manufactured house, or above ground gas or liquid storage tank.

(i) "Substantially improved" means any reconstruction, rehabilitation, addition to or other improvement of a structure, the cost of which equals or exceeds 50% of the market value of the structure before the improvement.

(j) "Variance" means a grant of relief by a community from the terms of a floodplain management zoning regulation.

(k) "Flood hazard map" means the document adopted by the governing body showing the limits of:

(1) the floodplain;

(2) the floodway;

(3) streets;

(4) stream channel; and

(5) other geographic features.

(Authorized by and implementing K.S.A. 12-766; effective, T-5-12-30-91, Jan. 1, 1992; effective Feb. 17, 1992.)

5-44-2. Floodplain management; conditions for application for approval. Before formal adoption by the governing body of any zoning regulation that establishes a floodplain zone or district, or regulates the development within a floodplain zone or district, the governing body shall apply to the chief engineer for approval of the zoning regulations. The governing body shall also apply to the chief engineer for approval of its zoning regulation when: (a) the governing body enters into, or alters its status under, the national flood insurance program;

(b) the governing body adopts a new or revised flood hazard map, base flood elevations, flood insurance study, or regulatory floodway;

(c) the governing body annexes areas containing floodplain;

(d) the governing body assumes administrative jurisdiction over the adjacent floodplain areas outside the governing body's boundaries; or

(e) the governing body changes variance procedures used in granting relief from floodplain regulations. (Authorized by and implementing K.S.A. 12-766; effective, T-5-12-30-91, Jan. 1, 1992; effective Feb. 17, 1992.)

5-44-3. Floodplain management; application for approval of zoning regulations; time limit. (a) The application for approval of zoning regulations shall consist of:

(1) a letter which:

(A) requests approval by the chief engineer under K.S.A. 12-766 on a proposed effective date, which shall not be prior to the approval by the chief engineer;

(B) proposes the date of adoption by the governing body; and

(C) states the reason for application for approval as enumerated in K.A.R. 5-44-2;

(2) a copy of the full text of the zoning regulation including maps, plans, profiles and specifications adopted by the floodplain management zoning regulations which meet the requirements of K.A.R. 5-44-4.

(b) When all the data required by the chief engineer is received, the chief engineer shall notify the governing body in writing as to the beginning and ending dates of the 90 day statutory time period for review. (Authorized by and implementing K.S.A. 12-766; effective, T-5-12-30-91, Jan. 1, 1992; effective Feb. 17, 1992.)

5-44-4. Floodplain management; zoning regulations; minimum standards and criteria. Any zoning regulation which regulates development of floodplains shall include the following minimum standards and criteria: (a) Flood hazard areas shall be identified as follows:

(1) The flood hazard area subject to floodplain management zoning regulation shall be identified by reference to a specific map used to identify the

flood hazard. The identification of the map shall include the preparer of the map and the date it was prepared.

(2) When the flood hazard map is revised and republished with a new effective date, the governing body's floodplain management zoning regulations shall amend the zoning regulations to adopt the new map by reference.

(b) The development standards shall meet or exceed the minimum requirements of the national flood insurance act of 1968, as amended, 42 U.S.C. Section 4001 *et seq.* and the regulations adopted pursuant to that act.

(c) Any development standards adopted by the governing body for which minimal requirements have been set by the chief engineer in K.A.R. 5-45-1 *et seq.* shall meet or exceed the requirements of the chief engineer.

(d) The governing body shall designate a local floodplain administrator by position or job title. The local floodplain administrator's responsibilities shall include:

(1) the review and issuance of floodplain development permits;

(2) the conduct or direction of appropriate inspections;

(3) the maintenance of any records necessary to document compliance with floodplain development permit conditions; and

(4) any other matters deemed appropriate by the governing body.

(e) The governing body shall designate by position or job title an enforcement officer who is responsible to enforce the actions of the local floodplain administrator.

(f) The local floodplain administrator and enforcement officer may be combined in a single position or job title.

(g) If any part of a proposed development is located within the floodplain, an application for floodplain development permit shall be made to the local floodplain administrator. The application for a floodplain development permit shall contain:

(1) Sufficient detail for the local floodplain administrator to determine the nature of proposed development and whether permits or approvals are needed from the governing body, state or federal authorities, especially any permits or approvals that may be required by K.S.A. 24-126 or K.S.A. 82a-301 *et seq.* and their respective regulations; and

(2) Written documentation of adequate protection from damages which could be caused by the base flood.

(h) If the proposed residential development will be located in an area designated as zone AO on a flood insurance rate map (FIRM), any new or substantially improved residential structure shall have the lowest floor (including the basement) elevated above the highest adjacent natural grade at least as high as the depth number specified in feet on the FIRM. If no depth number is specified on the FIRM, it shall be elevated at least two feet above the highest adjacent natural grade.

(i) If the proposed non-residential development will be located in an area designated as zone AO on a FIRM, any new or substantially improved non-residential structure shall be dry flood proofed or elevated to at least as high as the depth number specified in feet on the FIRM above the highest adjacent natural grade. If no depth number is specified on the FIRM, it shall be dry flood proofed or elevated at least two feet above the highest adjacent natural grade.

(j) If zone AO is not specified on the FIRM, or the proposed development will be located in the floodplain outside zone AO, then the lowest floor of any new or substantially improved residential structure shall be elevated at least one foot above the base flood elevation. The elevation of the lowest floor shall be certified by a licensed land surveyor.

(k) If zone AO is not specified on the FIRM, or the proposed development will be located in the floodplain outside zone AO, then any new or substantially improved non-residential structure shall be dry flood proofed or elevated to at least one foot above the base flood elevation. The elevation of the lowest floor shall be certified by a licensed land surveyor. If the structure is dry flood proofed, a licensed architect or a licensed professional engineer shall certify that the design and methods of construction of the dry flood proofing meet or exceed the minimum requirements of the national flood insurance act of 1968, as amended, 42 U.S.C. Section 4001 et seq. and the regulations adopted pursuant to that act. (Authorized by and implementing K.S.A. 12-766; effective, T-5-12-30-91, Jan. 1, 1992; effective Feb. 17, 1992.)

5-44-5. Floodplain management; variance procedures. Any floodplain management zoning regulations shall include procedures for the approval of a variance to the floodplain management zoning regulations. The procedures shall

stipulate the criteria for a variance and specify when a variance may be granted by the local floodplain administrator, the enforcement officer or board of zoning appeals. The procedures shall establish a board of zoning appeals for hearing appeals of decisions of the floodplain administrator or enforcement officer and establish the criteria for the appeals. Variances shall not be granted solely to avoid the requirements of a floodplain development permit. (Authorized by and implementing K.S.A. 12-766; effective, T-5-12-30-91, Jan. 1, 1992; effective Feb. 17, 1992.)

5-44-6. Floodplain management; waiver or stricter requirements. (a) The chief engineer may waive any of the regulations adopted under this article if it is shown to the satisfaction of the chief engineer that waiver of the regulation will not pose a hazard to the public safety and that such waiver is not adverse to the public interest.

(b) The chief engineer may invoke any jurisdiction granted by statute to impose stricter requirements than those required by rules and regulations where such jurisdiction or additional requirements are necessary to protect the public interest, protect the public safety or prevent damage to public or private property. (Authorized by and implementing K.S.A. 12-766; effective, T-5-12-30-91, Jan. 1, 1992; effective Feb. 17, 1992.)

Article 45.—DESIGN OF LEVEES

5-45-1. Levees and floodplain fills; definitions. As used in K.S.A. 24-126 and amendments thereto, in the regulations adopted pursuant thereto, and by the division of water resources in administrating K.S.A. 24-126, unless the context clearly requires otherwise, the following words and phrases shall have the meaning ascribed to them in this regulation: (a) "Approval" means the written approval of plans and specifications by the chief engineer authorizing the applicant to proceed with the construction and maintenance of a levee or floodplain fill project.

(b) "Authorized representative" means any staff employee designated by the chief engineer to perform duties and functions on behalf of the chief engineer.

(c) "Base flood" means a flood having a one percent chance of being equaled or exceeded in any one year.

(d) "Chief engineer" means the chief engineer, division of water resources, Kansas department of agriculture.

(e) "Design flood" means a flood having a selected probability of being equaled or exceeded in any one year for the degree of protection required.

(f) "Environmental mitigation" means any of the following:

(1) Site-specific modification of a project;

(2) implementation of a practice or management; or

(3) the reservation of a part of the project to protect or replace environmental values destroyed or adversely affected by the project.

(g) "Equal and opposite conveyance" means the location of development offsets from stream banks so that floodplain lands on each side of a stream outside the stream channel convey a share of the flood flows proportionate to the total conveyance available on each respective side of the stream.

(h) "Floodplain fill" means material, usually soil, rock, or rubble, that is placed in a floodplain to an average height of greater than one foot above the existing ground and that has the effect of diverting, restricting, or raising the level of floodwaters on a stream.

(i) "Floodway" means the channel of a stream and adjacent land areas that have been determined as being necessary to convey the base flood, as calculated using the minimum requirements of the national flood insurance act of 1968, 42 U.S.C. 4001 et seq., as amended September 23, 1994, and 44 C.F.R. part 59, subpart A, sec. 59.1 and 44 C.F.R. part 60, subpart A, sec. 60.3, as amended October 1, 1998.

(j) "Floodway fill" means floodplain fills, other than a levee, placed wholly or partially within the boundaries of the floodway at locations where the floodway has been identified.

(k) "Floodway fringe" means those portions of a floodplain outside of the boundaries of a regulatory floodway within reaches of a stream where such a floodway has been established.

(l) "Floodway fringe fill" means floodplain fills, other than a levee, placed wholly outside the floodway boundaries at locations where the floodway has been identified.

(m) "Levee" means any floodplain fill with an average height of more than one foot above the surrounding terrain constructed generally parallel to a water course and whose purpose is to repel floodwaters.

(n) "Perennial stream" means a stream, or a part of a stream, that flows continuously during

all of the calendar year, except during an extended drought.

(o) "Stream" means any watercourse that has a well-defined bed and banks, and that has a watershed above the geographic point in question that exceeds the following number of acres:

(1) Zone three: 640 acres for all geographic points within any county west of a line formed by the adjoining eastern boundaries of Phillips, Rooks, Ellis, Rush, Pawnee, Edwards, Kiowa, and Comanche counties;

(2) zone two: 320 acres for all geographic points within any county located east of zone three and west of a line formed by the adjoining eastern boundaries of Republic, Cloud, Ottawa, Saline, McPherson, Reno, Kingman, and Harper counties; and

(3) zone one: 240 acres for all geographic points within any county located east of zone two.

The stream need not flow continuously and may flow only briefly after a rain in the watershed. If the site of the project has been altered so that a determination of whether well-defined bed and banks exist is not possible, it shall be presumed that they did exist if the watershed acreage criteria have been met, unless the owner of the project can conclusively demonstrate that well-defined bed and banks did not exist before the construction of the project.

(p) "Watershed" means all of the area draining toward a selected point on a stream. (Authorized by and implementing K.S.A. 24-126; effective May 1, 1987; amended, T-5-12-30-91, Jan. 1, 1992; amended April 27, 1992; amended Sept. 22, 2000.)

5-45-2. Levees and floodplain fills; plans and specifications. Plans for a levee or a floodplain fill must be submitted on clearly legible prints (maximum size 24 inches by 36 inches) of the original tracings which are capable of reproduction. Plans for a levee or a floodplain fill shall include: (a) A general location map or aerial photograph showing:

(1) the stream;

(2) location of the proposed levee or floodplain fill;

(3) floodway limits where available;

(4) floodplain limits where available;

(5) section lines;

(6) property lines with names and addresses of adjoining landowners and any other landowners whose land may be hydraulically affected by the proposed levee or floodplain fill;

(7) drainage area;

(8) a bar scale;

(9) a north arrow;

(10) existing and proposed surface drainage flow patterns; and

(11) any other prominent features;

(b) a detailed plan view fully describing the levee or floodplain fill and the site, including:

(1) the design flood elevation and frequency;

(2) the base flood or floodplain limits where available;

(3) floodway limits where available;

(4) two-foot ground contours of the levee or floodplain fill and areas with local drainage problems; and

(5) the area reserved for environmental mitigation with a description of any necessary environmental mitigation measures to be implemented, if those measures may affect the hydraulics used to evaluate the project;

(c) a profile showing the proposed elevation of the top and base of the levee or floodplain fill, the design flood, the base flood, the stream bed and both banks;

(d) an elevation view at the most hydraulically restrictive location in the valley affected by the project, showing the levee or floodplain fill on a cross section of the stream and the valley up to the post project base flood elevation at the site. This cross section shall show:

(1) the stream;

(2) floodway limits where available;

(3) floodplain limits where available;

(4) base flood elevation; and

(5) design flood elevation;

(e) at least one permanent benchmark conveniently located for use after construction. The benchmark shall be placed where it is not likely to be destroyed. A three foot minimum length of pipe or steel driven flush with the ground in an area which is unlikely to be disturbed may be used. Wood or plastic stakes, nails or marks in trees shall not be considered as permanent benchmarks. The location and description of the benchmark shall be shown on the plans. They shall be properly referenced so they can be easily found in the field. The location, description and elevation of the permanent benchmark shall be shown on the plans. The benchmark may be a benchmark identified in the community's flood insurance rate map if the benchmark is less than 500

feet from the fill. Reference to the national geodetic vertical datum of 1988, or other acceptable national vertical datum, to a tolerance of plus or minus one half foot is required for all levees and floodplain fills on perennial streams. Reference to a tolerance of 0.05 foot is required where detailed floodplain data are available. Project datum is acceptable on all other levee and floodplain fill projects; and

(f) the land for which easements or rights-of-way have been acquired when the proposed levee or floodplain fill will affect land other than that owned by the applicant. (Authorized by and implementing K.S.A. 1991 Supp. 24-126; effective May 1, 1987; amended, T-5-12-30-91, Jan. 1, 1992; amended April 27, 1992.)

5-45-3. Levees and floodplain fills; specifications. The specifications for levees and floodplain fills shall be prepared on 8½ by 11 inch sheets of a good grade of white bond paper. The specifications shall be in sufficient detail to assure that the works will be properly executed and shall comply with currently accepted engineering practices. The specifications shall include provisions for: (a) adequate supervision during the period of construction by a person qualified to design the levee or floodplain fill;

(b) notification of the division of water resources of the status of construction; and

(c) inspection by a representative of the division of water resources. (Authorized by and implementing K.S.A. 24-126 as amended by L. 1991, ch. 56, sec. 27; effective May 1, 1987; amended, T-5-12-30-91, Jan. 1, 1992; amended April 27, 1992.)

5-45-4. Levees and floodplain fills; preparer of maps, plans, profiles, and specifications. In addition to the requirements of the Kansas board of technical professions, the following requirements shall apply: (a) Each map, plan, profile, and specification submitted to the chief engineer for approval pursuant to K.S.A. 24-126 and amendments thereto shall be prepared by a person who is competent in levee or floodplain fill design and construction.

(b) Map, plans, profiles, and specifications for any of the following described levees and floodplain fills shall be prepared by a licensed professional engineer that is competent in levee or floodplain fill design and construction:

(1) Class C levees;

(2) floodplain fills located in whole or in part in identified floodways; and

(3) floodplain fills that meet the following criteria:

(A) Are located in areas without a designated floodway;

(B) are greater than 3,200 cubic yards in volume;

(C) are more than four feet in height; and

(D) are more than 100 feet from other floodplain fills.

(c) No provision of this regulation, nor any decision made by the chief engineer pursuant to this regulation, shall alter the responsibilities or duties of any licensee of the Kansas board of technical professions to comply with that board's requirements. (Authorized by and implementing K.S.A. 24-126; effective May 1, 1987; amended, T-5-12-30-91, Jan. 1, 1992; amended April 27, 1992; amended Sept. 22, 2000.)

5-45-5. Levees; waiver and stricter requirements. The chief engineer may waive any of the regulations adopted under this article if it is shown to the satisfaction of the chief engineer that the waiver of the regulation will not pose a hazard to the public safety and that the waiver is in the public interest. The chief engineer may also invoke any jurisdiction granted by statute to impose stricter requirements than those required by rules and regulations where such jurisdiction or additional requirements are necessary to protect the public interest, protect the public safety or prevent damage to property. (Authorized by and implementing K.S.A. 24-126; effective May 1, 1987.)

5-45-6. Levees and floodplain fills; other maps, plans, profiles, data and specifications. The applicant shall also submit any other maps, plans, profiles and specifications of the levee or floodplain fill project and any other data which the chief engineer may require. (Authorized by and implementing K.S.A. 24-126 as amended by L. 1991, ch. 56, sec. 27; effective May 1, 1987; amended, T-5-12-30-91, Jan. 1, 1992; amended April 27, 1992.)

5-45-7. Levees and floodplain fills; application. (a) The application for approval of plans to construct a levee or floodplain fill shall be filed on the form(s) prescribed by the chief engineer, including application supplements, and shall be completed in proper form according to

the instructions. To be complete, the application shall include:

(1) application DWR No. 3-100.1;

(2) the application supplement, DWR Form No. 2-102;

(3) plans fully complying with requirements of K.A.R. 5-45-2;

(4) specifications fully complying with requirements of K.A.R. 5-45-3; and

(5) a copy of an application to the governing body for a floodplain development permit, if the proposed levee or floodplain fill will change the limits of the floodplain or floodway boundaries, or both.

(b) The statutory time limit on the chief engineer's deliberation for approval for floodway fringe fills shall not begin until the application is complete. When such a floodway fringe fill application is received by the chief engineer, it will be reviewed to determine whether or not it is complete. If the application is complete, the chief engineer will notify the applicant when the 90-day review period began and will end. If the application is not complete, the additional information will be requested and the applicant informed that the 90-day statutory review period has not yet begun. For a floodway fringe fill application, when comments are received as a result of the water projects environmental coordination act review under K.S.A. 82a-325, et seq., which require modification of the plans, the 90-day statutory time limit shall be suspended from the time the modifications are requested by the chief engineer until satisfactory modifications of the plans are received by the division of water resources. When the appropriate modifications have been received, the 90-day time limit will begin again with the same number of days remaining as were remaining at the time of the suspension. The applicant shall be notified in writing as to the dates of the suspension and restart of the 90-day time limit. (Authorized by and implementing K.S.A. 1991 Supp. 24-126; effective May 1, 1987; amended, T-5-12-30-91, Jan. 1, 1992; amended April 27, 1992.)

5-45-8. Levees; hazard classes. The following levee hazard classes are established: (a) Class A levee—failure of levee may allow damage to farm buildings, limited agricultural grounds or private roads.

(b) Class B levee—failure of levee may endanger extensive agricultural land, or damage isolated homes, secondary highways or minor railroads.

(c) Class C levee—failure of levee may cause loss of life, or cause serious damage to private, commercial or public property. (Authorized by and implementing K.S.A. 24-126; effective May 1, 1987.)

5-45-9. Levees; design storm flow determination. (a) In determining design storm flow magnitude, the applicant shall use an accepted engineering method.

(b) For drainage areas of less than 2 square miles the following methods are acceptable, where appropriate: (1) The rational formula for flow magnitude determination when used according to the following formula:

$$Q = CIA$$

Where C = the runoff coefficient
I = intensity of rainfall in inches per hour and
A = drainage area in acres.

To determine the proper intensity of rainfall for use with the formula, first determine the appropriate total rainfall from "Technical Paper Number 40, Rainfall Frequency Atlas of the United States, *Department of Commerce,* May 1961," and the time of concentration from the Kirpich nomograph and then obtain the intensity from the standard rainfall intensity-duration curves;

(2) The SCS method for estimating direct runoff, United States department of agriculture, soil conservation service;

(3) "Technical Release 55, Hydrology for Urban Areas, *United States Department of Agriculture, Soil Conservation Service."*

(c) For drainage areas two square miles or greater, the following methods of determining flow magnitude shall be acceptable, where appropriate: (1) the publication "Magnitude and Frequency of Floods in Kansas, Unregulated Streams, Technical Report 11, *Kansas Water Resources Board,* February 1975";

(2) "Technical Release 20, Computer Program for Project Formulation, Hydrology, *United States Department of Agriculture, Soil Conservation Service";* or

(3) "HEC-1 Flood Hydrograph Package, *Corps of Engineers Hydrologic Engineering Center."* (Authorized by and implementing K.S.A. 24-126; effective May 1, 1987.)

5-45-10. Levees; design criteria. Design for levees shall meet or exceed the following criteria: (a) Class A levee—the levee shall safely repel the appropriate design storm.

(b) Class B levee—the levee shall safely repel at least the ten year design storm.

(c) Class C levee—the levee shall safely repel at least the 100 year design storm. For class C levees the applicant shall submit complete water surface water profiles of both the ten and 100 year events, both before and after construction. (Authorized by and implementing K.S.A. 24-126; effective May 1, 1987.)

5-45-11. Levees; freeboard requirements. (a) Levees not within a floodway designated by the chief engineer are required to have the following freeboard:

Design flood frequency	*Freeboard required*
10 years	1 foot
25 years	2 feet
50 years or more	3 feet

(b) Levees constructed within a floodway designated by the chief engineer shall have a freeboard requirement designated on a site specific basis. (Authorized by and implementing K.S.A. 24-126; effective May 1, 1987.)

5-45-12. Levees and floodplain fills; setback. Except for highway and road crossings of streams, the minimum setback distance from the top of the stream bank to the nearest toe of the levee or the edge of the floodplain fill shall be 100 feet, or twice the width of the stream measured from the top of one bank to the top of the opposite bank, whichever distance is less, unless the applicant demonstrates that adequate bank protection will be utilized. (Authorized by and implementing K.S.A. 1991 Supp. 24-126; effective May 1, 1987; amended, T-5-12-30-91, Jan. 1, 1992; amended April 27, 1992.)

5-45-13. Levees; floodplain fills; unreasonable effect. (a) Except as set forth in subsection (b), no plans for any levee or floodplain fill that has an unreasonable effect on another shall be approved by the chief engineer. An unreasonable effect caused by a levee or floodplain fill shall be deemed any of the following:

(1) An increase in the elevation of the design and base flood profiles of more than one foot at any location outside a floodway;

(2) any increase in the elevation of the design and base flood profiles within a floodway; or

(3) a cumulative increase of more than one foot in the elevation of the design and base flood profiles.

(b) A levee or floodplain fill that has an unreasonable effect on another may be approved by the chief engineer subject to any conditions necessary to protect the public interest if either of the following criteria is met:

(1) The applicant demonstrates to the chief engineer that the applicant has obtained legal authorization from any landowner whose land is unreasonably hydraulically affected by a greater increase in the elevation of the design and base flood profile.

(2) The following conditions are met:

(A) The owner of the undeveloped, unplatted land that will be hydraulically affected by an increase in the design and base flood profiles of more than one foot by a federal or state cost-shared roadfill, bridge, or culvert replacement project has been notified of the proposed hydraulic effects by the chief engineer.

(B) The owner has failed to object within the time limit set forth in the notice.

(C) The chief engineer determines that the increase will not be likely to materially damage the private or public property. (Authorized by and implementing K.S.A. 24-126; effective May 1, 1987; amended, T-5-12-30-91, Jan. 1, 1992; amended April 27, 1992; amended Sept. 22, 2000.)

5-45-14. Levees and floodplain fills; hydrologic and hydraulic analysis. (a) The applicant shall submit a hydrologic and hydraulic analysis for every levee and floodplain fill project except floodway fringe fill projects and those levee projects and floodplain fill projects not identified in K.A.R. 5-45-4(b). The hydrologic and hydraulic analysis shall include the design and base floods for main streams, tributary streams, and local drainage, describing the existing and proposed conditions with the application and plans.

(b) The effect of a proposed levee or floodplain fill shall be calculated by the technique of equal conveyance reduction, except as provided in subsections (c) and (d), unless it meets either of the following criteria:

(1) The applicant demonstrates that the applicant has obtained legal authorization from any landowner whose land is unreasonably hydraulically affected by a greater encroachment toward the channel.

(2) The following conditions are met:

(A) The owner of the undeveloped, unplatted land that will be hydraulically affected by an increase in the elevation of the base flood profile of more than one foot by a federal or state cost-

shared roadfill, bridge, or culvert project has been notified of the proposed hydraulic effects by the chief engineer.

(B) The owner has failed to object within the time limit set forth in the notice.

(C) The chief engineer determines that the increase will not be likely to materially damage the private or public property.

(c) For a class A or class B levee, the effect of the proposed levee on the design flood profile shall be evaluated with the assumption that an equal setback levee is in place on the opposite side of the stream.

(d) For a class C levee, the effect of the proposed levee on the design flood profile shall be calculated by the technique of equal conveyance reduction from the outer floodplain limits outside the channel, unless the applicant demonstrates that the applicant has obtained legal authorization from all landowners whose land would be unreasonably hydraulically affected by a greater encroachment toward the channel. (Authorized by and implementing K.S.A. 24-126; effective, T-5-12-30-91, Jan. 1, 1992; effective April 27, 1992; amended Sept. 22, 2000.)

5-45-15. Floodplain fills; design criteria. Floodplain fills shall meet or exceed the following design criteria: (a) the sideslopes shall not be steeper than one vertical to three horizontal, unless the applicant submits data and analysis to show that a steeper slope will be stable.

(b) Floodplain fills shall be adequately protected from erosion and undermining from floods up to the level of the base flood elevation and surface drainage by the use of vegetative cover, riprap or other means.

(c) Floodplain fills shall not unreasonably obstruct or divert the flow of surface water and other waters from the main stream and tributaries to the main stream to the detriment of adjacent or hydraulically affected property owners.

(d) Floodplain fills shall not obstruct utility or other easements without proper authorization.

(e) Floodplain fills shall not unreasonably affect the environment without adequate environmental mitigation.

(f) Floodplain fills, other than levees, for residential buildings, including manufactured housing, are required to be of adequate height to raise the lowest floor, including the basement, at least one foot above the base flood elevation, unless:

(1) an exception has been granted by the flood insurance administrator of the flood insurance administration within the FEMA for the allowance of a basement; or

(2) the chief engineer has approved a community standard at or above base flood elevation.

(g) Floodplain fills other than levees for sewage lagoons and sanitary landfills are required to have at least one foot of freeboard above the base flood.

(h) Except for fills for highways and roads, all other floodplain fills other than levees are required to have at least one foot of freeboard above the design flood.

(i) If subsequent to approval of the floodplain fill by the chief engineer, a letter of map revision or letter of amendment is obtained from FEMA removing an area of the approved or permitted fill from the floodplain, then any permit or approval issued by the chief engineer no longer applies to that area removed from the floodplain. (Authorized by and implementing K.S.A. 1991 Supp. 24-126; effective, T-5-12-30-91, Jan. 1, 1992; effective April 27, 1992.)

5-45-16. Floodplain fills; disapproval. (a) A levee or floodplain fill should not have an unreasonable effect on adjacent landowners, be adverse to the public interest and environmental concerns or lack required environmental mitigation.

(b) Within six months of the disapproval, the applicant may make a written request to the chief engineer to rescind the disapproval by providing information or modifications of the plans requested by the chief engineer. (Authorized by and implementing K.S.A. 24-126 as amended by L. 1991, ch. 56, sec. 27; effective, T-5-12-30-91, Jan. 1, 1992; effective April 27, 1992.)

5-45-17. Exemption—floodway fringe fills. Floodway fringe fills are exempt from applying for and obtaining approval from the chief engineer if: (a) they are:

(1) up to 1600 cubic yards in size;

(2) with a maximum height of two feet;

(3) more than 100 feet away from any other floodplain fills; and

(4) constructed according to the design criteria in K.A.R. 5-45-15; or

(b) they are located in communities which have adopted local standards for floodway fringe fills approved by the chief engineer which meet or exceed the standards adopted by the chief engineer for individual floodway fringe fills. The standards shall include an appeal process, an environmental

assessment and a review of local drainage. (Authorized by and implementing K.S.A. 1991 Supp. 24-126; effective, T-5-12-30-91, Jan. 1, 1992; effective April 27, 1992.)

5-45-18. Floodplain fills; incidental to bridge and culvert replacement projects. Each floodplain fill constructed incidental to a bridge or culvert replacement project that otherwise meets the requirements of K.A.R. 5-46-1 shall be considered to have the necessary approval of plans pursuant to K.S.A. 24-126, and amendments thereto, and article 45 of the rules and regulations adopted by the Kansas department of agriculture, division of water resources. (Authorized by and implementing K.S.A. 24-126; effective Sept. 22, 2000.)

Article 46.—GENERAL PERMITS

5-46-1. General permits; bridge and culvert replacement projects. (a) Except as provided in subsection (e), the construction of any bridge or culvert replacement project with a watershed of 2,560 or more acres in zone one, 3,840 or more acres in zone two, and 5,120 or more acres in zone three shall meet the criteria in subsection (c) of this regulation. Before construction, the applicant shall apply for and obtain a general permit from the chief engineer. The application shall be filed on a form prescribed by the chief engineer and shall be accompanied by plans or sketches meeting the requirements of K.A.R. 5-42-2.

(b) Except as provided in subsection (e), the construction of any bridge or culvert replacement project with a watershed of fewer than 2,560 acres in zone one, 3,840 acres in zone two, and 5,120 acres in zone three shall meet the criteria in subsection (c) of this regulation. Before construction, the applicant shall properly complete an application for, and receive the consent of, the chief engineer. The application shall be filed on a form prescribed by the chief engineer.

(c) Each bridge replacement and culvert replacement project shall meet all of the following criteria:

(1) The project shall not be a change either in alignment or in the cross section of a stream of more than 200 feet in length on minor streams, and not more than 400 feet in length on moderate or major streams as measured along the original channel. A minor stream is defined as a stream or watercourse that has a mean annual flow of less than five cubic feet per second (cfs). The major streams are the Kansas River, the Arkansas River, and the Missouri River. A moderate stream is defined as a stream or watercourse with a mean annual flow equal to or greater than five cfs, but is not a major stream.

(2) The proposed culvert or bridge replacement shall have the following:

(A) A cross-sectional area at least equivalent to that of the original bridge or culvert for water to flow over, through or around; and

(B) a road grade across the floodplain and approaching the bridge or culvert that is not raised by more than an average of one foot. The average rise of the road grade shall be calculated by measuring the difference between the proposed grade and the existing grade at the beginning and end of each interval of 100 or fewer feet, dividing the sum of the two differences by two and multiplying the mean by the number of feet in the interval. The sum of these calculations from each interval shall then be added together and the total sum divided by the length, in feet, of the road alteration. The average road grade shall not increase by a cumulative amount of more than one foot since April 11, 1978.

(3) A vegetative strip measuring 50 feet from the bank and outward on each side of a channel change shall be maintained in a manner consistent with the existing riparian vegetation and other design criteria.

(4) The project shall not alter the channel's cross-sectional area by more than 15 percent, nor shall it alter the channel length by more than 10 percent.

(d) If any bridge or culvert replacement project does not meet the requirements of this regulation, the applicant may apply for a nongeneral permit pursuant to K.S.A. 82a-301 et seq., and amendment thereto, before construction.

(e) If any bridge or culvert replacement project does not meet the requirements of this regulation or the chief engineer determines that the project may have an unreasonable effect on the public interest, public safety, or environmental interests, the right to perform the following shall be reserved by the chief engineer:

(1) Require a general permit meeting the requirements of this regulation or a nongeneral permit meeting the requirements of K.S.A. 82a-301 et seq., and amendment thereto, before construction; and

(2) amend, modify, or revoke the prior general

permit or consent issued in accordance with this regulation. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective Sept. 22, 2000.)

5-46-3. General permits; sand and gravel removal operations. (a) Before the commencement or continuation of any sand or gravel removal from a site with a drainage area of 50 or more square miles above the site, the removal operation shall meet the criteria in subsection (c) of this regulation. Before the removal of any sand and gravel, the owner shall apply for and obtain a general permit from the chief engineer. The application shall be filed on a form prescribed by the chief engineer and shall be accompanied by plans meeting the requirements of K.A.R. 5-42-2.

(b) If the proposed sand or gravel removal operation meets the criteria set forth in subsection (c) of this regulation and there are fewer than 50 square miles of drainage area above the proposed sand or gravel removal site, a permit shall not be required unless the chief engineer determines that a permit is necessary to protect the public interest, public safety, or environmental interests.

(c) All sand and gravel operations covered by this regulation shall meet the following criteria:

(1) The sand and gravel removal operation shall be limited to removing a maximum of 100 cubic yards per year from each sand and gravel removal site. Other than bridge maintenance sites, all sand and gravel removal operations on the same stream and its tributaries shall be separated by at least 1,320 feet.

(2) A sand and gravel removal operation shall not be located within the following distances of a bridge, pipeline, cable crossing, levee, or other feature, except when the written permission or easement of the owner of the bridge, pipeline, cable crossing, levee, or other feature is obtained by the applicant, and a written waiver is granted by the chief engineer:

(A) 50 feet of the banks, or in the channels of the Missouri, Kansas, or Arkansas rivers, and 50 feet of the banks, or in the channels of their tributaries, for ½ mile upstream from the mouth of the tributaries;

(B) one mile of a public water supply intake;

(C) 500 feet of a bridge;

(D) 300 feet of a buried pipeline or cable crossing; and

(E) 200 feet of a levee or other feature subject to damage.

(3) Stockpiles of material shall be located in a manner that does not affect the flow of water on the property of any other landowner.

(d) If any sand or gravel removal operation covered by this regulation does not meet the requirements of this regulation, or if the chief engineer determines that the operation may have an unreasonable effect on the public interest, public safety, or environmental interests, the right to perform the following shall be reserved by the chief engineer:

(1) Require a nongeneral permit pursuant to K.S.A. 82a-301 et seq., and amendments thereto; and

(2) amend, modify, or revoke the general permit issued in accordance with this regulation. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective Sept. 22, 2000.)

5-46-4. General permits; pipeline crossings. (a) Before the construction of any pipeline or buried cable crossing of a stream having 50 or more square miles of drainage area above the proposed project site, the project shall meet the requirements of subsection (c) of this regulation. Before construction, the owner shall apply for and obtain a general permit from the chief engineer. The application shall be filed on a form prescribed by the chief engineer.

(b) Any pipeline or buried cable crossings of streams that have fewer than 50 square miles of drainage area above the proposed project site and that meet the requirements of subsection (c) of this regulation shall not be required to have a permit pursuant to K.S.A. 82a-301 et seq., and amendments thereto.

(c) All pipeline or buried cable crossings covered by this regulation shall meet the following requirements:

(1) Underground pipelines and cables shall be buried at a depth below the stream bed sufficient to prevent exposure. For navigable streams, underground pipelines and cables shall be buried at a minimum depth of seven feet beneath the stream bed. For all other streams, underground pipelines and cables shall be buried at a minimum depth of five feet beneath the stream bed. Pipelines and cables shall be buried sufficiently into the banks to allow for a moderate amount of stream meander without exposure. The minimum depth may be waived if the owner or applicant demonstrates that the underground pipeline or cable is adequately protected against erosion.

(2) After installation, the channel and banks shall be restored to the natural elevations and configurations as nearly as possible. Armoring devices shall be installed when necessary to ensure bank stability. Surplus excavated material shall be disposed of in a manner that will not obstruct the channel or act as a levee.

(d) If any pipeline or buried cable crossing covered by this regulation does not meet the requirements of this regulation, or if the chief engineer determines that a pipeline or cable crossing may have an unreasonable effect on the public interest, public safety, or environmental interests, the right to perform the following shall be reserved by the chief engineer:

(1) Require a nongeneral permit pursuant to K.S.A. 82a-301 et seq., and amendments thereto; and

(2) amend, modify, or revoke the general permit issued in accordance with this regulation. (Authorized by K.S.A. 82a-303a; implementing K.S.A. 82a-303; effective Sept. 22, 2000.)

Articles 47 to 49. RESERVED

Article 50.—WATER TRANSFERS

5-50-1. Definitions. As used in these rules and regulations, unless the context clearly requires otherwise: (a) "Application" means the document, made on the prescribed form furnished by the chief engineer, to request a permit to transfer water. The application shall be filed in the office of the chief engineer as provided in K.S.A. 82a-1501 et seq., as amended.

(b) "Approval of application" means issuance of a permit to transfer water as defined in K.S.A. 82a-1501(a)(1), as amended. (Authorized by K.S.A. 82a-1506; implementing K.S.A. 1995 Supp. 82a-1501; effective May 1, 1984; amended Dec. 27, 1996.)

5-50-2. Requirements for application. To be complete, a water transfer application shall show the following: (a) the name and mailing address of the applicant;

(b) the maximum quantity of water proposed to be transferred in a calendar year and the proposed maximum diversion rate;

(c) the location of the proposed point or points of diversion;

(d) the location of the proposed point or points of use;

(e) the proposed use made of the water;

(f) any economically and technologically feasible alternative source or sources of supply available to the applicant and to any other present or future users of the water proposed to be transferred. The water transfer application shall specify why this source of supply was selected over the alternative sources available;

(g) the proposed plan of design, construction and operation of any works or facilities used in conjunction with carrying the water from the point or points of diversion to the proposed point or points of use. The proposed plan shall be in sufficient detail to enable all parties to understand the impacts of the proposed water transfer;

(h) the estimated date for completion of the infrastructure and initial operation thereof;

(i) that the benefits to the state if the transfer is approved outweigh the benefits to the state if the transfer is not approved;

(j) that the proposed transfer will not impair water reservation rights, vested rights, appropriation rights or prior applications for permits to appropriate water;

(k) any current beneficial use of the water that is proposed to be transferred, including minimum desirable streamflow requirements;

(l) any reasonably foreseeable future beneficial use of the water;

(m) the economic, environmental, public health and welfare, and other impacts of approving or denying the transfer of water;

(n) any and all measures the applicant has taken to preserve the quality and remediate any contamination of water currently available for use by the applicant;

(o) the provisions of a revised management program adopted by a groundwater management district that are applicable to the proposed transfer whenever any of the proposed points of diversion are located within a groundwater management district;

(p) whether or not the applicant, and any entity to be supplied water by the applicant, have adopted and implemented conservation plans and practices that fulfill the following requirements:

(1) are consistent with guidelines developed and maintained by the Kansas water office, pursuant to K.S.A. 74-2608 and its amendments;

(2) have been in effect for not less than 12 consecutive months immediately before the filing of this water transfer application; and

(3) provide for a rate structure that encourages efficient use of water and results in conservation

and wise, responsible use of water, if the transfer is for use by a public water supply system;

(q) the effectiveness of conservation plans and practices that have been adopted and implemented by the applicant and any other entities to be supplied water by the applicant;

(r) if applicable, population projections for any public water supply system that will be supplied by the water transfer, and the basis for those projections;

(s) the projected water needs of the applicant and of any other entities to be supplied water by the applicant, and the basis for those projections;

(t) plans for any environmental mitigation made necessary by the proposed water transfer;

(u) a list of other federal, state and local permits necessary to complete the proposed water transfer and the projected dates they will be obtained;

(v) the current per capita per day usage of any public water supply user to be supplied water by the applicant, and the current average per capita per day usage of other similar users in a region of the state that is climatically similar. If the applicant's per capita per day usage exceeds the regional average, the applicant shall show why its per capita per day usage is reasonable.

(w) the projected per capita per day usage of any public water supply user to be supplied water by the applicant;

(x) a copy of the following contingently approved documents;

(1) a permit to appropriate water;

(2) an application for change in any or all of the following:

(A) the place of use;

(B) the type of use;

(C) point of diversion; or

(3) a contract to purchase water pursuant to the state water plan storage act;

(y) pursuant to K.A.R. 28-16-28b and K.A.R. 28-16-28d, the impacts of the proposed transfer on the water quality and designated uses of any stream that may be affected by the proposed transfer; and

(z) any additional factors that may be required by the chief engineer. (Authorized by K.S.A. 82a-1506; implementing K.S.A. 1995 Supp. 82a-1503; effective May 1, 1984; amended Dec. 27, 1996.)

5-50-3. (Authorized by K.S.A. 82a-1506; implementing K.S.A. 1995 Supp. 82a-1503; effective May 1, 1984; revoked Dec. 27, 1996.)

5-50-4. Emergency use. When a temporary emergency transfer of water has been approved, the chief engineer shall: (a) Require the applicant to compile and submit records, as necessary, regarding the daily rate and quantity of water transferred and any other information pertinent to the continued need for emergency transfer; and

(b) require the person requesting the transfer to consider alternate sources of water so the continued transfer will not be necessary. (Authorized by K.S.A. 82a-1506; implementing K.S.A. 1995 Supp. 82a-1502; effective May 1, 1984; amended Dec. 27, 1996.)

5-50-5. Emergency transfer of water. If the emergency causing the necessity for the transfer of water continues beyond one year, the person requesting the transfer may only file another new application for transfer for emergency use. This new application shall state the need for the water and the reasons why the need for transfer of water still exists and cannot be supplied by an alternate source. (Authorized by K.S.A. 82a-1506; implementing K.S.A. 1995 Supp. 82a-1502; effective May 1, 1984; amended Dec. 27, 1996.)

5-50-6. Authority of the chief engineer. All emergency transfers of water shall be reviewed by the chief engineer to determine whether the applicant complied with the terms, conditions, and limitations of the emergency transfer approval. (Authorized by K.S.A. 82a-1506; implementing K.S.A. 1995 Supp. 82a-1503; effective May 1, 1984; amended Dec. 27, 1996.)

5-50-7. Filing an application. Unless this requirement is waived by the chief engineer for good cause, a water transfer application shall not be considered complete until one of the following has been approved contingent upon receiving a permit to transfer water: (a) a new application to appropriate water pursuant to the Kansas water appropriation act (KWAA), K.S.A. 82a-701 *et seq.*;

(b) an application for a change in any or all of the following:

(1) point of diversion;

(2) place of use; or

(3) use made of water filed pursuant to the KWAA; or

(c) a contract for the purchase of water pursuant to the state water plan storage act, K.S.A. 82a-1301, *et seq.* (Authorized by K.S.A. 82a-1506;

implementing K.S.A. 1995 Supp. 82a-1503; effective Dec. 27, 1996.)

5-50-8. Selection of hearing officer. (a) The panel shall mail notices to, and request nominations for a hearing officer from:

(1) the applicant;

(2) entities in the area or basin where the potential point or points of diversion are located; and

(3) the commenting agencies.

(b) The panel shall also publish one notice in the Kansas register requesting nominations for a hearing officer. The panel shall allow 30 days following the notice for the nominations to be submitted.

(c) After the 30-day notice period has expired, the panel shall meet to consider the nominations and select an independent hearing officer. (Authorized by K.S.A. 82a-1506; implementing K.S.A. 1995 Supp. 82a-1501a; effective Dec. 27, 1996.)

E.16. Kentucky



DEPARTMENT FOR NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION
Department for Environmental Protection
Division of Water
(401 KAR 4:030)

RELATES TO: KRS 151.250
PURSUANT TO: KRS 151.125, 224.033(17), 224.045-(6)(b), 13.082
SUPERSEDES: DOW-Rg-2
NECESSITY AND FUNCTION: This regulation is necessary to establish minimum design criteria for dams and associated structures constructed in Kentucky.

Section 1. This regulation applies to all dams as defined by KRS 151.100 and to all other impounding obstructions which might create a hazard to life or property.

Section 2. Except as modified in this regulation, the procedures outlined by the latest edition of "Design of Small Dams" (Second Edition, 1973), available from the U.S. Government Printing Office and the Bureau of Reclamation, herein filed by reference, shall be the minimum criteria.

Section 3. The Division of Water Engineering Memorandum No. 5 outlined as follows: Section A. Definitions; Section B. Structure Classification; Section C. Hydrologic Criteria; Section D. Sediment Storage; Section E. Principal Spillways; Section F. Emergency Spillways; Section G. Earth Embankments; and Section E. Utilities Under Embankments; is hereby incorporated by reference and made a part of this regulation as if fully set out herein. Copies are available from the Division of Water upon request.

Section 4. Structure types not generally used in Kentucky, i.e., gravity, buttress, steel, timber, etc., will be considered on an individual basis and reviewed in accord with prevailing practices that are currently accepted by the engineering profession.

Section 5. In all cases the safety of the structure, the water and/or other material impounded therein, property and human life will be the principal governing factors. Under no circumstances will the proposed use of the structure and its contents, or the cost of providing an unquestionably safe structure be allowed to assume precedence over the possible hazard involved.

Section 6. Structures which are to be repaired or reconstructed must be made to conform to the criteria established by this regulation.

Section 7. Each of the following stated criteria indicates whether the limit is a maximum or minimum limit and is not to be construed as being satisfactory design criteria at all sites. Professional judgment, state laws and regulations, investigations, or analysis may dictate more conservative criteria.

Section 8. (1) Approval of all plans and specifications shall be divided into two (2) distinct parts:

(a) Issuance of a construction permit pursuant to KRS 151.250 shall constitute approval of the final engineering documents to allow construction to be started; and

(b) Final written approval by the department upon receipt of the "as-built" plans and specifications will constitute approval to impound.

(2) No approval to impound water and/or other material is implied or is in any way granted until the "as-built" plans and specifications have been approved, an on-site inspection has been made, and a written statement of approval issued. It is recommended that the owner and/or his engineer contact this division before initiation of final design for a pre-design conference.

Section 9. All plans and specifications submitted for consideration must bear the seal and signature of the responsible engineer as defined in KRS 322.010 (2), except officers and employees of the United States Government while engaged in engineering for the government. Each sheet of the drawings shall bear the seal and signature of the engineer or engineers responsible for its preparation.

Section 10. All structures, other-than Class A as defined in Engineering Memorandum No. 5 (2-1-75) shall have a complete sub-surface investigation and soil analysis submitted as an integral part of the drawings.

Section 11. (1) Elevation area capacity data and elevation discharge data must be submitted as a part of the plans for each structure. This elevation area capacity data shall give the area and capacities from the elevation of the lowest point in the impoundment area to at least the elevation at the top of the dam. When the configuration of the structure will not allow the elevation discharge relationship to be developed by methods accepted as standard by the engineering profession, the structure must provide the storage necessary to contain the entire storm runoff without probable damage to the structure or creating an unacceptable hazard to life or property.

(2) When this required basic information is furnished by the responsible design engineer, the Division of Water will upon request assist the engineering in preparing the floodroutings required by Engineering Memorandum No. 5.

(3) In the event that the elevation area capacity data is not furnished or the floodroutings show that insufficient floodwater storage has been provided, the plans will be returned to the design engineer without being approved.

Section 12. All information concerning elevations shall refer to mean sea level and the use of assumed elevations for any purpose is prohibited. Should an error in either the horizontal control or vertical control become known during construction, the necessary information to correct the distances and the elevations shall be referred to on the first sheet of the "as-built" drawings or referred to in the index. Clearly marked reference points and bench marks shall be maintained at the job site by the responsible engineer until final written approval is received.

Section 13. Unless waived in writing by the department, no structure shall be approved unless a positive means is provided to pass water through the structure in sufficient quantity to satisfy the needs of downstream users and to empty the reservoir within a reasonable length of time. Conditions considered in determining downstream water requirements and required minimum time to empty the impoundment shall be determined by the responsible engineer and referred to on the drawings.

Section 14. Construction supervision and inspection must be performed by or under the direction of the design engineer. Unless otherwise directed by the department the engineer shall submit monthly progress reports on forms to be supplied by the department. Copies of all testing reports shall be submitted with the progress reports.

Section 15. All "as-built" documents shall be submitted by the responsible engineer in the form of permanent type drawings of a standard and uniform size. Variations in size will be permitted for federal agencies in order that they may use their standard drawings. Drawings that do not conform to standard practices or drawings that are not easily legible will not be accepted.

Section 16. Because of the department's statutory duty to review federal projects for the Commonwealth under KRS 151.220, the United States Army Corps of Engineers is exempt from the provisions of this regulation and KRS 151.250.

ADOPTED: March 12, 1975
RECEIVED BY LRC: March 13, 1975 at 2:31 p.m.

DOW/CP-021
Revised 10/80

DEPARTMENT FOR NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION
Department for Environmental Protection

Division of Water
(401 KAR 4:040)

RELATES TO: KRS 151.250
PURSUANT TO: KRS l5l.l25, 224.033(17), 224.045(6)(b), 13.082
SUPERSEDES: DOW-Rg-3
NECESSITY AND FUNCTION: This regulation is necessary to exempt certain dams, embankments, levees, dikes, bridges, fills, and other stream obstructions proposed in conjunction with surface and deep mining from the provisions of KRS Chapter 151 to avoid duplication of effort within the Department for Natural Resources and Environmental Protection.

Section 1. As a part of the routine processing of application for permits for surface mining and the surface effects of deep mining, the engineering staff of the Division of Permits, Bureau of Surface Mining Reclamation and Enforcement, reviews all designs for dams, embankments, levees, dikes, bridges, fills, and other stream obstructions proposed in conjunction with surface or deep mining and, whereas a substantial number of such dams, embankments, levees, dikes, bridges, fills, and other stream obstructions are of such a size, type, and location as to present no potential hazard to life and/or property; this regulation exempts from the provision of KRS 151.250 all such dams, etc., as described above, except those dams which come within the hazard classification contained in Division of Water Engineering Memorandum No. 5 (2-1-75), and those obstructions as described, which, in the professional judgment of the Division of Permits engineering staff, present a potential hazard to life and/or property. Copies of Engineering Memorandum No. 5 (2-1-75) are available upon request from the Division of Water.

Section 2. Certified, "as-built" engineering plans for all dams which impound or divert water and/or other material and which (i) are twenty-five (25) feet or more in height or (ii) have an impounding capacity of fifty (50) acre-feet or more at the lowest point on the top of the dam must be forwarded by the Division of Permits to the Division of Water for inclusion in the Dam Safety Program required by KRS 151.295(c). Height is measured from the natural bed of the stream or watercourse at the downstream toe of the barrier to the low point in the top of the dam.

ADOPTED March 12, 1975
RECEIVED BY LRC: March 13, 1975, at 2:31 p.m.

Department for Natural Resources and Environmental Protection
Division of Water
Engineering Memorandum No. 5

	PAGE
SECTION A - DEFINITIONS	6
SECTION B - STRUCTURE CLASSIFICATION	8
SECTION C - HYDROLOGIC CRITERIA	11
SECTION D - SEDIMENT STORAGE	15
SECTION E - PRINCIPAL SPILLWAYS	16
SECTION F - EMERGENCY SPILLWAYS	25
SECTION G - EARTH EMBANKMENTS	34
SECTION H - UTILITIES UNDER EMBANKMENTS	35

SECTION A - DEFINITIONS

A spillway is an open or closed channel, or both, used convey water from a reservoir. It may contain gates, either manually or automatically controlled, to regulate discharge of water.

The principal spillway is the ungated spillway designed convey the water from the retarding pool at release rates established for the structure.

The emergency spillway of a dam is the spillway designed convey water in excess of that impounded for flood control or other beneficial purposes.

The retarding pool is the reservoir space allotted to the temporary impoundment of floodwater. Its upper limit is the elevation of the crest of the emergency spillway.

Retarding storage is the volume in the retarding pool.

The sediment pool is the reservoir space allotted to the accumulation of submerged sediment during the life of the structure.

The sediment storage is the volume allocated to total sediment accumulation.

The sediment pool elevation is the elevation of the surface the anticipated sediment accumulation at the dam.

An earth spillway is an unvegetated open channel spillway in earth materials.

A vegetated spillway is a vegetated open channel spillway in earth materials.

A ramp spillway is a vegetated spillway constructed on the downstream face of an earth dam.

A rock spillway is an open channel spillway in durable rock materials.

A control-section in an open channel spillway is that section where accelerated flow passes through critical depth.

The inlet channel of an emergency spillway is the channel upstream from the control section.

The exit channel of an emergency spillway is that portion of the channel downstream from the control section which conducts the flow safely to a point where it may be released without jeopardizing the integrity of the structure.

The emergency spillway-hydrograph is that hydrograph used to establish the minimum design dimensions of the emergency spillway.

The freeboard hydrograph is the hydrograph used to establish the minimum elevation of the top of the dam.

Joint extensibility is the length of a pipe joint measured from the center of the gasket to the point of flare of the bell ring or collar when the joint is engaged.

Joint gap is the longitudinal dimension between the end face of the spigot end of a pipe joint and the corresponding face of the bell end of the connecting pipe. It does not include the beveled portions designed for sealing compounds.

The rotation capacity of a pipe joint is the maximum angular deflection possible for the joint without binding or loss of watertightness.

The maximum possible high water is the maximum elevation of the water surface that might be attained either above or below the structure, which may be attributed to structure.

The height of the embankment is the distance in feet measured from the natural bed of the stream or watercourse at the downstream toe of the barrier to the low point in the top of the dam.

SECTION B - STRUCTURE CLASSIFICATIONS

		PAGE
I.	CLASS OF STRUCTURES	9
	A. Class (A) - Low Hazard	9
	B. Class (B) - Moderate Hazard	9
	C. Class (C) - High Hazard	9
II.	STRUCTURES IN SERIES	10

SECTION B - STRUCTURE CLASSIFICATION

In determining structure classification, a number of factors must be considered. Consideration must be given to the damage that might occur to existing and future developments downstream resulting from a sudden breach of the earth embankment and the structures themselves. The effect of failure on public confidence is an important factor. State and local regulations and the responsibility of the involved public agencies must be recognized. The stability of the spillway materials, the physical characteristics of the site and valley downstream, and the relationship of the site to industrial and residential areas all have a bearing on the amount of potential damage in the event of a failure.

Structure classification is determined by the above conditions. It is <u>not</u> determined by the criteria selected for design.

1. CLASS OF STRUCTURES

The following broad classes of structures are established to permit the association of criteria with the damage that might result from a sudden major breach of the structure.

A. <u>Class (A) - Low Hazard</u>

This classification may be applied for structures located such that failure would cause loss of the structure itself but little or no additional damage to other property. Such structures will generally be located in rural or agricultural areas where failure may damage farm buildings other than residences, agricultural lands, or county roads.

B. <u>Class (B) - Moderate Hazard</u>

This classification may be applied for structures located such that failure may cause significant damage to property and project operation, but loss of human life is not envisioned. Such structures will generally be located in predominantly rural agricultural areas where failures may damage isolated homes, main highways or major railroads, or cause interruption of use or service of relatively important public utilities.

C. <u>Class (C) - High Hazard</u>

This classification must be applied for structures located such that failure may cause loss of life, or serious damage to houses, industrial or commercial buildings, important public utilities, main

highways or major railroads. This classification must be used if failure would cause probable loss of human life.

The responsible engineer shall determine the classification of the proposed structure after considering the characteristics of the valley below the site and probable future development. Establishment of minimum criteria does not preclude provisions for greater safety when deemed necessary in the judgment of the engineer. Considerations other than those mentioned in the above classifications may make it desirable to exceed the established minimum criteria. A statement of the classification established by the responsible engineer shall be clearly shown on the first sheet of the plans.

II. STRUCTURES IN SERIES

When structures are spaced so that the failure of an upper structure could endanger the safety of a lower structure, the possibility of a multiple failure must be considered assigning the structure classification of the upstream structure.

Additional safety can be provided in either structure by (1) increasing the retarding storage and/or (2) increasing the emergency spillway capacity.

SECTION C - HYDROLOGIC CRITERIA

		PAGE
I.	RUNOFF	12
	A. Structure in Series	12
II.	PRINCIPAL SPILLWAY	13
III.	EMERGENCY SPILLWAY	13
IV.	FREEBOARD	13
V.	MINIMUM HYDROLOGIC CRITERIA	14

SECTION C - HYDROLOGIC CRITERIA

I. RUNOFF

Procedures for hydrologic design as contained in the USDA Soil Conservation Service National Engineering Handbook, Section 4 "Hydrology" will be accepted. Copies of this publication are available from the U. S. Government printing office.

The specific references for runoff determination are found in Chapter 10. All runoff volumes for design purposes will be based on Antecedent Moisture Condition II or greater. Chapter 21 contains hydrologic procedures for determining principal spillway capacities, retarding storage, and emergency spillway and freeboard hydrographs.

A. Structures in Series

For the design of a lower structure in a series, if the total drainage area above a lower structure exceeds 10 square miles and Section B-II of this memorandum applies, it is necessary to apply two sets of storms for development of both the emergency spillway and the freeboard hydrographs.

The first set of design storms will be selected for the development of the uncontrolled drainage area above a lower structure. The dimensions of the emergency spillway for a lower structure under this condition will be determined by reservoir routings of hydrographs developed for each storm.

The second set of design storms will be selected for the entire drainage area above the lower structure. Each design storm rainfall is determined by using this area in the areal adjustment of rainfall amounts. These design storm durations are determined by using the time of concentration of this area assuming no upper structures are in place. The design storm hydrographs will be routed through the emergency spillways of the upstream structures and the outflow routed to the lower structure and combined with the hydrograph for the uncontrolled area. The dimensions of the emergency spillway for a lower structure under this condition will also be determined by reservoir routings of the hydrographs developed for each storm.

The design storm imposing the most severe flow condition at the lower structure will be used.

II. PRINCIPAL SPILLWAY

The retarding storage and associated principal spillway discharge will be such that the emergency spillway will not operate more frequently than indicated in Table F-I, Section B, Emergency Spillways. The inflow hydrograph or the minimum runoff volume for developing the balance between principal spillway capacity and retarding storage will be determined by procedures in Chapter 21, Section 4, SCS National Engineering Handbook. In areas where streamflow records can be regionalized and transposed to ungaged watersheds (based on the volume-duration-probability analyses), the Division of Water will authorize the use of these data for developing the principal spillway capacity and retarding storage. When other streamflow data are used, sufficient documentation must be prepared to show how these values were determined.

In the determination of the retarding storage and the principal spillway capacity, it is assumed that the initial reservoir stage is at the crest of the principal spillway.

III. EMERGENCY SPILLWAY

The emergency spillway hydrograph will be routed through the reservoir starting with a water surface at the elevation of the principal spillway inlet or at the water surface elevation after 10 days of drawdown, whichever is higher. The 10-day drawdown will be computed from the maximum water surface elevation which would be attained during the passage of the minimum principal spillway design runoff for that class of structure.

IV. FREEBOARD

The freeboard hydrograph for class (A) and (B) structures will be routed through the reservoir starting at the same water surface elevation as for the emergency spillway hydrograph. The routing of the freeboard hydrograph for class (C) structures may be started at the crest of the principal spillway.

V. MINIMUM HYDROLOGIC CRITERIA

Minimum hydrologic criteria are established for the development of each hydrograph as follows:

Emergency Spillway Hydrograph

Class (A) $P_A = P_{100}$
Class (B) $P_B = P_{100} + 0.12 \times (PMP - P_{100})$
Class (C) $P_C = P_{100} + 0.26 \times (PMP - P_{100})$

Freeboard Hydrograph

Class (A) $P_A = P_{100} + 0.12 \times (PMP - P_{100})$
Class (B) $P_B = P_{100} + 0.40 \times (PMP - P_{100})$
Class (C) $P_C = PMP$

in which P denotes 6-hour design rainfall, P_{100} refers to 6-hour, 100-year precipitation, and PMP represents 6-hour Probable Maximum Precipitation.

The above values may be obtained from the "Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years", Technical Paper No. 40, Weather Bureau, U. S. Department of Commerce, Washington, D. C., and "Two To Ten-Day Precipitation For Return Periods of 2 To 100 Years In Contiguous United States", Technical Paper No. 49, Weather Bureau, U. S. Department of Commerce, Washington, D. C. These values may also be found in Division of Water, Kentucky Department for Natural Resources and Environmental Protection, Engineering Memorandum No. 2, “Rainfall Frequency Values for Kentucky.”

When hydrographs are required for drainage areas with times of concentration in excess of 6 hours, the above must be modified to reflect the appropriate storm period.

The establishment of the above criteria does not eliminate the need for sound engineering judgment but only establishes the lowest limit of design considered acceptable.

It is the responsibility of the design engineer to classify the structure and to determine if the design requirements are in excess of the minimum.

SECTION D - SEDIMENT STORAGE

Where the primary purpose is floodwater retardation or water storage or combination thereof, reservoirs are normally designed on the basis of a 50 to 100-year useful life. In order to assure full effectiveness, capacity must be provided in the reservoir to offset depletion due to sediment accumulation for a period equal to its design life.

SECTION E - PRINCIPAL SPILLWAYS

		PAGE
I.	CAPACITY OF PRINCIPAL SPILLWAYS	17
II.	ELEVATION OF PRINCIPAL SPILLWAYS	17
III.	DESIGN OF PRINCIPAL SPILLWAYS	18
A.	Layout	18
B.	Conduits	18
1.	Rigid Pipe	18
a.	Minimum inside Diameters on Yielding Foundations	19
b.	Minimum Inside Diameters on Rock Foundations	20
2.	Corrugated Metal Pipe	20
C.	Joints	21
D.	Anti-Seep Collars	22
E.	Cantilever Outlets	23
F.	Trash Racks	23
G.	Anti-Vortex Device	23
H.	Drawdown Facilities	24

SECTION E - PRINCIPAL SPILLWAYS

All component parts of the principal spillway except attached gates and trash racks will be of equal durability. The structural design criteria and detailing of such spillways will conform to recognized standards and codes of practice.

I. CAPACITY OF PRINCIPAL SPILLWAYS

The required capacity of the principal spillway depends on (1) the benefits that accrue to the reduction of the discharge rate, (2) damages that may result from prolonged storage in the retarding pool, (3) damages that may result from prolonged outflow, (4) the possibility of occurrence of significant runoff from two or more consecutive storm events within the time required to empty the retarding pool, and (5) limitations in water rights or other legal requirements.

It is desirable that the retarding pool be emptied in ten (10) days or less. It may be assumed that this requirement has been met if eighty (80) percent of the maximum volume of retarding storage has been evacuated in the ten (10) day period. The use of a longer period must be justified by an appraisal of the considerations listed above.

The discharge through gated outlets will not be considered in determining the emptying time of the retarding pool *unless* a specific reservoir operation plan has been approved and included in the plans.

II. ELEVATION OF PRINCIPAL SPILLWAYS

The crest of a single stage principal spillway will be placed at the elevation of the 50-year sediment pool except where a higher elevation is justified. For a two stage principal spillway, the crest of the lower inlet will be set at the same elevation as for a single stage structure. When a period greater than 50 years has been used for evaluation, it is recognized that structural changes may be necessary to make the structure function effectively during the latter part of its life.

For dry dams, the riser will be designed to permit design discharge at the 50-year sediment pool elevation with provisions for discharging water at lower elevations to satisfy the functional requirements of the structure. Flood routings must start at or above the anticipated elevation of the 50-year sediment pool.

When water is stored for beneficial use, the elevation of the lowest ungated inlet of the principal spillway will be determined by the volume, area, or depth of water required for the planned purpose or purposes in addition to the anticipated sediment storage during the design life.

III. DESIGN OF PRINCIPAL SPILLWAYS

A. Layout

The barrel of drop inlets should be straight in alignment when viewed in plan. Any required changes in alignment will be accomplished by angle changes at joints which do not exceed five degrees or by special elbows having a radius equal to or greater than the diameter or width of the conduit. Thrust blocks of adequate strength will be provided where special pipe elbows are used. They will be designed to distribute the thrust, due to change in direction, for the maximum possible discharge.

Drop inlet barrels will be installed with sufficient camber to insure free drainage to the outlet of all parts of the barrel at the time of construction and under the maximum anticipated foundation consolidation.

B. Conduits

All conduits under an earth embankment must support the external loads imposed with an adequate factor of safety. They must withstand the internal hydraulic pressures without leakage under full external load and settlement. They must convey water at the design velocity without damage to the interior surface of the conduit.

Principal spillway conduits under earth dams must be designed to support fill heights greater than the original constructed height where there is a reasonable possibility that it may become desirable to raise the embankment height at a later date to incorporate additional storage.

Principal spillway conduits are to be of reinforced concrete pipe, cast-in-place reinforced concrete, or ductile iron pipe, unless corrugated steel or welded steel pipe is used in accordance with subsection III-B-2, which follows:

1. Rigid Pipe

Rigid drop inlet barrels will be designed as positive projecting conduits. For reinforced Concrete Water Pipe Steel Cylinder Type, Prestressed, meeting specification AWWA C-301, the 3-edge bearing strength at the first 0.001 inch crack will be used in the design analysis with a factor of safety of at least one.

For reinforced Concrete Water Pipe - Steel Cylinder Type - Not Prestressed meeting specification AWWA C-300, for Reinforced Concrete Water Pipe - Non-cylinder Type - Not Prestressed meeting specification AWWA C-302, and other types of reinforced concrete pipe, the

3-edge bearing strength at the first 0.01 inch crack will be used in the design analysis with a factor of safety of at least 1.33.

Ductile Iron Pipe may be used as a principal spillway conduit under certain conditions. Fill heights and foundation conditions require special considerations such that each use will be checked on an individual basis. Cradling or encasement in concrete may be required in most instances.

Elliptical or other systems of reinforcement requiring special orientation of pipe sections are not permitted in pipe drop inlet barrels.

Reinforced concrete pipe, with or without cradles, will be designed to support at least 12 feet of earth fill above the pipe at all points along the conduit.

These safety factors are for uniform conditions. They should be increased if the strength and compressibility of the foundation are not reasonably uniform.

a. Minimum Inside Diameters on Yielding Foundations.

Class (A) dams: The minimum diameter of the principal spillway barrel will be 30 inches except:

(1) Where a joint extension safety margin of 1.5 inches is used, in which case the minimum diameter is to be 18 inches for fill heights up to 50 feet and 24 inches for greater heights.

(2) Where the drop inlet is designed hydraulically in such a way that the flow in the barrel under all possible conditions of discharge and foundation consolidation is positively known to be open channel flow with the water surface in the conduit subject to atmospheric pressure only, in which case the minimum diameter will be 18 inches.

(3) Where corrugated metal pipe is used the principal spillway must be designed in accordance with conditions presented in Section III-B-2 below.

Class (B) dams: The minimum diameter of the principal spillway barrel will be 30 inches, except where a joint extension safety margin of 1.5 inches is used, in which case the minimum diameter will be 24 inches.

Class (C) dams: The minimum diameter of the principal spillway barrel will be 30 inches.

b. Minimum Inside Diameter on Rock Foundations

Class (A) , (B) , and (C) dams: The minimum diameter of the barrel of reinforced-concrete pressure pipe drop inlets for class (1) dams is to be 18 inches for heights up to 50 feet and 24 inches for heights greater than 50 feet, and 24 inches for all class (B) and (C) dams. The barrel and cradle or bedding are to rest directly on firm bedrock thick enough so that there is essentially no foundation consolidation under the barrel. Under these conditions the cradle under the pipe need not be articulated.

2. Corrugated Metal Pipe and Welded Steel Pipe

Principal spillways of corrugated metal pipe or welded steel pipe may be used for class (A) dams under the following conditions, all of which must be met:

a. The minimum diameter of the barrel will be 18 inches.

b. The height of fill over the pipe will be less than 25 feet.

c. Corrugated steel pipe is to be close riveted, asbestos treated, and asphalt coated, with watertight connecting bands. The minimum gage is to be that specified for 35 feet of fill over the pipe.

d. Welded steel pipe conduits are to conform to ASTM specifications A53, A120, A135, A139, or A134 and are be structurally designed as rigid pipe. A joint extension safety margin of 1.5 inches is to be provided for conduits on yielding foundations. Welded pipe is to be protected by an approved exterior coating.

e. Joints between lengths of corrugated steel or welded steel pipe, other than welded joints, are to electrically bridged on the outside of the pipe with insulated copper wire, #6 AWG or larger, securely attach to uncoated pipe metal at both sides of the joint. The requirement applies whether or not the cathodic protection is completed by the installation of anodes, etc. The wire should have a tough, waterproof insulation designed for direct burial, with a rating of at least 600 volts. Bare wire and exposed pipe metal at the points of connection are to be thoroughly coated with a coating equivalent the original pipe coating to prevent the entry of moisture.

f. Soil investigations for resistivity and pH of the subgrade and backfill materials to be adjacent to the conduit are to be made if corrugated steel or welded steel pipe is to be used. The resistivity measurements are to be made on saturated samples.

g. Cathodic protection is to be provided for welded steel pipe conduits according to approved engineering criteria.

h. Cathodic protection meeting the above requirements is to be provided for corrugated steel pipe in soil whose resistivity in a saturated condition is less than 4000 ohms/cm³ or whose pH is lower than 5.0.

i. If cathodic protection for corrugated steel or welded steel pipe is not required according to the above criteria and is not installed during construction of the dam, pipe-to-soil potentials are to be measured within the first two (2) years after construction when the soil around the conduit is estimated to be at its normal post-construction moisture content, and cathodic protection is to be installed if such measurements indicate it is needed.

C. JOINTS

Conduit joints will be designed and constructed to remain water tight under maximum anticipated hydrostatic head and maximum probable conditions of joint opening including the effects of joint rotation and a margin of safety where required.

The required joint extensibility is equal to the unit horizontal strain in the earth adjacent to the barrel, multiplied by the length (in inches) of the section of barrel between joints, plus the extension (in inches) due to calculated joint rotation, plus a margin of safety if required. A margin of safety of 0.5 inch is recommended. The required joint extensibility, plus the maximum permissible joint gap equals the required joint length.

The calculation of the required joint extensibility for any particular dam and spillway depends, among other things, on the evaluation of the maximum potential foundation consolidation under the spillway barrel. For Classes (B) and (C) dams, the consolidation will be estimated from adequate foundation borings and samples, soil mechanics laboratory tests and engineering analysis.

For those Class (A) dams where undisturbed foundation samples are not taken for other purposes, approximate procedures based on soil classification and experience will be used for estimating foundation consolidation. When AWWA C-302 or other types of reinforced concrete pipe are used, they will have rubber to steel joints.

Only joints incorporating a round rubber gasket set in a positive groove which will prevent its displacement from either internal or external pressure under the maximum designed joint extensibility will be used on precast concrete pipe drop inlet barrels.

Articulation of the barrel will be provided at each joint in the barrel and at the junction of the barrel and the inlet (riser). Concrete bedding for pipe drop inlets need not be articulated: cradles will be articulated when on yielding foundations.

D. Anti-Seep Collars

All conduits through earth embankments, foundations, and abutments will be provided with anti-seep collars.

The minimum number of anti-seep collars will be determined by the size of collars and the length of that portion of the conduit which lies in the saturated zone of earth embankment.

The following criteria will be used to determine the size and number of anti-seep collars.

Let V = the vertical projection and minimum horizontal projection of the anti-seep collar in feet.

L = Length in feet of that portion of the barrel of a drop inlet or culvert lying within the zone of saturation, measured from the downstream side of the riser to the toe drain, or point where phreatic line intercepts the conduit.

n = Number of anti-seep collars.

The length of the line of seepage is defined as the distance along the line of contact between the earth embankment and the barrel and the anti-seep collars from the upstream end of the barrel to the point of intersection of the barrel and the phreatic line. The ratio of the length of the line of seepage (L + 2 n V) to L will not be less than 1.15.

Anti-seep collars should be equally spaced, except where necessary to avoid pipe joints, along that portion of the barrel within the saturated zone at distances of not more than 25 feet.

In the absence of positive evidence to the contrary (for purposes of computing anti-seep collar requirements) the location of the phreatic line in the earth dam embankment will be estimated on the assumption that the foundation of the embankment is impervious or that it is fully saturated.

E. Cantilever - Outlets

The invert of cantilever outlets of pipe drop inlets or culverts at its lower end will be at least one foot above the tailwater elevation of the downstream channel at maximum discharge.

Cantilever outlets will be supported on bents or piers and will extend a minimum of eight feet beyond the bents or piers. The bents will be located downstream from the intersection of the downstream slope of the earth dam embankment with the grade line of the channel below the dam. They will extend below the lowest elevation anticipated in the scour hole.

In determining the depth of the stilling basin, full consideration must be given to the total energy to be dissipated. The stilling basin will be excavated when soil conditions at the downstream end of the cantilever outlet indicate that a stilling basin will not be readily formed without extensive erosion of channel banks or the embankment.

Adequate safeguards must be taken to insure that the seepage forces into the stilling basin will not result in a piping failure.

F. Trash Racks

Trash racks will be designed and built to provide positive protection against clogging of the spillway at any point. The average velocity of flow through a clean trash rack will not exceed two feet per second with the water elevation in the reservoir five feet above the top of the trash rack or at the crest of the emergency spillway whichever is lower. Velocity will be computed on the basis of the net area of opening through the rack.

For dry dams, a trash rack may be used in lieu of a ported concrete riser. The principal spillway trash rack will extend sufficiently above the anticipated sediment elevation at the inlet to provide full design flow through the spillway with velocities through the net area of the trash rack above the sediment elevation not in excess of two feet per second when the water surface in the reservoir is five feet above the top of the trash rack.

G. Anti-Vortex Device

All closed conduit principal spillways designed for pressure flow will have an adequate anti-vortex device.

H. Drawdown Facilities

The necessary drawdown facility for any dam may be made an integral part of the principal spillway structure if the principal spillway configuration warrants, but in no case will the drawdown facility be allowed to be valved on the downstream side of the embankment. This precludes in any case a wet line under pressure through the embankment.

This above stated requirement will be waived in the case of a water supply line through the dam but provision must be made for a positive shutoff on the upstream side of the structure.

Department for Natural Resources and Environmental Protection
Division of Water
Engineering Memorandum No. 5

SECTION F - EMERGENCY SPILLWAYS

		PAGE
I.	SPILLWAY REQUIREMENTS	26
	A. Capacity of Emergency Spillways	26
	B. Elevation of the Crest of the Emergency Spillway	26
	C. Hydraulic Design	27
II.	VEGETATED AND EARTH EMERGENCY SPILLWAYS	27
	A. Layout	28
	1. Special Precautions for Class C Structures	29
	B. Frequency of Use of Earth and Vegetated Emergency Spillways	29
	C. Permissible Velocity in Vegetated or Earth Emergency Spillways	30
	1. Vegetated Emergency Spillways	31
	a. Ramp Spillways	31
	2. Earth Emergency Spillways	32
III.	ROCK EMERGENCY SPILLWAYS	33
IV.	STRUCTURAL EMERGENCY SPILLWAYS	33
V.	WATER SURFACE PROFILE	33

SECTION F - EMERGENCY SPILLWAYS

Emergency spillways are provided to convey large flows safely past an earth embankment. They are usually open channels excavated in earth or rock or constructed of compacted embankment or reinforced concrete.

An emergency spillway must be provided for each structure, unless the principal spillway is large enough to pass the routed freeboard hydrograph discharge and the trash that comes to it. A conduit type principal spillway having a barrel with a cross-sectional area of 36 square feet or more, an inlet which will not clog, and an elbow designed to facilitate the passage of trash, is a minimum size and design that may be utilized without an emergency spillway. If a principal spillway of this type and size is not provided, danger from clogging requires the use of an emergency spillway regardless of the volume of storage provided.

A single uncontrolled open channel spillway may be used for all purposes provided it is designed to accommodate all discharges, including the freeboard storm, without damage to the structure. However, a positive means to drain the lake must also be provided unless waived in writing by the Director.

I. SPILLWAY REQUIREMENTS

A. Capacity of Emergency Spillways

Emergency spillways will be proportioned so that they will pass the emergency spillway hydrograph at the safe velocity determined for the site. They will have sufficient capacity to pass the freeboard hydrograph with the water surface in the reservoir at or below the elevation of the settled height of the dam. When the principal spillway is of the size and design that requires the use of an emergency spillway, the capacity of the emergency spillway will not be less than that determined from

$$Q = 230 \times A^{0.5}$$

where Q is the spillway capacity in cubic feet per second and A is the drainage area in square miles but in no case shall a Q of less than 200 cfs be used.

B. Elevation of the Crest of the Emergency Spillway

The minimum crest elevation of the emergency spillway depends on the frequency of operation selected for the specific site. The minimum retarding storage volume and the associated

principal spillway discharge will be such that the emergency spillway discharge will not occur during the routing of the runoff from any duration storm of the selected frequency.

C. Hydraulic Design

The relationship between the water surface elevation in the reservoir and the discharge through the emergency spillway will be evaluated by computing the head losses in the inlet channel upstream of the control section, or if a control section is not used, by computing the water surface profile through the full length of the spillway.

Manning's formula will be used to evaluate friction losses and determine velocities. Policy on the selection of the "n" values is given in the discussion of the various types of emergency spillways.

II. VEGETATED AND EARTH EMERGENCY SPILLWAYS

Vegetated and earth emergency spillways are open channels and usually consist of an inlet channel, a control section, and an exit channel (see Section A - Definitions). Subcritical flow exists in the inlet channel and the flow is normally supercritical in the exit channel.

Vegetated emergency spillways are usually trapezoidal in the cross-section and are protected from damaging erosion by a grass cover. They are adapted to sites where a vigorous grass growth can be sustained by normal maintenance without irrigation.

Earth spillways are used in those areas where vegetative growth cannot be maintained. They are similar to vegetated spillways but are designed for lower permissible velocities and less frequent use. Normally they will require more maintenance after a flow occurs.

Earth and vegetated emergency spillways are designed on the basis that some erosion or scour may be permissible if its occurrence is infrequent, if maintenance facilities are provided, and if damage from a severe storm, as represented by the freeboard inflow hydrograph, will not endanger the structure.

A Manning's "n" of 0.040 will be used for determining the velocity and capacity in vegetated spillways. Permissible velocities in earth spillways will be based on an “n” value of 0.020 but the capacity of earth spillways will be based on an appraisal of the roughness condition at the site.

A. Layout

Emergency spillways should be located away from the dam site whenever possible. Topographic saddles generally make good sites.

The layout and profile of vegetated or earth spillways should provide a maximum bulk of material to provide safety against breaching of the spillway during the passage of the freeboard hydrograph. This can be accomplished by the proper selection of the location and layout of the spillway. A long, non-deepened inlet section will provide more bulk but has the disadvantage of requiring a higher stage in the reservoir for any given discharge. The exit channel should be as long as reasonably practical with just sufficient slope to meet hydraulic design requirements. The characteristics and layering of the materials on which the spillway is built must be considered in estimating the volume required to prevent breaching.

The inlet channel will be level for a minimum distance of 30 feet upstream from the control section. This level part of the inlet channel will be the same width as the exit channel, and its centerline will be straight and coincident with the centerline of the exit channel. A curved centerline is permissible in the inlet channel upstream from the level section, but it must be tangent to the centerline of the level section.

The centerline of the exit channel will be straight and perpendicular to the control section for a distance equal to at least one-half of the maximum base width of the dam. Curvature may be introduced below this point if it is certain that the flowing water will not impinge on the dam should the channel fail at the curve.

When a control section is utilized, the grade of the exit channel should be sufficient to insure supercritical flow for all discharges equal to or greater than 25 percent of the maximum discharge through the emergency spillway during the passage of the emergency spillway hydrograph. However, the slope in the exit channel need not exceed 4 percent (s=0.04 ft/ft) to meet this requirement.

The spillway discharge may be conducted by an exit channel to a point some distance above the stable grade of the natural stream channel. When this is done, the discharge is allowed to spread naturally over the existing topography and find its way to the channel downstream. This layout involves no consideration of velocities beyond the exit channel and during spillway discharge there may be considerable erosion on those reaches not designed on a permissible velocity basis.

Another approach is to construct a channel from the end of the exit channel to stable grade below. In this case, the lower constructed channel may be designed with higher velocities than are permissible in the exit channel proper. This assumes that erosion in the lower, well defined,

improved channel may be less damaging than that occurring where the discharge is permitted to meander over the natural relief in reaching stable grade.

In both layouts erosion will occur wherever the permissible velocities are exceeded and maintenance will be required to protect the integrity of the spillway.

1. Special Precautions for Class (C) Structures

Special consideration must be given to the layout of spillways on human hazard structures to assure that the spillway will not breach under the most extreme conditions of flow. The length of the exit channel should be increased to the maximum extent possible so that the area most subject to erosion is at a considerable distance from the dam. Within the limitations of the site, the profile of the spillway will be such that a maximum bulk of material is provided.

It is preferable that the flow be confined without the use of levees, but when they are necessary they will be high enough so that they will not be overtopped during the passage of the freeboard hydrograph. Levees will be constructed of erosion resistant materials and will be compacted to the degree necessary to develop this resistance. They will have a toe width not less than 12 feet and, if not protected with riprap, have side slopes not steeper than 3 horizontal to 1 vertical. When constructed on foundations subject to piping or undermining, they will be keyed into the foundation with a compacted core having a width not less than the top width of the levee and sufficient depth to reach sound material, or at least equal to the height of the levee.

Where the bulk or quality of the material in the spillway may be questionable, it may be desirable to provide a crest control structure at the control section. The purpose of this structure is to stabilize the crest of the emergency spillway for at least the period equal to the passage of the freeboard hydrograph. It is subject to eventual failure if the exit channel is not properly maintained.

Consideration should also be given to the reduction of the duration of flow through the emergency spillway by raising the elevation of the crest of the emergency spillway, thereby increasing the volume of storage in the retarding pool. An alternate or complementary procedure is to increase the capacity of the principal spillway by means of a two stage inlet of sufficient size to have an appreciable effect on the outflow hydrograph of the reservoir.

B. Frequency of Use of Earth and Vegetated Emergency Spillways

Table F-I gives the permissible frequency of use of earth and vegetated emergency spillways. For earth spillways, it refers to sites where peak flow of short duration may be expected, and where erosion resistant soils and moderate slopes exist. When vegetated spillways are used,

the sites must have these same characteristics, and in addition, conditions must be such that vigorous vegetation can be maintained without irrigation.

TABLE F-1
ALLOWABLE FREQUENCY OF USE OF EMERGENCY SPILLWAYS

Emergency Spillway Maximum Frequency of Use			
Class of Structure	Earth Once In	Vegetated Once In	Rock Once In
(A)	50 years	25 years	10 years
(B)	100 years	50 years	25 years
(C)	100 years	100 years	50 years

When conditions are less favorable, spillways must be designed for less frequent use by (1) raising the elevation of their crest, (2) providing a second stage of greater capacity to the principal spillway, or (3) increasing the capacity of the principal spillway.

The maintenance required for the emergency spillway will be increased as the flow frequency and duration increases. Good design requires balancing the spillway maintenance cost against the increased cost of modifying the other elements of the dam to reduce the flow frequency.

C. Permissible Velocity in Vegetated Earth Emergency Spillways

The maximum velocity limitations given below for vegetated or earth emergency spillways apply to the exit channel. They must not be exceeded from the control section to a point where (1) the distance from the control section is at least equal to one-half the maximum base width of the embankment and (2) a channel failure might cause the flow to impinge on the toe of the dam. The velocity limitations are based on the capacity required by routing the emergency spillway hydrograph and the assumption that uniform flow conditions exist in the exit channel. When the spillway is of the minimum capacity as determined by $Q=230 \cdot A^{0.5}$, the velocity limitation will only apply to the lesser flow that would be developed by routing the emergency spillway hydrograph.

1. Vegetated Emergency Spillways

When the anticipated average use of a vegetated emergency spillway is more frequent than once in 50 years, the maximum permissible velocity will be in accordance with the values given in Table F-II. The values may be increased 10 percent when the anticipated average use is not more frequent than once in 50 years or 25 percent when the anticipated average use is not more than once in 100 years.

The values given will be the upper limit for all grasses. Values for grasses or grass mixtures will be determined by comparison with the values shown, with due consideration given to the growth characteristics and density attained in the local area by the species under consideration.

Where bona fide studies or investigations have been made to determine the permissible velocity for a specific soil, and site, these values may be used in lieu of those shown in Table F-II.

TABLE F-II

PERMISSIBLE VELOCITIES FOR VEGETATED ARTS SPILLWAYS

Grasses or Grass Mixtures		
Soil Type	Slope	Permissible Velocity
Erosion Resistant	0 - 5% 5 - 10%	8.0 fps 7.0 fps
Easily Eroded	0 - 5% 5 - 10%	6.0 fps 5.0 fps

a. Ramp Spillways

The use of ramp spillways is prohibited.

2. Earth Emergency Spillway

The permissible velocity in earth spillways will be chosen after due consideration of the soils involved, the frequency of use of the spillway and other pertinent factors. Table F-III is taken from Fortier and Scobey's study, "Permissible Canal Velocities After Aging", and may be helpful in determining this velocity. The values given for non-cohesive soils are quite applicable and should not be exceeded unless bona fide studies have demonstrated that higher velocities are permissible. The table is not strictly applicable for cohesive soils since it applies to canal beds that are seasoned (perhaps permitting higher velocities) and subject to continuous flow and under conditions where erosion damage cannot be tolerated (requiring lower velocities).

TABLE F-III

PERMISSIBLE CANAL VELOCITIES AFTER AGING*

Original Material Excavated	Feet/Second
Fine sand, non-colloidal	1.50**
Sandy loam, non-colloidal	1.75
Silt loam, non-colloidal	2.00
Alluvial silts, non-colloidal	2.00
Ordinary firm loam	2.50
Volcanic ash	2.50
Fine gravel	2.50
Stiff clay, very colloidal	3.75
Graded, loam to cobbles, non-colloidal	3.75
Alluvial silts, colloidal	3.75
Graded silt to cobbles, colloidal	4.00
Coarse gravel, non-colloidal	4.00
Cobbles and shingles	5.00
Shale and hardpans	6.00

* Recommended in 1926 by Special Committee on Irrigation Research, American Society of Civil Engineers.
** Values shown apply to clear water, no detritus.

On easily erodible soils, consideration should be given to the use of mechanical control on the spillway crest to maintain the elevation and position of the control section.

III. ROCK EMERGENCY SPILLWAYS

Some of the principles used for the layout of earth emergency spillways are applicable to rock emergency spillways. Allowable average frequency of use and permissible velocities must be ascertained for the specific site based on a knowledge of the hardness, condition, durability, and structure of the rock formation. An individual appraisal is necessary to determine the proper roughness coefficient, “n”. In the absence of a complete investigation and a written recommendation to design the spillway as a rock spillway, the material shall be considered earth. A note showing the engineer's recommendation and bearing his seal and signature shall be a part of the plans. Table F-I gives the permissible frequency of use of rock emergency spillways.

IV. STRUCTURAL EMERGENCY SPILLWAYS

Chutes or drops, when used for emergency spillways, will be designed in accordance with the principles set forth in SCS National Engineering Handbook, Section 5, "Hydraulics", Section 11, "Drop Spillways", and Section 14, "Chute Spillways".

All structural concrete shall be designed by a registered professional engineer and shall conform to the latest accepted design codes.

V. WATER SURFACE PROFILE

The design engineer shall compute a complete water surface profile for both the emergency spillway storm and freeboard storm, to include an energy grade line, between the upstream and downstream normal flow depths. This profile shall be a part of the plans and be of such detail as to delineate the required information.

SECTION G - EARTH EMBANKMENTS

I. HEIGHT

The earth embankment will be high enough to prevent overtopping with the most severe of the following conditions: (1) the passage of the freeboard hydrograph or (2) the passage of the emergency spillway hydrograph, plus the necessary freeboard required by the site for frost conditions or wave action.

II. TOP WIDTH

The top width of earth embankments will not be less than the value given by the following equation:

$$W = \frac{H + 35}{5}$$

where H = Height of embankment in feet.
W = Minimum top width of embankment in feet.

III. WAVE EROSION PROTECTION

The earth embankment will be riprapped or other wave protection provided over the full range in stage between the lowest drawdown elevation and at least a few feet above the full normal pond elevation.

SECTION H - UTILITIES UNDER EMBANKMENTS

Existing pipelines, cables and conduits of a wide variety of sizes, materials and functions are frequently encountered at dam sites. These conduits usually are located at shallow depth in flood plain. They constitute a hazard to the safety of the dam and must be (1) relocated away from the site or (2) reconstructed or modified to provide the durability, strength and flexibility equal in all respects to the principal spillway designed for the site.

Every reasonable effort should be made to have such conduits, cables, and pipelines removed from the site. Most utilities and industries will want their facility removed from the site for easy maintenance. Only as a last resort and under the limitations imposed will conduits be permitted to remain under an earth dam embankment.

Conduits permitted to remain under any part of the embankment below the crest of the emergency spillway must be (1) provided with anti-seep collars when the location of the pipe creates a piping potential, (2) properly articulated on all yielding foundations, (3) encased in concrete or otherwise treated to insure durability and strength equal to that of the principal spillway, and (4) made absolutely watertight against leakage either into or out of the pipe.

Enclosure of the conduit, cable or pipeline within another conduit which meets the requirements of this section and which is positively sealed at the upstream end to prevent seepage into the enclosing conduit is acceptable. Such an enclosing conduit will extend the full distance through which the conduit being enclosed is beneath the embankment.

401 KAR 4:030. Design criteria for dams and associated structures.

RELATES TO: KRS 151.250

STATUTORY AUTHORITY: KRS 151.125, 224.01-110(6)(b), 224.10-100(17)

NECESSITY, FUNCTION, AND CONFORMITY: This administrative regulation is necessary to establish minimum design criteria for dams and associated structures constructed in Kentucky.

Section 1. This administrative regulation applies to all dams as defined by KRS 151.100 and to all other impounding obstructions which might create a hazard to life or property.

Section 2. Except as modified in this administrative regulation, the procedures outlined by the latest edition of "Design of Small Dams" (Second Edition, 1973), available from the U.S. Government Printing Office and the Department of Reclamation, herein filed by reference, shall be the minimum criteria.

Section 3. The Division of Water Engineering Memorandum No. 5 (2-1-75) outlined as follows: Section A. Definitions; Section B. Structure Classification; Section C. Hydrologic Criteria; Section D. Sediment Storage; Section E. Principal Spillways; Section F. Emergency Spillways; Section G. Earth Embankments; and Section H. Utilities Under Embankments; is hereby incorporated by reference and made a part of this administrative regulation as if fully set out herein. Copies are available from the Division of Water upon request.

Section 4. Structure types not generally used in Kentucky, i.e. gravity, buttress, steel, timber, etc., will be considered on an individual basis and reviewed in accord with prevailing practices that are currently accepted by the engineering profession.

Section 5. In all cases the safety of the structure, the water and/or other material impounded therein, property and human life will be the principal governing factors. Under no circumstances will the proposed use of the structure and its contents, or the cost of providing an unquestionably safe structure be allowed to assume precedence over the possible hazard involved.

Section 6. Structures which are to be repaired or reconstructed must be made to conform to the criteria established by this administrative regulation.

Section 7. Each of the following stated criteria indicates whether the limit is a maximum or minimum limit and is not to be construed as being satisfactory design criteria at all sites. Professional judgment, state laws and administrative regulations, investigations, or analysis may dictate more conservative criteria.

Section 8. (1) Approval of all plans and specifications shall be divided into two (2) distinct parts:

(a) Issuance of a construction permit pursuant to KRS 151.250 shall constitute approval of the final engineering documents to allow construction to be started; and

(b) Final written approval by the cabinet upon receipt of the "as-built" plans and specifications will constitute approval to impound.

(2) No approval to impound water and/or other material is implied or is in any way granted until the "as-built" plans and specifications have been approved, an on-site inspection has been made, and a written statement of approval issued. It is recommended that the owner and/or his engineer contact this division before initiation of final design for a predesign conference.

Section 9. All plans and specifications submitted for consideration must bear the seal and signature of the responsible engineer as defined in KRS 322.010(2), except officers and employees of the United States Government while engaged in engineering for the government. Each sheet of the drawings shall bear the seal and signature of the engineer or engineers responsible for its preparation.

Section 10. All structures, other than Class A as defined in Engineering Memorandum No. 5 (2-1-75) shall have a complete subsurface investigation and soil analysis submitted as an integral part of the drawings.

Section 11. (1) Elevation area capacity data and elevation discharge data must be submitted as a part of the plans for each structure. This elevation area capacity data shall give the area and capacities from the elevation of the lowest point in the impoundment area to at least the

elevation at the top of the dam. When the configuration of the structure will not allow the elevation discharge relationship to be developed by methods accepted as standard by the engineering profession, the structure must provide the storage necessary to contain the entire storm run-off without probable damage to the structure or creating an unacceptable hazard to life or property.

(2) When this required basic information is furnished by the responsible design engineer, the Division of Water will upon request assist the engineer in preparing the flood routings required by Engineering Memorandum No. 5 (2-1-75).

(3) In the event that the elevation area capacity data is not furnished or the flood routings show that insufficient floodwater storage has been provided, the plans will be returned to the design engineer without being approved.

Section 12. All information concerning elevations shall refer to mean sea level and the use of assumed elevations for any purpose is prohibited. Should an error in either the horizontal control or vertical control become known during construction, the necessary information to correct the distances and the elevations shall be referred to on the first sheet of the "as-built" drawing or referred to in the index. Clearly marked reference points and bench marks shall be maintained at the job site by the responsible engineer until final written approval is received.

Section 13. Unless waived in writing by the cabinet, no structure shall be approved unless a positive means is provided to pass water through the structure in sufficient quantity to satisfy the needs of downstream users and to empty the reservoir within a reasonable length of time. Conditions considered in determining downstream water requirements and required minimum time to empty the impoundment shall be determined by the responsible engineer and referred to on the drawings.

Section 14. Construction supervision and inspection must be performed by or under the direction of the design engineer. Unless otherwise directed by the cabinet the engineer shall submit monthly progress reports on forms to be supplied by the cabinet. Copies of all testing reports shall be submitted with the progress reports.

Section 15. All "as-built" documents shall be submitted by the responsible engineer in the form of permanent type drawings of a standard and uniform size. Variations in size will be permitted for federal agencies in order that they may use their standard drawings. Drawings that do not conform to standard practices or drawings that are not easily legible will not be accepted.

Section 16. Because of the cabinet's statutory duty to review federal projects for the Commonwealth under KRS 151.220, the United States Army Corps of Engineers is exempt from the provisions of this administrative regulation and KRS 151.250. (DOW-Rg-2; 1 Ky.R. 759; eff. 6-11-75.)

E.17. Louisiana



DAM SAFETY RULES AND REGULTIONS

Louisiana Department of Transportation and Development

TABLE OF CONTENTS

DAM SAFETY RULES AND REGULATIONS

Preface....5
History....5
Purpose....6
Applicability....6
Permitting....7
Submittals....8
Design....8
Construction....13
Maintenance and Operation....13
Inspections....14
Enforcement....14
Existing Structures....14
Emergency Preparedness Plans....15
References....15

APPENDICES

APPENDIX A Letters, Forms, Public Notice and Permits 17
APPENDIX B Recommended Glossary 21
APPENDIX C Figures 1 and 2 25
Figure 1 - Structures that are required to have an approved permit under the State Dam Safety Program
Figure 2 - Structures that must be submitted to the Director, Public Works and Flood Control Directorate, for review under the State Dam Safety Program
APPENDIX D Form letter from owner of dam 26
APPENDIX E Procedural Sequence 28
APPENDIX F Minimum Hydrologic and Hydraulic Submittals 31
to establish Impact Classification and Inflow Design Flood (IDF)
APPENDIX G Minimum Required Submittals 32

AKNOWLEDGEMENTS

The adopted rules and regulations were compiled after reviewing the works of various state and federal agencies and many professional organizations.

Special recognition is made to the following:

State of Oklahoma

State of Texas

State of Arizona

All other States submitting information for our review.

Department of the Army Corps of Engineers

Federal Emergency Management Agency

National Research Council

Committee on the Safety of Existing Dams

United States Committee of Large Dams

Association of State Dam Safety Officials

PREFACE

The Public Works and Flood Control Directorate of the Department of Transportation and Development serves as the Water Resources agency for the State of Louisiana, providing engineering and technical support for the orderly planning and development of programs and projects related to flood control, drainage, irrigation, water diversions, reservoirs, navigation, port development, hurricane protection, coastal engineering, and management and development of water resources.

Act No. 733 of the 1981 Legislature provides for a Dam Safety and Regulatory Program. The Public Works and Flood Control Directorate is charged with the responsibility for administering the program. The program is operated by the DOTD's Water Resources Design and Development Section, with administrative and enforcement authority vested in the Director of the Public Works and Flood Control Directorate.

HISTORY

More than 100 large dams in the United States have failed since 1930. The Baldwin Hills Reservoir near Los Angeles, the Teton Dam in Idaho, and the Barnes Lake Dam in Georgia are some of the better known failures. Dam disasters in the early 1970's, resulting in approximately 355 deaths and extensive property damage, led to the passage of the 1972 National Dam Inspection Act (Public Law 92-367, August 8, 1972). The Secretary of the Army, through the U.S. Army Corps of Engineers, was directed to inspect the majority of the nation's dams for protection of life and property. Yet, through November of 1976 no inspections had been conducted and the Corps recommended to Congress a program which emphasized voluntary state actions to inspect and regulate the 43,000 non-federal dams covered by the act. But, without federal assistance, many states could not conduct such a program.

In the summer of 1977, Congress appropriated $15 million, later increased to $18 million, for inspection of non-federal dams. In December of 1977, following the Barnes Lake Dam disaster which killed 39 persons, the president announced a federal program to inspect non-federal dams under the authority of the 1972 Act. The program's goal was to inspect approximately 9,000 non-federal, highly hazardous dams, at a cost of approximately $93 million. The president indicated that the federally-funded program could not be a substitute for effective dam safety action at the state level, and the program was intended to stimulate the states to action.

The Public Works and Flood Control Directorate was designated as Louisiana's representative in the program. A total of 343 dams were inventoried, of which 6 were classified as highly hazardous to downstream populations. In some instances, remedial measures were recommended to the dam owner for the protection of public safety. But, because Louisiana had no law relating to dam safety, the recommended measures could not be enforced.

With the passage of Act No. 733 of the 1981 Regular Session (LA. R.S. 38:21-28),

Louisiana acknowledged its responsibility of insuring the valuable resource of dams to their surrounding communities and also to protecting the life and property of the communities located downstream of dams, placing Louisiana in proper posture with the nationwide effort for dam safety.

PURPOSE

Simply stated, the purpose of Act No. 733 (LA. R.S. 38:21-28) is to recognize the inherent dangers posed by impoundments of significant volumes of water, and to require that owners of structures which impound water (or other liquids) assume the responsibility for that danger by ensuring that such structures are designed, constructed, and maintained so as to minimize the risk to life and property. Regardless of the circumstances of failure, the owner is ultimately responsible for loss of life and property damages that may occur from the failure of his dam.

The Department of Transportation and Development, Public Works and Flood Control Directorate, is charged with the responsibility for developing and enforcing a regulatory program to ensure that public safety and welfare is not compromised by the presence of dams or other impoundment facilities. The DOTD Dam Safety Program defines the minimum standards for the design, construction, operation, and maintenance of dams in the state of Louisiana, and DOTD has the responsibility and the authority to enforce the standards of the program. This manual documents the minimum standards for design, construction, operation and maintenance of dams and impoundment structures and the policies for the enforcement of those standards.

APPLICABILITY

The regulations of this program will govern the construction, enlargement, alteration or repair, maintenance and operation of all dams as defined by Act No. 733 (LA. R.S. 38:21-28) of the 1981 Regular Session of the Louisiana Legislature. The terms "dam" and "impoundment structure" are used interchangeably and shall mean the embankment, spillway(s), outlet works and other attendant parts. Included are all artificial barriers together with all appurtenant works which impound or divert water or any other liquid and which are:

1. Twenty-five feet or more in height and have an impounding capacity at maximum storage greater than fifteen acre-feet,

or

2. Have an impounding capacity at maximum storage of fifty acre-feet or more and are greater than six feet in height (see Figure 1, Appendix C).

All barriers which are six feet or more in height with maximum storage capacities of fifteen acre-feet or more must be submitted to DOTD for review (see Figure 2, Appendix C). The height of a dam is measured from the natural bed of the stream or watercourse at the downstream toe of the barrier, or if it is not across a stream or watercourse, the height from the lowest elevation of the outside limit of the barrier, to the top of the dam. The capacity at maximum storage is the volume in the reservoir in acre-feet when the water level in the reservoir is at top of dam elevation.

PERMITTING

APPLICATION FOR PERMIT -- A permit from the DOTD will be required prior to constructing any new impoundment structure or commencing any structural modifications to existing impoundment structures (see Appendix A). Permit forms may be obtained from the Director, Public Works and Flood Control Directorate, Louisiana Department of Transportation and Development, P.O. Box 94245, Baton Rouge, Louisiana, 70804-9245. The permitting process is designed to ensure that new structures and modifications to existing structures are designed and constructed in accordance with the requirements documented herein.

NATURAL RESOURCES CONSERVATION SERVICE -- The approval process may be abbreviated if dams meet the requirements of Pond Standard 378 of the Natural Resources Conservation Service National Handbook for Conservation Practices and the Natural Resources Conservation Service's engineering staff provides the design, layout, and construction inspection. In this case, the Natural Resources Conservation Service will certify that the dam design and construction meets the requirements of Pond Standard 378 and they will provide DOTD with the Pond Data Sheet, a map showing the location of the pond, and a letter signed by the owner of the dam (see Appendix D). The Natural Resources Conservation Service will agree to periodically inspect the structure to ensure that Pond Standard 378 is being maintained, and to inform the DOTD if the structure ever falls below Pond Standard 378.
NOTE: Natural Resources Conservation Service formerly the "Soil Conservation Service".

PUBLIC HEARINGS -- After an application has been filed and accepted, the public in the affected locale will be notified by publication in the local news publication. The Director of Public Works and Flood Control will prepare a notice, assigning a date and place for a public hearing of the application. The notice will contain information describing the application and the name and address of the applicant (see Appendix A). It will be the applicant's responsibility to have the notice published once a week for two consecutive weeks in the official journal of the parish in which the project will be constructed, and shall

provide notarized proof of publication on or before the hearing date. The applicant will bear the cost of the publication. The DOTD will conduct the public hearing, and the applicant will be required to attend to describe the nature and purpose of the proposed project and to answer questions.

ISSUANCE OF A PERMIT -- An "Impoundment Permit/Certificate of Completion" shall be issued for all dams, both existing and new construction. The "Impoundment Permit/Certificate of Completion" is not transferable. The owner of a dam must notify the DOTD 30 days prior to transferring ownership of the dam, and must return the "Impoundment Permit/Certificate of Completion" to the DOTD.

FAILURE TO OBTAIN APPROVAL -- If, prior to beginning construction, the owner fails to obtain approval, the owner will be cited and fined under the statutory authority of Louisiana Revised Statute, Title 38, Section 28. Also, the lake may be ordered to be drained until all approvals have been obtained.

SUBMITTALS

All designs for work to be permitted under the program will be submitted for review and approval with all necessary supportive documentation (See Appendix G). Normally, it is expected that an owner or prospective owner will establish contact with the DOTD to apply for a permit to construct or modify a dam. An example of a letter notifying the DOTD of intent to construct or modify a dam is provided in Appendix A. In some cases, however, structures are built and water is impounded without the knowledge or approval of the DOTD. When such structures are discovered, the owners will be contacted by the DOTD and required to furnish documentation that their structure meets the safety requirements of the program. In either case, the applicant will be guided by the Water Resources Design and Development Section throughout the review and approval process. The documentation required will be formal engineering designs and calculations, supported by sufficient field information, and certified by a professional civil engineer registered to practice in Louisiana. Because each step in the design of a dam is dependant upon the quality of the design judgements made in the previous steps, the applicant is advised to coordinate each of the three formal design stages, identified in the next section, with the DOTD review team prior to proceeding to the next step.

After general designs have been approved, the applicant may proceed with plans and specifications, which will also require approval before construction can begin. Plans and specifications will be of professional engineering detail and quality and will include all information and directions necessary to construct the dam in accordance with the design intent.

DESIGN

The proper design of a dam involves a complex combination of engineering applications. It is not within the scope or intent of this document, nor will it be the practice of the staff of DOTD, to instruct in the detailed procedures for the design of a dam. All dams and impoundment structures to be permitted under this program will be designed by a professional civil engineer(s), registered by the Louisiana State Board of Registration for Professional Engineers and Land Surveyors. The registered civil engineer will certify the designs and plans by professional seal. Designs must conform to nationally recognized standards, further explained in the following paragraphs and in the reference material. The completed design package will state the intended design life of the structure, and will include the operations and maintenance procedures necessary to ensure that the structure will function as designed for its stated design life.

Failure of an impoundment structure and the instantaneous release of large volumes of water is referred to as a dam breach and is the primary risk associated with dams, and is the fundamental reason for the state to assume regulatory authority over dams through the Dam Safety Program. Breaching may occur during fair weather due to the cumulative effects of erosion or seepage, or it may occur as a result of stresses caused by excess water produced during a storm event. The hydraulic and hydrologic (H&H) design will determine which of the two scenarios poses the greater hazard, the volume of water which is likely to be released, and the rate of flow.

It is the H&H design which determines the volumes and flow rates with which the impoundment structure(s) must contend. The geotechnical and structural designs must ensure that the impoundment structure(s) can safely accommodate the hydraulic forces imposed by the conditions predicted by the H&H design. Following are the sequential steps which are necessary in any dam/impoundment structure design, and each step must be documented with design calculations and all supporting data, certified by a Registered Professional Civil Engineer:

I. Hydrology and Hydraulics (H&H) Design

A. Impact (Hazard) Classification

B. Determination of controlling design condition and associated storm runoff.

C. Setting of spillway and stilling basin widths and elevations, top of embankment elevation, and normal pool stage.

II. Structural and Geotechnical Design of Embankment, Spillways, and Drawdown Structures.

III. Development and Documentation of Operations and Maintenance Procedures.

Note : For the purpose the Dam Safety Program, the "Emergency Spillway" shall be defined as being overtopped by the 100 year storm or greater and the "Principal Spillway" shall be defined as being overtopped by a storm less than the 100 year storm.

HYDROLOGY AND HYDRAULICS (H&H) DESIGN -- Before the structural design of the dam can begin, the requirements of hydraulic capacity must be determined. The height of the dam, the amount of freeboard above normal pool elevation, the size and

capacity of the principle and emergency spillways, must all be designed to balance the hydrological and hydraulic properties of the location of the reservoir. A properly designed drawdown structure, capable of reducing the stage of the reservoir at a suitable rate in the event of emergency, must also be designed to meet the capacity requirements of the site.

The H&H design begins with the Impact Classification (also referred to as Hazard Classification in some texts) of the dam (See Appendix F). The Impact Classification is determined by an evaluation of the probable maximum impacts of a dam breach. Low impact structures are those for which, because of size and/or location, little or no significant damage to life or property is likely to result from a failure of the structure. Significant impact structures are those which could cause appreciable damage to property or could pose possible threat to human life in the event of failure. High impact structures are those for which failure would cause excessive property damage or make loss of human life likely.

Note: The inflow design flood (IDF) is determined by the various Hydrograph Methods after the precipitation amount is developed. The major source of precipitation data is the National Weather Service (NWS). The DOTD has final authority for approval of the method to be utilized to determine the IDF.

TABLE I
IMPACT CLASSIFICATION AND INFLOW DESIGN FLOOD

IMPACT CATEGORY	POTENTIAL LOSS OF LIFE	POTENTIAL ECONOMIC LOSS	MINIMUM INFLOW DESIGN (IDF)
LOW	NOT LIKELY	MINIMAL	50-Yr. Freq.
SIGNIFICANT	POSSIBLE	APPRECIABLE	100-Yr. Freq.
HIGH	LIKELY	EXCESSIVE	1/2 PMF

Further guidance in assessing the potential hazards and associated impact classification for dams may be found in Reference 1. It is the responsibility of the owner/applicant to establish impact classification, and all dams will be considered to be of High Impact potential until demonstrated to be otherwise by a documented analysis provided by the applicant. The proposed impact classification must be supported by sufficient analysis and documentation, and DOTD will have final authority for assigning Impact Classification.

Having established the Impact Classification for the structure, the next step is to establish the magnitude of the meteorological event on which the entire design is to be based. Dams must be designed to be able to safely withstand the passage of a flood of design magnitude. The **Inflow Design Flood** (IDF) is the largest storm event to be considered in the design of the structure, and the magnitude of the storm event for which

the IDF is computed is related to the Impact Classification. The values shown for IDF in Table I are **minimums**, and the actual storm event to be used as the IDF will be determined by a site specific analysis. For low impact structures, the primary consideration is the protection against loss of the dam and its benefits in the event of failure, while for significant and high impact structures, adequate protection of life and property must be assured.

For dams classified as high impact, the IDF is defined as the flood event above which a breach of the dam does not increase hazard to downstream interests. The upper limit of the IDF for high impact structures is the **Probable Maximum Flood** (PMF), which is the flood which may be expected from the most severe combination of critical meteorological and hydrological conditions which are reasonably possible. While the PMF is the upper limit for the IDF, the IDF for high impact dams may be an event of smaller magnitude, depending upon an incremental hazard assessment, which is a routing of floods of increasingly larger magnitude through the structure and downstream channel reaches, comparing conditions with and without a dam failure, until a flood magnitude is reached for which the dam failure condition does not appreciably increase the hazard potential.

Dams classified as having significant impacts may or may not require a formal incremental hazard evaluation, depending upon the extent of existing and potential downstream development, the size of the reservoir, and the type and use of the dam. The upper limit of the IDF for significant impact structures is the PMF.

For dams with low impact classification, the incremental hazard evaluation is not required, and the IDF can be based upon factors related to loss of service of the dam, potential maintenance costs, etc., but with the 50-Yr. frequency storm being the minimum design event. The Water Resources Design and Development Section should be a partner in establishing the IDF, and designs should not proceed until agreement has been reached between the DOTD and the owner's engineer on the choice of the IDF. Establishing the IDF is the foundation for the entire design process, since the dam must be designed to safely pass and/or contain the IDF. A guideline for performing the incremental hazard evaluation necessary to establish the IDF is provided in Reference 1.

How the IDF is to be safely passed by the dam structure and the stability of the dam against the long-term effects of hydrostatic forces is the subject of the balance of the design effort, including the general configuration of the dam; length, elevation, and composition of principal and emergency spillways; freeboard above normal pool elevation; erosion protection; and stability design. The most practical way of assuring the integrity of the dam during an IDF

is to provide a concrete spillway which is capable of carrying the peak flow of the storm. Principal spillways are normally sized to carry flows from all but the largest of storms, with emergency spillways, which are not normally armored, functioning only during

major storm events. If the peak flow from the IDF can be contained within the principal and emergency spillways, the stability of the dam is not likely to be threatened by the erosive action of water flowing over the embankment. The designer may wish to balance the relative economy of providing spillway capacity versus storage capacity above normal pool stage. But, if design calculations indicate that the embankment will be overtopped by the IDF, provisions must be included in the design to prevent the embankment from failing under the erosive forces of the overtopping flows.

GEOTECHNICAL DESIGN -- It is essential to the stability of the structure that the material used in the impoundment structure, as well as the foundation and adjoining earth have the necessary structural properties to withstand the hydrostatic forces required by the design, that potential for destructive seepage is identified and appropriately dealt with, and that the surfaces of the structure are adequately protected from surface erosion.

Field investigations shall be adequate to define the soils and ground water conditions with respect to stability and seepage control. Stability analysis should consider after-construction conditions, based on the undrained shear strength parameters determined by laboratory tests. Long-term steady seepage, partial pool, and rapid drawdown analyses should also be performed, using shear properties appropriate to the subject materials and minimum safety factors shown in Table II.

TABLE II
FACTOR OF SAFETY
FOR STABILITY ANALYSIS

ANALYSIS CONDITION	FACTOR OF SAFETY
Rapid Drawdown	1.25
Partial Pool	1.40
Steady Seepage	1.40
After Construction	1.30
Earthquake	1.15

STRUCTURAL DESIGN -- Structural Designs are to be prepared in accordance with generally accepted structural engineering practices such as those of the American Concrete Institute, the American Institute of Steel Construction and the American Institute of Timber Construction. Components of the spillway or other appurtenant structures shall be designed to resist the most critical loading combination of dead loads plus live loads that may occur during its construction or design life. Some of the loads which must be considered in the design are: buoyancy forces, sliding forces, hydrostatic uplift forces, bearing forces, overturning forces, water drag forces, wing drag forces, gate-lifting and closing forces, soil and water pressure forces, impact forces, uniform and point live load forces, etc. The minimum factors of safety for buoyancy and sliding shall be 1.5 and 2.0, respectively. The overturning analysis must indicate that the resultant force falls within the center 1/3 of the base. The minimum factor of safety for pile design shall be 2.0.

CONSTRUCTION

It will be the owner's responsibility to ensure by the presence of professional construction supervision personnel that the structure is built in strict compliance with the approved designs and specifications. Adequate records shall be maintained to document that all materials and construction procedures meet or exceed those specified. The owner shall report on the construction to the DOTD. The work of construction, enlargement, alteration, repair or removal of a dam or reservoir for which approved application, designs, plans and specifications are required shall be under the responsible charge of a registered civil engineer. Upon completion of the work and prior to the impoundment of water, the engineer shall certify that all work has been done in compliance with the approved plans and specifications (Appendix A).

During construction, periodic inspections may be made by representatives of DOTD. The owner will be required to provide such works or tests as may be needed to disclose sufficient information to enable DOTD to determine that conformity with approved plans and specifications is being maintained. Inspections made by DOTD are "limited inspections" and do not relieve the owner or the owner's engineer from their responsibilities for conformance to accepted designs and procedures.

MAINTENANCE AND OPERATION

Once in service, the integrity of the impoundment structure must be sustained by regular maintenance, in accordance with the approved Operations and Maintenance document provided by the designer. The Operations and Maintenance Manual should contain forms and schedules for records and documentation of inspections, maintenance procedures, and repairs. The owner will be responsible for certifying, through properly documented records, to the DOTD that the required periodic inspections have been made, for correcting any deficiencies revealed during such inspections, and for maintaining

records of all operations and maintenance activities, as well as of original construction and any subsequent modifications.

An Emergency Preparedness Plan is required for all dams and reservoirs. The plan shall comply with the guidelines of the current issue of Louisiana's "Emergency Action Plan Guidelines", available from the DOTD's Director of Public Works and Flood Control. The Emergency Preparedness Plan will be a condition of the permit for the project, and it will be the owner's responsibility to implement the provisions of the plan in the event of emergency.

INSPECTIONS

The DOTD will periodically inspect every dam in the jurisdiction of the program. The purpose of the DOTD inspections is to ascertain whether the structure is being properly maintained in accordance with the approved Operations and Maintenance procedures. DOTD inspections are limited inspections and do not relieve the owner of responsibility to perform and document periodic inspections. If an inspection by DOTD reveals that a dam is unsafe or in danger of becoming unsafe, the DOTD, through the Director of Public Works and Flood Control, shall direct the owner to take whatever action is necessary to restore the dam to its design condition.

The owner has the primary responsibility for insuring the safe condition of the structure by regular maintenance and periodic inspection. The owner is required to immediately inform the Director of Public Works and Flood Control of any unusual circumstances or occurrences which may affect the condition or safety of the reservoir. Also, the Director will be notified prior to any planned draw downs of the reservoir.

ENFORCEMENT

If any dam or impoundment structure is determined to be unsafe, the Director of Public Works and Flood Control for the Department of Transportation and Development, pursuant to La R.S. 38:21-28, shall direct any such repairs or remediations for a dam or impoundment structure as he deems necessary to ensure that life and property is not unduly threatened by the impoundment. Such remedial action may include (1) directing that the water level behind the structure be lowered to a safe level, or (2) that the impoundment be completely drained until all necessary corrections to the structure have been made.

EXISTING STRUCTURES

All dams constructed or under construction prior to the promulgation of these rules will be reviewed to assess their disposition under the program regulations. Each dam is unique and must be judged on the basis of its own particular set of circumstances. Based on the circumstances of each individual case, a judgement will be made of what modifications or repairs are necessary to meet program standards. It is the intent of the program to eventually have every dam upgraded to meet program standards. DOTD will be the sole judge of whether an existing deficiency creates an unacceptable risk to the

general public. While it is not the intent of this program to lower the standards for existing dams, DOTD recognizes that it is not practical to force all dam owners to immediately retrofit their structures to meet new minimum Inflow Design Flood standards.

An "Impoundment Permit" is required for existing dams and will be issued after reviewing all historical data (designs, plans, specifications, operation and maintenance records, etc.) and performing a technical inspection (or inspections) to adequately assess the safety of the dam. The owner shall provide all historical data, if available.

EMERGENCY PREPAREDNESS PLAN

An **Emergency Preparedness Plan** is required for all dams and reservoirs both existing and new construction (See page 21, "Existing Structures"). The plan will comply with the guidelines of the current issue of Louisiana's "Emergency Action Plan Guidelines", available from the Director of Public Works and Flood Control, and shall be submitted as a necessary component of the Maintenance and Operating Procedures as a condition of the permitting process. It is the owner's responsibility that the provisions of the Emergency Action Plan are implemented in the event of an emergency situation.

A breach analysis is required to develop the emergency preparedness plan. The breach analysis will establish the magnitude of the inundated area (inundation map), peak flood elevations and arrival times of the peak flood elevations at critical locations. The worst case scenario breaching event will be somewhere between the "sunny day" breach and that event above which a breach of the dam does not increase hazard to downstream interests. If the dam owner wants to perform only one breach analysis instead of doing incremental analyses to find the worst case scenario breaching event, he can perform a breach analysis where the tail water is at the average annual elevation and the reservoir is at maximum design surcharge.

REFERENCES

1. Jerrold W. Gotzmer, William C. Jenkins, Ramon G. Lee, Joseph R. McCormick, Harvey H. Richardson, and David L. Sveum, Training Aids for Dam Safety, Module,: Evaluation of Hydrologic Adequacy, Interagency Committee on Dam Safety (Available from: Louisiana Transportation Research Center, 4101 Gourrier, Baton Rouge, Louisiana; telephone (504-767-9131).

2. Peter G. Grey, Terry G. Fairbanks, Tasso Schmigall, and Charles D. Wagner, Training Aids for Dam Safety, Module: Evaluation of Hydraulic Adequacy, Interagency Committee on Dam Safety (Available from: Louisiana Transportation Research Center, 4101 Gourrier,

Baton Rouge, Louisiana; telephone (504) 767-9131).

APPENDIX A
LETTERS, FORMS, PUBLIC NOTICE AND PERMITS

LETTER OF INTENT

Purpose: To notify the Louisiana State Dam Safety Program of the applicant's intent to construct, enlarge, alter, repair or remove a dam within the state.

Address To: Louisiana State Dam Safety Program
Louisiana Department of Transportation and Development
Public Works and Flood Control Directorate
Post Office Box 94245
Baton Rouge, Louisiana 70804-9245

Contents: 1) Name of proposed or existing dam

2) Purpose of dam

3) Owner's:
Name

Address

Telephone

4) Location of dam (section, township, range, parish)

5) Brief description of proposed dam construction, enlargement, alteration, repair or removal

*6) Height of Dam (height in feet from top of dam to lowest point at downstream toe of dam)

*7) Reservoir Capacity (volume in acre-feet with water at top of dam)

*NOTE: Items 6 and 7 can be approximated at this time.

Letters of No Objection and Other Permits

The applicant must forward copies of the pre-application to the appropriate state, federal and local agencies to obtain letters of no objection and/or permits as required by these agencies. Copies of the letters of no objection and permits must be submitted to the Louisiana State Dam Safety Program as part of the applicant's application under this program.

Pursuant to the rules and regulations of the State Dam Safety Program as established by Act No. 733 of the 1981 Regular Session, interested parties are hereby notified that a "Letter of Intent" and a "Pre-Application for Construction of Dam" have been received by the Director, Public Works and Flood Control Directorate, Department of Transportation and Development to construct the proposed
Dam and Reservoir Pre-Application Number PA_____ located in Section____ Township) _, Range____,_____ Parish.

Applicant:

(Name)

(Address)

(Phone)

Purpose and Brief Description of Dam:

All interested parties are hereby notified that a public hearing on the application will be held at p.m. on _____ at _ . Any interested party shall have the right to request a public hearing on the application. Requests for public hearings must be in writing and must be submitted no later than the close of the public hearing on _____ .Letters
must state, with particularity, the reasons for holding a public hearing, applicant's name and Pre-application number. Upon receiving a written request for a hearing within the time limits set forth in

this notice, the Director, Public Works and Flood Control Directorate, shall set a date, time and place for conducting a hearing on the application. During the hearings, any interested party shall have the right to protest the application and to appear and present evidence and testimony in support of such protest.

Letter for Approval of Construction

Purpose: To notify the applicant of the "Approval for Construction" of his "Application for Construction of Dam".

Address To: Applicant with copy to applicant's consulting engineering firm.

Letter of "Notice of Completion and As-Built Drawing

Purpose: To notify the Louisiana State Dam Safety Program that the construction of the subject project is complete and to certify that said construction was done in accordance with the approved designs, plans, drawings and specifications.

From: Applicant's Consulting Engineering Firm (letter must be signed and sealed by a Registered Professional Civil Engineer licensed in the State of Louisiana).

Address To: Louisiana State Dam Safety Program
Louisiana Department of Transportation and Development
Public Works and Flood Control Directorate
Post Office Box 94245
Baton Rouge, Louisiana 70804-9245

Note: As-Built Drawings must be received by the Director, Public Works and Flood Control Directorate, within 30 days after completion.

Private Impoundment Permit
(Certificate of Completion

Purpose: Authorizes the Owner of a Dam and Reservoir to impound water at his facility. Certifies that the applicant has met all requirements under the State Dam Safety Program (see sample next page).

APPENDIX B
RECOMMENDED GLOSSARY

ABUTMENTS - Those portions of the valley sides which underlie and support the dam structure, and are usually also considered to include the valley sides immediately upstream and downstream from the dam.

AUXILIARY OR EMERGENCY SPILLWAYS - A secondary spillway designed to operate only during unusually large storm events. Louisiana's dam safety program defines " unusually large storm events" as being equal to the 100 year storm event or larger.

BAFFLE BLOCKS - Baffle blocks are blocks constructed in a stilling basin to dissipate the energy of fast flowing water.

BERM - The berm of the dam is a horizontal step in a sloping profile. The berm is usually constructed with a slight slope for drainage purposes. The berm is often referred to as a seepage or stability berm.

BLANKET DRAIN - The blanket drain is a horizontal pervious zone located downstream of the impervious core. This zone is often referred to as a sand blanket.

BREACH - An eroded opening through a dam that drains the reservoir. A controlled breach is an intentionally constructed opening. An uncontrolled breach is an unintentional opening that allows uncontrolled discharge from the reservoir.

CHIMNEY DRAIN - The chimney drain is a vertical pervious zone located just downstream of the impervious core. The chimney drain is usually constructed with a sand material.

COFFERDAM - A temporary structure enclosing all or part of the construction area so that the construction can proceed in the dry.

CONDUIT - A conduit is a closed channel to convey discharges through or under a dam. The conduit can be a reinforced concrete pipe, a corrugated metal pipe or a single or multi-barrel reinforced concrete box culvert.

CREST LENGTH OF DAM - The crest length of the dam is the length of the top of dam. This length includes the spillway(s) and other appurtenant structures. The crest length of dam is basically the length from where the top of dam terminates on one abutment to a similar point on the other abutment.

CUTOFF TRENCH - The cutoff trench is an impervious barrier built into the foundation to reduce seepage under the dam. A cutoff wall or slurry wall could be used as a seepage barrier. The slurry wall is relatively thinner in the horizontal direction when compared to a clay core cutoff trench.

DAM - A dam is any artificial barrier, including appurtenant works, which does or will impound or divert water or any other liquid substance.

DOWNSTREAM SLOPE - The inclined surface of an embankment dam that faces away from the reservoir.

DRAWDOWN STRUCTURE - A drawdown structure is a low level outlet which can be used to lower the reservoir below normal pool stage. This may be necessary for lake management purposes, routine repairs or dam safety purposes.

EARTHFILL DAM - A dam constructed predominantly of fine-grained material. Earthfill dams are also known as rolled fill dams where material is placed in layers and compacted by using rollers or rolling equipment.

END SILL - The end sill is the area at the upstream and downstream end of the stilling basin base slab.

FOUNDATION OF DAM - The foundation of the dam is the natural material on which the dam is placed.

HEEL OF DAM - The heel of the dam is the junction of the upstream slope with the foundation. The heel of the dam is often referred to as the upstream toe.

IMPERVIOUS CORE - The impervious core is a zone of low permeability material. This zone is the water or seepage barrier and is often referred to as the clay core.

INTAKE STRUCTURE - The structure placed at the beginning of an outlet works waterway. The intake structure establishes the ultimate drawdown level of the reservoir by the position of its opening(s) to the outlet works. Intake structures may be vertical or inclined towers (drop inlets).

MAXIMUM CROSS SECTION DAM - Cross section of a dam at the point where the height of the dam is a maximum.

NON-OVERFLOW WALL - Non-overflow walls are walls which are usually constructed parallel to the spillway crest at an elevation equal to the top of dam elevation. These wall

are not designed to be overtopped and are often referred to as a closed dam section.

NORMAL POOL STAGE - Normal pool stage for controlled spillways is defined as the water level at the dam to which water may rise under normal operating conditions. This does not include flood surcharge.

OUTLET GATE - The outlet gate is a gate on the drawdown structure or spillway which is used to control the outflow of water. These gates are usually located on the upstream end of the drawdown structure, however, they can be located of the downstream end.

RIPRAP - Riprap is a layer of large uncoursed stones, broken rock or precast blocks placed in a random fashion on the upstream slope of the dam and stilling basin outlets. Riprap is a flexible type of slope protection which will deform if material is displaced from beneath.

PIPING -The progressive internal erosion of an embankment, foundation, or abutment material. The erosion (piping) begins on the downstream side and progresses upstream.

PROBABLE MAXIMUM FLOOD (PMP) -The flood that may be expected from the most severe combination of critical meteorologic conditions that are possible in the region.

PRIMARY OR PRINCIPAL SPILLWAYS - Primary or principal spillways are the first used spillway during flood flows.

RETAINING/TRAINING WALLS - Retaining/training walls are walls which are usually constructed perpendicular to the spillway crest. Retaining walls are walls which support an overturning load. Training walls are walls which confine or guide the flow of water. In many instances, these walls serve both purposes and can be referred to as either a retraining or training wall.

RISER - A type of drop inlet spillway with a vertical section of metal or concrete pipe that allows the reservoir to rise to a predetermined level before water flows into the pipe.

SLOPE - The embankment slope is the inclined face of the embankment spillway, channel. The slope can be an upstream slope or a downstream slope. The upstream slope is on the lake or reservoir side of the dam.

SLOPE PROTECTION - Slope protection is protection against wave action or erosion. The two most common types of slope protection, are riprap and soil cement.

SLUICE - A low-level opening for releasing water from a dam.

SOIL CEMENT - Soil cement is a well compacted mixture of soil, portland cement and water that produces a hard pavement. Soil cement is usually placed in horizontal layers. Soil cement is a rigid type of slope protection which attempts to span voids.

SPILLWAY CREST - The spillway crest is the overflow section or weir section of the spillway.

STILLING BASIN - A stilling basin is a basin constructed to dissipate the energy of fast flowing water. The stilling basin area is located just downstream of the spillway crest between the training/retaining walls.

STRUCTURAL HEIGHT - The distance between the lowest point in the excavated foundation and the top of the dam.

SURCHARGE/FLOOD SURCHARGE - Surcharge/flood surcharge is the volume or space between normal pool and the maximum water level.

TAILWATER - Tailwater is the level of water immediately downstream of the dam.

TOE OF DAM - The toe of the dam is the junction of the downstream slope with the foundation. The toe of the dam is often referred to as the downstream toe.

TOP OF DAM/CROWN - The top of dam is the uppermost surface of the dam. The top of dam can also be referred to as the crest of the dam. When the term "crest" is used, it must be specified that it is the "crest of the dam" and not the "crest of the spillway".

UNCONTROLLED OR UNGATED SPILLWAYS - Uncontrolled or ungated spillways are spillways where the flows over the spillway crest are controlled only by the elevation of the spillway crest. This type of spillway is often referred to as a fixed crest spillway.
Normal pool stage for uncontrolled spillways is defined as the lowest crest elevation of the principal spillway.

UPSTREAM SLOPE - The inclined surface of an embankment dam that is in contact with the reservoir.

APPENDIX C
FIGURES 1 and 2

FIGURE 1

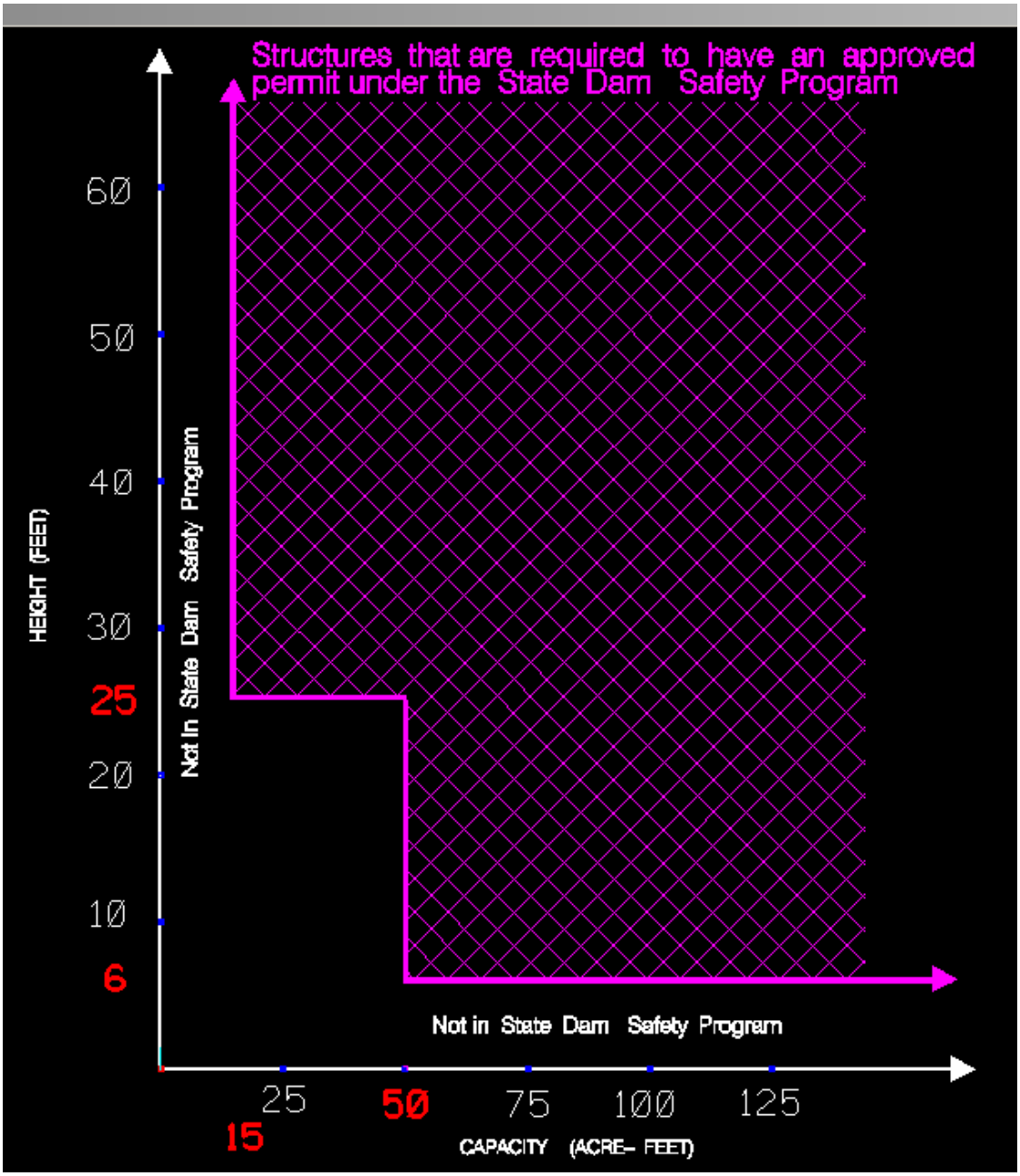
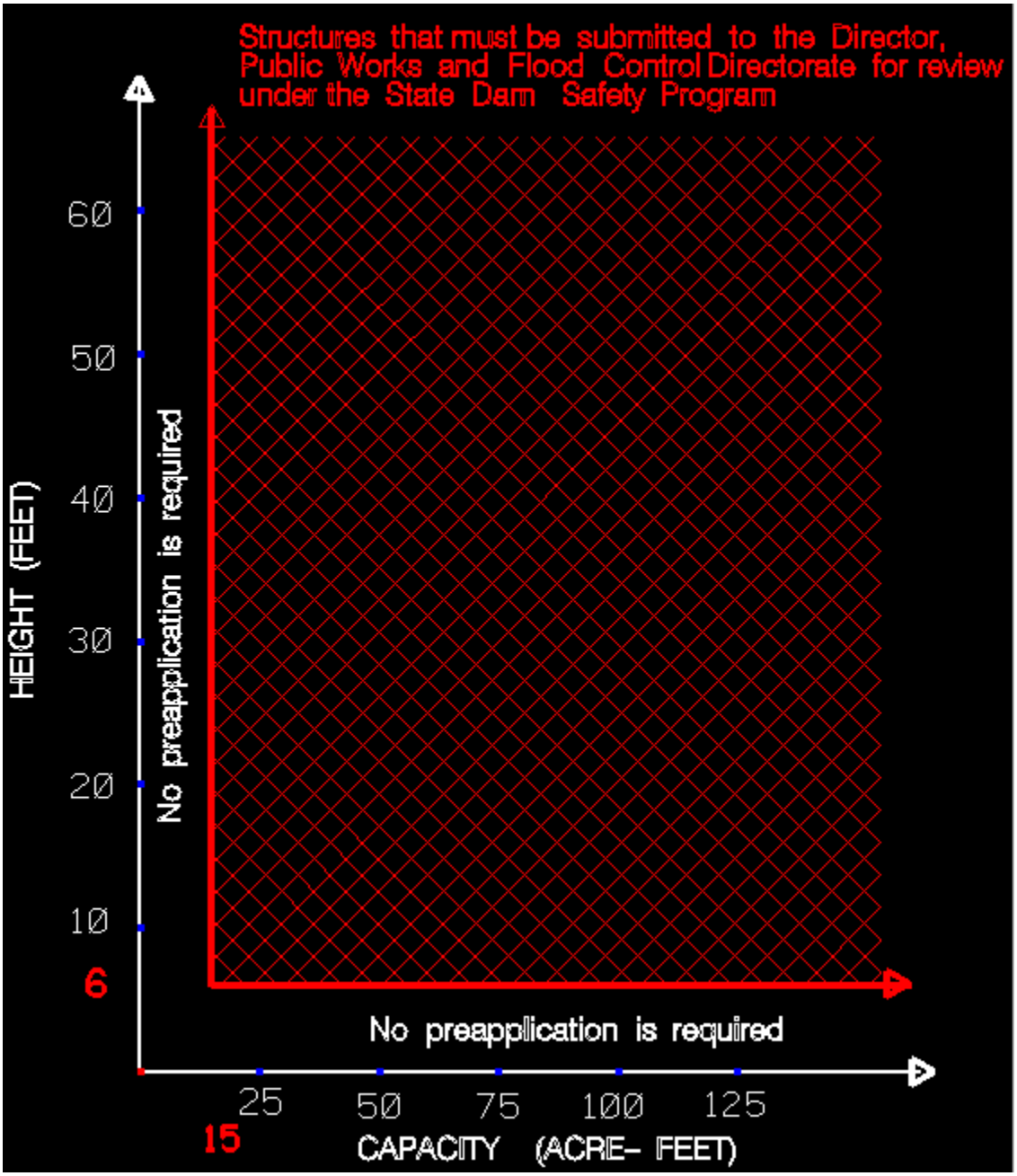


FIGURE 2


Structures that must be submitted to the Director, Public Works and Flood Control Directorate for review under the State Dam Safety Program
HEIGHT (FEET)
60
50
40
30
20
10
6
No preapplication is required
No preapplication is required
25
50
75
100
125
15
CAPACITY (ACRE- FEET)

APPENDIX D
FORM LETTER FROM OWNER OF A DAM

DATE:

Dam Safety Administrator
Louisiana DOTD
P. O. Box 94245, Capitol Station
Baton Rouge, Louisiana 70804-9245

RE: Pond Construction

I am aware that the design, construction and operation of all dams within Louisiana is regulated by the Rules and Regulations for Dam Safety Program as developed by the State of Louisiana, Department of Transportation and Development. I am also aware of the liability that is associated with owning a dam.

Since I am receiving design and construction assistance from the Natural Resources Conservation Service, formerly Soil Conservation Service, the dam described below is excluded from the approval process outlined in the Dam Safety Regulations. However, if for some reason (such as a land use change) the dam no longer comes within the criteria of the Soil Conservation Service National Handbook for Conservation Practices - Standard 378, I agree to modify the structure if necessary to comply with the requirements of the Dam Safety Regulations. I also agree to allow access for inspection of this structure.

Sincerely,

OWNER

DAM LOCATION:

APPENDIX E
PROCEDURAL SEQUENCE

(New Construction)

1. Applicant or his Engineer submits "Letter of Intent"

2. Applicant or his Engineer submits "Pre-Application for Construction of Dam"
3. Applicant publishes "Notice of Application" and a "Public Hearing(s)" is (are) held
4. Applicant or his Engineer completes "Designs, Plans and Specifications" as follows and submit "Application for Construction of Dams"
    a. "Impact (Hazard) Classification
    b. Determination of controlling design condition and associated storm runoff
    c. Setting of spillway and stilling basin widths and elevations, top of embankment elevation, and normal pool stage
    d. Plans, Specifications, Designs and other Submittals
5. DOTD issues "Approval or Denial of Application"; Approval is an "Approval for Construction"
6. Construction begins; Applicant or his Engineer and DOTD performs "Construction Inspections"
7. If "Deficiencies" are found by DOTD, Applicant or Applicant's Engineer; Applicant or his Engineer correct the deficiencies
8. Supervision of Construction by Owner
9. Applicant or his Engineer submits "Notice of Completion" and "As-Built Drawings" and final "Application for Construction of Dam"
10. DOTD issues "Certificate of Completion/Impoundment Permit"
11. Applicant or his Engineer submits "Maintenance and Operation Procedures" for DOTD's approval
12. Applicant or his Engineer submits "Emergency Preparedness Plan" for DOTD's approval

APPENDIX F
MINIMUM HYDROLOGIC AND HYDRAULIC SUBMITTALS TO ESTABLISH IMPACT CLASSIFICATION AND INFLOW DESIGN FILE (IDF)

Since the required submittals may vary for each dam, we recommend that you obtain copies of references number 1 and 2 on page 25 of the Dam Safety Rules and Regulations. After reviewing these documents, we would advise that you contact the Hydraulic Unit of the DOTD for further guidance.

APPENDIX G
MINIMUM REQUIRED SUBMITTALS

1) All structural, geotechnical, hydrologic and hydraulic design calculations. An engineer's report shall also be submitted which summarizes the design analyses and shall include, but is not limited to, the following:

   a) Formulas, methods and basic data assumptions used in the designs.

   b) List of all pertinent design codes.

   c) Summary tables which list design load cases, computed design factors of safety and required factors of safety as specified in these Rules and Regulations or required by pertinent design codes.

   d) All other information which aided in evaluating the design, supported assumptions and conclusions, and will facilitate an independent review.

2) Plans with sufficient details to construct all features of the dam in accordance with the design intent. Also, the plans shall include details to construct a permanent reference mark (bench mark) near, but separate from, the project. The exact location and elevation above mean sea level must be noted on the "As-Built" plans.

3) Specifications with sufficient details to construct all features of the dam in accordance with the design intent. The specifications shall also provide that the plans and specifications may not be changed without prior written approval by the DOTD.

4) Document(s) to show proof of ownership.

5) An inspection plan specific to the construction activity. The inspection plan is to

detect deficiencies or situations that may result in a threat to life and property.

6) An emergency action plan specific to the construction activity. The inspection plan in item 5 is part of the emergency action plan under this item.

7) If the applicant has an agreement or contract with another entity who will be responsible for the operation and maintenance of the dam, the applicant must provide copies of the agreement or contract document(s).

8) If the applicant is constructing the dam for the specific purpose of transferring ownership to a homeowners' association, a landowners' association, or any other entity, the applicant must provide a document which clearly states his intent, i.e., a dam which is constructed for a subdivision development where ownership will be transferred to a homeowners' association.

9) All other "Permits" required to construct the dam and "Letters of No Objection" which were obtained from various regulatory entities.

10) "As-Built" plans.

11) "Operation and Maintenance Manual".

12) "Emergency Preparedness Plan".

NOTE: The applicant should submit 2 copies of all preliminary submittals. The applicant must submit 5 copies of all final submittals.

Chapter 21. Dam Safety Program

§2101. Dam Safety

A. Introduction

1. The Public Works and Flood Control Directorate of the Department of Transportation and Development (DOTD) serves as the Water Resources agency for the state of Louisiana, providing engineering and technical support for the orderly planning and development of programs and projects related to flood control, drainage, irrigation, water diversions, reservoirs, navigation, port development, hurricane protection, coastal engineering, and management and development of water resources.

2. R.S. 38:21-28 legislation provides for a Dam Safety and Regulatory Program. The Public Works and Flood Control Directorate is charged with the responsibility for administering the program. The program is operated by the DOTD's Water Resources Design and Development Section, with administrative and enforcement authority vested in the Director of the Public Works and Flood Control Directorate.

B. Purpose. The purpose of R.S. 38:21-28 is to recognize the inherent dangers posed by impoundments of significant volumes of water, and to require that owners of structures which impound water (or other liquids) assume the responsibility for that danger by ensuring that such structures are designed, constructed, and maintained so as to minimize the risk to life and property. Regardless of the circumstances of failure, the owner is ultimately responsible for loss of life and property damages that may occur from the failure of his dam. The Department of Transportation and Development, Public Works and Flood Control Directorate, is charged with the responsibility for developing and enforcing a regulatory program to ensure that public safety and welfare is not compromised by the presence of dams or other impoundment facilities. The Louisiana Dam Safety Program defines the minimum standards for the design, construction, operation, and maintenance of dams in the state of Louisiana, and the DOTD has the responsibility and the authority to enforce the standards of the program. This rule documents the minimum standards for design, construction, operation and maintenance of dams and impoundment structures and the policies for the enforcement of those standards.

C. Glossary

*Abutments***C**those portions of the valley sides which underlie and support the dam structure, and are usually also considered to include the valley sides immediately upstream and downstream from the dam.

Auxiliary or *Emergency Spillway***C**a secondary spillway designed to operate only during unusually large storm events. Louisiana's Dam Safety Program defines " unusually large storm events" as being equal to the 100 year storm event or larger.

*Baffle Blocks***C**blocks constructed in a stilling basin to dissipate the energy of fast flowing water.

*Berm***C**a horizontal step in a sloping profile. The berm is usually constructed with a slight slope for drainage purposes. The berm is often referred to as a seepage or stability berm.

*Blanket Drain***C**a horizontal pervious zone located downstream of the impervious core. This zone is often referred to as a sand blanket.

*Breach***C**an eroded opening through a dam that drains the reservoir. A controlled breach is an intentionally constructed opening. An uncontrolled breach is an unintentional opening that allows uncontrolled discharge from the reservoir.

*Chimney Drain***C**a vertical pervious zone located just downstream of the impervious core. The chimney drain is usually constructed with a sand material.

*Cofferdam***C**a temporary structure enclosing all or part of the construction area so that the construction can proceed in the dry.

*Conduit***C**a closed channel to convey discharges through or under a dam. The conduit can be a reinforced concrete pipe, a corrugated metal pipe or a single or multi-barrel reinforced concrete box culvert.

*Crest Length of Dam***C**the length of the top of dam. This length includes the spillway(s) and other appurtenant structures. The crest length of dam is basically the length from where the top of dam terminates on one abutment to a similar point on the other abutment.

*Cutoff Trench***C**an impervious barrier built into the foundation to reduce seepage under the dam. A cutoff wall or slurry wall could be used as a seepage barrier. The slurry wall is relatively thinner in the horizontal direction when compared to a clay core cutoff trench.

*Dam***C**any artificial barrier, including appurtenant works, which does or will impound or divert water or any other liquid substance.

*Downstream Slope***C**the inclined surface of an embankment dam that faces away from the reservoir.

*Drawdown Structure***C**a low-level outlet which can be used to lower the reservoir below normal pool stage. This may be necessary for lake management purposes, routine repairs or dam safety purposes.

*Earthfill Dam***C**a dam constructed predominantly of fine-grained material. Earthfill dams are also known as rolled fill dams where material is placed in layers and compacted by using rollers or rolling equipment.

*End Sill***C**the area at the upstream and downstream end of the stilling basin base slab.

*Foundation of Dam***C**the natural material on which the dam is placed.

*Heel of Dam***C**the junction of the upstream slope with the foundation. The heel of the dam is often referred to as the upstream toe.

*Impervious Core***C**a zone of low permeability material. This zone is the water or seepage barrier and is often referred to as the clay core.

*Intake Structure***C**the structure placed at the beginning of an outlet works waterway. The intake structure establishes the ultimate drawdown level of the reservoir by the position of its opening(s) to the outlet works. Intake structures may be vertical or inclined towers (drop inlets).

*Maximum Cross Section of Dam***C**cross section of a dam at the point where the height of the dam is at it's maximum.

*Maximum Storage Capacity***C**the capacity at maximum storage is the volume in the reservoir in acre-feet when the level in the reservoir is at top of dam elevation.

*Non-Overflow Wall***C**a wall which is usually constructed parallel to the spillway crest at an elevation equal to the top of dam elevation. This wall is not designed to be overtopped and are often referred to as a closed dam section.

*Normal Pool Stage***C**the water level at the dam to which water may rise under normal operating conditions and for uncontrolled spillways is defined as the lowest crest elevation of the principal spillway. This does not include flood surcharge.

*Outlet Gate***C**a gate on the drawdown structure or spillway which is used to control the outflow of water.

*Piping***C**the progressive internal erosion of an embankment, foundation, or abutment material. The erosion (piping) begins on the downstream side and progresses upstream.

Primary or *Principal Spillway***C**the first used spillway during flood flows.

*Probable Maximum Flood (PMF)***C**the flood that may be expected from the most severe combination of critical meteorologic conditions that are possible in the region.

*Retaining/Training Walls***C**walls which are usually constructed perpendicular to the spillway crest. Retaining walls are walls which support an overturning load. Training walls are walls which confine or guide the flow of water. In many instances, these walls serve both purposes and can be referred to as either a retaining or training wall.

*Riprap***C**a layer of large uncoursed stones, broken rock or precast blocks placed in a random fashion on the upstream slope of the dam and stilling basin outlets. Riprap is a flexible type of slope protection which will deform if material is displaced from beneath.

*Riser***C**a type of drop inlet spillway with a vertical section of metal or concrete pipe that allows the reservoir to rise to a predetermined level before water flows into the pipe.

*Slope Protection***C**protection against wave action or erosion. The two most common types of slope protection, are riprap and soil cement.

*Sluice***C**a low-level opening for releasing water from a dam.

*Soil Cement***C**a well compacted mixture of soil, portland cement and water that produces a hard pavement. Soil cement is usually placed in horizontal layers. Soil cement is a rigid type of slope protection which attempts to span voids.

*Spillway Crest***C**the overflow section or top of weir section of the spillway.

*Stilling Basin***C**a basin constructed to dissipate the energy of fast flowing water. The stilling basin area is located just downstream of the spillway crest between the training/retaining walls.

*Structural Height***C**the distance between the lowest point in the excavated foundation and the top of the dam.

*Surcharge/Flood Surcharge***C**the volume or space between normal pool and the maximum design water level.

*Tailwater***C**the level of water immediately downstream of the dam.

*Toe of Dam***C**the junction of the downstream slope with the foundation. The toe of the dam is often referred to as the downstream toe.

*Top of Dam/Crown***C**the uppermost surface of the dam.The top of dam can also be referred to as the crest of the dam. When the term "crest" is used, it must be specified that it is the "crest of the dam" and not the "crest of the spillway."

Uncontrolled or *Ungated Spillways***C**spillways where the flows over the spillway crest are controlled only by the elevation of the spillway crest. This type of spillway is often referred to as a fixed crest spillway. *Normal Pool Stage* for uncontrolled spillways is defined as the lowest crest elevation of the principal spillway.

*Upstream Slope***C**the inclined surface of an embankment dam that is in contact with the reservoir.

D. Applicability

1. The regulations of this program will govern the construction, enlargement, alteration or repair, maintenance and operation of all dams as defined by R.S. 38:21-28. The terms *dam* and *impoundment structure* are used interchangeably and shall mean the embankment, spillway(s), outlet works and other attendant parts. Included are all artificial barriers together with all appurtenant works which impound or divert water or any other liquid and which are:

a. twenty-five feet or more in height and have an impounding capacity at maximum storage greater than 15 acre-feet, (See LAC 70:XIII.2103.A) or;

b. have an impounding capacity at maximum storage of 50 acre-feet or more and are greater than 6 feet in height (See LAC 70:XIII.2103.A).

2. All barriers which are 6 feet or more in height with maximum storage capacities of 15 acre-feet or more must be submitted to the DOTD for review (See LAC 70:XIII.2103.B). The height of a dam is measured from the natural bed of the stream or watercourse at the downstream toe of the barrier, or if it is not across a stream or watercourse, the height from the lowest elevation of the outside limit of the barrier, to the top of the dam.

E. Permitting

1. Application for Permit. Written approval for construction from the DOTD will be required prior to constructing any new impoundment structure or commencing any structural modifications to existing impoundment structures. Permit forms may be obtained from the Director, Public Works and Flood Control Directorate, Louisiana Department of Transportation and Development, Box 94245, Baton Rouge, LA, 70804-9245. The permitting process is intended to ensure that new structures and modifications to existing structures are designed and constructed in accordance with the requirements documented herein. (See LAC 70:XIII.2103.C)

2. National Resources Conservation Service (NRCS), formally called Soil Conservation Service (SCS). The approval process may be abbreviated if dams meet the requirements of "Pond Standard 378" of the National Resources Conservation Service *National Handbook for Conservation Practices* and the National Resources Conservation Service's engineering staff provides the design, layout, and construction inspection. In this case, the National Resources Conservation Service will certify that the dam design and construction meets the requirements of "Pond Standard 378" and they will provide the DOTD with the Pond Data Sheet, a map showing the location of the pond, and a letter signed by the owner of the dam (See LAC 70:XIII.2103.D). The National Resources Conservation Service will agree to periodically inspect the structure to ensure that "Pond Standard 378" is being maintained, and to inform the DOTD if the structure ever falls below "Pond Standard 378."

3. Public Hearings. After an application has been filed and accepted, the public in the affected locale will be notified by publication in the local news publication. The Director of Public Works and Flood Control will prepare a notice, assigning a date and place for a public hearing of the application. The notice will contain information describing the application and the name and address of the applicant (See LAC 70:XIII.2103.E). It will be the applicant's responsibility to have the notice published once a week for two consecutive weeks in the official journal of the parish in which the project will be constructed, and shall provide notarized proof of publication on or before the hearing date. The applicant will bear the cost of the publication. The DOTD will conduct the public hearing, and the applicant will be required to attend to describe the nature and purpose of the proposed project and to answer questions.

4. Issuance of a Permit. An "Impoundment Permit/Certificate of Completion" shall be issued for all dams, both existing and new construction. The "Impoundment Permit/Certificate of Completion" is not

transferable. The owner of a dam must notify the DOTD 30 days prior to transferring ownership of the dam, and must return the "Impoundment Permit/Certificate of Completion" to the DOTD.

5. Failure to Obtain Approval. If, prior to beginning construction, the owner fails to obtain approval, the owner will be cited and fined under the statutory authority of R.S. 38:28. Also, the lake may be ordered to be drained until all approvals have been obtained.

F. Submittals

1. All designs for work to be permitted under the program will be submitted for review and approval with all necessary supportive documentation (See LAC 70:XIII.2103.F). Normally it is expected that an owner or prospective owner will establish contact with the DOTD to apply for a permit to construct or modify a dam. An example of a letter notifying the DOTD of intent to construct or modify a dam is provided (See LAC 70:XIII.2103.G). In some cases, however, structures are built and water is impounded without the knowledge or approval of the DOTD. When such structures are discovered, the owners will be contacted by the DOTD and required to furnish documentation that their structure meets the safety requirements of the program. In either case, the applicant shall be guided by the Water Resources Design and Development Section throughout the review and approval process. The documentation required shall be formal engineering designs and calculations, supported by sufficient field information, and certified by a professional civil engineer registered to practice in Louisiana. Because each step in the design of a dam is dependant upon the quality of the design judgments made in the previous steps, the applicant is advised to coordinate each of the design stages identified in the next Section with the DOTD review team prior to proceeding to the next step.

2. After general designs have been approved, the applicant may proceed with plans and specifications, which will also require approval before construction can begin. Plans and specifications will be of professional engineering detail and quality and will include all information and directions necessary to construct the dam in accordance with the design intent.

G. Design

1. The proper design of a dam involves a complex combination of engineering applications. It is not within the scope or intent of this document, nor will it be the practice of the staff of the DOTD, to instruct in the detailed procedures for the design of a dam. All dams and impoundment structures to be permitted under this program will be designed by a professional civil engineer(s), registered by the Louisiana State Board of Registration for Professional Engineers and Land Surveyors. The registered civil engineer will certify the designs and plans by professional seal. Designs must conform to nationally recognized standards, further explained in the following Paragraphs and in the Appendices. The completed design package will state the intended design life of the structure, and will include the operations and maintenance procedures necessary to ensure that the structure will function as designed for its stated design life.

2. Failure of an impoundment structure and the instantaneous release of large volumes of water is referred to as a dam breach. It is the primary risk associated with dams, and is the fundamental reason for the state to assume regulatory authority over dams through the Louisiana Dam Safety Program. Breaching may occur during fair weather due to the cumulative effects of erosion or seepage, or it may occur as a result of stresses caused by excess water produced during a storm event. The hydraulic and hydrologic (H and H) design will determine which of the two scenarios poses the greater hazard, the volume of water which is likely to be released, and the rate of flow.

3. It is the H and H design which determines the volumes and flow rates with which the impoundment structure(s) must contend. The geotechnical and structural designs must ensure that the impoundment structure(s) can safely accommodate the hydraulic forces imposed by the conditions predicted by the H and H design. Following are the sequential steps which are necessary in any dam/impoundment structure design, and each step must be documented with design calculations and all supporting data, certified by a Registered Professional Civil Engineer:

a. Hydrology and Hydraulics (H and H) Design

i. Impact (Hazard) Classification.

ii. Determination of controlling design condition and associated storm runoff.

iii. Setting of spillway and stilling basin widths and elevations, top of embankment elevation, and normal pool stage.

b. Structural and geotechnical design of embankment, spillways, and drawdown structures.

c. Development and documentation of operations and maintenance procedures.

NOTE: For the purpose of the Dam Safety Program, the "Emergency Spillway" shall be defined as being overtopped by the 100-year storm or greater and the "Principal Spillway" shall be defined as being overtopped by a storm less than the 100-year storm.

4. Hydrology and Hydraulics (H and H) Design

a. Before the structural design of the dam can begin, the requirements of hydraulic capacity must be determined. The height of the dam, the amount of freeboard above normal pool elevation, the size and capacity of the principle and emergency spillways, must all be designed to balance the hydrological and hydraulic properties of the location of the reservoir. A properly designed drawdown structure, capable of reducing the stage of the reservoir at a suitable rate in the event of emergency, must also be designed to meet the capacity requirements of the site.

b. H and H design begins with the Impact Classification (also referred to as Hazard Classification in some texts) of the dam. The Impact Classification is

determined by an evaluation of the probable maximum impacts of a dam breach. Low impact structures are those for which, because of size and/or location, little or no significant damage to life or property is likely to result from a failure of the structure. Significant impact structures are those which could cause appreciable damage to property or could pose possible threat to human life in the event of failure. High impact structures are those for which failure would cause excessive property damage or make loss of human life likely.

NOTE: The inflow design flood (IDF) is determined by the various Hydrograph Methods after the precipitation amount is developed. The major source of precipitation data is the National Weather Service (NWS). The DOTD has final authority for approval of the method to be utilized to determine the IDF.

Table 1. Impact Classification and Inflow Design Flood

Impact Category	Potential Loss of Life	Potential Economic Loss	Minimum Inflow Design (IDF)
Low	Not Likely	Minimal	50-Yr. Freq.
Significant	Possible	Appreciable	100-Yr. Freq.
High	Likely	Excessive	1/2 PMF

c. Further guidance in assessing the potential hazards and associated impact classification for dams may be found in the publication referred to in Subsection N. It is the responsibility of the owner/applicant to establish impact classification, and all dams will be considered to be of High Impact potential until demonstrated to be otherwise by a documented analysis provided by the applicant. The proposed impact classification must be supported by sufficient analysis and documentation, and the DOTD will have final authority for assigning Impact Classification.

d. Having established the Impact Classification for the structure, the next step is to establish the magnitude of the meteorological event on which the entire design is to be based. Dams must be designed to be able to safely withstand the passage of a flood of design magnitude. The Inflow Design Flood (IDF) is the largest storm event to be considered in the design of the structure, and the magnitude of the storm event for which the IDF is computed is related to the Impact Classification. The values shown for IDF in Table I are minimums, and the storm event to be used as the IDF will be determined by a site specific analysis. For low impact structures, the primary consideration is the protection against loss of the dam and its benefits in the event of failure, while for significant and high impact structures, adequate protection of life and property must be assured.

e. For dams classified as high impact, the IDF is defined as the flood event above which a breach of the dam does not increase hazard to downstream interests. The upper limit of the IDF for high impact structures is the Probable Maximum Flood (PMF), which is the flood which may be expected from the most severe combination of critical meteorological and hydrological conditions which are reasonably possible. While the PMF is the upper limit for the IDF, the IDF for high impact dams may be an event of smaller magnitude, depending upon an incremental hazard assessment. The incremental assessment is a routing of floods of increasingly larger magnitude through the structure and downstream channel reaches, comparing conditions with and without a dam failure, until a flood magnitude is reached for which the dam failure condition does not appreciably increase the hazard potential.

f. Dams classified as having significant impacts may or may not require a formal incremental hazard evaluation, depending upon the extent of existing and potential downstream development, the size of the reservoir, and the type and use of the dam. The upper limit of the IDF for significant impact structures is the PMF.

g. For dams with low impact classification, the incremental hazard evaluation is not required, and the IDF can be based upon factors related to loss of service of the dam, potential maintenance costs, etc., but with the 50-year frequency storm being the minimum design event.

h. The Water Resources Design and Development Section should be a partner in establishing the IDF, and designs should not proceed until agreement has been reached between the DOTD and the owner's engineer on the choice of the IDF. Establishing the IDF is the foundation for the entire design process, since the dam must be designed to safely pass and/or contain the IDF. A guideline for performing the incremental hazard evaluation necessary to establish the IDF is provided in the publication referred to in Subsection N.

i. How the IDF is to be safely passed by the dam structure and the stability of the dam against the long-term effects of hydrostatic forces is the subject of the balance of the design effort, including the general configuration of the dam; length, elevation, and composition of principal and emergency spillways; storage capacity above normal pool elevation; erosion protection; and stability design. The most practical way of assuring the integrity of the dam during an IDF is to provide a concrete spillway which is capable of carrying the peak flow of the storm. Principal spillways are normally sized to carry flows from all but the largest of storms, with emergency spillways, which are not normally armored, functioning only during major storm events. If the peak flow from the IDF can be contained within the principal and emergency spillways, the stability of the dam is not likely to be threatened by the erosive action of water flowing over the embankment. The designer may wish to balance the relative economy of providing spillway capacity versus storage capacity above normal pool stage. But, if design calculations indicate that the embankment will be overtopped by the IDF, provisions must be included in the design to prevent the embankment from failing under the erosive forces of the overtopping flows.

5. Geotechnical Design

a. It is essential to the stability of the structure that the material used in the impoundment structure, as well as the foundation and adjoining earth have the necessary structural properties to withstand the hydrostatic forces required by the design, that potential for destructive seepage is identified and appropriately dealt with, and that the

surfaces of the structure are adequately protected from surface erosion.

b. Field investigations shall be adequate to define the soils and ground water conditions with respect to stability and seepage control. Stability analysis should consider after-construction conditions, based on the undrained shear strength parameters determined by laboratory tests. Long-term steady seepage, partial pool, and rapid drawdown analyses should also be performed, using shear properties appropriate to the subject materials and minimum safety factors shown in the following Table:

Table 2. Factor of Safety for Stability Analysis	
Analysis Condition	**Factor of Safety**
Rapid Drawdown	1.25
Partial Pool	1.40
Steady Seepage	1.40
After Construction	1.30
Earthquake	1.15

6. Structural Design. Structural Designs are to be prepared in accordance with generally accepted structural engineering practices such as those of the American Concrete Institute, the American Institute of Steel Construction and the American Institute of Timber Construction. Components of the spillway or other appurtenant structures shall be designed to resist the most critical loading combination of dead loads plus live loads that may occur during its construction or design life. Some of the loads which must be considered in the design are: buoyancy forces, sliding forces, hydrostatic uplift forces, bearing forces, overturning forces, water drag forces, wing drag forces, gate-lifting and closing forces, soil and water pressure forces, impact forces, uniform and point live load forces, etc. The minimum factors of safety for buoyancy and sliding shall be 1.5 and 2.0, respectively. The overturning analysis must indicate that the resultant force falls within the center 1/3 of the base. The minimum factor of safety for pile design shall be 2.0.

H. Construction

1. It will be the owner's responsibility to ensure by the presence of professional construction supervision personnel that the structure is built in strict compliance with the approved designs and specifications. Adequate records shall be maintained to document that all materials and construction procedures meet or exceed those specified. The owner shall report on the construction to the DOTD. The work of construction, enlargement, alteration, repair or removal of a dam or reservoir for which approved application, designs, plans and specifications are required shall be under the responsible charge of a registered civil engineer. Upon completion of the work and prior to the impoundment of water, the engineer shall certify that all work has been done in compliance with the approved plans and specifications (See §2103.H).

2. During construction, periodic inspections may be made by representatives of the DOTD. The owner will be required to provide such works or tests as may be needed to disclose sufficient information to enable the DOTD to determine that conformity with approved plans and specifications is being maintained. Inspections made by the DOTD are "limited inspections" and do not relieve the owner or the owner's engineer from their responsibilities for conformance to accepted designs and procedures.

I. Maintenance and Operations

1. Once in service, the integrity of the impoundment structure must be sustained by regular maintenance, in accordance with the approved Operations and Maintenance document provided by the designer. The Operations and Maintenance Manual should contain forms and schedules for records and documentation of inspections, maintenance procedures, and repairs. The owner will be responsible for certifying, through properly documented records, to the DOTD that the required periodic inspections have been made, for correcting any deficiencies revealed during such inspections, and for maintaining records of all operations and maintenance activities, as well as of original construction and any subsequent modifications.

2. An Emergency Preparedness Plan is required for all dams and reservoirs. The plan shall comply with the guidelines of the current issue of Louisiana's *Emergency Action Plan Guidelines*, available from the DOTD's Director of Public Works and Flood Control. The Emergency Preparedness Plan will be a condition of the permit for the project, and it will be the owner's responsibility to implement the provisions of the plan in the event of emergency.

J. Inspections

1. The DOTD will periodically inspect every dam in the jurisdiction of the program. The purpose of the DOTD inspections is to ascertain whether the structure is being properly maintained in accordance with the approved Operations and Maintenance procedures. The DOTD inspections are " limited inspections " and do not relieve the owner of responsibility to perform and document periodic inspections. If an inspection by the DOTD reveals that a dam is unsafe or in danger of becoming unsafe, the DOTD, through the Director of Public Works and Flood Control, shall direct the owner to take whatever action is necessary to restore the dam to its design condition.

2. The owner has the primary responsibility for insuring the safe condition of the structure by regular maintenance and periodic inspection. The owner is required to immediately inform the Director of Public Works and Flood Control of any unusual circumstances or occurrences which may affect the condition or safety of the reservoir. Also, the Director will be notified prior to any planned draw downs of the reservoir.

K. Enforcement. If any dam or impoundment structure is determined to be unsafe, the Director of Public Works and Flood Control, pursuant to R.S. 38:21-28, shall direct any such repairs or remediations for a dam or impoundment structure as he deems necessary to insure that life and property are not unduly threatened by the impoundment. such remedial action may include:

1. direction that the water level behind the structure be lowered to a safe level; or

2. that the impoundment be completely drained until all necessary corrections to the structure have been made.

L. Existing Structures

1. All dams constructed or under construction prior to promulgation of these Rules will be reviewed to assess their disposition under the program regulations. Each dam is unique and must be judged on the basis of its own particular set of circumstances. Based on the circumstances of each individual case, a judgment will be made of what modifications or repairs are necessary to meet program standards. It is the intent of the program to eventually have every dam upgraded to meet program standards. The DOTD will be the sole judge of whether an existing deficiency creates an unacceptable risk to the general public. While it is not the intent of this program to lower the standards for existing dams, the DOTD recognizes that it is not practical to require all dam owners to immediately retrofit their structures to meet new minimum Inflow Design Flood standards.

2. An "Impoundment Permit" is required for existing dams and will be issued after reviewing all historical data (designs, plans, specifications, operation and maintenance records, etc.) and performing a technical inspection (or inspections) to adequately assess the safety of the dam. The owner shall provide all historical data, if available.

M. Emergency Preparedness Plan

1. An Emergency Preparedness Plan is required for all dams and reservoirs both existing and new construction. The plan will comply with the guidelines of the current issue of Louisiana's *Emergency Action Plan Guidelines*, available from the Director of Public Works and Flood Control, and shall be submitted as a necessary component of the Maintenance and Operating Procedures and as a condition of the permitting process. It is the owner's responsibility to assure that the provisions of the Emergency Action Plan are implemented in the event of an emergency situation.

2. A breach analysis is required to develop the emergency preparedness plan. The breach analysis will establish the magnitude of the inundated area (inundation map), peak flood elevations and arrival times of the peak flood elevations at critical locations. The worst case scenario breaching event will be somewhere between the "sunny day" breach and that event above which a breach of the dam does not increase hazard to downstream interests. If the dam owner prefers to perform only one breach analysis rather than performing incremental analyses to discover the worst case scenario breaching event, he may perform a breach analysis where the tail water is at the average annual elevation and the reservoir is at maximum design surcharge.

N. References

1. Jerrold W. Gotzmer, William C. Jenkins, Ramon G. Lee, Joseph R. McCormick, Harvey H. Richardson, and David L. Sveum, *Training Aids for Dam Safety, Module: Evaluation of Hydrologic Adequacy, Interagency Committee on Dam Safety* (Available from: Louisiana Transportation Research Center, 4101 Gourrier, Baton Rouge, LA 70808, telephone (504) 767-9131).

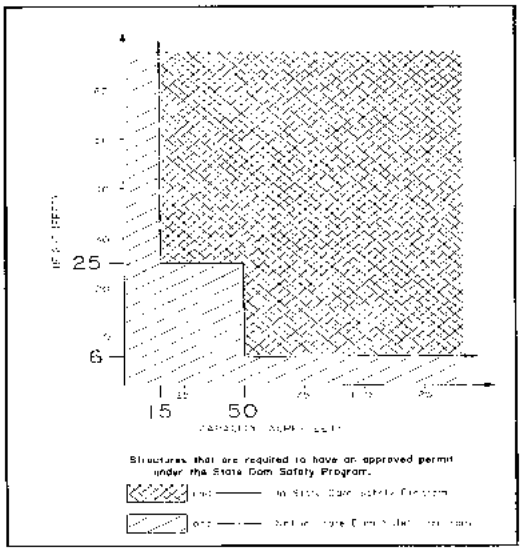
2. Peter G. Grey, Terry G. Fairbanks, Tasso Schmigall, and Charles D. Wagner, *Training Aids for Dam Safety, Module: Evaluation of Hydraulic Adequacy, Interagency Committee on Dam Safety* (Available from: Louisiana Transportation Research Center, 4101 Gourrier, Baton Rouge, LA 70808), telephone (504) 767-9131).

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

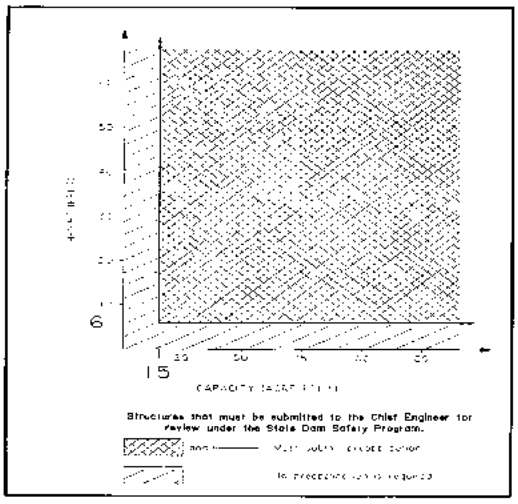
HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1234 (December 1996).

§2103. Figures and Forms

A. Structures that are required to have an approved permit under the State Dam Safety Program.



B. Structures that must be submitted to the Chief Engineer for review under the State Dam Safety Program.



C. Procedural Sequence

1) Applicant or his Engineer submits "Letter of Intent."

2) Applicant or his Engineer submits "Pre-Application for Construction of Dam."

3) Applicant publishes "Notice of Application" and a "Public Hearing(s)" is (are) held.

4) Applicant or his Engineer submits "Designs, Plans and Specifications" as follows and submits "Application for Construction of Dams."

a) "Impact (Hazard) Classification.

b) Determination of controlling design condition and associated storm runoff.

c) Setting of spillway and stilling basin widths and elevations, top of embankment elevation, and normal pool stage.

d) Plans, Specifications, Designs and other Submittals.

5) The DOTD issues "Approval or Denial of Application"; Approval is an "Approval for Construction."

6) Construction begins; Applicant or his Engineer performs "Construction Inspections."

7) If "Deficiencies" are found by the DOTD, Applicant or Applicant's Engineer; then the Applicant or his Engineer shall correct the deficiencies.

8) Supervision of Construction by the Owner.

9) Applicant or his Engineer submits "Notice of Completion" and "As-Built Drawings" and revised "Application for construction of Dam."

10) The DOTD issues "Certificate of Completion/Impoundment Permit."

11) Applicant or his Engineer submits "Maintenance and Operation Procedures" for the DOTD's approval.

12) Applicant or his Engineer submits "Emergency Preparedness Plan" for the DOTD's approval.

D. Pond Data Sheet

Date:

Dam Safety Administrator
Louisiana DOTD
P. O. Box94245, Capitol Station
Baton Rouge, Louisiana 70804-9245

RE: Pond Construction

I am aware that the design, construction and operation of all dams within Louisiana is regulated by the Rules and Regulations for Dam Safety Program as developed by the State of Louisiana, Department of Transportation and Development. I am also aware of the liability that is associated with owning a dam.

Since I am receiving design and construction assistance from the National Resources Conservation Service, the dam described below is excluded from the approval process outlined in the Dam Safety Regulations. However, if for some reason (such as a land use change) the dam no longer comes within the criteria of the National Resources Conservation Service National Handbook for Conservation Practices-Standard 378, I agree to modify the structure if necessary to comply with the requirements of the Dam Safety Regulations. I also agree to allow access for inspection of this structure.

Sincerely,

OWNER

DAM LOCATION:
DESCRIPTION:

E. Notice of Application

Pursuant to the Rules and Regulations of the Louisiana Dam Safety Program as established by R.S. 38:21-28 interested parties are hereby notified that a "Letter of Intent" and a "Pre-Application for Construction of Dam" have been received by the DOTD Public Works and Flood Control Directorate to construct the proposed Dam and Reservoir Pre-Application Number PA located in Section , Township , Range , Parish.

Applicant:
(Name)
(Address)
(Phone)

Purpose and Brief Description of Dam:

All interested parties are hereby notified that a public hearing on the application will be held at p.m. on at.

Any interested party shall have the right to request a public hearing on the application. Requests for additional public hearings must be in writing and must be submitted no later than the close of the public hearing on . Letters must state, with particularity, the reasons for holding a public hearing, applicant's name and pre-application number. On receiving a written request for an additional hearing(s) within the time limits set forth in this notice, the DOTD Public Works and Flood Control Directorate shall set a date, time and place for conducting a hearing on the application. During the hearings, any interested party shall have the right to protest the application and to appear and present evidence and testimony in support of such protest.

F. Minimum Required Submittals

1) All structural, geotechnical, hydrologic and hydraulic design calculations. An engineer's report shall also be submitted which summarizes the design analyses and shall include, but is not limited to, the following:

a) Formulas, methods and basic data assumptions used in the designs.

b) List of all pertinent design codes.

c) Summary tables which list design load cases, computed design factors of safety and required factors of safety as specified in these rules and regulations or required by pertinent design codes.

d) All other information which aided in evaluating the design, supported assumptions and conclusions, and will facilitate an independent review.

2) Plans with sufficient details to construct all features of the dam in accordance with the design intent. Also, the plans shall include details to construct a permanent reference mark (bench mark) near, but separate from, the project. The exact location and elevation above mean sea level must be noted on the "as-built" plans.

3) Specifications with sufficient details to construct all features of the dam in accordance with the design intent. The specifications shall also provide that the plans and specifications may not be changed without prior written approval by the DOTD.

4) Document(s) to show proof of ownership.

5) An inspection plan specific to the construction activity. The inspection plan is to detect deficiencies or situations that may result in a threat to life and property.

6) An emergency action plan specific to the construction activity. The inspection plan in item 5 is part of the emergency action plan under this item.

7) If the applicant has an agreement or contract with another entity who will be responsible for the operation and maintenance of the dam, the applicant must provide copies of the agreement or contract document(s).

8) If the applicant is constructing the dam for the specific purpose of transferring ownership to a homeowners' association, a landowners' association, or any other entity, the applicant must provide a document which clearly states his intent, i.e., a dam which is constructed for a subdivision development where ownership will be transferred to a homeowners' association.

9) All other "Permits" required to construct the dam and "Letters of No Objection" which were obtained from various regulatory entities.

10) "As-Built" plans.

11) "Operation and Maintenance Manual".

12) "Emergency Preparedness Plan".

NOTE: The applicant should submit 2 copies of all preliminary submittals. The applicant must submit 5 copies of all final submittals.

G. Letter of Intent

Purpose: To notify the Louisiana Dam Safety Program of the applicant's intent to construct, enlarge, alter, repair or remove a dam within the state.

Address To: Louisiana Dam Safety Program
Louisiana Department of Transportation and Development
Public Works and Flood Control Directorate
Box 94245
Baton Rouge, LA 70804-9245

Contents:
1) Name of proposed or existing dam
2) Purpose of dam:
3) Owner's:
Name:
Address:
Telephone:
4) Location of dam (section, township, range, parish).
5) Brief description of proposed dam construction, enlargement, alteration, repair or removal.
*6) Height of Dam (height in feet from top of dam to lowest point at downstream toe of dam).
*7) Reservoir Capacity (volume in acre-feet with water at top of dam).

NOTE: *Items 6 and 7 can be approximated at this time.

H. Letter of "Notice of Completion and As-built Drawings"

Purpose: To notify the Louisiana Dam Safety Program that the construction of the subject project is complete and to certify that said construction was done in accordance with the approved designs, plans, drawings and specifications.

From: Applicant's Consulting Engineering Firm (letter must be signed and sealed by a Registered Professional Civil Engineer licensed in the State of Louisiana).

Address To: Louisiana Dam Safety Program
Louisiana Department of Transportation and Development
Public Works and Flood Control Directorate
Box 94245
Baton Rouge, LA 70804-9245

NOTE: As-Built Drawings must be received by the DOTD Public Works and Flood Control Directorate within 30 days after completion.

I. Letters of No Objection and Other Permits. The applicant must forward copies of the pre-application to the appropriate state, federal and local agencies to obtain letters of no objection and/or permits as required by these agencies. Copies of the letters of no objection and permits must be submitted to the Louisiana Dam Safety Program as part of the applicant's application under this program.

J. Minimum Hydrologic and Hydraulic Submittals to Establish Impact Classification and Inflow Design Flood (IDF). Since the required submittals may vary for each dam, it is recommended that applicant or his engineer obtain copies of references number 1 and 2 of the Dam Safety Rules and Regulations. After reviewing these documents, the applicant or his engineer is advised to contact the Dam Safety Program of the Water Resources Design and Development Section of the DOTD for further guidance.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1234 (December 1996).

Chapter 7. Dam Safety Program

Subchapter A. Dam Safety

*Editor's Note: The name of the agency, The Public Works and Flood Control Directorate of the Department of Transportation and Development (DOTD), has changed to The Public Works and Hurricane Flood Protection Division of the Louisiana Department of Transportation and Development.

§701. Introduction

A. The *Public Works and Flood Control Directorate of the Department of Transportation and Development (DOTD) serves as the Water Resources agency for the state of Louisiana, providing engineering and technical support for the orderly planning and development of programs and projects related to flood control, drainage, irrigation, water diversions, reservoirs, navigation, port development, hurricane protection, coastal engineering, and management and development of water resources.

B. R.S. 38:21-28 legislation provides for a Dam Safety and Regulatory Program. The *Public Works and Flood Control Directorate is charged with the responsibility for administering the program. The program is operated by the DOTD's Water Resources Design and Development Section, with administrative and enforcement authority vested in the Director of the Public Works and *Flood Control Directorate.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1234 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

§703. Purpose

A. The purpose of R.S. 38:21-28 is to recognize the inherent dangers posed by impoundments of significant volumes of water, and to require that owners of structures which impound water (or other liquids) assume the responsibility for that danger by ensuring that such structures are designed, constructed, and maintained so as to minimize the risk to life and property. Regardless of the circumstances of failure, the owner is ultimately responsible for loss of life and property damages that may occur from the failure of his dam. *The Department of Transportation and Development, Public Works and Flood Control Directorate, is charged with the responsibility for developing and enforcing a regulatory program to ensure that public safety and welfare is not compromised by the presence of dams or other impoundment facilities. The Louisiana Dam Safety Program defines the minimum standards for the design, construction, operation, and maintenance of dams in the state of Louisiana, and the DOTD has the responsibility and the authority to enforce the standards of the program. This rule documents the minimum standards for design, construction, operation and maintenance of dams and impoundment structures and the policies for the enforcement of those standards.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1234 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

§705. Glossary

Abutments—those portions of the valley sides which underlie and support the dam structure, and are usually also considered to include the valley sides immediately upstream and downstream from the dam.

Auxiliary or *Emergency Spillway*—a secondary spillway designed to operate only during unusually large storm events. Louisiana's Dam Safety Program defines "unusually large storm events" as being equal to the 100 year storm event or larger.

Baffle Blocks—blocks constructed in a stilling basin to dissipate the energy of fast flowing water.

Berm—a horizontal step in a sloping profile. The berm is usually constructed with a slight slope for drainage purposes. The berm is often referred to as a seepage or stability berm.

Blanket Drain—a horizontal pervious zone located downstream of the impervious core. This zone is often referred to as a sand blanket.

Breach—an eroded opening through a dam that drains the reservoir. A controlled breach is an intentionally constructed opening. An uncontrolled breach is an unintentional opening that allows uncontrolled discharge from the reservoir.

Chimney Drain—a vertical pervious zone located just downstream of the impervious core. The chimney drain is usually constructed with a sand material.

Cofferdam—a temporary structure enclosing all or part of the construction area so that the construction can proceed in the dry.

Conduit—a closed channel to convey discharges through or under a dam. The conduit can be a reinforced concrete pipe, a corrugated metal pipe or a single or multi-barrel reinforced concrete box culvert.

Crest Length of Dam—the length of the top of dam. This length includes the spillway(s) and other appurtenant structures. The crest length of dam is basically the length from where the top of dam terminates on one abutment to a similar point on the other abutment.

Cutoff Trench—an impervious barrier built into the foundation to reduce seepage under the dam. A cutoff wall or slurry wall could be used as a seepage barrier. The slurry wall is relatively thinner in the horizontal direction when compared to a clay core cutoff trench.

Dam—any artificial barrier, including appurtenant works, which does or will impound or divert water or any other liquid substance.

Downstream Slope—the inclined surface of an embankment dam that faces away from the reservoir.

Drawdown Structure—a low-level outlet which can be used to lower the reservoir below normal pool stage. This may be necessary for lake management purposes, routine repairs or dam safety purposes.

Earthfill Dam—a dam constructed predominantly of fine-grained material. Earthfill dams are also known as rolled fill dams where material is placed in layers and compacted by using rollers or rolling equipment.

End Sill—the area at the upstream and downstream end of the stilling basin base slab.

Foundation of Dam—the natural material on which the dam is placed.

Heel of Dam—the junction of the upstream slope with the foundation. The heel of the dam is often referred to as the upstream toe.

Impervious Core—a zone of low permeability material. This zone is the water or seepage barrier and is often referred to as the clay core.

Intake Structure—the structure placed at the beginning of an outlet works waterway. The intake structure establishes the ultimate drawdown level of the reservoir by the position of its opening(s) to the outlet works. Intake structures may be vertical or inclined towers (drop inlets).

Maximum Cross Section of Dam—cross section of a dam at the point where the height of the dam is at it's maximum.

Maximum Storage Capacity—the capacity at maximum storage is the volume in the reservoir in acre-feet when the level in the reservoir is at top of dam elevation.

Non-Overflow Wall—a wall which is usually constructed parallel to the spillway crest at an elevation equal to the top of dam elevation. This wall is not designed to be overtopped and are often referred to as a closed dam section.

Normal Pool Stage—the water level at the dam to which water may rise under normal operating conditions and for uncontrolled spillways is defined as the lowest crest elevation of the principal spillway. This does not include flood surcharge.

Outlet Gate—a gate on the drawdown structure or spillway which is used to control the outflow of water.

Piping—the progressive internal erosion of an embankment, foundation, or abutment material. The erosion (piping) begins on the downstream side and progresses upstream.

Primary or *Principal Spillway*—the first used spillway during flood flows.

Probable Maximum Flood (PMF)—the flood that may be expected from the most severe combination of critical meteorologic conditions that are possible in the region.

Retaining/Training Walls—walls which are usually constructed perpendicular to the spillway crest. Retaining walls are walls which support an overturning load. Training walls are walls which confine or guide the flow of water. In many instances, these walls serve both purposes and can be referred to as either a retaining or training wall.

Riprap—a layer of large uncoursed stones, broken rock or precast blocks placed in a random fashion on the upstream slope of the dam and stilling basin outlets. Riprap is a flexible type of slope protection which will deform if material is displaced from beneath.

Riser—a type of drop inlet spillway with a vertical section of metal or concrete pipe that allows the reservoir to rise to a predetermined level before water flows into the pipe.

Slope Protection—protection against wave action or erosion. The two most common types of slope protection, are riprap and soil cement.

Sluice—a low-level opening for releasing water from a dam.

Soil Cement—a well compacted mixture of soil, portland cement and water that produces a hard pavement. Soil cement is usually placed in horizontal layers. Soil cement is a rigid type of slope protection which attempts to span voids.

Spillway Crest—the overflow section or top of weir section of the spillway.

Stilling Basin—a basin constructed to dissipate the energy of fast flowing water. The stilling basin area is located just downstream of the spillway crest between the training/retaining walls.

Structural Height—the distance between the lowest point in the excavated foundation and the top of the dam.

Surcharge/Flood Surcharge—the volume or space between normal pool and the maximum design water level.

Tailwater—the level of water immediately downstream of the dam.

Toe of Dam—the junction of the downstream slope with the foundation. The toe of the dam is often referred to as the downstream toe.

Top of Dam/Crown—the uppermost surface of the dam. The top of dam can also be referred to as the crest of the dam. When the term "crest" is used, it must be specified that it is the "crest of the dam" and not the "crest of the spillway."

Uncontrolled or *Ungated Spillways*—spillways where the flows over the spillway crest are controlled only by the elevation of the spillway crest. This type of spillway is often referred to as a fixed crest spillway. *Normal Pool Stage* for uncontrolled spillways is defined as the lowest crest elevation of the principal spillway.

Upstream Slope—the inclined surface of an embankment dam that is in contact with the reservoir.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1234 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

§707. Applicability

A. The regulations of this program will govern the construction, enlargement, alteration or repair, maintenance and operation of all dams as defined by R.S. 38:21-28. The terms *dam* and *impoundment structure* are used interchangeably and shall mean the embankment, spillway(s), outlet works and other attendant parts. Included are all artificial barriers together with all appurtenant works which impound or divert water or any other liquid and which are:

1. 25 feet or more in height and have an impounding capacity at maximum storage greater than 15 acre-feet, (See §729, Appendix 1); or

2. have an impounding capacity at maximum storage of 50 acre-feet or more and are greater than 6 feet in height (See §729, Appendix 1).

B. All barriers which are 6 feet or more in height with maximum storage capacities of 15 acre-feet or more must be submitted to the DOTD for review (See §731, Appendix 2). The height of a dam is measured from the natural bed of the stream or watercourse at the downstream toe of the barrier, or if it is not across a stream or watercourse, the height from the lowest elevation of the outside limit of the barrier, to the top of the dam.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1236 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

§709. Permitting

A. Application for Permit. Written approval for construction from the DOTD will be required prior to constructing any new impoundment structure or commencing any structural modifications to existing impoundment structures. Permit forms may be obtained from the Director, *Public Works and Flood Control Directorate, Louisiana Department of Transportation and Development, Box 94245, Baton Rouge, LA, 70804-9245. The permitting process is intended to ensure that new structures and modifications to existing structures are designed and constructed in accordance with the requirements documented herein. (See §733, Appendix 3.)

B. National Resources Conservation Service (NRCS), formally called Soil Conservation Service (SCS). The approval process may be abbreviated if dams meet the requirements of "Pond Standard 378" of the National Resources Conservation Service *National Handbook for Conservation Practices* and the National Resources Conservation Service's engineering staff provides the design, layout, and construction inspection. In this case, the National Resources Conservation Service will certify that the dam design and construction meets the requirements of "Pond Standard 378" and they will provide the DOTD with the Pond Data Sheet, a map showing the location of the pond, and a letter signed by the owner of the dam (See §735, Appendix 4). The National Resources Conservation Service will agree to periodically inspect the structure to ensure that "Pond Standard 378" is being maintained, and to inform the DOTD if the structure ever falls below "Pond Standard 378."

C. Public Hearings. After an application has been filed and accepted, the public in the affected locale will be notified by publication in the local news publication. The Director of Public Works and Flood Control will prepare a notice, assigning a date and place for a public hearing of the application. The notice will contain information describing the application and the name and address of the applicant (See §737, Appendix 5). It will be the applicant's responsibility to have the notice published once a week for two consecutive weeks in the official journal of the parish in which the project will be constructed, and shall provide notarized proof of publication on or before the hearing date. The applicant will bear the cost of the publication. The DOTD will conduct the public hearing, and the applicant will be required to attend to describe the nature and purpose of the proposed project and to answer questions.

D. Issuance of a Permit. An "Impoundment Permit/Certificate of Completion" shall be issued for all dams, both existing and new construction. The "Impoundment Permit/Certificate of Completion" is not transferable. The owner of a dam must notify the DOTD 30 days prior to transferring ownership of the dam, and must return the "Impoundment Permit/Certificate of Completion" to the DOTD.

E. Failure to Obtain Approval. If, prior to beginning construction, the owner fails to obtain approval, the owner will be cited and fined under the statutory authority of R.S. 38:28. Also, the lake may be ordered to be drained until all approvals have been obtained.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1236 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

§711. Submittals

A. All designs for work to be permitted under the program will be submitted for review and approval with all necessary supportive documentation (See §739, Appendix 6). Normally it is expected that an owner or prospective owner will establish contact with the DOTD to apply for a permit to construct or modify a dam. An example of a letter notifying the DOTD of intent to construct or modify a dam is provided (See §741, Appendix 7). In some cases, however, structures are built and water is impounded without the knowledge or approval of the DOTD. When such structures are discovered, the owners will be contacted by the DOTD and required to furnish documentation that their structure meets the safety requirements of the program. In either case, the applicant shall be guided by the Water Resources Design and Development Section throughout the review and approval process. The documentation required shall be formal engineering designs and calculations, supported by

sufficient field information, and certified by a professional civil engineer registered to practice in Louisiana. Because each step in the design of a dam is dependant upon the quality of the design judgments made in the previous steps, the applicant is advised to coordinate each of the design stages identified in the next Section with the DOTD review team prior to proceeding to the next step.

B. After general designs have been approved, the applicant may proceed with plans and specifications, which will also require approval before construction can begin. Plans and specifications will be of professional engineering detail and quality and will include all information and directions necessary to construct the dam in accordance with the design intent.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1236 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

§713. Design

A. The proper design of a dam involves a complex combination of engineering applications. It is not within the scope or intent of this document, nor will it be the practice of the staff of the DOTD, to instruct in the detailed procedures for the design of a dam. All dams and impoundment structures to be permitted under this program will be designed by a professional civil engineer(s), registered by the Louisiana State Board of Registration for Professional Engineers and Land Surveyors. The registered civil engineer will certify the designs and plans by professional seal. Designs must conform to nationally recognized standards, further explained in the following Paragraphs and in the Appendices. The completed design package will state the intended design life of the structure, and will include the operations and maintenance procedures necessary to ensure that the structure will function as designed for its stated design life.

B. Failure of an impoundment structure and the instantaneous release of large volumes of water is referred to as a dam breach. It is the primary risk associated with dams, and is the fundamental reason for the state to assume regulatory authority over dams through the Louisiana Dam Safety Program. Breaching may occur during fair weather due to the cumulative effects of erosion or seepage, or it may occur as a result of stresses caused by excess water produced during a storm event. The hydraulic and hydrologic (H and H) design will determine which of the two scenarios poses the greater hazard, the volume of water which is likely to be released, and the rate of flow.

C. It is the H and H design which determines the volumes and flow rates with which the impoundment structure(s) must contend. The geotechnical and structural designs must ensure that the impoundment structure(s) can safely accommodate the hydraulic forces imposed by the conditions predicted by the H and H design. Following are the sequential steps which are necessary in any dam/impoundment structure design, and each step must be documented with design calculations and all supporting data, certified by a Registered Professional Civil Engineer:

1. Hydrology and Hydraulics (H and H) Design

a. Impact (Hazard) Classification.

b. Determination of controlling design condition and associated storm runoff.

c. Setting of spillway and stilling basin widths and elevations, top of embankment elevation, and normal pool stage.

2. Structural and Geotechnical Design of Embankment, Spillways, and Drawdown Structures

3. Development and Documentation of Operations and Maintenance Procedures

> NOTE: For the purpose of the Dam Safety Program, the *Emergency Spillway* shall be defined as being overtopped by the 100-year storm or greater and the *Principal Spillway* shall be defined as being overtopped by a storm less than the 100-year storm.

D. Hydrology and Hydraulics (H and H) Design

1. Before the structural design of the dam can begin, the requirements of hydraulic capacity must be determined. The height of the dam, the amount of freeboard above normal pool elevation, the size and capacity of the principle and emergency spillways, must all be designed to balance the hydrological and hydraulic properties of the location of the reservoir. A properly designed drawdown structure, capable of reducing the stage of the reservoir at a suitable rate in the event of emergency, must also be designed to meet the capacity requirements of the site.

2. H and H design begins with the Impact Classification (also referred to as Hazard Classification in some texts) of the dam. The Impact Classification is determined by an evaluation of the probable maximum impacts of a dam breach. Low impact structures are those for which, because of size and/or location, little or no significant damage to life or property is likely to result from a failure of the structure. Significant impact structures are those which could cause appreciable damage to property or could pose possible threat to human life in the event of failure. High impact structures are those for which failure would cause excessive property damage or make loss of human life likely.

> NOTE: The inflow design flood (IDF) is determined by the various Hydrograph Methods after the precipitation amount is developed. The major source of precipitation data is the National Weather Service (NWS). The DOTD has final authority for approval of the method to be utilized to determine the IDF.

Table 1. Impact Classification and Inflow Design Flood

Impact Category	Potential Loss of Life	Potential Economic Loss	Minimum Inflow Design (IDF)
Low	Not Likely	Minimal	50-Yr. Freq.
Significant	Possible	Appreciable	100-Yr. Freq.
High	Likely	Excessive	1/2 PMF

3. Further guidance in assessing the potential hazards and associated impact classification for dams may be found in the publication referred to in §727. It is the responsibility of the owner/applicant to establish impact classification, and all dams will be considered to be of High Impact potential until demonstrated to be otherwise by a documented analysis provided by the applicant. The proposed impact classification must be supported by sufficient analysis and documentation, and the DOTD will have final authority for assigning Impact Classification.

4. Having established the Impact Classification for the structure, the next step is to establish the magnitude of the meteorological event on which the entire design is to be based. Dams must be designed to be able to safely withstand the passage of a flood of design magnitude. The Inflow Design Flood (IDF) is the largest storm event to be considered in the design of the structure, and the magnitude of the storm event for which the IDF is computed is related to the Impact Classification. The values shown for IDF in Table I are minimums, and the storm event to be used as the IDF will be determined by a site specific analysis. For low impact structures, the primary consideration is the protection against loss of the dam and its benefits in the event of failure, while for significant and high impact structures, adequate protection of life and property must be assured.

5. For dams classified as high impact, the IDF is defined as the flood event above which a breach of the dam does not increase hazard to downstream interests. The upper limit of the IDF for high impact structures is the Probable Maximum Flood (PMF), which is the flood which may be expected from the most severe combination of critical meteorological and hydrological conditions which are reasonably possible. While the PMF is the upper limit for the IDF, the IDF for high impact dams may be an event of smaller magnitude, depending upon an incremental hazard assessment. The incremental assessment is a routing of floods of increasingly larger magnitude through the structure and downstream channel reaches, comparing conditions with and without a dam failure, until a flood magnitude is reached for which the dam failure condition does not appreciably increase the hazard potential.

6. Dams classified as having significant impacts may or may not require a formal incremental hazard evaluation, depending upon the extent of existing and potential downstream development, the size of the reservoir, and the type and use of the dam. The upper limit of the IDF for significant impact structures is the PMF.

7. For dams with low impact classification, the incremental hazard evaluation is not required, and the IDF can be based upon factors related to loss of service of the dam, potential maintenance costs, etc., but with the 50-year frequency storm being the minimum design event.

8. The Water Resources Design and Development Section should be a partner in establishing the IDF, and designs should not proceed until agreement has been reached between the DOTD and the owner's engineer on the choice of the IDF. Establishing the IDF is the foundation for the entire design process, since the dam must be designed to safely pass and/or contain the IDF. A guideline for performing the incremental hazard evaluation necessary to establish the IDF is provided in the publication referred to in Subsection N.

9. How the IDF is to be safely passed by the dam structure and the stability of the dam against the long-term effects of hydrostatic forces is the subject of the balance of the design effort, including the general configuration of the dam; length, elevation, and composition of principal and emergency spillways; storage capacity above normal pool elevation; erosion protection; and stability design. The most practical way of assuring the integrity of the dam during an IDF is to provide a concrete spillway which is capable of carrying the peak flow of the storm. Principal spillways are normally sized to carry flows from all but the largest of storms, with emergency spillways, which are not normally armored, functioning only during major storm events. If the peak flow from the IDF can be contained within the principal and emergency spillways, the stability of the dam is not likely to be threatened by the erosive action of water flowing over the embankment. The designer may wish to balance the relative economy of providing spillway capacity versus storage capacity above normal pool stage. But, if design calculations indicate that the embankment will be overtopped by the IDF, provisions must be included in the design to prevent the embankment from failing under the erosive forces of the overtopping flows.

E. Geotechnical Design

1. It is essential to the stability of the structure that the material used in the impoundment structure, as well as the foundation and adjoining earth have the necessary structural properties to withstand the hydrostatic forces required by the design, that potential for destructive seepage is identified and appropriately dealt with, and that the surfaces of the structure are adequately protected from surface erosion.

2. Field investigations shall be adequate to define the soils and ground water conditions with respect to stability and seepage control. Stability analysis should consider after-construction conditions, based on the undrained shear strength parameters determined by laboratory tests. Long-term steady seepage, partial pool, and rapid drawdown analyses should also be performed, using shear properties appropriate to the subject materials and minimum safety factors shown in the following Table.

Table 2. Factor of Safety for Stability Analysis

Analysis Condition	Factor of Safety
Rapid Drawdown	1.25
Partial Pool	1.40
Steady Seepage	1.40
After Construction	1.30
Earthquake	1.15

6. Structural Design. Structural Designs are to be prepared in accordance with generally accepted structural engineering practices such as those of the American Concrete Institute, the American Institute of Steel Construction and the American Institute of Timber

Construction. Components of the spillway or other appurtenant structures shall be designed to resist the most critical loading combination of dead loads plus live loads that may occur during its construction or design life. Some of the loads which must be considered in the design are: buoyancy forces, sliding forces, hydrostatic uplift forces, bearing forces, overturning forces, water drag forces, wing drag forces, gate-lifting and closing forces, soil and water pressure forces, impact forces, uniform and point live load forces, etc. The minimum factors of safety for buoyancy and sliding shall be 1.5 and 2.0, respectively. The overturning analysis must indicate that the resultant force falls within the center 1/3 of the base. The minimum factor of safety for pile design shall be 2.0.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1237 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

§715. Construction

A. It will be the owner's responsibility to ensure by the presence of professional construction supervision personnel that the structure is built in strict compliance with the approved designs and specifications. Adequate records shall be maintained to document that all materials and construction procedures meet or exceed those specified. The owner shall report on the construction to the DOTD. The work of construction, enlargement, alteration, repair or removal of a dam or reservoir for which approved application, designs, plans and specifications are required shall be under the responsible charge of a registered civil engineer. Upon completion of the work and prior to the impoundment of water, the engineer shall certify that all work has been done in compliance with the approved plans and specifications (See §743, Appendix 8).

B. During construction, periodic inspections may be made by representatives of the DOTD. The owner will be required to provide such works or tests as may be needed to disclose sufficient information to enable the DOTD to determine that conformity with approved plans and specifications is being maintained. Inspections made by the DOTD are "limited inspections" and do not relieve the owner or the owner's engineer from their responsibilities for conformance to accepted designs and procedures.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1239 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

§717. Maintenance and Operations

A. Once in service, the integrity of the impoundment structure must be sustained by regular maintenance, in accordance with the approved operations and maintenance document provided by the designer. The Operations and Maintenance Manual should contain forms and schedules for records and documentation of inspections, maintenance procedures, and repairs. The owner will be responsible for certifying, through properly documented records, to the DOTD that the required periodic inspections have been made, for correcting any deficiencies revealed during such inspections, and for maintaining records of all operations and maintenance activities, as well as of original construction and any subsequent modifications.

B. An Emergency Preparedness Plan is required for all dams and reservoirs. The plan shall comply with the guidelines of the current issue of Louisiana's *Emergency Action Plan Guidelines*, available from the DOTD's Director of Public Works and Flood Control. The Emergency Preparedness Plan will be a condition of the permit for the project, and it will be the owner's responsibility to implement the provisions of the plan in the event of emergency.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1239 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

§719. Inspections

A. The DOTD will periodically inspect every dam in the jurisdiction of the program. The purpose of the DOTD inspections is to ascertain whether the structure is being properly maintained in accordance with the approved operations and maintenance procedures. The DOTD inspections are "limited inspections" and do not relieve the owner of responsibility to perform and document periodic inspections. If an inspection by the DOTD reveals that a dam is unsafe or in danger of becoming unsafe, the DOTD, through the Director of Public Works and Flood Control, shall direct the owner to take whatever action is necessary to restore the dam to its design condition.

B. The owner has the primary responsibility for insuring the safe condition of the structure by regular maintenance and periodic inspection. The owner is required to immediately inform the Director of Public Works and Flood Control of any unusual circumstances or occurrences which may affect the condition or safety of the reservoir. Also, the director will be notified prior to any planned draw downs of the reservoir.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1239 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

§721. Enforcement

A. If any dam or impoundment structure is determined to be unsafe, the Director of Public Works and Flood Control, pursuant to R.S. 38:21-28, shall direct any such repairs or remediations for a dam or impoundment structure as he

deems necessary to insure that life and property are not unduly threatened by the impoundment. such remedial action may include:

1. direction that the water level behind the structure be lowered to a safe level; or

2. that the impoundment be completely drained until all necessary corrections to the structure have been made.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1239 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

§723. Existing Structures

A. All dams constructed or under construction prior to promulgation of these Rules will be reviewed to assess their disposition under the program regulations. Each dam is unique and must be judged on the basis of its own particular set of circumstances. Based on the circumstances of each individual case, a judgment will be made of what modifications or repairs are necessary to meet program standards. It is the intent of the program to eventually have every dam upgraded to meet program standards. The DOTD will be the sole judge of whether an existing deficiency creates an unacceptable risk to the general public. While it is not the intent of this program to lower the standards for existing dams, the DOTD recognizes that it is not practical to require all dam owners to immediately retrofit their structures to meet new minimum Inflow Design Flood standards.

B. An "Impoundment Permit" is required for existing dams and will be issued after reviewing all historical data (designs, plans, specifications, operation and maintenance records, etc.) and performing a technical inspection (or inspections) to adequately assess the safety of the dam. The owner shall provide all historical data, if available.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1239 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

§725. Emergency Preparedness Plan

A. An Emergency Preparedness Plan is required for all dams and reservoirs both existing and new construction. The plan will comply with the guidelines of the current issue of Louisiana's *Emergency Action Plan Guidelines*, available from the Director of Public Works and Flood Control, and shall be submitted as a necessary component of the maintenance and operating procedures and as a condition of the permitting process. It is the owner's responsibility to assure that the provisions of the Emergency Action Plan are implemented in the event of an emergency situation.

B. A breach analysis is required to develop the emergency preparedness plan. The breach analysis will establish the magnitude of the inundated area (inundation map), peak flood elevations and arrival times of the peak flood elevations at critical locations. The worst case scenario breaching event will be somewhere between the "sunny day" breach and that event above which a breach of the dam does not increase hazard to downstream interests. If the dam owner prefers to perform only one breach analysis rather than performing incremental analyses to discover the worst case scenario breaching event, he may perform a breach analysis where the tail water is at the average annual elevation and the reservoir is at maximum design surcharge.

AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1239 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

§727. References

A. Jerrold W. Gotzmer, William C. Jenkins, Ramon G. Lee, Joseph R. McCormick, Harvey H. Richardson, and David L. Sveum, *Training Aids for Dam Safety, Module: Evaluation of Hydrologic Adequacy, Interagency Committee on Dam Safety* (Available from: Louisiana Transportation Research Center, 4101 Gourrier, Baton Rouge, LA 70808, telephone (225) 767-9131).

B. Peter G. Grey, Terry G. Fairbanks, Tasso Schmigall, and Charles D. Wagner, *Training Aids for Dam Safety, Module: Evaluation of Hydraulic Adequacy, Interagency Committee on Dam Safety* (Available from: Louisiana Transportation Research Center, 4101 Gourrier, Baton Rouge, LA 70808), telephone (225) 767-9131).

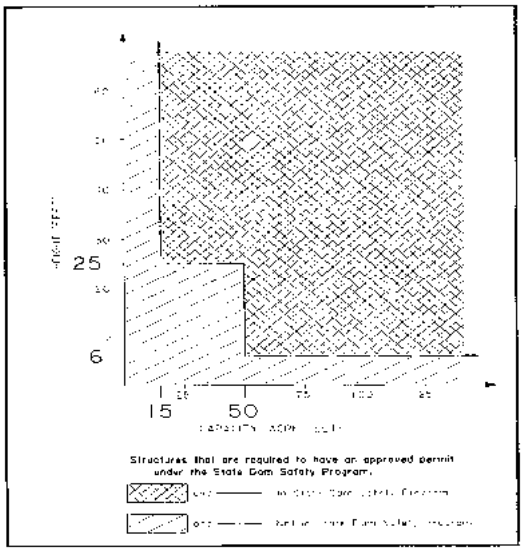
AUTHORITY NOTE: Promulgated in accordance with R.S. 38:24.

HISTORICAL NOTE: Promulgated by the Department of Transportation and Development, Office of Public Works, LR 22:1240 (December 1985), repromulgated by the Department of Transportation and Development, Office of Public Works, LR 31:942 (April 2005).

Subchapter B. Figures and Forms

§729. Appendix 1, Structures—Approved Permit

A. Structures that are required to have an approved permit under the State Dam Safety Program.


25
6
15
50
Structures that are required to have an approved permit under the State Dam Safety Program.

E.18. Maine



Maine Revised Statute Title 37-B, Chapter 24: DAM SAFETY

Table of Contents

Section 1111. DEFINITIONS..... 3
Section 1112. ADMINISTRATION..... 4
Section 1113. DUTIES OF THE DEPARTMENT..... 4
Section 1114. POWERS OF THE DEPARTMENT..... 5
Section 1115. JURISDICTION..... 5
Section 1116. DESIGN STANDARDS..... 6
Section 1117. INSPECTORS OF DAMS..... 6
Section 1118. DAM HAZARD EVALUATION..... 6
Section 1119. DAM CONDITION INSPECTION..... 7
Section 1120. ENFORCEMENT..... 8
Section 1121. APPEAL..... 8
Section 1122. EXEMPTIONS..... 9
Section 1123. RIGHTS OF OWNER..... 9
Section 1124. IMMUNITY..... 9
Section 1125. RELIEF OF OBLIGATION..... 9
Section 1126. ACCESS AND NOTIFICATION..... 9
Section 1127. EMERGENCY ACTION PLANS..... 10
Section 1128. NOTICE OF TRANSFER OF OWNERSHIP..... 10
Section 1129. VIOLATIONS..... 10
Section 1130. DAM REPAIR AND RECONSTRUCTION FUND..... 10
Section 1131. ESTABLISHMENT OF COMMISSION..... 11

37-B §1111. DEFINITIONS

As used in this chapter, unless the context otherwise indicates, the following terms have the following meanings. [2001, c. 460, §3 (NEW).]

1. **Dam.** "Dam" means any artificial barrier, including appurtenant works, the site on which it is located and appurtenant rights of flowage and access, that impounds or diverts water, and that:

A. Is 25 feet or more in height from the natural bed of the watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier to the maximum water storage elevation and impounds at least 15 acre-feet of water; or [2001, c. 460, §3 (NEW).]

B. Is 6 feet or more in height from the natural bed of the watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier to the maximum water storage elevation and has an impounding capacity at maximum water storage elevation of 50 acre-feet or more. [2001, c. 460, §3 (NEW).]

[2001, c. 460, §3 (NEW) .]

2. **Commissioner.** "Commissioner" means the Commissioner of Defense, Veterans and Emergency Management.

[2001, c. 460, §3 (NEW) .]

3. **Emergency.** "Emergency" means breaches and all conditions leading to or causing a breach, overtopping or any other condition in a dam and its appurtenant structures that may be construed as unsafe or threatening to life and property.

[2001, c. 460, §3 (NEW) .]

4. **Emergency situation.** "Emergency situation" means a situation determined by the commissioner, after consultation with other state and federal agencies if time permits, to present a potential but real and impending danger to life, limb or property because of flooding or potential and imminent flooding and includes a situation that the Governor declares to be an emergency pursuant to section 742.

[2001, c. 460, §3 (NEW) .]

5. **Emergency action plan.** "Emergency action plan" means a set of written instructions or guidelines for use by public officials that recommends actions that, when implemented, will minimize the effects of a dam failure on people and property.

[2001, c. 460, §3 (NEW) .]

6. **Hazard potential.** "Hazard potential" means the possible adverse incremental consequences that result from the release of water or stored contents due to failure of the dam or misoperation of the dam or appurtenances. The hazard potential classification of a dam does not reflect in any way on the current condition of the dam and its appurtenant structures. The classifications are as follows:

A. High hazard potential dam. "High hazard potential dam" means a dam assigned the high hazard potential classification where failure or misoperation will probably cause loss of human life; [2001, c. 460, §3 (NEW).]

B. Low hazard potential dam. "Low hazard potential dam" means a dam assigned the low hazard potential classification where failure or misoperation results in no probable loss of human life and low economic and environmental losses. Losses are principally limited to the owner's property; and [2001, c. 460, §3 (NEW).]

C. Significant hazard potential dam. "Significant hazard potential dam" means a dam assigned the significant hazard potential classification where failure or misoperation results in no probable loss of human life but can cause major economic loss, environmental damage or disruption of lifeline facilities or affect other concerns. Significant hazard potential dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure. [2001, c. 460, §3 (NEW).]

[2001, c. 460, §3 (NEW) .]

7. **Necessary remedial measure.** "Necessary remedial measure" means any repair or hazard-reducing measure relating to a structural component or operation of a dam needed to mitigate a specific condition at the dam that constitutes a threat to public safety.

[2001, c. 460, §3 (NEW) .]

8. **Person.** "Person" means any individual, firm, association, partnership, corporation, trust, municipality, quasi-municipal corporation, state department, federal department or other legal entity.

[2001, c. 460, §3 (NEW) .]

9. **Public safety.** "Public safety" or "safety of the public" means protection of life, health or property from any condition, event or action at a dam that might compromise the safety, stability or integrity of the dam or its ability to function safely.

[2001, c. 460, §3 (NEW) .]

10. **State dam inspector.** "State dam inspector" means an inspector appointed or hired under section 1117.

[2001, c. 460, §3 (NEW) .]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1112. ADMINISTRATION

The department shall administer this chapter. In carrying out the provisions of this chapter, the department shall consult as appropriate with other state agencies, including the Department of Conservation, the Department of Environmental Protection, the Department of Inland Fisheries and Wildlife, the Department of Marine Resources, the Department of Public Safety, the Department of Transportation, the Maine Land Use Regulation Commission and the State Planning Office, for their aid and assistance. [2009, c. 561, §35 (AMD).]

SECTION HISTORY
2001, c. 460, §3 (NEW). 2009, c. 561, §35 (AMD).

37-B §1113. DUTIES OF THE DEPARTMENT

The department shall inspect existing dams and reservoirs to determine their hazard potential, review the design and construction of new and reconstructed dams, assist dam owners in developing emergency action plans to minimize the effects of dam failure and take all necessary actions in emergency situations of probable dam failure in order to protect life and property. [2001, c. 460, §3 (NEW).]

Except for the Federal Government, a person may not exercise any authority over the emergency regulation or supervision of any dams or reservoirs in the State when that exercise would conflict with the powers and authority vested in the department. [2001, c. 460, §3 (NEW).]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1114. POWERS OF THE DEPARTMENT

1. **Rules.** In accordance with Title 5, chapter 375, subchapter II, the department may adopt, modify or repeal rules for carrying out this chapter. Rules adopted under this section are routine technical rules pursuant to Title 5, chapter 375, subchapter II-A.

[2001, c. 460, §3 (NEW) .]

2. **Emergency situation.** When an emergency situation arises, the commissioner shall warn the public of the emergency and, notwithstanding any other provision of law, shall take all actions necessary to protect life and property, which may include, but are not limited to, the following:

A. Taking full charge and control of any dam or reservoir; [2001, c. 460, §3 (NEW).]

B. Lowering the water level by releasing water from the reservoir; [2001, c. 460, §3 (NEW).]

C. Completely emptying the reservoir; [2001, c. 460, §3 (NEW).]

D. Breaching or removing the dam itself; and [2001, c. 460, §3 (NEW).]

E. Taking other necessary steps to safeguard life and property. [2001, c. 460, §3 (NEW).]

[2001, c. 460, §3 (NEW) .]

3. **Investigations.** For the purpose of enabling it to make decisions as compatible as possible with economy and protection of life and property and for the purpose of determining compliance with this chapter, the department may make necessary investigations and inspections. In making investigations and inspections required or authorized by this chapter, the department or its representatives may, as necessary in emergency situations, enter upon public or private property or in nonemergency situations secure administrative warrants from any District Court Judge or Superior Court Justice for the purpose of gaining entry onto private property.

[2001, c. 460, §3 (NEW) .]

4. **Injunction; civil or criminal proceedings.** In the event of violation of any of the provisions of this chapter or of any rule, order or decision of the department, the department may institute injunctive proceedings or other civil action as provided in this chapter.

[2001, c. 460, §3 (NEW) .]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1115. JURISDICTION

The inspection of and design standards for all dams are under the sole jurisdiction of the department, except that the department does not have jurisdiction over any dam licensed or inspected by any department of the Federal Government or by the International Joint Commission. [2001, c. 460, §3 (NEW).]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1116. DESIGN STANDARDS

All new dams that reasonably will be classified as high or significant hazard potential dams must be designed, constructed or reconstructed under the supervision of a registered professional engineer. Prior to construction, the dam owner shall provide a copy of the plans and specifications to the department. [2001, c. 460, §3 (NEW).]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1117. INSPECTORS OF DAMS

The commissioner shall appoint or hire one or more dam inspectors who are licensed as professional engineers under Title 32, chapter 19 and who are experienced in the inspection and design of dams. [2001, c. 460, §3 (NEW).]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1118. DAM HAZARD EVALUATION

1. **Evaluation.** The commissioner shall evaluate all dams to assign or reassign a hazard potential classification in accordance with the following schedule:

A. New or reconstructed dams, within 6 months of construction or reconstruction; [2001, c. 460, §3 (NEW).]

B. All other dams, at least once every 6 years; [2001, c. 460, §3 (NEW).]

C. Any dam, within 30 days of a request for an evaluation from the dam owner, the municipality in which the dam is located or the emergency management director of the county in which the dam is located; and [2001, c. 460, §3 (NEW).]

D. At any time a dam for which, in the judgment of the commissioner, such an evaluation is appropriate. [2001, c. 460, §3 (NEW).]

Notwithstanding the schedule of this subsection, the commissioner shall evaluate the hazard classification of a significant or high hazard potential dam within 30 days of receipt by the commissioner of a notice of transfer of ownership of the dam as required under section 1128 unless the dam has been evaluated under this subsection within 4 years preceding the notice of transfer of ownership.

Until the commissioner assigns or reassigns a hazard potential classification, a dam retains the hazard potential classification assigned in the 1981 United States Army Corps of Engineers' Inventory of Dams in the United States.

[2001, c. 460, §3 (NEW) .]

2. **Factors considered.** Before assigning a dam a hazard potential classification, the commissioner shall consider the potential risk to public safety and property that may result from the failure or operation of the dam. In addition, when reassigning a hazard potential classification, the commissioner shall review any changes in upstream and downstream conditions since the last hazard classification evaluation.

[2001, c. 460, §3 (NEW) .]

3. **Hazard report.** Before the commissioner assigns or reassigns a dam hazard potential classification, a state dam inspector shall visually inspect that dam and its upstream and downstream environs and provide a report to the commissioner recommending a hazard classification for that dam. The commissioner shall provide a copy of the report by certified mail to the dam owner, lessee or other person in control of the dam,

to the municipality in which the dam is located and to the emergency management director of the county in which the dam is located. The dam owner, lessee or other person in control of the dam must notify the commissioner within 20 days of receipt of the report if the dam owner, lessee or other person in control of the dam disagrees with the recommended hazard classification and must file within 3 months of receipt of the commissioner's classification the basis of the appeal with the commissioner. The commissioner may extend the 3 month period for good cause shown, but not more than an additional 3 months. The commissioner shall consider the evidence presented by the dam owner, lessee or other person in control of the dam as well as the evidence of the state inspector before issuing a final determination.

[2001, c. 460, §3 (NEW) .]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1119. DAM CONDITION INSPECTION

1. **Inspections.** A state dam inspector shall conduct an inspection of all high and significant hazard potential dams to determine whether the integrity, structural stability, function or operation of those dams constitutes a threat to public safety, in accordance with the following schedule:

A. All significant hazard potential dams, at least once every 4 years; [2001, c. 460, §3 (NEW).]

B. All high hazard potential dams, at least once every 2 years; [2001, c. 460, §3 (NEW).]

C. Any dam, within 30 days of a request for an inspection from the dam owner or the municipality in which the dam is located; and [2001, c. 460, §3 (NEW).]

D. At any time any dam that may, in the judgment of the commissioner, constitute a potential risk to public safety. [2001, c. 460, §3 (NEW).]

Notwithstanding the schedule outlined in this subsection, a state dam inspector shall conduct an inspection of a significant or high hazard potential dam within 30 days of receipt by the commissioner of a notice of transfer of ownership of the dam as required under section 1128 unless the dam has been inspected under this subsection within 4 years preceding the notice of transfer of ownership.

[2001, c. 460, §3 (NEW) .]

2. **Condition report.** After the on-site dam inspection, a state dam inspector shall provide a condition report to the commissioner detailing the operation and material condition of the dam and recommending all necessary remedial measures. The commissioner shall send a copy of the state dam inspector's condition report by certified mail to the dam owner, lessee or other person in control of the dam, the municipality in which the dam is located and the emergency management director of the county in which the dam is located if the condition report recommends any necessary remedial measures. The dam owner, lessee or other person in control of the dam must notify the commissioner within 20 days of receipt of the report if the owner disagrees with the findings and recommendations of the report. The dam owner, lessee or other person in control of the dam must provide the basis of disagreement to the commissioner within 3 months of receipt of the inspector's report. The dam owner, lessee or other person in control of the dam may apply for and be granted an extension of this deadline for good cause, but not for more than an additional 3 months.

[2001, c. 460, §3 (NEW) .]

3. **Review conference.** After receiving the inspector's report and prior to issuing any dam safety order, the commissioner shall hold a review conference and shall invite the emergency management director of the county in which the dam is located to the review conference as well as representatives from appropriate state agencies which may include the Department of Conservation, the Department of Environmental Protection, the Department of Inland Fisheries and Wildlife, the Department of Marine Resources, the Department of

Public Safety, the Department of Transportation, the Maine Land Use Regulation Commission and the State Planning Office, to discuss the public safety, environmental, economic and other concerns relating to the dam and the necessary remedial measures under consideration. A state dam inspector shall attend the review conference. The commissioner shall maintain a written record of the conference and shall make a copy of this record available to all parties participating in the conference.

[2009, c. 561, §36 (AMD) .]

4. **Order.** The commissioner shall consider the inspector's report, the evidence presented by the dam owner, lessee or other person in control of the dam and the record from the review conference before issuing a dam safety order directing that necessary remedial measures be undertaken by the dam owner, lessee or other person in control of the dam. The commissioner may issue such an order only if the commissioner determines that the integrity, structural stability, function or operation of the dam constitutes a threat to public safety. Necessary remedial measures may include, but are not limited to:

A. Breach or removal of the dam; [2001, c. 460, §3 (NEW).]

B. Repair or maintenance of the dam in a specified manner; [2001, c. 460, §3 (NEW).]

C. Operation of the dam in a specified manner; [2001, c. 460, §3 (NEW).]

D. Preparation of and adherence to any emergency action that is approved by the commissioner; and [2001, c. 460, §3 (NEW).]

E. Maintenance of appropriate records relating to water levels, dam operation and dam maintenance. [2001, c. 460, §3 (NEW).]

[2001, c. 460, §3 (NEW) .]

SECTION HISTORY
2001, c. 460, §3 (NEW). 2009, c. 561, §36 (AMD).

37-B §1120. ENFORCEMENT

The commissioner may commence an action to enjoin the violation of any provision of this chapter. The commissioner may enforce any order by any other appropriate remedy, including, but not limited to, entering the dam premises to carry out the terms of the order. [2001, c. 460, §3 (NEW).]

The owners, lessees or persons in control of the dam are jointly and severally liable for any costs incurred by the department in carrying out its responsibilities under section 1114, subsection 2 or in enforcing any order. If the owners, lessees or persons in control of the dam refuse to comply or do not fully comply with the department's order, the department shall initiate a civil action against the owners, lessees or other persons in control of the dam for damages in the amount of the costs incurred by the department in enforcing its order. [2001, c. 460, §3 (NEW).]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1121. APPEAL

Any person aggrieved by an order of the commissioner may appeal to the Superior Court under Title 5, chapter 375, subchapter VII. [2001, c. 460, §3 (NEW).]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1122. EXEMPTIONS

Dams licensed by or subject to the jurisdiction of the Federal Energy Regulatory Commission are exempt from this chapter. [2001, c. 460, §3 (NEW).]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1123. RIGHTS OF OWNER

This chapter may not be construed to deprive any owner of recourse to the court in which that owner may be entitled to relief under the laws of this State. [2001, c. 460, §3 (NEW).]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1124. IMMUNITY

An action may not be brought against the State, the department or its agents or employees for any action taken or failure to take action pursuant to this chapter. [2001, c. 460, §3 (NEW).]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1125. RELIEF OF OBLIGATION

This chapter may not be construed as relieving a person of duties, responsibilities or liabilities imposed by any other law, regulation, municipal ordinance or rule of law, including, but not limited to, the need to obtain permits or other approvals required to authorize repairs or other remedial measures at a dam and the need to comply with the terms and conditions of any outstanding water level or dam release order, except in an emergency situation as defined by this chapter. [2001, c. 460, §3 (NEW).]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1126. ACCESS AND NOTIFICATION

1. **Department access.** A state dam inspector and any department staff member must have full access to any dam site under the commissioner's jurisdiction for the purpose of conducting an inspection or enforcing an order under this chapter subject to the Maine Rules of Civil Procedure, Rule 80E.

[2001, c. 460, §3 (NEW) .]

2. **Owners, lessees; necessary access.** The owners, lessees or persons in control of a dam must have access over land abutting the dam site owned by others if the access, including the passage of vehicles, machinery and equipment, is reasonably necessary to comply with an order issued under this chapter. In passing over land owned by abutters, the owners, lessees or persons in control of a dam shall make every effort to minimize the intrusion, shall restore the land to its preexisting condition to the maximum extent practicable and are liable to the abutters for all property damage caused by their activities on the abutters' land. The abutters may not be held liable to any person for any personal injuries or property damage arising from the crossing of their land by the owners, lessees or persons in control of a dam.

[2001, c. 460, §3 (NEW) .]

SECTION HISTORY

2001, c. 460, §3 (NEW).

37-B §1127. EMERGENCY ACTION PLANS

Within 6 months after the determination of classification, the owner of a dam under the commissioner's jurisdiction that is classified as high or significant hazard potential shall prepare an emergency action plan, which must be updated every 2 years. Such emergency action plans must be reviewed for adequacy by the department. Emergency plans must follow a model plan supplied by the department. All emergency action plans must be available and on file at the appropriate local and county government offices and at the department. [2001, c. 460, §3 (NEW).]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1128. NOTICE OF TRANSFER OF OWNERSHIP

Forty-five days prior to any change of ownership of a dam, whether by sale, lease or gift, the owner or owners of a dam classified as a high or significant hazard potential dam shall provide in writing to the commissioner the name and address of the prospective new owner or owners along with any plan that the prospective owner has with regard to maintaining competent operations and correcting unsafe conditions, if any. For purposes of this section, "competent operations" means properly and safely maintaining the dam and ensuring compliance with all safety, environmental and water level rules or orders. [2001, c. 460, §3 (NEW).]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1129. VIOLATIONS

In addition to any other forfeitures or penalties provided by law, a person who violates any provisions of this chapter or any rule or order adopted, promulgated or issued under this chapter is subject to a civil penalty as assessed by the commissioner of not less than $100 nor more than $5,000 for each day that the violation continues. The penalty is payable to the State, to be recovered in a civil action. [2001, c. 460, §3 (NEW).]

SECTION HISTORY
2001, c. 460, §3 (NEW).

37-B §1130. DAM REPAIR AND RECONSTRUCTION FUND

1. **Fund established.** The Dam Repair and Reconstruction Fund, referred to in this section as the "fund," is established within the department. The department shall administer the fund and make low-interest loans from the fund for purposes pursuant to this section. The department may seek assistance from the Finance Authority of Maine in administering the fund.

[2001, c. 460, §3 (NEW) .]

2. **Purposes.** The department may use the fund to provide low-interest loans to municipalities for engineering, legal and construction costs involved in acquiring title to, establishing a long-term management plan for, repairs to, reconstruction of, breaching of or removal of a dam or to pay emergency costs incurred for actions taken pursuant to section 1114.

[2007, c. 167, §12 (AMD) .]

3. **Rulemaking.** The department shall adopt rules to implement this section, including criteria and procedures for the application for and award of low-interest loans from the fund and for repayment of loans to the fund. Rules adopted pursuant to this section are routine technical rules as defined in Title 5, chapter 375, subchapter II-A.

[2001, c. 460, §3 (NEW) .]

4. **Nonlapsing.** Any balance in the fund at the end of the fiscal year may not lapse but must be carried forward to the next fiscal year.

[2001, c. 460, §3 (NEW) .]

SECTION HISTORY
2001, c. 460, §3 (NEW). 2007, c. 167, §12 (AMD).

37-B §1131. ESTABLISHMENT OF COMMISSION

1. **Establishment of commission.** The River Flow Advisory Commission, as established by Title 5, section 12004-G, subsection 13-E and referred to in this section as the "commission," shall act as a technical advisory commission to the department and the Governor's office on issues of flow of the State's rivers and streams. The commission shall also facilitate communication of river flow data between dam operators, river basin managers, state agencies, the United States Geological Survey and the National Weather Service during floods and droughts and shall administer the State's hydrologic monitoring program in cooperation with the United States Geological Survey.

[2001, c. 662, §99 (NEW) .]

2. **Membership.** The commission is composed of these members:

A. The Director of the Maine Emergency Management Agency or the director's designee; [2003, c. 404, §11 (AMD).]

B. The State Geologist or the State Geologist's designee; [2001, c. 662, §99 (NEW).]

C. The Commissioner of Agriculture, Food and Rural Resources or the commissioner's designee; [2001, c. 662, §99 (NEW).]

D. The Commissioner of Environmental Protection or the commissioner's designee; [2001, c. 662, §99 (NEW).]

E. The Commissioner of Inland Fisheries and Wildlife or the commissioner's designee; [2001, c. 662, §99 (NEW).]

F. The Commissioner of Marine Resources or the commissioner's designee; [2001, c. 662, §99 (NEW).]

G. The Director of the State Planning Office or the director's designee; [2001, c. 662, §99 (NEW).]

H. The Commissioner of Transportation or the commissioner's designee; [2001, c. 662, §99 (NEW).]

I. The District Chief of the United States Geological Survey Water Resources Division Maine District Office; [2001, c. 662, §99 (NEW).]

J. The Meteorologists-in-Charge of the National Weather Service Forecast Offices in this State or the designee of the Meteorologists-in-Charge; [2003, c. 404, §12 (AMD).]

K. Representatives from private commerce and industry, including, but not limited to, the major hydroelectric power generators, as determined by the cochairs of the commission; [2003, c. 404, §12 (AMD).]

L. A representative of the public, appointed by the Governor; [2003, c. 404, §12 (AMD).]

M. The Commissioner of Health and Human Services or the commissioner's designee; and [2003, c. 404, §13 (NEW); 2003, c. 404, Pt. B, §7 (REV).]

N. The director of the Senator George J. Mitchell Center for Environmental and Watershed Research at the University of Maine, or the director's designee. [2003, c. 404, §13 (NEW).]

[2003, c. 404, §§11-13 (AMD); 2003, c. 404, Pt. B, §7 (REV) .]

3. **Chair.** The District Chief of the United States Geological Survey Water Resources Division Maine District Office and the Director of the Maine Emergency Management Agency or the director's designee shall act as cochairs of the commission.

[2003, c. 404, §14 (AMD) .]

4. **Terms of office.** The term of office of the public member is 5 years. The public member may be removed from office for cause by the Governor. Members from the State Government or Federal Government shall serve a term coincident with their governmental position. Members from private commerce and industry serve a term as determined by the respective entities that they represent.

[2003, c. 404, §14 (AMD) .]

5. **Voting.** A quorum of at least 7 members must be present for voting.

[2001, c. 662, §99 (NEW) .]

6. **Administrative provision.** The Maine Emergency Management Agency shall administer the affairs and activities of the commission.

[2001, c. 662, §99 (NEW) .]

7. **Records.** The commission shall keep accurate records of its proceedings and shall file them with the Maine Emergency Management Agency.

[2001, c. 662, §99 (NEW) .]

8. **Compensation.** Members of the commission are not entitled to receive compensation.

[2001, c. 662, §99 (NEW) .]

9. **Meetings.** The commission shall meet at least once per calendar year at the call of either of the cochairs to review hydrologic conditions prior to the spring snowmelt and runoff for the purpose of issuing an advisory statement on the potential for major river flooding. Either of the cochairs may call additional meetings as needed.

[2001, c. 662, §99 (NEW) .]

10. **Powers and duties.** The commission has the power and duty only to:

A. Advise the department and the Governor on issues of flow within the State's rivers and streams; [2001, c. 662, §99 (NEW).]

B. Assist in communication of river flow data between dam operators, river basin managers, state agencies and federal agencies; and [2001, c. 662, §99 (NEW).]

C. Administer the State's cooperative hydrologic monitoring program in cooperation with the United States Geological Survey. [2001, c. 662, §99 (NEW).]

[2001, c. 662, §99 (NEW) .]

SECTION HISTORY
2001, c. 662, §99 (NEW). 2003, c. 404, §§11-14 (AMD). 2003, c. 689, §B7 (REV).

The State of Maine claims a copyright in its codified statutes. If you intend to republish this material, we require that you include the following disclaimer in your publication:

All copyrights and other rights to statutory text are reserved by the State of Maine. The text included in this publication reflects changes made through the Second Regular Session of the 124th Legislature, is current through April 12, 2010, and is subject to change without notice. It is a version that has not been officially certified by the Secretary of State. Refer to the Maine Revised Statutes Annotated and supplements for certified text.

The Office of the Revisor of Statutes also requests that you send us one copy of any statutory publication you may produce. Our goal is not to restrict publishing activity, but to keep track of who is publishing what, to identify any needless duplication and to preserve the State's copyright rights.

PLEASE NOTE: The Revisor's Office cannot perform research for or provide legal advice or interpretation of Maine law to the public. If you need legal assistance, please contact a qualified attorney.

01-001 DEPARTMENT OF AGRICULTURE, FOOD & RURAL RESOURCES

Chapter 375: DETERMINATION OF THE SAFETY AND SUFFICIENCY OF A DAM OR RESERVOIR

SUMMARY: This Chapter describes the scope of a darn inspection, the engineering and hydrologic performance criteria that are used in the determination of whether a dam or reservoir is unsafe or insufficient, and the time schedule arid hearing procedures that apply to dam and reservoir inspection.

---

1. Introduction

The determination of the "safety and sufficiency of a dam or reservoir" as defined in 38 M.R.S.A. ə811 shall be made pursuant to this rule. When a dam or reservoir is in addition found to be "unsafe or dangerous to the lives or property of persons residing, carrying on business, or employed near or below the same" (ə812), the inspector of Dam shall recommend alterations, repairs and additions to the dam or reservoir for the protection of life and property. These include but are not limited to recommendations that the reservoir level be lowered in a safe manner, that structural repairs or additions be made to the dam or reservoir,, that certain operating procedures be adopted or implemented, or that the dam or reservoir be removed. Failure of the dam owner to comply with these recommendations may result in court action as described in 38 M.R.S.A. ə812.

2. Scope of Dam inspection

A. The inspector of Dam shall make a safety assessment of a given dam or reservoir with a degree of thoroughness appropriate for the particular facility, taking into account such factors as:

a. consequences of a total failure of the facility

b. stage of life of the project

c. level of safety required

d. nature of the facility and its site

The Inspector of Dam shall first make the appropriate determination of the level of consequences of a complete failure of the darn or reservoir. He shall then determine appropriate criteria for the performance of the facility. Next, he shall make a site inspection in which he searches for any field evidence of possible malfunctions of the facility. During or following the site inspection, the Inspector of Dam shall obtain any available documents on the investigation, design, construction, and performance of the dam.

B Following such site inspection, the Inspector of Dams shall take the testimony of witnesses concerning the safety and sufficiency of the dam or reservoir as provided in 38 M.R.S.A. ə811 and according to the procedure for the conduct of hearings contained in 01-019 CMR

30.4 and .5. For purposes of this chapter, unless the content otherwise indicates, all references to "The Chairman of the Soil and Water Conservation Commission" and "The Commission" which appear in 01-019 CMR 30.4 and .5 shall be deemed to refer to the Inspector of Dams.

3. Decision

A. Following the determination of the consequences of failure, the site inspection and hearing, and appropriate analyses, the Inspector of Dams shall forthwith report his findings and his opinion of the safety and sufficiency of the dam or reservoir to the Commissioner of the Department of Agriculture, Food and Rural Resources. Pursuant to 38 M.R.S.A. ɔ812, said findings and opinion shall include the Inspector's conclusion as to whether or riot such dam or reservoir is unsafe or dangerous to the lives or property of persons residing, carrying on business or employed near or below the same.

B. Such findings and opinion shall simultaneously be mailed to a representative of the petitioners, any intervenors, and the owners of the dam or reservoir. Within fourteen days of their receipt of such findings and opinion, these parties may file with the Inspector proposed findings, written comments, statements and arguments thereon. In the discretion of the inspector, additional time may be granted if the dam or reservoir owner desires to commission, at his own expense, an additional safety assessment of the dam or reservoir. Such request must be made within fourteen days of receipt of the Inspector's findings and opinion. Title 01-019 CMR 30.5M shall apply to these proceedings as modified by the procedures set forth herein.

C. Upon the expiration of the comment period or the Inspector's receipt of an additional safety assessment, as the case may be, the record shall be closed (subject to 01-019 CMR 30.5N). The Inspector shall thereupon issue a final report to the Commissioner of Agriculture, Flood and Rural Resources. In the case of finding a dam to be unsafe, or insufficient, the Commissioner shall notify all interested parties, including owners with riparian rights, municipalities in which the darns are located and any other persons or organizations he deems necessary.

4. Definition of "Unsafe and Insufficient"

A dam or reservoir shall be declared to be "unsafe" or "insufficient" if the Inspector of Dams, after utilizing all available data and testimony and making appropriate calculations using known values or reasonable assumptions, finds that the dam or reservoir does not meet minimum performance criteria appropriate to the facility. The types of performance features that should be evaluated are listed below:

A. Forces acting on the dam and evidence of horizontal translation that suggests there is too much force acting at any time against the facility;

B. Evidence of large total or differential deformation;

C. Evidence of slumps or bulges on the faces of the dam; an end-of-construction or steady state factor of safety against shear sliding and the factor of safety under conditions of reservoir drawdown and during appropriate earthquake loading;

D. Evidence that the phreatic surface within the dam during the full reservoir condition exists on the downstream face of the dam except through properly designed drains; evidence of bulges, seeps, or soft zones on the downstream face of the dam or on the immediate. abutments; evaluation of the effective stress within the dam;

E. Evidence that the dam is experiencing internal erosion of dam material or that the dam abutments or foundation could be subject to piping; an evaluation of internal drain design; an evaluation of seepage gradient within the dam;

F. An evaluation of the quantity and quality of seepage through the dam

G. An evaluation of whether a dam or reservoir is safe from runoff overtopping that could wash out the containment structure. In making this evaluation, the inspector shall consider whether the dam can safely sustain overtopping by the appropriate design storm, and if not, whether an emergency spillway is present. In appropriate cases where it is determined that an emergency spillway should be present, and only one spillway exists, the principal spillway may be considered to serve as an emergency spillway, provided that the principal spillway is large enough so that it cannot be blocked by driftwood and other floating or suspended debris. For each class of structure identified in paragraphs (1), (2) and (3), the inspector shall consider whether an emergency spillway is able to transmit without erosion,, or whether the dam can retain its integrity during overtopping, a storm of the frequency specified

(1) For class "a" structures, which are located in rural, agricultural, or urban areas dedicated to remain in flood tolerant usages where failure may only damage non-residential buildings, agricultural land, floodplains, or township and country roads: 25-year storm or flood;

(2) For Class "b" structures, which are located in predominantly rural or agricultural areas where failure may damage homes, industrial or commercial buildings, highways or railroads, or where failure may cause interruption of use or service of utilities: 100-year storm or flood;

(3) For Class "c" structures, where failure may cause loss of life: maximum probable flood.

H. An evaluation of the minimum freeboard during the reservoir levels that will prevail during the appropriate design storm or flood described in sub-section G above; in a reservoir where landsliding of earth or rack into the reservoir is possible, the potential for wave generation and wave run-up on the dam;

I. Evidence of holes or burrows that could render the dam unsafe;

J. Consequences of inappropriate dam placement;

K. An earthdam shall not be covered by brush, shrubs, or trees;

L. The mechanical facilities that provide control of the water levels in a reservoir shall be in good working order.

5. Qualifications in Declaring a Dam Safe

The Inspector of Dam shall declare a dam or reservoir "safe" if he finds no evidence that the dam or reservoir is unsafe during his field inspection or through his calculations of the safety based upon reasonable assumptions. In a case where the Inspector is of the opinion that there are insufficient field measurements or other data to verify definitively that certain safety criteria have been met (such as described in section 3, Sub-sections A through L), then the Inspector of Dam may declare a dam or reservoir safe subject to further specific studies which he shall recommend to the dam owner. The Inspector may also declare a dam safe subject to review by the Inspector at some later date.

STATUTORY AUTHORITY:

38 M.R.S.A. ə811 *et seq*.; 5 M.R.S.A. ə8051; *Batterton v. Francis*, 432 U.S. 416, 424, n. 9 (1976), *General Electric Co. v. Gilbert*, 429 U.S. 141-45 (1976), and *Skidmore v. Swift & Co*., 323 U.S. 134, 14 (1944), as to the inherent authority of an agency to promulgate interpretative regulations as opposed to regulations having the force of law. See also 2 Davis, *Administrative Law* ə7.9 *et seq*. (2d ed. 1979).

EFFECTIVE DATE:

June 30, 1981

EFFECTIVE DATE (ELECTRONIC CONVERSION):

May 4, 1996

CONVERTED TO MS WORD:

May 20, 2008

15 DEPARTMENT OF DEFENSE, VETERANS AND EMERGENCY MANAGEMENT

214 MAINE EMERGENCY MANAGEMENT AGENCY

Chapter 3: DESIGN AND CONSTRUCTION STANDARDS FOR NEW OR RECONSTRUCTED DAMS

3.1 GENERAL PROVISIONS

a. In accordance with the provisions of Section 1063, Chapter 22, Title 37-B M.R.S.A., it is the intent of these dam regulations to provide for the proper and safe design and construction of impounding structures not exempt from the law to the extent required for the protection of public safety.

b. These regulations shall not be construed or interpreted to relieve the owner or operator of any impoundment or impounding structure of any legal duties, obligations, or liabilities incident to ownership, design, construction, operation, or maintenance of the impounding structure.

c. These regulations shall not serve to negate nor to satisfy requirements applicable to existing or proposed impounding structures which may be imposed through provisions of other local, state or federal laws, regulations, or ordinances.

d. Any owner who owns, controls, operates, maintains, or manages an impounding structure or impoundment not exempt from the law, or any owner who proposes to perform any of the preceding, or any owner who proposes to construct an impounding structure not exempt from the law, shall engage a licensed Professional Engineer who is practicing in Maine in accordance with applicable laws of Maine to perform any engineering analysis required to comply with these regulations. Such plans and specifications, engineering analyses, and any other document prepared in compliance with the provisions of these dam regulations shall bear the Maine seal of the licensed Professional Engineer who has been engaged to prepare same.

e. These regulations are effective July 1, 1990.

3.2 DEFINITIONS

The following definitions shall apply to the terms used in these regulations:

a. "Agency" means the Maine Emergency Management Agency.

b. "Dam" means. any man-made artificial barrier, including appurtenant works, the site on which it is located and appurtenant rights of flowage and access, which impounds or diverts a river, stream or great pond and which is 2 feet or more in height and has an impounding capacity at water storage elevation of 15 acre-feet or more. Any such artificial barrier constructed solely for the purpose of impounding water to allow timber to be floated downstream in a logging operation shall not be considered a dam for the purposes of this chapter, unless it has been repaired, modified or maintained by or with the knowledge of the owner, lessee or person in control since the discontinuance of its use in connection with logging operations. Any adjacent property, easements, roads, bridges or works not necessary for the operation or maintenance of a dam or access to the dam shall not be included under the provisions of this chapter.

   For the purpose of this regulation, a dam shall be considered an "impounding structure".

c. "Dam reconstruction" means the rebuilding or replacement of all or part of an existing dam that no longer functions in the manner for which it was originally constructed.

d. "Director" means the Director of the Maine Emergency Management Agency.

e. "Emergency Operations Plan" means a set of written instructions or guidelines. for use by public officials which recommends actions which, when implemented, will minimize the effects of a dam failure on people and property.

f. "High or significant hazard" means that condition which poses a risk of loss of human life and substantial property damage.

g. "Public safety" or "safety of the public" means protection of life, health or property from any condition, event or action at a dam which might compromise the safety, stability or integrity of the dam or its ability to function safely.

h. "State Dam Inspector" means an inspector appointed or hired under Section 1064, Chapter 22, Title 37-B M.R.S.A.

i. "Impoundment" means a body of water the storage of which is caused by any existing or proposed impounding structure not exempt from the law.

j. "Owner" means the owner of the land on which is situated, and/or the holder of an easement permitting the construction of a dam and/or any person or entity agreeing to maintain a dam, which includes the State or any of its political subdivisions, including, but not limited to sanitation district commissions and authorities, and public or private institution, corporation, association, firm, or company organized or existing under the laws of this or any other state or country, or any person or group of persons acting individually or as a group.

k. "Design flood" is the runoff, at the site of the impounding structure, utilized in impounding structure design, construction, operation, and maintenance, which will be safely passed by the impounding structure and shall not be less than that recommended spillway design flood commensurate with the size and hazard potential of the particular impounding structure in accordance with the procedures recommended in these regulations.

l. "Design freeboard" means the minimum freeboard which would occur during passage of the design flood.

m. "Inundation zone" means an area that would be inundated in excess of storm water by the water released by the impoundment in the event of a dam breach and is that area which would be inundated immediately downstream from the site of the impounding structure extending to that point on the stream where the calculated water surface profile resulting from the design flood, determined absent the impounding structure, converges with that calculated water surface profile which would result from failure of the impounding structure at the appropriate impounding capacity, with the time of such failure to be considered coincident with the time of occurrence of maximum inflow to the impoundment resulting from the design flood.

n. "Height" means the structural height of a dam which is defined as the vertical distance from the natural bed of the stream or watercourse measured at the downstream toe of the dam to the top of the dam.

o. "Maximum impounding capacity" means normal full pond. It also means the volume in acre-feet that is capable of being impounded at the elevation of the crest of the impounding structure including flash boards if any or the elevation of top of gates, if appropriate.

p. "Impounding capacity" means the volume in acre-feet that is capable of being impounded at the elevation of the crest of the highest ungated outlet from the impoundment.

q. "Life of impounding structure" and "life of the project" means that period of time during which the impounding structure is designed and planned to perform effectively, including that period of time required to remove the structure when it is no longer capable of functioning as planned and designed.

r. "An impoundment constructed, maintained, or operated primarily for agricultural purposes" means an impoundment that is certified by the owner to be such.

s. "Watercourse" means a natural channel having a well-defined bed and banks and in which water flows when it normally does flow.

t. "Acre-foot" means a unit of volume equal to 43,560 cubic feet or 325,853 gallons (one foot of depth over one acre of area).

u. "Flood plain" means those areas adjoining a river, stream or watercourse which have been or hereafter are likely to be covered by flood waters.

3.3 THE CLASSES OF IMPOUNDING STRUCTURES

a. For the purposes of these regulations, existing or proposed impounding structures shall be classified as one of three categories in accordance with Table 1 of this chapter.

b. For the purposes of these regulations, hazards pertain to potential loss of human life or property damage(s) in the flood plain downstream from the structure in event of failure. Structures conforming to criteria for the "low hazard" potential category generally will be found in rural or agricultural areas where failure may damage some farm buildings, limited agricultural land, or country roads. "Significant hazard" potential category structures will be those located in predominantly rural or agricultural areas where failure may damage isolated homes, secondary highways, minor railroads, or other impounding structures or cause interruption of use of service of relatively important pubic utilities. Impounding structures in the "high hazard" potential category will be those located where failure may cause serious damage to homes, extensive agricultural, industrial, and commercial facilities, important public utilities, main highways, railroads, or other impounding structures. Hazard potential classifications shall be proposed by the owner and shall be subject to approval by the Agency. Present and projected development of the flood plain downstream from the impounding structure shall be considered in determining the classification. Impounding structures shall be subject to reclassification as set forth in Section 1065 of Chapter 22, Title 37-B M.R.S.A.

TABLE I

Hazard Potential Classification

Category	Urban Development	Economic Loss
Low Hazard	No permanent structure for human habitation	Minimal (undeveloped to occasional structures or agriculture)
Significant Hazard	No urban development and no more than a small number of habitable structures	Appreciable (notable agriculture, industry, or structures)
High Hazard	Urban development with more than a small number of habitable structures	Excessive (extensive community, industry, or agriculture)

SOURCE: U.S. Army Corps of Engineers

3.4 PROCEDURE(S)

3.41 WHO MUST FILE

An owner who proposes to construct or reconstruct an impounding structure, shall file with the Agency, on forms provided by the Agency for that purpose, a statement concerning the location, purpose, impounding capacity, and height of the existing or proposed impounding structure. If a proposed impounding structure is not exempt from the provisions of the law, construction may not commence until a full and complete filing has been completed with the agency.

3.42 PRELIMINARY REPORT

The owner of a proposed new impoundment or owner of an existing impoundment which is to be constructed or reconstructed shall submit to the Agency a written Preliminary Report regarding the proposed impounding structure. As a minimum, the Preliminary Report shall include the following information:

a. A general description of the impounding structure and appurtenances and a proposed classification as set forth in Section 3.3 of these regulations. The description shall include a statement of the purpose for which the impoundment and impounding structure is to be used.

b. A general description of properties located in the inundation zone downstream from the site of the proposed impounding structure, including the location and number of residential structures, buildings, roads, utilities and other property that would be endangered should failure of the impounding structure occur.

c. A statement from the governing body of the local political subdivision that they are aware of the intent to build or reconstruct an impounding structure and a description of the zoning ordinances and land use classifications applicable to the affected flood plain downstream and upstream from the site of the proposed impounding structure.

d. Maps showing the general location of the proposed impounding structure that include: the county or city in which the (existing or proposed) impounding structure (or would be) located, the location of roads, access to the site, and the outline of the impoundment. Existing serial photographs and existing topographic maps may be used for the purpose.

e. Preliminary drawings of a general nature which include cross sections, plans and profiles of the impounding structure, proposed pool levels, and type of spillways.

f. Preliminary design criteria, including a description of the size, ground cover conditions, and extent of development of the watershed, the geological and the geotechnical engineering assumptions for the foundations and materials to be used.

g. The owner's written request for preliminary and final inspection.

h. Written documentation by the owner's engineers certifying that dam construction will be consistent with final design plans and as-built plans.

i. A schedule for filling the reservoir.

3.43 FINAL DESIGN REPORT

Construction or reconstruction may not commence until a final design report is received by the Agency. The final design report shall include:

a. A report of geotechnical investigations of the foundation soils or bedrock and of the materials to be used to construct or reconstruct the impounding structure.

b. Design assumptions and analyses sufficient to indicate that the impounding structure will be stable during its construction or reconstruction and during the life of the impounding structure under all conditions of reservoir operations, including rapid filling and rapid drawdown of the impoundment.

c. Confirmation of the stability of the reservoir rim area in order to safeguard against reservoir ruin slides of such magnitude as to create waves capable of overtopping the impounding structure and confirmation of stability during seismic activity.

d. Design assumptions and analyses to indicate that seepage in, around, through, or under the impounding structure, foundation, and abutments win be reasonably and practically controlled so that internal or external forces or results thereof will not endanger the stability of the impounding structure.

e. Calculations and assumptions relative to design of the spillway(s).

f. Provision to insure that the impounding structure and appurtenances will be protected against significant deterioration or erosion due to freezing and thawing, wind and rain, or any combination thereof.

g. Other pertinent design date, assumptions, and analyses commensurate with the nature of the particular impounding structure and individual site conditions. When required by the Agency, a delineation of the inundation zone will be prepared by the owner for "high" and "significant hazard" impounding structures.

h. Plans and specifications as outlined in Section 3.54 of this chapter.

i. After verifying that the dam construction methods and design specifications were met, authorization to impound water will be issued prior to filling the reservoir.

j. The Agency shall accept, review, and notify the owner within [45] working days whether the Preliminary Design Report is acceptable or not. The same procedure shall be followed for the Final Design Report.

3.5 DESIGN OF STRUCTURES AND HYDROLOGY

3.51 INVESTIGATION; FOUNDATIONS; CONSTRUCTION MATERIALS, SURVEYS; AND HYDROLOGIC CALCULATIONS

a. The owner shall complete all investigations prior to submitting the design report. The scope and degree of precision required is a matter of engineering judgement based on the complexities of the site and the hazard potential classification of the proposed structure. The geotechnical engineering investigation shall consist of borings, test pits, and other subsurface exploration necessary to define adequately the existing conditions. The investigations shall be performed so as to define the soil, rock, and groundwater conditions.

b. All construction materials shall be adequately specified to insure that their properties meet design criteria. If on-site materials are specified, they shall be located and determined to be adequate in extent and in properties.

c. Surveys shall be made with sufficient accuracy to locate the proposed construction and to define the volume of the storage in the impounding structure. The area downstream from the proposed impounding structure shall be investigated in order to delineate the areas and extent of potential damage in case of failure. Locations of center lines and other horizontal and vertical control shall be shown on a map of the site.

d. The drainage area shall be determined. Present and projected conditions shall be reasonably considered in determining the runoff characteristics of the drainage area. All hydrologic assumptions shall be included in the design calculations which shall be submitted as part of the design report.

e. Periodic inspections will be conducted by a qualified Dam Inspector during the construction or reconstruction of all dams in this State. Additionally, written reports noting all conditions found will be forwarded to the Director, MEMA, within 15 working days. Conditions affecting public safety of employees shall be forwarded to the Director at the earliest opportunity.

3.52 THE DESIGN FLOOD

The magnitude of the minimum design flood to be utilized in impounding structure design, construction, operation, and maintenance shall not be less than the recommended spillway design flood commensurate with the size and hazard potential of the particular impounding structure in accordance with the recommended procedures contained within the Corps of Engineers published guidance and those which are incorporated in these regulations by reference to the extent they are not inconsistent with other provisions of these regulations and existing laws of Maine.

3.53 SPILLWAY DESIGN

a. Every impounding structure shall have a spillway system with adequate capacity to discharge water in keeping with potential hazards involved without endangering the safety of the impounding structure.

b. A spillway shall be required, unless it is demonstrated by the applicant that adequate capacity is provided by other means to prevent endangering the integrity of the impounding structure.

c. A vegetated earth or unlined emergency spillway may be approved when demonstrated that it will pass the spillway design flood without jeopardizing the safety of the structure.

3.54 PLANS AND SPECIFICATIONS

The plans and specifications for a new or reconstructed impounding structure shall consist of the following as a minimum:

a. The name of the project; the name of the owner; classification of the impounding structure as set forth in Chapter 3 of these regulations; designated access to the project; and the location with respect to highways, roads, streams, and existing impounding structures and impoundments that would affect or be affected by the proposed impounding structure.

b. Cross sections, profiles, logs of test borings, laboratory and in situ test data, drawings of principal and emergency spillways, and other additional drawings in sufficient detail to indicate clearly the extent and complexity of the work to be performed.

c. The technical provisions, as may be required to describe the methods of construction and construction quality control for the project.

d. Special provisions, as may be required to describe technical provisions needed to insure that the impounding structure is installed according to the approved plans and specifications.

Plans and specifications shall be submitted with the final design report.

e. The owner shall notify the Agency of any proposed changes in design, plans, and specifications that will affect the safety of the impounding structure.

3.6 CONSTRUCTION SCHEDULE

3.61 The applicant shall submit a construction schedule with the final design report that includes:

a. A time and construction sequence schedule that includes the estimated time to complete the construction activities.

b. Techniques to be used to divert stream flow during construction to prevent hazard to life, health, and property.

c. A plan of quality control testing to confirm that materials and construction methods met the design requirements set form in the specifications.

3.7 ACCEPTABLE DESIGN PROCEDURE AND REFERENCES

3.71 The following are acceptable as design procedures and references:

a. The design procedures, manuals, and criteria used by the United States Army Corps of Engineers.

b. The design procedures, manuals, and criteria used by the United States Department of Agriculture, Soil Conservation Service.

c. The design procedures, manuals, and criteria used by the United States Department of the Interior, Bureau of Reclamation.

d. The design procedures, manuals, data, and criteria used by the United States Department of Commerce, National Weather Service.

STATUTORY AUTHORITY: Section 1063 of Chapter 22, Title 37-B M.R.S.A.

EFFECTIVE DATE:
July 22 1990

EFFECTIVE DATE (ELECTRONIC CONVERSION):
May 13, 1996

NON-SUBSTANTIVE CHANGES:
January 28, 1999 - converted to Microsoft Word.
March 23, 1999 - minor spelling, grammar and formatting; insertion of missing word in 3.51(e).

E.19. Maryland



HAZARD CLASSIFICATIONS
&
DANGER REACH STUDIES FOR DAMS

By

Bruce W. Harrington, P.E.
MD Dept. of The Environment
Dam Safety Division

To determine the hazard classification of a proposed dam[1] or reevaluate the hazard classification of an existing dam, an incremental flood analysis is required. The first step in an incremental flood analysis is to determine downstream flood depths and velocities without the dam to establish baseline flooding conditions. The second step is to determine the increased flood depths and velocities associated with dam failures during the same hydrostatic and hydrodynamic loading conditions. These loading conditions include several storm events that will or could occur during the lifespan of the dam. The storms to be examined include the following loading conditions: 1) normal pool, 2) 100-year flood, 3) brim-up flood, 4) 50% probable maximum flood (PMF) and 5) PMF.

The normal pool or sunny day loading condition is the breach flow released from the dam during a normal pool failure. If there is no permanent pool, a sunny day failure would be assumed to occur at the first large opening in the principal spillway above the low flow outlet. The storm event that fills the reservoir up to the top of dam is the brim-up storm event. This storm event can be determined very quickly by selecting a few rainfall events larger than the design storm and routing them through the spillways. The PMF is the largest flood that is expected to occur on a watershed. The PMF is based on the most severe combination of meteorological and hydrological conditions that are reasonably possible.

In Maryland, all significant and high hazard dams require an emergency action plan to safeguard lives and reduce property damage in the event of a dam failure. In order develop an emergency action plan for an existing or proposed dam, a danger reach map must be completed. *If the hazard classification of an existing dam is well known, only a danger reach study is needed to define the downstream reach that would receive increased flooding if the dam were to fail.*

The hazard classification of the dam is usually based on the increased flood depths and velocities against or over downstream structures. These structures include houses, buildings, important utilities, roads and railroads. The U.S. Bureau of Reclamation Flood Danger Graphs[2] shown on pages 5, 6, and 7 of this document are used to determine if increased flood dangers will exists with a dam failure. If the depths and velocities with a dam failure increase from low to high danger as shown on the graphs, the dam would be classified as significant or a high hazard structure depending on the type of structure flooded and the probable loss of life. The definitions of low, significant & high hazard classifications for dams are defined on page 3.

[1] A dam also refers to an embankment pond or a road embankment used for stormwater management.
[2] "Downstream Hazard Classification Guidelines" ACER Technical Memorandum No. 11, USBR, 1988

After the hazard classification of the dam has been defined, the danger reach is typically determined by failing the dam during the normal pool and design storm loading conditions, and routing the dam failures downstream to a point where the increased flood depths are less than one foot. A low, significant, or high hazard dam is usually designed to safely pass the 100-year storm, 50% PMF, or PMF, respectively. The minimum freeboard above the design storm to the top of the dam is one foot but may be increased if there is no emergency spillway or if wave run-up is significant.

Dam Failure

A dam failure hydrograph is computed by the HEC-1 or National Weather Service (NWS) Dam-Break Models. For dams equal to or greater than 75 feet in height, the NWS Dam-Break Model is required. For dams smaller than 75 feet high, the HEC-1 or NWS Dam-Break Models may be used to determine the breach hydrograph. Although the NWS Dam-Break Model is considered to be the most accurate model to determine dam failures, it is also very complex and temperamental, and requires considerable engineering expertise.

To determine the dam failure hydrograph, four parameters are needed to define the breach formation through the dam. These parameters include the breach bottom width, side slopes, time of failure, and the selected failure and breach bottom elevations. For earth embankment dams, the average breach width ranges from 1 to 5 times the height of water against the dam at failure; the breach side slopes range between 0 to 1 foot horizontal to 1 foot vertical; and the time of failure ranges from about 10 minutes for small dams to approximately 4 hours for very large dams. In 1987, Froelich developed breach predictor equations that estimate the average breach width and time of failure based on the height of water above the breach bottom and the corresponding storage volume. These equations, which were revised by Froelich in 1995, are included on page 12 of this document. Examples of input data for the HEC-1 and NWS Dam-Break Models can be obtained by contacting the Maryland Dam Safety Division.

Hydrology

To determine the storms used for hazard classifications or danger reach delineations, the HEC-1 or TR-20 Computer Models are required for drainage areas less than or equal to 10 square miles. For dams less than 10 square miles of drainage area, use a 24-hour duration rainfall for the 100-year and brim-up storm events; and a 6-hour duration rainfall for the 50% PMF and PMF. For drainage areas larger than 10 square miles, the HMR-52 Model is recommended to determine the rainfall amount and distribution. The rainfall hyetograph data from the HMR-52 Model is inputted into the HEC-1 Model for flow computations.

I. Compute Storm Events and Breach Flows in the Danger Reach Area Below the Dam

A. Calculate runoff, flows, and hydrographs (hydrology) on the watershed above the dam and the danger reach area below the dam for the 100-year, brim-up, 50% PMF, and 100% PMF storm events. (**HEC-1, TR-20, & HMR-52 Models**).

B. Route storms as well as sunny day failure through dam and downstream floodplain with & without dam failure. ***If the hazard classification of the dam is known, only the sunny day and design storm (PMF for High Hazard Dams) are necessary to define the danger reach limits.*** The danger reach must extend downstream to a point where the increased flood levels is less than one foot.

Hydraulics

Compute the existing and proposed water surface elevations for the selected storm events. The HEC-1, HEC-2, HECRAS, or National Weather Service Dam-Break Models are used to determine the flood depths. For drainage areas less than 10 square miles, the HEC-2 or HECRAS Models are recommended because they are easy to learn and apply, and provide reasonably accurate water surface elevations.

For danger reaches that impact only downstream roads and a few buildings, the HEC-1 Model may be used for both hydrology and hydraulic calculations. The HEC-1 Model is not as accurate in calculating the depth of flooding because the floodplain cross sections are not detailed and the water surface slopes are approximated. To use only the HEC-1 Model for hydrologic and hydraulic computations, discuss the dam failure study with the Dam Safety Division for approval.

I. Calculate The Water Surface Profiles Both With and Without Dam Failure in The Danger Reach

A. Input flow values, stream cross-sections, Manning's roughness values, and dam & road structure data into the water surface profile models.

B. Determine increased flood risks to houses, buildings, and roads by using the enclosed USBR Hazard Graphs.

II. Determine Hazard Classification of Dam

A. Classify or reclassify dam as a low, significant, or high hazard structure.

1. Low Hazard - Unlikely loss of life; minor increases to existing flood levels at roads and buildings.

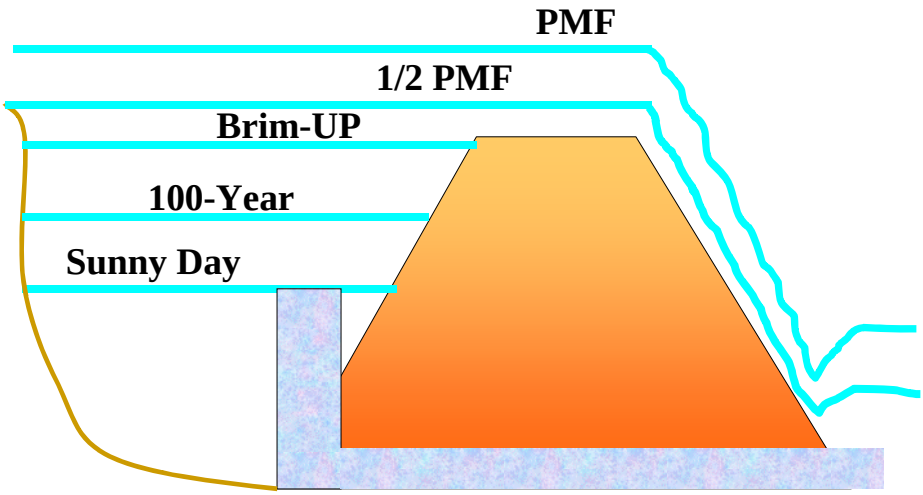
2. Significant Hazard - Possible loss of life, significant increased flood risks to roads and buildings with no more than 2 houses or 6 lives in jeopardy.

3. High Hazard - Probable loss of life; major increases to existing flood levels at houses, buildings, major interstates and state roads with more than 6 lives in jeopardy.

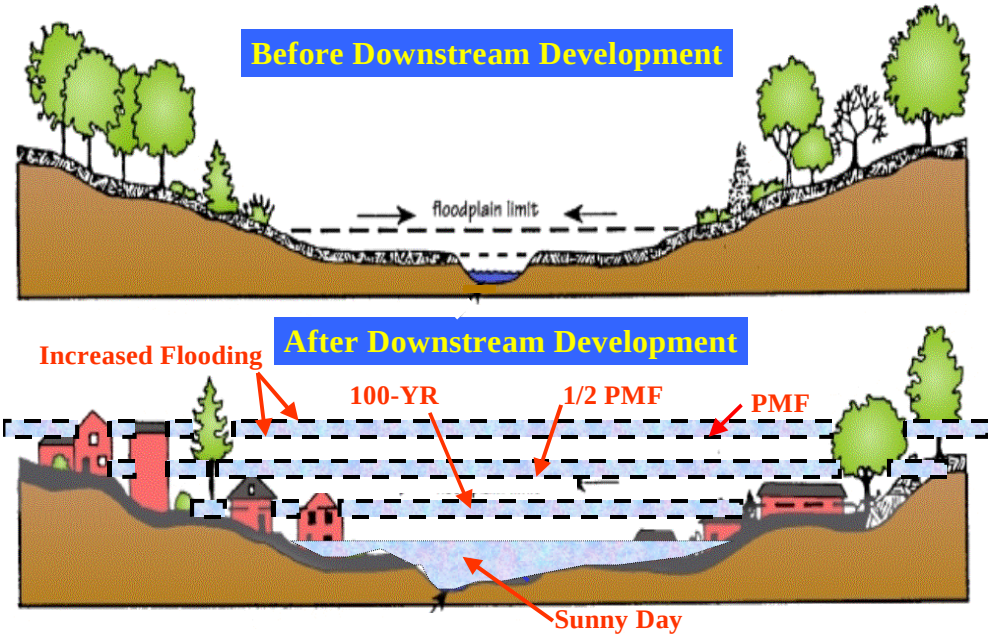
III. Develop Danger Reach Maps

A Plot the flood boundaries for the sunny day and design storm dam failures on topographic maps. The map must clearly show downstream roads, buildings, and houses within the danger reach, and the recommended evacuations routes. The danger reach maps are to be included in the Emergency Action Plan for the dam and should be no larger than 11" x 17" per panel.

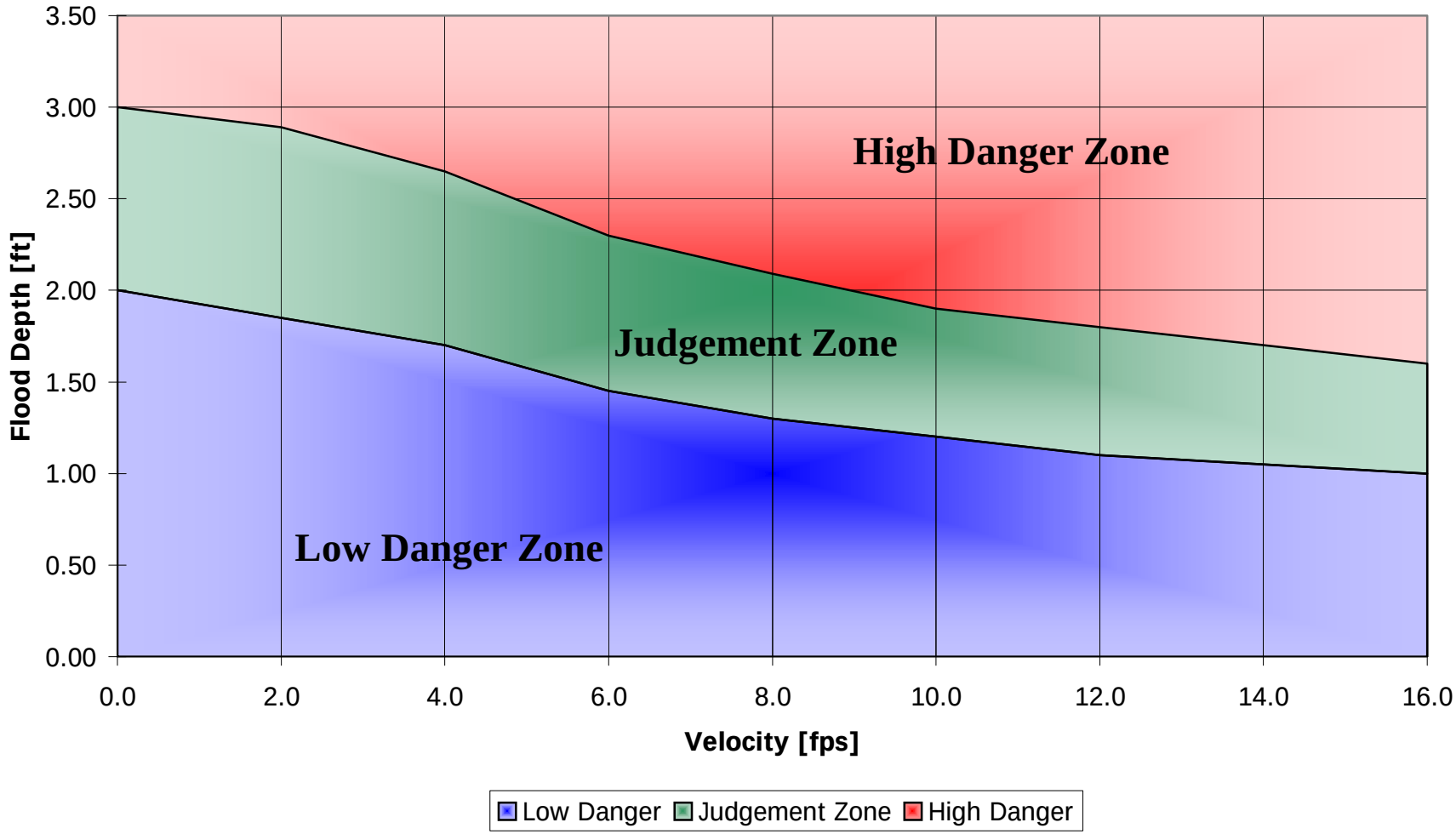
Failure Storms to Analyze



Increased Flood Risks

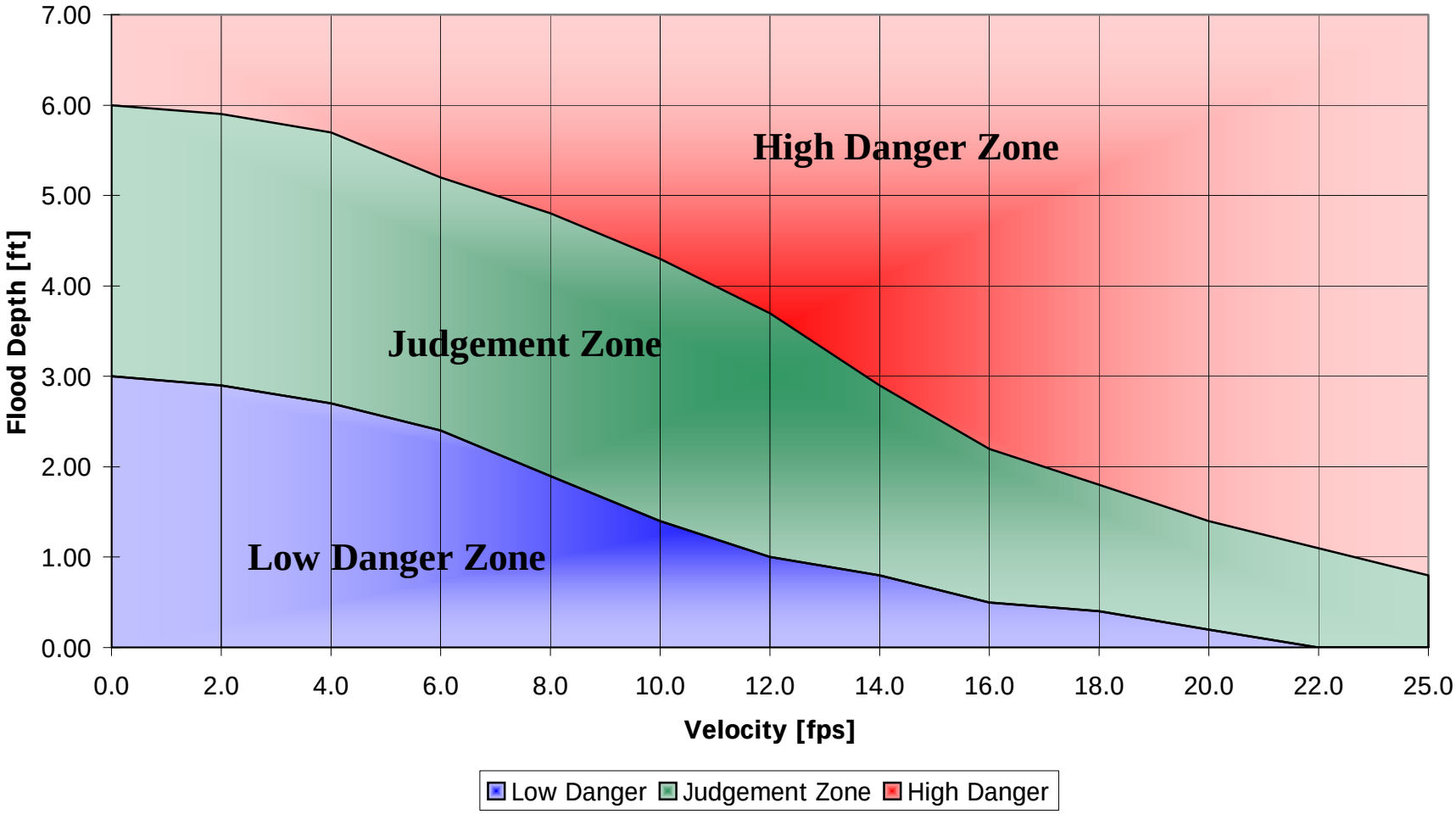


Flood Danger for Cars



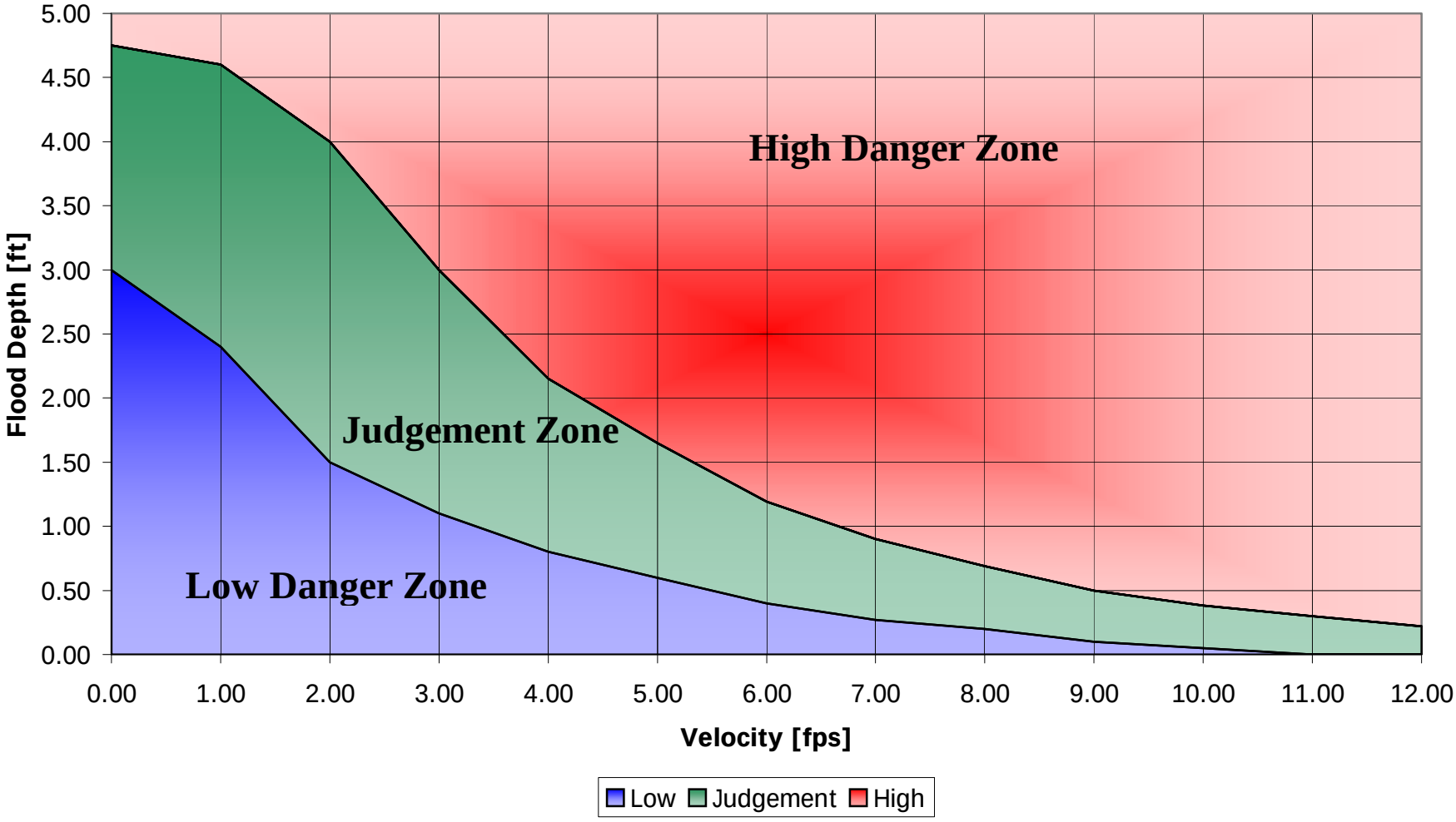
Source: ACER Technical Memorandum No. 11, "Downstream Hazard Classification Guidelines", USBR, 1988

Flood Danger for Houses

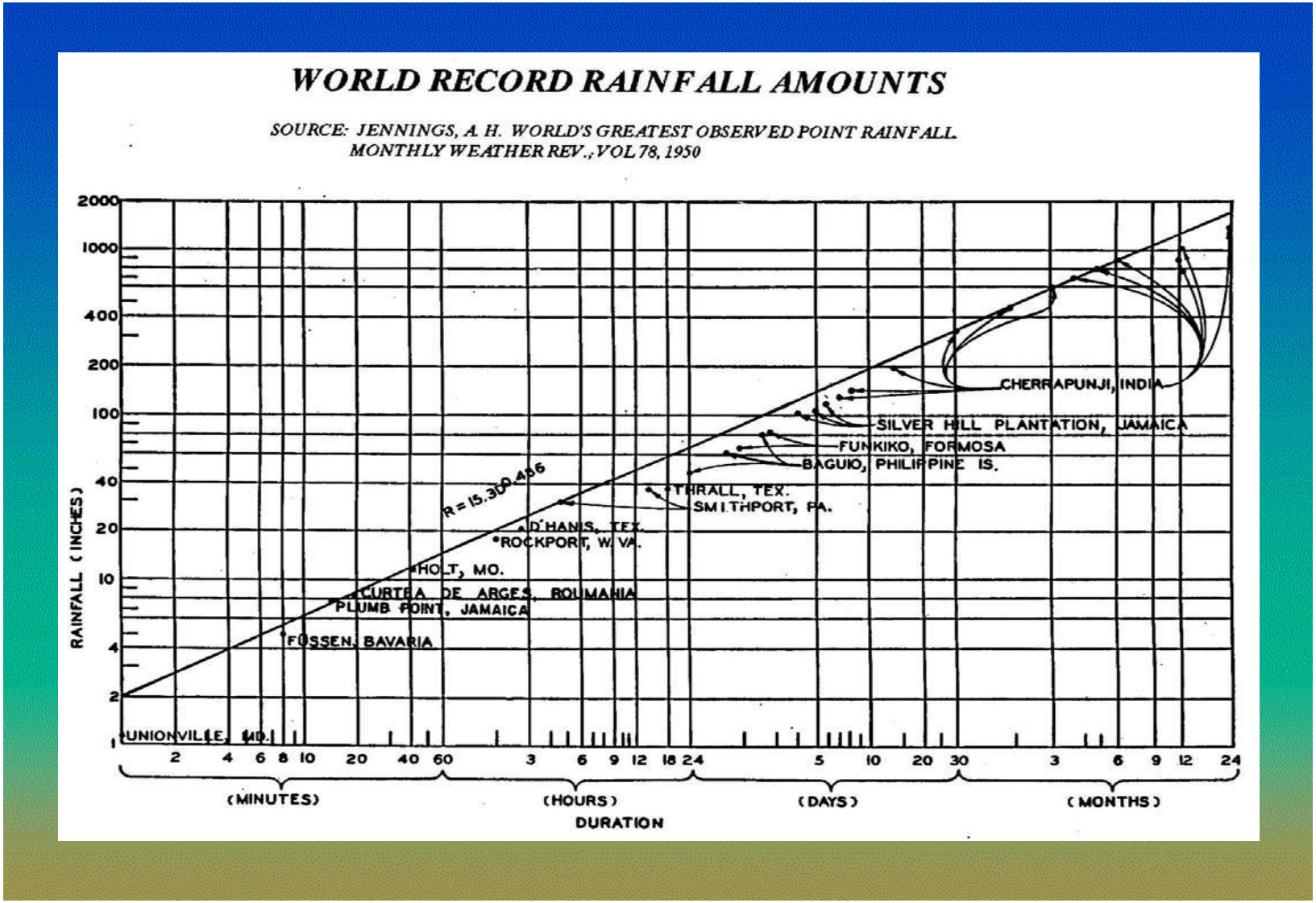


Source: ACER Technical Memorandum No. 11, "Downstream Hazard Classification Guidelines", USBR, 1988

Flood Danger for Adults



Source: ACER Technical Memorandum No. 11, "Downstream Hazard Classification Guidelines", USBR, 1988


WORLD RECORD RAINFALL AMOUNTS
SOURCE: JENNINGS, A. H. WORLD'S GREATEST OBSERVED POINT RAINFALL. MONTHLY WEATHER REV., VOL 78, 1950
RAINFALL (INCHES)
2000
1000
400
200
100
40
20
10
4
2
1
R = 15.30 D^0.456
CHERRAPUNJI, INDIA
SILVER HILL PLANTATION, JAMAICA
FUNKIKO, FORMOSA
BAGUIO, PHILIPPINE IS.
THRALL, TEX.
SMITHPORT, PA.
D'HANIS, TEX.
ROCKPORT, W. VA.
HOLT, MO.
CURTEA DE ARGES, ROUMANIA
PLUMB POINT, JAMAICA
FÖSSEN, BAVARIA
UNIONVILLE, MD.
2 4 6 8 10 20 40 60 3 6 9 12 18 24 5 10 20 30 3 6 9 12 24
(MINUTES)
(HOURS)
(DAYS)
(MONTHS)
DURATION

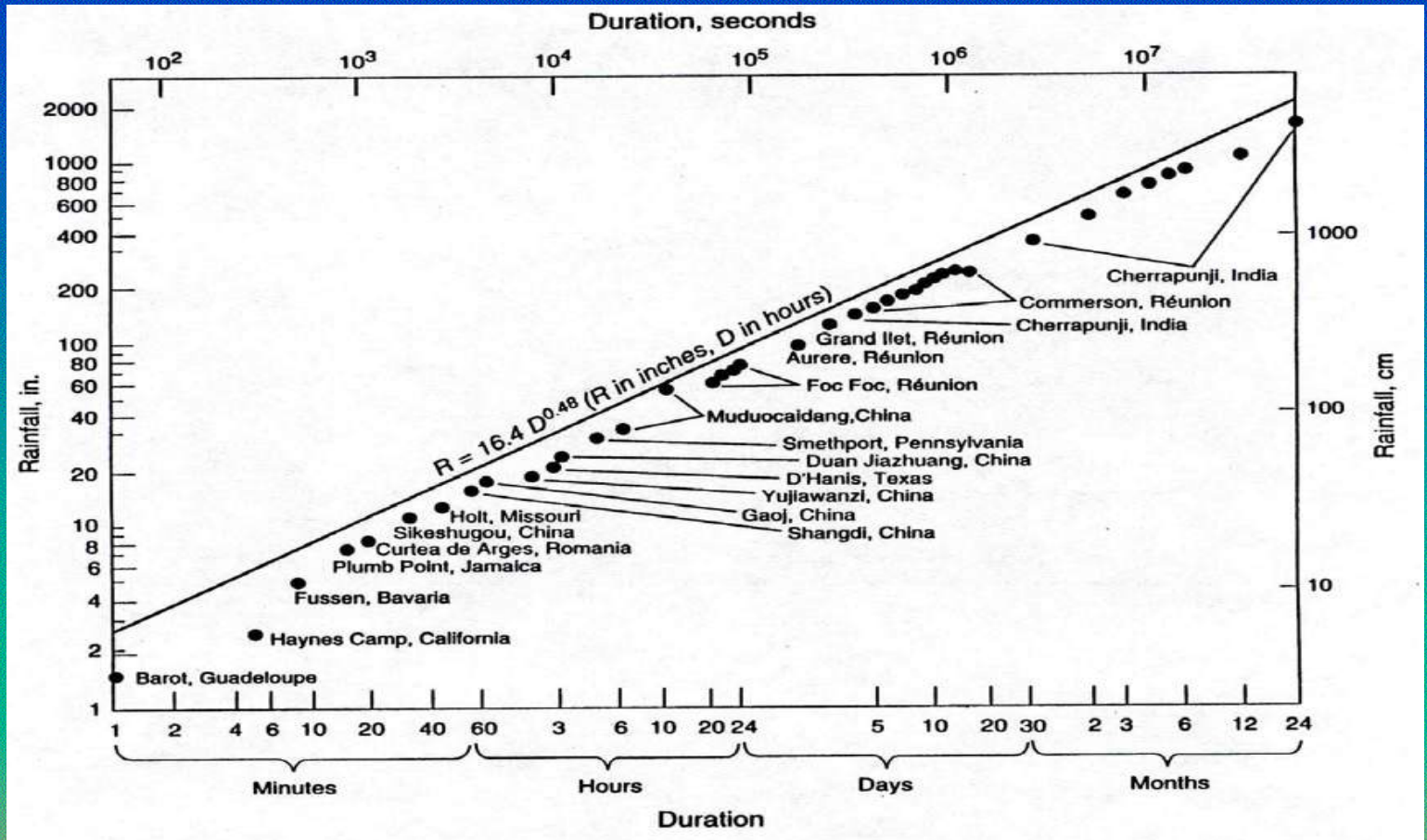
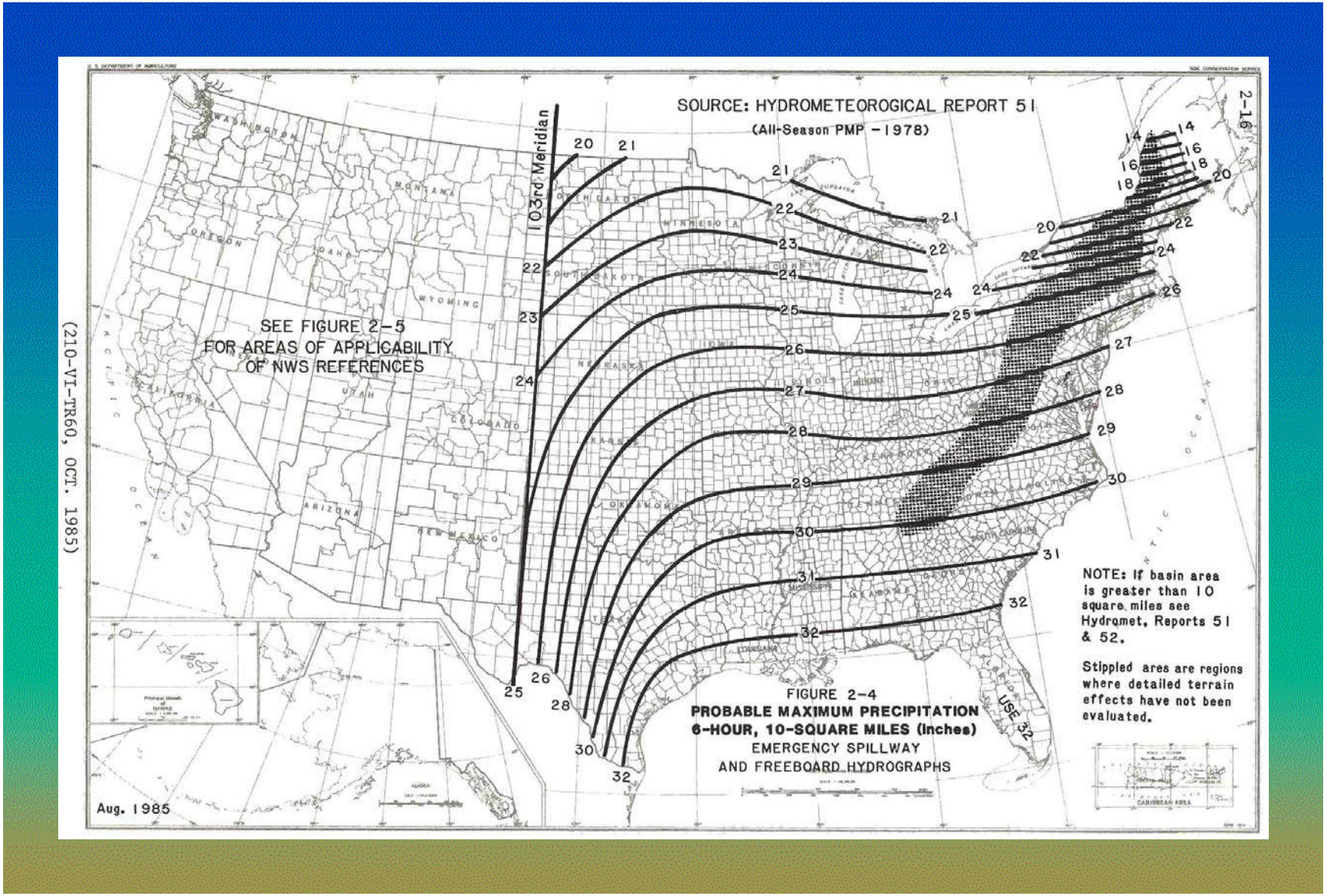


FIGURE 1 Maximum observed point rainfalls as a function of duration. (Courtesy of John Vogel, National Weather Service.), 1986.


SOURCE: HYDROMETEOROLOGICAL REPORT 51
(All-Season PMP - 1978)
2-16
103rd Meridian
SEE FIGURE 2-5
FOR AREAS OF APPLICABILITY
OF NWS REFERENCES
NOTE: If basin area is greater than 10 square miles see Hydromet. Reports 51 & 52.
Stippled ares are regions where detailed terrain effects have not been evaluated.
USE 32
FIGURE 2-4
PROBABLE MAXIMUM PRECIPITATION
6-HOUR, 10-SQUARE MILES (Inches)
EMERGENCY SPILLWAY
AND FREEBOARD HYDROGRAPHS
Aug. 1985
(210-VI-TR60, OCT. 1985)

Suggested Breach Parameters for Earth Dams

Source	Average Breach Width (ft)	Breach Side Slope (1V:ZH)	Breach Failure Time (hrs)
NWS (1988)	1H to 5H	Z = 0 to 1	0.1 to 2.0
COE (1980)	0.5H to 4H	Z = 0 to 1	0.5 to 4
FERC (1991)	1H to 5H	Z = 0 to 1	0.1 to 1.0
USBR (1982)	3H	N/A	0.00333b
Boss Dambrk (1988)	0.5 to 4H	Z= 0 to 1	0.5 to 4
Harrington (1999)	1H to 8H	Z= 0 to 1	H/120 to H/180

Note: H = Height of water against dam above breach bottom elevation in feet.

Froelich Breach Predictor Equations

$$b = 9.5 K_0 (V_s H)^{0.25}$$

$$\tau = 0.59 (V_s^{0.47}) / H^{0.91}$$

b = Average Breach Width (ft),

= Time of Failure (hrs)

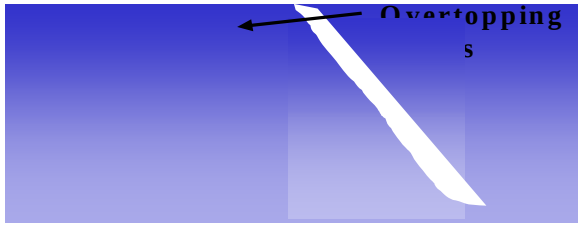
K_0 = 0.7 for Piping & 1.0 for Overtopping Failure

Vs = Storage Volume (ac-ft)

H = Selected Failure Depth (ft) above Breach Bottom

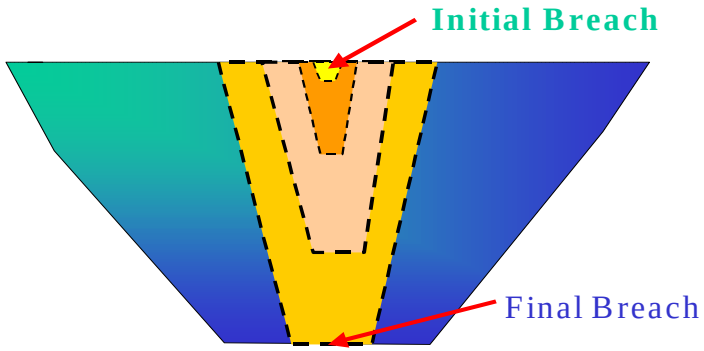
τ = Time of Failure (hrs)

Overtopping Failure

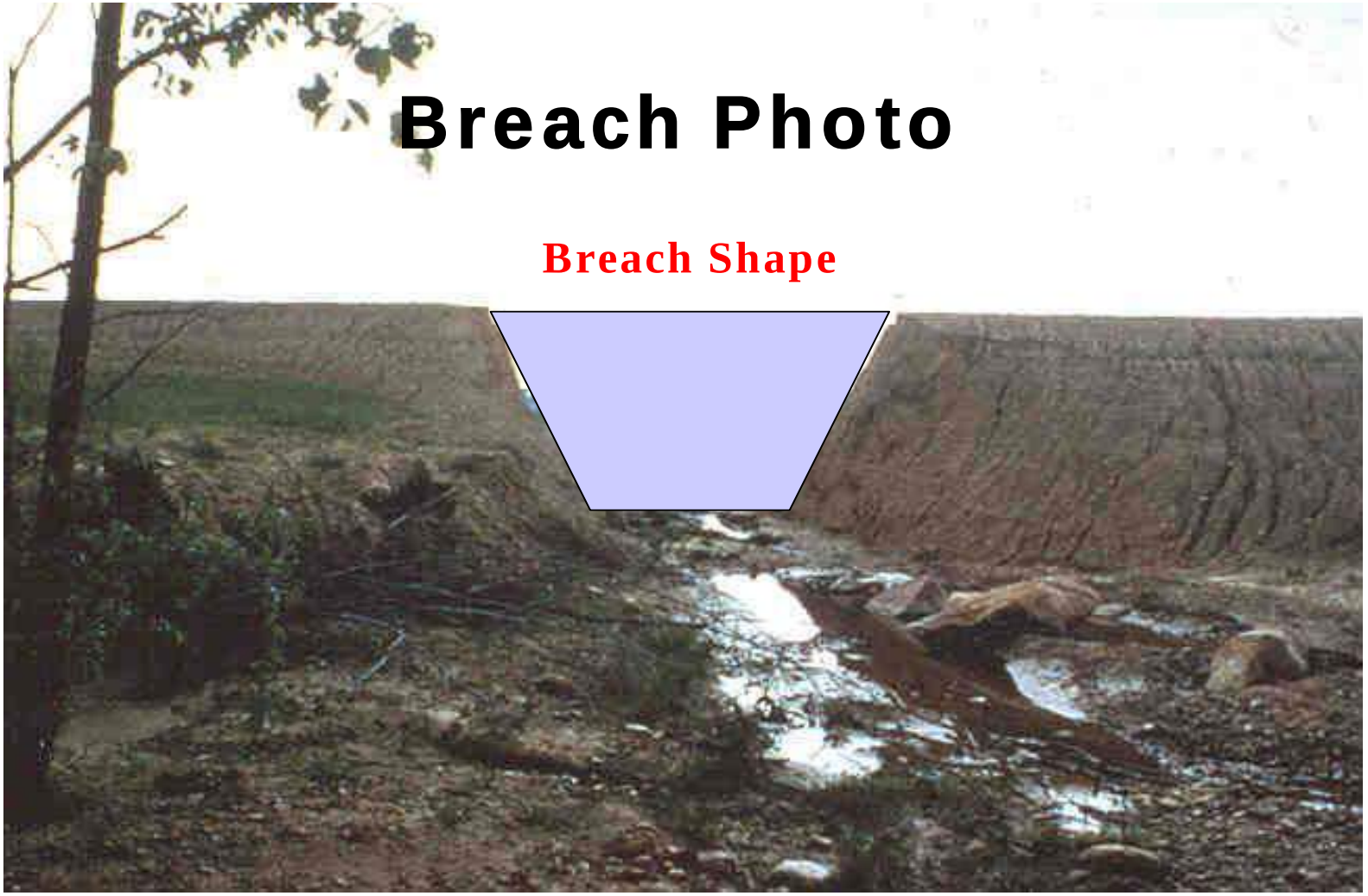


Profile View

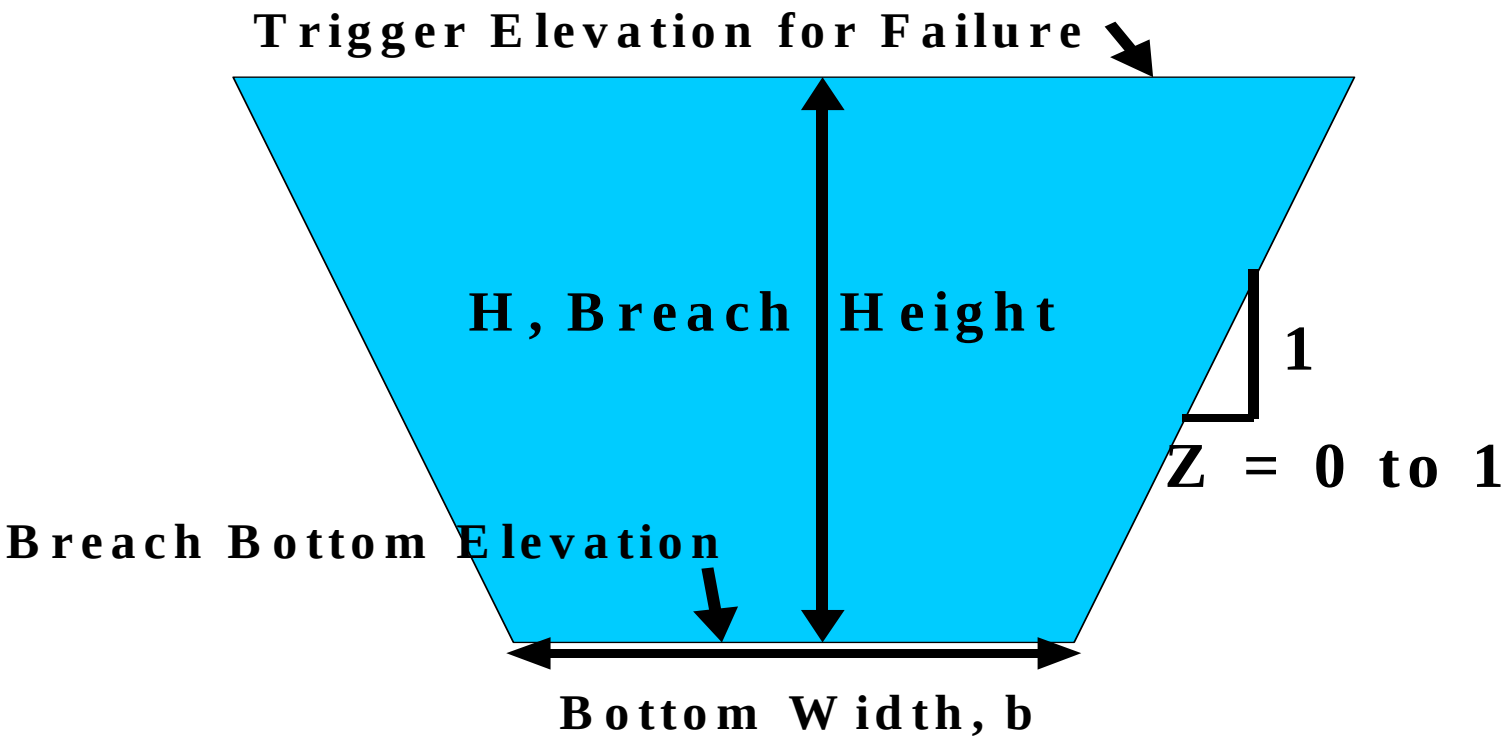
Overtopping Breach of Earth Dam



Cross Section View


Breach Photo
Breach Shape

Breach Parameters



26.17.04.05

.05 Dams and Reservoirs.

A. In addition to the general requirements in Regulation .04 of this chapter, the following special requirements shall apply to applications for dams and reservoirs:

(1) A person who applies to construct, reconstruct, repair, or alter a dam or reservoir shall engage a registered professional engineer, practicing in accordance with the laws of Maryland and qualified in the field of dam design and construction to prepare the designs and specifications and to provide supervision during construction of the proposed works. The engineer shall be the engineer-in-charge and shall:

(a) Be responsible for assuring that the designs conform to the high standards of professional competence in the specialty of dam design and construction;

(b) Assure that the construction is carried out in strict accordance with the approved plans and specifications and under the provisions of the permit; and

(c) Submit to the Administration a resume of all previous dam design and construction experience, listing specific responsibilities and a written certification of qualification to act as the engineer-in-charge.

(2) If an engineering team is planned for the design and construction, one registered professional engineer shall act as the engineer-in-charge. However, each individual on the project team shall document that individual's area of responsibility and technical experience. This documentation shall accompany the permit application.

(3) Making Application. The procedure for obtaining a permit for construction, reconstruction, repair, or alteration of a dam or reservoir is established in two steps:

(a) Step One. Plan Development Phase of Permit for a Waterway Obstruction. The applicant shall first obtain the Administration's written approval of the classification of the dam as outlined in §B of this regulation. The applicant shall then submit to the Administration an application which includes a feasibility report. Upon approval of the completed application, the Administration shall issue a Plan Development Permit. The decision of the Administration to issue or deny a Plan Development Permit shall constitute a final decision for the purposes of appeal to the Board of Review pursuant to Natural Resources Article, §1-107, Annotated Code of Maryland. The feasibility report shall include the following:

(i) Objectives and purposes of the project.

(ii) Alternate proposals studied.

(iii) General description of proposed dam and reservoir, including a plan view and cross section.

(iv) Conclusions on the dam site and adjacent valley walls and floor based upon geologic maps, surface investigations, seismic, geophysical, or geotechnical studies, or any preliminary soil borings made.

(v) Conclusions on the safety and effectiveness of the dam in impounding water.

(vi) Hydrologic studies including the determination of the inflow design flood, the danger reach, and the proposed operation of the dam and reservoir.

(vii) A map showing the project location, ownership of land affected, and showing any existing or proposed water or sewer lines, pipelines or electric transmission lines crossing the impoundment area and their planned relocation or protection. The map shall also show the location of other existing or proposed dams, reservoirs or other water resource projects, whose conditions of flow or operations may affect or be affected by this proposed project.

(viii) Type and source of materials to be used in construction. When natural materials (earth, rock, etc.) are to be used, the engineer shall indicate the approximate structural properties and availability of each kind of material.

(ix) Photographs of the proposed site.

(x) Estimated benefits from the project, including the design life of the project.

(xi) Estimated cost of the project and length of time required for construction of the structure and filling of the reservoir.

(xii) The owner's written assurance that funds will be available to complete the project as planned and for continued maintenance of the project throughout the life of the structure.

(xiii) An environmental study that includes measures to preserve or enhance the aesthetic, scenic, and wild values at the project site and upstream and downstream of the project. If the project is on a stream within the State Scenic and Wild Rivers Program, this information shall include measures to be taken to preserve the aesthetic and scenic values and the wild qualities of the stream.

(xiv) Foundation investigations shall define the location, type, strength, and other pertinent characteristics of the foundation material. Foundation investigations shall further disclose ground water conditions and other applicable information necessary for analysis of possible seepage problems.

(xv) Topographic surveys shall be made in sufficient accuracy to define the volume of storage in the reservoir and the flow limits. Property lines shall be shown in order that any potential effects of the water in the reservoir on adjacent properties may be determined. The downstream area shall be investigated and, if necessary, surveyed in order to establish the area of potential damage in case of failure.

(xvi) Establishment of proposed minimum releases after the reservoir is filled.

(b) Step Two. Construction Phase of Permit for a Waterway Obstruction. Before the Administration may issue a construction permit for the dam or reservoir, a separate permit application shall be accompanied by final construction plans, specifications, and other information that may be required. Final construction plans, specifications, and other data required before a permit may be issued shall include the following:

(i) Design report with all pertinent computations, including: geology (location and logs of soil and rock borings, conclusions, etc.); soil or rock mechanics tests; hydrology; design criteria; hydraulic design (flood routing, stage storage curve referenced to the lowest drain, velocities in downstream channel, etc.); structural design; stability analysis (including rapid drawdown); and, quantities and cost estimates.

(ii) Construction plans and location sketch, showing borrow areas, spoil areas, etc.

(iii) Construction specifications.

(iv) Provisions for minimum releases during construction and reservoir filling.

(v) Time schedule for construction.

(vi) Approved grading and sediment control plan, showing the measures for controlling sediment loss during and after construction.

(vii) Maintenance plan describing the steps to be followed by the owner to provide for the continued maintenance of the dam and reservoir during the expected life of the structure. This plan shall describe what work is to be called for at periodic intervals or when necessary to keep the structure in good condition. Among other items it shall address mowing or cutting of brushy growth on embankments, preventing erosion or gullying of embankment surfaces, clearing of toe drains, the prevention of accumulation of trash and debris, the protection against rust and spalling, and the exercise of valves or other mechanical equipment. The description of this program shall be submitted to this Administration for approval and inclusion among the required conditions of the construction permit.

(viii) Operations plan describing the steps to be followed by the owner to provide for the safe operation of the dam and reservoir and the continued minimum releases, withdrawals, etc.

(ix) A warning plan for Category I and Category II dams describing the steps to be followed in notifying persons whose lives, property, or health may be endangered by failure, improper operation, or other circumstances affecting the safety of the dam. The warning plan shall identify the most practical and expeditious means for notifying potentially affected persons in close proximity to the dam or property owners.

(x) A requirement by the Administration that the applicant post a construction bond, irrevocable letter of credit, or other security acceptable to the Administration to assure that funds are available to complete the construction of the proposed project and for continued maintenance of the project throughout the life of the structure.

B. Structure Classification and Design Criteria.

(1) Classification of Dams. The following table sets forth judgmental factors for minimizing the risk associated with the design of dams. The table is intended only as a guide. A proposed dam shall satisfy all four factors (normal pool storage volume, normal depth, potential for loss of life, and potential for damage) in order to avoid classification in a more rigorous category. Failure damage potential shall consider future development and use of the area flooded throughout the danger reach and the damage which would be expected from a complete breaching of the dam. If, in the opinion of the Administration, future development is probable in the area flooded throughout the danger reach, the dam shall be classed in Category I. The classification of the proposed dam shall be assigned by the Administration after the applicant has provided information on the potential damage within the danger reach, as defined herein. After the classification has been assigned, the inflow design flood and spillway design may be established. Dams qualifying for the Category III classification may be classed in Category IV, if all of the requirements of Environment Article, §5-503(b), Annotated Code of Maryland, are met with the exception of §5-503(b)(1).

GUIDE TO CLASSIFICATION OF DAMS

Category	Normal Pool Storage Volume in acre-feet)	Normal Depth (in feet)	Potential for Loss of Life	Potential for Damage
I	20,000 or more	50 or more	probable	Serious damage to: residential, industrial, or commercial buildings; important public utilities, public roads; or railroads
II	1,000 or more and less than 20,000	25 or more and less than 50	small possibility	Located in predominately rural or agricultural areas where failure may cause damage to isolated residences or cause interruption of use or service of public utilities or roads. Damage is within the financial capability of owner to repair.
III	less than 1,000	less than 25	very unlikely	Damage is of same magnitude as cost of dam and within the financial capability of owner to repair.
IV*	less than 100	less than 15		

*Category IV is reserved for those structures which have a contributing drainage area of less than 1 square mile (640 acres), and a normal depth of water less than 15 feet above the original stream bed, and a normal surface area less than 12 acres.

(2) Danger Reach. A danger reach shall be established for all proposed dams by routing a flood hydrograph resulting from a failure of the structure. Computation of the danger reach is an iterative process and, based upon the potential for damage and loss of life, may necessitate reclassification to a higher category by the Administration. The danger reach shall be established using methods that compare the depth and aerial extent of the flood waters without and with the proposed dam as follows:

(a) The inflow design flood shall be flood routed throughout the downstream valley without the proposed dam in place.

(b) A dam-breach flood wave shall be routed throughout the downstream valley assuming failure of the dam. The following procedures are incorporated by reference and shall be considered acceptable by the Administration:

(i) DAMBRK-The NWS Dam-Break Flood Forecasting Model, The Hydrologic Engineering Center, U.S. Army Corps of Engineers, February, 1984;

(ii) HEC-1 Flood Hydrograph Package, Computer Program 723-X6-L2010, The Hydrologic Engineering Center, U.S. Army Corps of Engineers, September, 1981 (Revised January, 1985);

(iii) Technical Release Number 66, Simplified Dam-Breach Routing Procedure (Revised December, 1981).

(c) Under §B(2)(b) of this regulation, consideration shall also be given to the peak discharge caused by the design storms in the uncontrolled area below the dam, together with the flow over and through the dam.

(3) Inflow Design Flood. The inflow design flood for Category I dams shall be the probable maximum flood. For Category II dams the inflow design flood shall be the standard project flood or the largest flood of record, whichever is greater. For Category III dams the inflow design flood shall be one having a recurrence interval of once in 100 years or longer. For Category IV dams the inflow design flood shall be as defined in USDA, Natural Resource Conservation Service, Maryland Conservation Practice, Standard Pond Code 378 (January, 2000), which is incorporated by reference in COMAR 26.17.02.01-1B(2). Criteria shall be provided or approved by the Administration for each of the above inflow design floods.

(4) Spillway Design. Established procedures for spillway design and capacity, when properly applied, will be accepted by the Administration. The effects of storage may be taken into account in establishing spillway capacity and top of dam. All spillways shall be designed to adequately handle debris either by trash racks or with sufficient opening. All dams shall have an overflow spillway included in the design. A constructed earthen embankment may not be used as an overflow spillway. All dams classed in Category I or II shall be designed with an emergency spillway which passes the inflow design flood without endangering the dam and whose predicted frequency of use is not greater than once in 100 years. Adequate provision shall be made to dissipate the energy of water flowing over or through the dam and to protect the downstream toe of the dam.

(5) Dams in Category IV. The designs, plans, and specifications for all dams not approved by the soil conservation district and classed in Category IV shall be reviewed by the Administration for technical compliance with the requirements in USDA, Natural Resource Conservation Service, Maryland Conservation Practice, Standard Pond Code 378 (January, 2000), which is incorporated by reference in COMAR 26.17.02.01-1B(2).

C. Design Specifications.

(1) Design References. References used by the designer shall be cited in the application submitted to the Administration, especially where unusual features are incorporated in the design.

(2) Freeboard. The design shall allow for certain freeboard as a minimum, not to be reduced under any circumstances during the operation of the dam and reservoir. The design freeboard is for that reservoir stage which will exist when the pool has reached maximum level during the inflow design flood with the outlet works and overflow spillway operating as planned. The freeboard is to be calculated to prevent overtopping and protect the dam against the destructive forces of waves, frost, settlement, and surface erosion.

(3) Safety Factor. The safety factor shall be that used in good engineering practice in dam design. In all important structural features, the safety factor used shall be shown in the design assumptions. The Administration requires a safety factor of at least 1.5 to be included in the structural design of the dam or any of its components during steady state seepage conditions, and at least 1.2 during rapid drawdown of the reservoir pool from the spillway crest. If site conditions or the downstream hazard category warrants, the Administration may require a safety factor of greater than specified in this section.

(4) Drains. Dams shall include a device to allow draining of the reservoir within a reasonable amount of time. The following factors shall be considered in determining the reasonable time period for drainage:

(a) The risk and nature of a potential dam failure;

(b) The time likely to be available to avert a failure after notice of conditions threatening the safety or stability of the

dam; and

(c) The influence of rapid drawdown on the stability of the dam, its appurtenant works, and the natural upstream slopes of the reservoir.

(5) Specifications. Specifications shall be written to assure that design criteria, with regard to the quality of the materials and methods of construction, will be met or exceeded.

(6) Providing Means for Inspections. The Administration may include, either at the time of granting a permit for construction of a dam or at a later date, a requirement that the owner provide and install devices necessary for the future inspection and surveillance of the dam. The number, type, and location of the devices shall be determined as a result of the Administration's evaluation of the size and nature of the dam, the complexity of local natural conditions, and the degree of risk resulting from any future deterioration or failure. The requirement may include provisions for the measurement of the settlement of the crest or slopes of dams, the movement of walls in the valley or reservoir, the increases in pore-water pressure in earth or the increases in flow from drainage systems, and the installation of other devices required to detect serious changes in the structure or the affected area to allow the repair of deficiencies before more serious risk develops.

(7) Multiple Dams. When dams are spaced so that the failure of an upstream dam or structure could endanger the safety of one downstream, the possibility of a multiple failure shall be considered in reviewing the design. Additional safety shall be provided in either structure by increasing the retarding storage or increasing the emergency spillway capacity, or both.

D. Construction Requirements.

(1) Construction shall be under the supervision of the engineer-in-charge as defined in §A(1) of this regulation.

(2) Appropriate tests, as required by the Administration, shall be made of materials used in the construction of the dam. Materials failing to meet applicable specifications shall be removed and replaced with acceptable materials.

(3) The engineer-in-charge shall submit periodic construction progress reports to the Administration. Progress report forms and the frequency of reporting will be provided by the Administration before construction.

(4) A history of the construction shall be maintained by the engineer-in-charge, and shall include:

(a) Date, location, and results of all materials tests made.

(b) Narrative of problems encountered during construction and changes in design. Necessity for these changes shall be reported to the Administration for approval before proceeding with construction.

(c) "As built" plans.

(5) The above information shall be maintained at the construction site. The information shall be submitted to the Administration within 60 days after the completion of the dam and shall be accompanied by the written certification from the engineer-in-charge to the Administration that the completed structure has been constructed in accordance with plans and specifications and changes approved by the Administration. The Administration shall supply certification forms.

(6) Before beginning the diversion of the streamflow through a temporary channel or conduit in order to dewater the foundation of the dam, the engineer-in-charge shall submit a plan to the Administration for approval describing the methods to be used for carrying the streamflow and keeping sediment reduced during this period. The engineer-in-charge shall be responsible for the implementation of the plan.

(7) Before beginning the filling of the reservoir the engineer-in-charge shall submit a report to the Administration stating that the structure has been made ready for filling and that the pool area has been cleared of debris. The report shall describe the limitations on the amount of water restrained from flowing downstream and describe the methods to be followed for the surveillance of the project during the period when the structure is receiving its initial loading.

E. Surveillance and Inspection of Completed Dams and Reservoirs.

(1) Responsibility for Inspections by Owner. The owner is responsible for the safety of the dam and for the necessary surveillance and inspections. The surveillance shall be performed by the owner, or a representative of the owner, and shall provide a close watch on the conditions affecting the dam's safety. The owner shall promptly notify the Administration of significant changes in condition.

(2) Responsibility for Inspections by Administration. In addition to the inspections by the owner, the Administration shall make inspections of all dams, reservoirs, and other waterway obstructions within its jurisdiction to provide for the public safety and welfare, to detect early signs of deterioration, and to enforce corrective measures. The Administration's agents shall be given free access to every part of the dam or reservoir under consideration, and the operators of these works shall assist in the inspection to the best of their abilities.

F. Repair of Dams. Before beginning the repair of any dam or reservoir, the owner shall apply for, in writing, and secure the Administration's written approval of the contemplated action. The application shall give the name and address of the applicant, details of the proposed changes, referenced to the existing structure, and shall be accompanied by the necessary plans and specifications. If the proposed work may best be explained by description, this description shall be included as part of the application along with the proposed time of commencement and completion of construction, as well as such other information as the Administration may require. In the event of an emergency in which repairs are necessary to safeguard life and property against predicted immediate danger, these repairs shall be made immediately by the owner. In these events, the Administration shall be notified within 24 hours of the emergency repairs needed and the extent of work underway, if any, and the work shall conform to these requirements as specified by the Administration.

G. Certain Small Ponds. Except for those ponds which are to be located in natural trout waters or those which are temporary and which are intended solely to trap sediment during construction operations, certain small ponds may be exempt from the permit requirements cited here if the plans and specifications are approved by the appropriate soil conservation district. The following shall apply to the approval of all ponds pursuant to Environment Article, §5-503(b), Annotated Code of Maryland:

(1) The plans and specifications shall be reviewed for technical compliance with the requirements in USDA, Natural Resource Conservation Service, Maryland Conservation Practice, Standard Pond Code 378 (January, 2000), which is incorporated by reference in COMAR 26.17.02.01-1B(2).

(2) The soil conservation district shall notify the Administration of all ponds approved pursuant to this section. The notification shall include a copy of the pond approval and a pond summary sheet. The notification shall be submitted to the Administration within 30 days of the end of each quarter (September 30, December 31, March 31, and June 30) in which the approval was granted.

(3) The soil conservation district, for all ponds approved pursuant to Environment Article, §5-503(b), Annotated Code of Maryland, shall submit a certification to the Administration within 90 days after the completion of construction. This certification shall state that the subject pond was constructed in conformance with the approved plans and specifications. A certification by a professional engineer, land surveyor, or landscape architect practicing in accordance with the laws of Maryland shall be acceptable to the Administration instead of a certification by the soil conservation district.

Maryland Dam Safety Manual



1996 Edition

(rev. November 2003)

PREFACE

This manual was developed by the Maryland Department of the Environment, Water Management Administration, Dam Safety Division, in order to assist owners in the regular operation, inspection, and maintenance of their dam. The information presented should also be valuable to many engineers who are preparing construction documents for a proposed structure. It is intended to serve as an information resource and educational tool for the dam owner and includes six basic sections: Owner Responsibilities, Operation, Maintenance and Repair, Inspections, Construction, and Emergency Procedures. It is hoped that this manual will be of assistance to the dam owner in becoming familiar with the general principles and features of their facility as well as developing adequate skills of observation and safety inspection. Timely maintenance can reduce expensive safety repairs at a later date.

Dam owners must maintain their facility in a safe condition. For this reason the main focus of this manual is directed towards developing an operation and maintenance program for the dam owner. Throughout the manual, it is recommended that the owner contact an engineer experienced with dams when certain observations are made. The importance of this recommendation cannot be overemphasized. Dams are complex structures and the causes and remedies of certain problems may not be obvious to a layperson.

This manual was prepared and revised under the guidance of the Maryland Dam Safety Division including Brad Iarossi, Harald Van Aller, Bruce W. Harrington, M.Q. (Cas) Taherian, Gene Gopenko, Robert S. Norton, Brian S. Clevenger, and Tona Ives. The manual was modeled after similar publications developed by the Ohio Department of Natural Resources, Division of Water, Dam Inspection Section; the North Carolina Department of Natural Resources and Community Development, Division of Land Resources, Land Quality Section; and the Commonwealth of Pennsylvania, Department of Environmental Resources, Division of Dam Safety. In addition, similar publications from many other states were also of considerable assistance. Funds for the development and distribution of this manual were provided by the Association of State Dam Safety Officials through a grant from the Federal Emergency Management Agency.



ASSOCIATION OF STATE
DAM SAFETY OFFICIALS
450 Old East Vine Street
Lexington, Kentucky 40507
Tel (606) 257-5140

TABLE OF CONTENTS

INTRODUCTION

OWNER RESPONSIBILITIES

OWNER LIABILITY 3
DAM SAFETY LAWS 5
UNAUTHORIZED CONSTRUCTION 6

OPERATION

COMMON DAM ELEMENTS 9
OPERATION PLANS 10
MONITORING DEVICES 13

MAINTENANCE AND REPAIR

EMBANKMENT 17

VEGETATION 19
EROSION 21
SEEPAGE 24
STABILITY 26
RODENT CONTROL 28
CREST OF THE DAM 30

SPILLWAY AND OUTLET WORKS 31

CONDUITS 33
TRASH RACKS 35
CONCRETE 36
VEGETATED SPILLWAYS 38
OUTLET 40
MECHANICAL EQUIPMENT 42
LAKE DRAINS 43

RESERVOIR 45

POOL LEVELS 47
AQUATIC VEGETATION 48
SEDIMENTATION 49
LAKE PERIMETER AND ACCESS ROADS 50
WINTERIZING TECHNIQUES AND PROBLEMS 50
VANDALISM 51
FISH STOCKING 52

INSPECTIONS

INSPECTION GUIDELINES 55
DAM INSPECTION CHECKLIST 56

CONSTRUCTION

ADMINISTRATIVE 61
TECHNICAL 62
SUPERVISION 65
CONSTRUCTION PROBLEMS 67

EMERGENCY PROCEDURES

TYPES OF FAILURES 71
HAZARD CLASSIFICATION 74
EMERGENCY WARNING PLANS 75
SAMPLE WARNING PLAN 77

APPENDICES

FEDERAL LEGISLATION 81
MARYLAND LEGISLATION 83
MARYLAND WATERWAY REGULATIONS 87
GLOSSARY 105
BIBLIOGRAPHY 113

INTRODUCTION

A dam is defined as any obstruction, wall, or embankment, together with its abutments and appurtenant works, constructed for the purpose of storing water. Dams may be constructed of earth, concrete, wood or rock. Most dams in Maryland consist of an earthen embankment to store water and a combination of spillways designed to pass water safely around or through the facility.

Millions of Marylanders are dependent on dams for water supply, flood control, power generation, recreation and irrigation. High standards including proper design and construction of dams, properly operated and well maintained dams and effective emergency warning plan can help prevent dam failures, save lives and property and enable us to continue to enjoy the benefit that dams provide.

Dams represent a potential danger. With the exception of a nuclear power plant, few manmade structures have the potential to cause catastrophic disaster as dams do if they fail. This country has witnessed some tremendous tragedies caused by dam failures including:

1) The South Fork Dam failure (Johnson Flood) of 1889 which took the lives of 2,209 people in Johnstown, Pennsylvania;

2) The Buffalo Creek Dam failure in 1972 killed 125 people in West Virginia;

3) The Teton Dam failure of 1976 caused 14 deaths and over $400 million in damages;

4) The Laurel Run Dam failure in 1977 killed 40 people in Pennsylvania; and

5) The Kelly Barns Dam failure in 1977 killed 39 people and $2.5 million in damages.

For centuries, dams have provided mankind with the essential benefits associated with water. Modern dams are often integrated into new communities to such a degree that they become a part of the landscape and are forgotten as an engineering structure that needs periodic maintenance. However, a well documented operation and maintenance program is necessary for every dam in order to detect symptoms of deterioration and plan for timely maintenance. Every program should include:

1) periodic technical inspections,
2) periodic maintenance inspections, and
3) informal observations by the dam owner.

BUFFALO CREEK DAM FAILURE FEBRUARY 26, 1972

The following accounts of this tremendous tragedy are excerpted from Everything in Its Path written by Kai T. Erikson, 1976.

"I walked to the back porch and saw my neighbors running and screaming. I heard one say 'the dam.' I then came running through the house and told my wife to head for the hills. When I got to the living room I saw the water rolling by the window. I knew then there was no way out of the house, and all hope just vanished. My wife started crying and praying. I saw a housetop going by with a friend of mine on top. Then I heard a big crash and saw the big wave of water coming with houses and trash in it. There was nothing we could do but watch and pray for the best and wonder how long our house would stand."

"And we stood there so helpless, couldn't do nothing. We were there watching people trying to get out of the way, and the water just swept them right down."

"One of our very close friends stayed drunk for almost five months because he could still hear his brother and sister screaming for their mother and his mother screaming 'God help us' when the water hit them. Sometimes he talks with me about it and I get the impression that he feels bad because he lived through it all. He is only twenty years of age, but I guess sometimes he feels like a thousand years old."

"I looked up the road and saw it coming, the water. I said, 'Here comes a big old doll.' But when it got to me, I said 'Lord, that's a kid,' and I took off down the creek after it."

"I can't forget the horrible expression in her eyes and on her face. She looked as though she was scared to death, not drowned."



OWNER RESPONSIBILITIES

The investment in safety must be accepted as an integral part of any existing or proposed dam, and not an extra item that can be eliminated if the budget is tight. This concept of safety applies throughout all phases of the project, from planning through design and construction, and most importantly throughout the life of the structure. A typical dam is not constructed to last indefinitely. As dams age they typically require increased efforts to operate and maintain them.

JOHNSTOWN FLOOD OF MAY 31, 1889

The following personal accounts, described by observers and survivors of this tragic dam failure which killed 2,209 people, were selected from The Johnstown Flood of 1889, The Tragedy of the Conemaugh, by Paula and Carl Degen, Eastern Acorn Press, 1984.

"It came like a thief, and was upon us before we were aware. Already when it reached us it had numbered its victims by the hundreds. Mineral Point and East Conemaugh were gone, a passenger train was engulfed. Woodvale was swept away. Conemaugh Borough was shaved off as if by the sharp surface of an avalanche; in a moment Johnstown was tumbling all over itself; houses at one end nodded to houses at the other end and went like a swift, deceitful friend to meet, embrace, and crush them. Then on sped the wreck in a whirl, the angry water baffled for a moment, running up the hill with the town and the helpless multitude on its back, the flood shaking with rage, and dropping here and there a portion of its burden--crushing, grinding, pulverizing all. Then back with the great frame buildings, floating along like ocean steamers, upper decks crowded, hands clinging to every support that could be reached, and so on down to the great stone bridge, where the houses, piled mountain high, took fire, and burned with all the fury of hell you read about."

"Everything about us was in inextricable confusion, showing the effects of the terrific convulsion through which nature and humanity had passed. Here were uprooted trees, houses upturned or demolished, furniture of every description--hardware, woodenware, parlor ornaments and kitchen utensils, mattresses, bodies of horses, cattle and swine, corpses of men, women, and children, railroad cars and locomotives--overturned or on end, and pressing down upon the half-buried bodies of the drowned." [The Reverend David J. Beale]

"The flood showed no mercy: it struck down young and old, man, woman, and child. One of the saddest stories is that of the Fenn family. The flood claimed the father and seven children. If God had spared me one I could have been resigned. But all, all! Father in Heaven, is not my cross heavier than I can bear?"

"Death by violence due to the flood caused by the breaking of the dam of the South Fork Reservoir. We find the owners of said dam were culpable in not making it as secure as it should have been, especially in view of the fact that a population of many thousands were in the valley below; and we hold that the owners are responsible for the fearful loss of life and property resulting from the breaking of the dam. (The Cambria County coroner's inquest)."

OWNER LIABILITY

The dam owner is liable for the damages resulting from a dam's misoperation or failure that would result in a sudden release of water downstream. In assessing the legal liability for a dam failure, there are two basic theories that are used, strict liability and negligence.



Earth Dam Failure

Strict Liability

The theory of strict liability essentially imposes liability as a risk of doing business and is derived from the old English case of Rylands v. Fletcher. In this case, a dam and reservoir were constructed by the defendants on a parcel of property with the owner's permission. A shaft gave way and caused the impounded water to destroy the plaintiff's property. The court ruled for the plaintiff, holding that when one brings onto his land, and collects and keeps there anything likely to do mischief, if it escapes, and it is a non-natural use of the land, he must keep it at his peril. The rule is that a defendant is liable when he damages another by a thing or activity unduly dangerous, in light of the place and its surroundings.

The concept of strict liability has been extended widely to activities that are considered abnormally dangerous. The basis for this is the risk of harm and potential magnitude of that harm. Factors to be considered in strict liability include the degree of risk, the potential gravity of harm should the risk materialize, the exercise of reasonable care, whether or not the activity is one of common usage, the appropriateness of the activity to the locality, and its value to the community.

Negligence

The alternative theory of liability is one of negligence, which is the most commonly utilized cause of action in tort litigation. Negligence is generally defined in terms of failure to exercise the standard of care of a reasonable person under similar circumstances. This standard in turn is based on the reasonable foreseeability of the risk. It is important to emphasize that the ultimate question though is, whether in light of that forseeability, how a reasonable person would have acted taking into account the potential magnitude of harm and the alternatives available. Thus, negligence can consist of a failure to act, or the failure to act in a reasonable manner.



Keep Off!

In Maryland, the General Assembly has added statutory requirements on top of the common law strict liability and negligence doctrines. Construction and repair of dams require state permits and those permits contain specific conditions for maintenance. Size, location, design, and public safety are all

issues addressed by State law and regulations. The Administration may order structures built without permission to be drained or removed.

It is the owner's responsibility and obligation to act in a reasonable manner to inspect and maintain the dam and its appurtenances. Additionally, the Dam Safety Division of the Water Management Administration performs periodic safety inspections of Maryland dams. After each inspection, the owner is presented with a summary of findings and maintenance recommendations. These recommendations should be implemented to insure the dam's continuing safety.

Public Safety

In addition to the responsibility for dam maintenance, owners should also be aware of their responsibility for public safety. This includes the safety of people not authorized to use the facility. "No Trespassing" signs should be posted and fences and warning signs should be erected around dangerous areas. Liability insurance can also be purchased to protect the owner in the event of accidents.

In conclusion, dam owners have both the legal and moral obligation to keep their dam in repair. The following guidelines should be followed:

- Periodically monitor the condition of the dam and correct any deficiencies. Depending on the size of the structure and its operational history, this could mean anything from a occasional casual site inspection to a full scale annual evaluation by a professional engineer experienced in dam design.

- When the dam is inspected by the State Dam Safety Division, recommendations should be carefully reviewed and repairs made shortly thereafter.

- If abnormal conditions develop at the dam, or the dam shows signs of potential failure, the owner must be prepared to notify local and state authorities so every action possible can be taken to protect lives and property downstream, as well as the dam itself.

Riparian Rights

Care should be taken by owners when releasing or impounding water to protect the rights of downstream property owners. The system of riparian rights has been established through the courts, and permits each riparian owner to make a "reasonable" use of the water, having regard to the same rights existing for the other downstream riparian owners.

Professional Assistance

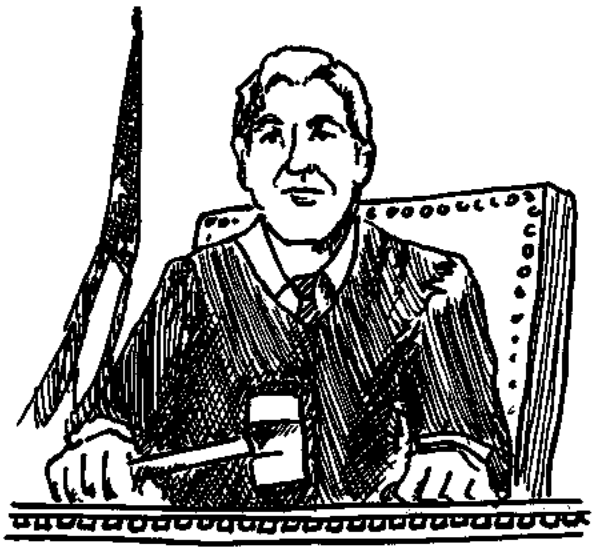
A dam with its associated works is a complex structure. Engineers who are experienced in the design, construction, and inspection of dams should be consulted for many of the operation guidelines and maintenance techniques identified in this manual.

The owner or operator of the dam should always keep in mind that each structure is unique in its construction and operation. When contacting a professional for assistance, there can be no substitute for the availability of historical records and documentation on the operation of the facility. Therefore, it is extremely important to follow the guidelines suggested in this manual.

Assistance in the form of technical advice and historical records is available from the Maryland Department of the Environment, Water Management Administration, Dam Safety Division, 1800 Washington Blvd., Suite 440, Baltimore, Maryland 21230-1718, Phone (410) 537-3538, Fax (410) 537-3553

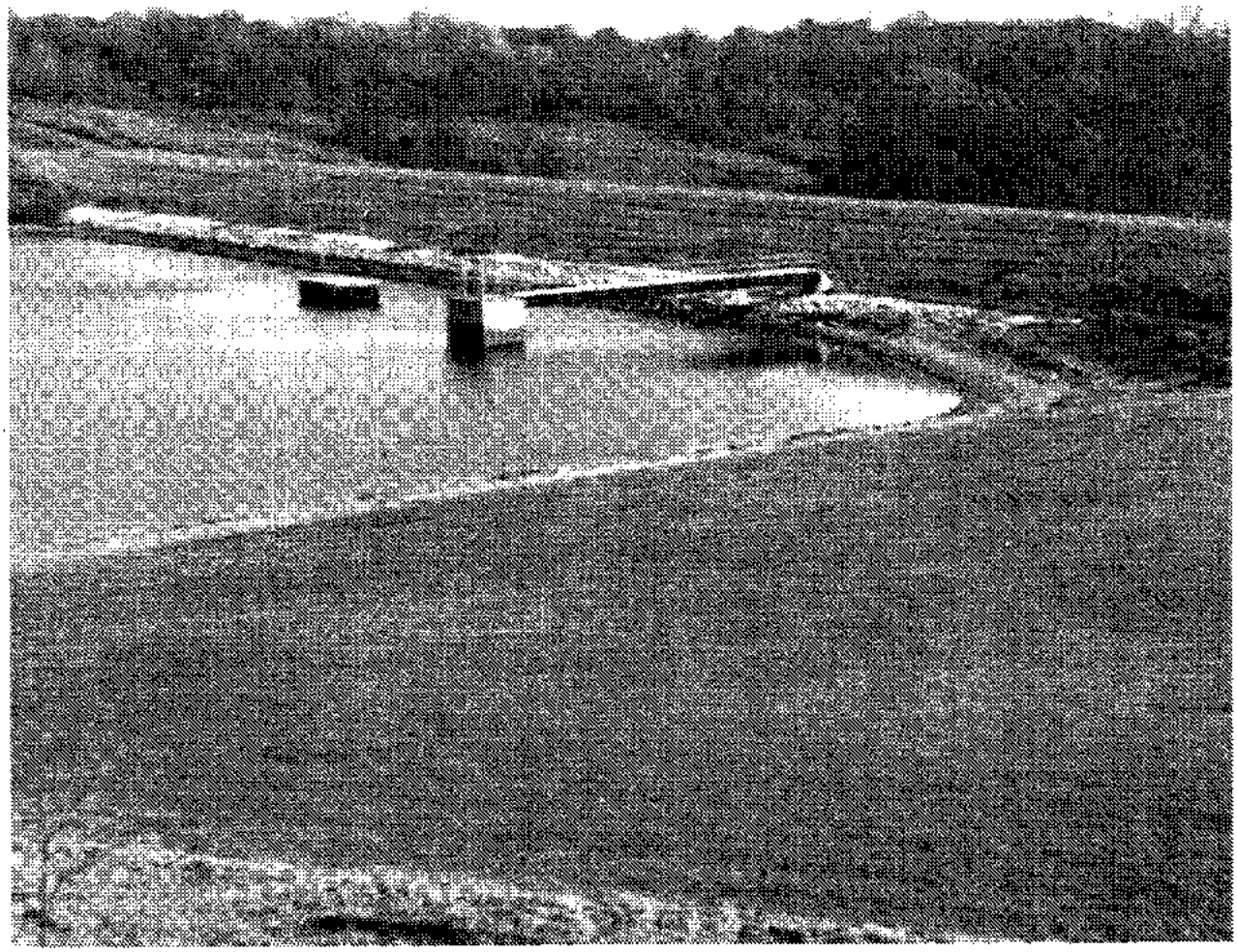
DAM SAFETY LAWS

Maryland laws and regulations place upon the dam owner the responsibility of constructing and maintaining a safe facility. These laws have been in existence since 1933 and are updated periodically in order to keep pace with changing engineering technology.



The Maryland Dam Safety Division issues permits to construct new dams or make major alterations to existing structures. The major emphasis of the administrative permit process is placed on the safety and longevity of the dam. In addition, the capabilities of the owner to operate and maintain the facility are also considered.

A chronology of the legislative history of Maryland's Dam Safety Program can be found in the Appendix. In addition, the most current Rules and Regulations governing the construction of dams are included to provide guidance to the dam owner.

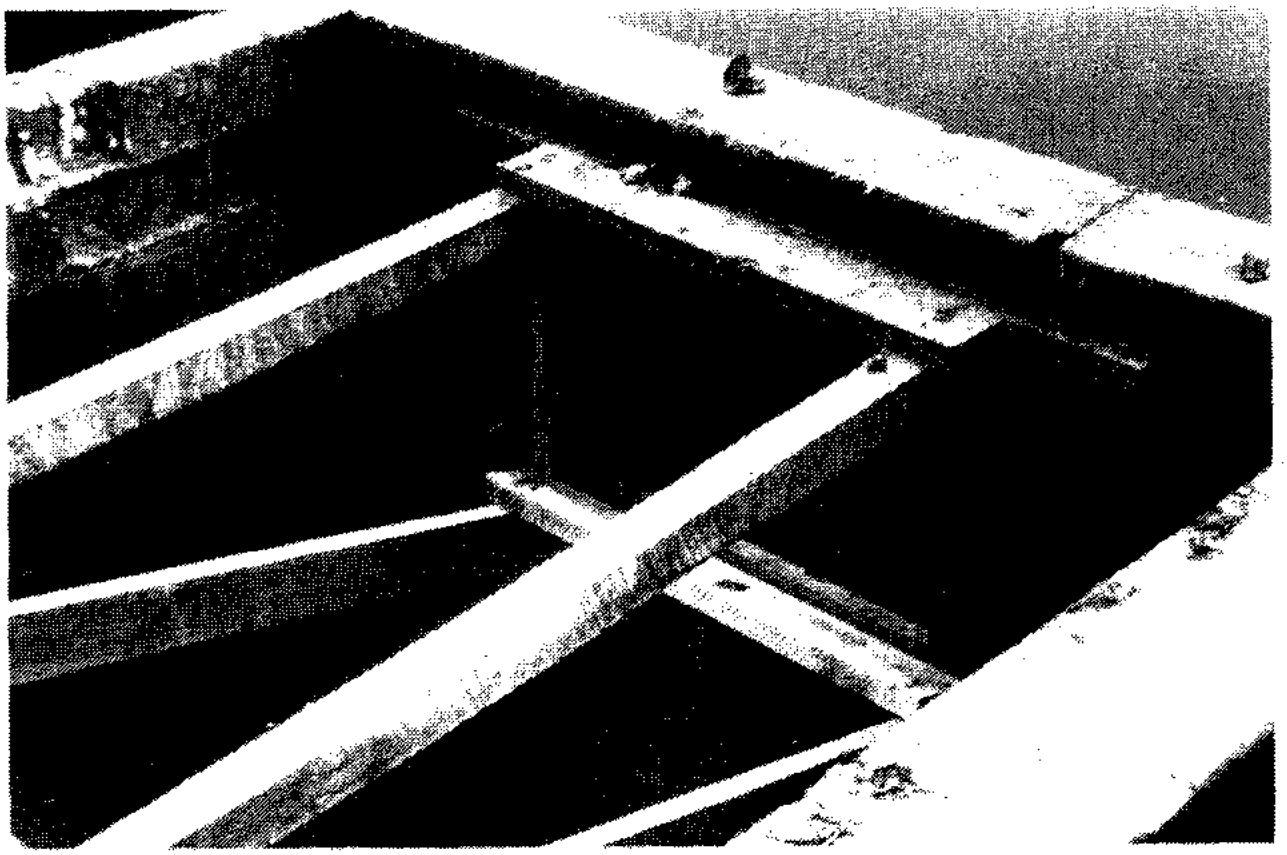


UNAUTHORIZED CONSTRUCTION

The modification of a dam or spillway without adequate engineering design and supervision could result in the spillway or dam being inadequate in capacity or function. This could lead to a costly repair or complete failure of the structure.

One of the more common errors made by dam owners is raising the normal pool elevation by permanently elevating the crest of the principal spillway. This action not only results in a decrease in storage available during a flood event, but also restricts the capacity of the spillway by reducing the total depth available to "push" water through the spillway. Raising the normal pool will usually cause the emergency spillway to flow more frequently than its design allows, thus increasing the overall maintenance cost. Furthermore, raising the normal pool without a state permit is a violation of Maryland dam safety laws.

It is important for the dam owner to realize that each part of the dam is equally important to the safety of the entire structure. Seemingly minor changes to the dam can cause misoperation or reduce the margin of safety that has been designed into the structure. For this reason, any proposed modifications to the dam require a state permit and should be discussed with the Dam Safety Division.



Unauthorized raising of the lake level with the addition of cinder blocks to this spillway structure. This modification resulted in the necessity to brace the spillway. If heavy rains were to occurr, the spillway would not be able to handle the incoming flows.



OPERATION

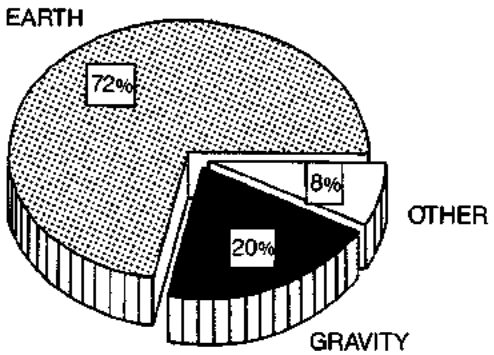
The types of dams discussed in this manual are normally used to store water for irrigation, water supply, recreation, and to provide stormwater management and flood control. Operation of these types of dams will rarely "push" water through the spillway. Raising the normal pool will usually cause the emergency spillway to flow more frequently than its design allows, thus increasing the overall maintenance cost. Furthermore, raising the normal pool without a state permit is a violation of Maryland dam safety laws.

It is important for the dam owner to realize that each part of the dam is equally important to the safety of the entire structure. Seemingly minor changes to the dam can cause misoperation or reduce the margin of safety that has been designed into the structure. For this reason, any proposed modifications to the dam require a state permit and should be discussed with the Dam Safety Division.

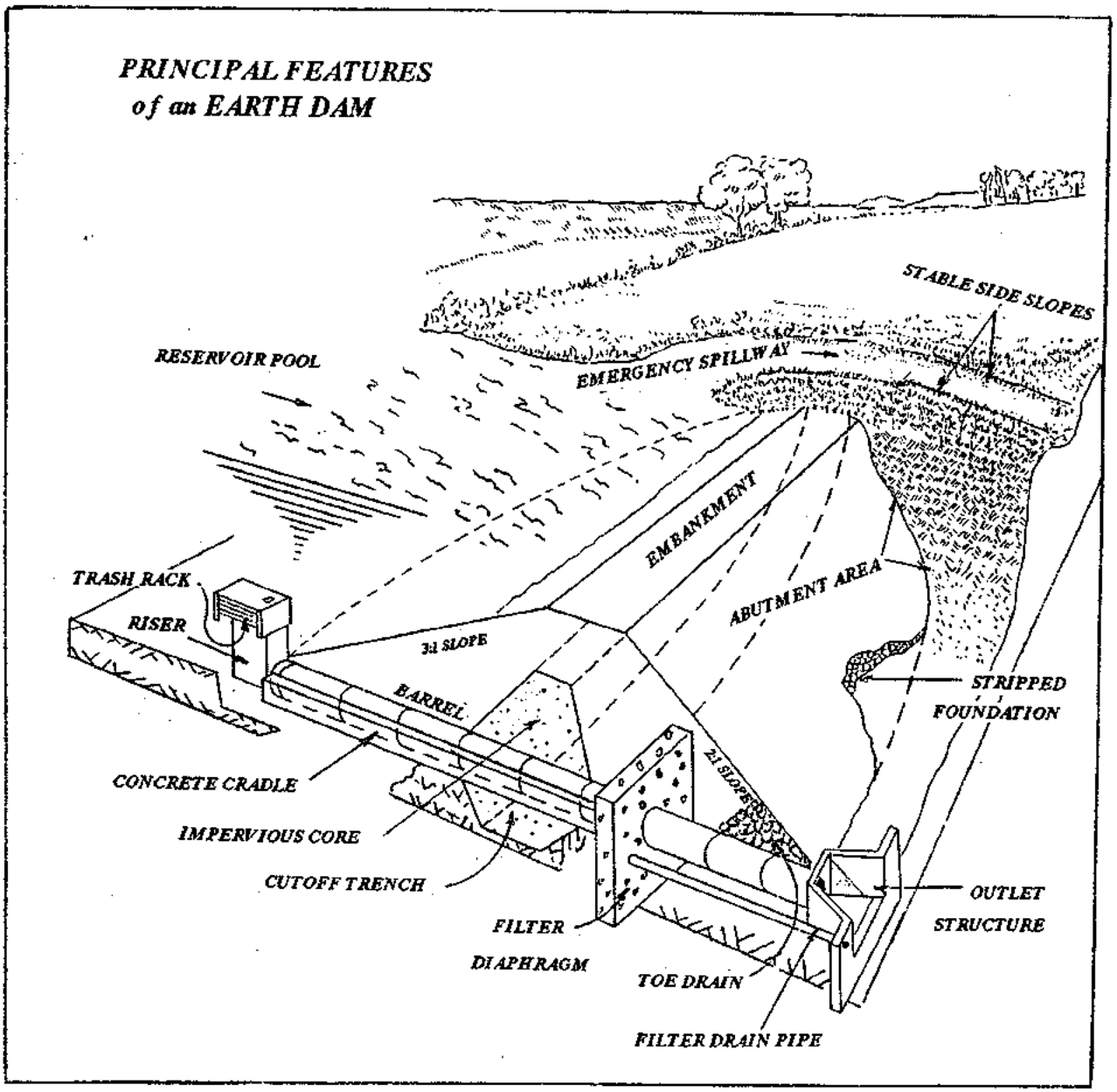
COMMON DAM ELEMENTS

Dams can be constructed of various materials such as concrete, earth, rock, and wood. Many of the common dam types are listed in the glossary. In Maryland, the different types of dams are listed in the adjacent chart:

As one can see, the majority of dams are constructed of earth. Therefore, the primary focus of this manual will be toward this type of dam. The figure below illustrates the common elements of an earthen dam.

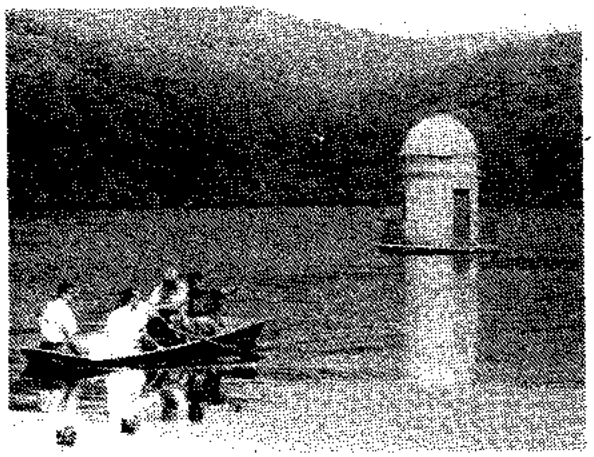


Maryland Dams By Type



OPERATION PLANS

The owner of each dam should adhere to a prescribed operation and maintenance program in order to insure the safety welfare of his investment. An effective operation program provides all of the necessary information for the owner to perform the tasks routinely required to operate and maintain the dam. The extent of the operation plan depends on the complexity of the dam itself. Regardless of the size of the structure there are many similarities between operation plans. The most effective plans are usually the simplest.



Site Inspection

The principal elements of an effective operation plan are presented below:

Background Data A typical dam owner possesses a good deal of information about his facility. Very often the information is scattered about or reviewed so rarely that it is of little use. This section of the operation plan serves to organize available background data to make it more accessible.

Schedule of Routine Tasks A schedule that includes both day-to-day tasks as well as tasks performed less frequently throughout a given year is important. The schedule serves to formalize inspection and maintenance procedures such that the owner could determine when a task is to be performed by merely consulting the schedule.

Emergency Procedures Perhaps the most important section contains a formal plan for reacting to dam emergencies. It involves coordination between the dam owner/operator, local agencies, and downstream residents.

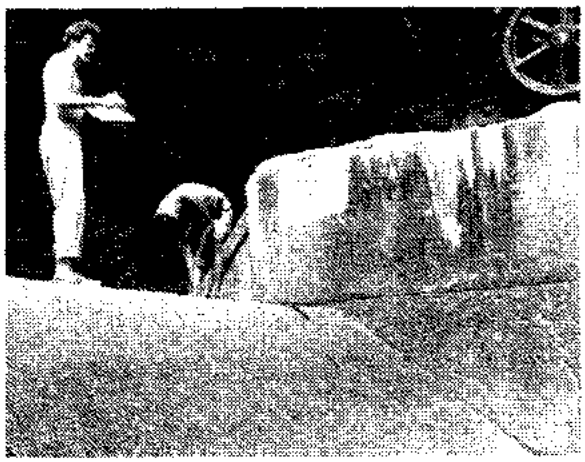
Record Keeping

The owner should maintain a complete and up-to-date set of plans and specifications ("as-built" drawings) for the dam, which should show all changes made over time. Knowing how a dam, its spillways, and other appurtenances were constructed or modified is very helpful in diagnosing problems.

Operation of a dam should include keeping accurate records of the following:

Observations: All observations should be recorded. Of particular importance is the periodic observation of existing seepage to detect any changes in flow. Photographs are valuable for recording observations and changes.

Maintenance: Written records of maintenance and major repairs will be important in periodic safety evaluations of the dam.



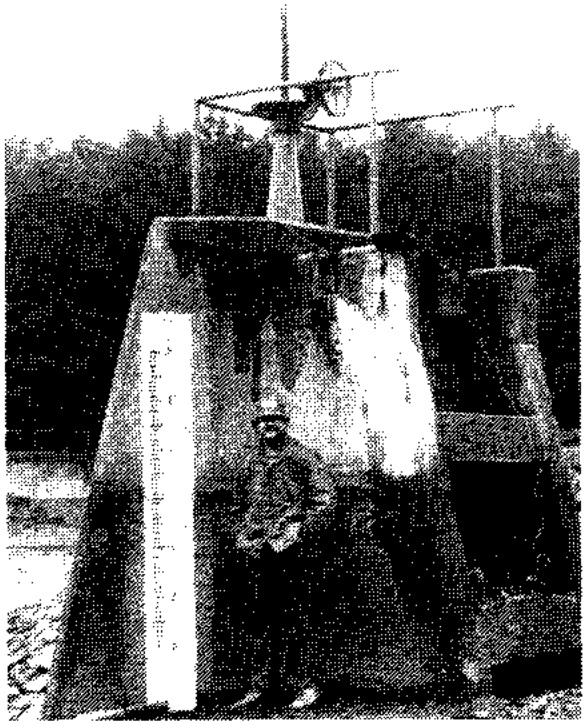
Record Keeping

Rainfall and Pool Levels: A record of the date, hour, and maximum elevation of extreme high water events and the associated rainfall is especially helpful in evaluating the performance of the dam and its spillway system. Rain gauges are

available at any local farm or garden store. Lake level staff gauges can be easily made, or measurement numbers can be painted on existing structures in the pool area.

Drawdown: A record should be kept of the amount, rate, and reason for pool level drawdown.

Other Operational Procedures: A complete listing of operational procedures should be maintained.



Reservoir Staff Gauge

General Instructions

The form on the following page is provided for the convenience of the dam owner or operator in keeping monthly records. This periodic monitoring program will help to develop a well documented history of the operation and performance of the facility. Guidelines in recording information are as follows:

Rainfall and Pool Level - Spaces have been provided for one month's records if daily readings are made. At a minimum, rainfall and pool level records should be kept of significant (very large) rainfall events. Weather conditions should include: rainfall duration and intensity estimates; temperature; ice and snow cover conditions; etc. General observations of the spillway performance and condition of the dam should be made.

Maintenance Performed - Maintenance and operation of equipment can be recorded under these headings. For example, if the lake drain is operated periodically, the date can be recorded here. Minor repairs, such as patching of spillway concrete or joints should also be recorded.

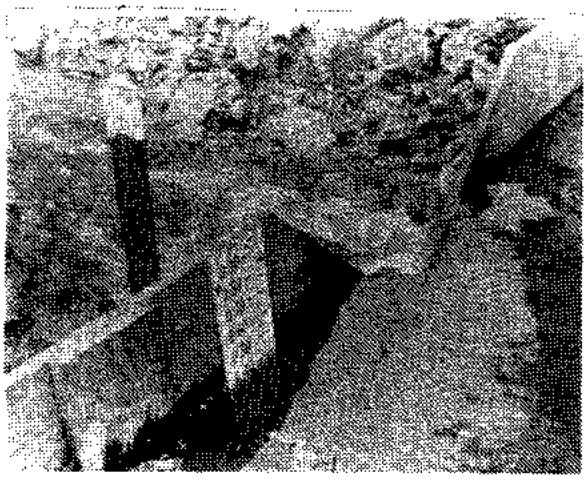
Flow Amounts - Records can be kept of any flows which are being periodically observed. Others could apply to seepage flow estimates of a certain area. Weather conditions during the observation are important to note.

OPERATION AND MAINTENANCE RECORDS

DATE	TIME	RAIN (inches)	POOL LEVEL	WEATHER CONDITIONS	GENERAL OBSERVATIONS OR COMMENTS	RECORDED BY

MONITORING DEVICES

Various devices such as weirs, piezometers, and settlement monuments are used to monitor earth embankments and concrete gravity structures. These devices can be used to determine if the structure is performing as designed, to detect signs of serious problems, or to provide further information after a problem has been detected. The use of extensive instrumentation is usually limited to large dams or those structures for which little design and construction documentation is available. A full-scale monitoring and instrumentation program requires professional design.



V-notch Weir for Seepage Monitoring

Monitoring by a private owner is usually limited to visual observation. It is very important that the observations be made periodically and accurately recorded. Several checklists for this purpose have been included in this manual. Owners are encouraged to use photographs with identifying dates and labels as a permanent record. These photos should be kept with the other dam records.

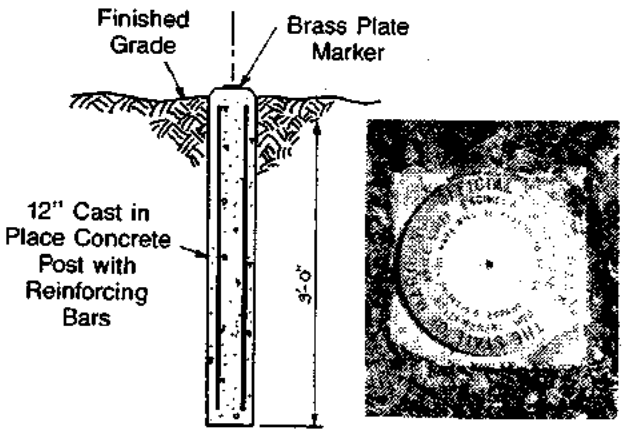
The following devices can easily be used by owners to monitor their embankments:

Weirs, Flumes, and Buckets Flow rates for weirs and flumes are obtained from a calibration chart that relates the depth of flow to gallons per minute of flow. The flow from pipe outlets can be measured by timing how long it takes to fill a bucket of known capacity. In order for the readings to be meaningful, they must be taken at regular intervals that are frequent enough to establish trends of seasonal variations in pool and groundwater levels as well as other factors that can affect the seepage rate. Many times after installation, weirs and flumes are neglected and good readings become useless for lack of comparative data. The v-notch weir is probably the most commonly used device to measure flow rates of seepage.

Yardstick or Folding Rule This portable monitoring device is not only inexpensive but has a number of uses. It can be used to measure cracks, scarps, erosion gullies, settlement, trees, wet areas, and slab or wall movement. Again, records should be kept of all observations for comparative purposes.

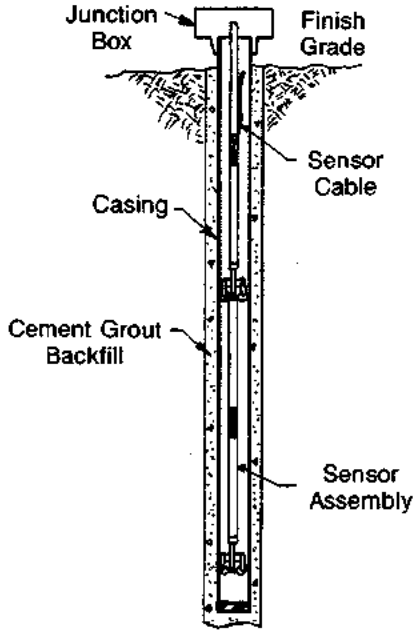
Camera Photographs which have been dated and labeled provide an excellent record of existing conditions, and if taken periodically from the same locations, can be used for comparison. Photographs should be taken during all inspections to supplement written and visual observations. They are valuable in documenting the location and severity of wet areas, erosion, and concrete deterioration.

Settlement monuments, piezometers, observation wells, and inclinometers are often found on large dams and are described briefly. Their installation requires professional assistance.



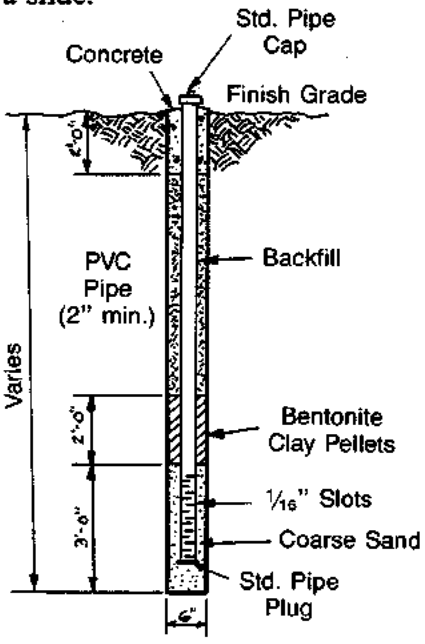
Survey Monument Detail

Settlement Monuments are usually installed along the crest of the dam to check its vertical and horizontal alignment (with known reference points and elevations). Measurements of these monuments must be precise and are obtained using surveying instruments.



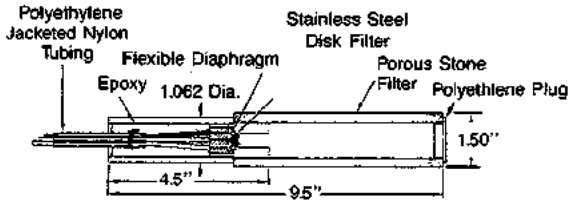
Slope Inclinometer

Inclinometers are instruments that are lowered into a vertical casing and measure horizontal deflection of the embankment. Inclinometers are often used to determine the rate of movement of a slide.

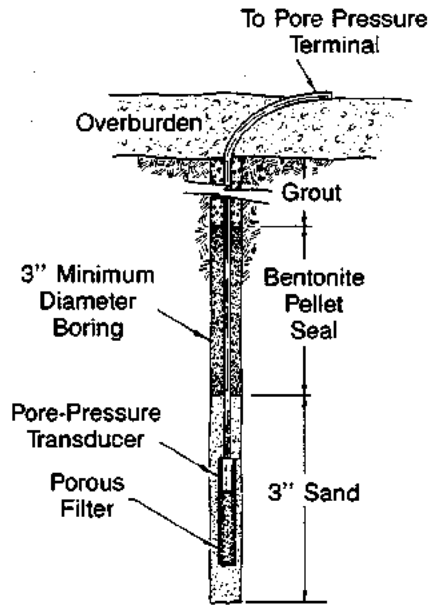


Open Pipe

Observation Wells (technically known as open standpipe piezometers) can be installed in the embankment and are used to determine the water levels. Measurements are made with a water level indicator that is lowered into the well.

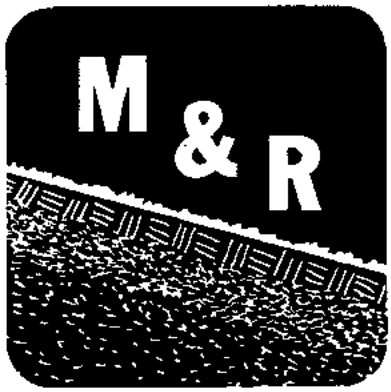


SINCO Pore-Pressure Transducer



Pneumatic Piezometers

Piezometers are instruments used to measure the water pressure in the embankment and foundation. Pore pressure within the embankment can be determined from these readings.



MAINTENANCE AND REPAIR

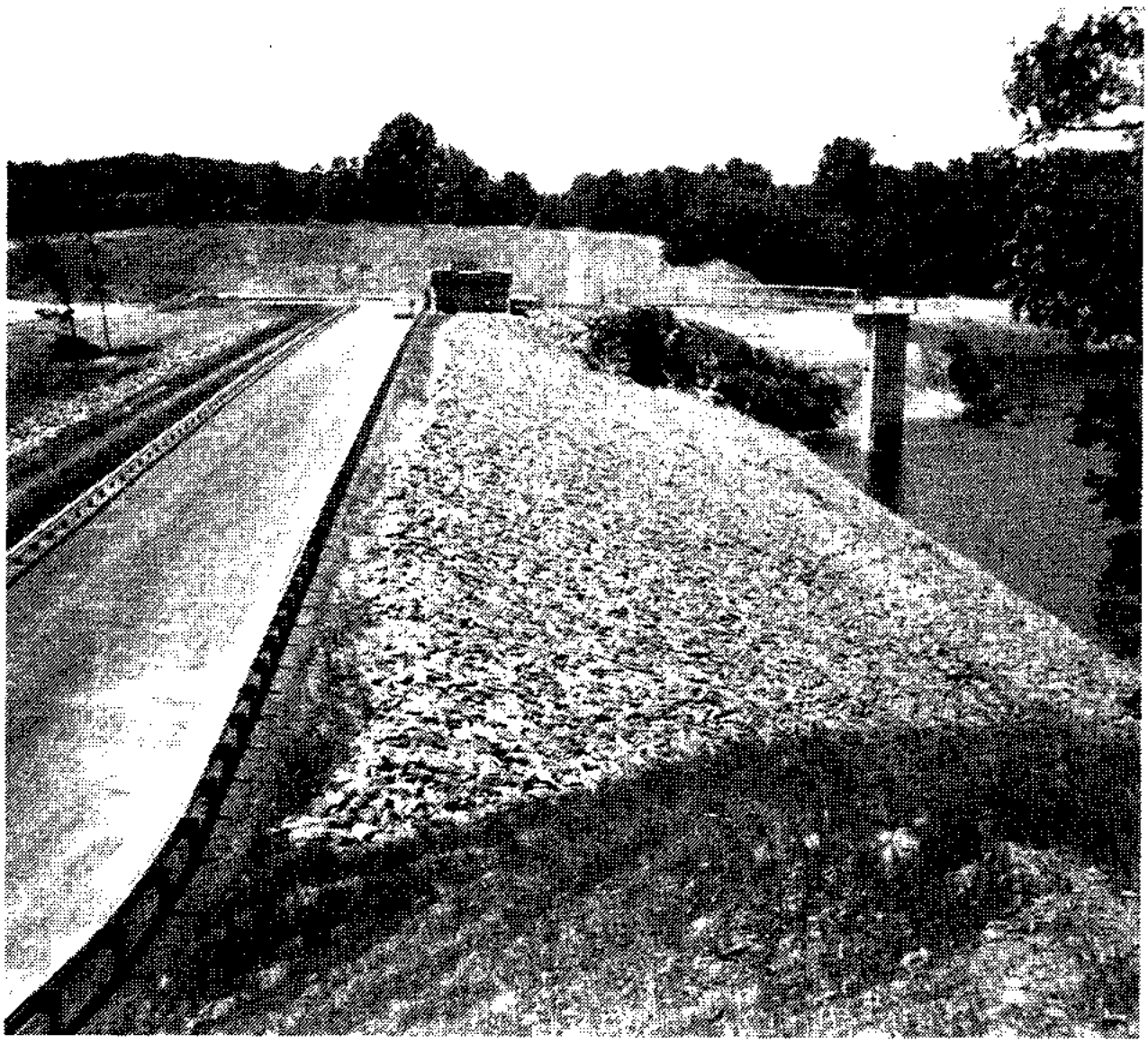
The importance of proper dam maintenance cannot be overemphasized. A regular program of inspection and care will help to keep many major problems from developing and avoid more costly repairs at a later date. The Water Management Administration requires all dam owners to maintain their facility in a safe condition so that it may not endanger human life or property located above or below the facility. Routine maintenance is defined as minor maintenance that does not modify the original design parameters of the facility. The Water Resources Administration requires the issuance of a Maintenance and Repair Permit for any repairs or maintenance that involves the modification of the dam or spillway from its original design and specifications. A permit is also required for any repairs or reconstruction that involve a substantial portion of the structure.

In general, maintenance items are required for the following major areas:

EMBANKMENT
SPILLWAY AND OUTLET WORKS
RESERVOIR

EMBANKMENT

The embankment section of the dam is usually constructed of earth or rock. Embankment dams are built with different design sections. Internal zoning of material ranges from simple to intricate. Practical experience suggests that embankment slopes should be easily maintainable while providing an adequate factor of safety against failure. Because the embankment is the main feature of the dam, the owner should provide for routine maintenance of the slopes and crest.



VEGETATION

The establishment and control of proper vegetation is an important part of dam maintenance. Properly maintained vegetation can help prevent erosion of embankment and earth channel surfaces. Proper maintenance also ensures a healthy stand of vegetation that can withstand extreme climatic conditions and pest, weed, or disease infestation better than poorly maintained vegetation. The uncontrolled growth of vegetation will damage embankments and concrete structures and make close inspection of the dam difficult. Aesthetics, unobstructed viewing during inspections, maintenance of a nonerodible surface, and discouragement of burrowing animal habitation are reasons for proper maintenance of the vegetative cover.



NO TREES ALLOWED!

Ground Covers

Grass is the most common type of vegetation found on an embankment. Grass is an effective and inexpensive way to prevent erosion of embankment surfaces. If properly maintained, it also enhances the appearance of the dam and provides a surface that can be easily inspected. Roots and stems tend to trap fine sand and soil particles, forming an erosion-resistant layer once the sod is well established. Grass vegetation is least effective in areas of concentrated runoff, such as the contact of the embankment and abutments, or in areas subjected to wave action. In these areas a riprap channel is recommended.

Types of vegetation that have been used on dams in Maryland are tall fescue, red fescue, clover, redtop, and sericea lespedeza. Deep rooted grasses should be planted in vegetated earth spillways. One hundred percent Kentucky 31 Fescue is excellent for erosion protection. Seeding should be accomplished between optimum planting dates. Seeding late in the year may result in winterkill of young seedings. The following spring an inspection of the seeded area should be made to determine if plant survival is satisfactory.

Before seeding, fertilizer and lime should be applied. Exact quantities necessary will vary with soil type and condition, and can be determined by having the soil tested. The fertilizer and lime should be raked, disced, or harrowed into the soil to a depth of not less than 4 inches. Periodic fertilization is necessary to maintain vigorous vegetation. Immediately following seeding, the area should be mulched. Mulching materials should be kept in place with a mulchanchoring device or with asphalt emulsion.

Additional information on the proper selection of grasses and legume mixtures, seeding rates, optimum planting dates, and vegetation maintenance is available in the "Maryland Standards and Specifications for Sediment and Erosion Control."

Trees and Brush

The presence of trees and brush is the most common form of neglect in the area of embankment maintenance. Uninformed owners will often allow trees and brush on their dams. **Woody vegetation is, however, one of the dam's worst enemies, and will lead to more serious maintenance problems if not controlled.**

Trees and brush should not be permitted on embankment surfaces or in vegetated earth spillways. Extensive root systems can provide seepage paths for water. Trees that blow down or fall over can leave large holes in the embankment surface that will weaken the embankment and can lead to increased erosion. Brush obscures the surface and limits visual inspection, provides a haven for

inspection, provides a haven for burrowing animals, and retards growth of grass vegetation. Tree and brush growth adjacent to concrete walls and structures may eventually cause damage and should be removed.



Failure Due to Root System

Trees that have been allowed to grow on the dam should be removed so desirable vegetation can be established and the surface can be mowed. The stumps can be removed either by pulling or with machines that grind them down. For trees greater than eight inches in diameter, all woody material should be removed to about 24 inches below the ground surface. The cavity should be filled with well compacted soil and grass vegetation established.

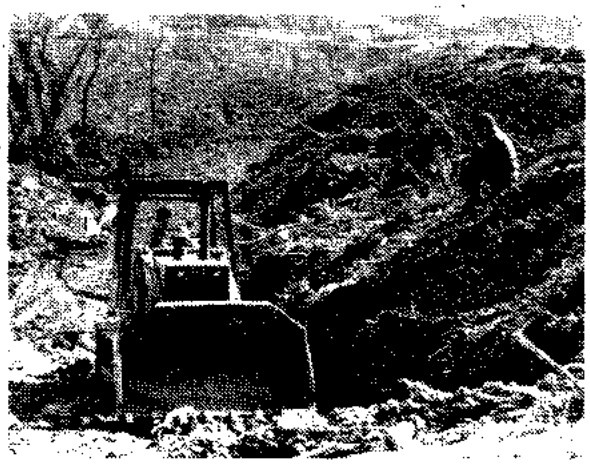
Stumps less than eight inches in diameter may be left in place if cut flush with the ground and treated with a silvicide.

Stumps of trees in riprap cannot easily be removed, but should be chemically treated so they will not continually form new sprouts. The removal of large trees and stumps is expensive and usually requires the use of heavy construction equipment.

Mowing and Brush Removal

Embankments, areas adjacent to spillway structures, vegetated channels, and other areas associated with a dam require periodic maintenance of the vegetative cover. Grass mowing, brush cutting, and removal of woody vegetation (including trees) is necessary for the proper maintenance of a dam. All embankment slopes and vegetated earth spillways should be mowed or trimmed at least once a year. Brush removal is also important beyond the downstream toe of the dam in order to allow inspection for "boils" (see Seepage).

Methods used in the past for control of vegetation that now may be considered unacceptable include chemical spraying and burning. More acceptable methods include the use of weed whips, power brush-cutters and mowers. It is important to remember to use the proper equipment for the slope and type of vegetation to be cut, and to always follow the manufacturer's recommended safe operation procedures.



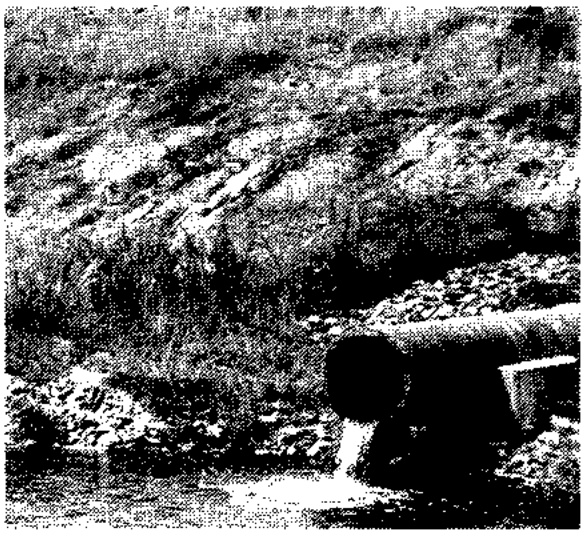
Tree/Stump Removal



Mowing Embankment With Special Equipment

EROSION

Whether on a slope or at a spillway outlet, erosion is a common maintenance problem on the embankment structure. Erosion is a natural process and its continuous forces will eventually wear down almost any surface. The rate of erosion is directly related to the lack of vegetation. Periodic and timely maintenance is essential in preventing continuous deterioration, more costly repairs at a later date, and possible failure of the dam.



Embankment Erosion

Vegetated Surfaces

A sturdy sod, free of weeds and brush, is one of the most effective means of erosion protection. Embankment slopes are normally designed and constructed so that the surface drainage will be spread out in thin layers as "sheet flow" on the grassy cover. When the sod is in poor condition or flows are concentrated at one or more locations, the resulting erosion will leave rills and gullies in the embankment slope. The owner should look for these areas and be aware of the problems that may develop.

Prompt repair of eroded areas is required to prevent more serious damage to the embankment. Rills and gullies should be filled with suitable soil (the upper 4 inches should be topsoil, if available), compacted, and then seeded. Methods described in the section on vegetation should be used to properly establish the grassed surface. Erosion in large gullies can be slowed by stacking bales of hay or straw across the gully until permanent repairs can be made.



Erosion Left Unattended

Repairs of the eroded areas should also address the cause of the erosion in order to prevent a continuing maintenance problem. Erosion may be aggravated by improper drainage, settlement, pedestrian traffic, animal burrows, or other factors. The cause of the erosion will have a direct bearing on the type of repair needed.

Paths from pedestrian traffic are problems common to many embankments. If a path has become established, vegetation in this area will not provide adequate protection and more durable cover will be required unless the traffic is eliminated. Small stones, asphalt, or concrete have been used effectively to cover footpaths. Embedding railroad ties or other treated wood beams into an embankment slope to form steps is one of the most successful and inexpensive methods used to provide a protected pathway.

Worn areas also result from unwanted two and four-wheel vehicle traffic. Control of these vehicles is discussed in the section on vandalism.

Another area where erosion commonly occurs is the contact between the embankment and the concrete walls of the spillway or other structures. Poor compaction adjacent to the

wall during construction and subsequent settlement could leave an area lower than the grade of the embankment. Runoff often concentrates along these structures, resulting in erosion. Possible solutions include regrading the area to slope away from the wall, adding more resistant surface protection, or constructing wood beam steps.



Pedestrian Path Erosion

Abutment Contacts

Adequate erosion protection is required along the contact between the downstream face of the embankment and the abutments. Runoff from rainfall concentrates in these gutter areas and can reach erosive velocities because of the steep slopes. Berms on the downstream face that collect surface water and empty into these gutters add to the runoff volume. Sod gutters may not adequately prevent erosion in these areas. A well graded mixture of rock with stones that are 9 to 12 inches in diameter, or larger, placed on a stone filter or filter fabric provides the best protection on small dams.

Paved concrete gutters do not hold up well, will not slow the velocity of the water, can become undermined, and therefore are not recommended. Groundhogs often construct burrows underneath these gutters, possibly since burrowing is easier due to existing undermining.

Erosion adjacent to gutters results from improper construction or design where the finished flow line of the gutter is too high with respect to adjacent ground. This condition prevents all or much of the runoff water from entering the gutter. The flow concentrates alongside the gutter, erodes a gully, and may eventually undermine the gutter.

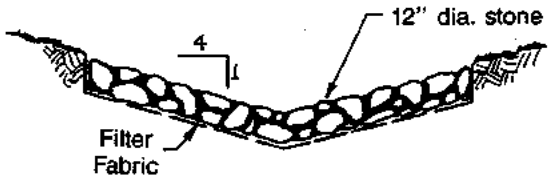


Care should be taken when replacing failed gutters or designing new gutters to assure that:

1. The channel has adequate capacity,
2. Adequate protection and a satisfactory filter have been provided,
3. Surface runoff can enter the gutter, and
4. The outlet is adequately protected from erosion.



Riprap Gutter Construction



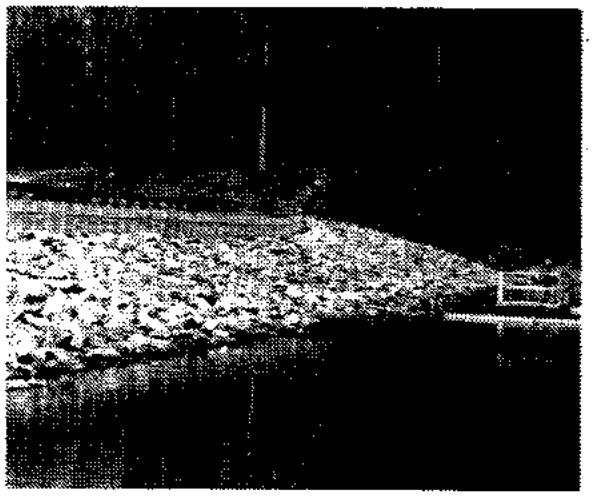
Riprap Ditch Detail

SLOPE PROTECTION

The upstream face of a dam is commonly protected against wave erosion by placement of a layer of rock riprap over a layer of filter material. This provides a surface on which the wave energy can dissipate.

Riprap should consist of a heterogeneous mixture of irregular shapes placed over a filter material. The maximum rock size and weight must be large enough to break up the energy of the anticipated wave action and hold the smaller stones in place. Generally, the largest stones should be at least 12 inches in diameter. The smaller rocks help to fill the spaces (or voids) between the rocks in the riprap. If the filter material can be washed out through these voids two filter layers will be required. The lower layer should be composed of sand or filter fabric to protect the soil surface. The second layer should be composed of coarser materials that prevent washout through the voids in the riprap.

A dam owner should expect some deterioration (weathering) of riprap. Freezing and thawing, wetting and drying, abrasive wave action, and other natural processes will eventually break down the riprap. The useful life of riprap varies with the characteristics of the stone used. Stone for riprap should be rock that is dense and well cemented.

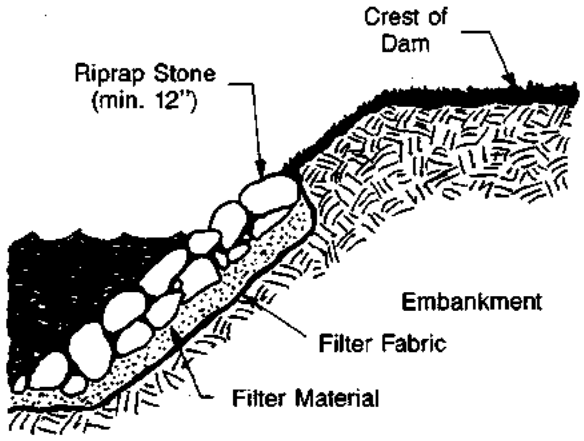


Properly Installed Protection

Another erosion problem which can develop on the upstream slope of the dam is "beaching." Waves caused by winds or power boats can erode the exposed face of the embankment. This action displaces the soil material farther down the slope, creating a "beach". Effective slope protection must prevent the soil particles from being removed from the embankment.

When beaching develops on the upstream slope of a dam, repairs should be made as soon as possible. The pool level should be lowered and the surface of the dam prepared for replacement of the slope protection. A small berm or "bench" should be made across the face of the dam to help hold the protective layer in place. The bench should be placed at the base of the new layer of protection. Depth of the bench will depend on the thickness of the protective layer. The layer should extend a minimum of 3 feet below the lowest anticipated pool level. Otherwise, wave action during periods when the lake level is drawn down can undermine and destroy the protective layer.

Sufficient maintenance funds should be allocated for the regular replacement of riprap. When riprap breaks down, erosion and beaching will occur more often than once every three to five years, professional advice should be sought to design more effective slope protection.

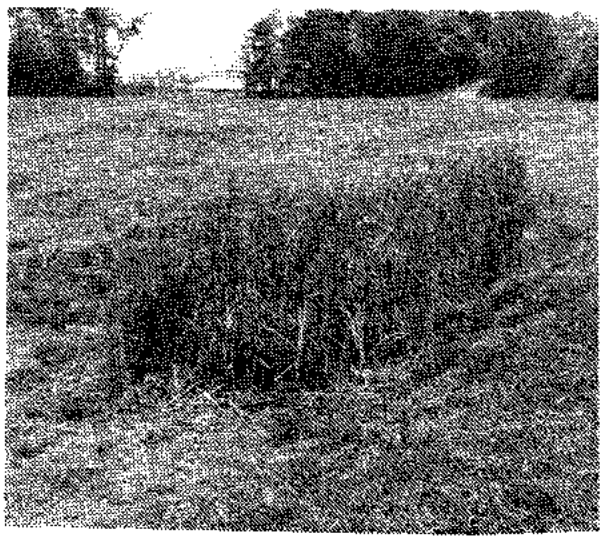


Slope Protection Detail

SEEPAGE

Contrary to popular opinion, wet areas downstream from dams are not usually natural springs but seepage areas. Even if natural springs exist in the area, they should be treated with suspicion and carefully observed. Flows from groundwater springs in existence prior to the reservoir usually increase in flow due to the pressure caused by a pool of water behind the dam.

All dams have some seepage as the impounded water seeks paths of least resistance through the dam and its foundation. However, seepage must be controlled in both velocity and quantity to minimize damage to the structure.

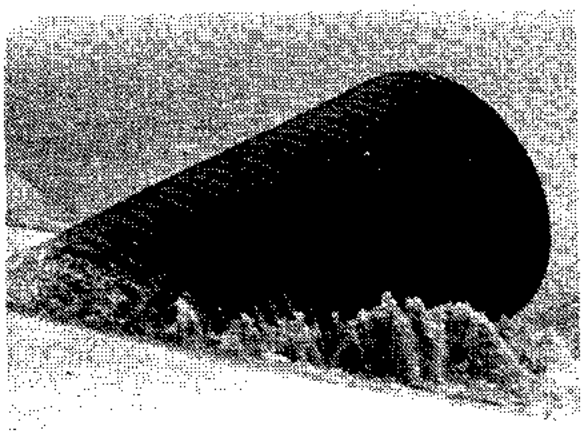


Evidence of Seepage

Detection

Seepage can emerge anywhere on the downstream face, beyond the toe, or on the downstream abutments at elevations below normal pool. Seepage may vary in appearance from a "soft," wet area to a flowing "spring." It may show up first as an area where the vegetation is more lush and darker green. Cattails, reeds, mosses, and other marsh vegetation often become established in a seepage area. In the winter, seepage areas may be evidenced by areas of ice buildup or areas of melted snow on the embankment. Downstream abutment contact areas should always be inspected closely for signs of seepage. Seepage can also occur along the contact between the embankment and a conduit spillway, drain, or other appurtenance. Slides on the embankment may be the result of seepage causing soil saturation or pressures in the soil pores.

At most dams, some water will seep from the reservoir through the foundation. Where it is not intercepted by a subsurface drain, the seepage will emerge downstream from or at the toe of the embankment. If the seepage forces are large enough, soil will be eroded from the foundation and be deposited in the shape of a cone around the seepage outlet. If these "boils" appear, professional advice should be sought immediately. Seepage flow which is muddy and carrying soil particles is evidence of "piping," and complete failure could occur within hours.



Piping Along Spillway Conduit

Piping can occur along a spillway and other conduits through the embankment, and these areas should be closely inspected. Sinkholes that develop on the embankment are signs that piping has begun, and may soon be followed by a failure of the dam. Emergency procedures, including downstream evacuation, must be implemented if this condition is noted. (See section on Emergency Procedures.)

A continuous or sudden drop in the normal lake level may be an indication that seepage is occurring. In this case, one or more locations of flowing water are usually noted downstream from the dam. This condition in itself may not be a serious problem, but will require frequent and close monitoring and professional assistance.

Control

The need for seepage control will depend on the quantity, content, and location of seepage. Controlling the quantity of seepage that occurs after construction is difficult, quite expensive, and not usually attempted unless the seepage is endangering the embankment or appurtenant structures. Typical methods used to control the quantity of seepage are installation of an upstream blanket, or the installation of relief wells or drainage trenches and drains. **All of these methods must be designed and constructed under the supervision of a professional engineer experienced with dams and require a state permit.**



Toe Drain Installation

Preventing loss of soil particles by seepage is extremely important. Modern design practice incorporates this control into the embankment through the use of cutoffs, internal filters, and adequate drainage provisions. Control of seepage at the downstream toe can be accomplished by using properly graded filters and providing proper drainage. The filter and drainage system should be designed to prevent migration of soil particles and still provide for passage of the seepage flow.

The location of a seepage or wet area on the embankment or abutment is often a primary concern. Excessive seepage pressure or soil saturation can threaten the stability of the downstream slope of the dam or the abutments. Seepage control can sometimes be accomplished by installing trench drains.

Monitoring

Regular monitoring is essential to detect seepage and prevent failure. Without knowledge of the dam's history, the owner has no idea whether the seepage condition is in a steady state (constant) or fluctuating condition. It is important to keep written records of points of seepage, quantity of flow, soil particle content, size of wet area, and type of vegetation for later comparison. The rate and content of flow emerging from these outlets should be monitored regularly and recorded. Photographs provide valuable records of seepage. The owner should always look for increases in flow and evidence of flow carrying soil particles.



Monitoring Internal Drain Seepage

Regular surveillance and maintenance of internal embankment and foundation drainage outlets is also recommended. Normal maintenance consists of removing any soil or other material that obstructs flow. Internal repair is complicated and often impractical and should not be attempted without professional advice.

STABILITY

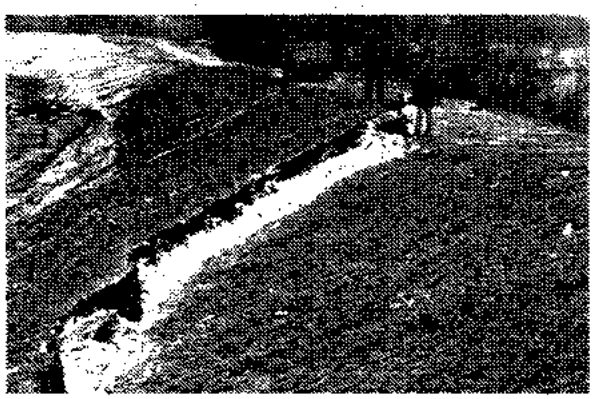
The embankment must safely contain the reservoir. Cracks, slides, sloughing, and settlement are signs of embankment distress and should indicate to the owner that maintenance or remedial work is required. The cause of the distress must be determined by an experienced engineer before undertaking repairs. This step is important because poorly conceived repairs may cause greater and more serious damage to the embankment and can cause failure of the dam.

Cracks

The entire embankment must be closely inspected for cracks. Short, isolated cracks are not usually significant, but larger well-defined cracks indicate a serious problem. There are two types of cracks that occur on the embankment surface - transverse and longitudinal.

Transverse cracks appear perpendicular to the dam axis and indicate differential settlement within the embankment. Such cracks provide avenues for seepage and the piping of embankment material could develop quickly.

Longitudinal cracks run parallel to the dam axis and may signal the early stages of a slide or slump on either face of the embankment. In recently built structures, these cracks may indicate inadequate compaction of the embankment or inadequate foundation preparation during construction.



Transverse Crack

Small cracks, as they appear, should be documented, immediately examined by a professional engineer or the Dam Safety Division, and then sealed. The seal will prevent surface water from entering the cracks and causing saturation of embankment material. Saturation could possibly trigger a slide or other serious problems.

Sealing can be accomplished by compacting clay in the cracks. After the cracks have been sealed, the areas should be monitored frequently to determine if movement is still occurring. Slides or crack locations can be documented with photographs and sketches or diagrams. Continued movement is an indication of a more serious problem such as a slide.

Slides

Slides and slumps are serious threats to the safety of a dam and can initiate catastrophic failure. The need for immediate professional assistance to determine the cause of cracks and slides and to recommend remedial action cannot be overemphasized.

Slides can be detected easily unless obscured by tall vegetation. Arc-shaped cracks are indications that a slide or slump is beginning. These cracks can develop into a large scarp in the slope at the top of the slide.



Slide Failure

If a slide develops, the reservoir should be drained. The scarp should be sealed to prevent rainfall and surface runoff from lubricating the interior slide surface, saturating the embankment, and causing future sliding. Sealing the scarp is only a temporary measure and should include contacting the Dam Safety Division.

Slide material in spillway and outlet areas should be removed immediately since its presence reduces the flow capacity. Shallow surface slides can be repaired by removing the slide material and rebuilding the slope to original grade with well compacted pervious material. The cause for any slide should be fully determined before permanent repairs are made to the slope.

Settlement

Settlement occurs both during construction and after the embankment has been completed and placed in service. To a certain degree, this is normal and should be expected. It is usually most pronounced at locations of maximum foundation depth or embankment height. Excessive settlement will reduce the freeboard (the difference in elevation between the water surface and the top of the dam) and may increase the probability of overtopping during a flood.



Excessive Settlement

Any areas of excessive settlement should be restored to original design elevations to reduce the risk of overtopping. A relatively large amount of settlement within a small area could indicate serious problems in the foundation or perhaps in the lower part of the embankment. Settlement accompanied by cracking often precedes failure. When either condition is observed, professional advice should be sought immediately. Settlement can be monitored by measuring the differences in elevation between the problem area and permanent reference monuments located away from the dam. Land surveying instruments are required to make these measurements.

Repair

Soil added to restore an embankment must be properly "keyed" into the base material. This is accomplished by removing the vegetation and all unsuitable material until a good firm base of undisturbed soil is uncovered. Unsuitable materials include wet, soft, porous, organic, and improperly compacted soils. The surface should then be roughened with a disc or similar device to obtain a good bond between "old" and "new" materials. The new soil should be successively placed in thin layers (6 to 8 inches thick) and each layer compacted before adding more material. Filters and drains may also be necessary to correct stability problems.

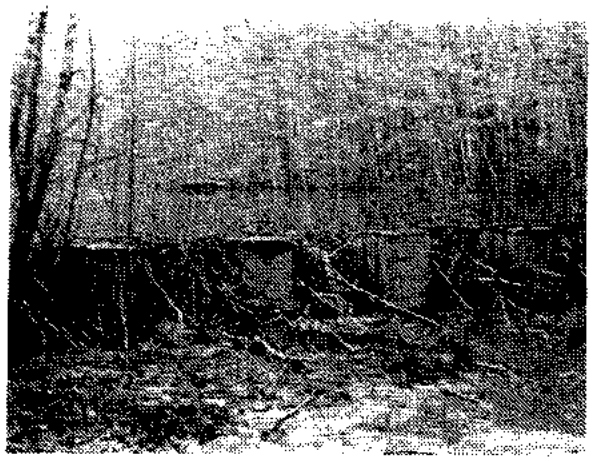
Repair of cracks, slides, and settlement is not considered routine maintenance and must be done under the supervision of a registered engineer who is experienced in the design and repair of dams. A permit must also be obtained from the Water Management Administration's Dam Safety Division.

RODENT CONTROL

Rodents such as the beaver, groundhog, and muskrat are attracted to dams and reservoirs, and can be quite dangerous to the structural integrity and performance of the embankment and spillway. Groundhog and muskrat burrows weaken the embankment and can serve as pathways for seepage. Beavers may plug the spillway and raise the pool level. Rodent control is essential in preserving a well maintained dam.

Beaver

Beavers will try to plug spillways with their cuttings. Routinely removing the cuttings is one way to alleviate the problem. Another successful remedy is the placement of electrically charged wires around the spillway inlet. Trapping beaver may be done by the owner during the appropriate season.



Beaver Dam Blockage in Spillway

Groundhog

Occupied groundhog burrows are easily recognized in the spring due to the groundhog's habit of keeping them "cleaned out." Fresh dirt is generally found at the mouth of active burrows. Half-round mounds, paths leading from the den to nearby fields, and clawed or girdled trees and shrubs also help identify inhabited burrows and dens.

When burrowing into an embankment, groundhogs stay above the phreatic surface (upper surface of seepage or saturation) to stay dry. The burrow is rarely a single tunnel. It is usually forked, with more than one entrance and with several side passages or rooms from 1 to 2 feet long.

Groundhog Control

Control methods should be implemented during early spring when active burrows are easy to find, young groundhogs have not scattered, and there is less likelihood of damage to other wildlife. In later summer, fall, and winter, game animals will scurry into groundhog burrows for brief protection and may even take up permanent nesting during the period of groundhog hibernation.

Groundhogs can be controlled by using fumigants or by shooting. Fumigation is the most practical method of controlling groundhogs. Around buildings or other high fire hazard areas, shooting may be preferable. Groundhogs will be discouraged from inhabiting the embankment if the vegetation cover is properly maintained.

Muskrat

Muskrats can be found wherever there are marshes, swamps, ponds, lakes, and streams having calm or very slowly moving water with vegetation in the water and along the banks. Muskrats make their homes by burrowing into the banks of lakes and streams or by building "houses" of rushes and other plants. Their burrows begin from 6 to 18 inches below the water surface and penetrate the embankment on an upwards slant. At distances up to 15 feet from the entrance, a dry chamber is hollowed out above the water level. Once a muskrat den is occupied, a rise in the water level will cause the muskrat to dig higher to excavate a new dry chamber in the embankment. Damage (and the potential for problems) is compounded where groundhogs or other burrowing animals construct their dens on the opposite side of the embankment.

Muskrat Control

Barriers to prevent burrowing offer the most practical protection to earth structures. A properly constructed riprap and filter layer may discourage burrowing. The filter and riprap should extend at least 3 feet below the water line. As the muskrat attempts to construct a burrow, the sand and gravel of the filter layer cave in and thus discourage den building. Heavy wire fencing laid flat against the slope and extending above and below the waterline can also be effective. Eliminating or reducing aquatic vegetation along the shoreline will discourage muskrat habitation.

Eliminating a Burrow

A method of backfilling a burrow on an embankment is "mudpacking." Lowering of the reservoir pool level may be necessary to accomplish this work. This simple, inexpensive method can be accomplished by placing one or two lengths of metal stove or vent pipe in a vertical position over the entrance of the den. After making sure that the pipe connection to the den does not leak, the mudpack mixture is then poured into the pipe until the burrow and pipe are filled with the mixture. The pipe is removed and dry earth is tamped into the entrance. The mudpack is made by adding water to a 90 percent earth and 10 percent cement mixture until slurry or thin cement consistency is attained. All entrances should be plugged with well compacted earth, and vegetation reestablished. Dens should be eliminated without delay because damage from just one hole can lead to failure of the dam.

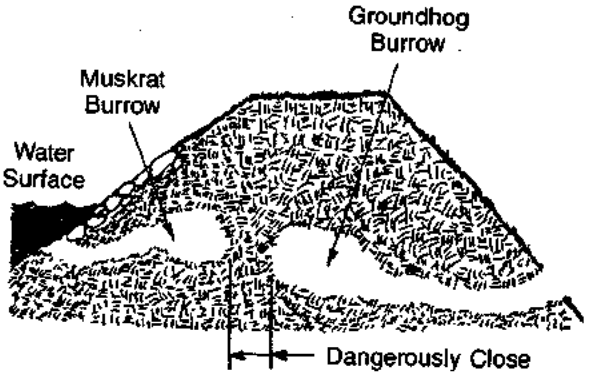


Burrow Under Slab

Hunting and Trapping Regulations

Because state regulations change from year to year, hunting and trapping or other methods used to eliminate animals from the dam may have certain restrictions. For more information, the dam owner should contact:

Maryland Department of Natural Resources
Wildlife Administration
Tawes State Office Building
Annapolis, Maryland 21401
(410) 974-3195.



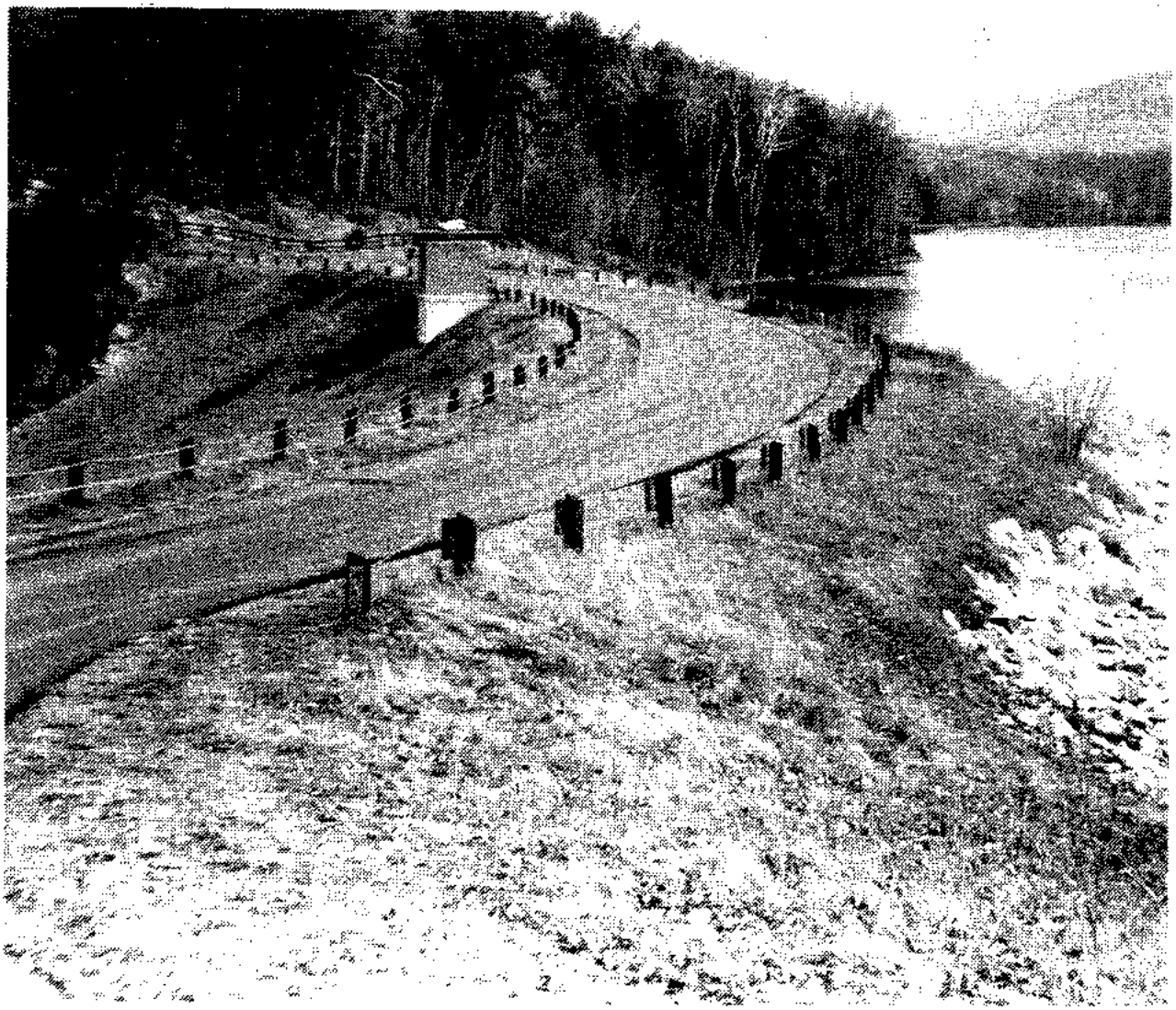
Rodent Burrows

CREST OF THE DAM

The crest, or top of the dam also requires attention and maintenance. The dam crest is usually constructed with a camber because some settlement of the embankment is anticipated.

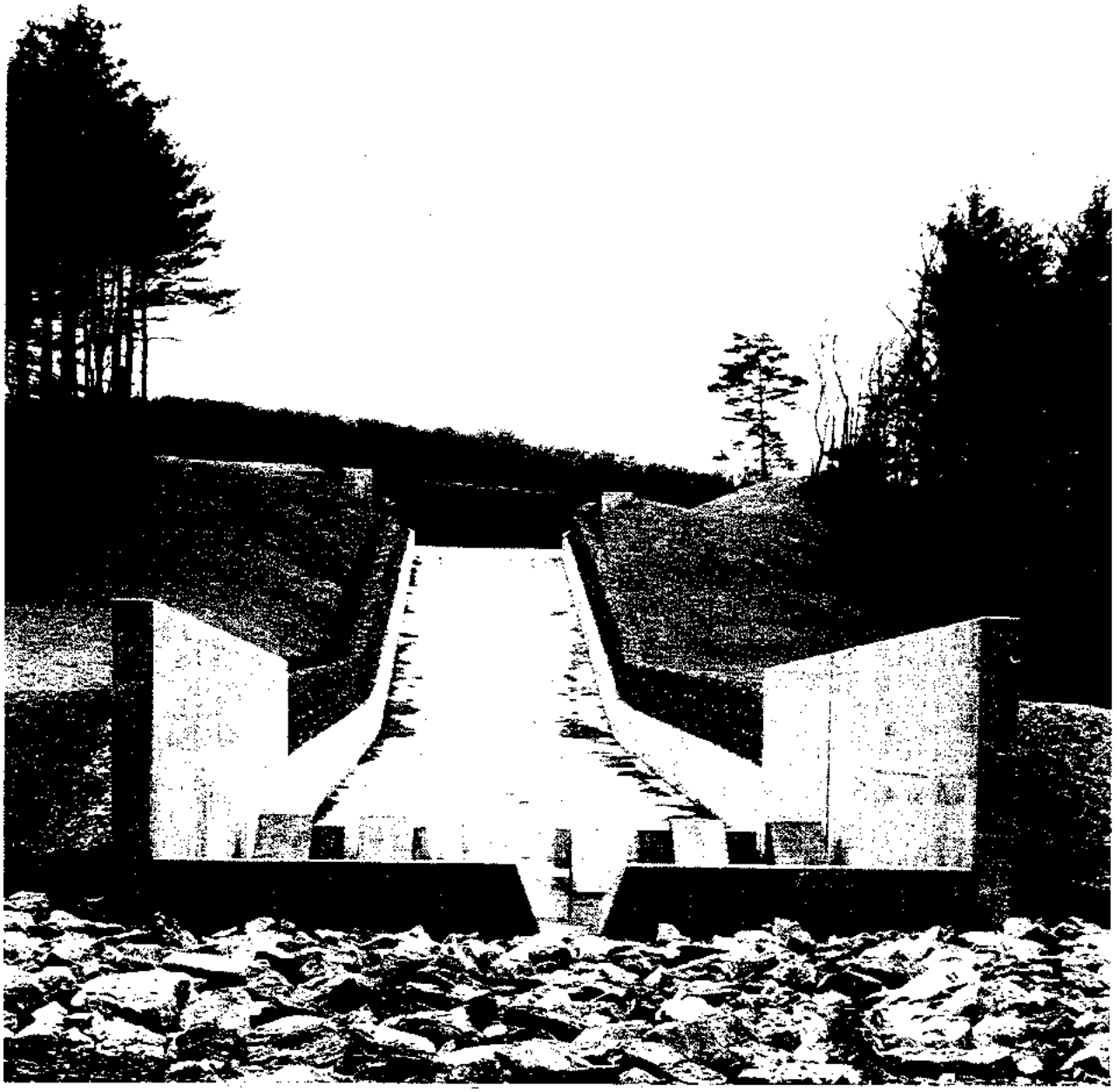
Roads are often constructed along the dam crest in order to gain access to the other side of the dam or to simply gain access to the dam itself. Roads along or on the crest of dams should be maintained not only to keep the road in passable condition, but, more importantly, to prevent damage to the embankment. A road on the dam should be constructed with the proper base and wearing surface. If a well designed wearing surface has not been provided, traffic should not be allowed on the crest during wet conditions. Water collected in ruts may cause localized saturation, thereby weakening the embankment. Ruts that develop in the crest should be repaired as soon as possible. The crest of the dam should be graded to direct all surface drainage into the impoundment. Road drainage should not be concentrated at one location.

Heavily traveled paved roads may require special means for collection and drainage of surface water. If properly designed and constructed, guard rails, curbs, gutters, and rigid pavement may also be located on the crest of the dam.



SPILLWAY AND OUTLET WORKS

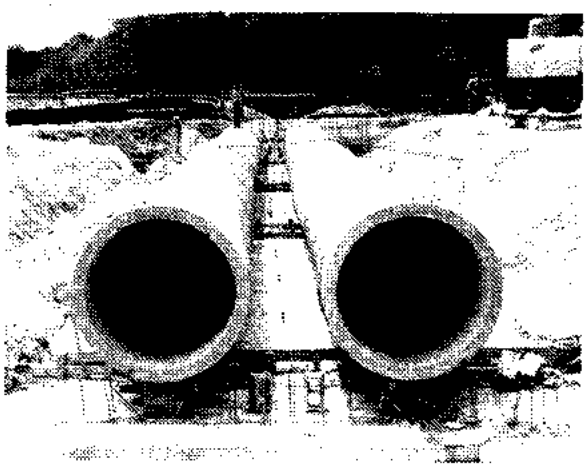
Many dams have a principal spillway that consists of a riser and conduit pipe. This spillway system carries the normal stream and small flood flows safely past the embankment. The emergency spillway will supplement the passage of larger flood flows around the dam to prevent major damage. Conduits are constructed of metal pipe or concrete depending on the size of the dam. Pipes through embankments are difficult to construct properly, can be extremely dangerous to the embankment if problems develop after construction, and are usually difficult to repair because of their location and size. These structures should not be neglected during the course of maintenance.



Principal Spillway • Edgemont Dam • City of Hagerstown, 1993
photo courtesy of Whitman, Requardt and Associates.

CONDUITS

Frequent inspection is necessary to ensure the spillway conduit is functioning properly. All conduits should be inspected thoroughly once a year. Conduits which are 36 inches or more in diameter can be entered and visually inspected. The conduits should be inspected for improper alignment (sagging), elongation and displacement at joints, cracks, leaks, surface wear, loss of protective coatings, corrosion, and blockage.

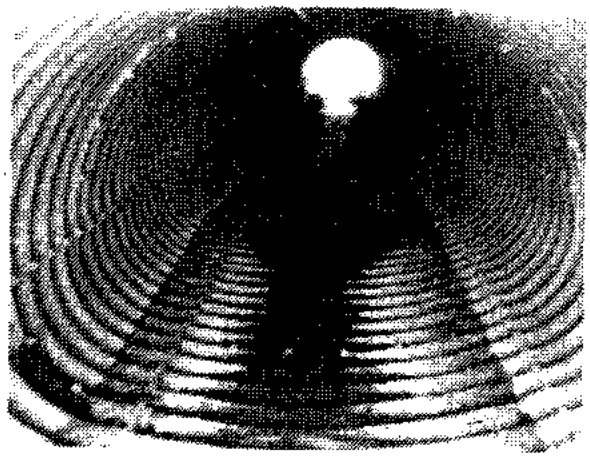


Concrete Conduit

Problems with conduits occur most often at joints, and special attention should be given to them during the inspection. The joints should be checked for gaps caused by elongation or settlement and loss of joint filler material. Open joints can permit erosion of embankment material into the pipe, or cause leakage of water into the embankment when the pipe is flowing full and under pressure. The outlet should be checked for signs of water seeping along the exterior surface of the pipe. A depression in the soil surface over the pipe may be a sign that soil is being removed from around the pipe.

Corrosion

Corrosion is a common problem of metal pipe spillways and other conduits. Exposure to moisture, acid conditions, or salt will accelerate the corrosion process. Metal pipes are available which have been coated to resist corrosion. Coatings can be of epoxy, aluminum, zinc (galvanized), or bituminous asphalt. These coatings are generally applied at the time the pipe is manufactured. Coatings applied to pipes in service are generally not very effective because of the difficulty in establishing a lasting bond.



Metal Conduit Deterioration

Repair

Effective repair of the internal surface or joint of a metal or concrete conduit is difficult, and should not be attempted without careful planning and proper professional supervision. Listed below are comments regarding common methods used in minor pipe repairs.

1. Asphalt mastic used as joint filler becomes hard and brittle, is easily eroded, and will generally provide a satisfactory seal for only about five years. Mastic should not be used if the pipe is expected to flow under pressure. For these reasons asphalt mastic is not recommended for other than temporary repairs.

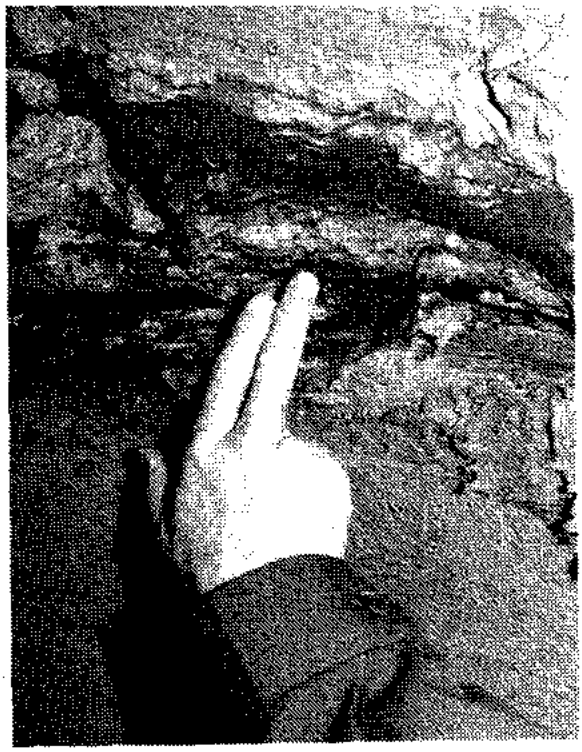
2. The instructions on the label should be followed when using thermosetting plastics (epoxy). Most of these products must be applied to a very clean and dry surface to establish an effective bond.

3. Joint filler compounds should be impervious to water, and should be flexible throughout the range of expected air and water temperatures.

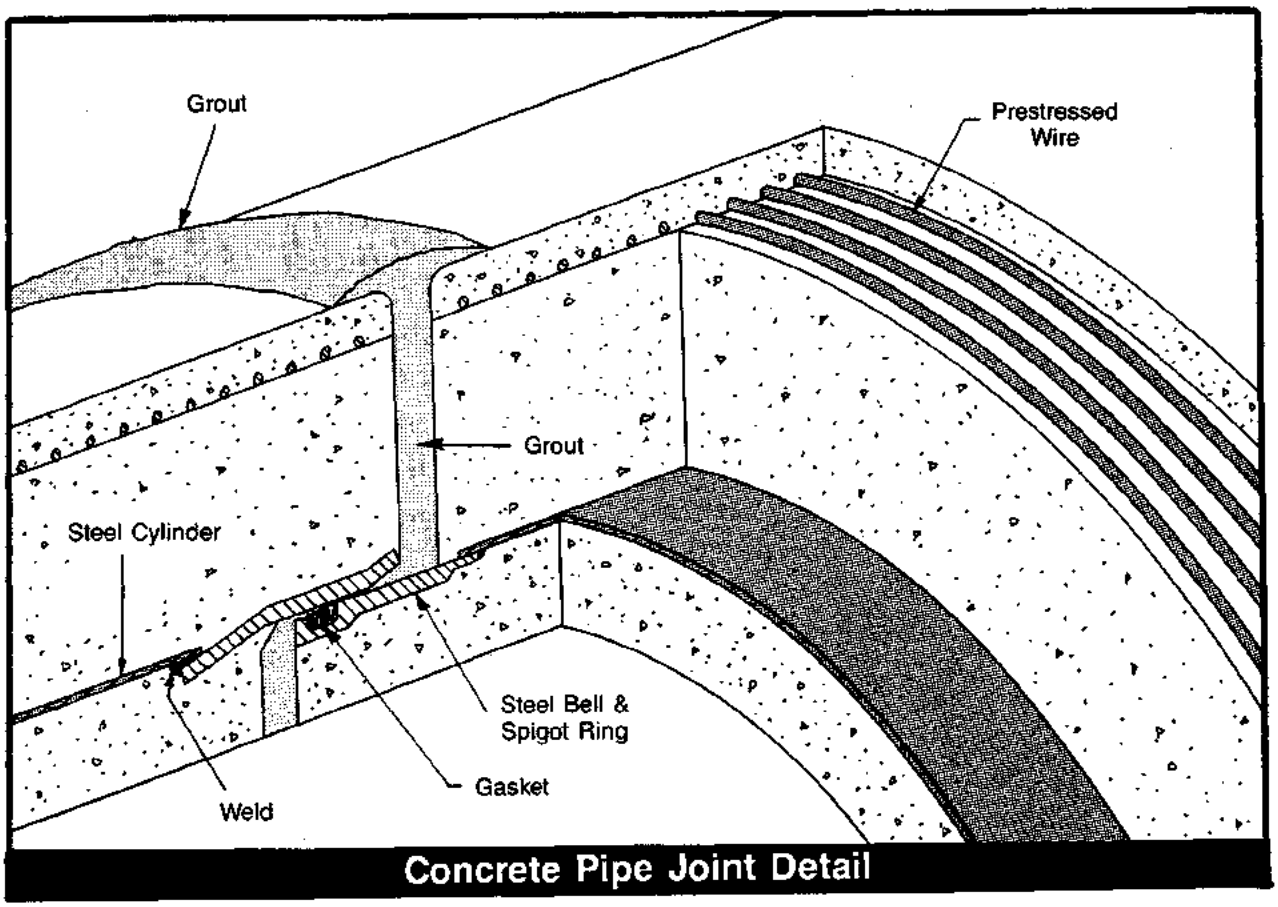
4. The internal surfaces of the conduit should be made as smooth as possible when repairs are made so that high-velocity flow will not damage the repair material.

5. Oakum or gasket-type material can be hammered, jacked, or forced into an open crack or joint and is one of the most effective methods used to repair large openings.

6. Hairline cracks in concrete are not generally considered a dangerous problem, and repair is not needed unless the cracks open up. Cracks are generally repaired with an epoxy compound.



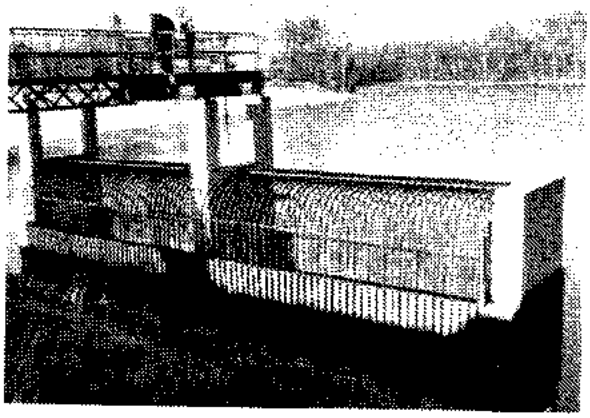
Severe Joint Deterioration



Concrete Pipe Joint Detail

TRASH RACKS

The importance of a safe spillway cannot be overemphasized. Pipe spillways should always contain some type of trash rack in order to prevent accumulation of debris and possible misoperation during a flood event. Even though the emergency spillway is available to pass excess flows, it is generally designed to operate on a very infrequent basis and will sustain some damage during operation.



Welded Bar Trash Rack

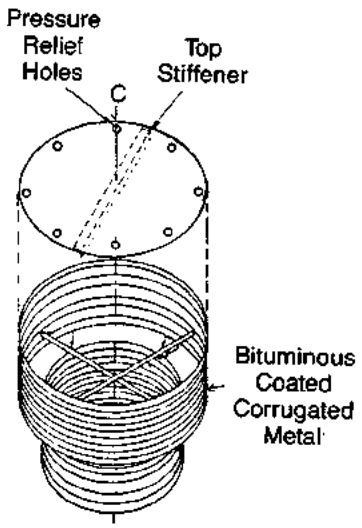
A properly designed riser structure includes a trash rack that will allow passage of smaller debris yet not become clogged as larger debris accumulates around it. There are generally two types of trash rack designs: welded bar and hood. In a welded bar trash rack, the recommended minimum spacing of steel bars is 6 inches on center. Hooded trash racks are generally one piece units and contain either anti-vortex plates or a top plate to prevent debris from entering the conduit. A hooded trash rack is generally installed on a corrugated metal pipe riser, whereas a welded cross-bar trash rack is bolted over the openings of a concrete riser. Both types of trash racks are designed to prevent:

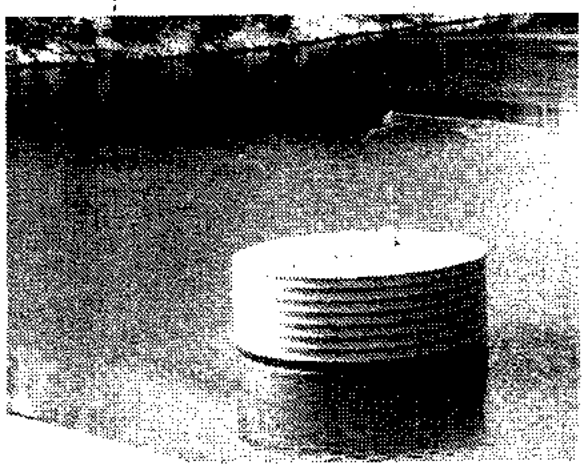
a) accumulation of small debris,
b) development of a whirlpool around the riser, and
c) damage from the hammering forces of debris.



Debris Accumulation

The trash rack unit should be checked periodically, especially after storm events, to ensure that it is functioning properly. Accumulated debris should be removed and maintenance performed if necessary. Under no circumstances should the unit be removed from the riser for an extended period.





CONCRETE

Concrete is a widely used material in dam construction. When made of quality materials and constructed properly, concrete is durable and strong. However, maintenance problems eventually develop in nearly all concrete structures. These problems are caused by design errors, construction errors, chemical attack, and natural forces.



Testing Concrete Strength

Inspection

Concrete surfaces should be inspected for cracking, spalling, displacement or movement, and deterioration by weathering, chemical reactions or leaching. Rust stains may indicate internal rusting and deterioration of reinforcing steel. Expansion and contraction joints should be inspected for signs of deterioration of the joint filler material, leakage, or abnormal movement. Drains designed to relieve water pressure beneath slabs and behind walls should be functional.

Repair Techniques

Concrete problems are structural problems that require structural solutions in order to be long lasting. Concrete repairs can be broken down into several categories as follows:

Patching	**Joint Repair**
Grouting	**Strengthening**
Coatings	**Crack Repair**

Concrete repair techniques are specialized, and depend on the concrete problems encountered. Dam owners are encouraged to consult with a professional in order to select the most appropriate repair method.

Extensive cracking, slab or wall movement, large areas of exposed reinforcing steel, and severe undermining are examples of structural problems which require professional advice and a permit from the Dam Safety Division before repairs can be made. These repairs, not addressed here, are generally expensive and require a custom designed solution.

Minor repairs, as outlined below, can be performed during routine maintenance. Although these repairs are seldom a permanent solution to concrete problems, minor repairs may help to prolong the useful life of the structure.



Concrete Spalling

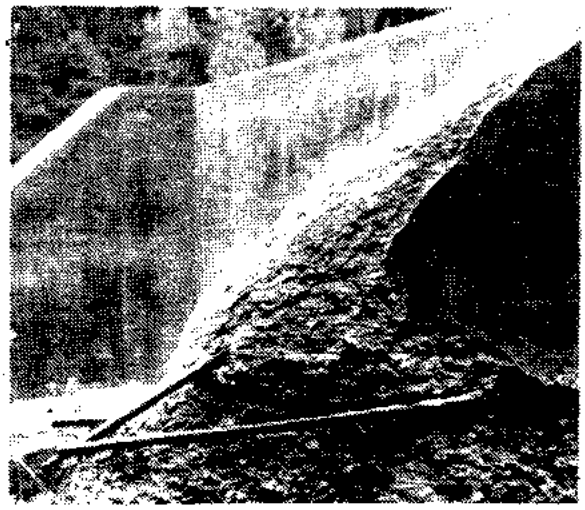
Spalled concrete. Spalling is the loss of surface concrete and can expose the reinforcing steel. Patching is the process of replacing this material. All loose and unsound concrete should be removed from the spalled area and beneath the reinforcing bars if they are exposed. The edges of the area to be repaired, should be saw cut to about 3/4" deep. An appropriate bonding agent

may be applied prior to patching with new concrete. If the spalled area is large enough, anchors must be installed to hold the replacement concrete in position. This work should be done by an experienced contractor.



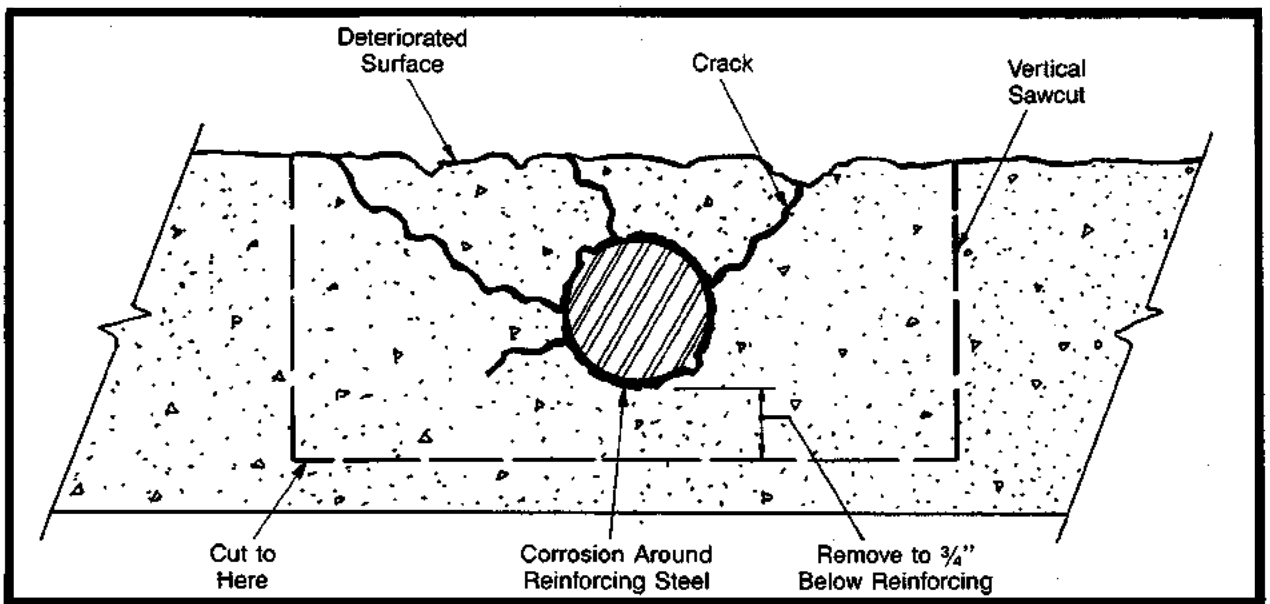
Abutment Wall Crack

Cracks. Small cracks may be repaired by surface sealing with an appropriate adhesive. Epoxy injection, and sawcut and seal techniques are used for larger cracks. Surface sealing is used to stop water flows or as a temporary measure until more permanent crack repairs can be made.



Concrete Deterioration

Surface deterioration. Concrete deterioration on dams is accelerated by the presence of chemicals in the water as well as the freeze-thaw process. Many types of commercial coatings are available to make the concrete resistant to this deterioration. The selection of an appropriate sealer is difficult and must be carefully matched to the specific problem. A specialty contractor should perform the repairs and apply the coating.



Concrete Crack Repair

VEGETATED SPILLWAYS

Dams are designed to safely pass a certain "inflow design flood." This flow is in excess of what is considered the normal operating range for the dam. A concrete dam that consists of a single monolithic structure is generally designed to pass the full range of flows anticipated. However, an earthen structure would most certainly be washed away if flow were to pass over top. Therefore, it is impractical, and economically unfeasible, to size the principal spillway to pass the inflow design flood. For this reason an earthen type of dam must allow flood flows to pass around the embankment section through an emergency spillway.

Emergency Spillway

It is extremely important that the dam owner understand the purpose and function of the emergency, or auxiliary, spillway. This area of the dam is often neglected because the owner rarely sees flow in the spillway. It is a common perception of the dam owner that his structure is fail-safe.



Emergency Spillway In Operation

The emergency spillway is designed to pass flood flows around the dam on an infrequent basis. This type of spillway usually consists of a vegetated earthen channel that is precisely dimensioned to convey water without overtopping the dam. A certain amount of erosion and damage to the spillway is anticipated into the overall design.

A typical spillway section consists of the inlet, control section, and outlet channel.

Spillway Inspection

Vegetated earth spillways are usually the most economical means to provide emergency spillway capacity. Normal flows are carried by the principal spillway, and infrequent large flood flows pass primarily through the emergency spillway. For dams with pipe-conduit spillways, an emergency spillway is almost always required as a back-up in case the pipe becomes plugged.

Maintenance and Repair of Vegetated Earth Spillways

Since the vegetated emergency spillway is used on an infrequent basis, maintenance of the channel should not be a burdensome task. As in the case of the embankment maintenance, there are certain items that need to be attended to that include:

1. **Maintenance of vegetation.** Periodic mowing to prevent trees, brush, and weeds from creating a flow obstruction,particularly at the control section. A poor vegetative cover will usually result in extensive, rapid erosion when the spillway flows, and require more costly repairs. The vegetative cover should be given the same care and maintenance as the embankment of the dam. Reseeding and fertilization is necessary to maintain a vigorous growth of vegetation. Kentucky 31 fescue is an excellent grass for erosion protection (see section on vegetation).

2. **Prompt repair of damage.** Repair of erosion damage, particularly after high flows. Erosion can be expected in the spillway channel during high flows, and can also occur as a result of rainfall and local runoff. The

latter is more of a problem in large spillways, and may require special treatment, such as terraces or drainage channels. Erosion of the side slopes will deposit material in the spillway channel, especially where the side slopes meet the channel bottom. In small spillways, this can significantly reduce the spillway capacity. This condition often occurs immediately after construction, before vegetation becomes established. In these cases, it may be necessary to reshape the channel to provide the flow capacity.

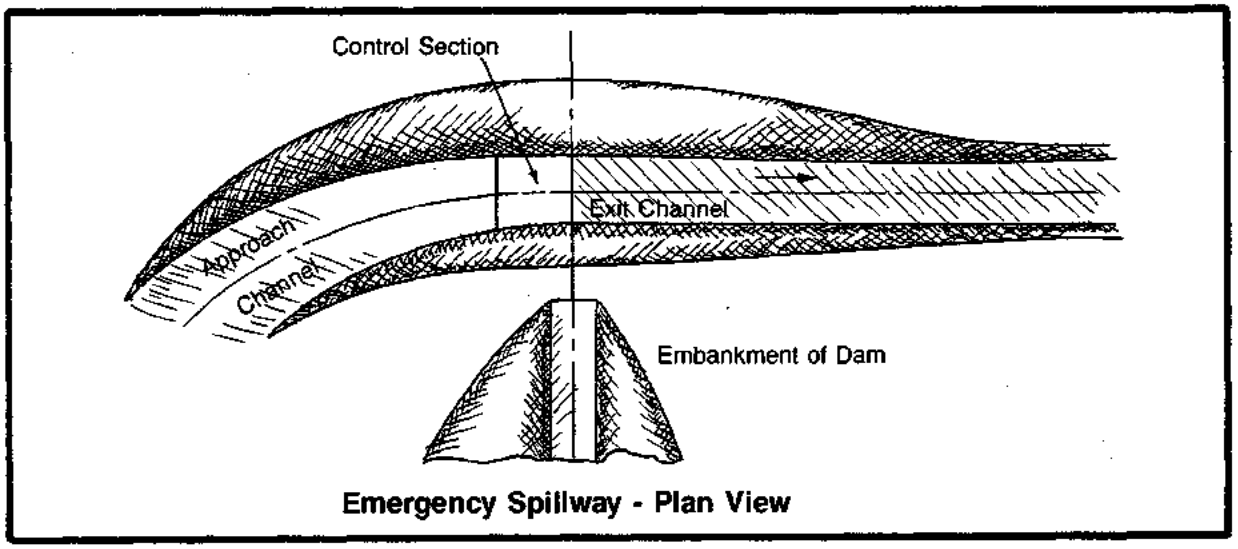
3. **Removal of flow obstructions.** Emergency spillways are often used for purposes other than the passage of flood flows. Among these uses are reservoir access, parking lots, boat ramps, boat storage, pasture and cropland. Permanent structures (buildings, fences, etc.) should not be constructed in these spillways. If fences are absolutely necessary, they should cross the spillway far enough away from its control section (at the highest point in the channel) so they do not interfere with flow. Any change to the dimensions of the spillway channel will alter its capacity to carry flood flows and could cause failure of the dam.



Eroded Spillway



Spillway After Repair



Emergency Spillway - Plan View

OUTLET

Erosion at the spillway outlet, whether it be a pipe or overflow spillway, is one of the more common spillway problems encountered in the maintenance of a dam. Severe undermining of the outlet can displace sections of pipe, cause slides in the downstream slope as erosion continues, and eventually lead to complete failure of the dam. Water must be conveyed safely from the lake to a point downstream of the dam without endangering the spillway or embankment. Often the spillway outlet is adequately protected for normal flow conditions, but not for extreme flows. It is easy to underestimate the energy and force of flowing water and overestimate the resistance of the outlet material (earth, rock, concrete, etc). The required level of protection is hard to establish by visual inspection, but can usually be determined by hydraulic calculations performed by a professional engineer.



Properly Constructed Outlet

Structures that provide for complete erosion control at a spillway outlet are usually expensive to construct, but often necessary. These structures consist of some type of impact basin to reduce flow velocities at the outlet. A concrete overflow section contains a bucket dissipator to deflect water away from the toe of the dam. The most common types of conduit outlet structures are the stilling basin and plunge pool. The major difference between these two designs is that the stilling basin is a concrete structure, whereas the plunge pool is an excavated pool that is armored with riprap for protection against scour. As areas of erosion and deterioration develop, repairs must be promptly initiated.

The following four factors, often interrelated, contribute to erosion and scour at the spillway outlet:

1. Flows emerging from the spillway are generally of high velocity such that the moving water will scour soil material from the outlet channel and leave eroded areas. This erosion is difficult to design for, and requires the outlet be protected for a safe distance downstream from the dam.



Erosion Under Outlet Slab

2. Flows emerging from the outlet are at an elevation above the stream channel. If the outlet flows emerge at the correct elevation, tailwater in the stream channel can be used to absorb a substantial amount of the high velocity flow.

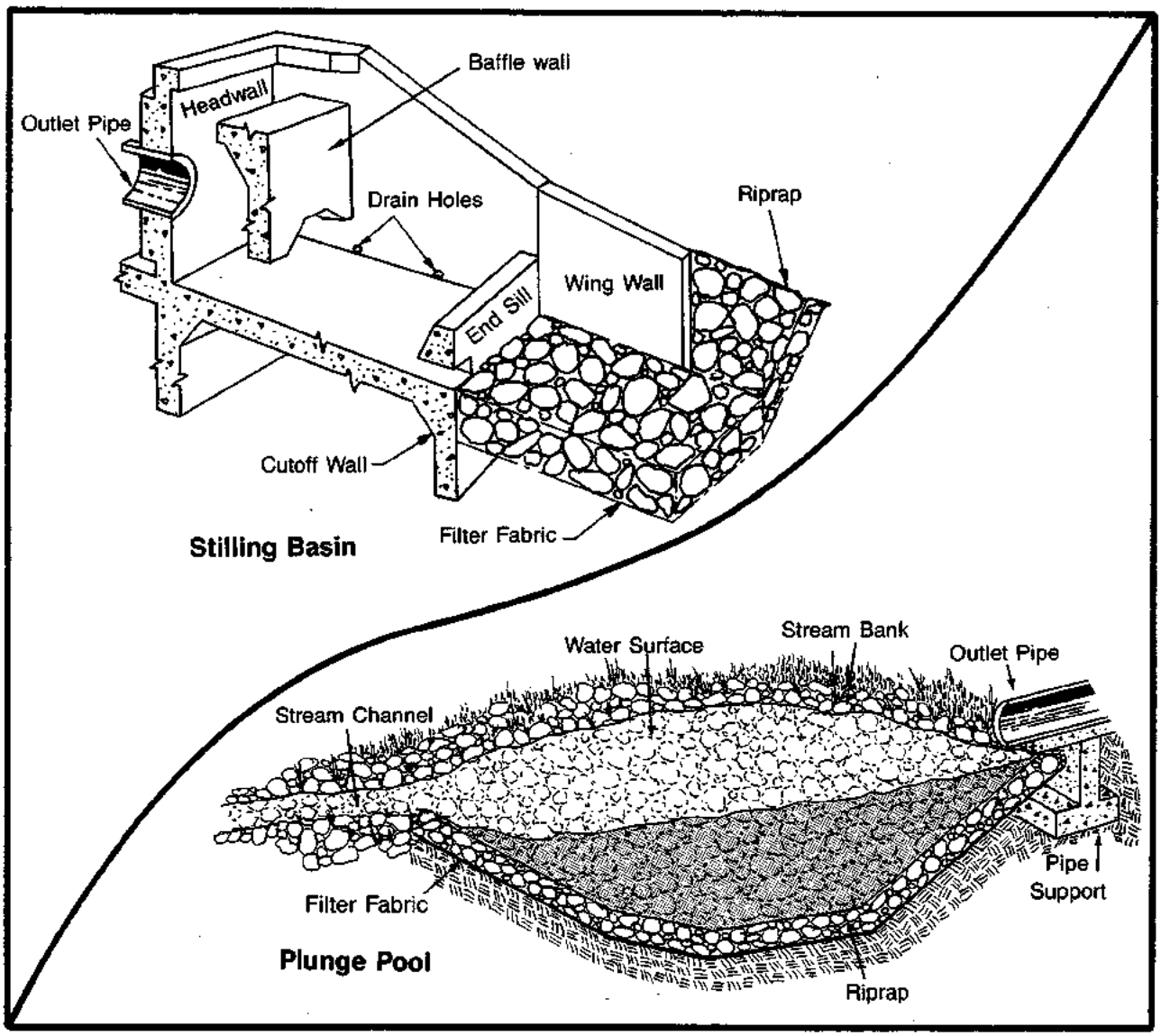
3. Flows leaving the outlet at high velocity can create negative

pressures that can cause material to be loosened and removed from the floor and walls of the outlet channel. This action is called "cavitation" when it occurs on concrete or metal surfaces. Venting can sometimes be used to relieve negative pressures.

4. Water leaking through pipe joints or flowing along a pipe from the reservoir may weaken the soil structure around the pipe outlet. Inadequate compaction adjacent to the conduit during construction adds to the problem.

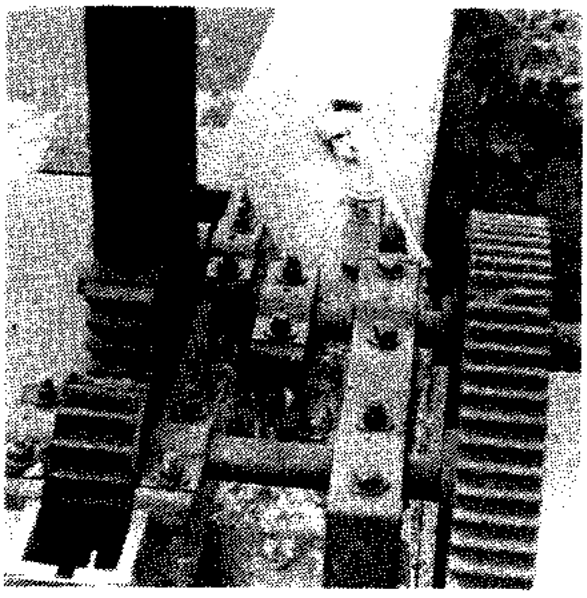
Eroded and undermined areas at spillway outlets can sometimes be repaired by filling these areas with large stone. Stone that is large enough to be effective needs to weigh at least 500 pounds (18 to 24 inches in diameter). Often stone this size is not available or is expensive to buy and haul. Concrete slurry can be used to bind smaller stones together to increase their effective size and weight. Gabions have been used successfully in areas where the velocity is low, but should be used cautiously where high velocity and turbulence are expected. Gabions require careful foundation preparation and experienced personnel for installation.

In many cases, professional help should be obtained for the design and construction of the outlet protection.



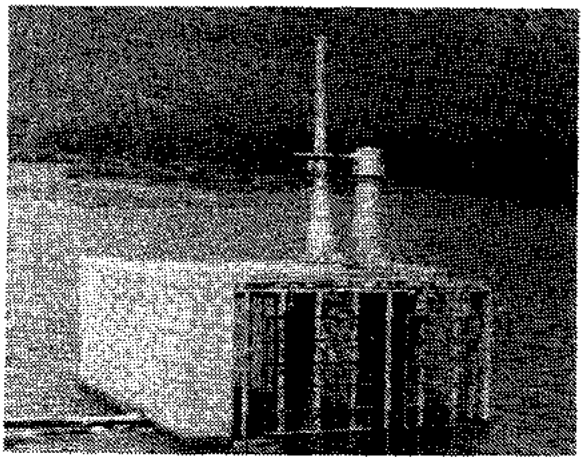
MECHANICAL EQUIPMENT

Mechanical equipment includes spillway gates, sluice gates valves for lake drains or water supply pipes, stoplogs, sump pumps, flashboards, relief wells, emergency power sources, siphons, and other devices. The owner should have copies of all manufacturers' literature for the mechanical equipment. All mechanical and associated electrical equipment should be tested according to the manufacturer's recommendations. Recommended maintenance should be performed at that time. The equipment test should be conducted through the full operating range under actual operating conditions to determine whether the equipment performs satisfactorily. Operating instructions should be checked for clarity, and maintained in a secure but readily accessible location. Each operating device should be permanently marked for easy identification. All equipment controls should be checked for proper security to prevent vandalism.

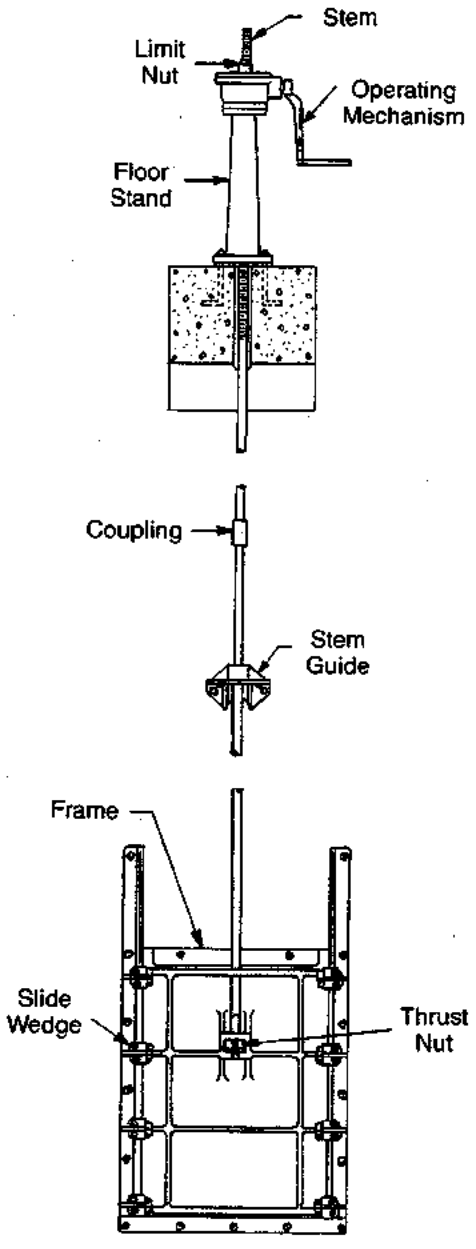


Protecting Metal Parts

Corrosion of metal parts of operating mechanisms can be effectively prevented at the time maintenance is performed by keeping these parts greased or painted.



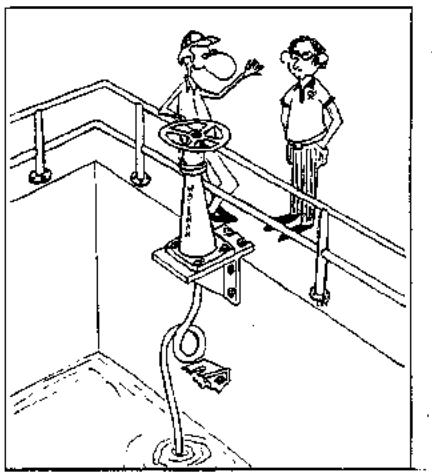
Mechanical Gate Lift



Water Control Gate

LAKE DRAINS

The lake drain should always be operable in order for the pool level to be drawn down in case of an emergency or for necessary repairs. Lake drain valves or gates that have not been operated for a long time present a special problem for dam owners. If the valve cannot be closed after it is opened, the impoundment could be completely drained. Therefore, before operating a valve or gate, it should be carefully inspected and all appropriate parts lubricated and repaired.



I turned it too hard!

An uncontrolled and rapid drawdown of the lake level could induce more serious problems such as slides in the saturated upstream slope of the embankment or reservoir area. Drawdown rates should not exceed 1 foot per week for slopes of clay or silt material except for emergency situations. Very flat slopes or slopes with free-draining upstream zones can withstand more rapid drawdown rates. It is prudent to advise downstream residents of large or prolonged discharges because of the possibility of downstream flooding.

If problems are encountered during the exercising of the drain valve, the operator should stop the test immediately. A professional engineer or the Dam Safety Division should be contacted for advice and assistance in properly exercising a questionable drain gate. Before testing a gate that is suspected to be faulty, the drain inlet upstream from the valve should be physically blocked. Some drain structures have been designed with this capability and have dual valves or gates, or slots for stoplogs (sometimes called bulkheads) located upstream of the drain valve. Divers can be hired to inspect the drain inlet, and may be able to construct a temporary block at the inlet for testing purposes.

Other problems may be encountered when operating the lake drain. Sediment can build up and block the drain inlet. Debris can be carried into the valve chamber, hindering its function if an effective trash rack is not present. These problems can be minimized if the valve or gate is operated and maintained periodically. The gate or valve controlling the lake drain should be operated from the fully closed to fully opened position as recommended by the manufacturer or at least once each year. Early detection of equipment problems or breakdowns, and confidence in equipment operability, are the benefits of periodic operation.

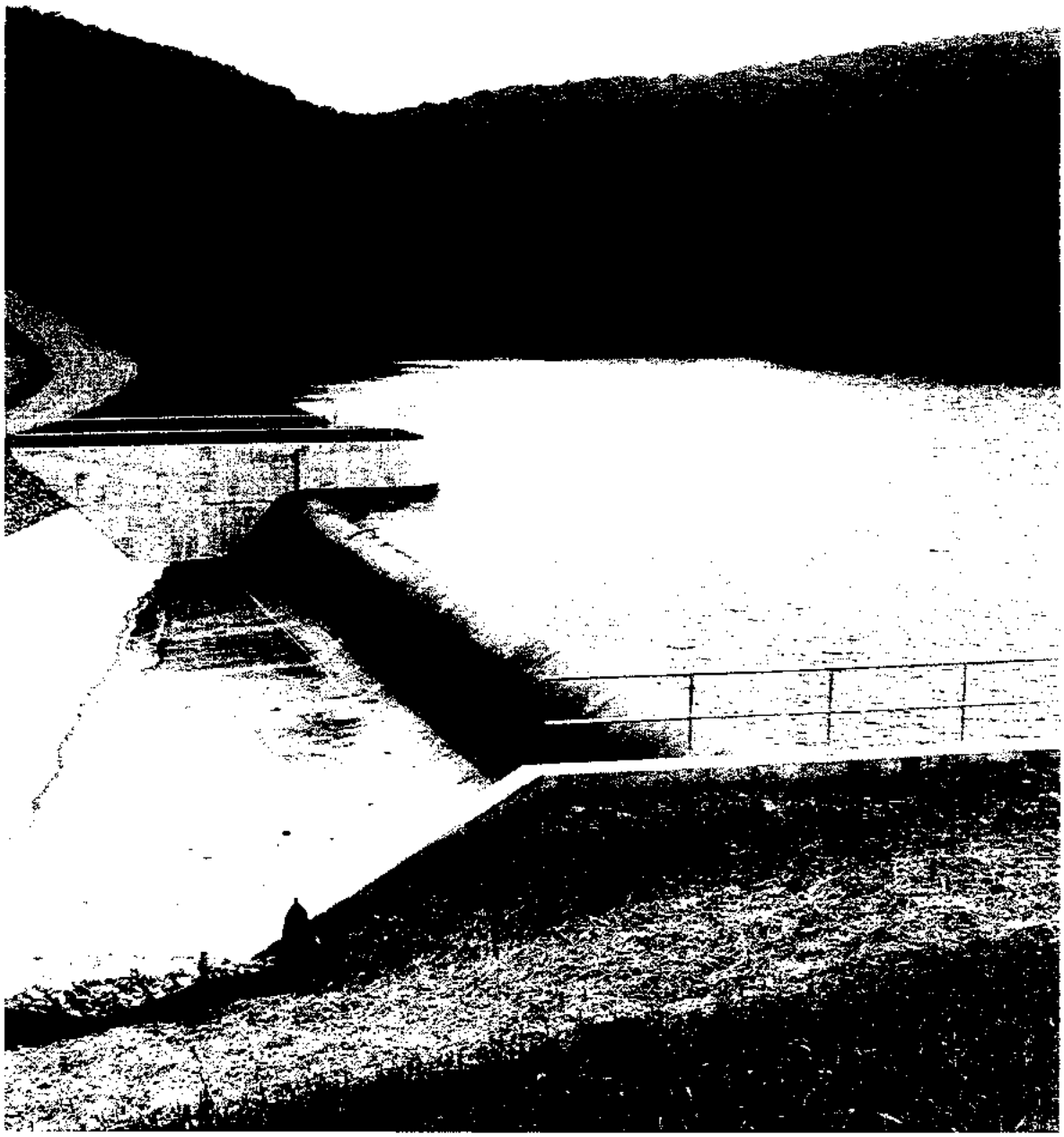
Some older dams have drains with valves at the downstream toe. If the valve is located at the downstream end of a pressurized conduit extending through the embankment, the conduit is under the constant pressure of the reservoir. If a leak in the conduit develops within the embankment, saturation, erosion, and possibly failure of the embankment could occur. A depression in the soil surface over the pipe may be a sign that soil is being removed from around it. These older structures should be monitored closely and owners should plan to relocate the valve upstream or install a new drain structure. Inspectors should closely examine the drain outlet for signs of possible problems.



Reservoir Lake Drain

RESERVOIR

A well documented operation and maintenance program for the dam will include periodic attention to the reservoir pool. The amount of attention needed will generally depend on the size of the facility as well as its intended use. The most frequent maintenance will include the removal of debris entering the reservoir in order to prevent clogging of the spillway section.



Edgemont Dam • City of Hagerstown, 1993
photo courtesy of Whitman, Requardt and Associates.

POOL LEVELS

Reservoir pool levels are often controlled by a combination of spillway gates, flashboards, and lake drain and release structures. The drawdown rate of the pool level should be made over a gradual period of time. Rapid drawdown of the lake could cause a failure of the embankment slope. The dam owner should follow the drawdown guidelines described in the Mechanical Equipment section under Spillway and Outlet Works.

Listed below are conditions or instances in which the pool level might be permanently or temporarily lowered.

1. Maintenance or repair activity requires the pool to be lowered. Drawdown is temporary until the work is accomplished.

2. Water is released to the downstream channel, supplementing streamflow during dry conditions. This may temporarily lower the lake level if there is little inflow to the lake.

3. Water supply reservoir levels will fluctuate according to the service area's demand for water. Flashboards are sometimes used to permanently or temporarily raise the pool level of water supply reservoirs. Flashboards should not be installed or allowed unless there is sufficient freeboard remaining to safely pass the inflow design flood. The installation of flashboards requires a permit from the Dam Safety Division.

4. The pool level is drawn down in the winter to facilitate repair of boat docks, to retard growth of aquatic vegetation along the shoreline, or to allow additional storage for spring runoff.

5. Pool levels are sometimes adjusted for recreation, hydropower, or waterfowl and fish management.



AQUATIC VEGETATION

Control of most aquatic vegetation can be accomplished through the use of chemical herbicides. Aquatic vegetation is classified into three major groups: **floating growth**, **submerged growth**, and **emergent growth**.

Floating growth is a floating dense mat of hair-like fibers. The most common form is filamentous planktonic algae. Most species can be controlled with very low concentrations of copper sulfate or Cutrine-Plus. Application instructions can be found on the product label. Caution should be exercised as copper sulfate can kill new hatches of fish if applied when fish are spawning.

Submerged growth is attached to the lake bottom and has most of its growth below the water surface. It grows mostly in clear, calm, shallow water. Herbicides for submerged weeds are available as liquids, wettable powders (to be mixed with water), and granules. Liquids and wettable powders release their active ingredients immediately and work best when used in spring through midsummer. Granular herbicides release their active ingredients more slowly and should be used early in the growing season or on a spot treatment basis.

Emergent growth is found along the shoreline and in shallow water where the stems and leaves extend out of the water. Cattails, bulrushes, and spatterdock are examples frequently found in these areas. A non-chemical method of control is to increase the water depth in the area of growth by maintaining a steep slope, at least 3H:1V, along the shore. Most herbicides used for land weed control can also be used for emergent growth if combined with a wetting and sticking agent. In addition to commercially available wetting and sticking agents, two tablespoons of liquid household detergent per gallon of herbicide may be used. The mixture is then sprayed until a thin film covers the leaves. Common herbicides include 2-4-D products and Diquat.

Chara, **duckweed**, and **watermeal** are growths that do not fit the above categories. **Chara (muskgrass, stonewart)** grows in dense clumps in shallow areas and is an advanced form of algae. **Duckweed**, a floating weed, has small three-lobed leaves with rootlets that hang down in the water. **Watermeal** consists of small green grains floating in the water.

The use of herbicides for aquatic management is controlled by the Department of Health and Mental Hygiene. These herbicides are classified as either "restricted use" or "general use" products and are identified as such on the product container. Maryland regulations require a permit for the use of **ANY** toxic material for aquatic life management. In addition, the application of a restricted use product requires certification by the Maryland Department of Agriculture. General use products may be applied by an individual property owner without the certification requirement.

With most general use commercial herbicides, application instructions, environmental precautions, and a list of weeds controlled will be found on the label. Always **READ THE LABEL CAREFULLY** and **NEVER** mix different herbicides. Herbicides can be purchased from a local agricultural supply center.

For information on obtaining a permit for the application of herbicides contact the Maryland Department of the Environment at 1-800-633-6101.

For a more complete discussion of aquatic weed control, contact the Maryland Department of Agriculture, Pesticide Regulation Branch, 50 Harry S. Truman Parkway, Annapolis, MD 21401, phone (410) 841-5710, or your local Cooperative Extension Office.

SEDIMENTATION

Sediment is the end product of erosion, which is the naturally occurring process of the wearing away of the earth's land surface. In addition to this natural process, erosion is worsened by man's activities that include construction, foresting, and agricultural practices. The sediment resulting from the entire erosion process in a watershed shows up as physical damage downstream such as:

a) filling in of stream channels and bridges,
b) environmental damage,
c) damage to recreational facilities, and
d) filling of reservoirs.



Sediment Damage

Damages

The damage resulting from sedimentation amounts to millions of dollars annually. These costs can have a significant impact on the useful life of a reservoir. The portion of eroded material that travels through the drainage network to the reservoir is referred to as the sediment yield. Old reservoirs, designed without consideration for sediment yield, are often abandoned because the cost to reestablish a desirable lake is prohibitive. New facilities that are permitted by the Dam Safety Division generally include additional reservoir storage capacity to account for sedimentation. This capacity shows up as an increased project cost to the dam owner.

Sediment Yield Rate

The very existence of a dam in a watershed drainage network upsets the natural equilibrium of the stream. Aggradation, or sediment deposition, occurs above the dam, while degradation of the stream channel can result downstream from the dam.

Sediment deposits first become apparent when deltas build up at the mouths of streams entering the lake. The coarser, heavier sediments are deposited at the inflow to the reservoir while finer particles may be carried as far as the upstream face of the dam. Aquatic vegetation, such as cattails and lily pads, soon develops in the shallow water over these deltas. As sediment deposition continues, the delta will rise above the water surface.

Sedimentation Control

Sediments entering the reservoir cannot be totally eliminated. Therefore, the dam owner should take measures to minimize the effects and consider the annual maintenance costs. One method of controlling sediments is to periodically dredge areas of the lake where sediments have accumulated. This method is usually expensive and includes finding a disposal area for the dredged material.

Another method of sediment control is the construction of sediment "forebays" at locations of stream inflow to the lake. While these areas will also have to be dredged periodically,they limit the amount of time and effort the contractor will have to put into the job. This in turn may limit the cost of dredging to the owner.

Another method of controlling sedimentation is to take an active role in community efforts to control erosion runoff from construction sites. Violations of sediment control laws should be reported to the local sediment control inspector.

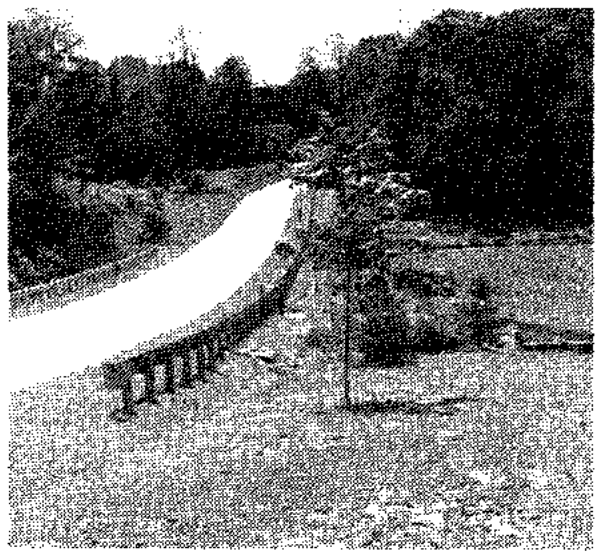
Finally, every method of controlling sediments should include periodically exercising the drain valve to keep sediments from obstructing or burying the inlet.

LAKE PERIMETER AND ACCESS ROADS

The safe operation of a dam also depends on the ability to gain access to all parts of the dam and reservoir. The perimeter of the reservoir can be affected by the fluctuating pool level and is a source of debris and sediments entering the lake.

A function performed during the routine maintenance program should include an inspection of the lake perimeter. Potentially damaging fallen trees, debris, and sediments should be removed.

The access road to the dam itself should also be inspected. The road should be suitable for maintenance equipment to gain access to the structure at all times. Cut-and-fill slopes, both uphill and downhill from the road should be stable. The road surface should be located above the projected high-water elevations of any adjacent streams and the reservoir pool, so access can be maintained during periods of high water.



Paved Access Road

WINTERIZING TECHNIQUES AND PROBLEMS

The pool level of a reservoir is often lowered for the winter months for various reasons: to facilitate repair of boat docks and other structures; to retard growth of aquatic vegetation; to provide additional spring flood storage; or to prevent ice damage. Rapid drawdown of the pool will leave the upstream slope saturated and without support, and could result in sloughs and slides. Unless there is an emergency, the owner should follow the drawdown guidelines described in the Mechanical Equipment section under Spillway and Outlet Works. If there is a question about the allowable drawdown rate, a professional should be contacted. The dam owner should also contact the Dam Safety Division immediately if the pool needs to be drawn down quickly.

Ice can pose problems at spillways and around other structures. Ice formation can be prevented by heaters, aeration equipment, or forced movement of water. Ice in conduit outlets or stilling basins can impair their proper functioning. The owner should be aware of these potential problems and take appropriate action during extended periods of severe cold weather. Ice damage from impact can also occur during thaw when large chunks of ice begin to break free.

Other winterizing activities should include:

1. Seeding bare areas so that vegetation is established before onset of winter.

2. Removing spillway flashboards for providing additional pool storage.

3. Opening valves slightly to provide a small flow to prevent freezing.

VANDALISM

Vandalism is a common problem faced by all dam owners. Particularly susceptible to damage are the vegetated surfaces of the embankment, mechanical equipment, manhole covers, and rock riprap. Every precaution should be taken to limit access to the dam by unauthorized persons and vehicles.

Unauthorized Vehicles

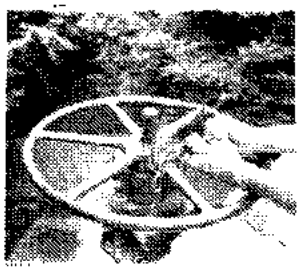
Motorcycles and four-wheel drive vehicles will severely damage the vegetation on embankments. Worn areas could lead to erosion and more serious problems. Barriers such as fences, gates, and cables strung between poles are effective ways to limit access by these vehicles. Fences must not be installed around the emergency spillway area because they can impede the safe discharge of flood waters. A metal or wooden guardrail constructed immediately adjacent to the toe of the downstream slope is an excellent means for keeping vehicles off embankments. However, this may interfere with the operation of mowing equipment.



Damage to Slope

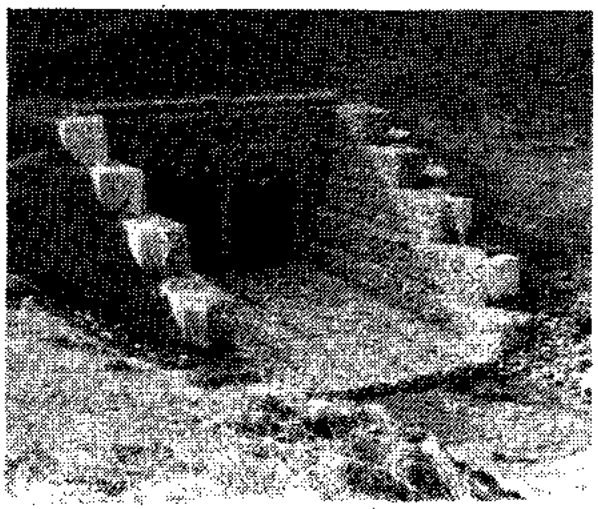
Mechanical Equipment

Mechanical equipment and its associated control mechanism should be protected. Buildings housing mechanical equipment should be sturdy, have protected windows, heavy-duty doors, and should be secured with deadbolt locks or padlocks. Detachable controls such as handles and wheels should be removed when not in use and stored inside. Other controls should be secured with locks and heavy chains where possible. Manhole covers are also subject to removal and are often thrown into the lake or spillway by vandals.



Rock Riprap

Rock used as riprap or inside gabion baskets is often thrown into the lake, spillways, stilling basins, and elsewhere. Riprap is often displaced by fishermen to form benches. The best way to prevent this abuse is to use rock too large and heavy to move easily. Otherwise, the rock must be constantly replenished and other damages repaired.



Removal of Rock Could Endanger Outlet

FISH STOCKING



Pond owners can receive advice on management of the lake for fishing from the Maryland Department of Natural Resources. Fishery management information is available that describes activities such as fertilization, liming, and stocking, as well as common problems associated with ponds, and recommended solutions. For additional information contact:

Maryland Department of Natural Resources
Freshwater Fisheries
Tawes State Office Building
Annapolis, Maryland 21401
(410) 974-3061

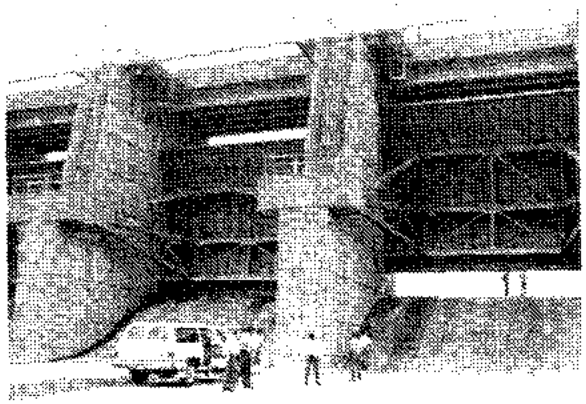


INSPECTIONS

Periodic inspection is an essential part of dam operation. Owners are encouraged to make a thorough visual inspection of their dams at least twice a year - once in the summer after mowing, and once in the winter when the vegetative cover is dormant. Inspections should also be made after extreme rainfall events. Owners of high hazard (Category I) dams are encouraged to have their dams inspected by a registered professional engineer at least once every 5 years.

INSPECTION GUIDELINES

The external surface of an earth dam can often provide clues to the condition of the interior of the structure. A thorough evaluation of all exposed surfaces of the dam should be made during the inspection. It is important to note changes in the appearance of the structure from one inspection to the next. If any of the following conditions are noted, **emergency procedures** are warranted: muddy water is flowing from the downstream slope or toe; cracks or depressions are forming on the embankment; movement of the embankment is occurring; or flood flow over top of the embankment is imminent.



Inspection of Large Dam

During the inspection, the embankment should be examined for settlement, displacement, cracking, erosion, and adequacy of the vegetative cover. The downstream slope and toe area should also be inspected for signs of seepage such as wet spots, wet ground vegetation, boils, or depressions. Internal drainage systems should be examined for chemical deposits, algae growth, corrosion or other deterioration, and clogging or obstruction. Any instrumentation for the structure should be examined and the appropriate readings and measurements taken. Observation wells, weirs, and water level gages can often be read with simple equipment. Settlement monuments, piezometers and slope inclinometers require specialized equipment for readings and engineering evaluation of the data is necessary.

The Dam Safety Division of the Water Resources Administration also conducts periodic inspections of many dams in an effort to assist owners in the safe operation of their structure. These inspections are made at intervals of one to five years that are determined by the type, size, and importance of the dam as well as its age and overall condition, spillway type, past performance, and potential to cause damage in the event of a failure.

DAM INSPECTION CHECKLIST

To help the dam owner perform periodic safety inspections of the structure, a checklist is provided. Each item of the checklist should be completed. **Repair** is required when obvious problems are observed. **Monitoring** is recommended if there is potential for a problem to occur in the future. **Investigation** is necessary if the reason for the observed problem is not obvious.

A brief description should be made of any noted irregularities, needed maintenance, or problems. Abbreviations and short descriptions are recommended. Space at the bottom of the form should be used for any items not listed.

The following chart may be used as a guide by the dam owner in determining the frequency of inspections for the dam. Each program is dependant on the particular condition of the dam. The Dam Safety Division is available to assist owners in tailoring a program for their facility.

DAM _____ **DATE** _____
OWNER _____ **WEATHER** _____
INSPECTED BY _____ **POOL LEVEL** _____

Item	Comments	Y/N	MONITOR	REPAIR	INVESTIGATE
1. CREST					
a. Visual settlement?					
b. Misalignment?					
c. Cracking?					
2. UPSTREAM SLOPE					
a. Erosion?					
b. Ground cover in good condition?					
c. Trees, shrubs, or other woody vegetation?					
d. Longitudinal/Vertical cracks?					
e. Adequate riprap protection?					
f. Stone deterioration?					
g. Settlements, depressions, or bulges?					
3. DOWNSTREAM SLOPE					
a. Erosion?					
b. Ground cover in good condition?					
c. Trees, shrubs, or other woody vegetation?					
d. Longitudinal/Vertical cracks?					
e. Riprap protection adequate?					
f. Settlements, depressions, or bulges?					
g. Soft spots or boggy areas?					
h. Movement at or beyond toe?					
i. Boils at toe?					
4. DRAINAGE-SEEPAGE CONTROL					
a. Internal drains flowing?	Est. Left _____ gpm Est. Right _____ gpm				
b. Seepage at toe?	Estimated _____ gpm				
c. Does seepage contain fines?					

INSPECTION CHECKLIST - PAGE 2

INSPECTED BY _____ **DATE** _____

Item	Comments	Y/N	MONITOR	REPAIR	INVESTIGATE
5. ABUTMENT CONTACTS					
a. Erosion?					
b. Differential movement?					
c. Cracks?					
d. Seepage?	Estimated _____ gpm				
e. Adequate erosion protection for ditches?					
6. INLET STRUCTURE	Concrete or Metal Pipe (circle one)				
a. Seepage into structure?					
b. Debris or obstructions?					
c. If concrete, do surfaces show:					
1. Spalling?					
2. Cracking?					
3. Erosion?					
4. Scaling?					
5. Exposed reinforcement?					
6. Other?					
d. If metal, do surfaces show:					
1. Corrosion?					
2. Protective Coating deficient?					
3. Misalignment or split seams?					
e. Do the joints show:					
1. Displacement or offset?					
2. Loss of joint material?					
3. Leakage?					
f. Are the trash racks:					
1. Broken or bent?					
2. Corroded or rusted?					
3. Obstructed?					
4. Operational?					
g. Sluice/Drain gates:					
1. Broken or bent?					
2. Corroded or rusted?					
3. Leaking?					
4. Not seated correctly?					
4. Periodically maintained?					
5. Operational?					

INSPECTION CHECKLIST - PAGE 3

INSPECTED BY _____ **DATE** _____

Item	Comments	Y/N	MONITOR	REPAIR	INVESTIGATE
7. PRINCIPAL SPILLWAY PIPE	Concrete or Metal Pipe (circle one)				
a. Seepage into conduit?					
b. Debris present?					
c. Do concrete surfaces show:					
1. Spalling?					
2. Cracking?					
3. Erosion?					
4. Scaling?					
5. Exposed reinforcement?					
6. Other?					
d. Do the joints show:					
1. Displacement or offset?					
2. Loss of joint material?					
3. Leakage?					
8. STILLING BASIN/POOL	Riprap or Concrete (circle one)				
a. If concrete, condition of surfaces?					
b. Deterioration or displacement of joints?					
c. Outlet channel obstructed?					
d. Is released water:					
1. Undercutting the outlet?					
2. Eroding the embankment?					
3. Displacing riprap?					
4. Scouring the plunge pool?					
e. Tailwater elevation and flow condition:					
9. EMERGENCY SPILLWAY					
a. Is the channel:					
1. Eroding or backcutting?					
2. Obstructed?					
b. Trees or shrubs in the channel?					
c. Seepage present?					
d. Soft spots or boggy areas?					
e. Channel slopes eroding or sloughing?					
10. RESERVOIR					
a. High water marks?					
b. Erosion/Slides into pool area?					
c. Sediment accumulation?					
d. Floating debris present?					
e. Adequate riprap protection for ditches?					



CONSTRUCTION

Modern dams are highly complex and exact structures. From the early dams and their failures, a great deal of knowledge has been gained on the design, construction, and safety of dams. Dams require the art of defensive engineering, which means that a wide range of forces and circumstances must be considered. Each project requires an array of different designs to call on because of: (a) unique site conditions, (b) the particular use of the dam, and (c) the hazards inherent to the particular site.

The necessity for the control of dam construction is obvious because of the potential for damage from failure. A safe and well engineered design may be entirely ruined by careless and shoddy construction. Careful attention to the details of construction is therefore as important as the preliminary investigation and design.

ADMINISTRATIVE

An owner contemplating the construction or repair of a dam must engage the service of a registered engineer. The engineer should be familiar with the State's administrative and technical requirements in order to assure that the dam is properly built or repaired. The Dam Safety Division requires an engineer to be licensed in the State and have prior experience in the design and construction of dams. The engineer is referred to as the Engineer-In-Charge (EIC) and is responsible for seeing the entire project through. Among other things, the EIC is responsible for the following throughout the construction process:

* Submitting periodic reports to the Dam Safety Division,
* Submitting design changes to the Dam Safety Division for approval,
* Certification that the structure is ready for filling, and
* Certification of project completion along with project narrative and "as-built" plans.



Good construction begins with good design. Decisions made during the design process will affect the cost of construction, operation and maintenance cost and, ultimately the life of the structure. Choices that are made on the basis of available funds often result in the dam owner spending additional monies at a later date to correct problems that arise.

There are short term vs. long term trade-offs that are made by the owner and his engineer throughout the design process. During this process it is important that thought be given to unanticipated problems that will arise during construction as well as the need for future operation, and maintenance, and repair. There are several fundamental questions that the engineer should ask himself throughout the design process:

1. Can the structure be built or repairs made with a minimum of effort and cost or does that project involve practices and procedures the contractors are not familiar with?

2. Are product materials readily available or must they be custom built for the job?

3. Are functioning parts of the dam (appurtenances) readily accessible for maintenance and repair?

All of these items can contribute not only to the increased cost of the project to the owner but to the long term operation and repair problems of the dam.

Plans and Specifications

Plans and specifications set the standard by which a dam is to be built or modified. Deviations from the standard that is prescribed by the designer will tend to weaken the structure, make it less durable or cause operation and maintenance problems. It is through the use of plans and specifications that the quality of the materials being used are described as well as the level of work quality the contractor must meet in placing the materials in the total structure.

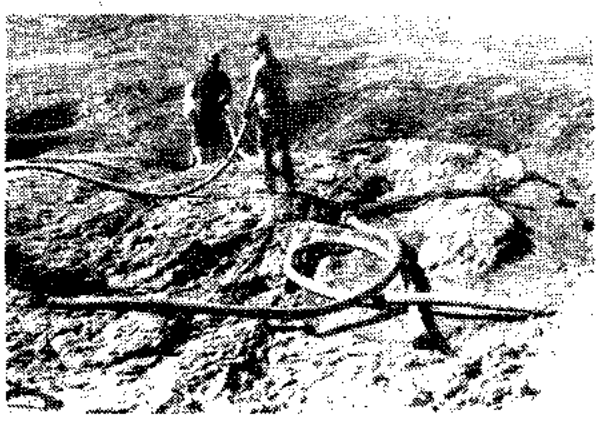
The following is a discussion of typical areas covered by specifications for dams:

Foundation preparation - In order for the dam to be a sound structure it must rest on a solid foundation. Foundation investigations consider the physical features of the site including topography, geology, material availability, and material properties. Specifications for the foundation preparation will address such concerns as:

a. geologic faults,
b. the ability of the foundation material to support the weight of the dam,
c. the control of excessive seepage, and
d. the uniform consolidation of the foundation and fill material.

To address these concerns, specifications may include sections on:

a. removal of unsuitable material,
b. grouting,
c. dental concrete,
d. removal of overhanging or sheer rock surfaces, and
e. core trenches, slurry trenches or other methods of cutting off the excessive seepage of water.

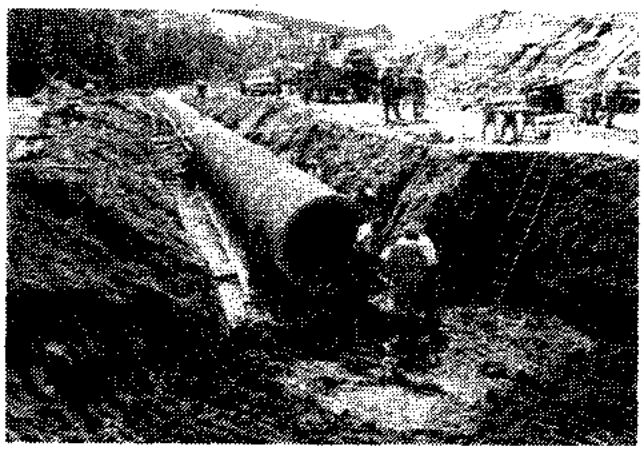


Preparing Rock Foundation

Pipe - Various types of pipe are used for a wide range of purposes in the construction of a dam. Of particular importance are pipes used as principal spillways and any other pipe that goes from the upstream to the downstream side of an earth dam. Pipe is a rigid structure. As such, voids can form around the pipe during consolidation of the embankment. These voids can provide channels for water to escape through the dam, which in turn may cause the dam to fail. For this reason, anti-seep collars are often specified. In addition to conveying water, the pipe must resist the load imposed by the surrounding fill, it must not leak, and joint elongation due to settlement must be accounted for. To accomplish this, pipe specifications will include:

a. size,
b. type,
c. joint design, and
d. load bearing capacity.

The design may include a concrete cradle for additional support. Specifications may also include instructions to the contractor on how to place the pipe and provisions for rejecting damaged pipe.

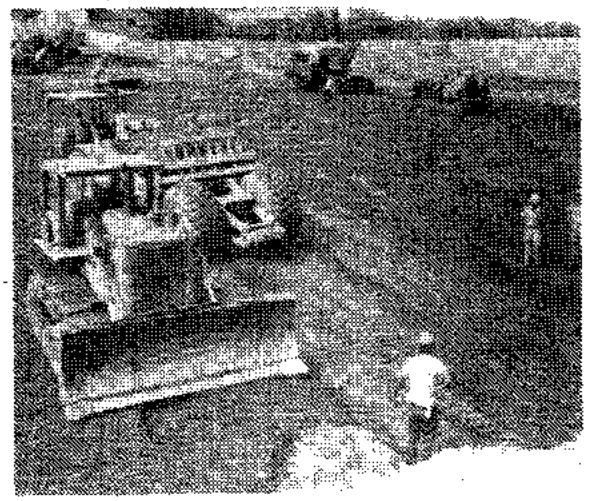


Close Inspection of Installation

Earth and Rock Fill - When a dam is to be built of locally available material, the specifications will address such concerns as: the ability of the embankment to support its own weight under conditions of high water, normal pool and rapid draw down; the degree of consolidation that will occur over time; and, depending upon the availability, a variety of material may be specified to be placed in "zones" of the fill. To address these concerns specifications will include:

a. the grain size distribution of each material to be used,
b. the in-place density of each material,
c. moisture content, and
d. quality of the material in terms contaminants such as organic material.

Specifications may also address how the contractor will do the work by specifying the sequence of construction and type of equipment to be used.



Proper Placement of Embankment Fill

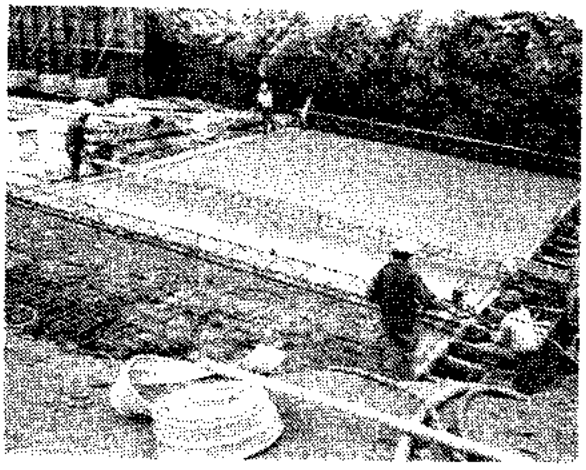
Concrete - Concerns regarding concrete are workability during placement, design strength, appearance of exposed surfaces and durability. To address these concerns specifications for concrete will include;

a. design mix (the ratio of cement, sand, coarse aggregate and water) which is frequently provided by the concrete supplier,
b. compressive strength after 28 days of curing,
c. amount of air entrainment,
d. slump,
e. quality of aggregate, and
f. cement type.

Specifications will also include how the

contractor is to perform, including:

a. placement methods (vibrating, limit height of fall, etc.),
b. surface finish,
c. control of cold joints, and
d. repair of faulty areas.



Concrete Pour

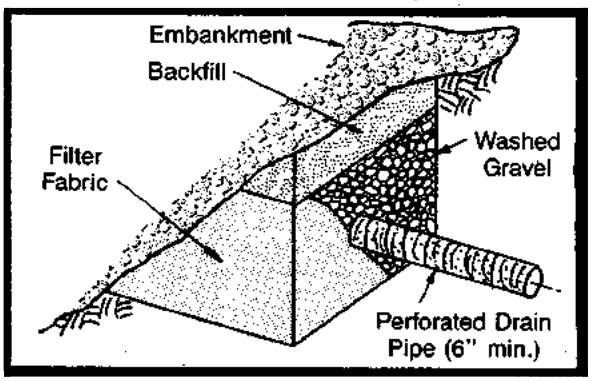
Gates and other mechanical equipment- Gates, valves and other mechanical equipment must operate under adverse conditions. Frequently, mechanical equipment is expected to operate after long periods of idleness. This is one area where a little extra money may be well spent on high quality equipment. Specifications for gates include:

a. size,
b. type,
c. material,
d. operating head,
e. size and type of valve stem,
f. size, type and location of stem guides, and
g. size and type of hoist.

Filter drains - Filter drains are placed in earth dams to provide for the safe passage of seepage from the embankment and foundation to the downstream toe of the dam, thereby preventing piping failures, slope failures and wet conditions on the downstream face. Drains must provide voids of sufficient size to provide for free passage of water and at the same time provide voids that are small enough to prevent migration of the finer fill material surrounding the drain. To accomplish this the specifications will include:

a. grain size distribution, and
b. requirements for durability and hardness.

In some cases drains may be constructed as layers of fine material and coarse material. Specifications may also include a filter fabric defining the transmissibility, type of weave and strength.



Riprap - Areas of the dam and exit channel that are subject to damage by wave action and high velocities are most frequently protected by riprap. The ability of riprap to resist erosion is based upon its size and weight. Therefore specifications for riprap will include:

a. size distribution, and
b. durability.

SUPERVISION

The supervision of construction or repair of a dam by a professional engineer is required. The engineer who designed the project is often required to be the EIC because he is the one individual most familiar with the thinking and interpretation of data made during the design process. If unanticipated conditions are encountered during construction, the design engineer is the one best able to make the necessary adjustments in the design.

Construction Inspections

The amount of supervision required of the EIC depends on the size and complexity of the dam to be constructed. In some cases the EIC, with the assistance of a competent inspector, may only have to make periodic visits to the site. In others, the EIC may have to spend full time at the site with the assistance of other engineers and staff inspectors.

Unanticipated conditions often dictate changes to the plan. These changes must be submitted to the Dam Safety Division for approval prior to the execution of the change. Here is one place where keeping the state field engineer informed can help expedite matters.

The EIC is also responsible for providing to the Dam Safety Division periodic reports that document work progress, problems encountered during construction, and other pertinent information. This report is part of the permit requirements. Upon completion of the project the EIC is responsible for certifying that the project was built in accordance with the plans and specifications. The Dam Safety Division maintains a permanent record of the construction history for future reference. These records are maintained in the event that future structural modifications are required or problems are encountered.

When construction of the dam is substantially complete, contractor or the owner will want to start filling the reservoir. At this time the EIC must prepare a letter stating that the reservoir is ready for filling and request permission from the Dam Safety Division to close the gates. The state field engineer will act on that request.

Within a reasonable period after completion of the dam (usually specified in the permit), a final inspection will be conducted by the EIC, Dam Safety Division and the owner. Thereafter, periodic Operation and Maintenance inspections are required by the owner. The Dam Safety Division will also periodically inspect the structure.



Testing Embankment Compaction



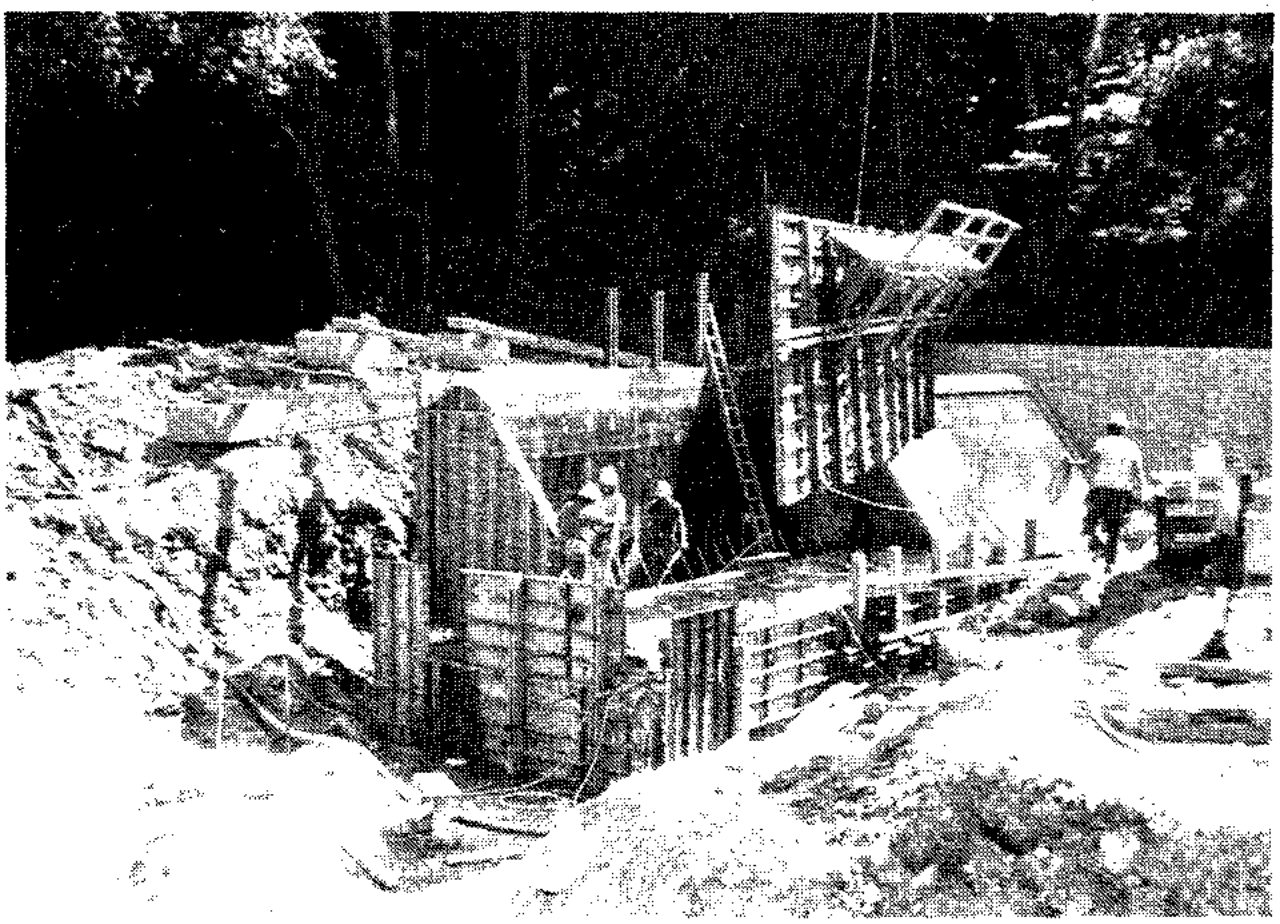
Testing Concrete Quality

State Inspections

Construction progress is closely monitored by a field engineer from the Dam Safety Division. Even though the state representative makes frequent visits to the site, he cannot duplicate or relieve the EIC of his responsibility. The field engineer can provide expeditious handling of temporary permits and requests for modifications to the plans and specifications. Additionally, he can provide an extra pair of eyes in the monitoring of quality control. If the field engineer sees something that appears to be wrong or questionable, he will bring it to the attention of the EIC. The state's field engineer can assist in various decision making processes in order to assure that a safe structure is built.

The best way to work effectively with the field engineer is to keep him advised as to problems encountered and the thought process leading to a solution. That way, when a design change is proposed he can approve it in a timely manner. One very helpful way to keep the field engineer informed is to allow him to participate in progress meetings. Such participation allows him to gain a feeling for the relationships among the EIC, the contractor and the owner.

The contractor should be aware of the fact that he must obtain permits for temporary construction which affects the stream (e.g. waterway crossings and stream diversions). Again the state field engineer can help expedite matters if he knows what is going on. The contractor, the owner and the EIC all want a quality job. However, in the unlikely event that it appears that a dam is not being built according to plans and specifications, the Dam Safety Division will take appropriate administrative and legal actions. These may include revoking the permit and ordering the owner to remove the partially completed obstruction.



CONSTRUCTION PROBLEMS

Construction projects are rarely completed without some delay or problem arising throughout the process. If a project is planned, coordinated, and supervised properly, the chance of major problems is minimized. However, there are several problems that occur with some frequency. When these problems develop there are delays that usually result in increased construction costs.

Scheduling

The first of these problems is the sequence of construction. The engineers should anticipate how the contractor is going to build the job and prepare construction plans that can be followed with a minimum amount of diversions, pumping, and other temporary construction. However, the contractor must also put some thought into the sequence of steps he is going to follow in construction of the dam. This is to insure that he has an efficient operation. Additionally, he must be sure he has the right material, equipment and manpower on the job at the right time.

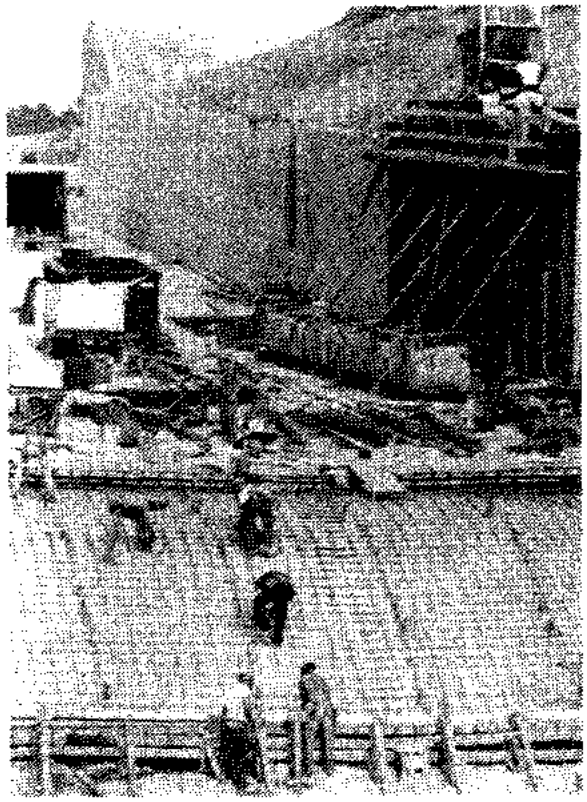
For example, it seems obvious that, in most cases, the outlet works must be completed early in the job, and yet, contractors continually place themselves in the position of having to pour concrete or place gates in the wet. A little forethought would prevent a lot of sand bagging and pumping.

Financial Health

As in any business operation, the contractor's goal is to make money while providing a quality product to his client. Of course, there are justifiable reasons for profit losses on a particular job. However, a contractor that is loosing money on a job may be cause for concern. For these reasons, the contracting process should provide for the elimination of bids that grossly fall short of the engineer's estimated cost. Additionally, throughout the course of the project all parties should periodically meet to discuss all aspects of the job progress. Potential financial problems should be discussed before the quality of the job suffers.

Ordering Supplies & Equipment

One frequent cause of delay is the time required for suppliers to provide mechanical equipment, particularly gates. Ordering mechanical equipment should be done very early in the job. Also, certain types of pipe are special order items. In some instances contractors have found it difficult to find a supplier for a specific product because the order is generally small in quantity.



Proper Scheduling Avoids Delays

Proper Equipment

Having the proper equipment on the job is important. "Making do" often leads to slow production and the correction of inadequate work. The most frequent problems on earth dams, in this regard, are improper or inadequate compaction equipment and a lack of means for providing moisture control.

Natural Hazards

Another problem the contractor must address, especially if it is not considered in the design, is the problem of flooding during construction. At the very least, the contractor should provide for removing equipment to high ground during floods. Other defensive measures may include constructing the upstream portion of the dam to an elevation sufficient to handle frequent events such as a 5 year flood or deliberately leaving a portion of fill low as a "relief plug."

Foul weather will generally upset the construction schedule. Not only can rain shut down a job, but it can cause earth work problems for days. Borrow and fill areas should permitted to drain to avoid saturated material. Cold weather disrupts concrete work and may necessitate costly heating and insulation to protect new pours. Such work is better scheduled in warmer months if possible.

Unapproved Construction

Sometimes, for whatever reason, a contractor will bury work that has not been inspected. If the EIC or his inspector is doing his job, he will require the contractor to uncover the buried work for inspection. The contractor can save himself a lot of grief, expense and delay if he makes sure the inspector is notified of the need for inspection in a timely manner.

Almost all of the above problems can be lumped under the general heading of construction management. Assuming the contract time is realistic, most of the problems that befall a construction job can be avoided by sound management and a cooperative climate between the contractor and the Engineer-In-Charge.



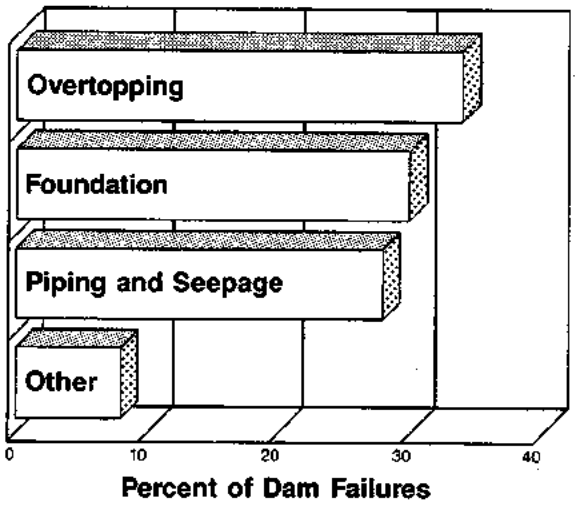
EMERGENCY PROCEDURES

Discussions throughout this manual have concentrated on the safe operation of dams by proper construction, operation and maintenance, and inspection practices. However, the most sophisticated design and construction techniques and a vigorous operation and maintenance program can not prolong the life expectancy of a dam indefinitely. The simple fact is that dams don't last forever. Unforeseen and unanticipated conditions can arise during a dam's existence that can alter the structure's performance and in some instances cause failure.

This section identifies the more common modes of dam failure and how their effects can be mitigated through adequate warning and evacuation planning. Emergency Warning Plans are generally implemented through the local Emergency Management Agency. Included with the discussions is an explanation of the safety hazard classification as it relates to various levels of downstream warning procedures.

TYPES OF FAILURES

In today's technical world, dam failures are rated as a "low probability-high loss" event. However, dams are subject to many forces that can cause failure. A number of studies have been made and suggest the following causes of dam failures:



Because dam failures can result from various conditions, a periodic review of all facets of a dam is necessary.

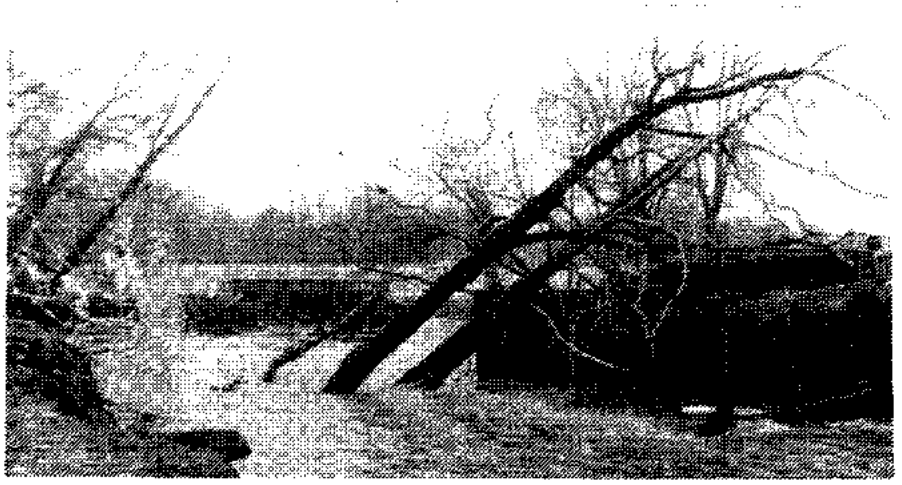
The majority of Maryland dams (75%) are constructed of earth. Therefore, the main discussion of failure types in this section is limited to embankment dams. However, the failures that will be described can be attributed to gravity, buttress, and other types of dams as well.

Overtopping Failures

Overtopping is the most common mode of failure with regard to earth dams and is the result of the structure's inability to safely discharge significant inflows to the reservoir. This causes uncontrolled water to flow over and around the embankment, eroding portions of the dam. Since earth structures are usually not designed to be overtopped, the



Earth dam in poor shape. Inadequate spillway capacity, tree growth, and weak embankment soils are causes for concern.



1 month later - The poor condition of the dam was no match for the heavy rains that overtopped the crest and caused failure.

erosion process begins as soon as water flows over the dam. Inadequate spillway capacity usually causes the overtopping of earth dams and will often lead to a complete breach of the dam. This mode of failure can also be caused by debris accumulation in appurtenances such as the riser and barrel structure or the emergency spillway.

One aspect of overtopping that an earth dam owner should be aware of is the concentration of flow. Where pedestrian paths or poorly maintained vegetative cover have created depressions or low spots along the crest, water will concentrate when overtopping begins, accelerating the erosion process. This problem can be corrected by keeping the dam crest level. Low spots should be filled and adequate vegetation established.

Methods of mitigating the effects of overtopping include providing for adequate spillway capacity or lowering the reservoir pool when flooding is anticipated. Temporary sandbagging can be used to prevent overtopping of the dam crest during a flood. Caution should be used when sandbagging, not only for safety reasons but also because additional water is impounded that could be released should the dam fail. Keeping the spillways free of debris and maintaining a level dam crest is helpful in deterring the effects of overtopping and should be part of the dam owner's regular operation and maintenance activities.

Piping and Seepage Failures

All dams have some quantity of seepage. Methods exist to control and convey seepage safely through the dam. When the volume of seepage exceeds the capacity of the dam's internal drainage system, problems will develop and can eventually cause partial or complete failure of the structure. Uncontrolled seepage can progressively erode portions of the embankment or foundation and cause an internal erosion or "piping" failure of the dam.

Once the "piping" of a dam progresses beyond a certain point it is virtually impossible to stop. Usually signs of uncontrolled seepage indicate a problem exists long before the structural integrity of the dam it threatened. Therefore regular and routine inspection of known seepage areas is essential. Should seepage increase significantly over what is normally observed or the seepage discharge suddenly becomes discolored or muddy, then a professional engineer should be contacted immediately and the Dam Safety Division notified.

Actions taken to delay or prevent complete failure of the dam when "piping" of the embankment has begun include: lowering the pool until the seepage problem has been corrected, covering the seepage area downstream with sand and gravel to prevent erosion of the embankment material, and, should the "pipe" progress to the upstream slope, attempt to plug the upstream end of the "pipe" with gravel, earth, straw or some other suitable material.

Structural Failures

Structural failures can occur in the embankment portion of a dam or its appurtenant structures. Embankment failures are typified by major differential settlement, cracks, or slumps in either the upstream or downstream slopes. These conditions, if left unattended, can lead to complete failure of the dam. They are generally preceded by less severe conditions that indicate a problem exists. Therefore, the point of regular and routine inspections cannot be overemphasized.

Cracks and major settlement in appurtenances can also cause dam failure. Settlement in an outlet pipe can result in loss of embankment material through an open construction joint and eventually lead to failure. Undermining of the pipe's outfall can reduce the conduit's support and cause partial failure of the principal spillway system. Again, these conditions usually do not happen overnight and can be detected long before failure occurs.

Maryland Dam Failures

It is believed that no lives have been lost in Maryland as a direct result of dam failure. However, we have not been without incident. Several dams have partially or completely failed due to various conditions that include: excessive rainfall, structural failures, and failure during

Several dams have partially or completely failed due to various conditions that include: excessive rainfall, structural failures, and failure during construction. Some examples follow that will describe the more recent dam failures.

Lake Waterford Dam

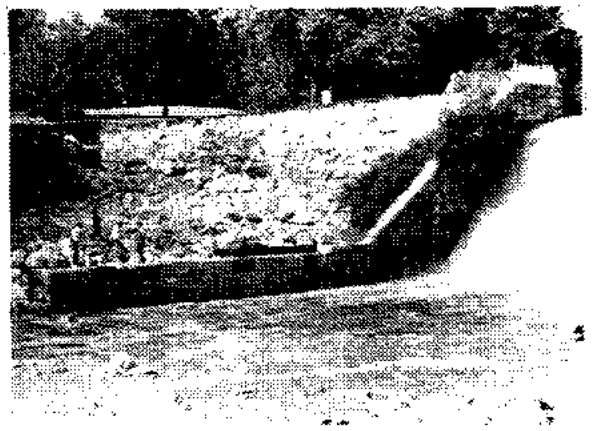
The Lake Waterford Dam is the focal point of a recreational park in Anne Arundel County. The dam, on the Magothy River, is fifteen feet high, 250 feet long, and has an overflow spillway ten feet wide. Believed to have been purchased from a private mill operator in 1925, this earth structure was overtopped and partially failed during Tropical Storm David in September, 1979. An inspection of the dam three months prior to failure revealed sparse vegetation and erosion gullies caused by pedestrian traffic on the crest and downstream slope. The inspection report stated that "In the event of overtopping of the embankment during major storm events, these gullies would be preferential flow paths, susceptible to rapid erosion and could possibly lead to failure of the dam." When overtopping did occur, water flowing in these gullies eroded portions of the embankment to the right of the overflow spillway exposing a concrete core wall.

The Lake Waterford Dam was repaired in 1993. A new principal pipe spillway along with a concrete ogee spillway were installed to safely pass the 100-year storm. In addition a cement bentonite slurry wall was installed and a fish passage was constructed to access the upstream spawning areas.

Lake Roland Dam

The Lake Roland Dam, on the Jones Falls in Baltimore County, has experienced significant structural damages in recent years. This structure, completed in 1861 to supply Baltimore City with water, is an earth and rockfill gravity dam 31 feet high, 310 feet long, and has a 120 foot wide uncontrolled ogee spillway. Lake Roland was retired as a water supplier around 1915 and has been used as a recreational facility since then. Inadequate spillway capacity led to two partial failures during Tropical Storms Agnes in 1972 and David in 1979. Overtopping of the right non-overflow portion of the dam during both storms resulted in erosion of the earth and rockfill, exposing the marble stone block wall. Subsequent repairs involved replacing backfill material consisting of soil and riprap that was surface grouted with mortar.

As of May 1993, the repair of Lake Roland Dam has begun and is scheduled to be completed by the end of 1993. The repairs include enlarging the principal spillway to 170 and construction of two auxillary spillways located on the old abutments. The modifications will enable the dam to safely pass over 90% of the PMF.



Severe Abutment Washout

Loveton

The Loveton Farms Stormwater Management facility is a "dry" pond in Baltimore County. It is a 20-foot high earth dam with a 78-inch diameter corrugated metal pipe spillway conduit. Completed in 1985, it failed by piping during heavy rains in 1989 causing extensive environmental damage. It was rebuilt in 1990.

A review of construction records after failure showed that the pipe was installed in a trench cut through the partially completed embankment fill. It is likely that piping was inititiated by seepage through transverse cracks that formed in the fill due to differential settlement. Other possible causes of failure are: improper compaction under the haunches of the pipe and joints that were not watertight.

HAZARD CLASSIFICATION

Dams are generally classified into usage categories according to their intended function, such as water supply, flood control, or recreation. The Maryland Dam Safety Division also categorizes dams according to their size and potential downstream hazard. Dams are classified as: **high hazard** (Class 1) where loss of life and extensive property damage are probable should the dam fail, **significant hazard** (Class 2) where failure would cause extensive damage to public or private property but the loss of life is very unlikely, and **low hazard** (Class 3) where failure would not cause the loss of life and the damage is within the financial capability of the owner to repair.

The hazard classification of a proposed dam is also used to determine the inflow design flood and the spillway characteristics of the dam itself. Detailed instructions to classifying a Maryland dam can be found in the Rules and Regulations governing Waterway Construction (COMAR 08.05.03.05.).

The National Dam Inspection Program took place between 1978 and 1981. The inventory survey indicated that 68,153 non-federal dams existed nationwide. During the inspection program, U.S. Army Corps of Engineers guidelines were used to assess the downstream hazard characteristics for the dams. The Corps used a system of three terms: high, significant, and low to describe a particular dam's hazard potential with regard to loss of life. No consideration was given to the condition or structural integrity of the dam. It was determined that approximately 13% of the nation's dams were classified as high hazard. Of the nation's high hazard dams, Maryland is responsible for less than 1%.

Danger Reach

In order to mitigate the downstream effects of a dam failure, the area of potential flooding must be known. The "danger reach" below a dam is defined as the area that would be inundated by a flood caused by the sudden release of stored water behind the dam that exceeds the expected amount of flooding had the dam not existed. By identifying those structures affected by the failure of a dam, the owner can determine the amount of warning required to protect those structures. For example, the owner of a Class 2 dam identifies three bridge crossings downstream that would be overtopped from excessive discharge from his dam. From that determination, procedures to prevent vehicle use of those bridges during anticipated high flows or failure can be develop. A Class 3 dam owner, having no permanent structures in the downstream danger reach, may want to warn his neighbor of high discharges caused by a problem at his dam so the neighbor can take necessary precautions (e.g. remove farm equipment and livestock from the downstream area.)

Warning procedures will be more sophisticated for Class 1 dams, but the owners of the less hazardous structures should not discount the necessity of warning downstream interests. Downstream development is another factor that must be considered when proposing a new dam. A dam, for instance, built 30 years ago and designated as a low hazard, Class 3 structure can easily become reclassed as a high hazard dam if development downstream is allowed within the danger reach. The reclassification of a dam to a higher category results in more conservative design parameters. For this reason the dam owner should consider upgrading the structure to provide additional freeboard or spillway capacity.

The danger reach for most of the high hazard dams in Maryland has been defined and can be obtained from the Maryland Dam Safety Division. This information is also available for some of the Class 2 and 3 dams. The ultimate responsibility for implementation of a warning plan that includes the danger reach rests with the dam owner.

EMERGENCY WARNING PLANS

Adequate warning and evacuation planning can prevent extensive property damage and loss of life should the dam fail. An **Emergency Warning Plan** is a non-structural method used to mitigate the effects of dam failure. The Emergency Warning Plan for a dam is based upon the potential for downstream flooding. Every dam owner should have one.

Maryland regulations require an Emergency Warning Plan for all proposed dams that are designated as Class 1 or Class 2 structures. Owners of existing Category 1 dams that were inspected under the Corps of Engineers National Dam Inspection Program were advised to develop a formal flood surveillance and warning plan to protect downstream interests.

Components of a Warning Plan

Much literature is available on the subject of warning systems. Depending on the size of a dam, the warning plan can range from a simple, one page telephone notification list to a sophisticated, telemetered network involving several major public agencies (e.g. - Civil Defense, Police, Fire and Rescue, etc.). Whatever level of warning is determined adequate, the Emergency Warning Plan must accomplish its intended goal: reducing the chance for loss of life and extensive property damage. Warning plans that are too voluminous will not be effective during emergencies if the involved agencies are not familiar with the procedures. Regardless of the size of the dam, an adequate Emergency Warning Plan possesses certain key elements that will ensure effective response. They are:

Surveillance and Mitigation
Communication and Notification
Evacuation

All involved parties should be familiar with the Emergency Warning Plan. The plan should be exercised and updated periodically by verifying personnel responsibilities and phone numbers.

Surveillance and Mitigation

This component of the warning plan is the most important because it identifies any problem that exists at the dam. Through the regular operation, maintenance, and periodic inspection of the dam, the owner should be well aware of problems associated with the structure. Therefore, rapid change in the "normal" condition of the dam should indicate that a problem exists and should be investigated thoroughly with continuous surveillance of the problem if warranted.
Also, advising various agencies that a potential problem exists and corrective action or possibly evacuation maybe required.

If it is known that a particular dam has inadequate spillway capacity and weather forecasters are predicting unusually high rainfall, the owner should maintain constant watch on his structure to insure adequate operation of the dam. Items of importance in this instance are the reservoir level, the rate of pool rise, excessive seepage, debris accumulation in the spillways, and any unusual observations. If the embankment is in danger of being overtopped then the previously discussed procedures for mitigation can be implemented (e.g. sandbagging, lowering the reservoir, etc.).

If time permits, a professional engineer experienced in dam design and operation should be consulted to determine the extent of the problem and assist in deciding whether emergency procedures should be initiated. Local public safety officials like the Civil Defense and Police should be alerted and kept apprised of the situation. Above all, surveillance in times of dam distress should be constant. At unmanned structures, provisions should be included to provide for surveillance of the structure, and travel time will need to be included in the warning plan. Constant communication between the dam owner and those agencies responsible for evacuation is essential. Surveillance should be maintained throughout the emergency and until the decision is made to resume normal operating procedures.

Communication and Notification

Once an emergency has been identified at a dam, communication and notification of

individuals and agencies responsible for various tasks is essential to protect life and property downstream. Communication links should be established immediately with those agencies who would provide for the public safety. Normally this link between the dam owner and the public can be established through the local Civil Defense Agency or Emergency Management Office in that particular jurisdiction. The local Civil Defense office has the communications expertise to alert the appropriate agencies so timely action can eventually save lives and property. Civil Defense can, in effect, act as the center for disbursing information to the police, fire and rescue, Red Cross, and the public regarding a developing emergency. It is therefore essential that constant dialogue be maintained with Civil Defense so information can be relayed.

It is prudent to include involved agencies when a warning plan is being developed. For example, if after initial discussions between the dam owner and the local Civil Defense it is determined that the police and fire department will be needed to block roadways and assist in evacuation activities, subsequent meetings should include those agencies to insure that their responsibilities are understood. Once the communications network, including backup, is established, a notification list can be formulated and distributed so all involved individuals understand what is expected of them.

A warning plan also needs to address when and how an emergency is to be terminated and what methods will be used to assure limited access and security in the danger reach. Agreement between involved individuals will dictate termination of an emergency both at the dam and in the downstream areas. Similar methods for evacuation can be used for terminating an emergency. However, all agencies should be involved with the decision.

Evacuation

If it should become necessary to evacuate a portion of a downstream community in the event of dam failure, several items need to be considered.

WHEN is evacuation warranted? Determinations regarding the stability of a dam should be made by an engineer experienced in dam design and operation. Certainly the order to evacuate should not be given if it is not warranted. However, the time involved for failure to occur often governs evacuation procedures. Provisions in a warning plan should account for failure that occurs over an extended period of time (overtopping) and one that occurs almost instantaneously (piping). Also, dams do not always fail between the hours 9 to 5, Monday through Friday. Provisions need to be included for evening and holiday emergencies.

WHO will be evacuated? As discussed above, all dam owners should be well aware of their structure's hazard potential. Danger reach and inundation information should be developed in order to identify those properties and people at risk. The size of the danger reach often determines evacuation procedures. Isolated dams with more than a small number of inhabitable structures will be treated differently than larger dams in major metropolitan areas.

HOW will evacuation occur? Alerting the downstream residents can be accomplished many ways. Methods should be used that are commensurate with the magnitude of evacuees. "Door to Door" evacuation will suffice in isolated areas if time permits but not in more populated areas. Radio and television can be utilized effectively as well as bullhorns or automated sirens. Choose the method best suited for the job at hand.

WHERE will evacuees go? Various civic agencies can assist with housing evacuated individuals. Shelters can be established in most areas and the Civil Defense and Red Cross should be able to assist with relocation.

A sample Emergency Warning Plan is shown on the following pages.

EMERGENCY WARNING PLAN

MONITORING AND EMERGENCY WARNING
PLAN AND PROCEDURES

for the

(Name of Dam)
ID#

Located at

(Town, County, State)

OWNER: _____

ISSUE DATE: _____
REVISED DATE: _____

Introduction

The purpose of the Emergency Warning Plan is to facilitate the evacuation of downstream residents if there is the possibility of dam failure. The establishment of an effective plan is an essential part of an impounding structure's operation program. Any plan drawn up by the dam owner is subject to review by the local Civil Defense Agency and the Dam Safety Division of the Water Management Administration.

An Emergency Warning Plan is fairly simple to formulate and will be very valuable if ever needed. An effective Plan incorporates several essential elements.

Surveillance

I. **Adverse Conditions:** When a flood watch or flood warning is issued by the National Weather Service, water levels are recorded and spillways, seepage zones, and discharge water levels are inspected.

1. Continuously monitor and record water levels in the reservoir.

2. Open gates or drains if necessary to lower the reservoir pool and provide additional flood storage.

II. **Standby Alert:** According to specific on site conditions at the dam; such as depth of spillway flows, cracking, seepage, piping, etc.

1. Constant surveillance by on site personnel.

2. Initial notification of Agencies to advise of status at site.

Notification

I. **Adverse Conditions:** Communicate data gathered by observers to the dam operator at appropriate intervals. The dam operator shall take the information and make judgement decisions.

II. **Standby Alert:** Proper authorities are notified of the need to initiate the warning plan or evacuation plan. This can be by telephone, ham radio, CB radio, or police, fire, and other emergency radio systems. It is important that any system chosen have an emergency backup. The Civil Defense Director shall notify: the mayor, police chief, fire chief, city manager, and the public.

Evacuation

Evacuation procedures may include any number of site specific measures such as evacuation of houses within so many vertical feet of a highway, or everyone down to a certain point. These details must be worked out in advance with cooperation between the local Office of Emergency Services. A narrative of these procedures should appear in this section in accordance with the county emergency operations plan. Evacuation areas and location of evacuation receiving centers must be shown on a map attached to this plan.

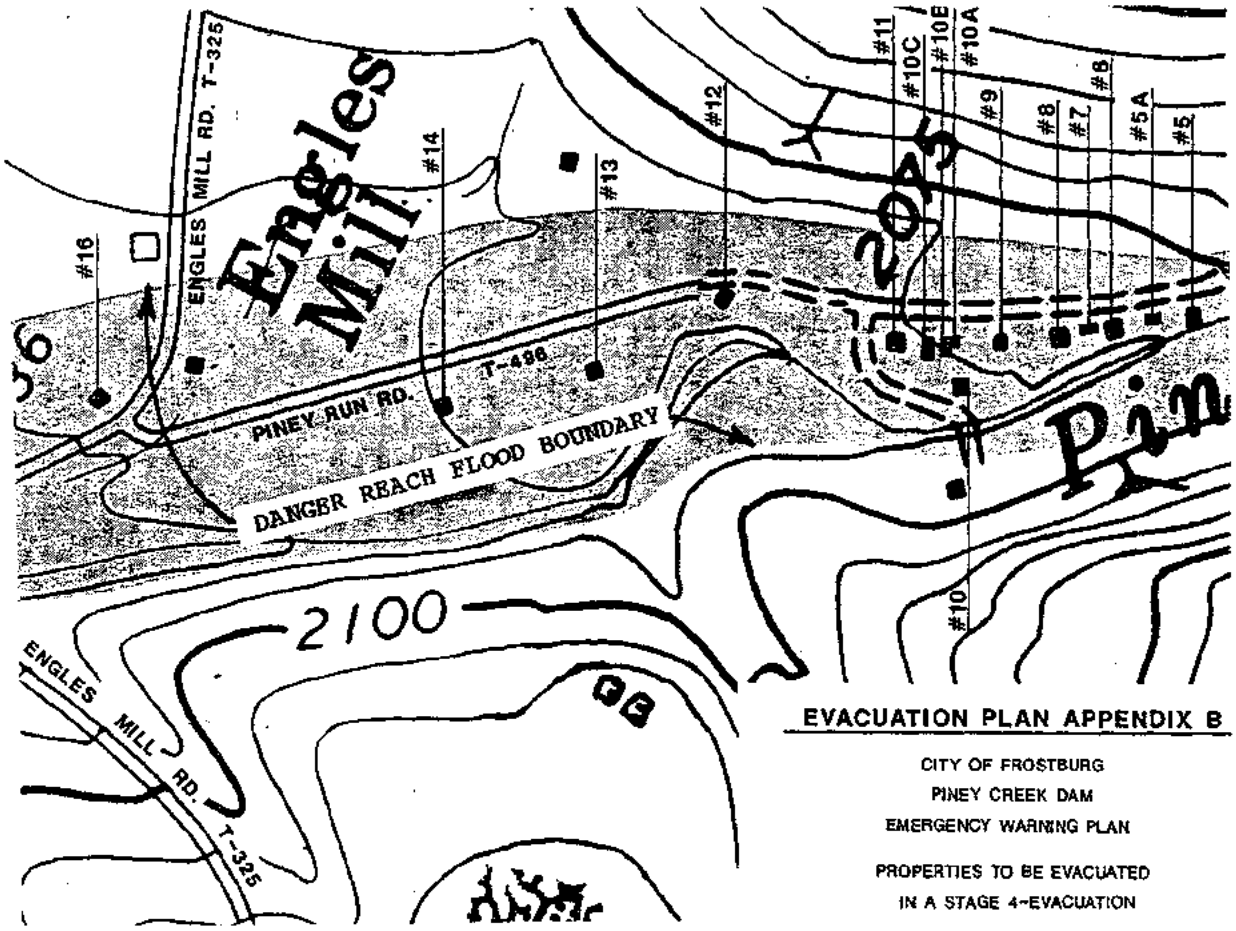
Post Evacuation

Should the Civil Defense Director decide that the emergency condition has passed, the evacuation order shall be cancelled. State dam safety officials shall be alerted and should inspect the facility.

Plan Review

Periodic verification must be made to confirm that the Emergency Warning Plan is adequate. Communication checks, drills, and map up-dates are necessary. An annual review and update is essential to maintain an effective plan.

Evacuation Map



FEDERAL LEGISLATION

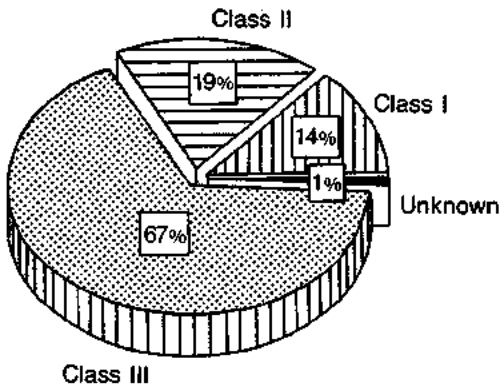
As a result of several dam failures in the United States in the early 1970's, the National Dam Inspection Act of 1972 (Public Law 92-367) was quickly enacted and signed by President Nixon on August 8, 1972. The Secretary of the Army, acting through the Corps of Engineers, was to carry out a national program to inventory and inspect non-federal dams "for the purpose of protecting human life and property." The activities to be carried out under P.L. 92-367 included the inspection of dams posing a threat to human life or property that were 25 feet or more in height or impounded 50 acre-feet or more at maximum water storage elevation. The Secretary of the Army was to report the findings these inspections to the governor of the state in which these dams were located along with recommendations to correct any deficiencies found.

Funding for P.L. 92-367 was limited by Congress and therefore the majority of effort was concentrated on developing a national inventory of dams. By 1975, a total of 49,322 structures comprised the National Dam Inventory.

Dam safety in the United States was given a significant boost in late 1977 in response to renewed public awareness stemming from additional catastrophic dam failures. One of these failures occurred on November 6, 1977 in then President Carter's home state of Georgia. The Kelly Barnes Dam failed, following several days of heavy rain, killing 39 people at a downstream bible college near Toccoa Falls in the northeastern part of the state.

The failure of the Kelly Barnes dam prompted the President, with Congressional appropriations of $15 million in 1978, to direct the Secretary of the Army to immediately begin the inspection of some 9,000 "high" hazard non-federal dams. Funding prior to the December, 1977 "Public Works Appropriation Act" (P.L. 95-96) had been denied by the Office of Management and Budget who observed that such inspections of non-federal dams were the responsibility of the particular states and should be accomplished as part of their normal responsibilities. P.L. 95-96 thus started the four year National Dam Inspection Program.

By the end of 1979 the inspection program was well under way and a total of 4565 high hazard dams had been evaluated. It was determined that 1334 (29%) of the inspected dams were found to be "unsafe". Of these dams it was determined that 5% were found to be in an "emergency" situation, requiring immediate corrective action. The balance of the "unsafe" dams were so designated primarily because of inadequate spillway capacity.



Non-Federal Dams
Hazard Classification

In 1979 the responsibility for coordinating non-federal dam safety shifted from the U.S. Corps of Engineers to the Federal Emergency Management Agency (FEMA). FEMA has the responsibility to coordinate the efforts of other federal agencies to implement the Federal Guidelines for Dam Safety. FEMA's current objectives for non-federal dam safety are to:

Assist each state in implementing an effective dam safety program.

Develop public awareness and support

dam safety programs.

Utilize the Interagency Committee on Dam Safety (ICODS) and other federal organizations to develop technical assistance materials for dam safety programs.

To date FEMA has encouraged additional research of dam safety including: funding for repairs, risk analysis, and status updates of the States Dam Safety Programs.

With the assistance and support from FEMA, the Association of State Dam Safety Officials (ASDSO) was formed in 1984. The purpose of the association is to further the safety of non-federal dams and provide a forum for the exchange of ideas and experiences of dam safety issues. The main objectives of the Association are:

Provide information and assistance to state dam safety programs.

Foster interstate cooperation.

Improve efficiency and effectiveness of state dam safety programs.

The Association has been responsible for attracting over 1,600 members including the 50 states. Numerous municipalities, corporations, and individuals have also become members of ASDSO. Support and encouragement of State Dam Safety Programs is provided with the Publication of a quarterly newsletter concerning dam safety. ASDSO also is responsible for:

Assisting states by providing funding and technical assistance towards holding public awareness workshops.

Publication of a Model State Dam Safety Program.

Development of a methodology for maintaining National Dam Inventory.

Offering Regional Technical Services to state dam safety engineers.

Holding an annual ASDSO Dam Safety Conference.

Establishing a Dam Performance Library at Stanford University.

Periodic updating of the national dam inventory which lists 74,464 total non federal dams. The inventory also indicates that high hazard dams represent approximately 9% of the nations total non-federal dams.

Even with the increased emphasis on dam safety nearly 1,915 non federal dams remain unsafe today (ASDSO, 1996).

The most recent federal legislation concerning dam safety was enacted with the passage of Public Law 99-662. Title XII of this law, known as the Dam Safety Act of 1986, includes provisions for:

a) encouragement and assistance in the development of State Dam Safety Programs;

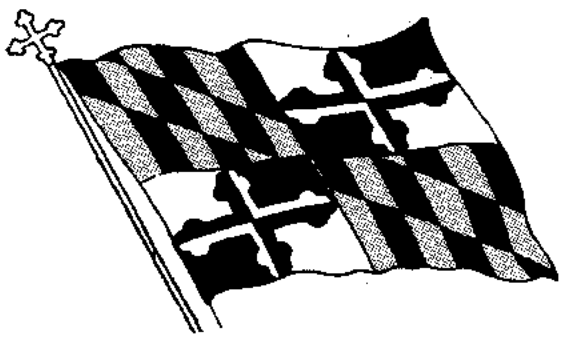
b) establishes a National Dam Safety Review Board;

c) authorizes a program of research into innovative dam safety inspection techniques.

At this time the proposed fiscal budget only includes provisions for the maintenance of a National Dam Inventory only.

MARYLAND LEGISLATION

Maryland recognized the need to regulate the water resources of the State as early as 1931 with the creation of the first "Water Resources Commission of Maryland." Chapter 247 of the Annotated Code of Maryland, enacted on June 1, 1931, authorized the Governor of the State "to appoint a commission of seven persons to review the underground and surface water resources of the State of Maryland in order to determine the most effective plan to preserve and allocate such water supply resources for maximum public benefit and use."



Water Resources Commission

This Commission was charged with the responsibility of developing programs to: measure stream flow; supervise the location, design, and construction of water supply dams and reservoirs; improve rivers of the state to prevent damaging floods; control public water supplies; regulate stream flows by storage reservoirs; and evaluate the necessity for creating water districts. By this Act the Commission was also to present a written report of its findings and recommendations to the General Assembly of 1933 with regard to policy, legislation, and methods of financing.

The Commission submitted its final report to the General Assembly in January 1933, and recommended that, since Maryland had no agency to review the design of dams and had no specific policies with regard to stream gaging, stream discharge regulations, and conservation of water supply uses, there should be created a permanent Water Resources Commission of Maryland. This permanent body would formulate water conservation policies, and provide for continuity of stream gaging and for the supervision of dams.

From those recommendations made by the initial Water Resources Commission, the 1933 State Legislature established Maryland's first comprehensive water resources authority by the approval of Chapter 526 of the Annotated Code. This Act provided for the control of appropriation and use of the state's surface and underground water. Chapter 526 established the Water Resources Commission as a permanent regulatory authority empowered to control the construction and repair of dams, devise a general water conservation program, provide public hearings for permit applications to appropriate state waters, and provide for appeals and penalties for violations of its orders.

Permit Authority Created

Aside from establishing the first permanent regulatory agency for Maryland's water resources, Chapter 526 created permit requirements for the use of State water. Therefore, from January 1, 1934 it became unlawful to use or appropriate any waters of Maryland without written consent of the Water Resources Commission. Plans, drawings, and specifications would be required for projects that "in any manner change or diminish the course, current, or cross-section of any stream or body of water". Chapter 526 also provided for public hearings to give affected individuals the opportunity to voice opinions both for and against the granting of a permit.

Also established in 1933 was the first authority for enforcement type action that could be exercised by the Water Resources Commission. The Commission was given the authority to require the owner of a reservoir, dam, or waterway obstruction to remove or repair said structure should it be

determined by outside complaint or investigation that a particular pre-existing or proposed project was judged to be unsafe.

Exclusions from the permit requirement were also provided for in Chapter 526. Structures built before January 1, 1934, as well as those water uses involving domestic and farming purposes, were not required to obtain a permit. Structures ten feet or less in height above the stream were exempt and dams impounding less than one million gallons were also not required to obtain a permit.

The basic legislative intent of the 1933 legislature has remained virtually unchanged through thirteen modifications to the original law. These modifications merely adjusted the exlusionary limits that required written approval from the Water Resources Commission. The following describes those law changes and some of the basic restructuring of the Commission's organization that has taken place since in 1933:

YEAR	LEGISLATION	COMMENTS
1931	Chapter 247, Annotated Code of Maryland	Commission created to investigate a plan to preserve and allocate the water resources of the State.
1933	Chapter 526, Annotated Code of Maryland	Permanent Water Resources Commission established and given regulatory authority.
1939	Article 96B enacted	Chapter 526 renamed to Article 96B
1941	Chapter 508 repealed and reenacted with ammendments as Sections of Article 96B	Creation of "The Board of Natural Resources." Changed all references of the Water Resources Commission to the Department of Geology, Mines and Water Resources.
1950	Chapter 72 repealed and reenacted as Section 5 of Article 96B	Permit exemption provisions were expanded to include muskrat ponds and farm ponds. A farm pond was defined as an all earth dam and spillway impounding nine or less feet, having a surface area of 60,000 square feet, and a contributory drainage area of less than 100 acres. Ponds were not to be built "closer than 500 feet to a place for human habitation or public road."
1951	Article 66C enacted	Previous legislation renamed to Article 66C
1957	Chapter 317 repealed and reenacted as Section 669 of Article 66C	Farm ponds were qualified and expanded to include ponds having a surface area of less than five acres or a depth of water of fifteen feet at the spillway level. Geographical drainage area limitations were added. Ponds exempt would not exceed 400 acres north and west of the B and O Railroad and 700 acres south and east of the B and O Railroad. Some offstream impoundments were also exempt. Some design considerations were also included with regard to minimum freeboard and allowable emergency spillway velocities.
1962	Chapter 18 repealed and reenacted as Section 721 of Article 66C	Waste stabilization lagoons under permit with the Maryland Department of Health and Mental Hygiene were added as exemptions.
1963	Chapter 611 repealed and reenacted as Section 721 of Article 66C	Exemptions for muskrat ponds were qualified to include structures that were less than "four feet in height" and for the propagation of "other wildlife species."
1964	Chapter 73 repealed and reenacted as Sections 15, 16, and 17 of Article 66C	Split Department of Geology, Mines and Water Resources into separate agencies. Created the Department of Water Resources that assumed water related duties.

1965	Chapter 752 repealed and re-enacted as Section 12 of Article 96A	Recreation ponds were added to the exemption list. Requirements of a drop inlet pipe or other mechanical spillway were established for dams draining greater than 5 acres. A minimum freeboard requirement of 1 foot was included and the normal surface area of 5 acres for farm ponds was changed to 12 acres.
1967	Chapter 416 repealed and re-enacted as Section 12 of Article 96A	This act exempted drainage systems built exclusively for the collection, conveyance, or disposal of storm water.
1972	Chapter 521 repealed and re-enacted as Section 12 of Article 96A	Deleted all previously mentioned permit exemptions (farm ponds, muskrat, sewage lagoons, storm water structures, and all size restrictions) and redefined those dams not requiring Administration approval. This exempted small ponds having a contributory drainage area of less than 1 square mile and a normal depth of water less than 15 feet and a normal surface area of less than 12 acres (approval from the Soil Conservation District was required).
1973	Recodification and renumbering as Title 8 of the Natural Resources Article	Restructuring of Departments and the creation of the Department of Natural Resources and the present Water Resources Administration.
1978	Amendments to Natural Resources Article 8-809	Provisions to allow the Department to investigate unsafe dams and repair them if necessary.
1991	Amendments to Natural Resources Article 8-806	Provided for a public informational hearing upon written request, notification of contiguous property owners and written notification of the Department's decision to interested persons. Also provided for requirements to obtain a contested case hearing if aggrieved by Department's decision.
1992	Amendments to Natural Resources Article 8-803(b)	Redefined the "small pond exemption" to be: 1) less than 640 acre drainage area; 2) less than 20 feet in height (measured from the top of the dam to downstream toe); and 3) low hazard structure.
1995	Recodification and renumbering as Title 5 of the Environment Article	Transferred regulatory functions from the Department of Natural Resources to the Department of the Environment.

Present Regulatory Authority

The Maryland General Assembly gives state agencies the authority to promulgate regulations in order to supplement and clarify existing laws. These regulations are found in the Code of Maryland Regulations (COMAR) under Construction on Non-Tidal Waters and Floodplains. The Water Resources Administration has rules and regulations that govern the construction, reconstruction, repair, or alteration of a dam.

Dams and reservoirs are the most stringently regulated of all waterway construction projects. Because of the complexity and cost involved in undertaking this type of project, the Water Resources Administration provides for a two step permit process. The main advantage of this process is that many of the detailed construction plans and specifications for the dam need not be prepared until after a ruling has been made on whether the overall project is in the best interests of the State's Water Resources. The permit and construction process for a new structure can be divided into the following major steps:

1. **Classification of Dam and approval of Engineer-In-Charge**

2. **Plan Development Permit**
   feasibility report
   environmental considerations
   general location and features of dam

3. **Opportunity for Hearing Process**
   public input

4. **Obstruction Permit**
   plans and specifications approval
   operation and maintenance program

5. **Construction of Dam**
   material tests
   construction reports
   design changes
   certification of readiness for filling
   "as built" plans

The Dam Safety Division requires that a registered professional engineer supervise the design and construction of new dams as well as major repairs to existing facilities.

The Engineer-In-Charge is encouraged to serve as the construction manager since he or she is the one person who is keenly aware of the design details. As stated throughout this manual, the overall safety and longevity of the dam is contingent on many factors. The best design program will only serve its purpose if a well prepared construction program is adhered to.

The regulations are intended to provide assistance and guidance in preparing new projects or undertaking major repair to existing facilities.

GLOSSARY

ABUTMENT - That part of the valley side against which the dam is constructed See also Left Abutment and Right Abutment.

ANTI-SEEP COLLAR - A projecting collar built around the outside of a tunnel or conduit to reduce the seepage along the outer surface of the conduit. Filter diaphrams are preferred over antiseep collars.

APPURTENANCES - The associated works of a dam other than the embankment or main impoundment structure, such as the outlet, spillway, outlet conduit, and tunnels.

AS-BUILT DRAWINGS - Plans or drawings portraying the actual dimensions and conditions of a dam, dike, or levee as it was built. Field conditions and material availability during construction often require changes from the original design drawings.

AXIS OF DAM - The plane or curved surface, arbitrarily chosen by a designer, appearing as a line, in plan or in cross section, to which the horizontal dimensions of the dam can be referred.

BASE WIDTH (BASE THICKNESS) - The maximum thickness or width of a dam measured horizontally between upstream and downstream faces and normal to the axis of the dam but excluding projections for outlets, etc.

BEACHING - The removal by wave action of a portion of the upstream (reservoir) side of the embankment and the resultant deposition of this material farther down the slope. Such deposition creates a relatively flat beach area.

BENCH - A horizontal step in the slope of an embankment.

BLANKET DRAIN - A drain that extends in a generally horizontal direction (much like a blanket) under a relatively large area of the downstream portion of the embankment, intercepts seepage through the embankment and the foundation, and prevents further saturation of the downstream toe.

BOIL - A disturbance in the surface layer of soil caused by water escaping under pressure from behind a water-retaining structure such as a dam or a levee. The boil may be accompanied by deposition of soil particles (usually sand) in the form of a cone ring around the area where the water escapes.

BREACH - An opening or a breakthrough of a dam sometimes caused by rapid erosion of a section of earth embankment by water.

CAMBER - A slight arch applied to the dam crest to account for embankment settlement.

CAVITATION - Wear on hydraulic structures where a high hydraulic gradient is present. Cavitation is caused by the abrupt change in direction and velocity of water reducing the pressure to vapor pressure and creating vapor pockets. These pockets collapse with great impact, producing very high impact pressures over small areas that eventually cause pits and holes in the surface. Noises and vibrations may be evident during high flows.

CONDUIT - A closed channel to convey the discharge through or under a dam.

CONCRETE DAM - Any dam constructed of concrete materials.

ARCH DAM - A concrete or masonry dam that is curved in plan so as to transmit the major part of the water load to the abutments.

BUTTRESS DAM - A dam consisting of watertight upstream face supported at intervals on the downstream side by a series of buttresses. Buttress dams can take many forms, eg. arch buttress dam, multiple arch dam, flat slab or Ambursen dam, solid head buttress dam.

GRAVITY DAM - A dam constructed of concrete and which relies upon its weight for stability. Concrete gravity dams can take several forms, e.g. arch gravity, curved gravity, and hollow gravity.

ROLLER COMPACTED CONCRETE DAM - A concrete dam constructed of a no-slump concrete that can be hauled in dump trucks, spread with a bulldozer or grader, and compacted with a vibratory roller.

CONSTRUCTION JOINT - The interface between two successive placing of pours of concrete where bonding, not permanent separation, is intended.

CONTRACTION JOINT - A joint constructed where shrinkage of the concrete would cause a crack.

CORE - The impervious or relatively impervious material forming the central part of a dam or embankment. Where a dam has a core, the outer zones are usually comprised of more pervious materials. Some dams are constructed entirely of a relatively homogeneous, impervious material with no distinct core. In this case, the entire dam is considered the core.

CORE WALL - A wall of substantial thickness built of impervious materials, usually of concrete or asphaltic concrete, in the body of an embankment to prevent leakage.

CORROSION - The chemical attack on a metal by its environment. Corrosion is a reaction in which metal is oxidized.

CREST LENGTH - The measured length of the top of the dam from abutment to abutment. This includes the length of spillway, powerhouse, navigation lock, fish passage, etc., where these structures from part of the length of the dam. If detached from the dam, these structures should not be included.

CREST OF DAM - The crown of an overflow section of the dam. In the United States, the term "crest of dam" is often used when "top of dam" is intended. To avoid confusion, the terms crest of spillway and top of dam should be used for referring to the overflow section and dam proper, respectively.

CRIB DAM - A gravity dam built up of boxes, cribs, crossed timbers, or gabions and filled with earth or rock.

CULVERT - (a) A drain or waterway structure built transversely under a road, railway, or embankment. A culvert usually comprises a pipe or a covered channel of box section. (b) A gallery or waterway constructed through any type of dam, which is normally dry but is used occasionally for discharging water; hence the terms scour culvert, drawoff culvert, and spillway culvert.

CURTAIN

DRAINAGE CURTAIN - See Drainage Well.

GROUT CURTAIN (GROUT CUTOFF) - A barrier produced by injecting grout into a vertical zone, usually narrow in horizontal width, in the foundation to reduce seepage under a dam. (See Grout)

CUTOFF - An impervious barrier used to reduce or prevent seepage from passing through the foundation under the dam.

CUTOFF TRENCH - The excavation later to be filled with impervious material so as to form the cutoff. Sometimes used incorrectly to describe the cutoff itself.

CUTOFF WALL - A wall of impervious material (e.g., concrete, asphaltic concrete, steel sheet piling) built into the foundation to reduce seepage under the dam.

DAM - Any manmade barrier, together with its abutments and appurtenant works, if any, constructed for the purpose of storing or directing water or for receiving dredge disposal material, as determined by the Administration.

DANGER REACH - That area downstream from a dam within which a sudden release of waters resulting from failure of the dam would cause an artificial flood.

DIKE - See Levee.

DISTRESS - A condition of severe stress, strain, or deterioration indicating possible or potential failure.

DIVERSION CHANNEL, CANAL, OR TUNNEL - A waterway used to divert water from its natural course. The term is generally applied to a temporary arrangement, e.g., to convey water around a dam site during construction. Channel is normally used instead of canal when the waterway is short. Occasionally the term is applied to a permanent arrangement (diversion canal, diversion tunnel, diversion aqueducts).

DRAIN GATE - See Emergency Gate.

DRAINAGE AREA - The area that drains naturally to a particular point on a river or stream.

DRAINAGE LAYER OR BLANKET - A layer of pervious material in a dam to relieve pore pressures or to facilitate drainage of the fill.

DRAINAGE WELL OR RELIEF WELL - Vertical wells or boreholes downstream of, or in the downstream berm of, an embankment to collect and control seepage through or under the dam and so reduce water pressure. A line of such wells forms a drainage curtain.

DRAWDOWN - The resultant lowering of water surface level due to release of water from the reservoir.

EMBANKMENT - Fill material, usually earth or rock, placed with sloping sides and usually with a length greater than its height. An "embankment" is a part of a dam.

EMBANKMENT-ABUTMENT CONTACT - That area at the intersection of either the upstream or downstream slope of an embankment and the valley wall or abutment.

EMBANKMENT DAM - Any dam constructed of excavated natural materials.

EARTH DAM (EARTHFILL DAM) - An embankment dam in which more than 50 percent of the total volume is formed of compacted fine-grained material obtained from a borrow area.

HOMOGENEOUS EARTHFILL DAM - An embankment dam constructed of similar earth material throughout, except for possible inclusion of internal drains or drainage blankets. This term is use to differentiate from a zoned earthfill dam.

HYDRAULIC FILL DAM - An embankment dam constructed of materials, often dredged, that are conveyed and placed by suspension in flowing water.

ROCKFILL DAM - An embankment dam in which more than 50 percent of the total volume comprises compacted or dumped pervious natural or crushed rock.

ROLLED FILL DAM - An embankment dam of earth or rock in which the material is placed in layers and compacted by using rollers or rolling equipment.

ZONED EMBANKMENT DAM - An embankment dam, the thickness of which is composed of zones of selected earth and rock materials having different degrees of porosity, permeability, and density.

EMERGENCY GATE - A standby or reserve gate used only when the normal means of water control is not available; also referred to as a drain gate.

FILTER DIAPHRAGM - A zone of granular material that is constructed around a conduit that passes through an embankment dam or foundation that will allow seepage flow without migration of soil particles. See SCS publication TR-60 "Earth Dams and Reservoirs".

FLASHBOARDS - Lengths of timber, concrete, or steel placed on the crest of a spillway to raise the retention water level but that may be quickly removed in the event of a flood either by a tripping device or by deliberately designed failure of the flashboards or their supports.

FLOODPLAIN - An area adjoining a body of water or natural stream that has been or may be covered by flood water. The floodplain is based on the 100 year frequency flood and is included as waters of the State (Annotated Code of Maryland, Natural Resources Article, §8-101(k)).

FLOOD ROUTING - The determination of the attenuating effect of storage on a flood passing through a valley, channel, or reservoir.

FOUNDATION OF DAM - The undisturbed material on which the dam structure is placed.

FREEBOARD - The vertical distance to the crest of a dam above the water surface at the time of maximum design flow over the spillway.

FUSE PLUG SPILLWAY - A form of auxiliary or emergency spillway comprising a low embankment or a natural saddle designed to be overtopped and eroded away during a very rare and exceptionally large flood.

GABION - A hollow cage or basket, usually of heavy wire, filled with stones or rock and used as a revetment or other protective device to sustain a wall or channel.

GROUT - A thin cement mortar used to fill voids, fractures, or joints in masonry, rock, sand and gravel, and other materials. As a verb it refers to filling voids with grout. Grout is usually applied under pressure.

HEIGHT OF DAM - The vertical measurement expressed in feet as measured from the downstream toe of the dam at its lowest point to the elevation of the top of the dam.

INFLOW DESIGN FLOOD - The largest flood that a given project is designed to pass safely. The reservoir inflow discharge hydrograph used to estimate the spillway discharge capacity requirements and corresponding maximum surcharge elevation in the reservoir.

LEFT ABUTMENT - The abutment on the left-hand side of an observer when looking downstream.

LEVEE - A long embankment structure. Usually built along a watercourse to protect land from flooding. If built of concrete or masonry, a levee is usually referred to as a flood wall. Also used to describe embankments that block areas on the reservoir rim that are lower than the top of the main dam and that are quite long.

MASONRY DAM - Any dam constructed mainly of stone, brick, or concrete blocks that may or may not be joined with mortar. A dam having only a masonry veneer facing should not be referred to as a masonry dam.

MAXIMUM CROSS SECTION OF DAM - Cross section of a dam at the point where the height of the dam is the maximum.

MAXIMUM POOL LEVEL - The maximum water level, including the flood surcharge the dam is designed to withstand.

NORMAL DEPTH - The maximum vertical distance from the stream bed invert at the upstream toe of the dam to the normal water surface.

OBSERVATION WELL - Small diameter perforated vertical tube installed within an embankment. Used to measure the height of the internal water surface (phreatic surface) in the embankment at the location of the well.

ONE-HUNDRED YEAR (100-YEAR) FLOOD - The flood magnitude having an exceedence frequency of one percent in any given year. It is often expressed as expected to be equalled or exceeded on the average of one in 100 years.

OUTLET - An opening through which water can be freely discharged from the reservoir to the stream.

OWNER - Any person or persons and their duly authorized agents, owning, operating, maintaining, or proposing to construct a dam, reservoir, or other obstruction, or to change the course, current, or cross section of any body of water in the State.

PERMEABILITY - A material property which defines the capacity to transmit water.

PERVIOUS ZONE - A part of the cross section of an embankment dam comprising material of high permeability.

PHREATIC SURFACE (SEEPAGE SURFACE) - The upper surface of seepage in an embankment. All the soil below the surface will be saturated when the equilibrium condition has been reached.

PIPE CONDUIT - Any tube or hollow channel that conveys water to or from a reservoir.

PIPING - Progressive erosion and removal of soil by concentrated seepage flows through a dam, dike, or levee, its foundation, or its abutment. As material is eroded, the area of the "pipe" increases and the quantity and velocity of flow increase, which in turn erodes more material. The process continues at a progressively faster rate until controlled, or failure occurs.

PLUNGE POOL - An excavated pool at the outlet structure that is designed to withstand erosion from high velocities. The plunge pool is armored with riprap.

PORE PRESSURE - The internal cellular pressure of a fluid (air and water) within the voids of a mass of soil, rock, or concrete.

PROBABLE MAXIMUM PRECIPITATION (PMP) - Theoretically the maximum depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographic location at a certain time of the year.

PROBABLE MAXIMUM FLOOD (PMF) - The most severe flood considered possible in a specific region. This may be:

a) The Probable Maximum Flood as determined by a source acceptable to the Administration; or

b) Calculated using a rational consideration of the chances of simultaneous occurrence of the maximum of several elements or conditions which contribute to the flood.

RANDOM FILL - Earth or rockfill, the grading of which is not specified and that is placed without treatment just as it comes from the excavation.

RESERVOIR - Any basin, either natural or artificial, used for collecting or storing of water. Reservoir capacity is the total volume in reservoir between lowest point in the reservoir and horizontal plane at crest of overflow spillway.

REGULATIONS - Title 26, Subtitle 17, Chapter 05, Regulations .01 thru .13 of the Code of Maryland Regulation (COMAR); also known as Construction on Non-Tidal Waters and Floodplains.

RIGHT ABUTMENT - The abutment on the right-hand side of an observer when looking downstream.

RIPRAP - A layer of large uncoursed stones, broken rock, or precast blocks placed in random fashion on the upstream slope of an embankment dam, on a reservoir shore or in a channel as a protection against flows, wave and ice action.

SCARP - The nearly vertical, exposed earth surface created at the upper edge of a slide or a beached area along the upstream slope.

SEEPAGE - The slow percolation (or oozing) of a fluid through a permeable material in and under the structure, the depth of water behind the structure, and the length of the path the water must travel through or under the structure.

SETTLEMENT (CONSOLIDATION) - The gradual process of soil compression due to the squeezing out of water, causing a building or embankment to settle.

SHELL - The upstream and downstream parts of the cross section of a zoned embankment dam on each side of the core or core wall.

SLIDE - The movement of a mass of earth and rock down a slope. In embankments and abutments, this involves the separation of a portion of the slope from the surrounding material.

SLOPE PROTECTION - The protection of the embankment slope against wave action and erosion.

SLOUGH - The separation from the surrounding material and downhill movement of a small portion of the slope. Usually a slough refers to a shallow earth slide.

SLUICE GATE - A gate used to control the flow of water through a sluice, or artificial discharge channel. Most sluice gates are used with square openings and are connected to a handwheel lift mechanism by a vertical stem.

SPALLING - Breaking (or erosion) of small fragments from the surface of concrete masonry or stone under the action of weather or abrasive forces.

SPILLWAY - A structure over or through which water is discharged. If the flow is controlled by gates, it is considered a controlled spillway; if the elevation of the spillway crest is the only control, it is considered an uncontrolled spillway.

EMERGENCY SPILLWAY (AUXILIARY SPILLWAY) - A secondary spillway designed to operate only during exceptionally large floods.

OGEE SPILLWAY (OGEE SECTION) - An overflow weir in which in cross section the crest, downstream slope, and bucket have an S or ogee form of curve. The shape is intended to match the underside of the nappe at its upper extremities.

OVERFLOW SPILLWAY - Any operating, emergency, or other spillway which discharges with a free water surface over or around the dam as opposed to a gate, or conduit which discharges through or beneath the dam or nearby ground.

PRINCIPAL SPILLWAY - The principal or first-used spillway that conveys all normal stream flows through the reservoir. The principal spillway generally carries all flows up to the emergency spillway.

RISER SPILLWAY - A principle spillway that consists of a circular or square standpipe that carries normal stream flows through the reservoir. This type of spillway is connected to a conduit that passes through the dam.

SERVICE SPILLWAY - A principal spillway used to regulate reservoir releases additional to or in lieu of the outlet.

SHAFT SPILLWAY (MORNING GLORY SPILLWAY) - A vertical or inclined shaft into which flood water spills and then is conducted through, under, or around a dam by means of a conduit or tunnel. If the upper part of the shaft is splayed out and terminates in a circular horizontal weir, it is termed a bellmouth or morning glory spillway.

SIDE CHANNEL SPILLWAY - A spillway, the crest of which is roughly parallel to the channel immediately downstream of the spillway.

SIPHON SPILLWAY - A spillway with one or more siphons built at crest level. This type of spillway is sometimes used for providing automatic surface-level regulation within narrow limits or when considerable discharge capacity is necessary within a short period of time.

SPILLWAY CHANNEL - A channel conveying water from the spillway crest to the river downstream.

STAFF GAUGE - A device marked in feet used to indicate and measure water levels.

STILLING BASIN - An energy-dissipating device located at the outlet of a spillway to dissipate the high velocity (energy) of the flowing water in order to protect the spillway structure and avoid serious erosion of the outlet channel and subsequent undermining. Stilling basins are generally constructed of concrete.

STORAGE - The retention of water or delay of runoff either by planned operation as in a reservoir, or by temporary filing of overflow areas, as in the progression of a flood crest through a natural stream channel.

SURVEY MONUMENT - A point established on or in the vicinity of an embankment. Provides a set point to survey and, over time, will indicate whether any movement has taken place.

TAILWATER LEVEL - The level of water in the discharge channel immediately downstream of the dam.

TOE OF DAM - The junction of the downstream face of a dam with the ground surface. Also referred to as downstream toe. For an embankment dam, the junction of the upstream face with ground surface is called the upstream toe.

TOE DRAIN - Drains commonly installed along the downstream toe of the dam to collect seepage discharging from the embankment and foundation and lead it to an outfall pipe which discharges away from the dam.

TRANSITION ZONE (SEMI-IMPERVIOUS ZONE) - A part of the cross section of a zoned embankment dam comprising material whose grading is of intermediate size between that of an impervious zone and that of a permeable zone.

TRASH RACK - A structure of metal or reinforced concrete bars located at the intake of a waterway to prevent entrance of floating or submerged debris of a certain size and larger.

TRENCH DRAIN - A drain commonly installed in or along an embankment, abutment, or the foundation of a dam in order to relieve uplift pressures and carry seepage away from dam. Toe drains are generally installed in the bottom of the trench.

UPLIFT - The upward pressure on the base of a structure.

WATERS OF THE STATE - Includes both surface and underground waters within the boundaries of the State of Maryland subject to its jurisdiction, including that portion of the Atlantic Ocean within the boundaries of the State, the Chesapeake Bay and its tributaries, and all ponds, lakes, river, streams, public ditches, tax ditches, and public drainage systems within the State, other than those designed and used to collect, convey, or dispose of sanitary sewage. The floodplain of free-flowing waters determined by the Department on the basis of the 100-year flood frequency is included as waters of the State.

WEIR - A type of spillway in which flow is constricted and caused to fall over a crest. Sometimes specially designed weirs are used to measure flow amounts. Types of weirs are used to measure flow amounts. Types of weirs include "broad-crested" "ogee" and "v-notch."

BIBLIOGRAPHY

_____. "Crack Repair," Volume 30, Number 1. Concrete Construction Publication, Inc. Addison, IL, (1985).

_____. "Four Steps to Successful Concrete Repair," Vol. 28, No. 1. Concrete Construction Publication, Inc. Addison, IL, (1983).

American Concrete Institute (ACI). "Guide for Making a Condition Survey of Concrete In Service." Journal of the American Concrete Institute. Vol. 65, No. 11: ACI, (1968).

American Concrete Institute (ACI). "Materials and General Properties of Concrete." ACI Manual of Concrete Practice, Part 1. Detroit, MI, (1982).

American Society of Civil Engineers. "Safety of Small Dams." Engineering Foundation Conference. (1974).

American Society of Civil Engineers. "The Evaluation of Dam Safety." Engineering Foundation Conference Proceedings. New York, NY: ASCE, (1976).

American Society of Civil Engineers (ASCE)/U.S. Commission on Large Dams (USCOLD). Lessons from Dam Incidents, USA. New York, NY: ASCE, (1975).

American Society of Civil Engineers. Responsibility and Liability of Public and Private Interests on Dams." Engineering Foundation Conference Proceedings. New York, NY: ASCE, (1976).

Creager, Justin and Hinds. Engineering for Dams, Volume I-III. John Wiley and Sons: New York, NY, (1961).

Department of the Army, Corps of Engineers. "Recommended Guidelines for Safety Inspections of Dams," National Program on Inspection of Dams, Vol. 1, Appendix D. Office of Chief of Engineers: Washington, D.C., (1975).

Department of the Army, Corps of Engineers. National Program for Inspection of Non-Federal Dams-Final Report to Congress. Office of Chief of Engineers: Washington, D.C., (1982).

Department of the Army, Corps of Engineers. Instrumentation of Earth and Rockfill Dams. Parts 1 and 2, EM 1110-2-1908. Office of Chief of Engineers: Washington, D.C., (1971 and 1976).

Department of the Army, Corps of Engineers. Earth and Rockfill Dams General Design and Construction Consideration, EM 1110-2-2300. Office of Chief of Engineers: Washington, D.C., (May, 1982).

Federal Emergency Management Agency. Updated Review Summary of State Non-Federal Dam Safety Programs. Washington, D.C., (1984).

Federal Emergency Management Agency. State Non-Federal Dam Safety Programs. Washington, D.C., (December, 1985).

Federal Emergency Management Agency. National Dam Safety Program-A Progress Report. Washington, D.C., (April, 1986).

Federal Emergency Management Agency. "Emergency Action Planning Guidelines for Dams." Interagency Committee on Dam Safety, Subcommittee on Emergency Action Planning. Washington, D.C., (1985).

Federal Emergency Management Agency. "Federal Guidelines for Dam Safety." Federal Coordinating Council for Science, Engineering and Technology, Ad Hoc Interagency Committee on Dam Safety. Washington, D.C., (1979).

Golze, A.R., ed. Handbook of Dam Engineering. Van Nostrand Reinhold Co.: New York, NY, (1977).

International Commission on Large Dams (ICOLD). General Consideration Applicable to Instrumentation for Earth and Rockfill Dams." Committee on Observations of Dam and Models, Bulletin No. 21. Boston, MA, (1969).

Jansen, R. B. Dams and Public Safety. U.S. Bureau of Reclamation: Washington, D.C. (1980).

National Research Council, Committee on Safety of Non-Federal Dams. Safety of Non-Federal Dams: A Review of the Federal Role. National Academy Press: Washington, D.C., (1982).

National Research Council, Committee on Safety Criteria for Dams. Safety of Dams Flood and Earthquake Criteria. National Academy Press: Washington, D.C., (1985).

National Research Council. "Safety of Existing Dams, Evaluation and Improvement." Committee on the Safety of Existing Dams. National Academy Press: Washington, D.C., (1983).

National Research Council. Safety of Existing Dams, Evaluation and Improvement. National Academy Press: Washington, D.C., (1983).

National Research Council. Geotechnical Instrumentation for Monitoring Field Performance. National Academy Press: Washington, D.C., (1982).

Sherard, Woodward, Gizienski, and Clevenger. Earth and Earth Rock Dams. John Wiley and Sons: New York, NY, (1963).

Spear, Andrew D. PP&L Owned Dams and Related Facilities Inspection Program. Pennsylvania Power and Light Company: Allentown, PA, (1981).

Tschantz, B.A. Report on Review of State Non-Federal Dam Safety Programs. University of Tennessee: Knoxville, TN, (February 28, 1983).

U.S. Dept of Agriculture, Forest Service and Soil Conservation Service, Guide for Safety Evaluation and Periodic Inspection of Existing Dams. Washington, D.C., (1980).

U.S. Department of the Interior, Water and Power Resources Services (Bureau of Reclamation). Concrete Manual. Denver, CO, (1981).

U.S. Department of the Interior, Bureau of Reclamation. Design of Small Dams. Denver CO, (1977).

U.S. Department of Agriculture, Soil Conservation Service. National Engineering Handbook.

U.S. Department of Agriculture, Soil Conservation Service, TR-60, Earth Dams and Reservoirs, (1985).

U.S. Department of the Interior, Bureau of Reclamation. Concrete Manual. Washington, D.C., (1975).

U.S. Department of the Interior, Bureau of Reclamation. Earth Manual. 2nd ed. Washington, D.C., (1974).

U.S. Department of Interior, Bureau of Reclamation, Division of Dam and Structural Safety. Operation and Maintenance Guidelines for Small Dams. Washington, D.C., (1982).

U.S. Department of the Interior, Water and Power Resources Service (Bureau of Reclamation). Safety Evaluation of Existing Dam. Denver, CO, (1980).

JOHNSTOWN FLOOD



A jam at stone bridge caused a 10- to 30-foot lake over Johnstown.



The fire there, probably caused by oil and hot coals, burned for 2 days.



As soon as the water receded, rescue workers began searching for survivors and bodies. Some waited days to be rescued.



Survivors lived in army tents and leantos. Prefabricated "Oklahoma" houses, furnished with essentials, were later sold for $250.



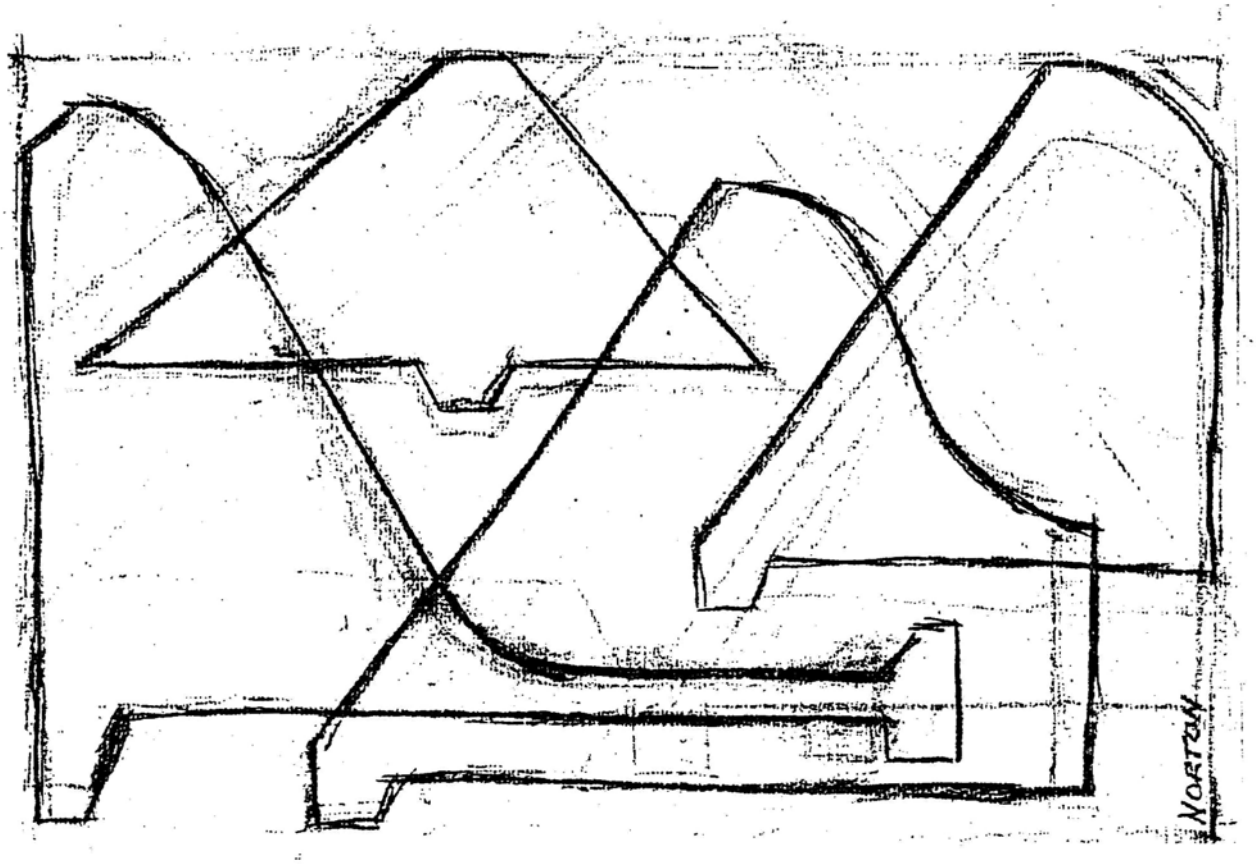
Shattered buildings were thrown into piles three stories high, completely filling some blocks.



The flood snapped large trees like sticks and turned them into battering rams that could pierce walls.

Cambria Iron Company's prompt reassurance that mills would be rebuilt heartened the many Johnstown citizens who depended on them.

Reprinted from the brochure
Johnstown Flood National Memorial
National Park Service
U.S. Department of Interior
Johnstown, Pennsylvania



Maryland Dam Safety Division
Water Management Administration
Maryland Department of the Environment
1800 Washington Boulevard, Suite 440
Baltimore, MD 21230-1718

Phone: (410) 537-3538
Toll-Free: 1 (800) 633-6101, ext. 3538
Fax: (410) 537-3553

For a dam emergency after normal working hours
please call toll-free 1-866-MDE-GOTO (1-866-633-4686)

See our web page at:

http://www.mde.state.md.us/programs/waterprograms/dam_safety/home/index.asp

E.20. Massachusetts



302 CMR 10.00: DAM SAFETY

Section

10.01: Authority and Purpose
10.02: Application
10.03: Definitions
10.04: Exclusions
10.05: Registration
10.06: Size and Hazard Classification
10.07: Inspection Schedule
10.08: Compliance with Inspection Results
10.09: Dam Construction, Repair, Alteration, Breach or Removal Permit
10.10: Revocation, Suspension, or Modifications of Chapter 253 Permits
10.11: Emergency Action Plans
10.12: Records
10.13: Liability
10.14: Design and Construction Criteria for New and Existing Dams
10.15: Schedule of Fees and Fines
10.16: Severability

10.01: Authority and Purpose

(1) 302 CMR 10.00 is promulgated pursuant to the authority granted the Department of Environmental Management (DEM) in M.G.L. c. 253, § 44.

(2) The purpose of 302 CMR 10.00 is to provide regulatory guidelines for the safety of dams by establishing reasonable standards and to create a public record for reviewing the performance of a dam.

10.02: Application

302 CMR 10.00 *et seq*. shall apply to the registration of dams, safety inspections, owner responsibilities, applications for review and approval of plans for the construction, alteration, modification, repair, enlargement, and removal of dams, quality assurance of construction, acceptance of construction, notification of intent to construct, and emergency action plans. 302 CMR 10.00 shall apply to any dam, as defined herein, constructed, altered or used to store and/or divert water in Massachusetts. Certain structures herein defined are exempt from 302 CMR 10.00.

10.03: Definitions

In addition to M.G.L. c. 253, § 44 as used in 302 CMR 10.00, the following terms shall have the following meanings:

(1) Undefined Terms. As used in 302 CMR 10.00 any term not defined in accordance with 302 CMR 10.03 shall have the meaning given to the term by any statutes, regulations, executive orders or policy directives governing the subject matter of the term. Examples include terms pertaining to:

(a) wetlands, which is defined by the Wetlands Protection Act, M.G.L. c. 131, § 40, and its implementing regulations, 310 CMR 10.00, and 33 USC 1341 and 314 CMR 9.00 regarding Water Quality Certification, as well as other statutes, regulations, executive orders, or policy directives that govern wetlands issues; and

(b) roadways or traffic, which is defined by the Massachusetts Highway Department's Highway Access Policy (adopted September 17, 1991), its Standard Operating Procedure for Review of State Highway Access permits (adopted September 17, 1991), and the Guidelines for EIR/EIS Traffic Impact Assessment (1989, as amended) by the Executive Office of Transportation and Construction and the Executive Office of Environmental Affairs, as well as other statutes, regulations, executive orders or policy directives that govern roadway and traffic issues.

10.03: continued

(2) Defined Terms. As used in 302 CMR 10.00, the following terms shall have the following meanings:

Abutment means that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment. Right and left abutments are those on respective sides of an observer looking downstream.

Acre-foot means a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. One million U.S. gallons = 3.068 acre foot.

Applicant means any person making application for a dam safety permit.

Appurtenant Works means structures, either in dams or separate therefrom, including, but not limited to, spillways; reservoirs and their rims; low level outlet works; and water conduits, including tunnels, pipelines or penstocks, either through the dams or their abutments.

Artificial Impoundment means as applied to dam safety, a reservoir created by a dam.

As- builts means plans, drawings and all other descriptive and factual information that depict how a dam was actually constructed or repaired. As-builts are required to be submitted to the Commissioner at dam completion.

Authority means M.G.L. c. 253, §§ 44 through 48.

Axis of Dam means a plane or curved surface, arbitrarily chosen by a designer, appearing as a line in a plan or cross section to which the horizontal dimensions of the dam can be referred.

Baffle Block means a block, usually of concrete, constructed in a channel or stilling basin to dissipate the energy of water flowing at high velocity.

Base Width (Base Thickness) means the maximum width or thickness of a dam measured horizontally between upstream and downstream faces and normal to the axis of the dam but excluding projections for outlets, etc.

Beaver Dams means dams that are constructed by beavers and that are not subject to 302 CMR 10.00. Control of beaver population and removal of beaver dams is regulated by M.G.L. c. 131, 321 CMR 2.00: *Miscellaneous Regulations Relating to Fisheries and Wildlife*, and also by the Local Boards of Health and Conservation Commissions.

Berm means a horizontal step or bench in the sloping profile of an embankment dam.

Boil means a disturbance in the surface layer of soil caused by water escaping under pressure from behind a water retaining structure such as dam or a dike. The boil may be accompanied by deposition of soil particles (usually sand) in the form of a ring (miniature volcano) around the area where the water escapes.

Certificate of Completion means a document signed and stamped by a registered professional engineer with contractor's signature and supporting as-builts, upon completion of the work, attesting that the work has been performed in accordance with the permit conditions.

Certificate of Compliance means when a dam has been deemed safe, evaluated, constructed, repaired, altered or removed to the satisfaction of the Commissioner under a properly issued permit, the Commissioner shall issue a certificate of compliance, on a form prescribed by the Commissioner, to the owner approving the dam but subject to terms and conditions, if any. Such certificate shall be recorded by the owner in the registry of deeds in the county where the dam lies.

10.03: continued

Certificate of Non-compliance means a certificate of non-compliance issued by the Commissioner determines that the dam or appurtenant features are unsafe. Such certificate shall be recorded by the Commissioner in the registry of deeds in the county where the dam lies.

Certificate of Registration means a form to be provided by the Commissioner to be completed by the owner and filed with the Department.

Cofferdam means a temporary structure enclosing all or part of a construction area so that construction can proceed in a dry area. A "diversion cofferdam" diverts a river into a pipe, channel or tunnel.

Commissioner means the Commissioner of the Department of Conservation and Recreation or his authorized designee.

Conduit means a closed channel for conveying discharge through or under a dam.

Crib Dam means a gravity dam built up of boxes, cribs crossed timbers, or gabions and filled with earth or rock.

Culvert means a drain or waterway built transversely under a road, railway, or embankment, usually consisting of a pipe or covered channel of box section. A gallery or waterway constructed through any type of dam, which is normally dry but is used occasionally for discharging water, hence the terms "scour culvert", "drawoff culvert", and "spillway culvert". A roadway or railway culvert shall not be considered a dam if its invert is at the natural bed of the water course, it has adequate discharge capacity, and it does not impound water under normal circumstances. A culvert with installed man made water control device which impounds, release or diverts water may be designated by the Commissioner as a dam.

Cutoff Wall means an impervious construction or material which reduces seepage or prevents it from passing through foundation material.

Dam means any artificial barrier, including appurtenant works, which impounds or diverts water, and which:

(a) is 25 feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum water storage elevation; or

(b) has an impounding capacity at maximum water storage elevation of 50 acre feet or more. Any other artificial barrier, including appurtenant works, the breaching of which could endanger property or safety, may be designated by the Commissioner as a dam, and shall be subject to M.G.L. c. 253, §§ 44 through 48.

The word "dam" shall not mean any of the following:

(c) any appurtenant works which temporarily impounds or diverts water used on land in agricultural use as defined pursuant to M.G.L. c. 131, § 40;

(d) any barrier or appurtenant works which has a size classification of small or low hazard potential classification that is used on land in agricultural use as defined in M.G.L. c. 131, § 40; and

(e) any barrier which is not in excess of six feet in height, regardless of storage capacity, or which has a storage capacity at maximum water storage elevation not in excess of 15 acre feet, regardless of height. The Commissioner shall make such determination by taking into consideration factors such as height, type of structure, condition of structure, volume of the impoundment, extent of development downstream, and other factors deemed appropriate by the Commissioner.

Dam Breach means an eroded opening through a dam which drains the impoundment. A controlled breach is a design and constructed opening. An uncontrolled breach is an unintentional opening which allows uncontrolled discharge from the impoundment,

Dam Break Analysis means a determination of a flood hydrograph resulting from a dam breach.

10.03: continued

Dam Certificate of Registration means a certificate to be issued by the Commissioner to the dam owner.

Dam Failure means an uncontrolled release of impounded water from a dam.

Dam Inspection Form or Format means a form or forms prescribed by the Commissioner containing information relative to the present condition, safety and adequacy of the dam and such other information as the Commissioner may require by regulation, signed by a registered professional engineer and filed with the Department.

Dams Not Regulated by M.G.L. c. 253, §§ 44 through 48 means dams constructed by beavers, created by ice, debris etc. and any other non man-made structures.

Dam Registration Form means a form or forms to be provided by the Commissioner to be prepared by the owner and filed with Commissioner containing the name of the owner, the location and the dimensions of the dam and such other information as the Commissioner may require by regulation.

Dam Safety Engineer means a person who is employed by the department who meets the requirements established by the Department of Personnel Administration

Database means electronic database of detailed information about dams. The database is owned, compiled, maintained and distributed by the Commissioner. Requests for database information are subject to M.G.L. c. 4, § 7, clause twenty-sixth (n) (Public Records) until suspended.

DEP means the Department of Environmental Protection

Department means the Department of Conservation and Recreation (DCR), as established in M.G.L. c. 21 § 1.

Drainage Area means the area which drains to a particular point on a river or stream.

Drawdown means the lowering of water surface level due to loss of water from a reservoir.

Embankment means the fill material, usually earth or rock, placed with sloping sides which provide a permanent barrier which impounds water.

Emergency Condition means unsafe dams with highest risk of failure, requiring immediate attention and a predetermined plan of action to reduce the highest level of risk, for the protection of public safety.

Emergency Action Plan means a predetermined plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam break.

Engineer/Design Engineer, *See* Registered Professional Engineer.

Factor of Safety means as applied to dam safety, the ratio of the forces or moments resisting mass movement to the forces or moments tending to produce mass movement.

Fees means as applied to dam safety, the cost of services listed under 302 CMR 10.15 and provided by the Department

Flashboards means a length of timber, concrete, or steel placed on the crest of a spillway to raise the retention water level but that may be quickly removed in the event of a flood either by a tripping device or by a deliberately designed failure of the flashboard or its supports.

Flow Net means graphical representation of families of streamlines and equipotential lines, used in groundwater studies to determine quantities, rate, and directions of flow.

10.03: continued

Freeboard means the vertical distance between a stated water level and the top of a dam. Net Freeboard, Dry freeboard, Flood Freeboard or Residual Freeboard is the vertical distance between the estimated maximum water level and the top of a dam.

Gravity Dam means a dam constructed of concrete and/or masonry that relies on its weight for stability.

Great Pond means a pond containing in its natural state more than ten acres of land, as defined in the Waterways regulations at 310 CMR 9.02.

Great Pond/Enlarged means as applied to dam safety, any change in or addition to an existing Great Pond which raises or may raise the water storage elevation, of the water impounded by a Great Pond, by construction of a dam.

Hazard Potential Classification means the rating for a dam based on the potential consequences of failure. The rating is based on potential for loss of life and damage to property that failure of that dam could cause downstream of the dam. The hazard potential classification for a dam also is based on the incremental adverse consequences of failure, and has no relationship to the current structural integrity, operational status, flood routing capability, or safety condition of the dam or its appurtenances.

Height of Dam means the vertical distance from the lowest elevation of the dam crest to the lowest point of natural ground, including any stream channel, along the downstream toe of the dam.

Hydraulic and Hydrologic (H&H) Analyses means the analytical process of computing the change in a flood wave as it passes through a reservoir or a channel.

Hydraulic Height means the height to which water rises behind a dam and the difference between the lowest point in the original streambed at the axis of the dam and the maximum controllable water surface.

Hydrograph/Flood means a graphical representation of the flood discharge with respect to time for a particular point on a stream or river.

Inspections

(a) Additional Required Inspection means an additional inspection by a registered professional engineer of the dam, in accordance with the inspection frequency established by the Commissioner, to detect apparent signs and changes of deterioration in material, developing weaknesses or unsafe hydraulic and/or structural behavior or any other deficiencies of the dam structure or function since the initial Phase I or poor/unsatisfactory condition was determined. The additional inspection report shall follow a form as established by the Commissioner.

(b) Follow-up Inspection means an inspection when it is desirable to obtain supplemental data and/or to observe or monitor a dam under particular conditions (i.e. wet season, dry season, foliage, etc.)

(c) Phase I Formal Inspection means the visual inspection of the dam, in accordance with the inspection frequency established by the Commissioner, by a registered professional civil engineer to evaluate or reevaluate the safety and integrity of the dam and appurtenant structures to determine if the structure meets current design criteria. Formal inspection includes field observations to detect any signs of deterioration in material, developing weaknesses or unsafe hydraulic and/or structural behavior and a review of the records on project design, construction and performance. The final formal inspection report shall follow a form or format as established by the Commissioner and shall be filed with the Office of Dam Safety. All formal field inspections shall be performed during good weather conditions.

10.03: continued

(d) Phase II Detailed Inspection means all studies, investigations and analyses appropriate to evaluate the structural safety and hydraulic capacity of a dam or reservoir and appurtenant works. This inspection may include, but is not limited to, structural stability analyses, detailed hydrologic/hydraulic assessment, dam breach analyses, subsurface investigation, soil and materials testing, foundation explorations, conclusions, conceptual alternatives, cost estimate and recommendations. This inspection shall be performed by a registered professional civil engineer.

(e) VIF (Verification In Field) Inspection means an inspection for jurisdictional determination, and/or to obtain supplemental data, and/or for any other reason(s) deemed appropriate by the Commissioner.

(f) Visual Inspection means a visual but technical evaluation that must be performed of the physical conditions which affect performance of the structure and may include an analysis of the dam's ability to pass flood waters and must be performed by a registered professional civil engineer or dam safety engineer.

Instrumentation means an arrangement of devices installed into or near dams (*i.e*. piezometers, inclinometers, strain gages, measurement points, *etc*.) which provide for measurements that can be used to evaluate the structural behavior and performance parameters of the structure.

Inundation Map means a map delineating the area that would be flooded by a particular flood event or dam failure.

Liability means legal liability associated with the ownership, operation, maintenance, repair and failure of a dam.

Lien means a notice for the payment by the owner to the Commonwealth of the costs and expenses incurred by the Commonwealth for any actions taken in accordance with M.G.L. c. 253, § 47 and shall be effective upon mailing to the owner at the address shown in the Certificate of Registration and recorded at the Registry of Deeds in the county where the dam lies.

Low Level Outlet (Bottom Outlet) means an opening at a low level in a reservoir generally used for emptying the reservoir or scouring sediment and sometimes for irrigation.

Materially Alter means any change to a dam or reservoir which affects the physical parameters and/or safety of the dam or reservoir which may include, but is not limited to changing the height of a dam, increasing the normal pool or spillway elevation or changing the elevation or physical dimensions of an emergency spillway.

Maximum Impoundment Elevation means the maximum elevation of water surface which can be contained by the dam without overtopping the embankment section.

Maximum Water Storage Elevation means the reservoir elevation level reached during the spillway design flood.

Normal Water Level means for a reservoir with a fixed overflow sill the lowest crest level of that sill. For a reservoir whose outflow is controlled wholly or partially by movable gates, siphon or other means, it is the maximum level to which water may rise under normal operating conditions, exclusive of any provision for flood surcharge.

One-hundred-year Storm Event means the storm which is estimated to have a 1% chance, or one chance in 100 of being equaled or exceeded in one year, or one chance in 100 hundred years of being equaled.

Operation and Maintenance Manual (O&MM) means a document identifying routine maintenance and operational procedures under routine and storm conditions.

Order means a written document prepared and issued by the Commissioner which mandates specific actions to be accomplished by a dam owner within a specified time frame. Failure to comply with an order shall make the owner subject to fines as provided for in 302 CMR 10.15.

10.03: continued

Orientation:

(a) Upstream means the side of the dam that borders the reservoir.
(b) Downstream means the high side of the dam, the side opposite the upstream side.
(c) Right means the area to the right when the viewer is looking downstream.
(d) Left means the area to the left when the viewer is looking downstream.

Owner means the person or persons, including any individual, firm, partnership, association, syndicate, company, trust corporation, municipality, agency, political or administrative subdivision of the commonwealth or any other legal entity of any kind holding legal title to a dam, but excluding the United States, its agencies or any person who operates a dam owned by the United States.

Permit or Chapter 253 Dam Safety Permit means a written approval, pursuant to M.G.L. c. 253, §§ 44 through 48, to construct, repair, alter, breach or remove a dam. The technical aspect of the Permit must be reviewed and approved by a Dam Safety Engineer.

Phreatic Surface means the free surface of groundwater at atmospheric pressure.

Piezometer means as applied to dam safety, an instrument used for measuring water pressure within soil, rock or concrete.

Piping means the progressive development of internal erosion by seepage, appearing downstream as a hole or seam discharging water that contains soil particles..

Poor Condition means dams with major structural, operational, maintenance and flood routing capability deficiencies. Also unsafe-nonemergency dams.

Probable Maximum Flood (PMF) means the most severe flood that is considered reasonably possible at a site as a result of the most severe combination of critical meteorological and hydrologic conditions possible in the region.

Registered Professional Engineer means a civil engineer licensed and registered in the Commonwealth of Massachusetts with experience in dam safety inspections and engineering. Individuals licensed and registered in another state, but not in Massachusetts must be approved by the Commissioner.

Removal means the destruction or breaching of a dam to the extent that no water can be impounded by the dam.

Repairs means any work done at a dam which affects the integrity of the dam. This includes but is not limited to, work requiring excavation into the embankment fill or foundation of a dam or work requiring removal or replacement of major structural components of a dam.

Reservoir means the area which contains or will contain the body of water impounded by a dam.

Riprap means is a layer of large uncoursed stones, broken rock, or pre-cast blocks placed in random fashion on the upstream slope of an embankment dam, on a reservoir shore, or on the sides of a channel as a protection against wave and ice action. Very large rip-rap is sometimes referred to as armoring.

Risk means a measure of the likelihood and severity of adverse consequences. In dam safety applications, life-safety risk is expressed in units of loss-of-lives per year; economic, societal and environmental risks are expressed in units of dollars per year. The risk may be associated with an individual failure mode or it may be total risk, representing the cumulative risk associated with all failure modes

Risk Assessment means as applied to dam safety, the process of identifying the likelihood and consequences of dam failure to provide the basis for informed decisions on a course of action.

10.03: continued

Roll Dams means low head dams usually run of the river overflow weir or spill way structures that produce vertical water surface drops of one to 15 feet and change river flows from super-critical to sub-critical.

Run-of-the-river-dam means a dam situated on a river or stream whose spillway length and width of impoundment is nearly equal to the width of the original river or stream bank to bank.

Safety Evaluation means as applied to dam safety, the process of determining the ability of a dam and its appurtenances to pass a given flood.

Seepage means the interstitial movement of water that may take place through a dam, its foundation, or its abutments.

Siphon/Inverted means a conduit or culvert to permit water to pass under an intersecting roadway, stream or other obstruction.

Spillway means a structure over or through which flood flows are discharged. If the flow is controlled by gates, it is a controlled spillway; if the elevation of the spillway crest is the only control, it is an uncontrolled spillway.

Spillway/Auxiliary (Emergency Spillway) means a secondary spillway designed to operate only during exceptionally large floods.

Spillway(s) Design Flood (SDF) means the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway(s) and outlet works, and for determining maximum temporary storage and height of dam requirements.

Stoplogs means large logs or timbers or steel beams placed on top of each other with their ends held in guides on each side of a channel or conduit to control water level in reservoir.

Tailwater Level means as applied to dam safety, the level of water in the discharge channel immediately downstream of the dam.

Toe of Dam means the junction of the downstream face of a dam with the ground surface, also referred to as downstream toe. For an embankment dam, the junction of the upstream face with ground surface is called the upstream toe.

Unsafe Dam means a dam whose condition, as determined by the Commissioner, is such that a high risk of failure exists. Among the deficiencies which would result in this determination are: excessive seepage or piping, significant erosion problems, inadequate spillway capacity and/or condition of outlet(s), and serious structural deficiencies, including movement of the structure or major cracking.

Uplift means as applied to dam safety, the upward pressure in the pores of a material(interstitial pressure) or on the base of a structure.

Water Storage Elevation means the maximum elevation without encroaching on the approved freeboard at maximum design flood.

Weir means a low dam or wall built across a stream to raise the upstream water level. Termed fixed-crest weir when uncontrolled. A structure built across a stream or channel for the purpose of measuring flow. Types of weir include broadcrested weir, sharp-crested weir, ogee weir, and V-notched weir.

10.04: Exclusions

Dams owned and operated by the United States, its agencies or any person who operates a dam owned by the United States are excluded from the provisions in 302 CMR 10.00, together with dams and reservoirs licensed and subject to inspection by the Federal Energy Regulatory Commission (FERC) provided that a copy of all FERC approved periodic inspection reports are provided to the Department. All other dams are subject to 302 CMR10.00 unless exempted in writing by the Commissioner, M.G.L. c. 253, §§ 44 through 48, or 302 CMR 10.00. Examples of exempt dams could be temporary drainage detention ponds, surface impoundments (other than water) for industrial or commercial wastes which are regulated by other agencies or storage tanks.

10.05: Registration

(1) General. The purpose of registration is to establish a public record of the dam.

(2) The owner of any dam subject to 302 CMR 10.00 shall cause to be filed with the Commissioner, within 30 days following notice by him, on a form prescribed by him, a Dam Registration Form containing the name of the owner, the location and dimensions of such dam and such other information as the Commissioner may reasonably require.

(3) A registration form shall not be deemed received by the Commissioner until all information required by statute or 302 CMR 10.00 is furnished.

(4) In the event that the owner fails to file the dam registration form in the time prescribed, the Commissioner may notify the owner of such failure and offer a 30 day grace period after which a Certificate of Non-compliance will be issued and recorded at the Registry of Deeds in the county where the dam lies, with all costs of recording, and interest thereon, to be assessed against the owner.

(5) Upon receipt and approval of the Dam Registration Form, a Certificate of Registration will be issued to each owner. Within 14 days of receipt such Certificate of Registration must be recorded by the owner at the Registry of Deeds in the county where the dam lies, and a copy of the recorded Certificate filed with the Commissioner within ten days of recording.

(6) The owner shall notify the Commissioner by registered or certified mail, of the proposed transfer of legal title of such dam 30 days prior to any such transfer. Upon receipt of such notice, a new Certificate of Registration will be issued. Such Certificate shall contain any outstanding obligations of the registered owner under M.G.L. c. 253, §§ 44 through 50.

10.06: Size and Hazard Classification

(1) General. Dams shall be classified for purposes of establishing inspection schedules and adherence to design criteria, in accordance with their potential for damage to life or property in the area downstream from the dam in the event of failure of the dam or appurtenant facilities. This determination shall be made by the Commissioner and noted on the owner's Certificate of Registration. It may be necessary to periodically reclassify dams as additional information becomes available and/or conditions change. The criteria established in 302 CMR 10.06(2) through (4) shall be used by the Commissioner to determine the size and hazard potential classification based upon the extent of development downstream from the dam, taking into consideration factors such as height, type of structure and volume of impoundment, pursuant to M.G.L. c. 253.

(2) Size Classification. The classification for size based on the height of the dam and storage capacity shall be in accordance with the Size Classification Table. The height of the dam is established as described in 302 CMR 10.06 with respect to maximum water storage elevation. The storage capacity of the dam is the volume of water contained in the impoundment at maximum water storage elevation measured as defined in 302 CMR 10.06(2). Size class may be determined by either storage or height, whichever gives the larger size classification.

10.06: continued

SIZE CLASSIFICATION TABLE

Category	Storage (acre-feet)	Height (feet)
Non-jurisdictional	Not in excess of 15 regardless of height	Not in excess of six regardless of storage capacity
Small	≥ 15 and <50	≥6 and <15
Intermediate	≥50 and <1000	≥ 15 and <40
Large	≥1000	≥40
For dams not in excess of 25 feet in height or having maximum impounding capacity not in excess of 50 acre-feet, the Commissioner shall make jurisdictional determination by taking into consideration factors or combination of factors such as height, type of structure, volume of the impoundment, extent of downstream development, and other factors deemed appropriate by the Commissioner.		

(3) Hazard Potential Classification. The classification for potential hazard shall be in accordance with the Hazard Potential Classification Table in 302 CMR 10.06(3). The hazards pertain to potential loss of human life or property damage in the event of failure of the dam or appurtenant works. Development of the area downstream from the dam that would be affected by its failure shall be considered in determining the classification. Dams will be subject to reclassification if the Commissioner determines the hazard has changed.

HAZARD POTENTIAL CLASSIFICATION TABLE

High Hazard (Class I):	Dams located where failure will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).
Significant Hazard	Dams located where failure may cause loss of life and damage home(s), industrial or commercial facilities, secondary highway(s) or railroad(s) or cause interruption of use or service of relatively important facilities.
Low Hazard (Class III):	Dams located where failure may cause minimal property damage to others. Loss of life is not expected.

(4) Dams in Series.

(a) If an upstream dam has the capability to create failure in a downstream dam because of its failure flood wave, it shall have the same or higher hazard classification as the downstream dam. If the failure flood wave of the upstream dam will not cause failure of the downstream dam, the upstream dam may have a different hazard potential classification from the downstream dam.

(b) The classification of each dam shall be reviewed during each subsequent periodic inspection.

(c) Potential damage to habitable structures will be considered minor when habitable structures are not within the direct path of the probable flood wave produced upon failure of a dam or where such structures will experience:

1. no more than 2.0 feet incremental rise of flood water above the lowest ground elevation adjacent to the outside foundation walls; or
2. no more than 2.0 feet incremental rise of flood water above the lowest habitable floor elevation of the structure; the lower of the two elevations governing.

(5) Failure Damage. The extent of potential damage resulting from a dam breach may justify designating damage as either major or minor. Such a designation may be made after a detailed analysis has established the relative impact of the probable dam breach and has considered the following factors:

10.06: continued

(a) the conditions prior to and after a dam breach;
(b) the extent to which access has been affected, both before and after a dam breach; and
(c) the extent of damage.

(6) Hazard Reconsideration. An owner may at any time request the Commissioner to reconsider the hazard determination. The owner's request must be filed by a registered professional civil engineer, specifying the findings and analyses with which the owner disagrees. The Commissioner will issue a written decision to the owner and the registered professional civil engineer within 30 days of receipt of a request for hazard reconsideration, and such decision shall be final and binding upon the parties.

10.07: Inspection Schedule

(1) Upon the failure of an owner to file a dam inspection report within the time prescribed, the Commissioner or his designee, in accordance with M.G.L. c. 253, § 47 may enter upon the property on which the Department's jurisdictional dam(s) and appurtenant works lie at any time to conduct any kind of dam safety evaluation(s) and/or action(s) as required, and/or to obtain the requisite information.

(2) The owner shall periodically inspect all dams in accordance with the following schedule. These time periods are the maximum time between inspections, more frequent inspections may be performed at the discretion of the Commissioner.

FORMAL INSPECTION FREQUENCY

Hazard Potential	Inspection Frequency
Low	ten years
Significant	five years
High	two years

ADDITIONAL INSPECTION FREQUENCY

High and Significant Hazard potential dams whose condition are determined to be poor and/or emergency by formal inspection must be inspected and reported on at least every six months by a registered professional engineer employed by the owner until the dam safety repairs are completed and the dam is found to be in satisfactory condition.

Any dam determined to be in an unsafe condition must be monitored at frequencies assuring the safety of the public.

Updates on the condition of the dam shall be provided by a registered professional engineer to the Office of Dam Safety and local emergency management officials until the dam is made safe.

(3) Inspections scheduled according to the time period set forth above, may be modified, at the discretion of the Commissioner, in special cases where it is desirable to observe a dam under particular conditions (*i.e.* wet season, dry season, foliage, *etc.*).

(4) The Commissioner may require scheduled inspections on a more frequent basis if particular conditions exist which require more frequent monitoring.

10.07: continued

(5) When the Commissioner reschedules the inspection of a particular dam for any reason cited in 302 CMR 10.07, the date of that inspection may become the starting date from which the date of the next regularly scheduled periodic inspection will be computed.

(6) The owner shall employ the services of a registered professional engineer experienced in the design, construction and inspection of dams, to inspect the owner's dam according to the inspection schedules determined by the Commissioner and on forms prescribed by the Commissioner.

(7) The owner shall furnish a copy of each completed inspection report in a format determined by the Commissioner within 30 days of the date of the inspection to the Commissioner.

(8) The inspection report shall be sealed by a registered professional engineer, as described herein.

(9) The owner must submit a statement of his or her intent to implement such recommendations of the registered professional engineer, if required.

(10) Upon review and approval of submitted inspection report, the Commissioner will determine compliance and appropriate procedure(s) in accordance with 302 CMR 10.08.

10.08: Compliance with Inspection Results

(1) The Commissioner shall determine whether the dam and appurtenant features meet accepted dam safety standards. If the Commissioner determines that the dam does not meet these standards and a threat to life and/or property exists, he shall issue a Certificate of Non-compliance. Certificates shall be recorded by the Commissioner with the Registry of Deeds for the county where the dam lies.

(2) A Certificate of Non-compliance shall be issued if the Commissioner determines that the dam or appurtenant features are unsafe, as defined under 302 CMR 10.06.

(3) If the Commissioner issues a Certificate of Non-compliance, after receiving the owner's inspection form, or at any other time, the Commissioner may order the owner of the dam to: cause a detailed inspection of the dam by a registered professional engineer, including such tests as the Commissioner may require or recommend to determine the course of action necessary to bring the dam into compliance and a time schedule by which the work shall be accomplished; or take whatever action is necessary to reduce the safety risk, as determined by the Commissioner.

(4) Notice of such aforementioned orders shall be served upon the owner(s) by registered or certified mail, return receipt requested, and recorded by the Commissioner in the Registry of Deeds in the county where the dam lies.

(5) When the dam meets minimum dam safety standards, or has been corrected or removed pursuant to an order by the Commissioner, the Commissioner shall issue a Certificate of Compliance to the owner.

(6) The Commissioner has the authority, pursuant to M.G.L. c. 253, § 47, and in accordance with the Memorandum of Understanding Between the DEP and the DCR relative to lake water level drawdowns/dam repair projects to determine the maximum allowable water elevation for reservoirs and impoundments where dams have been determined to be unsafe. In determining the maximum allowable water elevation, the Commissioner may consider the recommendations of a registered professional engineer representing the owner, if the owner has retained one. The owner shall not store water in excess of the stated elevation so determined by the Commissioner.

10.08: continued

(7) When the spillway capacity of the existing dam does not meet stated criteria a relative impact analysis may be required to be performed by the owner. This analysis will address such factors as: downstream impact area; capacity and/or condition of outlet work(s); overtopping potential; operation plans; consideration of incremental impacts of possible failure; and emergency action plans. Upon review and approval by the Commissioner a reduction in the standard design flood may be allowed to such dam.

10.09: Dam Construction, Repair, Alteration, Breach or Removal Permit

(1) General Application. Any person(s) who proposes to construct, repair, materially alter, breach or remove a dam, pursuant to M.G.L. c. 253, must file with the Commissioner a permit application to determine whether or not a Chapter 253 Dam Safety Permit is required. Routine maintenance-related work does not require a Chapter 253 Dam Safety Permit. Approved permits issued by the Commissioner do not relieve the applicant from required compliance with M.G.L. c. 131, § 40, and, where applicable, M.G.L. c. 131, §§ 5C and 19. Applications shall be sent by certified mail, return receipt requested. All permit applications must comply with DCR's standard design and construction criteria (*see* 302 CMR 10. 14). If the Commissioner determines that the proposed dam falls within the jurisdiction of 302 CMR 10.00, the owner must complete the construction, repair, alteration, breach or removal permit application as follows:

(a) Preliminary Report. The Permit application for any dam shall include a preliminary report. (Filing of the preliminary report prior to filing the final report, early in the site investigation and design schedule, is encouraged to assure the state's concurrence with the hazard classification, site investigation, and design concept.) The preliminary report shall be filed with the permit application and shall include, but not be limited to, the following information:

1. completion of all required information on the application;
2. maps showing the location of the proposed structure that include the county, location of state roads, access to site, and outline of the reservoir (aerial photographs or U.S. Geological Survey may be used);
3. preliminary drawings or sketches that include cross sections, plans and profiles of the dam, propose pool levels, and type of all spillways;
4. preliminary design criteria and basis for selection including a description of the size, ground cover conditions, and extent of development of the watershed, drainage area, spillway design storm, geology and geotechnical engineering assumptions for the foundation and embankment materials, and type of materials used in the principal spillway(s); and
5. book and page number of location of the dam as recorded in the Registry of Deeds with the name of the Registry.

(b) Final Design Report. Approval or denial of a permit to construct, repair, alter, breach or remove a dam will be issued within 60 days from the time the final design report and permit application is received. The final design report shall include, but may not be limited to, the following information:

1. a report of the investigation of the foundation soils or bedrock and the borrow materials, including the location of borrow areas, that are to be used to construct or repair the dam;
2. analysis and/or criteria to indicate that the dam will be stable during construction and filling and under all conditions of reservoir operations;
3. computations indicating that the dam is safe against overtopping during occurrence of the inflow design flood and wave action; wave action need not be considered when the design flood is based on the probable maximum precipitation (PMP);

10.09: continued

4. criteria, design data or references to indicate that seepage flow through the embankment, foundation, and abutments will be controlled to limit internal erosion and sloughing in the area where the seepage occurs;
5. calculations and assumptions relative to design of the spillway(s);
6. provisions to protect the upstream slope, crest, and downstream slope of earth embankments and abutments from erosion due to wind and rain;
7. other design data, assumptions and analysis data pertinent to individual dams and site conditions;
8. a proposed construction schedule;
9. a proposed filling schedule for the reservoir;
10. a maintenance and operation plan; and
11. for all new high and significant hazard potential dams, an emergency action plan to be implemented in the event of a dam failure.

The preliminary report and the final design report may be submitted as one document.

(2) Construction Documents. Two sets of plans and specifications must be submitted along with the Final Design Report. The documents shall be detailed engineering design drawings and specifications and that include the following at a minimum:

(a) sheet one showing the name of the project; name of owner; hazard classification of the dam; designated access to the project; and location with respect to highways, roads, streams, and any dam(s) that would affect or be affected by the proposed structure;
(b) maps showing the drainage area and outline of the reservoir and the ownership of properties covered by the reservoir or flood pools;
(c) geologic investigation, cross section, profiles, logs of borings, location of borrow areas, drawing of principal and emergency spillways, drawn in sufficient detail to clearly indicate the extent and complexity of the work performed;
(d) the technical provisions, as may be required, to describe the method of construction and quality control for the project; and
(e) special provisions, as may be required, to describe technical provisions needed to ensure that the dam is installed according to the approved plans and specifications.

(3) Notification. The Commissioner shall notify the applicant in writing within 60 days following the receipt of the completed application if the application is approved or disapproved. If the application is disapproved an explanation will be provided.

(4) Permit. Approval of construction, drawdown, repair, alteration, brief or removal of a dam will be contained in a Chapter 253 Permit to be issued by the Commissioner. A permit may be subject to written general stipulations and/or written specific stipulations deemed necessary by the Commissioner. No construction shall be performed until the permit is issued and recorded in the Registry of Deeds for the county within which the dam lies. The permit shall be valid for the construction schedule specified in the approved final design report and application. Construction must commence within two years after the permit is issued. If construction does not commence within two years after the permit is issued, the permit shall expire and a new application shall be submitted unless prior to the permit expiration date, upon written application and for good cause shown, the Commissioner extends the time for commencing construction.

(5) Recording a Chapter 253 Permit. A permit to construct, drawdown, repair, alter, breach or remove a dam shall be recorded at the Registry of Deeds in the county where the dam lies. Recording must be done prior to the commencement of construction and a copy of the recorded permit filed with the Commissioner.

10.09: continued

(6) Construction/Drawdown Notification. At least 21 days before construction or controlled drawdown is commenced, the owner shall provide notice by certified and/or registered mail to the Commissioner and the local Conservation Commission and to the Commonwealth Division of Fish and Wildlife, Field Headquarters, 1 Rabbit Hill Road, Westborough, MA 01581 attn: Natural Heritage and Endangered Species Section. When repairs are necessary to safeguard life and property, they may be started under the provisions of M.G.L. c. 253, § 47 upon notification by the Commissioner of an emergency condition. The owner shall assign a registered professional engineer to monitor any drawdown for the first four hours after its commencement, observing conditions at least on an hourly basis. Thereafter, the owner or his registered professional engineer shall monitor the drawdown at least once each 24 hours until drawdown has been completed. Emergency drawdowns in accordance with an order issued by the Commissioner excepted, to meet standards established by the Commonwealth Division of Fish and Wildlife drawdown rates should not exceed four cubic feet per second per square mile of drainage area (CFSM), as measured at the outlet structure. During reimpoundment, 0.5 cfsm should be maintained at the outflow.

(7) Entry. During construction the Commissioner or his designee may enter upon the property to inspect during construction without prior notice and may direct any additional testing or actions as required.

(8) Removal of Dams. If it is desirable to remove a dam due to new construction, abandonment or unsafe conditions, the owner shall be required to comply with 302 CMR 10.09 regarding the construction and repair of dams. Upon complete removal of the dam, the Commissioner will issue a Certificate of Approval stating that the removal has been in accordance with the approved plans and specifications, or any approved revisions thereof.

10.10: Revocation, Suspension, or Modifications of Chapter 253 Permits

Chapter 253 Permits may be revoked, suspended, modified or denied by the Commissioner for causes including but not limited to, the following:

(1) violation of any permit condition;

(2) failure to fully disclose all relevant facts or obtaining a permit through misrepresentation;

(3) violation of any provisions of M.G.L. c. 253, or 302 CMR 10.00 *et seq.*;

(4) change or newly discovered condition or circumstance that makes or would make the dam unsafe; or

(5) change of conditions develop that are hazardous to life and/or property.

10.11: Emergency Action Plans

(1) All dams classified or reclassified as high hazard potential shall have an Emergency Action Plan ("EAP"). If the Commissioner requires it, the owner of a non-high hazard potential dam shall also be required to provide an EAP. Approval to construct a new significant hazard potential dam or high hazard potential dam shall be contingent upon the submission of an EAP to the Commissioner. All EAP's are subject to approval by the Commissioner. The EAP shall, at a minimum, contain the following:

(a) the identification of equipment, manpower and material available for implementation of the plan;

(b) a notification procedure for informing the local emergency agencies;

(c) a dam failure inundation map for high hazard potential dams and a topographic map for significant hazard potential dams showing the stream which will be flooded; and

(d) a procedure for warning nearby local residents if failure of the dam is imminent and a listing of addresses and telephone numbers of downstream residents who may be affected by the failure of the dam.

10.11: continued

(2) Prior to submission of an EAP to the Commissioner, the owner shall submit a copy of the proposed EAP to the local and state emergency agencies, and all local emergency coordinators involved in the plan, for review. The owner shall submit with the EAP, recommendations received from said agencies and coordinators, if any.

(3) Annually, the owner shall review the EAP, update it and provide the updated EAP to all involved agencies for review.

(4) EAP'S shall be provided by the owner in both hard copy and electronic format to the Commissioner and the Massachusetts Emergency Management Agency.

10.12: Records

Upon request by the Commissioner, an owner shall make available for inspection and review, all plans, specifications and other such pertinent material relating to the dam. The Commissioner shall return all such material upon completion of his inspection.

10.13: Liability

(1) The owner shall be responsible and liable for damage to property of others or injury to persons, including but not limited to loss of life, resulting from the operation, failure of or misoperation of a dam.

(2) 302 CMR 10.00 shall not relieve from or lessen the responsibility of any person owning, or operating a dam from any damages to persons or property caused by defects, nor shall the Commissioner be held liable by reason of any inspections or permits issued.

10.14: Design and Construction Criteria for New and Existing Dams

(1) General. Design and construction of dams shall comply with 302 CMR 10.14. Design and construction standards that are not included in 302 CMR 10.14, shall conform to design procedures established by: The U.S Army Corps of Engineers, the U.S. Bureau of Reclamation, the U.S. National Resource Conservation Agency and other generally accepted engineering practices and principles. Where specific site conditions may exist which warrant appropriate changes in the following design and construction criteria, the Commissioner shall review and approve the design.

(2) Foundations and Abutments. The foundations and abutments investigation shall consist of borings, test pits, and other subsurface exploration necessary to assess the soil, rock, and groundwater conditions.

(3) Construction Materials. Specifications for construction materials shall establish minimum acceptance criteria so that anticipated design properties are achieved. If the use of on site borrow materials is specified, exploration, testing, and calculations shall be performed to indicate that there are sufficient quantities of material available that meet the design criteria.

(4) Surveys. Surveys shall be made with sufficient accuracy and scale to locate the proposed construction and to define the volume of the storage in the reservoir. The downstream area shall be investigated in order to delineate the area of potential damage in case of failure. Locations of centerlines, and other horizontal and vertical control points, shall be shown on a map of the site.

(5) Hydrologic Investigation. The drainage area shall be determined. Present land use shall be considered in determining the runoff characteristics of the drainage area. All hydrologic assumptions and design calculations shall be included in the report.

10.14: continued

(6) Spillway Design.

(a) The spillway system shall have a capacity to pass a flow resulting from a design storm, as indicated in the following table, unless the applicant provides calculations, designs and plans to show that the design flow can be stored, passed through, or passed over the dam without failure occurring.

SPILLWAY DESIGN FLOOD
DESIGN STORM

Hazard	Size	Existing Dams	New Dams
Low	small intermediate large	50 year 50 year 100 year	100 year 100 year 100 year
Significant	small intermediate large	100 year 100 year 500 year	500 year 500 year ½ PMF
High	small intermediate large	500 year ½ PMF ½ PMF	PMF PMF PMF

(b) Vegetated earth or unlined emergency spillway(s) will be approved when computations indicate that it will pass the design flood without jeopardizing the safety of the structure. The risk of recurring storms, excessive erosion, and inadequate vegetative cover will be considered acceptable in such a spillway when its average frequency of use is predicted to be no more than indicated in the following table.

EMERGENCY SPILLWAY FREQUENCY TABLE

Hazard	Size	Existing Dams	New Dams
Low	small intermediate large	25 years 25 years 25 years	25 years 25 years 25 years
Significant	small intermediate large	25 years 25 years 50 years	50 years 50 years 50 years
High	small intermediate large	50 years 50 years 100 years	100 years 100 years 100 years

(c) The Department recognizes that the relationships between valley slope and width, total reservoir storage, drainage area, and other hydrologic factors have a critical bearing on determining the safe spillway design flood. Rational selection of a safe spillway design flood for specific site conditions based on quantitative and relative impact analysis is acceptable. The spillway should be sized so that the increased downstream damage resulting from an overtopping failure of the dam would not be significant when as compared with the damage caused by the flood in the absence of dam overtopping failure. In lieu of quantitative and relative impact analysis, the preceding table shall be used as spillway design criteria.

(d) Lined Spillways and Channels. The design report shall include design data criteria for open channel, drop, ogee, and chute spillways and other spillway types that include crest structures, walls, channel linings, and miscellaneous details. All masonry or concrete structures shall have joints that are relatively water tight and shall be placed on foundations capable of sustaining applied loads without undue deformation. Provisions must be made for handling leakage from the channel or under seepage from the foundation which might cause saturation of underlying materials or uplift against the undersurfaces.

10.14: continued

(7) Conduits.

(a) A conduit shall be provided to drain each reservoir. Any new and/or existing conduit design shall include the computation of the minimum time required to drain the reservoir.

(b) All pipe conduits shall convey water at the design velocity without damage to the interior surface.

(c) Protection shall be provided to prohibit unsafe seepage along conduits through the dam, abutments, and foundations. The specific design for seepage protection along conduits shall be shown in the drawings and specifications.

(d) Adequate allowances shall be incorporated in the design to compensate for differential settlement and possible elongation of the pipe conduit.

(e) Trash racks shall be installed at the intake of conduits to prevent clogging the conduit.

(f) Pipe Conduit Materials:

1. Pipe conduits shall be designed to support the total external loads in addition to the total internal hydraulic pressure without leakage.

2. Reinforced or Prestressed Concrete Pipe Conduits.

a. All conduits shall be designed and constructed to remain watertight under maximum anticipated hydraulic pressure and maximum probable joint opening, including the effects of joint rotation and extensibility.

b. Provisions for safe movement of the barrel shall be provided at each joint in the barrel and at the junction of the barrel and riser or inlet. Cradles shall be articulated if constructed on a yielding foundation.

c. The owner's engineer shall submit the final design details of the proposed pipe to be used for all significant and high hazard potential dams.

3. Corrugated Metal Pipe Conduits.

a. Corrugated metal pipe shall not be used in any dam, except for special cases where the design engineer can adequately demonstrate satisfactory performance. Any exemption which allows their use must be issued in writing by the Commissioner.

4. Dissipating Devices. All gates, valves, conduits and concrete channel outlets shall be provided with a dissipater designed and constructed to control erosion and prevent damage to the embankment or the downstream outlet or channel.

5. In the case of repair to an existing dam, the owner's engineer may determine that the conduit should not be repaired or replaced and shall submit reasons to support this determination in the application for the Chapter 253 Permit to repair.

(8) Seepage Control.

(a) All dams shall be designed and constructed to prevent the development of instability due to excessive seepage forces, uplift forces, or loss of materials in the embankment, abutments, spillway areas, or foundation. Seepage analyses for design shall identify areas having high internal uplift or exit gradients.

(b) The design shall include an embankment internal drainage system, a zoned embankment, a foundation cut-off, an upstream blanket, a sufficiently wide homogeneous section, or other methods to protect against instability from excessive seepage forces or high hydraulic gradients.

(c) For high hazard potential dams, a flow net analysis shall be made to determine the location of the phreatic surface, flow lines, and equipotential lines within the embankment and its foundation. These analyses may be based on graphical construction, electrical or liquid analogs, soil prototype methods, or other generally accepted methods. The flow net and stability analysis shall be the maximum water storage elevation. Possible fluctuations in tail water elevation shall be included in the analysis. The flow net and seepage analysis shall be included in the final design report.

(d) Piezometers for confirming the location of the phreatic surface assumed for seepage and slope stability analyses shall be considered by the design engineer for low and significant hazard potential dams and shall be required for high hazard potential dams. Where piezometers are required, their design, depths and locations shall be provided in the final design report.

10.14: continued

(9) Structural Stability and Slope Protection.

(a) Design and construction of dams to assure structural stability shall be consistent with accepted engineering practice. The scope and degree of precision that will be required for a specific project will depend on the conditions of the site and the damage potential of the proposed structure. Consideration in design for structural stability shall include, but are not necessarily limited to, the following:

1. The hazard potential of the dam under present downstream conditions and under conditions which would likely develop during the life of the reservoir;
2. foundation bearing capacity, compressibility, and permeability; the extent and reliability of the site investigation; and the predictability of the site and foundation conditions;
3. the reliability of construction materials, such as borrow soils, in terms of sufficient volume to complete construction without unanticipated interruption and in terms of predictability of physical properties such as strength, permeability, and compressibility;
4. durability of construction materials;
5. construction conditions at the site;
6. the degree of quality control to be exercised during construction;
7. pore pressure build-up during construction;
8. the rate of filling the reservoir and the rate of possible reservoir drawdown;
9. tailwater conditions and the impact of drawdown;
10. possible effects of landslides and subsurface solution activity on the structural stability of the dam and spillway structures; and
11. the extent of of the proposed use of piezometers and other devices which will be used to monitor the completed dam and the means of access for inspections.

(b) Slope stability analysis shall be considered by the design engineer for all embankment dams and are required for high hazard potential dams. Where slope stability analysis is required documentation in the final design report, such analysis shall include the design cross section(s) showing the soil parameters assumed for analysis, the location of the phreatic surface assumed for analysis, stability computations, and the location and computed safety factor(s) for the most critical circle(s) or failure wedge(s).

(c) Minimum factors of safety are listed in the following table. Final accepted factors of safety may depend upon the degree of confidence in the engineering data available. In selecting a minimum acceptable factor of safety, an evaluation should be made on both the degree of conservatism with which assumptions were made in choosing soil strength parameters and pore water pressures, and the influence of the method of analysis which is used.

1. 302 CMR 10.14(8)(c) shall not be applicable to embankments on clay shale foundations, soft sensitive clays, or materials with large strength loss under stresses.
2. For embankments over 50 ft. high on relatively weak foundations, a minimum factor of safety of 1.4 shall be used.

10.14: continued

SLOPE STABILITY ANALYSIS
MINIMUM FACTORS OF SAFETY

Loading Condition	Minimum Factor of Safety Analyzed	Slope to be
End of construction condition	1.3	upstream and downstream
Sudden drawdown from maximum pool	>1.1*	upstream
Sudden drawdown from spillway crest or top of gates	1.2	upstream
Steady seepage with maximum storage pool	1.5	upstream and downstream
Steady seepage with surcharge pool	1.4	downstream
Earthquake (for steady seepage conditions with seismic loading using seismic coefficient method)	>1.0	upstream and downstream

(d) Foundation bearing capacity and sliding base analysis shall be considered for all dams and are required for high hazard dams. Where bearing capacity or sliding base analysis is required, documentation of assumptions, computations, and safety factors shall be included in the final design report.

(e) Resistance of appurtenant structures against flotation uplift shall be provided for all dams. If the structures are anchored by dead weight alone, the buoyant weight shall be used for analysis. If the structures are anchored to soil or rock, the minimum factor of safety for that portion of the resistance provided by soil or rock anchorage shall be 2.0 unless the design engineer provides a thoroughly documented basis for using a lower safety factor.

(f) For concrete, masonry, or other similar dams of relatively narrow cross section, resistance against overturning and sliding under maximum design loading conditions shall be considered; overturning and sliding stability computations shall be required for significant and high hazard dams.

(g) The anticipated reservoir and tailwater drawdown conditions shall be considered in all stability computations and shall be included in the design documents provided in the final design report.

(h) The slopes shall be protected against erosion by wave action, and the crest and downstream slope shall be protected against erosion due to wind and rain. Riprap and other erosion protection shall be provided over the full range in stage between the lowest drawdown elevation and at least two feet above maximum water storage elevation. Exemptions for specific site conditions, slowly rising reservoirs, such as waste storage facilities, may be approved in writing by the Commissioner upon written request by the Applicant.

(i) All significant and high hazard potential dams shall be designed to withstand seismic accelerations of the following intensities: Zone 1 = 0.025 g., Zone 2 = 0.05 g., Zone 3 = 0.15 g. Zones refer to "Geologic Hazard Maps".

(j) Loading Combinations. The following conditions and requirements are suitable in general for gravity dams of intermediate size. Loads which are not indicated such as wave action, or any unusual loadings should be considered where applicable.

*The factor of safety shall not be less than 1.5 when drawdown rate and pore water pressures developed from flow nets are used in the stability analyses and where rapid drawdown is a normal operating condition as with pumped storage reservoir.

10.14: continued

Case I: Usual Loading Combination--Normal Operating Condition The reservoir elevation is at the normal pool, as governed by the crest elevation of an overflow structure or the top of the closed spillway gates, whichever is greater. Normal tailwater is used. If applicable, horizontal silt pressure should be also be considered.

Case II: Unusual Loading Combination--Flood Discharge The projected inflow design flood up to and including the Probable Maximum Flood, if appropriate, that results in reservoir and tailwater elevations that exert the greatest head differential and uplift pressure upon the structure shall be used. However, unusual conditions, such as high tailwater, shall be examined on a case by case basis as it is possible that the worst case loading condition exists under other than extreme floods.

Case IIA: Unusual Loading Combination--Ice Case I loading plus ice pressure, if applicable. Generally ice pressure will not be a factor in the stability analyses, but may affect the operation, or structural integrity of flashboards and spillway gates.

Case III: Extreme Loading Combination--Normal Operating with Earthquake Case I loading except that the inertial force due to the earthquake acceleration of the dam, and the increased hydrostatic forces due to the reservoir reaction on the dam are added.

(k) Stability Criteria. Specific stability criteria for a particular loading combination shall be dependent upon the type of analysis being done (i.e. foundation or concrete analysis), the degree of understanding of the foundation-structure interaction and site geology, and, to some extent, on the method of analysis.

1. For new dams, preliminary analyses shall be based upon more conservative criteria than final designs. As the design process progresses the designer has available more sophisticated, and detailed, foundation information and material testing results. Therefore, when the unknowns associated with the preliminary designs are reduced by the final design stage, lower safety factors may be acceptable.
2. For existing dams, assumptions used in the analysis shall be based upon construction records and the performance of the structures under historical flood loadings. In the absence of available design data and records, site investigations shall be conducted to verify all assumptions.
3. Recommended safety factors shall apply to the calculations of stress and the shear-friction factor of safety within the structure, at the rock/concrete interface and in the foundation. Safety factors shall be determined using the gravity method of analysis.

RECOMMENDED FACTORS OF SAFETY Dams having a high or significant hazard potential.	
Loading Condition	Factor of Safety
Usual Unusual Extreme	3.0 2.0 >1.0

Dams having a low hazard potential.

Loading Condition	Factor of Safety
Usual Unusual Extreme	20 1.25 >1.0

(10) Design Life of a Dam. The selection of materials and equipment to be used in a dam and all of its appurtenant features shall either be based on sufficient quality and durability to function satisfactorily throughout the design life or to provide for safe and economical replacement within the design life span.

10.14: continued

The design life of a dam shall be the period of time the dam can be expected to perform effectively as planned. The design life of a dam shall be determined by the following:

(a) the time required to fill the reservoir with sediment from the contributing watershed;
(b) the durability of appurtenances and materials used to construct the dam; and
(c) the time required to perform the specific function for which the dam was designed.

(11) Additional Design Requirements.

(a) All elements of the dam shall conform to good and generally accepted engineering practice. The safety factors, design standards, and design references that are used shall be included in the final design report.

(b) Monitoring or inspection devices may be required by the Commissioner for use by the inspectors or owners during construction and filling and after completion of construction. The Commissioner may also require that such monitoring or inspection devices, existing or installed by requirement, be read and documented at specified intervals and that copies of such be forwarded to his office.

(12) Construction Schedule. The applicant shall submit a construction schedule that includes:

a) suggested techniques and work force to be used to demonstrate that the dam will be constructed according to the plans and specifications;
(b) an estimated time to complete the construction activities;
(c) techniques to be used to divert the stream flow to prevent interference with construction; and
(d) the extent and method of quality control.

(13) Proposed Changes In Design. The owner shall notify the Commissioner in writing of any proposed changes in design, plans, and specifications that will affect the stability of the dam. Approval shall be in the form of a written addendum to the Chapter 253 Permit and must be obtained prior to installation.

(14) As-built Plans. Two complete sets of as-built plans shall be submitted to the Commissioner within 30 days of completion of the project.

(15) Engineer's Certification. The registered professional civil engineer who has inspected the construction of the dam, shall submit a written statement bearing his/her professional seal that the dam and all appurtenances have been built, repaired, altered, or removed in conformance with the plans, specifications, and drawings approved by the Commissioner and that the dam is in compliance with 302 CMR 10.00. For repairs accomplished, the certification shall be for the repairs only.

(16) Acceptable Design: Procedures and Technical References. The following represent acceptable design procedures and references:

(a) the design procedures, manuals and criteria used by the United States Corps of Engineers;
(b) the procedures, manuals, and criteria used by the United States Soil Conservation Service;
(c) the procedures, manuals, and criteria used by the United States Bureau of Reclamation; and
(d) other procedures that are approved by the Commissioner.

(17) Granting of Final Approval. Unless the Commissioner has reason to believe that the dam, on completion, is unsafe or not in compliance with any applicable requirement, regulation, or law, or of any condition or specification contained within the Permit, upon completion of construction and upon receipt of the engineer's statement, the Commissioner shall grant final approval of the work and shall issue a Certificate of Compliance, subject to such terms as he deems necessary for the protection of life and property.

E.21. Michigan





DEPARTMENT OF ENVIRONMENTAL QUALITY

LAND AND WATER MANAGEMENT

DAM SAFETY

(By authority conferred on the department of natural resources by section 57 of Act No. 300 of the Public Acts of 1989, being S281.1357 of the Michigan Compiled Laws)

R 281.1301 Definitions.

Rule 1. (1) As used in these rules, "Act" means Act No. 300 of the Public Acts of 1989, being S281.1301 et seq. of the Michigan Compiled Laws.

(2) Terms defined in the act have the same meanings when used in these rules.

History: 1993 AACS.

R 281.1302 Permit applications and procedures.

Rule 2. (1) An application for a permit for a proposed project shall be made on a form that is prescribed and provided by the department. The application form shall be the same form that is used for other department-administered statutes that require permits at the land-water interface. Application forms may be obtained from the land and water management division or from any district or regional office of the department.

(2) An application fee for a permit to repair, alter, remove, or abandon a dam shall be submitted with the application form. Submission of an application fee for a permit to construct, reconstruct, or enlarge a dam may be deferred until plans and specifications are submitted. The fee for enlargement of a dam that is part of a mine tailings basin system shall be based on the height of the new embankment section as measured by the vertical distance from the lowest point of the embankment crest to the lowest tailings foundation elevation. The fee shall be paid by check, money order, or draft made payable to: "State of Michigan".

(3) When the proposed project includes related multiple impoundments, an applicant may apply for a single permit, but an appropriate fee shall be required for each impoundment.

(4) An application for a permit to construct a new dam, enlarge an existing dam, or reconstruct a failed dam shall be reviewed by the department in a 2-step process. The first step shall be a review of the conceptual plans to determine if the proposed project may have a significant adverse effect on public health, safety, welfare, property, or natural resources or the public trust in those natural resources. The second step shall be the review of plans and specifications to determine if the engineering design is acceptable.

(5) An application for a permit to construct a new dam, enlarge an existing dam, or reconstruct a failed dam shall include all of the following:

(a) A description and evaluation of the loss of natural resources that are associated with the project.

(b) A description of the natural resources that are associated with or created by the impoundment and how they offset the natural resources lost by the creation of the impoundment.

(c) The project assessment required pursuant to the provisions of R 281.1304. However, an assessment is not required for a permit to enlarge an

existing dam when the purpose of the impoundment will remain the same as the original impoundment and the surface area of the impoundment will be increased by 10% or less.

(d) Conceptual plans that are adequate to evaluate the project's impacts on public health, safety, welfare, property, or natural resources or the public trust in those natural resources. Conceptual plans shall include, at a minimum, all of the following:

(i) A site plan that shows all of the following:

(A) The location of the dam.

(B) The existing stream channel.

(C) The normal shoreline of the proposed impoundment.

(D) Property lines.

(E) Dimensions or proper scale.

(ii) Transverse and longitudinal cross-sections through the dam that show all of the following:

(A) The spillway or spillways.

(B) Upstream and downstream water levels.

(C) The stream channel bottom.

(iii) The location of all occupied dwellings within 1/4 of a mile of the proposed impoundment if the dam is new or if the impoundment elevation is changed. Projects that do not propose an impoundment elevation change are excluded from this requirement.

(iv) Ingress and egress routes for construction activities.

(6) The first step of the review shall commence once the department has received all of the following:

(a) The application form with all necessary information filled in.

(b) All additional information requested by the department that is required to evaluate the proposed activity's effects on the public health, safety, welfare, property, or natural resources or the public trust in those natural resources. Requests by the department for additional information shall be made in writing.

(c) All appropriate application fees, except as noted in subrule (2) of this rule.

(d) The assessment described in R 281.1304 when required pursuant to the provisions of subrules (5) and (7) of this rule.

(e) Conceptual plans for the project as described in this subrule and subrules (5), (7),and (8) of this rule.

Engineering plans and specifications are not required for the department to complete the first step of the review.

(7) An application for a permit to abandon or remove a dam shall include all of the following:

(a) A site plan that shows all of the following:

(i) The location of the dam.

(ii) The impoundment.

(iii) The existing stream channel.

(iv) The proposed location of the stream channel.

(b) A description of the method to be employed in removing or abandoning the dam.

(c) An evaluation of the capacity of the remaining structure to pass flood flows after the proposed work is completed, including hydraulic computations to support the evaluation.

(d) An evaluation of the quantity and quality characteristics of the sediments that have accumulated in the dam impoundment.

(e) A description of the methods to be employed to control sediments during and after removing or abandoning the dam.

(f) The project assessment required pursuant to the provisions of R 281.1304.

(8) An application for a permit to repair or alter a dam shall include both of the following:

(a) A description of the proposed work, including the volumes of materials to be dredged or filled.

(b) Engineering plans and specifications for the proposed work.

(9) After receipt of an application, the department may request, in writing, from the applicant, such additional information, assessment, design calculations, records, or documents as are determined to be necessary to evaluate the proposed project.

(10) Based in part on the information provided by the applicant and in part on comments received by the department during the 20-day comment period as provided by section 23 of the act, the department shall conduct the first step of the review to determine the effects of the proposed project on public health, safety, welfare, property, or natural resources or the public trust in those natural resources and riparian rights. The department shall make 1 of the following determinations:

(a) The proposed activity is permitable as submitted.

(b) The proposed activity is permitable if certain described modifications are made.

(c) The proposed activity is not permitable and cannot be modified to result in the granting of a permit.

(11) An application for a permit shall not be considered complete until the assessment required in R 281.1304 has been completed and the department has received all of the following:

(a) All information that is requested on the application form.

(b) Any other information that is required by written notice from the department.

(c) The application fee, unless the fee is deferrable pursuant to the provisions of subrule (2) of this rule.

(d) Acceptable conceptual plans and specifications.

The department shall grant or deny a permit within 60 days after the submission of a complete application or within 120 days after the submission of a complete application if a public hearing is held.

(12) An application shall be considered to be withdrawn and the file for the application shall be closed if an applicant fails to respond to any written inquiry or request from the department within 30 days of the request. If the applicant cannot provide the specific information that the department requests within the 30-day period, the applicant may keep the application open by advising the department, in writing, within the 30-day period, of when the information can be submitted. The applicant's proposed deadline shall be reasonable. If the information is not provided by the applicant's deadline, the application shall then be closed.

(13) The department shall advise an applicant of its determination. If an activity is permitable as submitted or is permitable if modified, the department shall then review engineering plans and specifications. If the department has not yet received required application fees or engineering plans and specifications, the department shall request the fees or plans and specifications at the time an applicant is advised of the department's determination.

(14) When the department determines that engineering plans and specifications are acceptable, a permit shall be issued or, if a permit has already been issued, the applicant shall be notified, in writing, that plans and specifications are acceptable and the project may commence. If the engineering plans and specifications are determined to be unacceptable, the department shall advise the applicant of why the plans and specifications are unacceptable and provide a concise written statement explaining how the plans and specifications may be corrected.

History: 1993 AACS.

R 281.1303 Permit conditions.

Rule 3. (1) A permit shall provide that the work authorized by the permit shall be completed within a specified time period, which shall not be more than 2 years after the date that the permit is issued. Extensions of time of up to 2 years each may be granted by the department for good cause shown by the applicant. An administrative fee shall not be required for an application for extensions of time.

(2) A permit does not obviate the necessity of receiving approval from the United States army corps of engineers, when applicable, the state department of public health, or a local unit of government, when applicable, including a local unit of government that is responsible for administering the provisions of Act No. 245 of the Public Acts of 1970, as amended, being S281.631 et seq. of the Michigan Compiled Laws, and Act No. 347 of the Public Acts of 1972, as amended, being S282.101 et seq. of the

Michigan Compiled Laws.

(3) The department shall not issue a permit, except for a permit pursuant to the provisions of section 25(2) of the act or a permit under a minor project category, until 20 days after the mailing of the list to each eligible subscriber as provided for in sections 21(1) to (3) and 23(1) of the act.

(4) Upon request, the department shall provide any person with a copy of a permit application and supporting documents pursuant to the provisions of Act No. 442 of the Public Acts of 1976, as amended, being S15.231 et seq. of the Michigan Compiled Laws.

(5) If the mitigation proposed in a mitigation plan that is submitted by an applicant is approved by the department, the department may incorporate the mitigation actions as permit conditions for the improvement of the existing resources or the creation of a new resource to offset resource losses that result from the proposed project.

(6) A temporary emergency action plan may be required by permit condition which would be effective during, and applicable to, the construction period.

History: 1993 AACS.

R 281.1304 Project assessment.

Rule 4. (1) In each application for a permit as required pursuant to the provisions of R 281.1302, (5) and (7), an assessment of all known existing and potential adverse effects within the scope of the project shall be provided by the applicant and reviewed by the department to determine whether the project will have a significant adverse effect on public health, safety, welfare, property, or natural resources or the public trust in those resources. This assessment shall include evaluations of both positive and negative impacts of the project commensurate with the scope of the project and mitigating measures to minimize impacts on all of the following:

(a) Wetlands.
(b) Fisheries.
(c) Wildlife.
(d) Threatened and endangered species.
(e) Water quality.
(f) Streamflows.
(g) Sediment transport.
(h) Turbidity.
(i) Water chemistry.
(j) Water temperature.
(k) Riparian rights.

The assessment shall include impacts of the impoundment on the stream below the impoundment and shall address impacts both during construction and after completion of the project.

(2) If the department determines that more detailed study is needed, it may require the applicant to provide the additional information or cause such a study to be made. The department shall state, with specificity, in writing, the requirements or criteria for such additional information or study. All available data shall be evaluated by the department in its review of an application for a permit.

History: 1993 AACS.

R 281.1305 Engineering plans and specifications.

Rule 5. (1) Engineering plans and specifications for the construction of new dams, the reconstruction of failed dams, or the enlargement of dams shall be prepared by a licensed professional engineer, be submitted to the department, be approved by the department before the commencement of construction, and include, at a minimum, all of the following:

(a) A map that shows the location of the project and a topographic map of the dam site and impoundment area. Mapping shall show all of the following:

(i) Maximum flood storage elevations of the impoundment.
(ii) Property boundaries of the site, including flowage easements.
(iii) Borrow area or areas.
(iv) Ingress and egress routes.
(v) Work limits.
(b) Detailed design plans that show all of the following:
(i) A profile along the centerline of the embankment and the spillway or spillways.
(ii) Cross-sections of the dam at representative locations that show suitable detail of the upstream and downstream slopes and crest.
(iii) The findings of investigations and analyses of embankment and foundation materials, including the locations of soil borings, soil boring logs, and proposed foundation treatment.
(iv) Other drawings that are necessary to fully depict the project as determined by the department upon consultation with the applicant.
(v) Other analyses that are necessary to document the adequacy of the design of the structure and protection of natural resources, public safety, and public trust as determined by the department upon consultation with the applicant.
(c) An operation plan that describes how the streamflows will be maintained under various conditions.
(d) Technical specifications related to the scope of work for the dam and appurtenant structures. Specifications shall reference nationally recognized and acceptable engineering specifications.
(2) Engineering plans and specifications for the repair, alteration, removal, or abandonment of a dam, with the exception of minor alteration or repair projects, shall be prepared by a licensed professional engineer, be submitted to the department, and be approved by the department before commencement of construction. Plans and specifications for repair and alteration shall include sufficient detail and analyses for the department to determine whether the proposed activity adequately protects the structural integrity of the dam. Plans and specifications for removal and abandonment of a dam shall include sufficient detail and analyses for the department to determine whether the proposed activity adequately protects natural resources, public safety, and the public trust.
(3) The hazard potential classification and spillway design flood determination of a dam site shall be determined by the department. The department may require the applicant to provide additional information for the department's use in these determinations. Spillway capacity requirements are fulfilled if the specified design flood is stored in the impoundment, attenuated in the impoundment system, or passed through the spillway.
(4) When mitigation for the loss of natural resources is required for a proposed activity, plans and specifications for the mitigation may be required.

History: 1993 AACS.

R 281.1306 Minor project categories.
Rule 6. (1) The department shall grant or deny an application for a minor project after all of the following steps have been completed:
(a) Submission of a complete application.
(b) An on-site inspection by a department representative.
(c) A review of all appropriate information by the department.
(2) A review of a minor project does not require any of the following:
(a) Submission of the application materials by the department to any of the individuals or agencies listed in section 23(1) of the act.
(b) A 20-day comment period as provided for in section 23 of the act.
(c) A public hearing.
(3) Required plans and specifications for a minor project do not need to be prepared by a licensed professional engineer.
(4) The following alterations and repairs shall be considered minor projects pursuant to section 27 of the act if the activity involves a temporary drawdown of 2 feet or less or involves a temporary drawdown where the dam owner is the sole riparian to the lands surrounding the

impoundment:
(a) Dredging or filling of more than 25 cubic yards, but less than 300 cubic yards, as a single and complete project. For dredging projects, the project will not be considered minor unless evidence is provided with the application that the materials to be dredged are not contaminated pursuant to the provisions of Act No. 64 of the Public Acts of 1979, as amended, being S299.501 et seq. of the Michigan Compiled Laws.
(b) Erosion protection measures that fulfill an identifiable need for erosion protection, bank stabilization, or the protection or improvement of the dam and its inlet and outlet channels. The fill material that is associated with erosion protection measures shall be in compliance with any of the following provisions:
(i) It shall have a volume of more than 25 cubic yards, but shall not have a volume of more than 300 cubic yards.
(ii) It shall not have a surface area of more than 10,000 square feet.
(iii) There shall not be more than 2 cubic yards per lineal foot.
(c) Other repairs and alterations that have a minimal effect on the structural integrity of the dam.
(5) Dredging or filling in volumes of less than 25 cubic yards shall be considered maintenance and does not require a permit pursuant to the provisions of the act.

History: 1993 AACS.

R 281.1307 Performance bonds.
Rule 7. (1) As authorized by the provisions of section 31(5) of the act, a permit to construct a new dam or reconstruct a failed dam may require a performance bond. A performance bond may be in the form of any of the following:
(a) A surety bond.
(b) A secured trust fund.
(c) A letter of credit.
(d) Insurance.
(e) A financial test.
(f) A corporate guarantee.
(g) Another suitable instrument or mechanism.
(h) A combination of the items listed in subdivisions (a) to (g) of this subrule as approved by the department.
The department shall consider an applicant's past performance in determining if a performance bond shall be required.
(2) The performance bond shall be secured and documentation shall be submitted to the department before the commencement of construction. The bond, instrument, mechanism, or fund or combination of these methods of assurance shall be in the amount equal to a reasonable estimate of the cost, adjusted for inflation, that is required to adequately complete a project or remove a completed or partially completed dam and to provide for complete or partial restoration of a project site. Performance bonds may be required in the following instances if there is a reasonable possibility that the permittee may not complete the project:
(a) Where total project completion is essential for the protection of public health, welfare, or safety or to protect natural resources and the public trust in those natural resources.
(b) For temporary dams or dams that are constructed or reconstructed for a specific purpose and period of time after which removal is planned.
(c) For phased construction projects where dam construction or reconstruction is an integral and necessary part of the total project and is to be phased in over a number of years.
(d) Projects to be constructed in the future to mitigate the loss of natural resources or environmental degradation.

History: 1993 AACS.

R 281.1308 Project completion explained.
Rule 8. Pursuant to the provisions of section 35(1)(a) of the act,

completion of a new, reconstructed, enlarged, repaired, or altered dam occurs when all the work depicted on all approved drawings and all specification requirements have been accomplished and all permit conditions have been implemented before the expiration of a permit.

History: 1993 AACS.

R 281.1309 Inspection schedule.

Rule 9. Inspection reports that are prepared pursuant to the provisions of R 281.1310 are due on a calendar year basis. The department shall notify the dam owner of the due date, by certified mail, not later than January 31 of the year in which the inspection report is due. In establishing an inspection schedule, as authorized pursuant to the provisions of section 37(2) of the act, the department shall compile an alphabetical listing of dams in each hazard potential classification of high, significant, and low. The inspection schedule shall be established based on the following provisions:

(a) For high hazard potential dams, every third dam in the alphabetical listing of these dams shall be inspected each year as follows:

(i) The first, fourth, seventh, tenth, and so on dam in the alphabetical listing will be due for inspection the first year.

(ii) The second, fifth, eighth, eleventh, and so on dam in the alphabetical listing will be due for inspection the second year.

(iii) The third, sixth, ninth, twelfth, and so on dam in the alphabetical listing will be due for inspection the third year.

(iv) The cycle shall be repeated every 3 years.

(b) For significant hazard potential dams, every fourth dam in the alphabetical listing of these dams shall be inspected each year as follows:

(i) The first, fifth, ninth, thirteenth, and so on dam in the alphabetical listing shall be due for inspection the first year.

(ii) The second, sixth, tenth, fourteenth, and so on dam in the alphabetical listing shall be due for inspection the second year.

(iii) The third, seventh, eleventh, fifteenth, and so on dam in the alphabetical listing shall be due for inspection the third year.

(iv) The fourth, eighth, twelfth, sixteenth, and so on dam in the alphabetical listing shall be due for inspection the fourth year.

(v) The cycle shall be repeated every 4 years.

(c) For low hazard potential dams, every fifth dam in the alphabetical listing of these dams shall be inspected each year as follows:

(i) The first, sixth, eleventh, sixteenth, and so on dam in the alphabetical listing shall be due for inspection the first year.

(ii) The second, seventh, twelfth, seventeenth, and so on dam in the alphabetical listing shall be due for inspection the second year.

(iii) The third, eighth, thirteenth, eighteenth, and so on dam in the alphabetical listing shall be due for inspection the third year.

(iv) The fourth, ninth, fourteenth, nineteenth, and so on dam in the alphabetical listing shall be due for inspection the fourth year.

(v) The fifth, tenth, fifteenth, twentieth, and so on dam in the alphabetical listing shall be due for inspection the fifth year.

(vi) The cycle shall be repeated every 5 years.

(d) Depending on its hazard potential classification, a new, reconstructed, or enlarged dam shall be scheduled for inspection 3, 4, or 5 years after the date of written notice of final project approval as required pursuant to the provisions of section 35(2) of the act or 3, 4, or 5 years after the expiration date of the permit if final approval cannot be granted. The cycle shall be repeated every 3, 4, or 5 years according to the dam's hazard potential classification.

(e) If the hazard potential classification of a dam changes, its next inspection shall be scheduled based on the date of its previous inspection and the cycle of inspections required for the new hazard potential rating.

(f) If an existing dam is discovered that falls under the authority of the act, it shall be added to the end of the appropriate alphabetical listing, and its first inspection shall be scheduled based on the system described in subdivisions (a) to (c) of this rule. If the department

determines that a condition may exist that endangers the dam, an inspection shall be required immediately.

(g) The department may alter the inspection schedule in consideration of the dates of recent inspections and department-permitted and approved repairs and alterations.

(h) Owners of more than 1 dam may request that the department schedule their inspection reports to be due the same year if the dams have the same hazard potential classification.

History: 1993 AACS.

R 281.1310 Inspection reports.

Rule 10. (1) Inspection reports shall include all of the information required in section 37(3) of the act.

(2) An inspection report shall include all of the following parts:

(a) A title sheet that includes all of the following information:

(i) The name of the dam.

(ii) The inventory identification number.

(iii) The county and river or stream where the dam is located.

(iv) The owner's and operator's names, addresses, and telephone numbers.

(v) The hazard potential classification.

(vi) The names of inspectors.

(vii) The date of inspection.

(viii) The name, address, registration number, and signature of the licensed professional engineer who is in charge of the inspection report.

(b) A conclusions and recommendations section that includes all of the following information:

(i) An evaluation of the dam's overall condition and a summary of the findings of the field inspection and analyses contained in the report.

(ii) Identification of any deficiencies that, if left uncorrected, could lead to the failure of the dam.

(iii) Prioritization of recommendations to correct observed deficiencies or operation and maintenance items for the dam.

(iv) Recommendations for further detailed studies or investigations, including an assessment of the adequacy of the current hazard potential classification if appropriate.

(c) A project information section that includes all of the following information:

(i) A description of the dam, outlet, spillway, and other principal features, together with pertinent data.

(ii) The purpose of the dam.

(iii) A summary of available design, geotechnical, maintenance, construction, repair, and alteration information and operating history.

(iv) A reference to past inspection reports.

(v) The date of construction, if known.

(d) A field inspection section that briefly describes the physical condition of the principal features of the dam and appurtenant structures, including the impoundment level, as they were observed during the field inspection.

(e) A structural stability section that includes a visual assessment of the stability of the dam on the basis of available data, together with the observations of the field inspection and the results of any calculations performed.

(f) A hydrologic and hydraulic section that includes an evaluation of spillway adequacy, including a description of pertinent available information, such as any of the following:

(i) Hydrologic design data provided by the department.

(ii) Drainage area.

(iii) Floods of record.

(iv) Previous evaluations.

(g) An operation and maintenance section that includes all of the following:

(i) An assessment of operating equipment and procedures.

(ii) Evaluation of the current maintenance plan.

(h) Appendices that include all of the following:

(i) A map that shows the location of the dam.
(ii) Engineering plans of the dam, if available, or sketches of the dam and its principal parts, including a plan view and cross sectional views of pertinent features. If there have been changes to the dam since the submittal of previous plans or sketches, supplemental plans or sketches that depict the changes shall be submitted. If engineering plans or sketches have been submitted in a previous inspection report and if there have been no changes to the dam, it is not necessary to submit duplicate plans or sketches in subsequent reports.
(iii) Photographs of the dam, downstream channel, and deficiencies cited in the report.

History: 1993 AACS.

R 281.1311 Emergency action plans.
Rule 11. (1) An emergency action plan for a high or significant hazard potential dam shall be submitted to the county or local emergency management coordinator for review for consistency with county or local emergency operations plans and the Michigan emergency preparedness plan.
An emergency action plan for an existing dam shall be submitted to the department with documentation that the plan has been submitted to the county or local emergency management coordinator not later than the time that the first inspection report for the dam is due or at another time agreed to by the department. An emergency action plan for a newly constructed dam shall be submitted to the department with documentation that the plan has been submitted to the county or local emergency management coordinator not later than the date of expiration of the permit for construction of the dam, including any extensions of time for completion.
(2) At the time subsequent inspection reports are due, the owner shall determine if the plan is up to date. The owner shall advise the department of the findings of this review and shall submit any revisions to the department and to the county or local emergency management coordinator.
(3) The emergency action plan shall include a description of the circumstances under which it shall be activated, what actions shall be taken, and who shall be responsible to take those actions when the plan is activated.
(4) The emergency action plan shall include the name, address, and telephone number of all of the following entities:
(a) The person who is responsible for the operation of the dam.
(b) The alternate person who is responsible for the operation of the dam.
(c) The local emergency management coordinator or coordinators.
(5) The emergency action plan shall include either of the following:
(a) A listing of occupied facilities, buildings, and residences that may be threatened with flooding due to the failure of the dam.
(b) Mapping that is adequate to clearly delineate the areas of potential inundation resulting from a failure of the dam.
The degree of detail for mapping or listings shall be determined through consultations between the dam owner and the appropriate emergency services agencies that are responsible for implementing the emergency action plan.

History: 1993 AACS.

R 281.1312 Administrative monetary penalties.
Rule 12. (1) As authorized pursuant to the provisions of section 51(8) of the act, an administrative penalty of not more than $500.00 per day may be assessed to a person as set forth in the schedule in subrule (2) of this rule for any of the following reasons:
(a) Violation of any or all of the conditions of a minor project permit that is issued pursuant to the provisions of section 27 of the act.
(b) Failure to submit an inspection report as required pursuant to the provisions of section 37 of the act.
(c) Failure to provide a more detailed investigation or evaluation of

certain dam features as required by section 37(5) of the act.

(d) Failure to comply with a first department order to limit dam operations as authorized pursuant to the provisions of section 39(1) of the act where significant impairment of resources has not resulted.

(e) Failure to notify the department and affected off-site public authorities and safety agencies, pursuant to the provisions of section 41(1) of the act, of any flood or unusual circumstance or occurrence, within 24 hours of the circumstance or occurrence, that endangers the safety of a dam, but where significant damage to property or natural resources does not occur.

(f) Failure to notify the department of actions taken in response to emergency conditions pursuant to the provisions of section 41(2) of the act.

(g) Failure to comply with the provisions of an emergency order that relates to any of the following as authorized pursuant to the provisions of section 43(2) of the act:

(i) Maximum drawdown levels and discharge rates.

(ii) Conducting required sediment surveys, water quality sampling, or monitoring.

(iii) Any other requirement where significant impairment of resources has not resulted.

(h) Failure to prepare, keep current, and submit to the department an emergency action plan as required pursuant to the provisions of section 47 of the act.

(i) Failure to comply with a first order to comply with permit conditions or to restore the site affected to its original condition pursuant to the provisions of section 49(1) of the act.

(j) Violation of any of the following permit conditions:

(i) Failure to supply data or information.

(ii) Failure to provide required minimum flow releases where significant impairment of resources has not resulted.

(iii) Violation of any permit condition where significant impairment of resources has not occurred.

Each violation and act of noncompliance and each day such a violation or act occurs or continues to occur will be considered a separate violation.

(2) The following administrative penalty schedule shall apply for noncompliance or violations as set forth in subrule (1) of this rule:

(a) First through the fifth day the violation occurs - not more than $100.00 per day.

(b) Sixth through the tenth day the violation occurs - not more than $200.00 per day.

(c) Eleventh through the fifteenth day the violation occurs - not more than $300.00 per day.

(d) Sixteenth through the twentieth day the violation occurs - not more than $400.00 per day.

(e) Twenty-first day until the violation is resolved - not more than $500.00 per day.

(3) All administrative penalties will be assessed by written notice from the department. The notice shall state the specific reasons for the penalty, the number of days the department considers the person in violation, and the total amount due based on the schedule in subrule (2) of this rule.

(4) If so requested, the department shall provide a person, subject to the administrative penalty provisions of section 51(8) of the act, an opportunity for a hearing pursuant to the provisions of Act No. 306 of the Public Acts of 1969, as amended, being S24.201 et seq. of the Michigan Compiled Laws.

(5) Notice of intent to assess administrative penalties pursuant to section 51(8) of the act shall be given either through written notice by certified mail or personal service on the person by the director, his or her designated representative, or a peace officer.

(6) Penalties that are administered pursuant to the provisions of section 51(8) of the act may be in addition to any other penalties or remedies authorized by the act or its rules.

History: 1993 AACS.

R 281.1313 Dams exempt from rules.

Rule 13. A dam is exempt from these rules if it is exempt from the act pursuant to the provisions of section 13(2) and (3) of the act.

History: 1993 AACS.

Michigan.gov Home | DELEG | Contact | State Web Sites | Site Map
Privacy Policy | Link Policy | Accessibility Policy | Security Policy
Copyright © 2001-2010 State of Michigan

NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION ACT (EXCERPT)
Act 451 of 1994

PART 315
DAM SAFETY

324.31501 Meanings of words and phrases.

Sec. 31501. For purposes of this part, the words and phrases defined in sections 31502 to 31505 have the meanings ascribed to them in those sections.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31502 Definitions; A to D.

Sec. 31502. (1) "Abandonment" means an affirmative act on the part of an owner to discontinue maintenance or operation of a dam.

(2) "Administrative procedures act of 1969" means Act No. 306 of the Public Acts of 1969, being sections 24.201 to 24.328 of the Michigan Compiled Laws.

(3) "Alteration" means a change in the design of an existing dam that directly affects or may directly affect the structural integrity of a dam.

(4) "Appurtenant works" means the structure or machinery incident to or annexed to a dam that is built to operate and maintain a dam, including spillways, either in a dam or separate from the dam; low level outlet works; and water conduits such as tunnels, pipelines, or penstocks, located either through the dam or through the abutments of the dam.

(5) "Auxiliary spillway" means a secondary spillway which is operational at all times and does not require stoplog removal or gate manipulation.

(6) "Dam" means an artificial barrier, including dikes, embankments, and appurtenant works, that impounds, diverts, or is designed to impound or divert water or a combination of water and any other liquid or material in the water; that is or will be when complete 6 feet or more in height; and that has or will have an impounding capacity at design flood elevation of 5 surface acres or more. Dam does not include a storage or processing tank or standpipe constructed of steel or concrete, a roadway embankment not designed to impound water, or a dug pond where there is no impoundment of water or waste materials containing water at levels above adjacent natural grade levels.

(7) "Days" means calendar days, including Sundays and holidays.

(8) "Design flood" means the design flow rate for spillway capacity and dam height design.

(9) "Design flood elevation" means the maximum flood elevation that is considered in the design of the spillway capacity and freeboard for a dam.

(10) "Downstream toe elevation" means the elevation of the lowest point of intersection between the downstream slope of an earthen embankment and the natural ground.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31503 Definitions; E to H.

Sec. 31503. (1) "Emergency action plan" means a plan developed by the owner that establishes procedures for notification of the department, public off-site authorities, and other agencies of the emergency actions to be taken prior to and following an impending or actual failure of a dam.

(2) "Enlargement" means any change in or addition to an existing dam which raises or may raise the design flood elevation of the water impounded by the dam.

(3) "Failed dam" means a dam not capable of impounding water at its intended level due to a structural deficiency.

(4) "Failure" means an incident resulting in an unplanned or uncontrolled release of water from a dam.

(5) "Flood of record" means the greatest flow rate determined by the department to have occurred at a particular location.

(6) "Freeboard" means the vertical distance between the design flood elevation and the lowest point of the top of the dam.

(7) "Half probable maximum flood" means the largest flood that may reasonably occur over a watershed, and is derived from the combination of hydrologic runoff parameters and the half probable maximum storm

© Legislative Council, State of Michigan Courtesy of www.legislature.mi.gov

that produces the maximum runoff.

(8) "Half probable maximum storm" means the spatial and temporal distribution of the probable maximum precipitation, divided by 2, that produces the maximum volume of precipitation over a watershed.

(9) "Hazard potential classification" means a reference to the potential for loss of life, property damage, and environmental damage in the area downstream of a dam in the event of failure of the dam or appurtenant works.

(10) "Height" means the difference in elevation measured vertically between the natural bed of a stream or watercourse at the downstream toe of the dam, or, if it is not across a stream channel or watercourse, from the lowest elevation of the downstream toe of the dam, to the design flood elevation or to the lowest point of the top of the dam, whichever is less.

(11) "High hazard potential dam" means a dam located in an area where a failure may cause serious damage to inhabited homes, agricultural buildings, campgrounds, recreational facilities, industrial or commercial buildings, public utilities, main highways, or class I carrier railroads, or where environmental degradation would be significant, or where danger to individuals exists with the potential for loss of life.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31504 Definitions; I to P.

Sec. 31504. (1) "Impoundment" means the water held back by a dam.

(2) "Low hazard potential dam" means a dam located in an area where failure may cause damage limited to agriculture, uninhabited buildings, structures, or township or county roads, where environmental degradation would be minimal, and where danger to individuals is slight or nonexistent.

(3) "Maintenance" means the upkeep of a dam and its appurtenant works but does not include alterations or repairs.

(4) "One-hundred year flood" means a flood that has a 1% chance of being equaled or exceeded in any given year.

(5) "Owner" means a person who owns, leases, controls, operates, maintains, manages, or proposes to construct a dam.

(6) "Probable maximum precipitation" means the theoretically greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographic location at a certain time of year.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31505 Definitions; R to T.

Sec. 31505. (1) "Removal" means the physical elimination of a dam or impoundment.

(2) "Repair" means to substantially restore a dam to its original condition and includes only such restoration as may directly affect the structural integrity of the dam.

(3) "Riparian owner" means a person who has riparian rights.

(4) "Riparian rights" means rights which accrue by operation of law to a landowner on the banks of an inland lake or stream.

(5) "Significant hazard potential dam" means a dam located in an area where its failure may cause damage limited to isolated inhabited homes, agricultural buildings, structures, secondary highways, short line railroads, or public utilities, where environmental degradation may be significant, or where danger to individuals exists.

(6) "Spillway" means a waterway in or about a dam designed for the discharge of water.

(7) "Spillway capacity" means the maximum rate of discharge that will pass through a spillway at design flood elevation.

(8) "Two-hundred year flood" means a flood that has a 0.5% chance of being equaled or exceeded in any given year.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31506 Jurisdiction of dams and impoundments; exemptions.

Sec. 31506. (1) Except as otherwise provided in subsections (2) and (3), dams and impoundments in the

© Legislative Council, State of Michigan Courtesy of www.legislature.mi.gov

state are under the jurisdiction of the department.

(2) The following are exempt from this part:

(a) Projects licensed, projects that have preliminary permits, or projects for which an application for licensure has been filed under the federal power act, chapter 285, 41 Stat. 1063, 16 U.S.C. 791a to 793, 796 to 797, 798 to 818, 820 to 824a, and 824b to 825r, if federal dam safety inspection provisions apply during the license period and the inspection reports are provided to the department.

(b) Projects located on boundary waters under the jurisdiction and supervision of the United States army corps of engineers.

(c) Impoundments licensed pursuant to part 115 that contain or are designed to contain type III wastes as defined in rules promulgated under that part.

(3) Until January 1, 1998, a permit shall not be required under this part for the repair, reconstruction, or improvement of a dam, a portion of which is at least 75 years old, was damaged or destroyed by an act of God and is located in a county that has a per capita income of less than $8,500.00. However, a person who is performing a project for the repair, reconstruction, or improvement of a dam that is exempt from obtaining a permit under this subsection shall submit to the department and the joint capital outlay committee plans and specifications for the project. These plans and specifications shall be prepared by a licensed professional engineer and shall meet acceptable standards in the industry in order for a dam to be repaired, reconstructed, or improved. In reviewing plans and specifications for the project, the joint capital outlay committee may recommend environmental considerations to protect water quality such as underspill devices, minimum flow releases and removal of contaminated sediments that may be resuspended in the water column upon impoundment. Such contaminated sediments shall be disposed of in accordance with state law.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995;—Am. 1995, Act 100, Imd. Eff. June 22, 1995.

Popular name: Act 451

Popular name: NREPA

324.31507 Prohibited conduct; exception.

Sec. 31507. (1) A person shall not construct, enlarge, repair, reconstruct, alter, remove, or abandon any dam except in a manner provided for in this part.

(2) This section does not apply to maintenance performed on a dam that does not affect the structural integrity of the dam.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31508 Preparation of plans and specifications; licensed professional engineer required; exceptions.

Sec. 31508. (1) Except as otherwise provided in subsection (2), a licensed professional engineer shall prepare all plans and specifications, except for minor projects undertaken pursuant to section 31513.

(2) A person who is not a licensed professional engineer may prepare plans and specifications only for repairs or alterations to a dam where the application is made by a nonprofit organization under the following circumstances:

(a) The nonprofit organization has assets of less than $30,000.00, is exempt from taxation under section 501(c)(3) of the internal revenue code of 1986, 26 U.S.C. 501, and is not composed primarily of the owners of property adjacent to or contiguous to an impoundment.

(b) The proposed repairs or alterations have a projected total cost of less than $25,000.00.

(c) The impoundment is open to the public and a notice of public access is posted.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31509 Activities requiring permit; application for permit; fees; waiver and disposition of fees.

Sec. 31509. (1) Except as otherwise provided in this part or as authorized by a permit issued by the department pursuant to part 13, a person shall not undertake any of the following activities:

(a) Construction of a new dam.

(b) Enlargement of a dam or an impoundment.

(c) Repair of a dam.

© Legislative Council, State of Michigan Courtesy of www.legislature.mi.gov

(d) Alteration of a dam.
(e) Removal of a dam.
(f) Abandonment of a dam.
(g) Reconstruction of a failed dam.

(2) An application for a permit shall include information that the department determines is necessary for the administration of this part. If a project includes activities at multiple locations, 1 application may be filed for the combined activities.

(3) An application for a permit for construction of a new dam, reconstruction of a failed dam, or enlargement of a dam shall be accompanied by the following fees:

(a) For a dam with a height of 6 feet or more but less than 10 feet, $500.00.
(b) For a dam with a height of 10 feet or more but less than 20 feet, $1,000.00.
(c) For a dam with a height of 20 feet or more, $3,000.00.

(4) An application for a permit for the repair, alteration, removal, or abandonment of a dam shall be accompanied by a fee of $200.00, and an application for a permit for a minor project pursuant to section 31513(1) shall be accompanied by a fee of $100.00.

(5) The department shall waive the fees under this section for applications from state agencies, department sponsored projects located on public lands, and organizations of the type described in section 31508(2)(a) through (c).

(6) The department shall forward fees collected under this section to the state treasurer for deposit in the land and water management permit fee fund created in section 30113.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995;—Am. 2004, Act 325, Imd. Eff. Sept. 10, 2004.

Popular name: Act 451

Popular name: NREPA

324.31510 Request for notification of pending applications for permits; annual fee; biweekly list of applications; copies; contents.

Sec. 31510. (1) A person who wants to be notified of pending applications for permits issued under this part may make a written request to the department, accompanied by an annual fee of $25.00. The fee shall be deposited in the state treasury and credited to the general fund.

(2) The department shall prepare a biweekly list of the applications made during the previous biweekly period and shall promptly mail copies of the list for the remainder of the calendar year to the persons who have requested notice and paid the fee under this section.

(3) The biweekly list shall state the name and address of each applicant, the legal description of the lands included in the applicant's project, and a summary statement of the purpose of the project.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31511 Copies of application and statement; submission; public hearing; notice.

Sec. 31511. (1) Upon receipt of an application for a permit under this part, the department shall submit copies of the application accompanied by a statement indicating that the department may act upon the application without a public hearing unless a written request is filed with the department within 20 days after the submission for review. The department shall submit copies of the application to all of the following:

(a) The local unit of government where the project is to be located.
(b) The adjacent riparian owners.
(c) Any person considered appropriate by the department.
(d) Any person who requests copies.
(e) A watershed council, organized pursuant to part 311, of the watershed within which the project is located or is to be located.

(2) The department may hold a public hearing upon the written request of any of the following:

(a) An applicant.
(b) A riparian owner.
(c) A person or local unit of government that is entitled to receive a copy of the application pursuant to subsection (1).

(3) A public hearing held pursuant to this section shall be held in compliance with the open meetings act, Act No. 267 of the Public Acts of 1976, being sections 15.261 to 15.275 of the Michigan Compiled Laws. Public notice of the time, date, and place of the hearing shall be given in the manner provided by that act.

© Legislative Council, State of Michigan Courtesy of www.legislature.mi.gov

Additionally, the department shall mail copies of the public notice to the persons who have requested the biweekly list pursuant to section 31510, the person requesting the hearing, and the persons and local units of government that are entitled to receive a copy of the application pursuant to subsection (1).

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31512 Necessity for immediate action; emergency conditions; application for permit to reconstruct failed dam.

Sec. 31512. (1) When immediate action is necessary to protect the structural integrity of a dam, the department may issue a permit before the expiration of the 20-day period referred to in section 31511(1). This subsection does not prohibit an owner from taking action necessary to mitigate emergency conditions if imminent danger of failure exists.

(2) A person applying for a permit to reconstruct a failed dam shall file a complete application not less than 1 year after the date of the failure. If such an application is filed more than 1 year after the date of the failure, the department shall consider the application to be an application to construct a new dam.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995;—Am. 2004, Act 325, Imd. Eff. Sept. 10, 2004.

Popular name: Act 451

Popular name: NREPA

324.31513 Minor project categories; rules.

Sec. 31513. (1) The department shall promulgate rules to establish minor project categories for alterations and repairs that have minimal effect on the structural integrity of a dam. The department may act upon an application and grant a permit for an activity or project within a minor project category, after an on-site inspection of the dam, without providing public notice.

(2) All other provisions of this part shall be applicable to minor projects, except that a final inspection by the department or certification of the project by a licensed professional engineer shall not be required for a project completed under a permit granted pursuant to subsection (1).

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31514 Effect of proposed activity on public health, safety, welfare, property, or natural resources.

Sec. 31514. The department shall not issue a permit to construct a new dam, reconstruct a failed dam for which a complete application to reconstruct has been submitted more than 1 year after the date of the failure, or enlarge the surface area of an impoundment by more than 10% unless it determines, after a review of the application submitted, that the proposed activity for which a permit is requested will not have a significant adverse effect on public health, safety, welfare, property, or natural resources or the public trust in those natural resources.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31515 Approval of plans and specifications; completion of permitted activity; time; extension; approval of changes; duration and renewal of permit; terms and conditions; mitigating measures; recommendations; performance bond; suspension, revocation, annulment, withdrawal, recall, cancellation, or amendment of permit; hearings.

Sec. 31515. (1) Except as otherwise provided in this section, a permit issued by the department under this part shall require that plans and specifications be approved by the department before construction begins. The department shall approve or reject complete plans and specifications within 60 days after their receipt. The permitted activity shall be completed within a specified time not to exceed 2 years after the date of issuance of the permit. Upon the written application of the permittee, and for good cause shown, the department may extend the time for completing construction. The permittee shall notify the department at least 10 days before beginning construction and shall otherwise notify the department as the department may require.

(2) A change in approved plans and specifications shall not be implemented unless the department gives its prior approval. The department shall approve or reject changes in plans and specifications within 30 days after

© Legislative Council, State of Michigan Courtesy of www.legislature.mi.gov

the request for the changes.

(3) A permit is effective for the length of time specified in the permit unless it is revoked pursuant to this part. The department may renew a permit.

(4) A permit to alter, repair, or construct a new dam, reconstruct a failed dam, or enlarge the surface area of an impoundment by more than 10% may specify the terms and conditions including, but not limited to, requirements for minimum flows, cold water release, impoundment fluctuations, portage, contingency plans, and conditions under which the work is to be performed. The terms and conditions of a permit shall be effective for the life of the project. The department may consider, in issuing a permit, any mitigating measures in conjunction with the permitted activities and may make recommendations as to fish passage that may be required by part 483.

(5) A permit to construct a new dam or reconstruct a failed dam may require a performance bond to assure completion of the project or to provide for complete or partial restoration of the project site, as determined by the department in rules promulgated by the department.

(6) A permit may be suspended, revoked, annulled, withdrawn, recalled, canceled, or amended after a hearing for a violation of any of its provisions, a violation of this part, a violation of a rule promulgated under this part, or any misrepresentation contained in the application. Hearings shall be conducted by the department in accordance with the provisions for contested cases in the administrative procedures act of 1969.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31516 Spillway capacity; minimum criteria; freeboard; auxiliary spillway; duty of owner.

Sec. 31516. (1) Spillway capacity shall meet the following minimum criteria:

(a) Low hazard potential dams shall be capable of passing the 100-year flood, or the flood of record, whichever is greater.

(b) Significant hazard potential dams shall be capable of passing the 200-year flood, or the flood of record, whichever is greater.

(c) High hazard potential dams, less than 40 feet in height, as measured from the 200-year design flood elevation to the lowest downstream toe elevation, shall be capable of passing the 200-year flood, or the flood of record, whichever is greater.

(d) High hazard potential dams, 40 feet or greater in height, as measured from the 200-year design flood elevation to the lowest downstream toe elevation, shall be capable of passing the half probable maximum flood. The half probable maximum flood criterion may be reduced to not less than the 200-year flood, with proper documentation evidencing a failure of a dam under half probable maximum flood conditions will not cause additional flood damage or loss of life.

(e) Spillway design capacity shall not be less than the flood of record.

(2) Freeboard shall be considered when determining spillway capacity.

(3) If a dam cannot pass the design flood, an auxiliary spillway must be provided. The owner must document, to the satisfaction of the department, that the dam has sufficient spillway capacity, and that proper means are available to operate the spillway or spillways during the design flood.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31517 Duties of owner; inspection; notice of final approval; notice of project not completed in accordance with plans, specifications, or conditions; enforcement action.

Sec. 31517. (1) Except for minor projects authorized pursuant to section 31513, the owner shall do both of the following:

(a) Within 10 days after the completion of a new, reconstructed, enlarged, repaired, or altered dam, notify the department of its completion.

(b) Within 20 days after submitting the notice of completion, file with the department as-built plans and a statement signed by a licensed professional engineer certifying that the project was constructed in conformance with plans and specifications approved by the department.

(2) The department shall inspect the project and shall provide the owner with written notice of final approval if the project is determined to have been completed in accordance with approved plans, specifications, and permit conditions.

(3) If the project is determined not to be completed in accordance with plans and specifications approved by the department and permit conditions, the department shall provide notice to the permittee as to the

© Legislative Council, State of Michigan Courtesy of www.legislature.mi.gov

specific reasons the department determines the project not to be completed in accordance with those plans, specifications, or conditions. The department may then take enforcement action as provided in this part.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31518 Inspection reports; determination of hazard potential classification; inspection schedule; notice; additional inspection reports; contents of inspection report; visual inspection and report; detailed investigation or evaluation; life or property threatened by breach of dam; cause of action; ordering actions to alleviate danger.

Sec. 31518. (1) An owner shall submit to the department inspection reports prepared by a licensed professional engineer that evaluate the condition of the dam. The inspection report shall be submitted as follows:

(a) Not less than once every 3 years for high hazard potential dams.

(b) Not less than once every 4 years for significant hazard potential dams.

(c) Not less than once every 5 years for low hazard potential dams.

(2) The department shall determine the hazard potential classification of all dams and shall establish an inspection schedule. The inspection schedule shall require annual submission of inspection reports for approximately 1/3 of all high hazard potential dams, 1/4 of all significant hazard potential dams, and 1/5 of all low hazard potential dams. The department shall notify owners in writing when inspection reports are due. The department may order additional inspection reports following an event or change in condition that could threaten a dam.

(3) An inspection report required by this section shall include, at a minimum, all of the following:

(a) An evaluation of the dam's condition, spillway capacity, operational adequacy, and structural integrity.

(b) A determination of whether deficiencies exist that could lead to the failure of the dam.

(c) Recommendations for maintenance, repair, and alterations of a dam as are necessary to eliminate any deficiencies.

(4) Instead of engaging a licensed professional engineer to prepare an inspection report, local units of government or an organization of the type described in section 31508(2)(a) through (c) may request the department to conduct a visual inspection of a dam owned by that local unit of government and prepare a report on the condition of the dam in accordance with subsection (3). The department shall notify a requesting local unit of government as to when the inspection is to occur.

(5) If an inspection report discloses the need for a more detailed investigation or evaluation of certain dam features for the purpose of determining the condition of the dam, the department may order the completion and submission of that detailed investigation or evaluation at the expense of the owner. An investigation or evaluation required under this subsection shall be conducted under the supervision of a licensed professional engineer.

(6) If an owner does not submit an inspection report as required by subsection (1) or conduct additional investigations if required by subsection (5), the department or any person who would have life or property threatened by a breach of the dam may have a report prepared and recover the costs of preparing the report in a civil action commenced in a court of competent jurisdiction. This subsection does not limit the right of any person to bring a cause of action in a court of proper jurisdiction to compel an owner to comply with the requirements of this part.

(7) If, based on the findings and recommendations of the inspection report and an inspection by the department, the department finds that a condition exists which endangers a dam, it shall order the owner to take actions that the department considers necessary to alleviate the danger.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31519 Order to limit dam operations; order to remove dam; hearing.

Sec. 31519. (1) Where significant damage to the public health, safety, welfare, property, and natural resources or the public trust in those natural resources or damage to persons or property occurs or is anticipated to occur due to the operation of a dam, the department may order the owner to limit dam operations. These orders may include, but are not limited to, cold water release, minimum flow releases from dams, impoundment fluctuation restrictions, or requirements for run-of-the-river operation. In issuing these orders, the department shall take into account social, economic, and public trust values.

© Legislative Council, State of Michigan Courtesy of www.legislature.mi.gov

(2) Where significant damage to persons, property, or natural resources or the public trust in those natural resources occurs as a result of the condition or existence of a dam, the department may order the removal of the dam following a determination by the department that, due to the continued condition or existence of the dam, the dam is likely to continue to cause significant damage. In issuing a removal order, the department shall take into account social and economic values, the natural resources, and the public trust in those natural resources and shall not issue a removal order when those factors exceed adverse impacts on natural resources or present danger to persons or property. The department shall not issue a removal order involving a dam subject to the regulatory authority of the Michigan public service commission or the federal energy regulatory commission unless that commission has concurred in writing with the order.

(3) Prior to finalizing an order under this section, the department shall provide an owner an opportunity for a hearing pursuant to the administrative procedures act of 1969.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31520 Sudden or unprecedented flood; unusual or alarming circumstance or occurrence; emergency drawdowns, repairs, breaching, or other action; notice.

Sec. 31520. (1) The owner or his or her agent shall advise the department and the affected off-site public authorities and safety agencies of any sudden or unprecedented flood or unusual or alarming circumstance or occurrence existing or anticipated that may affect the safety of the dam within 24 hours of the flood, circumstance, or occurrence.

(2) The owner shall notify the department as soon as possible of any necessary emergency drawdowns, repairs, breaching, or other action being taken in response to an emergency condition.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31521 Emergency orders.

Sec. 31521. (1) The department may issue emergency orders as provided in this section. The department may, by written notice, order an owner to immediately repair, draw down, breach, or cease operation of a dam where a dam is in imminent danger of failure and is causing or threatening to cause harm to public health, safety, welfare, property, or the natural resources or the public trust in those natural resources. If an owner fails to comply with an order, or is unavailable or unable to be contacted, then the department may undertake immediate repair, drawdown, breaching, or cessation of operation, as may be necessary to alleviate the danger, and may recover from the owner the costs incurred in a civil action commenced in a court of competent jurisdiction. The department may terminate an emergency order upon a determination in writing that all necessary emergency actions have been complied with by the owner and that an emergency no longer exists.

(2) When ordering emergency actions under subsection (1), the department may specify maximum drawdown level and discharge rates and require sediment surveys, water quality sampling, monitoring, or any other action determined necessary by the department to ensure adequate protection of the public health, safety, welfare, property, or natural resources or the public trust in those natural resources. The department may modify the requirements of an emergency order if, during the conduct of ordered actions, it determines that the modification is necessary to protect the public health, safety, welfare, property, or natural resources or the public trust in those natural resources.

(3) Upon the issuance of an emergency order, the department shall provide the owner with an opportunity for a hearing pursuant to the administrative procedures act of 1969 within 15 days of the date of its issuance. At the hearing, the department shall determine, based on information and fact, if the emergency order shall be continued, modified, or suspended as necessary to protect public health, safety, welfare, property, or natural resources or the public trust in those natural resources.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31522 Structural integrity and operation of dam; investigations and studies.

Sec. 31522. The department may make, or cause to be made, hydrologic or other investigations and studies as may be required to facilitate its decisions regarding the structural integrity and operation of a dam.

© Legislative Council, State of Michigan Courtesy of www.legislature.mi.gov

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31523 Emergency action plans; submissions; review; consistency with other plans; contents of plans.

Sec. 31523. (1) An owner shall prepare, and keep current, emergency action plans for all high and significant hazard potential dams owned by that person.

(2) Emergency action plans shall be submitted to the department.

(3) The applicable county or local emergency management coordinators shall review for consistency emergency action plans with the county or local emergency operations plan prior to submission of those plans to the department.

(4) An emergency action plan shall be consistent with the applicable provisions of the affected county or local emergency operations plans and the Michigan emergency preparedness plan as developed pursuant to the emergency preparedness act, Act No. 390 of the Public Acts of 1976, being sections 30.401 to 30.420 of the Michigan Compiled Laws.

(5) Emergency action plans shall include, but not be limited to, the name, address, and telephone number of the person, and of an alternate person, responsible for operation of the dam; the name and telephone number of local emergency management coordinators; and a listing of occupied facilities, buildings, and residences that may be threatened with flooding due to a failure of the dam.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31524 Violation; order; suspension, modification, or revocation of permit; remedies cumulative; civil action.

Sec. 31524. (1) If the department determines that a person is in violation of this part, a rule promulgated under this part, or a condition set forth in a permit issued under this part, the department may issue an order requiring the person to comply with the conditions or to restore the site affected by the violation as nearly as practicable to its original condition. Restoration may include, but is not limited to, removing fill material deposited or replacing soil, sand, or minerals.

(2) An order shall state the nature of the violation and the required remedial action, and shall specify a time for compliance that the department determines is reasonable, taking into account the seriousness of the violation and the nature of any threat to public health, safety, welfare, property, or natural resources, or the public trust in those natural resources, that may be involved.

(3) If the department determines that a person is in violation of this part, a rule promulgated under this part, an order issued by the department, or a permit, the department, after notice and opportunity for hearing pursuant to the administrative procedures act of 1969, may suspend, modify, or revoke a permit. The remedies under this section and section 31525 are cumulative and do not prevent the department from imposing other penalties available under this part, a rule promulgated under this part, or an order of the department.

(4) If the department determines that a person is in violation of this part, a rule promulgated under this part, an order issued by the department pursuant to this part, or a permit issued pursuant to this part, the department may bring a civil action in the circuit court.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31525 Commencement of civil action; request; place; civil fine; contempt; willful or reckless violation as misdemeanor; penalty; subsequent violations; fine for failure to obtain permit; restoration of site; schedule of administrative monetary penalties for minor violations.

Sec. 31525. (1) The attorney general may commence a civil action for appropriate relief, including injunctive relief, upon request of the department under section 31524.

(2) Any civil action under this section may be brought in the circuit court for the county of Ingham or for the county in which the dam is located.

(3) In addition to any other relief granted under this section, the court may impose a civil fine of not more than $10,000.00 for each day of violation of this part, a rule promulgated under this part, or a permit issued under this part.

© Legislative Council, State of Michigan Courtesy of www.legislature.mi.gov

(4) A person found guilty of contempt of court for the violation of an order of the court shall be subject to a civil fine not to exceed $10,000.00 for each day of violation.

(5) A person who willfully or recklessly violates this part, a rule promulgated under this part, an order issued by the department, or a condition in a permit issued under this part, which violation places or may place a person in imminent danger of death or serious bodily injury or may cause serious property damage or serious damage to natural resources, or a person who has knowledge of or is responsible for such a violation, is guilty of a misdemeanor, punishable by imprisonment for not more than 1 year or a fine of not less than $2,500.00 or more than $25,000.00 for each day of violation, or both. A person who violates this section a second or subsequent time is guilty of a felony, punishable by imprisonment for not more than 2 years or a fine of not less than $10,000.00 for each day of violation, or both.

(6) A person required to obtain a permit for activity regulated under this part who does not obtain that permit shall be fined not less than twice the fee charged for the appropriate permit application.

(7) In addition to the orders of compliance and penalties provided under this part, the court may order a person who violates this part, a rule promulgated under this part, or a permit issued under this part to restore the site affected by the violation as nearly as practicable to its original condition. Restoration may include, but is not limited to, removing fill material deposited or replacing soil, sand, or minerals.

(8) The department may establish, by rule, a schedule of administrative monetary penalties for minor violations of this part, a rule promulgated under this part, a permit issued pursuant to this part, or an order issued by the department pursuant to this part.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31526 Person aggrieved by action or inaction of department; hearing; determination; judicial review.

Sec. 31526. (1) A person aggrieved by any action or inaction of the department under this part or rules promulgated under this part may request a hearing on the matter involved. The hearing shall be conducted by the department in accordance with the provisions for contested cases in the administrative procedures act of 1969.

(2) A determination of action or inaction by the department following the hearing may be subject to judicial review as provided in the administrative procedures act of 1969.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31527 Entering private or public property; time; purpose.

Sec. 31527. The department may enter in or upon any private or public property anytime where the public safety may be in danger and at all reasonable times, after attempting to contact the owner before entering the site and having shown proper identification, for the purpose of inspecting or investigating conditions relating to the construction, operation, or safety of a dam and for the purpose of determining compliance with the terms, conditions, and requirements of permits, orders, or notices of approval issued under this part and rules promulgated under this part.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31528 Rules.

Sec. 31528. The department shall promulgate rules as necessary to implement and enforce this part.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

324.31529 Construction of part.

Sec. 31529. (1) This part does not abrogate requirements of parts 31, 91, 301, 303, 305, 307, and 483 or other applicable law.

(2) This part does not relieve an owner of any legal duty, obligation, or liability incident to the ownership or operation of a dam or impoundment.

(3) This part does not deprive an owner of any legal remedy to which he or she may be entitled under the

© Legislative Council, State of Michigan Courtesy of www.legislature.mi.gov

laws of this state.

History: Add. 1995, Act 59, Imd. Eff. May 24, 1995.

Popular name: Act 451

Popular name: NREPA

© Legislative Council, State of Michigan Courtesy of www.legislature.mi.gov

E.22. Minnesota



CHAPTER 6115

DEPARTMENT OF NATURAL RESOURCES

PUBLIC WATER RESOURCES

PERMIT, INSPECTION, AND MONITORING FEES

6115.0010 STATUTORY AUTHORITY.
6115.0020 SCOPE.
6115.0030 DEFINITIONS.
6115.0060 PERMIT FEES APPLICATIONS.
6115.0065 AMENDMENT AND TRANSFER FEE.
6115.0080 FIELD INSPECTION FEES.
6115.0090 FEES FOR MONITORING ACTIVITIES.
6115.0110 ANNUAL WATER APPROPRIATION PROCESSING FEE.
6115.0120 WATER APPROPRIATION PROCESSING FEE EXEMPTIONS.

FEES FOR UNDERGROUND GAS OR LIQUID STORAGE

6115.0130 FEE SCHEDULE FOR UNDERGROUND STORAGE OF GAS OR LIQUID IN NATURAL FORMATIONS.

STANDARDS AND CRITERIA FOR GRANTING PERMITS TO CHANGE THE COURSE, CURRENT, OR CROSS-SECTION OF PUBLIC WATERS

6115.0150 PURPOSE AND STATUTORY AUTHORITY.
6115.0160 SCOPE.
6115.0170 DEFINITIONS.
6115.0190 FILLING INTO PUBLIC WATERS.
6115.0191 SPECIFIC STANDARDS; FILLING.
6115.0192 RELATIONSHIP TO STANDARDS AND CRITERIA FOR OTHER ACTIVITIES INVOLVING CHANGES IN COURSE, CURRENT, OR CROSS-SECTION.
6115.0200 EXCAVATION OF PUBLIC WATERS.
6115.0201 SPECIFIC STANDARDS; EXCAVATION.
6115.0202 RELATIONSHIP TO STANDARDS AND CRITERIA FOR OTHER ACTIVITIES INVOLVING CHANGES IN COURSE, CURRENT, OR CROSS-SECTION.
6115.0210 STRUCTURES IN PUBLIC WATERS.
6115.0211 SPECIFIC STANDARDS; STRUCTURES.
6115.0212 RELATIONSHIP TO STANDARDS AND CRITERIA FOR OTHER ACTIVITIES INVOLVING CHANGES IN COURSE, CURRENT, OR CROSS-SECTION.
6115.0215 RESTORATION OF PUBLIC WATERS.
6115.0216 SPECIFIC STANDARDS; RESTORATION.
6115.0217 APPLICATION OF OTHER STANDARDS; RESTORATION.
6115.0220 WATER LEVEL CONTROLS.
6115.0221 SPECIFIC STANDARDS; WATER LEVEL CONTROLS.
6115.0222 RELATIONSHIP TO STANDARDS AND CRITERIA FOR OTHER ACTIVITIES INVOLVING CHANGES IN COURSE, CURRENT, OR CROSS-SECTION.
6115.0230 BRIDGES AND CULVERTS, INTAKES AND OUTFALLS.
6115.0231 SPECIFIC STANDARDS; BRIDGES, CULVERTS, INTAKES, AND OUTFALLS.
6115.0232 RELATIONSHIP TO STANDARDS AND CRITERIA FOR OTHER ACTIVITIES INVOLVING CHANGES IN COURSE, CURRENT, OR CROSS-SECTION.
6115.0240 APPLICATION FOR PUBLIC WATERS WORK PERMITS.
6115.0250 PERMIT REVIEW.
6115.0255 PUBLIC WATERS ENFORCEMENT PROCEDURES.
6115.0260 STATUTORY REQUIREMENTS.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0270 DRAINAGE OF PUBLIC WATERS.
6115.0271 SPECIFIC STANDARDS; DRAINAGE.
6115.0272 RELATIONSHIP TO STANDARDS AND CRITERIA FOR OTHER ACTIVITIES INVOLVING CHANGES IN COURSE, CURRENT, OR CROSS-SECTION.
6115.0280 ALTERATIONS OF PUBLIC WATERS FOR MINING.

DAMS
6115.0300 PURPOSE AND STATUTORY AUTHORITY.
6115.0310 SCOPE.
6115.0320 DEFINITIONS.
6115.0330 SEVERABILITY.
6115.0340 CLASSIFICATION OF DAMS.
6115.0350 GENERAL PROCEDURES FOR ALTERATION, REPAIR, OR REMOVAL OF A DAM.
6115.0360 INSPECTIONS.
6115.0370 TRANSFER OF DAM OWNERSHIP.
6115.0380 OPERATION AND MAINTENANCE.
6115.0390 TERMINATION OF OPERATIONS AND PERPETUAL MAINTENANCE.
6115.0400 REPORTS TO LEGISLATURE ON PUBLICLY OWNED DAMS.
6115.0410 NEW DAMS OR ENLARGEMENTS.
6115.0420 LEGAL CLAIMS.
6115.0430 LIABILITY OF OWNER AND PERMITTEE.
6115.0440 OWNER'S RIGHTS.
6115.0450 INSPECTIONS.
6115.0460 COMPLIANCE WITH OTHER LAWS.
6115.0470 ACQUISITION OF PROPERTY.
6115.0480 ASSIGNMENT OF PERMITS.
6115.0490 WARNING SYSTEMS AND EMERGENCY PROCEDURES.
6115.0500 PERMIT AND HEARING PROCEDURES.
6115.0510 REQUIRED INFORMATION AND WAIVERS.
6115.0520 INSPECTION FEES.

WATER APPROPRIATION AND USE PERMITS
6115.0600 POLICY.
6115.0610 PURPOSE AND STATUTORY AUTHORITY.
6115.0620 SCOPE.
6115.0630 DEFINITIONS.
6115.0640 COORDINATION WITH OTHER AGENCIES.
6115.0650 SEVERABILITY.
6115.0660 APPLICATION FOR PERMIT.
6115.0670 COMMISSIONER'S ACTIONS ON PERMIT APPLICATIONS.
6115.0680 ADDITIONAL REQUIREMENTS AND CONDITIONS FOR AGRICULTURAL IRRIGATION.
6115.0690 ADDITIONAL REQUIREMENTS AND CONDITIONS FOR PUBLIC WATER SUPPLIES.
6115.0700 ADDITIONAL REQUIREMENTS AND CONDITIONS FOR WATER LEVEL MAINTENANCE FOR BASINS.
6115.0710 ADDITIONAL REQUIREMENTS AND CONDITIONS FOR DEWATERING.
6115.0720 ADDITIONAL REQUIREMENTS AND CONDITIONS FOR MINING AND PROCESSING OF METALLIC MINERALS AND PEAT.
6115.0730 WELL INTERFERENCE PROBLEMS INVOLVING APPROPRIATION.
6115.0740 WATER USE CONFLICTS.
6115.0750 PROVISIONS AND CONDITIONS OF WATER APPROPRIATION PERMITS.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0760 LOCAL PERMITS.
6115.0770 WATER CONSERVATION.
6115.0780 ABANDONMENT OF WELLS.
6115.0790 FIELD INVESTIGATIONS.
6115.0800 INFORMATION ON APPROPRIATION PERMIT LAWS.
6115.0810 WATER APPROPRIATION AND USE MANAGEMENT PLANS.

LAKE IMPROVEMENT DISTRICTS
6115.0900 PURPOSE.
6115.0910 SCOPE.
6115.0920 DEFINITIONS.
6115.0930 SEVERABILITY.
6115.0940 GOALS FOR LAKE IMPROVEMENT DISTRICTS.
6115.0950 ELIGIBILITY FOR LAKE IMPROVEMENT DISTRICTS.
6115.0960 CRITERIA AND STANDARDS FOR ESTABLISHMENT OF LAKE IMPROVEMENT DISTRICTS.
6115.0970 CREATION OF LAKE IMPROVEMENT DISTRICT.
6115.0980 ADMINISTRATION OF LAKE IMPROVEMENT DISTRICTS.

STATE WATER BANK PROGRAM
6115.1200 STATUTORY AUTHORITY AND PURPOSE.
6115.1210 DEFINITIONS.
6115.1220 PROCEDURES.
6115.1230 EFFECTIVE DATE.
6115.1240 PAYMENT RATES.
6115.1250 TERMS FOR WATER BANK AND LEASE AGREEMENTS.
6115.1260 MODIFICATIONS OF WATER BANK AND LEASE AGREEMENTS.
6115.1270 AGREEMENT TERMINATIONS.
6115.1280 EXTENSION OF WATER BANK OR LEASE AGREEMENT.

AGRICULTURAL DIKE CONSTRUCTION ALONG THE RED RIVER OF THE NORTH AND BOIS DE SIOUX RIVERS
6115.1300 PURPOSE.
6115.1310 SCOPE.
6115.1320 DEFINITIONS.
6115.1330 SEVERABILITY.
6115.1340 DESIGN CRITERIA.
6115.1350 HYDROLOGIC DATA FOR DESIGN.
6115.1360 DIKES ACROSS NATURAL WATERWAYS AND LEGAL DRAINS.
6115.1370 FARMSTEAD DIKING.
6115.1380 PERMIT APPLICATION.
6115.1390 EXCEPTION TO CRITERIA.
6115.1400 APPLICATION OF RULES TO EXISTING DIKES.

CONSOLIDATED CONSERVATION AREAS DRAINAGE PROJECTS
6115.1500 PURPOSE.
6115.1510 DEFINITIONS.
6115.1520 DRAINAGE PROJECTS.
6115.1530 DETERMINING BENEFIT AND PARTICIPATION.
6115.1540 FINDINGS AND REPORT.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.1550 APPEAL.

PERMIT, INSPECTION, AND MONITORING FEES

6115.0010 STATUTORY AUTHORITY.

The commissioner of natural resources is authorized by Minnesota Statutes, sections 103G.301, subdivision 2 to 5, and 103G.315, subdivision 12, to establish fee schedules for permit applications, field inspections, and monitoring, with regard to permits required by Minnesota Statutes, chapter 103G.

Statutory Authority: *MS s 105.44; 103G.301; 103G.315*

History: *10 SR 236*

Posted: *June 11, 2008*

6115.0020 SCOPE.

The fees established in parts 6115.0010 to 6115.0100 shall not be imposed on any state or federal agency.

Statutory Authority: *MS s 105.44*

History: *10 SR 236*

Posted: *June 11, 2008*

6115.0030 DEFINITIONS.

Words used in parts 6115.0010 to 6115.0100 have the meanings normally ascribed to them except:

A. "Appropriation of water," "waters of the state," and "public waters" have the meanings given by Minnesota Statutes, section 103G.005.

B. "Field inspection" means an on-site determination of relevant characteristics of the area involved in or affected by the proposed or permitted project.

C. "Monitoring" means checking on the status or progress of activities authorized by permit, and checking and inspecting special aspects of proposed permit applications, during construction, implementation, or after completion of permitted activities.

D. "Division" means the Division of Waters, Department of Natural Resources.

E. "Commissioner" means the commissioner of natural resources or the commissioner's authorized representative.

F. "Project cost" means the total cost of all materials, services, equipment purchase or rental, and labor expended for the portion of the project proposed in the permit application which are directly governed by protected waters permit rules, parts 6115.0150 to 6115.0280.

G. "Protected waters" means those waters of the state identified as public waters or wetlands under Minnesota Statutes, sections 103G.005, subdivisions 15 and 15a, and 103G.201.

H. "Ordinary high water mark" means the boundary of protected waters as defined in Minnesota Statutes, section 103G.005, subdivision 14.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

I. "Shoreline" means:

(1) for water bodies other than watercourses, the lateral measurement along the contour of the ordinary high water mark; and

(2) for watercourses, the top of the bank of the channel (coincides with ordinary high water mark as defined in Minnesota Statutes, section 103G.005, subdivision 14).

J. "State agency" has the meaning given in Minnesota Statutes, section 16B.01, subdivision 2.

Statutory Authority: *MS s 105.44; 103G.301; 103G.315*

History: *10 SR 236*

Posted: *June 11, 2008*

6115.0040 [Repealed, 10 SR 236]

Posted: *June 11, 2008*

6115.0050 [Repealed, 10 SR 236]

Posted: *June 11, 2008*

6115.0060 PERMIT FEES APPLICATIONS.

Subpart 1. **Fee.** A permit application fee of $75 shall accompany permit applications submitted under Minnesota Statutes, section 103G.271, appropriation and use of water, Minnesota Statutes, section 103G.531, subdivision 2, relating to dams, and Minnesota Statutes, section 105.391, relating to water bank.

Subp. 2. **Protected waters; fee.** The permit application fee for works affecting protected waters, authorized under Minnesota Statutes, sections 103G.245 and 103G.297, shall be based on estimated project cost, the amount of material deposited in or removed from the protected waters, and the amount of shoreline affected by the project. The commissioner shall make the final determination of project costs used to calculate the permit application fee. The permit application fee shall be the greater of the fees calculated from the following parameter schedules, but not less than $75 nor more than $500:

A. Project cost parameter. If the project cost is greater than $7,500, the fee shall be one percent of the project cost. If a dispute arises between the commissioner and a permit applicant over project cost, the commissioner may require the permit applicant to submit a project cost estimate prepared by a registered professional engineer, contractor, planning consultant, or other qualified professional entity.

B. Shoreline affected parameter. If the project affects more than 100 feet of shoreline, the fee shall be 75 cents per foot of shoreline affected. For channel excavation projects, the shoreline affected is the difference in length in feet between the existing channel and the proposed channel.

C. Fill-excavation parameter. If the project requires more than 100 cubic yards of fill or excavation, the fee shall be 75 cents per cubic yard of material filled or excavated. For channel excavation projects, the volume in cubic yards is only that material filled or excavated in existing protected waters.

D. The permit application fee for protection of shoreline from erosion by placement of riprap and to recover shoreland lost by erosion or other natural forces, shall be limited to $75.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 3. **Failure to remit.** If the permit application fee does not accompany the application, the applicant will be so notified. If no fee is received within 30 days from mailing of the written notice, the commissioner shall consider the application withdrawn and no further action shall be taken on it unless the applicant submits a new application accompanied by the minimum fee.

Subp. 4. **Multiple applications.** If a project requires several permit applications, the permit application fee must accompany each application. Projects that involve a combination of work that results in both the alteration of protected waters and the use of waters of the state, shall be required to submit only one permit application and one set of fees. The type of permit application to be used and the fees to be charged shall be determined by the ultimate purpose of the project.

Subp. 5. **Nonrefundable.** The permit application fee is not returnable, whether the application is permitted, modified, or denied, unless the commissioner determines the activity does not require a permit.

Subp. 6. **Applications after commencement.** The permit application fee for permit applications filed after the work applied for has been partially or wholly completed, except for emergency work provided for in existing permit rules and policies, shall be double the amount that would have been charged if a timely application had been filed. In the case of a belated permit application, the permit application fee shall accompany the application or the commissioner shall proceed to issue a restoration order under Minnesota Statutes, section 103G.315, subdivision 7.

Subp. 7. **Fees following a hearing.** If a hearing is demanded, and if the outcome of the hearing is a decision to issue a permit, payment of all required fees must precede issuance. The fee charged will be based on the schedules contained in this part regardless of whether a permit application has been filed.

Subp. 8. **Form of payment.** Payment of all fees covered by parts 6115.0010 to 6115.0030, 6115.0060, 6115.0080 to 6115.0100, and 6115.0130 shall be made by check or money order payable to the Minnesota Department of Natural Resources. Cash cannot be accepted.

Statutory Authority: *MS s 105.44; 103G.301; 103G.315*

History: *10 SR 236; 13 SR 2825*

Posted: *June 11, 2008*

6115.0065 AMENDMENT AND TRANSFER FEE.

Each request by a permittee to amend or transfer an existing permit shall be accompanied by a $75 fee, unless exempted under part 6115.0120. Any amendment initiated by the department is exempt from fees. Projects that involve a combination of transfer and amendment requests shall only be required to pay the $75 fee.

Statutory Authority: *MS s 105.44*

History: *10 SR 236; 13 SR 2825*

Posted: *June 11, 2008*

6115.0070 [Repealed, 10 SR 236]

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0080 FIELD INSPECTION FEES.

Subpart 1. [Repealed, 13 SR 2825]

Subp. 2. **Computation.** If a field inspection is conducted, field inspection fees shall be charged only for: (1) projects requiring an environmental assessment worksheet (EAW) or environmental impact statement (EIS) pursuant to Minnesota Statutes, chapter 116D and the environmental review program rules, parts 4410.0200 to 4410.6500. Projects that do not require a mandatory environmental assessment worksheet (EAW) or environmental impact statement (EIS) under parts 4410.4300 and 4410.4400, at the time the permit application is made, shall not be charged field inspection fees; (2) projects undertaken without a permit or application as required by Minnesota Statutes, section 84.083, and chapters 103A, 103B, and 103E to 103G; or (3) projects undertaken in excess of limitations established in an issued permit.

The fee charged will be the actual cost of the field inspection, but shall not be less than $100.

Examples of field inspection costs are:

A. state salaries, including fringe benefits and overhead, (travel and inspection time of state employees multiplied by actual hourly rates);

B. transportation to and from inspection site, laboratories and other documented travel sites, based on current Department of Administration rates or rates specified in applicable bargaining unit agreements;

C. expense of purchase, rental, or repair of special equipment and supplies;

D. living expenses away from home, based on current Department of Administration rates or rates specified in applicable bargaining unit agreements;

E. inspection and consultant services contracted for by the state; and

F. laboratory expenses and analysis of data.

Subp. 2a. **Dams and water level controls.** Field inspection fees shall not be charged for any dam subject to parts 6115.0300 to 6115.0520. Such dams are subject to the inspection fee requirements of part 6115.0520. Field inspection fees for all other water level control structures shall be charged pursuant to parts 6115.0010 to 6115.0130.

Subp. 3. [Repealed by amendment, 10 SR 236]

Statutory Authority: *MS s 105.44; 103G.301; 103G.315*

History: *10 SR 236; 13 SR 2825*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0090 FEES FOR MONITORING ACTIVITIES.

If the project requires an environmental assessment worksheet (EAW) or environmental impact statement (EIS) pursuant to Minnesota Statutes, chapter 116D, and parts 4410.0200 to 4410.6500, the commissioner shall charge an additional fee for monitoring subject to the following:

A. Where the commissioner determines that a permitted activity requires monitoring of water or related land resources, the permit shall specify the procedures and scope of such monitoring. Actual costs of the monitoring shall be paid by the permittee in accordance with procedures set forth in the permit.

B. When the commissioner determines after the permit is issued, that there is a need for monitoring, the commissioner shall notify the permittee in writing of the nature of and reasons for the monitoring, and after opportunity for hearing, shall modify the permit accordingly. The actual costs of the monitoring shall be paid by the permittee.

Actual costs incurred and charged by the state are determined in the same manner as prescribed for field inspections.

The commissioner may allow the permittee to provide the monitoring service or employ a consultant for that purpose, subject to the right of the commissioner to charge for state costs related to private monitoring, including the costs of periodically monitoring the monitor.

Fees for monitoring activities shall not be charged for any dam subject to parts 6115.0300 to 6115.0520.

Statutory Authority: *MS s 105.44*

History: *10 SR 236*

Posted: *June 11, 2008*

6115.0100 [Repealed, 10 SR 236]

Posted: *June 11, 2008*

6115.0110 ANNUAL WATER APPROPRIATION PROCESSING FEE.

Subpart 1. **In general.** An annual water appropriation processing fee shall be submitted for each water appropriation permit in force at any time during the year. The fees are required whether or not the permittee appropriated or used any water as authorized by permit during the year.

Subp. 2. **Fee schedule.** The fee shall be based on the following schedule:

A. for irrigation permits, $15 for the first permitted 160 acres or portion thereof, and $25 for each additional permitted 160 acres or portion thereof;

B. for all other permits, $5 for each permitted 10,000,000 gallons or portion thereof;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

C. the annual water appropriation processing fee shall not exceed a total fee of $500 per permit.

Subp. 3. **Billing and payment.** A notice of the fees owed will be mailed to the permittee, with the reporting forms, by the commissioner.

The fee, with accompanying report, for the calendar year's appropriation or use of water, shall be sent to the commissioner no later than February 15 of the following year.

Failure to pay the fee shall be sufficient cause for terminating a permit 30 days following written notice by the commissioner.

The effective date of this part is August 1, 1985.

Statutory Authority: *MS s 105.44*

History: *10 SR 236*

Posted: *June 11, 2008*

6115.0120 WATER APPROPRIATION PROCESSING FEE EXEMPTIONS.

The following water appropriation permit actions are exempt from amendment or transfer fees:

A. a change in mailing address;

B. a change of authorized agent when land ownership has not changed;

C. an assignment of a permit within the immediate family;

D. a change in pump location on surface water sources for the same operation;

E. an addition of a new well that replaces an old well for the same permitted operation and is completed at a similar depth in the same aquifer;

F. a decrease in the permitted pumping rate, amount of water authorized, or irrigated acreage;

G. an increase in the permitted pumping rate within ten percent;

H. an increase in the permitted appropriation within ten percent of the annual authorization for nonirrigation permits; or

I. an increase of less than 30 acres in the number of permitted irrigated acres.

Any amendments or transfers that exceed the exemptions in items A to I require a processing fee under part 6115.0065.

Statutory Authority: *MS s 105.44*

History: *13 SR 2825*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

FEES FOR UNDERGROUND GAS OR LIQUID STORAGE

6115.0130 FEE SCHEDULE FOR UNDERGROUND STORAGE OF GAS OR LIQUID IN NATURAL FORMATIONS.

Subpart 1. **In general.** This schedule is established pursuant to Minnesota Statutes, section 103I.681, subdivision 11. It provides for payment of permit application fees and additional fees for processing and analyzing the application, and issuing the permit. It also includes fees for the inspection and monitoring of activities authorized by the permit.

Subp. 2. **Permit application fee.** A permit application fee of $30, check or money order, payable to the commissioner of management and budget, shall accompany each permit application for underground storage of gas or liquid.

If the fee does not accompany the application, the applicant will be so notified, and there will be no further action taken on the application until the fee is submitted.

Subp. 3. **Additional fees.** The applicant or permittee shall pay the actual costs of field inspection and monitoring as follows.

A. When a field inspection is conducted, the costs charged will be the sum of: salaries (inspection time of state employees multiplied by actual hourly rates); transportation to and from inspection site, based on current state Department of Administration rates; fair rental for any special equipment and supplies; and inspection and consultant services contracted for by the state.

B. When the commissioner determines that a permitted activity requires monitoring of water or related land resources, the permit shall specify the procedures and scope of such monitoring. Actual costs of the monitoring, whether conducted by state personnel or by consultants hired by the state, shall be paid by the permittee in accordance with procedures in the permit.

When the commissioner determines after the permit is issued that there is a need for monitoring, the commissioner shall notify the permittee in writing of the nature of and reasons for the monitoring, and after opportunity for hearing, shall modify the permit accordingly. The actual costs of monitoring shall be paid by the permittee.

The commissioner may allow the permittee to provide monitoring services, or employ a consultant for that purpose, subject to the right of the commissioner to charge for state costs related to private monitoring, including the costs of periodically monitoring the monitor.

Subp. 4. **Refund of fees.** The permit application fee for a permit application shall not be refunded for any reason, even if the application is denied or withdrawn.

Subp. 5. **Billing and payment of fees.** The commissioner shall submit an itemized bill to the applicant or permittee for all additional fees. Fees are payable within 30 days of receipt; failure to pay

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

is grounds for suspending the permit or for taking other legal actions as required. In the case of an applicant, a permit shall not be issued until all fees owed have been paid.

Statutory Authority: *MS s 105.44; 103G.301; 103G.315*

History: *10 SR 236; L 2003 c 112 art 2 s 50; L 2009 c 101 art 2 s 109*

Posted: *August 7, 2009*

STANDARDS AND CRITERIA FOR GRANTING PERMITS TO CHANGE THE COURSE, CURRENT, OR CROSS-SECTION OF PUBLIC WATERS

6115.0150 PURPOSE AND STATUTORY AUTHORITY.

The purpose of parts 6115.0150 to 6115.0280 is to provide for the orderly and consistent review of permit applications in order to conserve and utilize the water resources of the state in the best interest of its people. In deciding whether to issue permits, the department is guided by the policies and requirements declared in Minnesota Statutes, sections 103A.201, 103A.208, 103F.101, 103F.105, 103F.205, 103F.351, 103G.297, 103G.305, and 116D.04.

The proposed development must also be consistent with the goals and objectives of applicable federal, state, and local environmental quality programs and policies, including but not limited to shoreland management, floodplain management, water surface use management, boat and water safety, wild and scenic rivers management, water quality management, recreational or wilderness management, critical areas management, scientific and natural areas management, and protected species management.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0160 SCOPE.

To achieve the purpose declared in part 6115.0150, parts 6115.0160 to 6115.0280 set forth minimum standards and criteria for the review, issuance, and denial of permits for proposed projects affecting public waters. Permits are required for any activity affecting the course, current, or cross-section of public waters unless specifically exempted within parts 6115.0160 to 6115.0280.

These standards and criteria apply to the public waterbasins, public watercourses, and public water wetlands identified on public water inventory maps authorized by Minnesota Statutes, section 103G.201. The designation of waters of the state as public waters does not grant the public additional rights or grant right of access to the waters, diminish the right of ownership or usage of the beds underlying the designated public waters, affect state law forbidding trespass on private lands, or require the commissioner to acquire access to the designated public waters under Minnesota Statutes, section 97A.141.

These standards and criteria apply to any and all work that will cause or result in the alteration of the course, current, or cross-section of public waters except for the following:

A. utility crossings of public waters that are regulated under Minnesota Statutes, section 84.415, and rules adopted thereunder;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. planting, destruction, and control of aquatic vegetation that is regulated under Minnesota Statutes, section 103G.615, and rules adopted thereunder;

C. water aeration systems that are regulated under Minnesota Statutes, section 103G.611, and rules adopted thereunder;

D. watercraft, buoys, or other structures that are regulated under Minnesota Statutes, section 86B.111, 86B.211, or 86B.401, and rules adopted thereunder; or

E. water appropriations that are regulated under Minnesota Statutes, section 103G.271, and rules adopted thereunder.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; L 1986 c 386 art 4 s 11; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0170 DEFINITIONS.

Subpart 1. **Certain terms.** For the purposes of parts 6115.0150 to 6115.0280, certain terms or words used are interpreted as follows: the word "shall" is mandatory, not permissive. All distances unless otherwise specified are measured horizontally.

Subp. 2. **Alteration.** "Alteration" means any activity that will change or diminish the course, current, or cross-section of public waters.

Subp. 3. **Beds of public waters.** "Beds of public waters" means all portions of public waters located below the ordinary high water level.

Subp. 3a. **Boat storage structure.** "Boat storage structure" means a structure that is supported on the bed of a public water and has walls, a roof, and either an open well for boats or a floor from wall to wall.

Subp. 3b. **Boathouse.** "Boathouse" means a floating structure that is moored by spuds, cables, ropes, anchors, or chains; may be intended for habitation; and has walls, a roof, and either an open well for boats or a floor from wall to wall. Boathouse does not include a houseboat or boat storage structure.

Subp. 4. **Breakwater.** "Breakwater" means an offshore structure intended to protect a shore area, harbor, or marina from wave and current action, erosion, or sedimentation.

Subp. 5. **Commissioner.** "Commissioner" means the commissioner of natural resources.

Subp. 6. **Department.** "Department" means the Department of Natural Resources.

Subp. 7. **Dock.** "Dock" means a narrow platform or structure extending waterward from the shoreline intended for ingress and egress for moored watercraft or seaplanes or to provide access to deeper water for swimming, fishing, or other water-oriented recreational activities.

Subp. 8. **Drainage.** "Drainage" means any method for removing or diverting waters from public waterbasins or public water wetlands. The methods include, but are not limited to, excavation of an open ditch, installation of subsurface drainage tile, filling, diking, or pumping.

Subp. 9. **Drawdown.** "Drawdown" means a temporary lowering of water levels, for a maximum duration of two years.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 9a. **Ecology of the waters.** "Ecology of the waters" means the natural aquatic environment, including organisms, physical characteristics, and interactions between and among the organisms and their surroundings.

Subp. 9b. **Energy exchanger.** "Energy exchanger" means a structure designed for placement on the bed or excavated into the bed of public waters for the purpose of exchanging energy for heating or cooling and includes accompanying hoses or lines connecting the energy exchange components.

Subp. 10. **Excavation.** "Excavation" means the displacement or removal of the sediment or other materials from the beds of public waters by means of hydraulic suction or mechanical operations.

Subp. 11. **Fill.** "Fill" means any material placed or intended to be placed on the bed or bank of any public water.

Subp. 12. **Filter.** "Filter" means a transitional layer of gravel, small stone, or fabric between the fine material of an embankment and riprap shore protection materials.

Subp. 13. **Floating structure.** "Floating structure" means any structure, except for boathouses, watercraft, and seaplanes, that is supported entirely by its own buoyancy and can be removed from public waters before winter freeze-up by skidding intact or by disassembly with hand tools.

Subp. 14. **Floodplain.** "Floodplain" means the areas adjoining a watercourse which has been or hereafter may be covered by the regional flood.

Subp. 15. **Floodway.** "Floodway" means the channel of the watercourse and those portions of the adjoining floodplains which are reasonably required to carry and discharge the regional flood.

Subp. 16. **Harbor.** "Harbor" means either an inland or offshore area protected from waves which is intended for the mooring of watercraft.

Subp. 16a. **Houseboat.** "Houseboat" means a motorboat that has either a pontoon or a flat-bottomed hull configuration and a permanent enclosed superstructure that houses, at a minimum, built-in sleeping, cooking, and toilet facilities.

Subp. 16b. **Ice ridge.** "Ice ridge" means a linear mound of lakebed materials pushed up onto the lakeshore by the action of ice.

Subp. 17. **Inland boat slip.** "Inland boat slip" means an inland excavation generally having a uniform width which serves as a protective area for launching and mooring of a single watercraft.

Subp. 18. **Inland excavation.** "Inland excavation" means any excavation intended to extend the cross-section of public waters landward of the natural or preexisting shoreline.

Subp. 18a. **Local government unit.** "Local government unit" has the meaning given in part 8420.0111, subpart 38.

Subp. 18b. **Local origin.** "Local origin" means a source for live plant materials and their propagules that is limited to areas of the same region where the plant materials are proposed to be planted, not to exceed 200 miles from where the plant materials are proposed to be planted.

Subp. 19. **Low-water ford type crossing.** "Low-water ford type crossing" means a stream crossing which conforms to the natural cross-section of the stream and utilizes the placement of a suitable substrate to allow vehicular passage without confining the stream flow within culverts or other hydraulic enclosures.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 20. **Marina.** "Marina" means either an inland or offshore commercial mooring facility for the concentrated mooring of seven or more watercraft or seaplanes wherein commercial ancillary services common to marinas are provided.

Subp. 21. **Maximum.** "Maximum," with respect to storage capacity, refers to the most severe design condition, including surcharge (floodwater storage).

Subp. 22. **Mining activity.** "Mining activity" means the construction, reconstruction, repair, relocation, expansion, or removal of any facility for the extraction, stockpiling, storage, disposal, or reclamation of metallic or nonmetallic minerals. Facilities include all mine pits, quarries, stockpiles, tailings basins, and any structures which drain or divert public waters to allow mining. Ancillary facilities such as access roads, bridges, culverts, and water level control structures are not mining activities.

Subp. 23. **Mooring.** "Mooring" means any containment of free-floating watercraft that provides a fixed fastening for the craft.

Subp. 23a. **Mooring facility.** "Mooring facility" means a concentrated area intended solely for the mooring or containment of seven or more watercraft or seaplanes by docks, mooring buoys, or other means.

Subp. 23b. **Native plants.** "Native plants" means indigenous plant species growing in an ecological classification system province or a major watershed in Minnesota prior to European settlement.

Subp. 24. **Offshore.** "Offshore" means the area waterward of the ordinary high water level of a public water.

Subp. 25. **Ordinary high water level.** "Ordinary high water level" means the boundary of public waters as defined in Minnesota Statutes, section 103G.005, subdivision 14.

Subp. 26. [Repealed, 27 SR 529]

Subp. 26a. **Permit.** "Permit" means a public waters work permit required under Minnesota Statutes, section 103G.245.

Subp. 27. **Port.** "Port" means a water transportation complex established and operated under the jurisdiction of a port authority pursuant to Minnesota Statutes, chapter 458.

Subp. 28. **Port facility.** "Port facility" means any facility useful in the maintenance and operation of a port. Facilities include, but are not limited to, transportation facilities, terminal and storage facilities, floating and handling equipment, power stations, and other facilities necessary for the maintenance and operation of a port.

Subp. 29. **Principal spillway.** "Principal spillway" means a spillway designed to convey water from an impoundment at release rates established for the structure.

Subp. 30. **Professional engineer.** "Professional engineer" means an engineer registered to practice in Minnesota.

Subp. 30a. **Project.** "Project" means a specific plan, contiguous activity, proposal, or design necessary to accomplish a goal. As used in parts 6115.0150 to 6115.0280, a project may not be split into components or phases for the sole purpose of gaining an exemption from permit requirements.

Subp. 31. **Public water or public waters.** "Public water" or "public waters" means those waters of the state identified under Minnesota Statutes, section 103G.005, subdivision 15 or 15a, or 103G.201.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 31a. **Public water wetlands.** "Public water wetlands" means those public waters of the state identified as public water wetlands under Minnesota Statutes, section 103G.005, subdivision 15a, or 103G.201, as shown on the public water inventory maps.

Subp. 31b. **Public waterbasins.** "Public waterbasins" means those public waters of the state identified as public waterbasins under Minnesota Statutes, section 103G.005, subdivision 15, clauses (1) to (8), or 103G.201, as shown on the public water inventory maps. Public waterbasins includes public water wetlands reclassified as public waters according to the procedures in Minnesota Statutes, section 103G.201.

Subp. 31c. **Public watercourse.** "Public watercourse" means those public waters of the state identified as natural and altered natural watercourses under Minnesota Statutes, section 103G.005, subdivision 15, clauses (9) and (10), or 103G.201, as shown on the public water inventory maps.

Subp. 31d. **Public waters inventory or protected waters inventory.** "Public waters inventory" or "protected waters inventory" means the map prepared by the commissioner on file with the auditor of a county under Minnesota Statutes, section 103G.201.

Subp. 31e. **Public waters work permit.** "Public waters work permit" means a permit issued by the commissioner under Minnesota Statutes, section 103G.245.

Subp. 32. **Reconstruction.** "Reconstruction" means the rebuilding or renovation of an existing structure, where the cost of such work will exceed 50 percent of the replacement cost.

Subp. 33. **Regional flood.** "Regional flood" means the flood which is representative of large floods known to have occurred generally in Minnesota and reasonably characteristic of what can be expected to occur on an average frequency in the magnitude of the 100-year recurrence interval.

Subp. 34. **Retaining walls.** "Retaining walls" means vertical or nearly vertical structures constructed of mortar-rubble masonry, handlaid rock or stone, vertical timber pilings, horizontal timber planks with piling supports, sheet pilings, poured concrete, concrete blocks, or other durable materials and constructed approximately parallel to the shoreline.

Subp. 35. **Riprap shore protection.** "Riprap shore protection" means coarse stones, boulders, cobbles, artificially broken rock or concrete, or brick materials laid loosely or within gabion baskets against the slope of the existing bank of a public water.

Subp. 36. [Repealed, 27 SR 529]

Subp. 36a. **Shoreline zone.** "Shoreline zone" means an area immediately waterward of the ordinary high water level that may include the littoral area of a water body.

Subp. 37. **Structure.** "Structure" means any building, footing, foundation, slab, roof, boathouse, deck, wall, dock, bridge, culvert, or any other object extending over or under, anchored to, or attached to the bed or bank of a public water.

Subp. 38. **Structural height.** "Structural height" means the vertical distance from the natural bed of the stream or watercourse measured at the downstream toe of the control structure or from the lowest elevation of the outside limit of the control structure, if it is not across a stream channel or watercourse, to the maximum storage elevation.

Subp. 39. **Swellhead.** "Swellhead" means the difference between the headwater elevation necessary to pass the regional flood through the proposed structure and the tail water elevation below the structure.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 40. **Temporary structure.** "Temporary structure" means any dock, floating structure, watercraft lift, watercraft canopy, or other structure that can be removed from public waters by skidding intact or by disassembly with hand tools.

Subp. 41. **Watercourse.** "Watercourse" means any channel having definable beds and banks capable of conducting generally confined runoff from adjacent lands. During floods water may leave the confining beds and banks but under low and normal flows water is confined within the channel. A watercourse may be perennial or intermittent.

Subp. 42. **Water level control structure.** "Water level control structure" means any structure which impounds or regulates the water surface elevation or flow of public waters, including dams regulated under the provisions of parts 6115.0300 to 6115.0520.

Subp. 42a. **Watercraft canopy.** "Watercraft canopy" means a structure or device with a fabric covered roof and without walls or a floor that is placed on the bed of a public water, is designed to shelter watercraft, and is designed and constructed so that all components may be removed from the lake or stream bed on a seasonal basis by skidding intact or by disassembly with hand tools.

Subp. 42b. **Watercraft lift.** "Watercraft lift" means a structure or device without walls that is placed on the bed of a public water, is designed to lift watercraft above the level of the public water when not in use, and is designed and constructed so that all components may be removed from the lake or stream bed on a seasonal basis by skidding intact or by disassembly with hand tools. A watercraft lift may be designed to include a fabric covered roof.

Subp. 43. **Wharf.** "Wharf" means a permanent structure constructed into navigable waters as a part of a port facility for berthing or mooring commercial watercraft, or for transferring cargo to and from watercraft in an industrial or commercial enterprise, or for loading or unloading passengers from commercial watercraft, or for the operation of a port facility.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529; 34 SR 145*

Posted: *August 27, 2009*

6115.0180 [Repealed by amendment, 8 SR 533]

Posted: *June 11, 2008*

6115.0190 FILLING INTO PUBLIC WATERS.

Subpart 1. **Goals.** It is the goal of the department to limit the placement of any fill material into public waters in order to:

A. minimize encroachment, change, or damage to the environment;

B. regulate the quantity and quality of fill and the purposes for which filling may be allowed based upon the capabilities of the waters to assimilate the material; and

C. maintain consistency with floodplain, shoreland, and wild and scenic rivers management standards and ordinances.

Subp. 2. **Scope.** Filling as used in this part involves placement of unconfined or loosely confined materials in public waters.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 3. **Prohibited placement.** Placement is prohibited in the following cases:

A. to achieve vegetation control;

B. to create upland areas, except where expressly provided herein;

C. to stabilize beds of public waters which cannot support fill materials because of excessive depths of muck, steep bank, bed slope, or other conditions;

D. to stabilize or impound the site of active springs;

E. to dispose of rock, sand, gravel, or any other solid material resulting from activities carried out above the ordinary high water level;

F. to construct a roadway or pathway, or create or improve land accesses from peripheral shorelands to islands, or to facilitate land transportation across the waters; however, when a project is proposed by a federal, state, or local government agency and this provision would prevent or restrict the project, or create a major conflict with other public purposes or interests, the commissioner may waive this provision if:

(1) there is no other feasible and practical alternative to the project that would have less environmental impact; and

(2) the public need for the project rules out the no-build alternative; or

G. filling posted fish spawning areas.

Subp. 4. **No permit required.** No permit is required for the following activities unless prohibited under subpart 3:

A. to install a beach sand blanket if:

(1) the sand or gravel layer does not exceed six inches in thickness, 50 feet in width along the shoreline, or one-half the width of the lot, whichever is less, and does not extend more than ten feet waterward of the ordinary high water level;

(2) the beach sand blanket does not cover emergent vegetation, unless authorized by an aquatic plant management permit; and

(3) local watershed district and local zoning officials are given at least seven days notice by the landowner;

B. for one additional installation of a sand or gravel layer subsequent to an initial installation at the same location and not exceeding the same amounts and dimensions allowed under item A; or

C. to place fill in a public watercourse having a total drainage area, at its mouth, of five square miles or less, if the watercourse is not an officially designated trout stream and the placement of fill does not result in:

(1) any diversions of water from the drainage area;

(2) any impoundment of waters by damming the watercourse; or

(3) any actions that would result in erosion and cause sedimentation of downstream waters as determined by the county or local soil and water conservation district.

Subp. 5. **Permits required.** Permits are required for the placement of fill in public waters, except as provided under subparts 3 and 4, and a project must meet all of the following requirements:

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

A. the project does not exceed more than a minimum encroachment, change, or damage to the environment, particularly the ecology of the waters;

B. the fill consists of clean inorganic material that is free of pollutants and nutrients;

C. the existence of a stable, supporting foundation is established by appropriate means, including soil boring data where deemed necessary by the commissioner;

D. where erosion protection is deemed necessary by the commissioner, the site conditions and fill material are capable of being stabilized by an approved erosion control method such as riprap, retaining wall, or other method which is consistent with existing land uses on the affected public water;

E. the proposed project represents the minimal impact solution to a specific need with respect to all other reasonable alternatives;

F. the size, shape, depths, shoreline, and bottom character and topography, and susceptibility of the beds of public waters to actions of wind, waves, and currents are such that the fill will be stable;

G. adverse effects on the physical or biological character of the waters are subject to feasible and practical measures to mitigate the effects;

H. the proposed filling is consistent with applicable floodplain, shoreland, and wild and scenic rivers management standards and ordinances for the waters involved; and

I. the proposed filling is consistent with water and related land management plans and programs of local and regional governments, provided such plans and programs are consistent with state plans and programs.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0191 SPECIFIC STANDARDS; FILLING.

Subpart 1. **In general.** In addition to compliance with the general standards in part 6115.0190, subparts 2 to 5, specific requirements for certain activities shall be met as follows.

Subp. 2. [Repealed, 27 SR 529]

Subp. 3. **Navigational access.** Filling to gain navigational access to waters shall be permitted only where access to navigable depths cannot be reasonably attained by utilizing a dock, the excavation of an offshore access channel, or other alternatives which would result in less environmental impact.

Fill for navigational access shall not extend beyond the edge of open water, shall not exceed side slopes greater than 2:1 horizontal:vertical, shall not exceed a maximum width of 15 feet at the base of the fill, and shall not extend to a water depth greater than four feet.

Subp. 4. **Shoreline lost by erosion.** Permits for filling to recover shoreland lost by erosion or other natural forces shall be granted if:

A. the loss of shoreline is a threat to health and safety through the impending loss or damage to existing shoreline developments; or

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. the loss of shoreline has occurred as a result of changes in water level or flow conditions caused by artificial manipulation of flows or levels of the waters involved within a period of not more than five years prior to the date when an application for filling is submitted.

The requirements of items A and B do not preclude the issuance of permits to recover up to 400 square feet of eroded area or to place riprap materials or use other structural means for protection of the shoreline to prevent continuous erosion.

Subp. 5. **Port development or improvement.** Filling necessary for port development or improvement is allowed only on those waters that are under the jurisdiction of established port authorities subject to the following:

A. no filling is allowed to extend beyond the limits of federally established harbor lines, or when no harbor line has been established, beyond the maximum distance waterward which could be attained without obstructing navigational use of the waters;

B. the proposed development is part of a comprehensive port development plan that has been approved by the commissioner; and

C. adverse effects of the proposed filling on the physical and biological character of the area are subject to mitigation measures approved by the commissioner.

Subp. 6. **Fish and wildlife habitat.** Filling to restore or improve fish and wildlife habitat, except for filling in designated trout streams, shall be permitted provided plans are submitted showing the nature and degree of habitat to be benefited, and the project will not create other adverse effects such as flooding, erosion, sedimentation, or navigational obstructions.

Subp. 7. **Trout streams.** Filling in trout streams officially designated by the commissioner is allowed only if:

A. the amount, method of placement, and location of the fill will not result in increased water temperatures, excessive sedimentation in the stream, or destruction of fish habitat; and

B. there is no other feasible or practical alternative other than filling.

Subp. 8. **Other purposes.** Filling for other purposes not specifically listed shall be subject to the general standards in part 6115.0190, subparts 2 to 5 and submission of information to show that:

A. the intended purpose of the fill is reasonable with respect to all other alternatives and there are no feasible and practical means to attain the intended purpose without filling; and

B. the proposal will adequately protect public safety and promote the public welfare.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 27 SR 529*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0192 RELATIONSHIP TO STANDARDS AND CRITERIA FOR OTHER ACTIVITIES INVOLVING CHANGES IN COURSE, CURRENT, OR CROSS-SECTION.

Unless otherwise specified in other parts, parts 6115.0190 and 6115.0191 shall apply to filling proposed as part of any other activity or activities including but not limited to: Excavations parts 6115.0200 to 6115.0202, Structures parts 6115.0210 to 6115.0212, Water level controls parts 6115.0220 to 6115.0222, Bridges and culverts parts 6115.0230 to 6115.0232, Drainage of public waters parts 6115.0270 to 6115.0272, and Alterations of public waters for mining part 6115.0280.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0200 EXCAVATION OF PUBLIC WATERS.

Subpart 1. **Goals.** It is the goal of the department to limit the excavation of materials from the beds of public waters in order to:

A. preserve the natural character of public waters and their shorelands, in order to minimize encroachment, change, or damage to the environment, particularly the ecosystem of the waters;

B. regulate the nature, degree, and purpose of excavations so that excavations will be compatible with the capability of the waters to assimilate the excavation; and

C. control the deposition of materials excavated from public waters and protect and preserve the waters and adjacent lands from sedimentation and other adverse physical and biological effects.

Subp. 2. **Scope.** Excavation as used in this part includes any activity that results in the displacement or removal of bottom materials or the widening, deepening, straightening, realigning, or extending of public waters. It may involve proposals for excavations landward or waterward from the ordinary high water level.

Subp. 3. **Prohibited excavation.** Excavation is prohibited in the following cases:

A. where it is intended to gain access to navigable water depths when such access can be reasonably attained by alternative means which would result in less environmental impact;

B. where inland excavation is intended to extend riparian rights to nonriparian lands, or to promote the subdivision and development of nonriparian lands;

C. when the proposed excavation will be detrimental to significant fish and wildlife habitat and there are no feasible, practical, or ecologically acceptable means to mitigate the effects;

D. when the proposed excavation will take threatened or endangered species listed in chapter 6134 without authorization by the commissioner according to parts 6212.1800 to 6212.2300;

E. where it is intended to provide fill materials for development purposes except as provided under part 6115.0280;

F. where the excavation would not provide an effective solution to a problem because of recurrent sedimentation and there are feasible and practical alternative solutions which do not require excavation;

G. unless the excavation project includes provisions for acceptable disposal of excavated materials as provided in these rules; or

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

H. where the excavation would cause increased seepage of water which would lower the water level of public waters and result in subsurface drainage.

Subp. 4. **No permit required.** No permit for excavation is required for the following activities unless prohibited in subpart 3:

A. for excavations in a public watercourse having a total drainage area, at its mouth, of five square miles or less, if the watercourse is not an officially designated trout stream and the excavation will not result in:

(1) any diversions of water from the drainage area;

(2) any impoundment of waters by damming the watercourse; or

(3) any actions that would result in erosion and cause sedimentation of downstream waters as determined by the county or local soil and water conservation district;

B. to remove debris such as trees, logs, stumps, and trash provided such removal does not alter the original alignment, slope, or cross-section of the waters; or

C. for repair of a public drainage system lawfully established under Minnesota Statutes, chapters 103D and 103E, and sponsored by the public drainage authority consistent with the definition of "repair" in Minnesota Statutes, section 103E.701, subdivision 1.

Subp. 5. **Permits required.** Permits are required for the excavation and removal of any materials from public waters or any excavations extending into or out of public waters, except as provided in subparts 3 and 4, and a project is subject to the following general criteria:

A. the project is reasonable and practical based upon geologic and hydrologic conditions, including but not limited to:

(1) quantity and quality of local drainage at the site;

(2) type of sediment/soil strata and underground formations in the vicinity;

(3) life expectancy of the excavation with respect to bedload, longshore drift, and siltation patterns in the project vicinity; and

(4) protection of the water body from increased seepage, pollution, and other hydrologic impacts;

B. the disposal of excavated materials is subject to the following requirements:

(1) the disposal of any excavated materials containing pollutants is subject to requirements of Minnesota Statutes, chapter 115; and

(2) the most acceptable means of disposing of clean materials, free from pollutants, that are excavated from public waters listed in order of preference are:

(a) complete removal of excavated materials from the waters and disposal or reuse for other purposes outside of the floodplain;

(b) deposition in stable on-land disposal sites located above the ordinary high water level and outside of floodway districts established under local ordinance. Provisions must be included for sodding, seeding, or otherwise properly stabilizing these materials;

(c) temporary deposition along shorelines or within floodplains by stockpiling materials for subsequent removal to areas outside of any public waters and outside of established floodplain

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

districts provided that: any stockpile materials are removed within one year of stockpiling; and the stockpile is constructed so that any materials or waters entering or leaving the stockpile are controlled to prevent any introduction of sediment into the environment surrounding the stockpile;

(d) redeposition of excavated materials, consisting of inorganic materials free from pollutants, into public waters shall only be permitted when it will result in improvement of natural conditions of public waters for the public benefit and will not result in sedimentation, obstruction of navigation, or a loss of fish or wildlife habitat. Separate permit provisions are required for redeposition of excavated materials subject to the standards and criteria of subparts 2 to 5; and

(e) determination of the public benefit served by redeposition of excavated materials is based on the value to the public of redeposited materials in order to protect shorelines from the damaging effects of erosion due to winds and waves when there are no other feasible, practical, and ecologically acceptable means to protect the shoreline; or create or improve habitat areas for fish and wildlife; or mitigate or enhance the physical and biological environment within public waters when mitigative or enhancement measures are required as a condition of a permitted activity within the waters involved and there are no other feasible, practical, and ecologically acceptable mitigative measures;

C. the proposed project represents the "minimal impact" solution to a specific need with respect to all other reasonable alternatives and does not exceed more than a minimum encroachment, change, or damage to the environment, particularly the ecology of the waters;

D. the excavation is limited to the minimum dimensions necessary for achieving the desired purpose;

E. when excavation is proposed in a public water that is perched on an impervious stratum, soil borings show that the proposed excavation will not rupture the impervious stratum;

F. the biological character of the waters and surrounding shorelines is affected to the minimum degree feasible and practical;

G. adverse effects on the physical or biological character of the waters are subject to feasible and practical measures to mitigate the effects;

H. the water supply, navigational, and drainage characteristics of the waters is protected to ensure that the interests of the public and of private riparian landowners are not adversely affected by the proposed excavation;

I. the proposed excavation is consistent with applicable floodplain, shoreland, and wild and scenic rivers management standards and ordinances for the waters involved;

J. the proposed excavation is consistent with plans and management programs of local and regional governments, provided that such plans are consistent with state plans and programs; and

K. for harbors, boat slips, and other mooring facilities, the excavation is appropriately sized to provide a single mooring space for each riparian lot to be served. The number of mooring spaces to be provided shall generally be the amount of natural shoreline to be served divided by the lot requirements of the local land use control authority and the state shoreland management standards.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; L 1985 c 172 s 80; L 1985 1Sp16 art 2 s 19; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0201 SPECIFIC STANDARDS; EXCAVATION.

Subpart 1. **In general.** In addition to compliance with the general standards in part 6115.0200, subparts 2 to 5, specific requirements shall be met for the activities described in subparts 2 to 7.

Subp. 2. **Excavations for beach development.** The existing site conditions will not provide a suitable beach using a sand blanket alone. When the proposal includes the installation of a beach sand blanket, the area to be excavated shall be consistent with the criteria for filling under part 6115.0190, subparts 2 to 5. The depth of excavation needed to reach a suitable beach stratum shall be the minimum depth necessary considering anticipated site maintenance and reasonable water depths for a beach.

Subp. 3. **Waterbasin excavations.** Excavations for improvement or enhancement of hydrologic and biologic conditions in all, or large portions of waterbasins:

A. A public need for the excavation has been established by local governmental resolution specifying the public interests to be improved or enhanced, except where the project is state sponsored.

B. The proposed project is intended to achieve one or more of the following public purposes:

(1) to improve navigation, swimming, and other recreational uses;

(2) to reduce winter fish-kill potential;

(3) sediment removal to eliminate a source of nutrients and/or contaminants.

C. The proposed excavation is part of an overall improvement or enhancement project based upon adequate background and field test data for which a comprehensive plan is submitted at the time of application detailing all of the following:

(1) Objectives to be accomplished, and an analysis of any alternative means considered to meet the objectives and the rationale for selecting excavation.

(2) Sufficient soil boring and bottom sampling data to evaluate sediment quality and bottom "seal" conditions. Where excavation is proposed on a waterbasin that is perched on an impervious stratum, soil borings must show that the proposed excavation will not rupture the impervious stratum.

(3) The methods, uses, and locations to be employed in excavating and disposing of excavated material consistent with the provisions of parts 6115.0190 to 6115.0192.

(4) Existing water quality data and provision for future water quality monitoring including any water returned to the waterbasin during the removal of excavated materials.

(5) A timetable which indicates anticipated yearly excavation areas and volumes of materials to be removed, plus the selected disposal methods, uses, and deposition locations for each excavation period.

(6) A detailed description of proposed excavation and disposal equipment and facilities, including, where applicable, the length of discharge pipe purchased or available for the project and the pumping characteristics of the equipment.

Subp. 4. **Excavations for navigation-related purposes.** Excavations for navigation-related purposes:

A. Access channels from shorelines for recreational craft. Excavations for accesses from shorelines to reach navigable depths shall not be allowed if access could reasonably be obtained through use of a dock to reach navigable depths, and prevalent wind, wave, and current conditions would not impair reasonable access to reach navigable depths.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

When shoreline conditions and wind, wave, and current conditions preclude access to navigable depths, excavations for navigational access shall be allowed provided the access channel shall not exceed four feet in depth, more than 15 feet in bottom width, and will not extend to an offshore water depth greater than four feet.

B. Other navigational channels. Excavations shall be limited to the minimum depth and width necessary to allow reasonable use of anticipated watercraft.

Excavations to provide maintenance of navigational channel projects shall be limited to the length, width, and depth dimensions of the original channel.

Subp. 5. **Harbors and boat slips.** Harbors and boat slips:

A. Excavations for development of offshore or inland harbors or boat slips for the mooring of more than 25 watercraft or watercraft larger than 20 feet in length shall be restricted to those waters which have the following characteristics:

(1) waterbasins having areas of 1,000 acres or more;

(2) watercourses which are used for commercial or industrial navigational purposes.

B. Excavations for development of offshore harbors serving fewer than 25 watercraft shall be limited to those water areas where the location of the proposed offshore harbor would not create unreasonable obstructions to public use and navigation on the water involved. Unreasonable obstructions include any development which would result in threats to public health, safety, or welfare.

C. Excavations for development of private inland harbors or boat slips serving fewer than 25 watercraft or watercraft less than 20 feet in length shall be limited to those waters where:

(1) prevalent wind, wave, or current conditions along the shoreline where excavation is proposed are of a magnitude and frequency which precludes the use and maintenance of docks to moor watercraft. Determinations of magnitude and frequency which would inhibit use of docks shall be based on supporting facts including:

(a) the character of the water involved and its shoreline in relation to exposure to severe wind, wave, or current actions and the configuration and area of the water;

(b) the frequency of occurrence of storms producing severe winds and waves based on climatological data for the area; and

(c) the average number of days during each month of the navigational season when the shoreline is affected by severe winds, waves, or currents;

(2) the presence of lake bed and bank conditions would preclude the use and maintenance of docks and the conditions of the site and the number, type, or size of watercraft intended to be moored would preclude the development and use of on-land facilities, such as rollers, winch and track systems, sliderails, or other facilities which could be used to haul watercraft out of the water for on-land storage; or

(3) the proposed site is located in an area of the water body where offshore mooring or excavations or extensive dock development would create unreasonable obstructions to public use and navigation of the water body.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

D. The width and length of boat slips shall not exceed 150 percent of the width and length of the anticipated watercraft and all authorized boat slips shall be oriented to maximize the degree of wave protection.

E. Excavations for development of inland harbors shall be limited to those waters described in item C and shall meet the following additional requirements:

(1) Requirements applicable to all commercial and industrial inland harbors:

(a) The mooring area of the harbor shall be compactly shaped in order to minimize the surface area excavated in relation to the number of mooring spaces to be provided and shall be located at an adequate distance from the shoreline to provide wave protection and prevent breakthrough.

(b) No branch or connecting channels shall be permitted extending laterally outward from authorized inland excavations.

(c) If practical, a "dogleg" shall be incorporated in the approach channel located between the mooring area and the shoreline to minimize visual impact from the water body and promote wave dissipation.

(d) The excavation shall not extend more than 200 feet inland from the public water unless evidence is provided to show that greater distances are required because of the dimensions of the watercraft to be moored.

(e) The methods, use, and deposition locations to be employed in disposing of excavated materials shall be consistent with the provisions of part 6115.0200, subpart 5, item B.

(2) An application for a permit shall contain plans, maps, and supporting data regarding proposed excavation site soil borings, ground water levels and characteristics, water quality, topography, drainage, and vegetation which shall substantiate that the proposed project must be reasonable and practical based upon geologic and hydrologic conditions including:

(a) quantity and quality of stream flow and local drainage at the proposed project site;

(b) water stagnancy problems including the capability of being flushed or drained;

(c) interference with stream flow or longshore drift;

(d) type of soil strata and underground formations in the project vicinity;

(e) protection of the water body itself in terms of reduced water supply, increased seepage or drainage, pollution, increased flooding, and other adverse hydrological impacts;

(f) adequate entrance openings;

(g) ample turning radius;

(h) adequate depth and size for the anticipated watercraft usage;

(i) adequate reduction of wave heights in mooring areas;

(j) proper harbor shape to reduce wave resonance;

(k) need for and feasibility of maintenance dredging;

(l) adequate height of perimeter wall;

(m) need for wave absorbers within the harbor; and

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(n) bank stabilization by appropriate erosion control measures.

(3) Additional requirements applicable to specific types of harbors. Private inland harbors serving two or more single family residential riparian lots shall, if practical, be located along the mutual boundary of properties to be served.

Private inland harbors for proposed multifamily or cluster developments, residential planned unit developments, or for resorts, campgrounds, or other commercial purposes. The development plan shall be approved by the local governmental unit. The permit shall be of the title-registration type including a provision that the individual waterfront lots in the development have priority rights to the available mooring spaces thus obviating issuance of future permits for individual harbors for these lots. The harbor shall be appropriately sized, consistent with the number of watercraft to be served. For residential and commercial planned unit developments, the number of mooring spaces to be permitted shall be consistent with part 6120.3800.

Public inland harbor projects must be justified by:

(a) a public need for the proposed inland harbor established by local governmental resolution specifying public interests to be enhanced;

(b) the harbor shall be appropriately sized consistent with the demand for mooring facilities in the area and the number of watercraft to be served;

(c) the harbor shall be available for use by the general public; and

(d) the harbor may extend more than 200 feet inland provided the plans minimize the total length by which the public water is proposed to be extended in keeping with the number of watercraft to be served and the topography.

Subp. 6. **Excavations for fish and wildlife habitat improvement.** Excavation to restore or improve fish and wildlife habitat require plans showing the nature and degree of habitat to be benefited, and information showing that the project will not create other adverse effects such as flooding, erosion, sedimentation, or navigational obstructions.

Excavations in trout streams officially designated by the commissioner shall be allowed only if:

A. the amount, method, and location of the excavation will not result in increased water temperatures, cause excessive sedimentation in the stream, or destruction of fish habitat; and

B. there is no other feasible or practical alternative other than excavation.

Subp. 7. **Excavations in public watercourses.** Except as noted in part 6115.0200, subpart 4, a permit shall be required for any excavation in a public watercourse and shall be subject to the following specific requirements in addition to the general requirements of part 6115.0200, subparts 2 to 5:

A. The watercourse capacity shall be sufficient to adequately convey normal runoff.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. The watercourse bottom gradients shall be such that normal low flow velocities are nonerosive and the sideslopes shall be graded such that bank slumping is not a hazard. Where excavation will result in excessive bank erosion, energy dissipation structures, channel and bank protection, or other engineering measures shall be required.

C. The outlet shall be adequate in that it:

(1) sufficiently conveys the discharge waters from the area proposed for excavation;

(2) does not produce substantial increases in downstream overbank flooding; and

(3) does not produce downstream erosion hazards as a result of the watercourse excavation.

D. When projects involve widening or straightening which alters the watercourse banks, all sideslopes which contribute direct surface runoff into the authorized altered watercourse, and a strip of land along both sides of the watercourse, one rod wide or to the top of the spoil bank, whichever is the greater, shall be seeded and maintained in permanent grasses. No mowing of this grassed strip shall be allowed until after July 31 of each year.

E. The alignment and slope of the excavated channel shall be such as to provide a smooth transition between the existing and the excavated channel.

F. Disposal of excavated material from channel excavation shall be consistent with part 6115.0200, subpart 5, except where the original channel is allowed to be filled as part of the project.

G. No significant increase in flood damages will be permitted. Floodwater retardance structures may be required to minimize any increase in flood damage.

H. The applicant shall submit the names and addresses of landowners located immediately upstream, downstream, and adjacent to any proposed watercourse alteration resulting from excavation. In addition, the applicant shall submit the names and addresses of other landowners and occupants that the commissioner, after reviewing the plans for the proposed excavation, believes will have a substantial interest in the channel change or will be substantially affected by the watercourse alteration.

I. The preferred alternative to widening, deepening, or straightening a watercourse for control of flood waters is the construction of water impoundment structures in upstream areas. Where impoundments are infeasible, impractical, or would result in adverse effects on health and safety or greater adverse environmental effects, the preferred alternative is the construction of flood bypass channels to convey high velocity flood flows.

Excavations in public watercourses for flood management purposes shall be allowed only where an upstream impoundment or a flood bypass channel is infeasible or impractical or excavation is the least damaging environmentally.

Excavations for widening, deepening, or straightening portions of watercourses shall be based on flood management plans which provide details on the relationship of the proposed excavation to management of flood flows for the entire watercourse and shall be consistent with state standards and state

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

approved local standards for floodplain management including maximum use of nonstructural measures where feasible and practical.

J. Excavations shall be limited to the minimum extent necessary to facilitate construction of the road crossing and shall include provisions for adequate riprap or other bank protection measures to protect altered banks from erosion.

K. Excavations for construction of sediment traps or settling basins to control sedimentation and water quality shall be based on plans approved by the Pollution Control Agency or the local soil and water conservation district and shall be consistent with any state and local standards, regulations, and requirements.

L. Watercourse channel excavations to restore or improve fish and wildlife habitat shall require plans showing the nature and degree of habitat to be benefited, and information showing that the project will not create other adverse effects such as flooding, erosion, sedimentation, or navigational obstructions.

M. Watercourse channel excavations in trout streams officially designated by the commissioner shall only be allowed if:

(1) the amount, method, and location of the channel excavation will not result in increased water temperatures, cause excessive sedimentation in the stream, or destruction of fish habitat; and

(2) there is no other feasible or practical alternative other than channel excavation.

N. The straightening or realignment of a watercourse with a total drainage area, at its mouth, greater than five square miles shall only be permitted where the project will not result in increased downstream flooding, erosion, or sedimentation. Where it is proposed to straighten or realign a watercourse with a total drainage area, at its mouth, greater than five square miles, the applicant may be required to submit appropriate hydraulic data. Such data may include:

(1) contributing watershed above the project;

(2) data for the flood of record;

(3) maximum observed high water level;

(4) flow data, based on the best available technology as follows:

(a) existing and proposed time of concentration;

(b) existing and proposed stage downstream;

(c) existing and proposed mean velocity downstream;

(5) certification that the data was prepared by a registered professional engineer.

O. The alteration of watercourses by straightening or realigning channels to facilitate adjacent land use shall be allowed only if the applicant provides evidence:

(1) that the alteration is reasonable, practical, and will adequately protect public safety and welfare; and

(2) that the alteration will involve a minimum of encroachment, change, or damage to the environment, particularly to the ecological system of the waterway.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

P. All other proposals for excavations in public watercourses shall meet the general requirements of part 6115.0200, subparts 2 to 5 and the specific requirements of subparts 2 to 6 and shall require submission of supporting evidence as provided in items N and O.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0202 RELATIONSHIP TO STANDARDS AND CRITERIA FOR OTHER ACTIVITIES INVOLVING CHANGES IN COURSE, CURRENT, OR CROSS-SECTION.

Unless otherwise specified in other parts, parts 6115.0200 and 6115.0201 shall apply to excavations proposed as part of any other activity or activities including but not limited to: filling, parts 6115.0190 to 6115.0192; structures, parts 6115.0210 to 6115.0212; water level controls, parts 6115.0220 to 6115.0222; bridges and culverts, parts 6115.0230 to 6115.0232; drainage of public waters, parts 6115.0270 to 6115.0272; and alterations of public waters for mining, part 6115.0280.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0210 STRUCTURES IN PUBLIC WATERS.

Subpart 1. **Goals.** It is the goal of the department to limit the occupation of public waters by offshore navigational facilities, retaining walls, and other structures in order to:

A. preserve the natural character of public waters and their shorelands;

B. provide a balance between the protection and utilization of public waters; and

C. encourage the removal of existing structures which do not serve the public interest from the beds of public waters at the earliest practicable date.

Subp. 2. **Scope.** This part applies to the placement, construction, reconstruction, repair, relocation, abandonment, or removal of any structure placed on or in public waters.

Subp. 3. **Prohibited placement of structures.** Placement of structures, temporary structures, and floating structures is prohibited when the structure, temporary structure, or floating structure:

A. will obstruct navigation or create a water safety hazard;

B. will be detrimental to significant fish and wildlife habitat. Construction is prohibited in posted fish spawning areas;

C. is designed or intended to be used for human habitation or as a boat storage structure;

D. is designed or intended to include walls, a roof, or sewage facilities; or

E. will take threatened or endangered species listed in chapter 6134 without authorization by the commissioner according to parts 6212.1800 to 6212.2300.

Subp. 4. **No permit required.** No permit is required for the following activities, unless prohibited under subpart 3:

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

A. to construct, reconstruct, or install a dock, floating or temporary structure, watercraft lift, or mooring facility if:

(1) the structure or mooring facility will not constitute a hazard to navigation or public health, safety, and welfare, as determined by the commissioner;

(2) the structure will allow the free flow of water beneath it;

(3) the structure or mooring facility is not used or intended to be used as a marina;

(4) the structure or mooring facility is consistent with or allowed under local land use controls, as determined by the local government land use authority;

(5) the length of the structure is limited to that necessary to accomplish its intended use, including reaching navigable water depths;

(6) the structure, other than a watercraft lift or watercraft canopy, is not more than eight feet in width and is not combined with other similar structures so as to create a larger structure; and

(7) docks placed on rock filled cribs are located only on waters where the bed is predominantly bedrock, which is incapable of accepting pilings;

B. to construct or reconstruct a boat launching ramp if:

(1) privately owned ramps do not exceed 12 feet in width and do not extend more than ten feet beyond the shoreline or into water more than four feet in depth, whichever is less. Excavations five cubic yards or less, and placement of up to five cubic yards of crushed rock, gravel, clean sand, or small stone are allowed to provide a stable base or maintain use of the ramp;

(2) publicly owned ramps do not exceed 36 feet in width and do not extend more than 30 feet waterward of the shoreline or into water more than four feet in depth, whichever is less. Excavations of 200 cubic yards or less, and placement of up to 80 cubic yards of crushed rock, gravel, clean sand, or small stone are allowed to provide a stable base or maintain use of the ramp. The use of coffer dams constructed of metal sheet piling or other portable materials is allowed to construct and maintain public boat launching ramps if all materials are completely removed from public waters within 30 days of completion of the project;

(3) the ramp is constructed of gravel, natural rock, concrete, steel matting, or other durable inorganic material not exceeding seven inches in thickness; and

(4) the ramp is not located on a federally designated wild and scenic river; or

C. to remove structures or other waterway obstructions if:

(1) the original cross-section and bed conditions are restored insofar as practicable;

(2) the structure is completely removed including any footings or pilings that obstruct navigation;

(3) the structure is not located on an officially designated trout stream; and

(4) the structure does not function as a water level control device.

Subp. 5. **Permits required; criteria.** Permits are required for the construction, reconstruction, repair, or relocation of any structure or mooring facility on or in public waters, except as provided under subparts 3 and 4, and a project must meet the following general criteria:

A. the proposed project must represent the minimal impact solution to a specific need with respect to all other reasonable alternatives;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. the project does not exceed more than a minimum encroachment, change, or damage to the environment, particularly the ecology of the waters;

C. the proposed structure is consistent with applicable floodplain, shoreland, and wild and scenic rivers management standards and ordinances for the waters involved;

D. adverse effects on the physical or biological character of the waters are subject to feasible and practical measures to mitigate the effects;

E. the proposed structure is consistent with water and related land management plans and programs of local and regional governments, provided these plans and programs are consistent with state plans and programs; and

F. except for mooring facilities and boat ramps, all new structures have a title-registered permit, unless a public agency or local governmental unit accepts responsibility for future maintenance or removal.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0211 SPECIFIC STANDARDS; STRUCTURES.

Subpart 1. **In general.** In addition to compliance with the general standards in part 6115.0210, subparts 2 to 5, specific requirements shall apply to the activities described in subparts 3 to 8.

Subp. 2. [Repealed, 27 SR 529]

Subp. 3. **Wharves.** A permit is required for the construction or reconstruction of all wharves. The following order of preference for construction types shall be utilized: bulkheaded shoreline, inland slip with bulkheaded sidewalls, and wharf projecting into public waters.

Wharves shall be approved if the structure:

A. is part of a designated port facility;

B. is consistent with local land use plans and ordinances;

C. does not extend further waterward than any existing wharves in the area or beyond any established harbor line, whichever is less;

D. is of the minimum practicable size; and

E. is not an obstruction to flood flows or longshore drift and is adequately designed to resist the natural forces of ice, wind, and wave.

Subp. 4. **Breakwaters.** A permit is required for the construction or reconstruction of all offshore breakwaters. These structures shall be approved if the following general conditions and the additional listed specific conditions are met:

A. alternative dock or inland facilities are infeasible;

B. the structure is limited to those waters where:

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(1) prevalent wind, wave, or current conditions along the shoreline are of a magnitude and frequency that preclude the use and maintenance of docks to moor watercraft. Determinations of magnitude and frequency that would inhibit the use of docks is based on supporting facts including:

(a) the character of the water involved and its shoreline in relation to exposure to severe wind, wave, or current actions and the configuration and area of the water;

(b) the frequency of occurrence of storms producing severe winds and waves based on climatological data for the area; and

(c) the average number of days during each month of the navigational season when the shoreline is affected by severe wind, waves, or currents; and

(2) the conditions of the site and the number, type, or size of watercraft intended to be moored would preclude the development and use of on-land facilities, such as rollers, winch and track systems, sliderails, or other facilities that could be used to haul watercraft out of the water for on-land storage;

C. the facility is adequate in relation to appropriate engineering factors, including but not limited to those listed in part 6115.0201, subpart 5, item E, subitem (2), units (f) to (n);

D. the plan is adequate in relation to the geologic and hydrologic factors listed in part 6115.0201, subpart 5, item E, subitem (2), units (a) to (e);

E. the structure is designed in a compact fashion so as to blend in with the surrounding shoreline and so that all mooring and maneuvering activities can be normally confined to an area bounded by the property lines as extended into the public waters while minimizing the surface area occupied in relation to the number of watercraft to be served; and

F. the breakwaters do not exceed the minimum thickness necessary to withstand the anticipated forces consistent with maintenance requirements and are faced with an adequate layer of natural rock riprap of appropriate size and gradation.

Subp. 4a. **Mooring facilities.** Except as provided in part 6115.0210, subpart 4, item A, a permit is required for the construction of all offshore mooring facilities. A mooring facility shall be approved if the following general conditions and the additional listed specific criteria are met:

A. the mooring facility is designed in a compact fashion so as to blend in with the surrounding shoreline and so that all mooring and maneuvering activities can be normally confined to an area bounded by the property lines as extended into public waters while minimizing the surface area occupied in relation to the number of watercraft to be served;

B. the mooring facility minimizes encroachment waterward of the ordinary high water level;

C. for docks or mooring facilities more than eight feet in width, the applicant provides reasonable justification that the proposed width represents the minimal impact solution to a specific need with respect to all reasonable alternatives; and

D. offshore mooring facilities shall be approved, subject to the listed specific conditions:

(1) private offshore mooring facilities not serving as marinas, if the mooring facility is consistent with or allowed under local land use controls, as determined by the local government land use authority;

(2) public offshore mooring facilities not serving as marinas, if:

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(a) a local unit of government passes a resolution that specifies the public interests to be benefited by the proposal;

(b) the mooring facility is appropriately sized consistent with the demand for mooring facilities in the area and the number of watercraft to be served; and

(c) the mooring facility is available for use by the general public; and

(3) offshore marinas, if:

(a) the area is zoned for such use or the local government land use authority grants a land use permit; and

(b) the marina is sized consistent with the demand for mooring facilities in the area and the number of watercraft to be served.

Subp. 5. **Retaining walls and erosion and sedimentation control structures.** A permit is required for the construction or reconstruction of all retaining walls and erosion and sedimentation control structures that do not impound water. The construction of retaining walls is discouraged because their appearance is generally not consistent with the natural environment and their construction and maintenance cost is generally greater than riprap.

The issuance of permits is contingent on the following conditions:

A. existing or expected erosion problems preclude the use of riprap shore protection, there is a demonstrated need for direct shoreland docking, or the design is consistent with existing uses in the area. Examples are: riverfront commercial-industrial areas having existing structures of this nature, dense residential shoreland areas where similar retaining walls are common, resorts where floating docks may be attached to such a bulkhead, or where barges are utilized to transport equipment and supplies;

B. adequate engineering studies are performed of foundation conditions, tiebacks, internal drainage, construction materials, and protection against flanking;

C. the facility is not an aesthetic intrusion upon the area and is consistent with all applicable local, state, and federal management plans and programs for the water body; and

D. encroachment below the ordinary high water level is held to the absolute minimum necessary for construction.

Subp. 6. **Boat launching ramp.** A permit is required for the construction or reconstruction of any boat launching ramp not covered under part 6115.0210, subpart 4, item B, and shall be granted if:

A. the applicant demonstrates a need for a launching facility;

B. the proposed ramp is of the minimum dimensions necessary for launching of watercraft;

C. the proposed ramp does not obstruct flowing water; and

D. construction does not necessitate alteration of shoreland that could result in substantial erosion and sedimentation.

Subp. 6a. **Boathouses.** A permit is required for the construction, reconstruction, relocation, removal, or repair of a boathouse. The permit shall be granted if the following conditions are met:

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

A. the boathouse is located in an area of historic boathouse use. "Historic boathouse use" shall be determined by the commissioner and shall be based on a review of factual information such as photographs, local government comments, newspaper accounts, or other relevant information;

B. the boathouse is approved by the local unit of government by means of a resolution with supporting documentation that identifies the owner, length, width, height, number of rooms, and sanitary facilities of the boathouse; and

C. the boathouse was located on public waters before January 1, 1997.

Subp. 6b. **Energy exchangers.** A permit is required for the construction, reconstruction, relocation, or repair of energy exchangers located on the bed of a public water. The permit shall be granted if the following general conditions and the additional listed specific conditions are met:

A. there are no other feasible and practical alternative sites for the project that would have less environmental impact;

B. a closed loop design is utilized;

C. the facility is designed in accordance with sound engineering practices;

D. the facility is not located in a designated trout stream or lake, a designated wild and scenic river, or an outstanding resource value water as defined in part 7050.0180;

E. the facility is designed in a fashion and located so as not to cause a navigation hazard;

F. the facility will not exceed more than a minimum encroachment, change, or damage to the environment, particularly the ecology of the waters;

G. the facility will not take threatened or endangered species identified in chapter 6134 without authorization by the commissioner according to parts 6212.1800 to 6212.2300;

H. the facility will not contain substances, if released into public waters, that would be detrimental to water quality or plant or animal life forms; and

I. the construction, relocation, or reconstruction of privately owned structures shall be permitted only when a federal, state, or local governmental agency accepts responsibility for future maintenance of the facility or its removal in the event that the private owner fails to maintain or abandons the facility.

Subp. 7. **Other facilities.** A permit is required for the construction, reconstruction, relocation, removal, repair, and abandonment of all other offshore structures, boat storage structures, cables other than utility crossings, pilings, or other structures not covered by specific regulations.

A. Permits for structural repair, relocation, or modification, other than minor maintenance work such as reroofing, painting of structures, or similar work, shall be issued if all of the following conditions are met:

(1) the applicant demonstrates a need for the work;

(2) the cost of the work will not exceed 50 percent of the replacement cost of the structure;

(3) the degree of permanence of the structure will not be materially increased by virtue of constructing a new foundation or replacing the majority of the structure above the foundation;

(4) the structure being repaired has appropriate permits from the local land use or sanitary authority; and

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(5) the degree of obstruction or structure size is not increased.

B. Permits for construction, relocation, or reconstruction of publicly owned structures shall be issued where:

(1) public need is documented and outweighs adverse environmental impact;

(2) the site is adequately protected from the forces of ice and wave pressures; and

(3) the proposed construction is of sound design and is not necessarily obtrusive or visually incompatible with the natural surroundings.

C. The construction, relocation, or reconstruction of privately owned structures, other than docks and mooring facilities, shall be permitted only when a governmental agency or local unit of governmental accepts responsibility for future maintenance of the structure or its removal.

Subp. 8. **Removal of structures.** Where the commissioner has determined that a structure is no longer functional, constitutes a public nuisance or a hazard to navigation, or poses a threat to public health or safety, the structure shall be removed from public waters under the applicable provisions of these rules. Except as provided under part 6115.0210, subpart 4, item C, a permit is required for the removal or abandonment of all existing waterway obstructions including boathouses, bridges, culverts, pilings, piers, and docks. Permits shall be issued provided:

A. the original cross-section and bed conditions will be restored insofar as practicable;

B. adequate provisions are made to mitigate any side effects resulting from removal, such as restoration of wave or current forces; and

C. no portion of the structure remains which would obstruct or impair navigation, interfere with the passage of flood waters, or contribute to erosion and sedimentation.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0212 RELATIONSHIP TO STANDARDS AND CRITERIA FOR OTHER ACTIVITIES INVOLVING CHANGES IN COURSE, CURRENT, OR CROSS-SECTION.

Unless otherwise specified in other parts, parts 6115.0210 and 6115.0211 shall apply to structures proposed as part of any other activity or activities including but not limited to: filling, parts 6115.0190 to 6115.0192; excavations, parts 6115.0200 to 6115.0202; water level controls, parts 6115.0220 to 6115.0222; bridges and culverts, parts 6115.0230 to 6115.0232; drainage of public waters, parts 6115.0270 to 6115.0272; and alterations of public waters for mining, part 6115.0280.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0215 RESTORATION OF PUBLIC WATERS.

Subpart 1. **Goals.** It is the goal of the department to encourage the restoration of public waters to:

A. improve and protect fish and wildlife habitat and the diversity of the habitat;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. preserve the natural character of public waters and their shoreline zones;

C. encourage the use of natural materials for shoreline zone protection and restoration;

D. limit the removal of natural materials from the beds of public waters; and

E. prevent erosion and siltation of public waters, while maintaining natural processes.

Subp. 2. **Scope.** This part applies to placement, construction, reconstruction, repair, relocation, abandonment, or other work needed to restore or protect public waters or to removal of any materials, structure, fill, water level control, excavation, or drainage device placed on or in public waters. For purposes of this part, "restoration" means the repair, reconstruction, or recreation of essentially natural or native conditions of a public water and its shoreline or banks. This part does not apply to restoration orders issued by the commissioner consistent with part 6115.0255.

Subp. 3. **Prohibited work.** Public waters alteration, protection, or restoration work is prohibited when the work:

A. is detrimental to significant fish and wildlife habitat and there are no feasible, practical, or ecologically acceptable means to mitigate the effects;

B. takes threatened or endangered species listed in chapter 6134 without authorization by the commissioner according to parts 6212.1800 to 6212.2300;

C. obstructs navigation or creates a water safety hazard, as determined by the commissioner;

D. violates the regulations of any local zoning authority or water management agency;

E. results in the creation of land above the ordinary high water level that is not deemed essential by the commissioner as part of the project;

F. uses materials that are not clean and free of pollutants, nutrients, and exotic species sources;

G. manipulates water levels solely to satisfy private interests; or

H. will adversely impact public infrastructure, particularly roads and drainage systems.

Subp. 4. **No permit required.** No permit is required for the following activities, unless prohibited elsewhere in parts 6115.0150 to 6115.0280:

A. to perform bank or shoreline zone restoration work using willow wattles, willow posts, brush mattressing, brush layering, fiber roll breakwaters, plant carpets, root wads, and other natural materials installed by hand for the purpose of shoreline zone restoration work, if:

(1) the project is approved by the commissioner and designed or reviewed by the local soil and water conservation district or the local watershed district;

(2) the design does not interfere with navigation or other riparian uses of the waterbody;

(3) the project is done during times of the year when it will not interfere with fish spawning or the nesting of protected bird species;

(4) local origin native plant species, adapted for the site, are used;

(5) an aquatic plant management permit is obtained, when aquatic macrophytes are used;

(6) the waterward encroachment is the minimum necessary for the purpose of the project; and

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(7) a maintenance plan is developed for the project and a copy submitted for review to the department area fisheries office;

B. to remove or grade an ice ridge, if all of the following conditions are met:

(1) the ice ridge resulted from ice action within the last year;

(2) the project is either exempt from local permits or is authorized by issuance of a local government permit;

(3) the total length of shoreline zone to be affected does not exceed 200 feet;

(4) all ice ridge material that is composed of muck, clay, or organic sediment is deposited and stabilized at an upland site above the ordinary high water level of any public water;

(5) all ice ridge material that is composed of sand or gravel is removed as provided in subitem (4) or graded to conform to the original cross-section and alignment of the lakebed, with a finished surface at or below the ordinary high water level;

(6) no additional excavation or placement of fill material occurs on the site;

(7) all exposed areas are immediately stabilized as needed to prevent erosion and sedimentation; and

(8) local zoning officials, the watershed district, if applicable, and the soil and water conservation district are given seven days' prior notice;

C. to construct, reconstruct, or abandon a water level control structure on a public watercourse with a contributing watershed of 300 acres or less, except on officially designated trout streams, if the structure does not qualify as a dam under parts 6115.0300 to 6115.0520;

D. to excavate or place fill for the purpose of planting or collecting native aquatic plants for restoration purposes, if the work is authorized by an aquatic plan management permit; and

E. to install natural rock riprap and associated filter materials where there is a demonstrated need to prevent erosion or to restore eroded shoreline, when there is a demonstrated need for such work, except along the shores of Lake Superior and officially designated trout streams, if:

(1) the rock is sized appropriately with the erosion potential of the wave or current action of the particular water body, but in no case shall the rock average less than six inches in diameter or more than 30 inches in diameter;

(2) the rock is placed so that it conforms to the natural alignment of the shoreline zone;

(3) the finished slope, as measured on top of the rocks, is not steeper than three to one (horizontal to vertical);

(4) no materials are placed more than six feet waterward of the ordinary high water level, unless the commissioner determines that this dimension may be measured from another point due to the particular nature of water levels of the public water;

(5) the total length of shoreline to be affected does not exceed 200 feet for public waterbasins or public water wetlands or five times the width of the public watercourse measured at bank full conditions;

(6) the riprap does not cover emergent vegetation, unless authorized by an aquatic plant management permit;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(7) the riprap does not obstruct navigation or the flow of water;

(8) a filter, consisting of crushed rock, gravel, or suitable filter fabric material is placed underneath the rock; and

(9) the rock and any filter material are free from organic material, soil, clay, debris, trash, or any material that may cause siltation or pollute the waterbody.

Subp. 5. **Permit required; criteria.** A permit is required for the restoration of public waters, except as provided under subpart 4, and shall be granted if all of the following conditions are met:

A. the proposed project represents the minimal impact solution to a specific need with respect to all other reasonable alternatives;

B. the proposed project is intended to achieve one or more of the following purposes:

(1) improve navigational or recreational uses;

(2) improve or restore fish or wildlife habitat;

(3) expose sediment to remove or eliminate nutrients or contaminants;

(4) restore shorelines or watercourse channels to more natural conditions;

(5) improve or restore natural hydrologic conditions; or

(6) improve or restore water quality;

C. the project does not exceed more than a minimum encroachment, change, or damage to the environment, particularly the ecology of the waters;

D. adverse effects of the proposed project on the physical or biological character of the waters are avoided when possible and are subject to feasible and practical measures to mitigate the effects;

E. the proposed project is consistent with applicable floodplain, shoreland, and wild and scenic rivers management standards and ordinances for the waters involved;

F. the proposed project is consistent with water and related land management plans and programs of local and regional governments, provided the plans and programs are consistent with state plans and programs; and

G. projects that involve the placement of fill to recover shoreland lost by erosion or other natural forces are subject to part 6115.0191, subpart 4, except that part 6115.0191, subpart 4, does not preclude the issuance of a permit to place riprap materials or use other structural and vegetative means for protection of the shoreline zone to prevent continuing erosion.

Statutory Authority: *MS s 103G.315*

History: *27 SR 529*

Posted: *June 11, 2008*

6115.0216 SPECIFIC STANDARDS; RESTORATION.

Subpart 1. **In general.** In addition to compliance with the general standards in part 6115.0215, subparts 2 to 5, specific requirements apply to the activities described in subparts 2 to 6.

Subp. 2. **Riprap shore protection.** The protection of shoreline from continued erosion by placement of natural rock riprap along the shore shall be approved if:

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

A. the riprap materials are of sufficient size, quality, and thickness to withstand ice and wave action. The riprap must be placed with a minimum amount of space between the larger materials and the space between them must be filled with firmly seated smaller rocks or gabion baskets to procure a uniform surface;

B. the site soils are capable of supporting riprap and a filter consisting of well-graded gravel, crushed stone, or fabric is installed to prevent undercutting of the riprap;

C. when site conditions warrant, the toe end of the riprap is installed in a trench excavated into the bed of the public water to anchor the riprap from ice and wave action, with all excavated materials either used to back fill behind the riprap or removed from the bed of the public water;

D. the encroachment into the water is the minimum amount necessary to provide protection and does not unduly interfere with the flow of water; and

E. adequate engineering studies are done to certify the adequacy of the design of the riprap project, if deemed necessary by the area hydrologist.

Subp. 3. **Bioengineering projects.** The grading or filling of materials below the ordinary high water level to facilitate the installation or use of willow wattles, willow posts, brush mattressing, brush layering, fiber roll breakwaters, plant carpets, root wads, and other natural materials for erosion protection and shoreline zone restoration purposes shall be approved if:

A. the methods and materials used are designed in consultation with department or local government staff experienced in the use of such materials;

B. excavation and fill placement needed in conjunction with bioengineering projects are minimized and are subject to all requirements related to fill and excavation in parts 6115.0190, 6115.0191, 6115.0200, and 6115.0201; and

C. a separate aquatic plant management permit is obtained whenever the project involves planting aquatic plants other than willow and dogwood.

Subp. 4. **Structural erosion control projects.** Installation of rock gabions, A-jacks, cable concrete, bendway weirs, interlocking concrete blocks, eddy rocks, deflectors, gravel riffles, or other structural methods of erosion control or bank stabilization shall be approved if:

A. adequate engineering studies are performed to determine the suitability for use of any of these types of erosion control projects, as determined by the department;

B. the project is not an aesthetic intrusion upon the area and is consistent with all applicable local, state, and federal management plans, programs, and ordinances relating to the affected waterbody;

C. encroachment below the ordinary high water level is limited to the minimum necessary for the construction project;

D. when the project involves the removal of aquatic plants, a separate aquatic plant management permit is obtained;

E. the project does not adversely impact native plants, trees, or animals; and

F. any retaining wall complies with requirements for structures under parts 6115.0210 and 6115.0211.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 5. **Wave breaks.** Grading, filling, or excavation to install rock, silt fence, or any other material or device designed solely for the purpose of protecting native aquatic plants from wave or current action during their establishment shall be approved if:

A. the materials do not obstruct navigation or the flow of water;

B. the project is done in conjunction with an issued aquatic plant management permit; and

C. temporary (less than two years) wave breaks are preferred over permanent structures, which must also meet the requirements of parts 6115.0210 and 6115.0211.

Subp. 6. **Other erosion control projects.** Using a structure, material, fill, excavation, or other technique that is not covered under subparts 2 to 5 and that is designed primarily to control erosion of the shoreline zone or to restore the shoreline zone to a more natural condition or altering the shoreline zone in any way that is not covered by specific regulations shall be approved if:

A. the intended purpose of the project is reasonable with respect to all other alternatives;

B. any method of erosion control that is not widely accepted as being effective is used only as a temporary or experimental project, provided that the project sponsor must totally repair the shoreline zone if the project proves to be unsuccessful within five years. A public entity must be a cosponsor of the temporary or experimental project and accept responsibility for maintenance, repair, and removal of the project;

C. the project complies with all other federal, state, and local regulations and ordinances; and

D. the project adequately protects public safety and promotes the public welfare.

Subp. 7. **Contaminated site restoration projects.** Restoration of a site contaminated with materials or water determined to be hazardous or toxic through a publicly funded study or site cleanup process shall be approved if:

A. the study includes a discussion of alternative approaches to restore the contaminated site; and

B. the commissioner, in consultation with the Minnesota Pollution Control Agency, participated in either the development of the site restoration plan or study and concurs with the site restoration plan or study recommendations or participated in the development of the site restoration funding initiative and concurs with the funded initiative.

Statutory Authority: *MS s 103G.315*

History: *27 SR 529*

Posted: *June 11, 2008*

6115.0217 APPLICATION OF OTHER STANDARDS; RESTORATION.

Unless otherwise specified in other parts, parts 6115.0215 and 6115.0216 apply to projects proposed as part of any other activity or activities including, but not limited to:

A. filling, parts 6115.0190 to 6115.0192;

B. excavations, parts 6115.0200 to 6115.0202;

C. structures, parts 6115.0210 to 6115.0212;

D. water level controls, parts 6115.0220 to 6115.0222;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

E. bridges and culverts, parts 6115.0230 to 6115.0232;

F. drainage of public waters, parts 6115.0270 to 6115.0272; and

G. alterations of public waters for mining, part 6115.0280.

Statutory Authority: *MS s 103G.315*

History: *27 SR 529*

Posted: *June 11, 2008*

6115.0220 WATER LEVEL CONTROLS.

Subpart 1. **Goals.** It is the goal of the department to manage public waters to:

A. maintain or restore natural flow and natural water level conditions to the maximum feasible extent;

B. encourage the construction of small off-channel retarding structures for the conservation of water in altered, natural waterbasins, consistent with any overall plans for the affected watershed area; and

C. limit the artificial manipulation of water levels, except when the balance of affected public interests clearly warrants the establishment of appropriate controls and it is not proposed solely to satisfy private interests.

Subp. 2. **Scope.** The construction, repair, reconstruction, or abandonment of any structure intended to impound, divert, or control the level or flow of public waters is subject to the provisions of this part.

Subp. 3. **Prohibited water level control facilities.** Construction or reconstruction of water level control facilities is prohibited when it is intended to manipulate water levels solely to satisfy private interests.

Subp. 4. **No permit required.** No permit is required to construct, reconstruct, or abandon a water level control structure on public watercourses with a contributing watershed of 300 acres or less, except on officially designated trout streams, provided the structure does not qualify as a dam under the rules for dam safety.

Subp. 5. **Permits required.** Permits are required for the construction, repair, reconstruction, or abandonment of any water level control structure, except as provided in subparts 3 and 4, and a project must meet the following general criteria:

A. the project will involve a minimum of encroachment, change, or damage to the environment, including but not limited to fish and wildlife habitat, navigation, water supply, storm water retention, and agricultural uses;

B. adverse effects on the physical or biological character of the waters are subject to feasible and practical measures to mitigate the effects;

C. the proposed project is consistent with applicable floodplain, shoreland, and wild and scenic rivers management standards and ordinances for the waters involved;

D. the proposed project is consistent with water and related land management plans and programs of local and regional governments, provided such plans and programs are consistent with state plans and programs;

E. the construction or reconstruction complies with parts 6115.0300 to 6115.0520 with respect to dam safety for the protection of human life and property;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

F. the construction or reconstruction of water level control structures or changing the level of an existing structure shall be approved only to:

(1) control and store flood waters;

(2) maintain low flows for instream flow or water level protection;

(3) manage water quality, including the prevention or control of erosion and sedimentation;

(4) improve water-based recreation;

(5) create, improve, and maintain water supplies;

(6) create, improve, or maintain aquatic habitat for fish and wildlife species;

(7) establish, improve, or maintain the generation of hydroelectric power; or

(8) restore the existing control elevation to a historic natural water elevation if detailed engineering surveys establish that the proposed control elevation does not exceed the estimated natural control elevation; and

G. the construction or reconstruction of water level control structures or changing the level of an existing structure on watercourses shall be approved only to:

(1) control and store flood waters;

(2) improve water-based recreation;

(3) create, improve, and maintain water supplies;

(4) establish, improve, or maintain the generation of hydroelectric power; or

(5) create, improve, or maintain aquatic habitat for fish and wildlife species.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0221 SPECIFIC STANDARDS; WATER LEVEL CONTROLS.

Subpart 1. **Specific requirements.** In addition to the general standards in part 6115.0220, subparts 2 to 5, specific requirements for water level control structures shall be met according to this part.

Subp. 2. **Permanent lake level control facilities.**

A. Permanent lake level control facilities shall be approved when the commissioner initiates proceedings for the purpose of conserving or utilizing the water resources of the state and assumes responsibility for operation and future maintenance, or when all of the following conditions are met:

(1) the ordinary high water level and runout elevation of the water body have been determined by a detailed engineering survey, or by order of the commissioner following a public hearing;

(2) the proposed facilities are "reasonably consistent with natural conditions:"

(a) where a functioning outlet existed in a state of nature or for a long period of time following lawful creation or alteration of an outlet by the activities of people or animals, or cataclysmic events, the proposed outlet is at essentially the same control elevation;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(b) where no natural or artificial outlet exists and the lake is for all practical purposes "landlocked," the control elevation shall not be more than 1-1/2 feet below the ordinary high water level, unless the commissioner finds that:

i. the control is necessary to prevent adverse impacts to the lake or adjoining property;

ii. other reasonable or cost-effective alternatives are not available;

iii. natural resource or hydrologic conditions exist in the watershed that would limit the potential for continuous discharge of excess waters from the lake; and

iv. the outlet and discharge of excess waters is addressed in an approved water management plan under Minnesota Statutes, chapter 103B or 103D; and

(c) the commissioner may issue a permit to restore the existing control elevation to a historic natural water elevation if detailed engineering surveys establish that the proposed control elevation does not exceed the estimated natural control elevation;

(3) the project is sponsored by a governmental unit, which assumes responsibility for operation and future maintenance, except when:

(a) the majority of the riparian owners sign the permit application;

(b) appropriate easements or other property interests have been obtained from all affected owners;

(c) a title-registration type permit is issued to the owner or owners of the property upon which the proposed water level control structure will be located; and

(d) the structure will further public interests in navigation, propagation of fish or wildlife, or other beneficial public uses of the water;

(4) justification has been made of the need in terms of public and private interests and the available alternatives, including the impact on receiving waters and public uses thereof, through a detailed hydrologic study; and

(5) a detailed plan is developed for operation and control including:

(a) manner and time of operation;

(b) frequency of maintenance;

(c) appropriate monitoring of water levels, water quality, and other factors; and

(d) management of excess waters.

B. In addition to the requirements of item A, subitem (2), unit (b), if the proposed control elevation is more than 1-1/2 feet below the ordinary high water level, the permit applicant must serve a copy of the application on each county and municipality within which any portion of the lake is located and the lake improvement district, if one exists. The commissioner must not issue a permit to establish a control elevation more than 1-1/2 feet below the ordinary high water level of a lake if a county, municipality, watershed district, or lake improvement district required to be served under this item or Minnesota Statutes, section 103G.301, subdivision 6, files a written objection to the issuance of the permit with the commissioner within 30 days after receiving a copy of the application.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 3. **Fish and wildlife management.** Fish and wildlife management proposals made pursuant to Minnesota Statutes, section 97A.101, or other appropriate authority shall be approved when:

A. the public water has been designated for wildlife management purposes;

B. there is a specific water level management plan for the lake basin;

C. any drawdown of the lake is only temporary and the management plans include a permanent facility for restoration of water levels following such drawdowns;

D. any alteration of a watercourse included in the plan follows the requirements specified in part 6115.0201, subpart 7;

E. appropriate easements or fee title is obtained; and

F. specified management personnel are required to establish a lake level gauge and keep a record of water levels with a specified frequency during seasons of active water level manipulation and with a lesser frequency during all other open water seasons.

Subp. 4. **Certain landlocked waterbasins.** Plans for landlocked waterbasins less than 25 acres in surface area and contained completely within the municipal boundaries of a single city shall be approved when:

A. a municipal drainage plan for the affected tributary watershed is prepared by a qualified engineer or hydrologist and is approved by the affected watershed district and the city;

B. the city has a field survey made of the waterbasin after consultation with the department, including but not limited to:

(1) the elevation of the aquatic vegetation fringe;

(2) the elevation of the tree line and a description of the location, type, and size of representative trees;

(3) groundwater elevations, if appropriate; and

(4) other information as requested by the department;

C. control elevations and associated physical parameters are approved by the department and the city; and

D. the city holds a public hearing on the proposal and provides a transcript of the proceedings to the department. Provision of a transcript may be waived by the department.

Subp. 5. **Other controls.** Permits for the construction, reconstruction, and abandonment of water level control structures not covered under subparts 2 to 4 shall be issued if:

A. the need is established in terms of quantifiable benefits;

B. the structural design is done by a professional engineer or by a qualified engineer of the Natural Resources Conservation Service or the Corps of Engineers and includes the following considerations:

(1) gravity forces;

(2) hydrostatic pressure;

(3) uplift forces;

(4) overturning moment;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(5) resistance to sliding;

(6) ice pressures;

(7) earthquake forces;

(8) slope stability, including consolidation and pore pressures;

(9) seepage collection or prevention;

(10) foundation conditions, including appropriate borings and determination of the strength of foundation materials;

(11) specifications for materials of construction and their placement or installation;

(12) adequate construction inspection to assure conformance with design assumptions; and

(13) adequacy of the cofferdam or diversion during construction, if any; and

C. adequate assurances are made for future maintenance of new water level control structures:

(1) for water level control structures 25 feet or more in structural height or having a maximum storage capacity of 50 acre-feet or more, permits shall be issued only to governmental agencies, public utilities, or corporations having authority to construct and maintain such projects, except that a title-registration type permit may be issued to the owner or owners of the private property upon which the proposed water level control structure will be located when the provisions of subpart 2, item A, subitem (3), are met;

(2) for other water level control structures, title-registration type permits shall be issued to the owner or owners of the private property upon which the water level control structure will be located if the permit runs with the land and requires breaching or removal if the structure ever falls into a state of disrepair or becomes unsafe; and

(3) periodic engineering inspections of authorized water level control structures may be made by the department or its designee.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; L 1986 c 386 art 1 s 19; 17 SR 1279; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0222 RELATIONSHIP TO STANDARDS AND CRITERIA FOR OTHER ACTIVITIES INVOLVING CHANGES IN COURSE, CURRENT, OR CROSS-SECTION.

Unless otherwise specified in other parts, parts 6115.0220 and 6115.0221 shall apply to water level control structures proposed as part of any other activity or activities including but not limited to: filling, parts 6115.0190 to 6115.0192; excavations, parts 6115.0200 to 6115.0202; structures, parts 6115.0210 to 6115.0212; bridges and culverts, parts 6115.0230 to 6115.0232; drainage of public waters, parts 6115.0270 to 6115.0272; and alterations of public waters for mining, part 6115.0280.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0230 BRIDGES AND CULVERTS, INTAKES AND OUTFALLS.

Subpart 1. **Goals.** It is the goal of the department to allow crossings of public waters, including the construction of water intake and sewer outfall structures in public waters, only when less detrimental alternatives are unavailable or unreasonable, and where such facilities adequately protect public health, safety, and welfare.

Subp. 2. **Scope.** The construction or reconstruction of any bridge, culvert, intake, outfall, or other crossing of public waters is subject to this part. Abandonment or removal of all crossings and structures governed by this part requires a permit according to part 6115.0211, subpart 8.

Subp. 3. **Prohibited crossings.** Crossings are prohibited when the project:

A. will obstruct navigation or create a water safety hazard;

B. will cause or contribute to significant increases in flood elevations and flood damages either upstream or downstream;

C. involves extensive channelization above and beyond minor stream channel realignments to improve hydraulic entrance or exit conditions, except when a separate permit is obtained according to part 6115.0201, subpart 7;

D. will be detrimental to water quality or significant fish and wildlife habitat;

E. will take threatened or endangered species listed in chapter 6134 without authorization by the commissioner according to parts 6212.1800 to 6212.2300; or

F. will provide private access to an island.

Subp. 4. **No permit required.** No permit is required to construct the following types of crossings on public waters, unless prohibited in subpart 3:

A. to construct or reconstruct a bridge or culvert on a public watercourse with a total drainage area, at its mouth, of five square miles or less, except on officially designated trout streams;

B. to construct or reconstruct a low-water ford type crossing, if:

(1) the stream bed is capable of supporting the crossing without the use of pilings, culverts, dredging, or other special site preparation;

(2) the water depth does not exceed two feet under normal summer flow conditions;

(3) the crossing conforms to the natural cross-section of the stream channel and does not reduce or restrict normal low-water flows;

(4) the original stream bank at the site does not exceed four feet in height;

(5) the crossing is constructed of gravel, natural rock, concrete, steel matting, or other durable inorganic material not exceeding one foot in thickness;

(6) the approach is graded to a finished slope not steeper than 5:1 horizontal:vertical, and all graded banks are seeded or mulched to prevent erosion and sedimentation; and

(7) the crossing is not placed on an officially designated trout stream, on a wild, scenic, or recreational river, or on an officially designated state water trail;

C. to construct or reconstruct a temporary bridge, if:

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(1) the stream bank is capable of supporting the bridge without the use of foundations, pilings, culverts, excavation, or other special site preparation;

(2) nothing is placed in the bed of the stream;

(3) the bridge is designed and constructed so that it can be removed for maintenance and flood damage prevention;

(4) the bridge is firmly anchored at one end and so constructed as to swing away to allow flood waters to pass;

(5) the lowest portion of the bridge is at least three feet above the ordinary high water level on navigable streams; and

(6) the bridge is consistent with state and local rules and regulations for floodplain, shoreland, and wild, scenic, or recreational rivers management standards and ordinances;

D. to maintain the hydraulic adequacy of any storm sewer or agricultural drain tile outfall or ditch that has been functioning within the previous five years, if such work does not alter the original course, current, or cross-section of the public waters; or

E. to install an agricultural drain tile outletting into public waters, if the bank is restored to the original cross-section or contour and no permanent structure is placed below the ordinary high water level, except for the drain tile.

Subp. 5. **Permits required.** Permits are required for the construction or reconstruction of any bridge, culvert, intake, outfall, or other crossing of public waters, except as provided in subparts 3 and 4, and a project must meet the following general criteria:

A. the project must not exceed more than a minimum encroachment, change, or damage to the environment, particularly the ecology of the waters;

B. adverse effects on the physical or biological character of the waters are subject to feasible and practical measures to mitigate the effects;

C. the proposed crossing is consistent with applicable floodplain, shoreland, and wild and scenic rivers management standards and ordinances for the waters involved;

D. the proposed crossing is consistent with water and related land management plans and programs of local and regional governments, provided such plans and programs are consistent with state plans and programs; and

E. crossings of public waterbasins or public water wetlands are allowed only when there is no feasible and practical alternative that does not require filling, excavating, or the placement of a structure in public waters.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529; L 2010 c 361 art 4 s 82*

Posted: *July 23, 2010*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0231 SPECIFIC STANDARDS; BRIDGES, CULVERTS, INTAKES, AND OUTFALLS.

Subpart 1. **Specific requirements.** In addition to the general standards in part 6115.0230, subparts 2 to 5, specific requirements for bridges, culverts, intakes, outfalls, and other crossings of public waters shall be met according to this part.

Subp. 2. **Bridges, culverts, and other crossings.** The construction, reconstruction, or relocation of all bridges, culverts, or other crossings over public waters shall be approved if all of the following criteria are met:

A. the hydraulic capacity of the structure is established by a competent technical study. The sizing shall not be based solely on the size of existing upstream and downstream structures. If a state or federal floodplain information study exists for the area, or a United States Geological Survey gaging station is located nearby on the stream, the hydraulics of the proposed bridge/culvert design must be consistent with these data. The department may waive this requirement if:

(1) the department has performed a hydraulic study based upon available information and reasonable assumptions;

(2) the department has made a field investigation of the project site; and

(3) the project will not cause flood-related damages or problems for upstream or downstream interests;

B. new crossings and replacements of existing crossings comply with local floodplain management ordinances, with provisions of part 6120.5700, subpart 4, item A, and with the following:

(1) for new crossings, no approach fill for a crossing shall encroach upon a community designated floodway. When a floodway has not been designated or when a floodplain management ordinance has not been adopted, increases in flood stage in the regional flood of up to one-half of one foot shall be approved if they will not materially increase flood damage potential. Additional increases may be permitted if: a field investigation and other available data indicate that no significant increase in flood damage potential would occur upstream or downstream, and any increases in flood stage are reflected in the floodplain boundaries and flood protection elevation adopted in the local floodplain management ordinance;

(2) for replacement of existing crossings, if the existing crossing has a swellhead of one-half of one foot or less for the regional flood, the replacement crossing shall comply with the provisions for new crossings in subitem (1). If the existing crossing has a swellhead of more than one-half of one foot for the regional flood, stage increases up to the existing swellhead shall be allowed if field investigation and other available data indicate that no significant flood damage potential exists upstream from the crossing based on analysis of data submitted by the applicant. The swellhead for the replacement crossing may exceed the existing swellhead if it complies with the provisions for new crossings found in subitem (1); and

(3) the decks and approaches to bridges or culverts on major transportation routes and on roads that provide access to development at urban densities shall be no lower than two feet below the flood protection elevation as defined in part 6120.5700, subpart 5, unless it can be shown that alternative routes or access can be provided during the regional flood;

C. the structure provides for game fish movement, unless the structure is intended to impede rough fish movement or the stream has negligible fisheries value;

D. the structure will not obstruct reasonable public navigation. For bridges over public watercourses, three feet above the calculated 50-year flood stage ordinarily satisfies navigational clearance

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

requirements. For bridges over public waterbasins or public water wetlands, and all culverts, three feet of clearance above the ordinary high water level ordinarily satisfies navigational requirements;

E. any project proposed near an existing or proposed segment of the state trails system should be consistent therewith; and

F. bridges and walkways to islands comply with the following:

(1) bridges and walkways over watercourses to islands must be designed to cause negligible backwater effects during floods and must be securely anchored or otherwise capable of withstanding the dynamic forces of flowing water, ice, and debris; and

(2) permits for reconstruction of existing bridges or walkways over public waterbasins and public water wetlands to islands that are intended to provide public access shall be issued only if the existing crossing provides the only existing land access to the island, there is existing development on the island, and the design provides for any public navigational needs and is consistent with the natural surroundings.

Subp. 3. **Intakes and outfalls.** The construction, reconstruction, or relocation of all water intake and sewer outfall structures placed in public waters shall be approved if all of the following criteria are met:

A. adequate attention is given to methods of screening the structure from view as much as possible from the surface of the public water through the use of existing vegetation or new plantings;

B. the project is not detrimental to public values, including but not limited to fish and wildlife habitat, navigation, water supply, water quality, or storm water retention;

C. no site conditions will require frequent future disruption of the beds of public waters;

D. adequate precautions are planned during and after construction to prevent silt, soil, and other suspended particles from being discharged into public waters;

E. adjacent to the intake structure, the banks and bed of the public water are protected from erosion and scour by placement of suitable riprap shore protection;

F. the banks are revegetated by seeding and/or sodding;

G. the structure is designed by a professional engineer;

H. for intake structures, excavation is detailed in the application and on design plans. When necessary, a water appropriation permit must be obtained from the department prior to operation of the intake structure. An appropriate sized screen must be used to prevent fish intake; and

I. outfall structure design:

(1) when necessary, incorporates a stilling-basin, surge-basin, energy dissipator, or other device or devices to minimize disturbance and erosion of natural shoreline and bed resulting from peak flows;

(2) when feasible, utilizes discharge to stormwater treatment ponds, artificial stilling or sedimentation basins, or other devices for entrapment of floating trash and litter, sand, silt, debris, and organic matter prior to discharge to public waters; and

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(3) when feasible, maximizes use of natural or artificial ponding areas to provide water retention and storage for the reduction of peak flows into public waters.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0232 RELATIONSHIP TO STANDARDS AND CRITERIA FOR OTHER ACTIVITIES INVOLVING CHANGES IN COURSE, CURRENT, OR CROSS-SECTION.

Unless otherwise specified in other parts, parts 6115.0230 and 6115.0231 shall apply to bridges and culverts proposed as part of any other activity or activities including but not limited to: filling, parts 6115.0190 to 6115.0192; excavations, parts 6115.0200 to 6115.0202; structures, parts 6115.0210 to 6115.0212; water level controls, parts 6115.0220 to 6115.0222; drainage of public waters, parts 6115.0270 to 6115.0272; and alterations of public waters for mining, part 6115.0280.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0240 APPLICATION FOR PUBLIC WATERS WORK PERMITS.

Subpart 1. **Forms and submission.** All applications pursuant to parts 6115.0150 to 6115.0280 shall be made on forms prepared by the department and submitted to the regional office for the area where the majority of the proposed project is located.

Subp. 2. **Who may apply.** Applications shall be submitted by the riparian owner of the land on which a project is proposed, except:

A. a governmental agency, public utility, or corporation authorized by law to conduct the project may apply if the property rights acquired or to be acquired are fully described in the application;

B. a holder of appropriate property rights such as a lease or easement may apply if the application is countersigned by the owner and accompanied by a copy of the lease or other agreement. A permit shall be issued for the term of the lease only, subject to cancellation prior to the termination date of the agreement if the agreement is canceled; and

C. a prospective lessee of state-owned lands may apply for a permit in the applicant's own name after requesting a lease from the departmental official responsible for the affected lands. Both the lease request and the permit application shall be processed concurrently with appropriate coordination.

Subp. 3. **Information required.** Pursuant to Minnesota Statutes, section 103G.305, an application is complete when:

A. it includes all of the information specified in parts 6115.0150 to 6115.0280;

B. it is accompanied by appropriate photographs, maps, sketches, drawings, or other plans that adequately describe the proposed project;

C. it includes a brief statement regarding the following points:

(1) anticipated changes in water and related land resources;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(2) unavoidable anticipated detrimental effects on the natural environment;

(3) alternatives to the proposed action;

(4) that the proposed project is reasonable and practical and will adequately protect public safety and promote the public welfare; and

(5) a demonstration by the applicant that the proposed activity authorized by part 6115.0190, subpart 5; 6115.0200, subpart 5; 6115.0210, subpart 5; 6115.0215, subpart 5; 6115.0220, subpart 5; 6115.0230, subpart 5; 6115.0270, subpart 4; or 6115.0280, subpart 4, complies with all the following principles in descending order of priority:

(a) avoids direct or indirect impacts to public waters that may destroy or diminish the public waters;

(b) minimizes the impact to the public water by limiting the degree or magnitude of the public water activity and its implementation;

(c) rectifies the impact by repairing, rehabilitating, or restoring the affected public water;

(d) reduces or eliminates the impact to the public water over time by preservation and maintenance operations; and

(e) for a major change in the public waters, replaces unavoidable impacts to the public water by restoring degraded or impacted public waters having equal or greater public value or, if public waters restoration opportunities are not reasonably available, creating and protecting additional replacement water areas having greater public value;

D. application fees are paid. Final permits shall not be issued until any field inspection fees are paid; and

E. proof of service of a copy of the application and accompanying documents on the mayor of the city or the secretary of the board of the district is included with the application if the project is within or affects a city, watershed district, or soil and water conservation district.

Subp. 4. **Fees.** All applications shall be accompanied by an application fee as required by part 6115.0060. An additional fee may be charged for field inspections conducted by department personnel in the course of review subject to the provisions of part 6115.0080.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 17 SR 1279; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0250 PERMIT REVIEW.

Subpart 1. **Field inspection.** The department may conduct field investigations to determine a project's nature, scope, and impact on water and related land resources. The department shall determine which applications must be investigated and such inspections shall be made in a timely fashion.

Subp. 1a. **Effect on environment and mitigation.** The commissioner may not issue a permit that causes pollution, impairment, or destruction of the air, water, land, or other natural resources so long as there is a feasible and prudent alternative consistent with the reasonable requirements of the public health, safety, and welfare. If the commissioner determines that a major change in public waters is justified and

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

can be authorized by parts 6115.0190, subpart 5; 6115.0200, subpart 5; 6115.0210, subpart 5; 6115.0215, subpart 5; 6115.0220, subpart 5; 6115.0230, subpart 5; 6115.0270, subpart 4; or 6115.0280, subpart 4, the permit must include provisions to compensate for the detrimental aspects of the change. Compensation for the identified detrimental aspects of the permitted project include:

A. restoring degraded or impacted public waters having equal or greater public value;

B. creating or restoring additional replacement water areas having equal or greater public value; or

C. any other measures approved by the commissioner that compensates for the detrimental aspects of the change.

Subp. 2. **Coordination with other agencies.** Nothing in these standards is intended to supersede or rescind the laws, rules, regulations, standards, and criteria of other federal, state, regional, or local governmental subdivisions with the authority to regulate work in the beds or on the shorelands of public waters. The issuance of a permit shall not confer upon an applicant the approval of any other unit of government for the proposed project. The department shall coordinate the review with other units of government having jurisdiction in such matters.

Subp. 3. **Procedure upon decision.** The commissioner may grant permits, with or without conditions, or deny them. In all cases, the applicant, the managers of the watershed district, the board of supervisors of the soil and water conservation district, or the mayor of the city may demand a hearing in the manner specified in Minnesota Statutes, section 103G.311, within 30 days after receiving mailed notice outlining the reasons for denying or modifying an application. Any hearing shall be conducted as a contested case hearing before an administrative law judge from the independent Office of Administrative Hearings according to Minnesota Statutes, chapter 14 and section 103G.311.

Subp. 4. **General permits.** The commissioner is authorized to issue general permits to a governmental subdivision or to the general public for classes of activities having minimal impact on public waters under which more than one activity may be conducted with a single permit.

Subp. 5. **Public water wetland permit processing.**

A. Public waters work permit applications submitted to the commissioner for proposed projects in public water wetlands shall be granted if authorized by parts 6115.0190 to 6115.0232 or parts 6115.0270 to 6115.0280 and if the public water wetland is:

(1) assigned a shoreland classification;

(2) classified as lacustrine wetland or deepwater habitats according to the document under item C; or

(3) where the state or federal government has become titleholder to any of the beds or shores of the public water wetlands, subsequent to the preparation of the public waters inventory maps on file with the auditor of the county and where the responsible state or federal agency declares that the water is necessary for purposes of public ownership.

B. All other public waters work permit applications for proposed projects in public water wetlands shall be:

(1) granted, with or without conditions, if authorized by parts 6115.0190 to 6115.0232 or 6115.0270 to 6115.0280 and if the permit application complies with provisions for sequencing under part

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

8420.0520, and replacement provisions under parts 8420.0522 to 8420.0544, 8420.0810, and 8420.0820, or denied; or

(2) waived pursuant to item D.

C. The following documents are incorporated by reference:

(1) Classification of Wetlands and Deepwater Habitats of the United States, Lewis M. Cowardin et al., United States Department of the Interior, Fish and Wildlife Service (1979); and

(2) Guidelines for Ordinary High Water Level (OHWL) Determinations, John Scherek and Glen Yakel, Minnesota Department of Natural Resources, Division of Waters (June 1993).

These documents are available through the Minitex interlibrary loan system and are not subject to frequent change.

D. Public waters work permits in public water wetlands:

(1) notwithstanding parts 6115.0150 to 6115.0280, the authority of the commissioner to require a permit for activities within public water wetlands is waived to the local unit of government under chapter 8420 when the commissioner has received notice or application from the landowner or project sponsor and when the commissioner has provided the applicant or project sponsor and the local unit of government a notice within 15 days of receipt of the notice or permit application that the department will waive public waters work permit jurisdiction to the local unit of government; or

(2) the commissioner shall not waive the requirement for a public waters work permit in a public water wetland for activities:

(a) allowed under part 8420.0122, subparts 1 to 7 and 10;

(b) in public water wetlands assigned a shoreland classification;

(c) in public water wetlands classified as lacustrine wetland or deepwater habitats according to the document under item C; or

(d) in public water wetlands where the state or federal government has become titleholder to any of the beds or shores of the public water wetlands, subsequent to the preparation of the public waters inventory maps on file with the auditor of the county and where the responsible state or federal agency declares that the water is necessary for purposes of public ownership.

E. Notwithstanding parts 6115.0150 to 6115.0280, the authority of the commissioner to require a permit for public road activities that are associated with the repair, rehabilitation, reconstruction, or replacement of currently serviceable existing public roads is waived to the public road authority under chapter 8420:

(1) for projects that affect less than 10,000 square feet of public water wetlands, upon receipt of a copy of the state, city, county, or town public road authority report that is submitted to the Board of Water and Soil Resources in compliance with part 8420.0544, item D, except for projects in public water wetlands:

(a) assigned a shoreland classification;

(b) classified as lacustrine wetland or deepwater habitats according to the document under item C, subitem (1); or

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(c) when the state or federal government has become titleholder to any of the beds or shores of the public water wetlands, subsequent to the preparation of the public waters inventory maps on file with the auditor of the county and when the responsible state or federal agency declares that the water is necessary for purposes of public ownership; or

(2) for projects that affect 10,000 square feet or more of public water wetlands, when the commissioner has provided the public road authority notice of the waiver within 15 days of receipt of a copy of the state, city, county, or town public road authority report that is submitted to the Board of Water and Soil Resources in compliance with part 8420.0544, item D, except for projects in public water wetlands:

(a) assigned a shoreland classification;

(b) classified as lacustrine wetlands or deepwater habitats according to the document under item C, subitem (1); or

(c) when the state or federal government has become titleholder to any of the beds or shores of the public water wetlands, subsequent to the preparation of the public waters inventory maps on file with the auditor of the county and when the responsible state or federal agency declares that the water is necessary for purposes of public ownership.

Subp. 6. **Wetland areas of public waters affected by public road permit projects.**

A. For purposes of this subpart, "wetland areas of public waters" means areas that are contiguous with the ordinary high water level and that generally exhibit emergent vegetation within:

(1) public waterbasins;

(2) public water wetlands assigned a shoreland classification;

(3) public water wetlands classified as lacustrine wetlands or deepwater habitats according to the document under item C; or

(4) public water wetlands where the state or federal government has become titleholder to any of the beds or shores of the public water wetlands subsequent to the preparation of the public water inventory maps on file with the auditor of the county and where the responsible state or federal agency declares that the water is necessary for purposes of public ownership.

B. Public waters work permit applications submitted by a public road authority to the commissioner for proposed projects in wetland areas of public waters shall be granted if authorized by parts 6115.0190 to 6115.0232 or 6115.0270 to 6115.0280.

C. The classification of lacustrine wetlands and deepwater habitats found in Classification of Wetlands and Deepwater Habitats of the United States, Lewis M. Cowardin et al., United States Department of the Interior, Fish and Wildlife Service (1979) is incorporated by reference. This document is available through the Minitex interlibrary loan system and is not subject to frequent change.

D. Notwithstanding parts 6115.0150 to 6115.0280, the authority of the commissioner to require a permit for public road activities in, on, or over wetland areas of public waters according to the document under item C is waived for:

(1) all activities authorized by the local government unit under chapter 8420 when the commissioner has received notice or application from the public road authority and when the commissioner has notified the public road authority and the local unit of government of the waiver within 15 working days of receipt of the notice or application; or

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(2) activities authorized by the public road authority having jurisdiction under chapter 8420 for public road activities that are associated with the repair, rehabilitation, reconstruction, or replacement of currently serviceable existing public roads when the commissioner has notified the public road authority of the waiver within 15 working days of receipt of a copy of the state, city, county, or town public road authority report that is submitted to the Board of Water and Soil Resources in compliance with part 8420.0544, item D.

Subp. 7. **Written agreements with local government units.**

A. For projects affecting both public waters and wetlands, the local government may, by written agreement with the commissioner, waive the requirement for a replacement plan or a no-loss or exemption determination if a public waters work permit is required and the commissioner includes provisions of Minnesota Statutes, sections 103A.201, 103B.3355, 103G.222, and 103G.2372, and rules adopted thereunder, in the public waters work permit.

B. The written agreement may be done on a project-by-project basis when:

(1) the agreement identifies the parties having authority to make the agreement and the proposed project subject to the agreement;

(2) the commissioner requires an individual public waters work permit for the proposed project;

(3) the majority of the proposed project impacts on public waters and wetlands are to public waters;

(4) the proposed wetland impacts are subject to approval of a wetland replacement plan or a no-loss or exemption determination by the local unit of government according to part 8420.0210, 8420.0220, or 8420.0230;

(5) the local government unit provides the commissioner with specific language addressing no-loss or exemption determinations or allowable wetland impacts and required wetland replacement for incorporation into the commissioner's public waters work permit; and

(6) the local government unit agrees to assist the commissioner should appeals be brought against the commissioner based on the language impacting the wetlands covered in the public waters work permit.

C. The written agreement may be done on a local unit of government basis, a watershed basis, a waterbody basis, or a project activity basis when:

(1) the written agreement identifies the parties having authority to enter into the agreement, the location of agreement application, and the scope of proposed activities subject to the agreement;

(2) the commissioner requires an individual public waters work permit for the proposed project;

(3) the majority of the proposed project impacts to public waters and wetlands are to public waters;

(4) the wetland impacts are subject to approval of a wetland replacement plan or a no-loss or exemption determination by the local unit of government according to part 8420.0210, 8420.0220, or 8420.0230;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(5) the local government unit provides the commissioner with specific language addressing no-loss or exemption determinations or allowable wetland impacts and required wetland replacement for incorporation into the commissioner's public waters work permit;

(6) the local government unit agrees to assist the commissioner should appeals be brought against the commissioner based on the language impacting the wetlands covered in the public waters work permit; and

(7) the agreement addresses enforcement procedures and procedures for the commissioner or the local government unit to terminate the written agreement.

Subp. 8. **Local plan implementation.** Notwithstanding parts 6115.0150 to 6115.0280, the commissioner may authorize alternative regulation of public waters activities that are specifically identified in a local plan, ordinance, or other similar written document approved by the commissioner and subject to the following:

A. the proposed activities are subject to the following principles in descending order of priority:

(1) avoid direct or indirect impacts to the public water that may destroy or diminish the public water;

(2) minimize the impact to the public water by limiting the degree or magnitude of the public water activity;

(3) rectify the impact by repairing, rehabilitating, or restoring the affected public water;

(4) reduce or eliminate the impact to the public water over time by preservation and maintenance operations; and

(5) replace unavoidable impacts to the public water when a major change in the resource is justified, by including provisions to compensate for the detrimental aspects of the change according to subpart 1a;

B. the proposed activities, their dimensional standards, the criteria used to issue or deny applications, and allowable locations are identified in the local plan;

C. adverse effects of the proposed activity on the physical and biological character of the area are subject to mitigation measures identified in the local plan;

D. the proposed activities are consistent with locally adopted controls;

E. the plan addresses enforcement procedures;

F. the plan includes procedures for the commissioner to reassume the permit authorities in parts 6115.0150 to 6115.0280 upon notice, if determined necessary by the commissioner or plan sponsor;

G. the local plan sponsor publishes a notice in the State Register identifying:

(1) the local plan sponsor that is developing an alternative plan for regulation of public waters;

(2) the scope of activities and the location of the public waters impacted by the plan;

(3) the groups the local plan sponsor has been working with in the development of the plan;

(4) the name and address of the local plan sponsor who can be contacted for copies of the plan, and the name and address of the plan contact for the department; and

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(5) a statement that the interested public has a time period of no less than 30 days in which to forward comments to the plan sponsor and the department plan contact for consideration before the plan sponsor submits the draft plan to the commissioner for approval;

H. when considering whether the plan should be approved, the commissioner shall determine that:

(1) the proposed plan, when not in conformity to parts 6115.0150 to 6115.0280, provides an explanation of how the proposed changes are justified;

(2) the public values provided by public waters subject to the plan are maintained or improved; and

(3) the proposed plan provides a mechanism for a periodic review of the plan contents and a procedure to revise the plan, if determined necessary by the commissioner and plan sponsor, or to terminate the plan upon notice being provided by either the plan sponsor or commissioner; and

I. nothing in the review of local plans proposed under this part shall be construed as prohibiting or discouraging a local plan from creating standards that are more restrictive than parts 6115.0150 to 6115.0280.

Statutory Authority: *MS s 14.386; 103G.315; 105.415*

History: *8 SR 533; L 1984 c 640 s 32; 25 SR 143; 27 SR 529; 32 SR 281; 34 SR 145*

Posted: *August 27, 2009*

6115.0255 PUBLIC WATERS ENFORCEMENT PROCEDURES.

Subpart 1. **Enforcement options.** Parts 6115.0150 to 6115.0280 may be enforced through one or any combination of the following authorities:

A. criminal proceedings under Minnesota Statutes, section 103G.141, subdivision 1;

B. orders of the commissioner under Minnesota Statutes, sections 103G.251 and 103G.315; and

C. cease and desist orders, restoration orders, and replacement orders under Minnesota Statutes, section 103G.2372.

The choice of enforcement authorities is dependent on the scope of the activity conducted without a public waters work permit.

Subp. 2. **Enforcement authorities.** The commissioner, conservation officers, and other peace officers may issue cease and desist orders and restoration and replacement orders according to Minnesota Statutes, section 103G.2372.

Subp. 3. **Cease and desist orders.**

A. Cease and desist orders may be issued when the enforcement authority has probable cause to believe that any activity is being or has been conducted in public waters without a valid permit from the commissioner.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. A cease and desist order must not be issued if a landowner has documentation of a valid public waters work permit from the commissioner authorizing the work that was done or if a landowner has documentation proving that no permit is required.

C. The cease and desist order shall direct a landowner to:

(1) stop all work, conduct no further work, and take immediate corrective action to stabilize the site from imminent erosion or restore water flow if ordered by the enforcement authority; and

(2) immediately submit a written project application form to the area hydrologist.

D. The enforcement authority issuing a cease and desist order shall promptly submit copies of the order to the commissioner.

E. The commissioner or agent shall review the evidence, including any evidence produced by a landowner, inspect the site if necessary, and determine:

(1) whether the area in question is a public water;

(2) whether a public waters work permit is required; and

(3) whether a public waters work permit application should be submitted or whether a restoration order or replacement order should be issued immediately, if it is determined that a public waters work permit application submitted in response to the cease and desist order would be denied in its entirety for being inconsistent with parts 6115.0150 to 6115.0280.

F. Pending a resolution of any criminal proceedings, if it is determined that the activity does not require a permit or if a permit is issued, the commissioner or agent shall request that the enforcement authority rescind the cease and desist order, pending the outcome of any decision that is appealed, and notify the soil and water conservation district, the commissioner, and the landowner. If the application is denied, the commissioner shall immediately notify the soil and water conservation district, the enforcement authority, and the landowner.

G. A cease and desist order must advise the landowner that violation of the order is a misdemeanor.

Subp. 4. **Restoration and replacement orders.**

A. If the commissioner or agent, with the concurrence of the enforcement authority, determines that restoration may not restore all the loss caused by the drain, excavate, structure, or fill activity, the enforcement authority may order restoration, a combination of restoration and replacement, or replacement rather than restoration.

B. The enforcement authority shall issue a restoration order or replacement order if:

(1) a cease and desist order has been issued and the landowner has not submitted a written project notification form to the area hydrologist within three weeks; or

(2) the commissioner has denied a permit application, determined that a permit application submitted for the activity subject to a cease and desist order would be denied in its entirety for being inconsistent with parts 6115.0150 to 6115.0280, or determined that some combination of restoration of the site and off-site restoration or replacement is necessary.

C. Promptly upon being informed of the need, the commissioner or agent shall inspect the site and prepare a plan for restoring the site. Restoration shall be ordered unless the commissioner or agent, with the concurrence of the enforcement authority, concludes that restoration would cause additional impairment

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

or further degradation of the public water. The commissioner or agent shall incorporate the restoration plan into a restoration order and send it to the enforcement authority for service in person or by certified mail to the landowner.

D. A restoration order must specify a date by which the landowner must restore the public waters according to the commissioner's plan and obtain a certificate of satisfactory restoration from the commissioner or agent.

E. A replacement order must specify a date by which the landowner must submit a replacement plan to the commissioner and a subsequent date by which the landowner must replace the public waters and obtain a certificate of satisfactory replacement from the commissioner or agent.

F. A restoration or replacement order must advise the landowner that violation of the order is a misdemeanor.

G. If, as part of a misdemeanor proceeding, the court orders restoration or replacement, the commissioner or agent, with the concurrence of the enforcement authority, shall determine which is appropriate, and if it is restoration, the method of restoration. If the court orders replacement, the landowner must follow the replacement plan ordered by the commissioner or agent.

H. If a landowner seeks approval of a public waters work permit after the proposed project has already impacted the public water, the commissioner may require the landowner to replace the impacted public water at a ratio not to exceed twice the replacement ratio otherwise required.

Subp. 5. **Appeals of replacement and restoration orders.**

A. A landowner may appeal the terms and conditions of a restoration or replacement order issued under subparts 2 to 4, to the commissioner, within 30 days of receipt of written notice by filing a written request for review. If the written request is not submitted within 30 days, the restoration or replacement order becomes final. The commissioner shall review the request and supporting evidence and render a decision within 60 days of the request for review.

B. If a landowner wishes to appeal the decision of the commissioner after review under item A, the landowner must file a written request within 30 days for a contested case hearing under Minnesota Statutes, chapter 14. The demand for hearing must be accompanied by a bond as required under Minnesota Statutes, section 103G.311, subdivision 6.

Statutory Authority: *MS s 14.386; 103G.315; L 2000 c 382 s 20*

History: *25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0260 STATUTORY REQUIREMENTS.

Further provisions for the administration of parts 6115.0150 to 6115.0280 are found in Minnesota Statutes, chapter 103G, including but not limited to sections 103G.135, 103G.141, 103G.241, 103G.251, 103G.295, 103G.301, 103G.305, 103G.311, and 103G.315.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0270 DRAINAGE OF PUBLIC WATERS.

Subpart 1. **Goals.** It is the goal of the department to protect and preserve public waterbasins and public water wetlands from damage or destruction by drainage.

Subp. 2. **Scope.** Parts 6115.0270 to 6115.0272 relate to the partial drainage or temporary drawdown of public waterbasins and public water wetlands for all purposes except mining of metallic or nonmetallic minerals which are subject to provisions of part 6115.0280.

Subp. 3. **Prohibited activity.** The permanent or total drainage of public waterbasins and public water wetlands is prohibited.

Subp. 4. **Permits required.** A permit is required for the partial drainage or temporary drawdown of public waterbasins and public water wetlands and shall be granted if all of the following conditions are met:

A. the proposed project is intended to achieve one or more of the following purposes:

(1) improve navigational or recreational uses;

(2) improve or restore fish or wildlife habitat;

(3) expose sediment in order to remove or eliminate nutrients or contaminants;

(4) alleviate flooding of agricultural lands caused by artificial obstruction of downstream drainage or increased upstream discharge; or

(5) allow the mining of iron ore, taconite, copper, copper-nickel, or nickel under Minnesota Statutes, section 103G.297;

B. the project will involve a minimum of encroachment, change, or damage to the environment, including but not limited to fish and wildlife habitat, navigation, water supply, water quality, and storm water retention;

C. adverse effects on the physical or biological character of the waters are subject to feasible and practical measures to mitigate the effects;

D. the proposed project is consistent with applicable floodplain, shoreland, and wild and scenic rivers management standards and ordinances for the waters involved; and

E. the proposed project is consistent with water and related land management plans and programs of local and regional governments, provided such plans and programs are consistent with state plans and programs.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0271 SPECIFIC STANDARDS; DRAINAGE.

In addition to compliance with the general standards in part 6115.0270, subparts 2 to 4, specific requirements for drainage or drawdown activities shall be met as follows:

A. the drainage or diversion of public waters for mining iron ore, taconite, copper, copper-nickel, or nickel shall be approved only when all of the provisions of Minnesota Statutes, section 103G.297 and part 6115.0280 have been met;

B. the drainage or diversion of public waters for mining all other metallic and nonmetallic minerals shall be approved only when the public waters being drained are replaced by public waters that will have equal or greater public value, subject to provisions of part 6115.0280; and

C. all other drainage or diversion of public waters allowed in part 6115.0270, subparts 2 to 4, shall be approved if all of the following specific criteria are met:

(1) for public waterbasins and public water wetlands, permits shall be issued only to governmental agencies having the authority to undertake such projects. In addition, a public need for the partial drainage or temporary drawdown shall be established by specifying the public interests to be enhanced;

(2) written consent for the partial drainage or temporary drawdown of public waterbasins and public water wetlands is obtained from all riparian owners;

(3) partial drainage or temporary drawdown of public waterbasins and public water wetlands shall be approved only when the applicant has submitted data to confirm:

(a) that the partial drainage will improve navigation or recreational uses;

(b) that the partial drainage will improve or restore fish and wildlife habitat; or

(c) that agricultural lands have been flooded due to artificial obstruction of downstream drainage or increased upstream discharge;

(4) any proposed temporary drawdown shall not exceed two years in duration under normal climatic conditions;

(5) there are no feasible and practical means to attain the intended purpose without drainage; and

(6) the proposal adequately protects public safety and promotes the public welfare.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

6115.0272 RELATIONSHIP TO STANDARDS AND CRITERIA FOR OTHER ACTIVITIES INVOLVING CHANGES IN COURSE, CURRENT, OR CROSS-SECTION.

Unless otherwise specified in other parts, parts 6115.0270 and 6115.0271 shall apply to drainage activities proposed as part of any other activity or activities including but not limited to: filling, parts 6115.0190 to 6115.0192; excavations, parts 6115.0200 to 6115.0202; structures, parts 6115.0210 to

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0212; water level controls, parts 6115.0220 to 6115.0222; and bridges and culverts, parts 6115.0230 to 6115.0232.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533*

Posted: *June 11, 2008*

6115.0280 ALTERATIONS OF PUBLIC WATERS FOR MINING.

Subpart 1. **Goals.** It is the goal of the department to ensure that alterations of public waters for mining or reclamation of mining areas will minimize adverse environmental effects, preserve water resources to the maximum extent feasible and practical, and encourage the planning of future land and water utilization while at the same time promoting the orderly development of mining and the use of sound mining practices.

Subp. 2. **Scope.** Mining activities which may involve alterations of public waters include the mining of metallic minerals including but not limited to iron ore, taconite, copper, copper-nickel, nickel, cobalt, and gold; and the mining of nonmetallic minerals including but not limited to sand and gravel, stone, clay, marl, oil, gas, and coal; and the mining of peat.

Subp. 3. **Permits required for alterations of public waters.** Permits are required for any alterations of public waters to facilitate mining of iron ore, taconite, copper, copper-nickel, or nickel minerals or reclamation of mining areas provided that:

A. permits to mine are obtained when required by Minnesota Statutes, sections 93.44 to 93.51; and

B. permits for alterations in public waters shall be granted according to Minnesota Statutes, section 103G.297. Applications for permits for alterations in public waters shall include an analysis showing why underground mining without drainage, diversion, or control of public waters is not feasible or economical.

Subp. 4. **Permit required for mining of certain minerals and peat.** Permits are required for mining of nonmetallic minerals, peat, and other metallic minerals not regulated in Minnesota Statutes, section 103G.297, or reclamation of mining areas and shall be granted if the applicant provides evidence that:

A. there is no other feasible and practical location for the proposed mining activity;

B. there is no other feasible or economical method to mine except by draining, diverting, or controlling the public waters;

C. the proposed alteration of public waters is necessary and no other feasible and economical method for it is reasonably available;

D. the proposed alteration of public waters will not substantially impair the interests of the public in lands or waters or the substantial beneficial public use thereof, except as expressly authorized in the permit, and will not endanger public health or safety;

E. the proposed mining operations will be in the public interest and that the public benefits resulting from it will be sufficient to warrant the proposed alteration of public waters;

F. the activities represent the minimal impact solution with respect to watershed modifications, watercourse diversions or changes, drainage, runoff and seepage management, and avoidance of major adverse changes in the ecosystem of public waters having substantial public value;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

G. whenever public watercourses must be diverted or changed to facilitate mining, the design and construction of the diversion or change shall provide for:

(1) maintenance of adequate flows and levels in order to protect instream flows and prevent downstream flooding;

(2) measures to prevent bank erosion and sedimentation in order to protect water quality; and

(3) details on the location, relocation, and utilization of the watercourse after cessation of mining;

H. whenever public waterbasins and public water wetlands are allowed to be drained to facilitate mining, and such drainage is justified and legally permitted, compensation for the loss of the basin is provided for by either:

(1) immediate replacement of the public waterbasins and public water wetlands with waters of equal or greater value; or

(2) submission of acceptable plans for the eventual replacement of the public waterbasins and public water wetlands with waters of equal or greater value upon cessation of mining activities; and

I. whenever a water impoundment is necessary and justified to facilitate mining, the design, construction, operation, and maintenance of the impoundment structure shall:

(1) meet the applicable requirements of parts 6115.0300 to 6115.0520 pertaining to dam safety;

(2) provide hydrologic and hydraulic measures to ensure that any public waters downstream of the impoundment area are adequately protected with respect to maintenance of water quantity and quality and prevention of flooding; and

(3) include plans detailing the disposition and utilization of the impoundment area after cessation of mining activities.

Subp. 5. **Compensatory measures for detrimental aspects of mining.** Whenever metallic, nonmetallic, and peat mining activities in the beds of public waters will result in detrimental effects on the physical and biological character of public waters, measures to compensate for the detrimental aspects shall be required in the permit conditions.

Statutory Authority: *MS s 103G.315; 105.415*

History: *8 SR 533; 25 SR 143; 27 SR 529*

Posted: *June 11, 2008*

DAMS

6115.0300 PURPOSE AND STATUTORY AUTHORITY.

The purpose of these rules is to regulate the construction and enlargement of dams, as well as the repair, alteration, maintenance, operation, transfer of ownership, and abandonment, in such a manner as to best provide for public health, safety, and welfare. In the application of these parts, the department shall be guided by the policies and requirements declared in Minnesota Statutes, section 84.083, and chapters 103A, 103B, 103E to 103G, and 116D.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

The rules are pursuant to Laws of Minnesota 1978, chapter 779, section 8, and are intended to be consistent with the goals and objectives of applicable federal and state environmental quality programs and policies including, but not limited to, mineland reclamation, and the management of: shorelands, floodplains, water surface use, boat and water safety, wild and scenic rivers, critical areas, recreational or wilderness areas, scientific and natural areas, and protected vegetative species.

To achieve this purpose, the commissioner hereby sets forth minimum standards and criteria for dam classification and identification of hazards to health, safety, and welfare and for permits for dam projects for water and waste impoundments and for ordering repairs.

Statutory Authority: *MS s 103G.515; 103G.531; 105.535*

Posted: *June 11, 2008*

6115.0310 SCOPE.

These parts shall apply to all dams defined in part 6115.0320 unless excluded in other sections of the rules. They are supplementary and complimentary to the rules which establish standards and criteria for granting permits to change the course, current, or cross-section of public waters (parts 6115.0150 to 6115.0210, 6115.230, and 6115.0240 to 6115.0260).

Where these parts conflict with other appropriate rules and requirements, the most restrictive provision shall apply.

All provisions of part 6115.0220 are superseded by these parts as they relate to dams as defined herein, except the section relating to water level controls.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

6115.0320 DEFINITIONS.

Subpart 1. **Scope.** For the purposes of these parts, certain terms used herein shall be interpreted as follows. These definitions are in addition to those contained in part 6115.0170, except where the same word is contained in both lists of definitions in which case the definitions in these parts shall apply in respect to dam safety administration.

Subp. 2. **Alteration.** "Alteration" means any activity which will affect the safety of a dam and/or which will result in a change in the course, current, or cross-section of public waters.

Subp. 3. **Commissioner.** "Commissioner" means the commissioner of the Department of Natural Resources and any duly authorized representative.

Subp. 4. **Cost.** "Cost" includes labor and materials; preliminary investigations and surveys; construction plant properly chargeable to the project; excluding costs of right-of-way, detached powerhouses, electrical generating machinery, and roads and railroads affording access to the project.

Subp. 5. **Dam.** "Dam" means any artificial barrier, together with appurtenant works, which does or may impound water and/or waste materials containing water except:

A. dams which are less than 25 feet in height and have storage capacity at maximum storage elevation of less than 50 acre-feet, which shall be exempt from dam safety permit requirements if they do not have potential for loss of life resulting from failure or misoperation;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. any artificial barrier which is not in excess of six feet in height regardless of storage capacity or which has a storage capacity not in excess of 15 acre-feet regardless of height;

C. underground or elevated tanks to store water and/or waste;

D. any artificial barrier constructed solely for the purpose of containment of sewage or biological treatment of wastewater which is under the jurisdiction of the Minnesota Pollution Control Agency;

E. United States owned dams;

F. dikes and levees constructed for flood control purposes to divert flood waters and which are not intended to act as impoundment structures.

This does not preclude the need for any permits from the commissioner which may be required

under applicable provisions of parts 6115.0200 to 6115.0260 as further explained in part 6115.0340.

Subp. 6. **Enlargement.** "Enlargement" means any change which may raise the maximum storage elevation of the dam.

Subp. 7. **Height.** "Height" means the vertical distance from the natural bed of the stream or watercourse measured at the downstream toe of the dam or from the lowest elevation of the outside limit of the dam, if it is not across a stream channel or watercourse, to the maximum storage elevation.

Subp. 8. **Maintenance.** "Maintenance" means any work which will not result in a change in the hydraulic capacity of the structure or entail any changes in the structural character of the dam.

Subp. 9. **Maximum storage elevation.** "Maximum storage elevation" means the highest elevation to which water or waste materials can be effectively stored behind the dam on either a temporary or permanent basis, whichever is greater.

Subp. 10. **Owner.** "Owner" means the owner or lessee of the property to which the dam is attached, unless the dam is sponsored by a governmental agency which will be responsible for operation and maintenance of the dam, in which case that sponsoring agency shall be considered the owner.

Subp. 11. **Repair.** "Repair" means any work which will change the hydraulic capacity of the structure or entail any changes in the structural character of a dam.

Subp. 12. **Shall.** "Shall" is mandatory and not permissive.

Subp. 13. **Surface.** "Surface" shall be determined by multiplying total dam length by average height.

Subp. 14. **Total dam length.** "Total dam length" means the maximum horizontal distance between the outer limits of all artificial containment structures, including any artificially constructed dike, which are essential to containment, but does not include the length of emergency spillways which are located outside the abutments of the dam.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0330 SEVERABILITY.

The provisions of these rules shall be severable, and the invalidity of any paragraph, subparagraph, or subdivision thereof shall not make void any other paragraph, subparagraph, subdivision, or any other part.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

6115.0340 CLASSIFICATION OF DAMS.

All existing and proposed dams shall be classified by the commissioner into the following three hazard classes: those dams where failure, misoperation, or other occurrences or conditions would probably result in:

A. Class I: any loss of life or serious hazard, or damage to health, main highways, high-value industrial or commercial properties, major public utilities, or serious direct or indirect, economic loss to the public;

B. Class II: possible health hazard or probable loss of high-value property, damage to secondary highways, railroads or other public utilities, or limited direct or indirect economic loss to the public other than that described in Class III; and

C. Class III: property losses restricted mainly to rural buildings and local county and township roads which are an essential part of the rural transportation system serving the area involved.

Any dam whose failure, misoperation, or other occurrences or conditions would result only in damages to the owner and would not otherwise affect public health, safety, and welfare as described in Classes I, II, and III, shall not be subject to this hazard classification. A dam which is not classified as a hazard Class I, II, or III dam, and those which are not included in the definition of dam at part 6115.0230, subpart 5, definition of dam, shall be subject to applicable provisions of parts 6115.0200 to 6115.0260, and shall not be subject to these dam safety rules. Changes in development in the vicinity of the dam may result in future reclassification.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

6115.0350 GENERAL PROCEDURES FOR ALTERATION, REPAIR, OR REMOVAL OF A DAM.

Subpart 1. **Application.** Before commencing action, the owner shall make a separate application for each existing dam proposed to be changed upon forms provided by the commissioner, except as provided in subpart 2 for emergencies. The application shall contain:

A. name and address of owner(s);

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. proposed changes;

C. maps, plans, and specifications which set forth pertinent details including location, type, dimensions, and storage capacity; and

D. proposed date of start and completion of construction.

A filing fee of $15 shall accompany the application in the form of a check or money order payable to the commissioner of management and budget.

Subp. 2. **Emergency work.** Emergency work:

A. Actions by the owner. Where immediate action is necessary for public health, safety, and welfare, repairs may be started, but the owner shall notify the commissioner at once. As soon as practicable, the owner shall apply for a permit for the emergency necessary permanent repairs.

B. Commissioner's actions. Where necessary to protect public health, safety, and welfare, if the condition of any dam or impoundment is imminently dangerous to the safety or life or property or imminent floods threaten the safety of a dam or impoundment, the commissioner may, in an emergency, require and enforce lowering or completely emptying of the water level from the impoundment and taking any other steps essential to safeguard life and property.

Subp. 3. **Removal.** Before commencing removal, the owner shall comply with the application requirements of subpart 1. After removal, the owner shall submit evidence as to the manner in which the work was performed and the conditions obtained after the removal. The commissioner shall inspect to determine that a sufficient portion of the dam has been removed to eliminate the hazard directly attributable to the presence of the dam.

Statutory Authority: *MS s 105.535*

History: *L 2003 c 112 art 2 s 50; L 2009 c 101 art 2 s 109*

Posted: *August 7, 2009*

6115.0360 INSPECTIONS.

Subpart 1. **Hazard classification.** The commissioner shall make initial inspections of each dam in the state to determine the appropriate hazard classification or exemption according to criteria in part 6115.0340.

Subp. 2. **Dam safety.** The commissioner shall make an initial detailed systematic technical inspection and evaluations of every Class I, II, or III dam in order to assess the general safety conditions including:

A. a review and analysis of available data on the design, construction, and operation;

B. a visual inspection of the dam and downstream and upstream areas:

(1) an examination of significant structural, geotechnical, hydraulic, and hydrologic features including, where applicable, electrical and mechanical equipment for the operation of control facilities;

(2) evidence of leakage, erosion, seepage, slope instability, undue settlement, displacement, tilting, cracking, deterioration, and improper functioning of drains and relief wells; and

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(3) adequacy and quality of maintenance and operating equipment and procedures;

C. a report on general condition including, when possible, an assessment of storage capacity, hydraulic and hydrologic capabilities, structural stabilities, and any other conditions which constitute a hazard based upon current prudent design considering the size and hazard class of the dam.

The safety evaluations involve constraints on water control such as blocked entrances, restrictions on operation of spillway and outlet gates, if any, inadequate energy dissipators or restrictive channel conditions, significant reduction in impoundment capacity by sediment deposits and for waste impoundments, the material balance. Where essential design data are lacking, evaluations of watershed characteristics, rainfall, and impoundment records may be used to evaluate effects of the dam.

The report shall determine the need for emergency measures or actions; corrective actions relating to design, construction, and operation; and additional detailed studies, investigations, and analyses.

Subp. 3. **Timing.** Subject to the availability of staff and funds:

A. The commissioner shall make initial inspections of all Class I, II, and III dams as soon as reasonably possible based on the degree of hazard involved.

B. After the initial detailed inspections, the commissioner shall make periodic inspections of dams based on the following schedule: Class I dams, at least one time every year; Class II dams, at least one time every four years; and Class III dams, at least one time every eight years. The commissioner shall utilize the services of governmental agencies to the maximum extent feasible to provide for periodic inspections.

Subp. 4. **Reports on inspections.** Upon completion of each inspection, the commissioner shall notify the owner of the dam, in writing, of the results of the inspection and if the dam needs corrective action, the commissioner shall order such action.

Statutory Authority: *MS s 103G.515; 105.535*

History: *25 SR 1916*

Posted: *June 11, 2008*

6115.0370 TRANSFER OF DAM OWNERSHIP.

The owner shall not transfer the ownership of any Class I or II dam without a permit from the commissioner. For Class III dams, the owner, or the party to whom a dam is transferred, shall apply to the commissioner for a permit for the transfer of ownership within 30 days after the ownership changes. Permits shall be issued based on evaluation of the hazard class, the conditions, and the financial capabilities of the transferee.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

No state agency or political subdivision may purchase or accept as a gift any privately owned dam subject to department permit requirements until after compliance with the commissioner and legislative action provided in Minnesota Statutes, section 103G.525.

Statutory Authority: *MS s 103G.515; 103G.531; 105.535*

Posted: *June 11, 2008*

6115.0380 OPERATION AND MAINTENANCE.

Subpart 1. **Responsibilities.** The owner shall operate and maintain the dam. Regulation of maintenance and operation for public health, safety, and welfare is vested with the commissioner.

Subp. 2. **Reports and records.** Owners may be required to keep records and report on maintenance, operation, staffing, and engineering and geologic investigations and any other data necessary to protect the public health, safety, and welfare. In addition, the owner shall fully and promptly advise the commissioner of any unusual or alarming circumstance or occurrence affecting the dam.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

6115.0390 TERMINATION OF OPERATIONS AND PERPETUAL MAINTENANCE.

Subpart 1. **Owner's duty.** Unless the dam is removed, the owner shall perpetually maintain the dam and appurtenances so as to ensure the integrity of the structure.

Subp. 2. **Financial responsibility.** The commissioner may impose such requirements as may be necessary prior to the ultimate termination of the owner's operation to ensure that the owner will be financially responsible for carrying out the activities required for perpetual maintenance, and that adequate funding will exist.

Subp. 3. **Plans for termination.** In respect to dams utilized for waste disposal, the owner shall prepare and submit to the commissioner plans for termination of operations and perpetual maintenance which will address the owner's plans for both an unanticipated or premature termination of operations and for the ultimate intended termination of operations. The plans for termination of operations and perpetual maintenance shall, at a minimum, address the following issues, where applicable:

A. perpetual maintenance and safety of the dam including adequate monitoring programs;

B. disposal and treatment of ponded and channeled waters;

C. monitoring and mitigation of surface water and groundwater pollution;

D. silt, sedimentation, and erosion control; and

E. vegetation and landscaping.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

6115.0400 REPORTS TO LEGISLATURE ON PUBLICLY OWNED DAMS.

As required by Laws of Minnesota 1978, chapter 779, section 7 (Minnesota Statutes, section 103G.511), the commissioner shall make an annual report to the legislature on the status of dams owned

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

by the state or local governmental units which shall include recommendations for action including any requests for state share or matching funds for grants-in-aid to local governments.

Statutory Authority: *MS s 103G.515; 103G.531; 105.535*

Posted: *June 11, 2008*

6115.0410 NEW DAMS OR ENLARGEMENTS.

Subpart 1. **Waivers for Class III dams.** For Class III dams which are sponsored by a governmental agency which will be responsible for operation and maintenance or for which the design, construction supervision, and inspection is performed by a federal agency, the commissioner may waive certain details of the required submittals, provided that the federal agency will furnish the commissioner with adequate facts on the design and construction inspection to allow the commissioner to adequately evaluate the permit and approvals.

Subp. 2. **Permit application.** A separate application, including a preliminary report for each new dam or each dam proposed to be enlarged, shall be filed with the commissioner upon forms provided by the commissioner which shall contain the following:

A. name and address of the owner(s) or prospective owner;

B. purpose;

C. location, type, size, and height of the dam; and

D. storage capacity of the impoundment.

For waste impoundment dams, the permit application shall include facts necessary for the issuance of a permit which extends throughout the life of the impoundment project.

Subp. 3. **Preliminary report.** The preliminary report shall consist of:

A. A general statement setting forth the effect on the environment.

B. Maps showing the location of county, township, and section lines; the outline of the impoundments; the location of state, county, and township roads; the locations of utilities, e.g. pipelines, transmission, telegraph, and telephone lines; the topography; and other structure or facilities including dwellings affected by the proposed dam. State, county, and USGS maps and aerial photographs may be used for this purpose.

C. A written report of surface conditions, i.e. geology, topography, which is based on a field examination by the applicant's engineer and other qualified personnel.

D. Typical cross-sections of the dam accurately showing elevations, proposed impoundment levels, and top width.

E. Logs of borings in the foundation and in the borrow areas, and results of seismic and resistivity subsurface investigations, when they are readily available.

F. Preliminary design assumptions, operational aspects, tentative conclusions, and references. The design assumptions shall pertain to such hydrologic features as drainage area, rainfall data, runoff, inflow, area-capacity-elevation data, and flood routing, in addition to structural, geologic, and geotechnical assumptions.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

G. A preliminary cost estimate.

H. Where applicable, future plans on ultimate project size including dams and impoundments.

I. A general description of all other activities and elements related to and part of the total dam project, such as operational plans and details of smaller dams, dikes, diversions, reclaim water facilities, and other facility and utility lines including pipelines, roads, and railroads. The report shall identify each element or activity of the total dam project which would require a permit under the provisions of parts 6115.0150 to 6115.0260.

Subp. 4. **Filing fees.** Each application for a permit must include a $15 fee in the form of a check or money order payable to the commissioner of management and budget.

Subp. 5. **Professional engineer's requirements.** The applicant must engage professional engineer(s) registered in the state of Minnesota or acting solely as officers or employees of the United States as provided in Minnesota Statutes, section 326.13, clause (3), who are proficient in dam engineering to prepare the engineering documents, plans, and specifications, to inspect the construction, or enlargement, and to establish operation and maintenance procedures for the structure.

Subp. 6. **Final design requirements.** Upon acceptance and agreement by the commissioner of the preliminary report, the applicant shall submit to the commissioner, for approval, a final design report, together with plans and specifications and the initial inspection fee. The final design report shall include, but is not limited to, the following:

A. general description of the project, such as its service life, production rates, required storage and area(s); geological considerations such as physiography, topography, geology, seismicity, groundwater conditions, and maps; hydrologic studies such as physical features, climatology, design, storm and design flood characteristics, flood routing, water-material balance, free-board requirements, dam-break flood; geotechnical information, such as rock-soil sampling and logging, geophysical investigations, field and lab testing, instrumentation data; considerations of construction materials and their properties, such as quantities required, borrow and aggregate locations and volumes, field and lab work and investigations, concrete, waste materials generation and placement techniques, investigation of the stored waste materials such as generations, transportation, mechanical/chemical/special testing, disposal practice;

B. analytical determinations, such as seepage and underseepage studies, stability, deformation and settlement analysis; analytical and design details of facilities, such as dam, foundation, impoundment, abutments, spillways (for the purpose of these rules, spillway means any facility appurtenant to the dam available to discharge excess water and/or waste from the impoundment) or decant facilities, diversions, outlet works, instrumentation; operational aspects, such as impoundment operating criteria, initial filling criteria, responsibility and coordination, emergency procedures and warning systems: air, water, and solid pollution controls, sedimentation, and erosion controls: operational and postoperational maintenance and abandonment considerations; surveillance and inspection programs; and

C. a detailed cost estimate.

Subp. 7. **Plans and specifications.** Plans shall consist of a bound portfolio of the drawings with all sheets being of the same size, and shall be of such scale that specifications can be drafted, and construction accomplished. Specifications shall contain:

A. general provisions, specifying the rights, duties, responsibilities of the owner, designer, contractor; the prescribed order of work;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. technical provisions describing approved work methods, equipment materials, and desired end results; and

C. special conditions.

Subp. 8. **Permit standards.** Approval or denial shall be based on the potential hazards to the health, safety, and welfare of the public and the environment including probable future development of the area downstream or upstream. The applicant may be required to take measures to reduce risks, and the commissioner shall furnish information and recommendations to local governments for present and future land use controls to minimize risks to downstream areas.

The commissioner shall determine if the proposal is adequate with respect to:

A. For Class I, a showing of lack of other suitable feasible and practical alternative sites, and economic hardship which would have a major adverse effect on population and socioeconomic base of the area affected.

B. For Class II, a showing of lack of other suitable feasible and practical alternative sites and that the dam will benefit the population or socioeconomic base of the area involved.

C. The need in terms of quantifiable benefits.

D. The stability of the dam, foundation, abutments, and impoundment under all conditions of construction and operation, including consideration of liquefaction, shear, or seepage failure, overturning, sliding, overstressing and excessive deformation, under all loading conditions including earthquake. This determination must be based on current, prudent engineering practice, and the degree of conservatism employed must depend on hazards.

E. Discharge and/or storage capacity capable of handling the design flood based on current, prudent engineering practice and the hazard classification.

F. Compliance with prudent, current environmental practice throughout its existence.

Subp. 9. **Work inspection and construction reports.** Work inspection and construction reports:

A. Conformity with approved designs, plans, and specifications.

(1) The permittee shall be responsible for providing adequate controls of construction and operation activities and for the development of data in the ordinary course of those activities on design, construction, and operation assumptions. The owner may engage a professional engineer to operate and inspect the construction, but the designer should also periodically monitor construction.

(2) All construction shall be carried out in accordance with the approved design, plans, and specifications. No alteration, modification, or addition to the approved designs, plans, and specifications that could adversely affect the safety or environmental impact of the dam shall be made by the permittee without prior permission of the commissioner. Such approvals shall be provided, if a proper margin of safety is maintained, as rapidly as possible to preclude interference with construction work schedules. Emergency short-term revisions may be made by the permittee followed by prompt notice to the commissioner. Records of alterations, modifications, or additions to the approved design, plans, and specifications, for which written approval of the commissioner was not required shall be submitted with the construction report as provided in item C.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(3) The commissioner shall make inspections for the purpose of securing conformity with approved designs, plans, and specifications and shall require the owner to perform, at the permittee's expense, work or tests as found necessary to disclose sufficient information to determine if there is conformity.

(4) If, at any time as work progresses, the commissioner finds that changes are necessary to protect health, safety, welfare, and the environment, the commissioner shall order the owner to revise designs, plans, and specifications.

(5) At the commissioner's discretion, the commissioner may observe and approve foundation preparation and may approve construction material placement on an intermittent or continuing basis when field conditions dictate. The commissioner shall be notified at least three days in advance of start of construction.

B. Permanent markers. At least one permanent marker for vertical and horizontal control shall be established in the natural ground by the permittee in the vicinity of each dam so as to be accessible and protected against disturbance throughout its existence. The permanent marker for vertical control must be based upon datum and degree of accuracy based upon considerations of the hazards involved and the size of the dam, as specified by the commissioner.

The permittee shall submit the locations of these permanent markers plotted on the best available maps or plans within time limits prescribed in the permit.

C. Construction report. The permittee may be required to submit monthly reports on construction observation and quality control, when construction is complex or hazardous, including: daily construction documentation; foundation preparation and treatment, quality control tests; records and summaries of actual tests of foundation and construction materials, cutoff trench, grouting, etc; instrumentation installation and maintenance of records and readings; geologic mapping, if any, of exposed foundations; of logs of drill holes and other exploration features, if any, completed during construction; review and evaluation of disclosed field conditions by the designer; and any other items which may be pertinent to a construction quality assurance program.

Subp. 10. **As-built plans and data.** Immediately upon completion of construction the permittee shall file supplementary drawings or descriptions of the dam as actually constructed, or any other items which may be of permanent value bearing on the adequacy and permanency of the dam. In enlargements the data need apply only to the new work.

Subp. 11. **Statement of completion and affidavit of cost.** Within 90 days following completion of construction, the permittee shall notify the commissioner, by certified mail, including a statement of the designer or professional engineer in charge of construction inspection that to the best of knowledge the dam was completed in accordance with the approved designs, plans, and specifications and any revisions thereof.

As soon as practicable thereafter, the permittee shall file an affidavit stating the actual cost in detail or that the permittee is unable to report the actual cost stating the reasons therefor. In the latter event the commissioner shall make at the owner's expense an appraisal of the cost of construction or enlargement and determine what further fee, if any, is required. If a further fee is required, the commissioner shall notify the owner by certified mail of the amount within 15 days including notice that permittee may appear

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

within 60 days thereafter to protest the amount of the fee, in whole or in part and the sufficiency of the appraisal upon which such determination was based.

Subp. 12. **Issuance of impoundment approval.** Impoundment approvals may be necessary for Class I and Class II dams to allow adequate time for inspection before actual impoundment begins.

The type, location, hazard involved, and the purpose served by the dam will be considered in respect to the degree and nature of impoundment approval needed. Certain waste disposal dams which will not be constructed to maximum storage elevation in five years will require a series of impoundment approvals for various stages of construction.

Pending issuance of an impoundment approval (or reissuance in the event of termination) where required the owner of the dam shall not, through action or inaction, allow an impoundment.

The impoundment approval shall contain such terms and conditions as the commissioner may prescribe.

The commissioner may also revoke or amend the terms and conditions of any approval.

Subp. 13. **Performance reports.** The permittee may be required in the case of complex or hazardous dams to submit yearly a performance report detailing the instrumentation data and analysis and interpretation of these data as they relate to the safety of the dam and design assumptions. The frequency of submission may be modified if field conditions so dictate.

Statutory Authority: *MS s 105.535*

History: *17 SR 1279; L 2003 c 112 art 2 s 50; L 2009 c 101 art 2 s 109*

Posted: *August 7, 2009*

6115.0420 LEGAL CLAIMS.

Any permit shall be permissive only and shall not be construed as estopping or limiting any legal claims of persons other than the state against the permittee, or as estopping or limiting any legal claims of the state against the permittee for violation of any of the terms or conditions of the permit.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0430 LIABILITY OF OWNER AND PERMITTEE.

Nothing in these parts shall be construed to relieve an owner of a dam or permittee of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

6115.0440 OWNER'S RIGHTS.

Nothing in these parts shall be construed to deprive any owner of such recourse to the courts.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

6115.0450 INSPECTIONS.

Owners of dams shall allow the commissioner prompt access to and inspection of all records, plants, structures, facilities, and operations at all reasonable times. Entry is subject to reasonable compliance with the owner's safety rules and avoidance of unreasonable impairment of or interference with construction and operation. Inspection shall be limited to testing and observing rather than supervising and shall not relieve the owner from the full responsibility of providing adequate inspection and supervision.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

6115.0460 COMPLIANCE WITH OTHER LAWS.

The owner of a dam shall comply with all other state and federal laws and regulations and shall obtain such other permits as may be required including particularly any laws and rules regarding mineland reclamation.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

6115.0470 ACQUISITION OF PROPERTY.

Where activities authorized by a permit involve the rights or interests of any other persons, or of any public interests, the permittee, before proceeding, shall acquire all necessary interests or permissions, including paying the costs of the alteration, relocation, or replacement of any publicly owned facility.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0480 ASSIGNMENT OF PERMITS.

Permits may be assigned in whole or in part only if the commissioner is notified and approves the assignment in writing. Provisions of the permit shall extend to and bind the successors in authority of the commissioner and the legally assigned successors in interest of the permittee.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

6115.0490 WARNING SYSTEMS AND EMERGENCY PROCEDURES.

Class I dam owners shall prepare and file for approval a contingency plan for notifying any persons whose lives, property, or health may be endangered by failure, misoperation, or other circumstances or occurrence affecting the dam, identifying most practical and expeditious means for warning considering the time factor involved based on the proximity of the dam to affected parties. If there is no feasible or practical means to provide for adequate evacuation warning in sufficient time if a catastrophe occurs the owner shall be responsible for notifying affected downstream property owners of that fact.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

6115.0500 PERMIT AND HEARING PROCEDURES.

Parts 6115.0300 to 6115.0520 are subject to the permit and public hearing provisions of Minnesota Statutes, sections 103G.251, 103G.295, 103G.297, and 103G.301 to 103G.315, including:

A. The commissioner must act on permit applications within 30 days of the time that all required data and fees are filed in the commissioner's office.

B. The commissioner may cancel or modify a permit at any time if the commissioner deems it necessary for any cause for the protection of the public interests.

C. Whether or not a dam is under permit, on determining that it is unsafe or needs repair or alteration, the commissioner shall notify the owner to repair, alter, or remove the dam as the exigencies of the case may require.

D. An order requiring immediate action is effective on the date thereof, but shall not be in effect for more than 30 days from that date unless the permittee is on the same date mailed written notice of the order which includes notice of a Minnesota Statutes, section 103G.311, public hearing on a date not more than 30 days from the date of the notice.

E. If at any time during construction of a project, the commissioner finds that the work is not being done in conformance with approved designs, plans, and specifications, except as provided in part 6115.0410, subpart 9, item A, subitem (2), the commissioner shall notify the permittee and shall order immediate compliance and may order that no further work be done until such compliance has been effected and approved.

F. If the permittee fails to comply with approved designs, plans, and specifications or if conditions are revealed which will not permit the construction of a safe dam, the permit may be revoked.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

G. Initiating any work by the permittee, authorized in an issued permit or approval, constitutes acceptance of all terms and conditions contained therein.

Statutory Authority: *MS s 103G.515; 103G.531; 105.535*

History: *17 SR 1279*

Posted: *June 11, 2008*

6115.0510 REQUIRED INFORMATION AND WAIVERS.

When necessary to assess the safety of a dam or proposed project, the applicant or owner may be required to submit additional information at personal expense. Whenever information or conditions required by these parts is unnecessary, the commissioner shall waive those provisions and shall allow appropriate revisions to make the requirements less burdensome.

Statutory Authority: *MS s 105.535*

History: *17 SR 1279*

Posted: *June 11, 2008*

6115.0520 INSPECTION FEES.

Subpart 1. **Exemption.** No inspection fee shall be charged for dams owned or sponsored by a governmental agency or for any Class III dam for which the design, construction supervision, and inspection is provided by a federal agency.

Subp. 2. **Fee schedule.** The initial fee required by part 6115.0410, subpart 6 shall be based on the following formula and no fees pursuant to parts 6115.0010 to 6115.0040 shall be charged:

A. for the first $100,000 of estimated cost (as defined in part 6115.0320, that portion of engineering evaluations and studies relating to safety which is also part of the final design report performed for the applicant which were included with environmental assessment worksheets and with environmental impact statements required by law shall be subtracted provided that the applicant provides a notarized detailed accounting of expenditures), a rate of 2-1/2 percent;

B. for the next $400,000, 1-1/2 percent;

C. for the next $500,000, one percent;

D. one-half of one percent of all costs in excess of $1,000,000; and

E. if the final total cost exceeds the estimate, the difference as provided in part 6115.0410, subpart 11.

For dams which will not be constructed to maximum storage elevation within five years of the date construction begins (such as dams for storage of mining waste materials) computation will be based on applicant's work schedule outlining proposed staging and a certified estimate of costs based on staging and a certified estimate of costs based on staging intervals not exceeding five years in duration. At the end of each stage, or at intervals not exceeding five years in duration, until completion, the applicant shall file

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

an affidavit of actual costs for each stage or interval not exceeding five years. Whenever the actual costs exceeds the estimate the applicant shall pay the difference.

Subp. 3. **Periodic fees.** Periodic fees shall be charged to owners for each year and inspection is made pursuant to part 6115.0360, subpart 3, of $30 per dam plus an additional fee based on surface (as defined in part 6115.0320) of $0.01 per square foot for the first 1,000 and $0.001 for each square foot in excess of 1,000, payable on or before the end of the state fiscal year, June 30.

Subp. 4. **Annual records.** The commissioner shall keep annual records of inspection costs which shall be provided upon request of any applicant who paid inspection fees.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

WATER APPROPRIATION AND USE PERMITS

6115.0600 POLICY.

The purpose of these parts is to provide for the orderly and consistent review of permit applications for appropriation and use of waters of the state in order to conserve and utilize the water resources of the state in the public interest. In the application of these parts, the Department of Natural Resources shall be guided by the policies and requirements declared in Minnesota Statutes, section 84.083, and chapters 103A, 103B, 103E to 103G, and 116D.

Any appropriation must be consistent with laws and rules of federal, state, and local governments.

Statutory Authority: *MS s 103G.515; 103G.531; 105.535*

Posted: *June 11, 2008*

6115.0610 PURPOSE AND STATUTORY AUTHORITY.

These parts set forth minimum standards and criteria pertaining to the regulation, conservation, and allocation of the water resources of the state, including the review, issuance, and denial of water appropriation applications and the modification, suspension, or termination of existing permits.

Further provisions for the administration of these parts are found in Minnesota Statutes, section 84.083, and chapters 103A, 103B, and 103E to 103G. Permits for water appropriation for mining shall be in agreement with provisions of Minnesota Statutes, section 103G.297.

Statutory Authority: *MS s 103G.515; 103G.531; 105.535*

Posted: *June 11, 2008*

6115.0620 SCOPE.

Permits shall be required for, and these parts shall apply to, any appropriation of waters of the state, except for the following:

A. Appropriation of water for domestic uses serving less than 25 persons for general residential purposes.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. Test pumping of a groundwater source.

C. Withdrawal for any use at a rate not to exceed 10,000 gallons per day and totaling no more than 1,000,000 gallons per year.

D. Agricultural field tile or open ditch drainage systems, including pumping, to remove water from crop lands. This shall not preclude the need for compliance with Minnesota Statutes, chapter 103E and for permits for changes in course, current, or cross-section of public waters in the event that the agricultural drainage system adversely affects public waters. Adverse effects on public waters may include partial or complete drainage of public waters, high water or flooding conditions on surrounding lands, and accelerated erosion and sedimentation.

E. Reuse and discharge of waters resulting from an appropriation of waters of the state for which a permit has been granted, subject to applicable laws, and rules of other state and federal governmental agencies.

Statutory Authority: *MS s 103G.515; 103G.531; 105.535*

History: *L 1985 c 172*

Posted: *June 11, 2008*

6115.0630 DEFINITIONS.

Subpart 1. **Scope; shall.** For the purpose of these rules, the terms or words defined in this part have the meanings given therein, except where the context clearly indicates otherwise. The word "shall" is mandatory, not permissive.

Subp. 2. **Aquifer.** "Aquifer" means any water-bearing bed or stratum of earth or rock capable of yielding groundwater in sufficient quantities that can be extracted.

Subp. 3. **Appropriation.** "Appropriation" shall have the meaning prescribed in Minnesota Statutes, section 105.37, subdivision 5, "appropriation includes but is not limited to taking, regardless of the use to which the water is put."

Subp. 4. **Artesian aquifer or confined aquifer.** "Artesian aquifer" or "confined aquifer" means a water body or aquifer overlain by a layer of material of less permeability than the aquifer. The water is under sufficient pressure so that when it is penetrated by a well, the water will rise above the top of the aquifer. A flowing artesian condition exists when the water flow is at or above the land surface.

Subp. 5. **Basin.** "Basin" means a depression capable of containing water which may be filled or partly filled with waters of the state. It may be a natural, altered, or artificial depression.

Subp. 6. **Commissioner.** "Commissioner" refers to the commissioner of the Department of Natural Resources or the commissioner's authorized representative.

Subp. 7. **Consumptive use or consumption.** "Consumptive use" or "consumption" refers to water withdrawn and not directly returned to the same waters as the source for immediate further use in the area.

Subp. 8. **Division.** "Division" means the Division of Waters, Department of Natural Resources.

Subp. 9. **Domestic use.** "Domestic use" means use for general household purposes for human needs such as cooking, cleaning, drinking, washing, and waste disposal, and uses for on-farm livestock watering excluding commercial livestock operations which use more than 10,000 gallons per day and 1,000,000 gallons per year.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 10. **Dug pit.** "Dug pit" means an artificial excavation such as sump, trench, pond, water hole, or other basin constructed for the purpose of intercepting and capturing surface and ground water, and often involving groundwater under water table or unconfined conditions.

Subp. 11. **Groundwater.** "Groundwater" means subsurface water in the saturated zone. The saturated zone may contain water under atmospheric pressure (water table condition), or greater than atmospheric pressure (artesian condition).

Subp. 12. **Protected flow.** "Protected flow" is defined as the amount of water required in the watercourse to accommodate instream needs such as water-based recreation, navigation, aesthetics, fish and wildlife habitat, water quality, and needs by downstream higher priority users located in reasonable proximity to the site of appropriation.

Subp. 13. **Protection elevation.** "Protection elevation" is defined as the water level of the basin necessary to maintain fish and wildlife habitat, existing uses of the surface of the basin by the public and riparian landowners, and other values which must be preserved in the public interest.

Subp. 14. **Public water supply.** "Public water supply" refers to the various supplies of water used primarily for domestic supply purposes and obtained from a source or sources by a municipality, a water district, a person, or corporation where water is delivered through a common distribution system, as further defined in Minnesota Statutes, section 144.382, subdivision 4.

Subp. 15. **Safe yield for water table condition.** "Safe yield for water table condition" means the amount of groundwater that can be withdrawn from an aquifer system without degrading the quality of water in the aquifer and without allowing the long term average withdrawal to exceed the available long term average recharge to the aquifer system based on representative climatic conditions.

Subp. 16. **Safe yield for artesian condition.** "Safe yield for artesian condition" means the amount of groundwater that can be withdrawn from an aquifer system without degrading the quality of water in the aquifer and without the progressive decline in water pressures and levels to a degree which will result in a change from artesian condition to water table condition.

Subp. 17. **Water table aquifer or unconfined aquifer.** "Water table aquifer" or "unconfined aquifer" means an aquifer where groundwater is under atmospheric pressure.

Subp. 18. **Waters of the state.** "Waters of the state" means any waters, surface or underground, except those surface waters which are not confined but are spread and diffused over the land. "Waters of the state" includes all boundary and inland waters (Minnesota Statutes, section 103G.005, subdivision 17).

Subp. 19. **Watercourse.** "Watercourse" means any natural, altered, or artificial channel having definable beds and banks capable of conducting confined runoff from adjacent lands (Minnesota Statutes, section 103G.005, subdivisions 3, 5, and 13).

Subp. 20. **Well.** "Well" means any excavation that is drilled, cored, bored, washed, driven, dug, jetted, or otherwise constructed where the intended use is for the location, diversion, or acquisition of groundwater (Minnesota Statutes, section 103I.005, subdivision 21).

Statutory Authority: *MS s 103G.515; 103G.531; 105.535*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0640 COORDINATION WITH OTHER AGENCIES.

Nothing in these parts is intended to supersede or rescind the laws, rules, regulations, standards, and criteria of other international, federal, state, regional, or local governmental subdivisions with the authority to regulate the appropriation of waters of the state. The issuance of a permit shall not confer upon an applicant the approval of any other unit of government for the proposed project. The department shall coordinate the review of permit applications with other units of government having jurisdiction in such matters.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

6115.0650 SEVERABILITY.

The provisions of these rules shall be severable, and the invalidity of any paragraph, subparagraph, or subdivision thereof, shall not make void any other paragraph, subparagraph, subdivision, or any other part.

Statutory Authority: *MS s 105.535*

Posted: *June 11, 2008*

6115.0660 APPLICATION FOR PERMIT.

Subpart 1. **Requirement.** Applications shall be submitted for each surface or ground water source from which water is proposed to be appropriated. A separate application shall be required for the following:

A. for each distribution system if the water is used in more than one common distribution system;

B. for each well(s) completed in different aquifers if groundwater is to be appropriated from separate wells completed in more than one aquifer; and

C. for each basin or watercourse involved if surface water is to be appropriated from several different basins or watercourses.

Subp. 2. **Evidence of ownership.** The applicant must provide written evidence of ownership, or control of, or a license to use, the land overlying the groundwater source or abutting the surface water source from which water will be appropriated.

Subp. 3. **Information required.** All applicants shall submit the following information when it is reasonably available. Additional submittals may be required as prescribed in parts 6115.0680 to 6115.0720 and where deemed necessary by the commissioner in order to adequately evaluate the applications:

A. A completed application on forms supplied by the commissioner.

B. The required application fee (Minnesota Statutes, sections 103G.301, subdivisions 2 to 5, and 103G.315, subdivision 12).

C. Aerial photographs, maps, sketches, detailed plat, topographic maps, or other descriptive data sufficient to show:

(1) the location of the area of use;

(2) the outline of the property owned, or controlled by the applicant in proximity to the area of use;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(3) the location of the proposed point of appropriation such as well(s) location, stream bank pump(s) or the location of other facilities for appropriation of water;

(4) if ground water is involved, the location of test hole borings which have been drilled on the property from which the appropriation will be made.

D. Signed statement that copies of the application and accompanying documents have been sent to the mayor of the city, secretary of the board of supervisors of the soil and water conservation district, or the secretary of the board of managers of the watershed district if the proposed project is within a city or within or affects a watershed district or soil and water conservation district or a city (Minnesota Statutes, section 103G.301, subdivision 6).

E. Statement of justification supporting the reasonableness and practicality of use with respect to adequacy of the water source, amounts of use, and purposes, including available facts on:

(1) hydrology and hydraulics of the water sources involved, including for surface waters the applicant's analysis of the effect of proposed withdrawals on levels and flows and anticipated impacts, if any, on instream flow or lake level conditions to the extent that such facts are not already available to the commissioner;

(2) proposed pumping schedule including rates, times, and duration;

(3) amounts of water to be appropriated on a maximum daily, monthly, and annual basis;

(4) means, methods, and techniques of appropriation;

(5) alternative sources of water or methods which were considered, to attain the appropriation objective and why the particular alternative proposed in the application was selected.

F. Information on any water storage facilities and capabilities and any proposed reuse and conservation practices.

G. Application for use of surface water shall include the following additional data:

(1) A contingency plan which describes the alternatives the applicant will utilize if at any time appropriation is restricted to meet instream flow needs or to protect the level of a basin. The contingency plan shall be feasible, reasonable, and practical; otherwise the applicant shall submit as part of the application a written statement agreeing in such case to withstand the results of no appropriation (Minnesota Statutes, section 103G.285, subdivision 6).

(2) For appropriation from natural basins or natural watercourses, facts to show that reasonable alternatives for appropriating water have been considered including use of water appropriated during high flows and levels and stored for later use and the use of ground water.

(3) For basins less than 500 acres in surface area the applicant shall notify all riparian landowners and provide the commissioner with a list of all landowners notified; attempt to obtain a signed statement from as many riparian landowners as the applicant is able to obtain stating their support to the proposed appropriation; and provide an accounting of number of signatures of riparian owners the applicant is unable to obtain (Minnesota Statutes, section 103G.285, subdivision 4).

H. Application for use of groundwater, except for agricultural irrigation (part 6115.0680) shall include the following data:

(1) test hole logs (if any) and water well record(s);

(2) hydrologic test data; and

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(3) hydrologic studies, if the above data are insufficient to allow the commissioner to properly assess the capability of the aquifer system in the area of withdrawal or are inadequate to allow assessment of the effects of the proposed appropriation on the water resource and on nearby wells.

Subp. 4. **Waiver.** Whenever information required by parts 6115.0660 and 6115.0680 to 6115.0720 is unnecessary or inapplicable, the commissioner shall waive those requirements.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

6115.0670 COMMISSIONER'S ACTIONS ON PERMIT APPLICATIONS.

Subpart 1. **In general.** Upon receipt of the information required from the applicant under parts 6115.0660 and 6115.0680 to 6115.0720, where applicable, the commissioner shall take action on the application as follows.

Subp. 2. **Review and analysis of data.** Review and analysis of data:

A. The commissioner shall consider the following factors, as applicable:

(1) the location and nature of the area involved and the type of appropriation and its impact on the availability, distribution, and condition of water and related land resources in the area involved;

(2) the hydrology and hydraulics of the water resources involved and the capability of the resources to sustain the proposed appropriation based on existing and probable future use;

(3) the probable effects on the environment including anticipated changes in the resources, unavoidable detrimental effects, and alternatives to the proposed appropriation;

(4) the relationship, consistency, and compliance with existing federal, state, and local laws, rules, legal requirements, and water management plans;

(5) the public health, safety, and welfare served or impacted by the proposed appropriation;

(6) the quantity, quality, and timing of any waters returned after use and the impact on the receiving waters involved;

(7) the efficiency of use and intended application of water conservation practices;

(8) the comments of local and regional units of government, federal and state agencies, private persons, and other affected or interested parties;

(9) the adequacy of state water resources availability when diversions of any waters of the state to any place outside of the state are proposed;

(10) the economic benefits of the proposed appropriation based on supporting data when supplied by the applicant.

B. The commissioner shall further consider the following factors for appropriation from watercourses:

(1) historic streamflow records, and where streamflow records are not available, estimates based on available information on the watershed, climatic factors, runoff, and other pertinent data;

(2) physical characteristics such as discharge, depth, and temperature, and an analysis of the hydrologic characteristics of the watershed;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(3) aquatic system of the watercourse, riparian vegetation, and existing fish and wildlife management within the watercourse;

(4) frequency of occurrence of high and low flows;

(5) feasibility and practicability of off-stream storage of high flows for use in providing water supply during periods of normal low flows, when supply is limited by existing and anticipated use.

C. The commissioner shall further consider the following factors for appropriation from basins:

(1) total volume of water within the basin;

(2) slope of the littoral zone;

(3) available facts on historic water levels of the basin and other relevant hydrologic factors;

(4) cumulative long-range ecological effects of the proposed appropriation;

(5) natural and artificial controls which affect the water levels of the basin.

D. The commissioner shall further consider the following factors for appropriation of groundwater:

(1) type and thickness of the aquifer;

(2) subsurface area of the aquifer;

(3) area of influence of the proposed well(s);

(4) existing water levels in the aquifer and projected water levels due to the proposed appropriation;

(5) other hydrologic and hydraulic characteristics of the aquifer involved; and

(6) probable interference with neighboring wells.

Subp. 3. **Decision on applications.** The commissioner is authorized to grant permits, with or without conditions, or deny them. In all cases, the applicant, the managers of the watershed district, the board of supervisors of the soil and water conservation district, or the mayor of the city may demand a hearing in the manner specified in Minnesota Statutes, section 103G.311, subdivision 5, within 30 days after receiving mailed notice outlining the reasons for denying or modifying an application.

Decisions by the commissioner are further subject to the administrative provisions of Minnesota Statutes, sections 103G.241, 103G.251, 103G.295, 103G.297, and 103G.301 to 103G.315. These sections include information and requirements on procedure, authority, timing of actions, fees, notice, investigations, violations and penalties, and special provisions regarding mining operations.

Based on these statutory requirements and other applicable provisions of Minnesota Statutes, section 84.083, and chapters 103A, 103B, and 103E to 103G, the commissioner shall make decisions as follows:

A. No permit shall be granted if:

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(1) for application involving diversion of any waters of the state, surface or ground water, to a place outside the state, the remaining waters in the state will not be adequate to meet the state water resources needs during the specified life of the diversion (Minnesota Statutes, section 103G.265, subdivision 2);

(2) there is no conflict between competing users but the quantity of available waters of the state, in the area involved, are inadequate to provide the amounts of water proposed to be appropriated;

(3) the appropriation is not reasonable, practical, and does not adequately protect public safety and promote the public welfare (Minnesota Statutes, section 103G.315);

(4) the appropriation is not consistent with approved state, regional, and local water and related land resources management plans, provided that regional and local plans are consistent with statewide plans (Minnesota Statutes, section 103G.271, subdivision 2);

(5) there is an unresolved conflict between competing users for the waters involved and the conflict has not been resolved pursuant to provision of part 6115.0740.

B. Approval of any surface water appropriation application shall be further subject to the following:

(1) For all watercourses, proposals for appropriation during periods of flood flows and high water levels shall be given first consideration unless this is not practical, reasonable, or feasible (Minnesota Statutes, section 103G.261).

(2) For natural and altered watercourses, except for drainage ditches established under Minnesota Statutes, chapter 103E, consumptive appropriation may be limited consistent with Minnesota Statutes, section 103G.285, subdivision 2, provided that adequate data are available to set such limits for watercourses. Where protected flow is designated by the commissioner, no appropriation shall be allowed when the flow is below that protected flow.

(3) Permits to appropriate water for any purpose from streams designated trout streams by rule, pursuant to Minnesota Statutes, section 97C.021, shall be limited to temporary appropriations when not in conflict with the special designation, such as during periods of high flows or high water levels (Minnesota Statutes, section 103G.285, subdivision 5).

(4) For natural and altered basins the commissioner shall:

(a) Establish a protection elevation below which no appropriation shall be allowed (Minnesota Statutes, section 103G.285, subdivision 3, paragraph (b)).

(b) Limit the collective maximum annual withdrawals to not exceed a total volume of water amounting to one-half acre-foot per acre of surface water basin based on Minnesota Department of Natural Resources Bulletin No. 25, "An Inventory of Minnesota Lakes." The actual collective annual allocation may be considerably less than the maximum. This limitation is as provided by Minnesota Statutes, section 103G.285, subdivision 3, paragraph (a).

(c) For natural and altered basins less than 500 acres, an application shall not be approved if the commissioner determines that the proposed appropriation would lower the water level in the basin to an extent which would deprive the public and riparian property owners of reasonable use of and access to the water.

(5) The establishment of protection elevation and limitation on maximum withdrawals contained in units (a) and (b), shall not apply to artificial and altered basins constructed primarily for the

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

purpose of storing high waters and flood flows as water conservation or contingency flow alternatives when such alternatives are approved by the commissioner.

(6) Protected flows and protection elevations shall be established for the purposes as defined in part 6115.0630 and shall be based on available information considered in subpart 2, items B and C. For new applications the proposed establishment of protected flows or protection elevations shall be part of the permit process outlined in subpart 3 including opportunity for public hearing. Existing permittees who will be affected by the proposed establishment of protected flows or protection elevations shall be notified of such proposals and shall be provided opportunity for public hearing before modification of their permits based on the procedures outlined in part 6115.0750, subpart 5, item B. Upon the submission of data set forth in part 6115.0670, subpart 2, item A or B for the specified watercourse segment or basin by a state agency agreeing to pay the costs of any necessary public hearings, the commissioner shall establish requested protected flows and elevations.

C. Approval of appropriation from ground water shall be further subject to the following:

(1) The amounts and timing of water appropriated shall be limited to the safe yield of the aquifer to the maximum extent feasible and practical.

(2) If the commissioner determines, based on substantial evidence, that a direct relationship of ground and surface waters exists such that there would be adverse impact on the surface waters through reduction of flows or levels below protected flows or protection elevations the amount and timing of the proposed appropriation from ground water shall be limited.

(3) Appropriation of ground water shall not be approved or shall be issued on a conditional basis in those instances where sufficient hydrologic data are not available to allow the commissioner to adequately determine the effects of the proposed appropriation. If a conditional appropriation is allowed, the commissioner shall make further approval, modification, or denial when sufficient hydrologic data are available.

(4) The commissioner shall limit the use of dug pits for appropriating water when such pits are so located that they may reasonably be expected to affect protected flows of watercourses or protection elevations of basins.

Subp. 4. **Waiver.** The commissioner shall waive any of the provisions of subpart 3 if it is determined that conditions are such that implementation of a provision would be unnecessary or inapplicable or if an applicant provides sufficient evidence to show just cause why such provision would not be reasonable, practical, or in the public interest. In the event the commissioner does not grant an applicant's request for waiver the applicant may demand a hearing.

Subp. 5. **Specific types of appropriation and use.** Additional requirements and decisions governing agricultural irrigation, public water supplies, dewatering, water level maintenance, and mining are also contained in parts 6115.0680 to 6115.0720.

Statutory Authority: *MS s 103G.315; 105.415*

History: *L 1985 c 172; L 1991 c 259 s 23*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0680 ADDITIONAL REQUIREMENTS AND CONDITIONS FOR AGRICULTURAL IRRIGATION.

Subpart 1. **Additional application information.** For ground water appropriation, the applicant must submit to the commissioner the following data in addition to the requirements of part 6115.0660:

A. If the application is for use of groundwater from an aquifer system for which adequate groundwater availability data are available and therefore is designated by the commissioner as a Class A application, (Minnesota Statutes, section 103G.295, subdivision 3):

(1) copies of test hole log(s) to identify the aquifer the proposed well will penetrate;

(2) copies of the water well record(s) and production test data;

(3) additional aquifer test data as may be required by the commissioner if the test holes, water well records, and production test data are insufficient to allow the commissioner to properly assess the capability of the aquifer system in the area of withdrawal, or are inadequate to allow assessment of the effects of the proposed appropriation on other nearby wells.

B. If the application is for use of groundwater from an aquifer system for which inadequate groundwater availability data are available and therefore is designated by the commissioner as a Class B application, (Minnesota Statutes, section 103G.295, subdivision 3) the applicant shall supply the following additional information as required by Minnesota Statutes, section 103G.295, subdivision 4, including:

(1) copies of test hole log(s) to identify the aquifer the proposed well will penetrate;

(2) copies of water well record(s) and production test data;

(3) the anticipated groundwater quality in terms of the measures of quality commonly specified for the proposed water use, when existing data indicate the water supply is not suitable for irrigation;

(4) the location of each domestic well, for which information is readily available, located within the area of influence or within 1-1/2 mile radius of the proposed irrigation well, whichever is less;

(5) readily available information from water well records, reports, studies, and field measurements regarding the domestic wells within the area of influence or a 1-1/2 mile radius of the proposed irrigation well whichever is less, such as:

(a) owner's name, address, and phone number;

(b) depth of well in feet;

(c) diameter of well and casing type (concrete curb, steel, wooden, clay tile, etc.);

(d) nonpumping water level (in feet) below land surface;

(e) age of well (when constructed);

(f) type of pump (shallow-jet, deep well jet, submersible reciprocating, etc.) and rate of discharge; and

(g) length of drop pipe in well;

(6) results of a pumping test of the aquifer system as required in Minnesota Statutes, section 103G.295, subdivision 4, paragraph (a), clause (5).

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(7) The commissioner shall in any specific application, waive any of the requirements of subitems (1) to (6), when the necessary data are already available, as required in Minnesota Statutes, section 103G.295, subdivision 4.

Subp. 2. **Commissioner's actions.** The commissioner shall analyze and evaluate applications based on facts supplied by the applicant pursuant to parts 6115.0660 and subpart 1 of this part. Decisions shall be subject to the applicable procedures outlined in part 6115.0670 and based on recommendations of the soil and water conservation district, soil surveys, and other available data on soil characteristics relating to soil suitability for agricultural irrigation and adequacy of existing or proposed soil and water conservation measures in order to protect water quality and prevent erosion and sedimentation.

The commissioner shall determine the amount of water allowed to be used under the above

paragraph based on:

A. Acreage of lands involved.

B. Climatic characteristics of the area involved.

C. Dominant soil types of the acreage to be irrigated and major crops to be irrigated.

D. Best available technology, methodology, and crop-water use requirement information including, but not limited to, Irrigation Guide for Minnesota, Soil Conservation Service, U.S. Department of Agriculture, Saint Paul, Minnesota, 1976.

E. When adequate data on soil moisture and local climatic conditions are available for the area, the commissioner may in cooperation with irrigators and agricultural experts establish an irrigation scheduling system to provide for improved conservation of water.

F. For irrigation from surface water, where stream flow or lake level records are unavailable or when available records indicate that flows or levels during the irrigation season would be inadequate if all potential riparian landowners would use the water for irrigation, the amount of appropriation shall be limited to no more than one-half acre-foot per acre of riparian land owned or controlled by the applicant except for appropriation for wild rice paddies as is provided in item G. Riparian lands for the purpose of these rules shall be those 40-acre tracts or government lots, or portions thereof, that directly abut a basin or watercourse. This provision shall apply until a protected flow or protection elevation has been established in accordance with part 6115.0670, subpart 3, item B.

G. The amount of appropriation for wild rice paddies shall be based on consideration of climatic characteristics of the area and the best available technology relating to amounts of water needed to raise wild rice.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

6115.0690 ADDITIONAL REQUIREMENTS AND CONDITIONS FOR PUBLIC WATER SUPPLIES.

Subpart 1. **Additional application information.** The applicant shall be required to submit to the commissioner all or portions of the following data in addition to the requirements of part 6115.0660:

A. the number of domestic users;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. reasonable projection of population growth;

C. the number and type of industrial and commercial users of the public water supply system;

D. the amount of water to be supplied to domestic, industrial, and commercial users respectively;

E. other users by type of use and amount to be used from the public water supply system such as golf courses, recreational lake level maintenance, water transferred to other supply systems;

F. information regarding the quantity of the appropriated water to be used in distribution and waste water treatment facilities, not including volume of actual waste water; and

G. details on emergency plans for water shortage periods outlining public information programs, priorities for limitations of discretionary water use, and alternate sources of public water supplies.

Subp. 2. **Commissioner's actions.** The commissioner shall allow the appropriation of water for public water supply systems based on evaluation and analysis of the data submitted by the applicant under provisions of parts 6115.0660 and subpart 1 of this part and the procedures outlined in part 6115.0670 and subject to subpart 3.

Subp. 3. **Other requirements.** Appropriation permits issued to public water supply authorities shall be subject to requirements of Minnesota Statutes, section 103G.291, relating to critical water deficiency periods and restriction of nonessential uses.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

6115.0700 ADDITIONAL REQUIREMENTS AND CONDITIONS FOR WATER LEVEL MAINTENANCE FOR BASINS.

Subpart 1. **Additional application information.** For water appropriation applications for the purpose of establishing and maintaining water levels for basins the applicant shall submit the following data in addition to the requirements of part 6115.0660:

A. information on the basin and proposed source of supply or source of discharge, including facts indicating how the water will be appropriated and discharged and the proximity of the basin to the proposed source of supply or source of discharge; and

B. information on the design of any discharge facility into or out of the basin.

Subp. 2. **Commissioner's actions.** The commissioner shall evaluate and make decisions on applications based on facts supplied by the applicant and subject to the applicable procedures outlined in part 6115.0670 and the following determinations:

A. effects on public welfare of the proposed appropriation;

B. the proposed appropriation is reasonable, practical, technically feasible, and effectively accomplishes its purpose;

C. the proposed appropriation will have minimal or no detrimental effect on the basin, the proposed source of supply, or the receiving water and property of riparian owners;

D. the quality of the water of the basin or the receiving water source will not be detrimentally impaired by the appropriation; and

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

E. the proposed appropriation is consistent with part 6115.0221, item A, subitem (2), public waters permits rules.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

6115.0710 ADDITIONAL REQUIREMENTS AND CONDITIONS FOR DEWATERING.

Dewatering, which involves appropriation of water from ground or surface water sources for purpose of removing excess water, shall be subject to water appropriation permit requirements, unless otherwise exempted by these parts. The commissioner shall evaluate and make decisions on such application based on applicable provisions of parts 6115.0660 and 6115.0670 and the following additional requirements:

A. The applicant must show there is a reasonable necessity for such dewatering and the proposal is practical.

B. The applicant must show that the excess water can be discharged without adversely affecting the public interest in the receiving waters, and that the carrying capacity of the outlet to which waters are discharged is adequate.

C. The proposed dewatering is not prohibited by any existing law.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

6115.0720 ADDITIONAL REQUIREMENTS AND CONDITIONS FOR MINING AND PROCESSING OF METALLIC MINERALS AND PEAT.

Subpart 1. **Additional application information.** All applicants for permits for mining and processing of metallic minerals and peat must provide the following information in addition to the requirements of Minnesota Statutes, section 103G.297 and part 6115.0660:

A. all plans and specifications regarding withdrawal, use, storage, and disposal of waters of the state;

B. details of the rates, volumes, and source of water to be appropriated and consumed in the processing, including all losses such as uncontrolled seepage, evaporation, plant losses, and discharge volumes;

C. criteria used in estimating the proposed appropriation, distribution, and discharge based on climatic averages and extremes;

D. details of the sources, rates, and volumes of water released from the mining operations involved;

E. details of the hydrologic and hydraulic impacts and effects of the operation on the watershed(s) including changes in basins, watercourses, and groundwater systems.

Subp. 2. **Commissioner's actions.** The commissioner shall analyze, evaluate, and make decisions on appropriations for mining and processing of metallic minerals based on facts submitted by the applicant

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

pursuant to subpart 1 and part 6115.0660, subject to the conditions outlined in part 6115.0670 and the following considerations:

A. The commissioner shall direct the applicant to utilize available surplus water from preexisting mining operations or facilities, whether owned or controlled by the applicant or others, whenever feasible and practical unless justification is provided on why such practice should not be allowed. If the commissioner finds that an existing permittee has available unused water, for which there is inadequate justification, the commissioner, after notice and opportunity for hearing, shall amend the existing permit to promote better utilization of the water.

B. The commissioner shall base the allocation of water on consideration of the legal requirements for water quality, the impact of the appropriation on those requirements, and the following order of priorities of water supply sources located within reasonable distance to the mining or processing site:

(1) runoff from the mining areas;

(2) water from active mine pits and tailing basins when such water is not utilized for other purposes or operations;

(3) water from existing mining operation reservoirs where such water is not utilized for other purposes or operations;

(4) water from other mining and processing operations;

(5) water from inactive mine pits;

(6) water from streams appropriated during periods of high flows;

(7) water from groundwater sources;

(8) water collected and stored behind off-stream impoundments;

(9) water collected and stored behind impoundments on streams; and

(10) water from natural basins greater than 500 acres in size.

C. If the disposal of excess water is necessary and if any mining operation in the area has caused or will cause a substantial reduction in watercourse flow, the commissioner shall where feasible and practical require the permittee to discharge excess water in a manner that would restore the flow. Such action shall consider the existing and anticipated use of excess water by higher priority users and must be in compliance with appropriate rules of the Minnesota Pollution Control Agency.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

6115.0730 WELL INTERFERENCE PROBLEMS INVOLVING APPROPRIATION.

Subpart 1. **For new applications.** If the commissioner determines that an adequate supply of water is available and that the proposed project is reasonable and practical as determined based on parts 6115.0670 and 6115.0680 to 6115.0720, but that there is a probable interference with public water supply well(s) and private domestic well(s) which may result in reducing the water levels beyond the reach of those wells, the following procedures shall apply:

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

A. The applicant shall be responsible for obtaining and providing to the commissioner, available information including depth, diameter, nonpumping and pumping levels, quality, and well construction details for all domestic and public water supply wells located within the area of influence of the proposed appropriation well.

B. The commissioner may require aquifer tests or other field tests to be conducted.

C. The commissioner shall determine the probable interference with the domestic and public water supply wells based on theoretic computations using available information regarding the aquifer characteristics obtained from aquifer tests and/or from hydrologic studies, and the probable effects of lowering the water levels in the domestic and public water supply wells due to the proposed appropriation in the area. For public supply wells only the probable interference with that portion which is used for domestic water supply is considered.

D. The commissioner shall provide the prospective appropriator with an evaluation of the nature and degree of effect of the appropriation on the water levels of the domestic well(s) and public water supply well(s).

E. The commissioner shall not issue the permit until the applicant agrees to exercise any of the following options within 30 days after written notification by the commissioner:

(1) accept a modification or restriction of the permit application to provide for an adequate domestic water supply; or

(2) submit a written agreement signed by the applicant and all parties identified under item C as having probable interference. Such agreement shall outline the measures that will be taken to ensure maintenance of water supplies to such identified parties to the extent that would have existed absent the proposed appropriation. In cases where no agreement can be reached, the commissioner shall implement the settlement procedure identified in item D.

Subp. 2. **For existing permits.** If complaints are made to the commissioner by private domestic well owner(s) or public water supply authority regarding the effects of a water appropriation on the domestic water supplies, the following procedures shall be followed:

A. The commissioner shall provide complaint forms to the parties making the complaint, thereafter referred to as "complainant."

B. Upon receipt of the completed complaint forms the commissioner shall notify the permittee, the applicable watershed district, and the soil and water conservation district and any other governmental agency or person who may be affected or has expressed interest in the complaint.

C. The commissioner shall investigate and assess the complaint by:

(1) Analyzing and evaluating the submitted complaint forms, hydrologic facts and characteristics of the water supply systems involved.

(2) Requesting additional facts from the complainant(s) and the permittee when necessary. In order to assure that available data on domestic well(s) are provided, the complainant shall cooperate with the permittee in providing such facts as may be available and allowing the commissioner access to obtain necessary available facts. If the complainant does not cooperate in providing available facts or allowing the commissioner access to the domestic well(s), the commissioner shall dismiss the complaint.

(3) Conducting, if necessary, a field investigation.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(4) Additional hydrologic tests and evaluation shall be required if hydrologic information is unavailable or inadequate to make a determination of necessary facts in the matter. For irrigation appropriations, the timing and conduct of such tests shall be in accordance with the provision of Minnesota Statutes, section 103G.271, subdivision 3, relating to modifying or restricting appropriation for irrigation.

(5) In evaluating the probable influence of the water appropriation on the domestic well(s) and public water supply well(s) the commissioner shall consider whether the domestic well(s) provides a dependable water supply while meeting the appropriate health requirements for the existing use of the affected well. For public water supply wells only the probable interference with that portion which is used for domestic water supply is considered.

D. Where adverse effects on the domestic well(s) are substantiated, the commissioner shall notify the permittee of the facts and findings of that complaint evaluation. In the event that the commissioner determines that the domestic water supply is endangered the commissioner shall, pursuant to part 6115.0750, subpart 7, unless a temporary solution is worked out, restrict or cancel the appropriation until such time as a decision has been made by either negotiation, settlement, or hearing.

E. The permittee shall within 30 days after written notification by the commissioner take appropriate action by exercising any of the following options:

(1) Requesting the commissioner to modify or restrict the permit in order to provide for an adequate domestic water supply.

(2) Negotiating a reasonable agreement with the affected well owner(s). If no agreement is reached, the settlement procedure outlined in subpart 4 shall apply; or

(3) Requesting a public hearing.

Subp. 3. **New domestic wells installed after appropriation permits have been issued.** In the event that new domestic wells, exempt from permit requirements, are installed in area of adequate ground water supplies where permits have been issued for appropriation the following shall apply:

A. It shall be the responsibility of the prospective new domestic well owner to ensure that the new domestic well will be constructed at adequate depth so that it will provide an adequate domestic water supply which will not be limited by the permitted appropriation.

B. Holders of valid permits for appropriation of water in areas where adequate water supplies are available shall not be responsible for well interference problems, involving new domestic wells exempt from permit, when such exempt domestic wells are installed subsequent to authorized appropriation.

Subp. 4. **Settlement.** If the applicant or permittee and the complainant(s) have been unable to negotiate a reasonable agreement pursuant to subparts 1, item E and 2, item E, the following procedure shall be implemented:

A. The applicant or permittee shall submit to the complainant a notarized written offer including a statement that the complainant must respond in writing to the commissioner within ten days from the receipt of the offer either accepting the offer or explaining why it is rejected. The offer must be submitted to the complainant with a copy to the commissioner within 40 days after the receipt of the written notification provided in subparts 1, item E and 2, item E, based on the following:

(1) If an existing domestic well provides an adequate domestic water supply which meets state health standards, and such well no longer serves as an adequate supply because of the proposed or permitted appropriation in the vicinity the applicant or permittee shall be responsible for all costs necessary

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

to provide an adequate supply with the same quality and quantity as prior to the applicant's or permittee's interference.

(2) If an existing well provides an adequate domestic water supply but does not meet state health standards and such well would no longer serve as an adequate supply because of the proposed or permitted appropriation in the vicinity, the applicant or permittee shall be responsible for that portion of costs of providing an adequate water supply, but shall not be responsible for those costs necessary to bring the domestic well(s) to state health standards.

B. The complainant shall, within ten days from the receipt of the notarized written offer, respond to the commissioner in writing either accepting the offer or making argument on why the offer is not reasonable. If no response is received from the complainant, within the time limit, the commissioner shall dismiss the complaint.

C. If the offer is not accepted, the commissioner shall make a decision based on the written offer and arguments and available facts, within ten days as follows:

(1) that the applicant or permittee has submitted a reasonable offer, the commissioner shall issue or continue the permit involved;

(2) that the applicant or permittee has not submitted a reasonable offer, the commissioner, after notice and opportunity for hearing, shall deny, modify, or terminate the permit involved;

(3) that there is a need for a public hearing in which case it is ordered.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

6115.0740 WATER USE CONFLICTS.

Subpart 1. **Conflict defined.** For the purpose of these rules a conflict occurs where the available supply of waters of the state in a given area is limited to the extent that there are competing demands among existing and proposed users which exceed the reasonably available waters. Existing and proposed appropriations could in this situation endanger the supply of waters of the state so that the public health, safety, and welfare would be impaired.

Subp. 2. **Procedure.** Whenever the total withdrawals and uses of ground or surface waters would exceed the available supply based on established resource protection limits, including protection elevations and protected flows for surface water and safe yields for groundwater, resulting in a conflict among proposed users and existing legal users the following shall apply:

A. In no case shall a permittee be considered to have established a right of use or appropriation by obtaining a permit.

B. The commissioner shall analyze and evaluate the following:

(1) the reasonableness for use of water by the proposed and existing users;

(2) the water use practices by the proposed and existing users to determine if the proposed and existing users are or would be using water in the most efficient manner in order to reduce the amount of water required;

(3) the possible alternative sources of water supply available to determine if there are feasible and practical means to provide water to satisfy the reasonable needs of proposed and existing users.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

C. If conflicts can be resolved by modifying the appropriation of the proposed and existing users, the commissioner shall do so.

D. If conflicts cannot be resolved through modification of proposed and existing permits the commissioner shall base the decision regarding issuance of new applications and retention, modification, or termination of existing permits on the basis of existing priorities of use established by the legislature as follows:

(1) If the unresolved conflict involves users who are or would be in the same priority class, the commissioner shall require the proposed users and existing permitted users to develop and submit a plan which will provide for proportionate distribution of the limited water available among all users in the same priority class. The commissioner shall withhold consideration of new applications and shall, if the existing permitted appropriations endanger the supply of waters of the state, suspend or limit existing permits until a plan is approved by the commissioner.

The plan must include proposals for allocating the water which address the following: possible reduction in the amounts of appropriation so that each user would receive a proportionate amount of water for use; and possible restrictions in the timing of withdrawals so that each user would be allowed to withdraw a proportionate share of water for use over certain periods of time.

If the commissioner approves the proposed plan, new permits will be issued and existing permits will be amended in accordance with that plan.

If the commissioner determines that the proposed plan is not practical or reasonable, the commissioner shall develop a new plan or modify the proposed plan to provide proportionate share of water among the users involved. The commissioner shall issue new permits and amend existing permits based on that plan.

(2) If the unresolved conflict involves users who are or would be in a different priority class the available water supply shall be allocated to existing and proposed users based on the relative priority of use. Highest priority users shall be satisfied first. Any remaining available water supply shall be allocated to the next succeeding priority users, until no further water is available. Users in the same priority class shall be offered the same options as provided in subitem (1).

Subp. 3. **Notice and hearing.** All actions by the commissioner shall be made after notice and opportunity for public hearing.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0750 PROVISIONS AND CONDITIONS OF WATER APPROPRIATION PERMITS.

Subpart 1. **In general.** Water appropriation permits shall include the following provisions and conditions, unless otherwise required by law.

Subp. 2. **Term of permits.** Permits shall be issued for temporary or for long-term appropriation.

Temporary permits involve a one-time, limited life, not more than 12 months, nonrecurring appropriation of waters of the state, such as for highway construction, exploratory drilling for minerals, hydrostatic testing of pipelines and other short-term projects. Requested time extensions shall be permitted, but in no case shall the total length of time the permit remains in force exceed two years.

Long-term permits will remain in effect subject to applicable permit provisions and conditions of the permit, the law, and these parts, provided that in cases where the permittee is not the landowner of record, the term of the permit shall be the same as that of the property rights or license held.

Subp. 3. **Monitoring.** Monitoring:

A. All permittees shall measure and keep monthly and yearly records of the quantity of water used or appropriated at the point of taking from each source under permit.

B. Each installation for appropriating or using water shall be equipped with a device or employ a method to measure the quantity of water appropriated to within ten percent of actual withdrawal.

The commissioner shall determine the method to be used for measuring water appropriated based on: the quantity of water appropriated or used; the source and location of the appropriation; the method of appropriating or using water; other facts supplied by the permittee.

The commissioner shall require flow meters to be used whenever the rate of appropriation is greater than 1,500 gallons per minute, unless the permittee can show justification why flow meters cannot practically be used or are not necessary considering the factors contained in the two preceding paragraphs. Such justification must be supported by facts which indicate the technical difficulties which would be encountered if flow meters were required.

C. For surface water appropriations, where applicable, the permittee shall measure flows or levels in the watercourse or basin at a specific gauge designated by the commissioner and located within the area of appropriation. The commissioner shall require permittees to pay necessary costs of establishing and maintaining such gages as provided in parts 6115.0010 to 6115.0100, rules for permit fees.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

For groundwater appropriation, the commissioner, based on availability of hydrologic data on the aquifer involved, frequency and rate of pumping, and probability of conflict or well interference, shall require the permittee to measure and keep records of the water levels in each production well at reasonable times prescribed in the permit. Observation wells may be required as a condition of the permit to better evaluate hydrologic conditions and effects in areas where hydrologic data are unavailable, where probable conflict or well interference problems may occur and where such wells are required by law.

Subp. 4. **Reporting.** Annual calendar year monthly records of the amount of water appropriated or used and the water level measurements shall be recorded for each installation. Such readings and the total amount of water appropriated and used shall be reported annually to the commissioner, on or before February 15 of the following year upon forms to be supplied by the commissioner unless otherwise specified in the permit.

Such records shall be submitted with an annual water appropriation processing fee as required by Minnesota Statutes, sections 103G.271, subdivision 6, and 103G.281, subdivision 3, for each permit whether or not any water was appropriated during the year.

Additional information shall be required such as acreage irrigated, identification of water disposal sites, and amount of water discharged, when necessary for the statewide water information system (Minnesota Statutes, section 103G.275, subdivision 2).

Failure to report and pay the fee shall be sufficient cause for terminating a permit 30 days following written notice by the commissioner of the violation of the permit.

No fee is required from any state agency as defined in Minnesota Statutes, section 16B.01, subdivision 2, or any federal agency.

Subp. 5. **Amendments to permits.** Amendments to permits:

A. Major modification of any water appropriation permit shall not be made before obtaining the written permission from the commissioner. Major modification includes changes such as substantial increase or decrease in the rate and quantity of water withdrawn, any change in source of appropriation or substantial change in the amount of land irrigated, when applicable.

Request for amendment can be made by letter or on forms supplied by the commissioner. New applications shall be required when there are changes in the source of supply, the purpose of appropriation,

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

or when the proposed increases in rates and amounts of water would probably create conflict or well interference.

Requests for amendments shall be reviewed as if they were for a new application, subject to provisions of parts 6115.0600 to 6115.0800.

B. Pursuant to authority in Minnesota Statutes, section 103G.315, subdivision 11, the commissioner may modify or amend any existing permits based on the following procedures and the criteria in parts 6115.0670 to 6115.0720, where applicable.

The commissioner shall notify the permittee of the intent to amend the permit. The notice will include details on modifications to be implemented by the permittee and the timing to complete the modifications.

The permittee shall respond within 30 days from receipt of the notice. Such response period shall be thereafter extended by the commissioner for good cause shown.

If no response is received in 30 days and no extension of response time is authorized by the commissioner, the proposed amendments shall be made.

The commissioner based on the permittee's response and the criteria established in these rules shall either modify the proposed amendment or adopt the original proposed amendment.

C. All amendments and modifications are made after notice and opportunity for hearing.

Subp. 6. **Transfers or assignments of permits.** If the property involving a water appropriation permit is sold, transferred, or assigned to another person, the permit may be transferred to the transferee without the necessity of reapplication, subject to the following.

The transferee shall, within 90 days after date of property sale, transfer, or assignment, or within a longer period of time allowed by the commissioner for good cause shown, submit written notification to the commissioner stating the intention to continue the appropriation as stated in the permit. If the transferee intends to make major modifications to the existing permit, a new application shall be required subject to the provisions of subpart 5.

No permit is assigned except with the written consent of the commissioner.

Subp. 7. **Limitations on permits.** All permits issued by the commissioner since 1949 are subject to the provisions of Minnesota Statutes, section 103G.315, subdivision 11, relating to cancellation and

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

conditions of permits and Minnesota Statutes, section 103G.315, subdivisions 2 to 6, 8, and 9, relating to terms and reservations with respect to the amount and manner of such use or appropriation or method of construction or operation of controls as appears reasonably necessary for the safety and welfare of the people of the state.

The commissioner, subject to the terms and conditions of such existing permits, may modify, restrict, or cancel an existing appropriation or use until such time as a decision has been reached by either negotiation, settlement, or after a public hearing. If a permit does not contain a provision which restricts appropriation or use for the protection of safety or welfare of the people of the state the commissioner cannot modify or restrict an existing appropriation until opportunity is provided for a public hearing and where ordered a public hearing has been completed.

Subp. 8. **Terminations.** Permits shall be terminated under the following:

A. Request by the permittee.

B. When any of its provisions are violated.

C. When the permittee sells, transfers, or assigns the property described in the permit and the transferee does not wish to continue appropriating.

D. Upon finding that the permittee has violated the provisions of any applicable laws and rules.

E. Where the permittee has not for five consecutive years, from the date of issuance of the permit, appropriated the water. Such time shall be extended by the commissioner for good cause shown.

F. When the lease or contract for deed is forfeited or canceled.

G. Permits for agricultural irrigation shall be subject to termination by the commissioner upon justifiable recommendation of the supervisors of the soil and water conservation district, wherein the land irrigated is located, regarding the inadequacy of the soil and water conservation measures.

H. When the commissioner deems it necessary for the conservation of the water resources of the state or in the interest of public health, safety, and welfare.

I. When the commissioner deems it necessary pursuant to parts 6115.0730 and 6115.0740.

J. Any action pursuant to items B and D to I shall be subject to appropriate notice and opportunity for hearing, except as provided in subpart 7.

K. In the case of permits for mining issued in conjunction with Minnesota Statutes, section 103G.297, procedures for termination shall be subject to provisions of Minnesota Statutes, section 103G.297, subdivision 8.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0760 LOCAL PERMITS.

The commissioner, pursuant to Minnesota Statutes, section 103G.271, subdivision 4, shall delegate to municipal, county, or regional level of government the authority to process and approve permit applications for the appropriation and use of waters of the state in amounts of more than 10,000 gallons per day and more than 1,000,000 gallons per year, but less than 3,600,000 million gallons per year. Such delegation shall be made at the municipal, county, or regional level which means a governmental entity, or several governmental entities in combination, having authority or jurisdiction over areas of geographical extent beyond the limits of a single county, or a watershed district. The delegation by the commissioner shall be subject to the following requirements:

A. The authorized unit of government has established an administrative process which includes provisions for establishing a water appropriation management planning process consistent with part 6115.0810.

B. The review and approval of applications are consistent with the applicable provisions of these parts.

C. A formalized agreement is made and signed by the commissioner and the appropriate municipal, county, or regional level authority involved.

D. Copies of all applications and records of local actions on applications are provided to the commissioner upon receipt and action.

E. Records of water appropriation amounts and the processing fee shall be submitted by the permittee to the commissioner as required by part 6115.0750, subparts 3 and 4, and Minnesota Statutes, sections 103G.271, subdivision 6, and 103G.281, subdivision 3.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

6115.0770 WATER CONSERVATION.

In order to maintain water conservation practices in the water appropriation and use regulatory program it is necessary that existing and proposed appropriators and users of waters of the state employ the best available means and practices based on economic considerations for assuring wise use and development of the waters of the state in the most practical and feasible manner possible to promote the efficient use of waters.

Based on data submitted by applicants and permittees and current information on best available water conservation technology and practice the commissioner, in cooperation with the owners of water supply systems, may analyze the water use practices and procedures and may require a more efficient use of water to be employed by the permittee or applicant, subject to notice and opportunity for hearing.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.0780 ABANDONMENT OF WELLS.

The permittee shall notify the commissioner prior to abandoning, removing, covering, plugging, or filling the well or wells by means of which a water appropriation was made. The commissioner shall require abandonment procedures and methods consistent with the Minnesota Department of Health rules, parts 4725.2300 to 4725.3200.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

6115.0790 FIELD INVESTIGATIONS.

In order to fully evaluate water appropriations, the commissioner shall conduct field investigations to determine the nature and scope of the appropriation and the impact it has or will have on water and related land resources. Such field inspection shall be made in a timely fashion and shall be coordinated with one or more of the following divisions of the department: Enforcement, Fish and Wildlife, Forestry, Minerals, Lands, and Parks and Recreation. A fee shall be charged for field inspections subject to rules for permit fees, part 6115.0080.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

6115.0800 INFORMATION ON APPROPRIATION PERMIT LAWS.

The applicants or existing permittees shall, upon request to the commissioner, be furnished copies of applicable portions of the law or synopsis, where they exist, relating to their proposed or existing appropriation.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

6115.0810 WATER APPROPRIATION AND USE MANAGEMENT PLANS.

Subpart 1. **In general.** In order to address the provisions of Minnesota Statutes, sections 103B.155, 103G.261, 103G.265, and 103G.271, subdivision 2, the commissioner, in cooperation with other state and federal agencies, regional commissions and authorities, local governments and citizens, establishes the following process for the preparation and implementation of the elements of any state, regional, and local plan relating to water appropriation and use.

Subp. 2. **Criteria and procedures.** Since the availability, distribution, and utilization of waters of the state and the character and use of related land resources vary considerably throughout the state, a comprehensive water appropriation management planning process must be based on these considerations and according to the following principles and procedures:

A. Water appropriation management plans should be prepared for specific definable areas of the state on consideration of:

(1) The hydrologic and physical characteristics of the water and related land resources for which a management plan is necessary. The area must be of sufficient size and areal extent so that the interrelationship of geohydrologic and climatic factors can be adequately defined and managed.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

(2) The determination by the commissioner of the need for establishment of a water appropriation management plan for the waters of the state within a specific definable area based on:

(a) areas where development of the waters of the state is, or is likely to, increase considerably within the next five to ten years;

(b) areas where severe water availability problems exist or are soon likely to exist;

(c) areas where there are adequate facts and available geohydrologic data relating to the availability, distribution, and use of the waters of the state and where there is local interest in establishing water appropriation management plans.

B. Upon establishment of the need for a water appropriation management plan pursuant to item A, the commissioner shall establish a management planning process including procedures, a public participation process, and development of a planning team consisting of representatives of the department, permittees, any other interested, concerned, and involved government or citizen group listed in subpart 1 to review and cooperate in preparation of the plan.

Subp. 3. **General requirements and contents of plans.** Every water appropriation plan should, at a minimum, include:

A. An evaluation of the amount and dependability of information on the hydrologic systems of the area and the adequacy of the information to provide necessary facts on the amounts of water which can be reasonably withdrawn from the waters of the state in the area without creating major environmental problems or diminishing the long-term seasonal supply of water for various purposes. This will provide essential background information for establishing protected flows and protection elevations, part 6115.0670, subpart 3, item B, subitem (6).

B. An evaluation of data on stream quality and flows, lake water quality and levels, groundwater quality and levels, and climatic factors. This will provide essential data useful to the applicant and the commissioner in permit application considerations, parts 6115.0660 to 6115.0720.

C. An evaluation of present and anticipated future use of waters and lands and the amounts and distribution of use within the area. This will facilitate the determinations necessary under part 6115.0670, subpart 2, item A, subitem (2).

D. An evaluation of the problems and concerns relating to use of the waters within the area.

E. Water conservation alternatives and methods and procedures for dealing with water shortages or excesses during periods of deficient or excess water. See parts 6115.0660, subpart 3, item F; 6115.0690, subpart 1, item G; and subpart 2 of this part.

F. Considerations of the relationship of the water appropriation and use management plan to other water resources programs of the state, such as floodplain management, shoreland management, water surface use management, water quality management, soil and water conservation management, and agricultural land management.

Statutory Authority: *MS s 103G.315; 105.415*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

LAKE IMPROVEMENT DISTRICTS

6115.0900 PURPOSE.

In order to provide for the orderly establishment of lake improvement districts in a manner that will preserve and protect the lakes of Minnesota and increase and enhance the use and enjoyment of these lakes, the commissioner of the Department of Natural Resources does hereby provide guidelines, criteria, and standards for establishment of lake improvement districts by counties, cities, and towns, as authorized by Minnesota Statutes, sections 103B.511 to 103B.581, 103G.605, 103G.621, and 459.20, in furtherance of the policies declared in Minnesota Statutes.

These rules establish minimum guidelines, criteria, and requirements relating to:

A. procedures by which proposed lake improvement districts shall be reviewed prior to establishment;

B. standards and criteria which all proposed lake improvement districts shall meet before establishment, modification, or termination.

Statutory Authority: *MS s 103B.511; 378.41*

Posted: *June 11, 2008*

6115.0910 SCOPE.

These parts shall apply to all existing and proposed lake improvement districts. These parts shall not apply to lake conservation districts established by special legislation of the Minnesota state legislature.

Statutory Authority: *MS s 378.41*

Posted: *June 11, 2008*

6115.0920 DEFINITIONS.

Subpart 1. **Shall.** For the purpose of these parts, certain terms or words used herein shall be interpreted as follows: the word "shall" is mandatory, not permissive.

Subp. 2. **Agency.** "Agency" means the Minnesota Pollution Control Agency.

Subp. 3. **Commissioner.** "Commissioner" means the commissioner of the Department of Natural Resources or authorized representative.

Subp. 4. **Direct drainage basin.** "Direct drainage basin" means that portion of a lake's total watershed which is not drained to an upstream water basin, as defined herein. The determination of size and physical limits of a lake's direct drainage basin shall be made by the commissioner.

Subp. 5. **District boundaries.** "District boundaries" means, for the purpose of these parts, the territorial boundaries of a lake improvement district. All lands and waters within the direct drainage basin, as defined herein, shall be included within the district boundaries, except those exclusions for which written approval is obtained from the commissioner. The boundaries shall include a sufficient amount of the lake's watershed and related land to develop and implement feasible solutions to the problems the district intends

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

to address. The boundaries shall also include all lands and waters which can reasonably be considered adversely affected by the proposed programs, plans, or actions of the lake improvement district.

Subp. 6. **Lake.** "Lake" means, for the purpose of these parts, any public water basin identified and classified in the shoreland management ordinances of the local county or municipal unit of government.

Subp. 7. **Lake improvement district.** "Lake improvement district" means a district formed around a lake in accordance with Minnesota Statutes, sections 103B.501 to 103B.581. A lake improvement district is a local unit of government established by resolution of appropriate county boards and/or city governing bodies, or by the commissioner, for the implementation of defined lake management projects and for the assessment of the costs thereof.

Subp. 8. **Natural hydrologic boundaries.** "Natural hydrologic boundaries" means the boundaries of a lake's direct drainage basin, as defined herein.

Subp. 9. **Resident.** "Resident" means a person 18 years of age or older who meets the residency requirements of Minnesota Statutes, section 200.031.

Subp. 10. **Resident owner.** "Resident owner" means a Minnesota resident who is the owner of land or the contract purchaser of land within the boundaries of a lake improvement district.

Subp. 11. **Water basin.** "Water basin" means an enclosed basin normally partly or completely filled with water. The water basin may have inlet and outlet streams, it may have only an inlet or outlet, or it may be completely enclosed.

Subp. 12. **Watershed.** "Watershed" means the entire surface drainage area that contributes water to a lake.

Statutory Authority: *MS s 103B.511; 378.41*

History: *17 SR 1279*

Posted: *June 11, 2008*

6115.0930 SEVERABILITY.

The provision of these rules shall be severable, and the invalidity of any paragraph, subparagraph, or subdivision thereof shall not make void any other paragraph, subparagraph, subdivision, or any other part.

Statutory Authority: *MS s 378.41*

Posted: *June 11, 2008*

6115.0940 GOALS FOR LAKE IMPROVEMENT DISTRICTS.

Proposals for the establishment of lake improvement districts shall be evaluated according to the degree to which they promote the following goals:

A. lake protection and rehabilitation;

B. protection and enhancement of environmental values by preventing degradation of fish and wildlife habitat, surface and ground water quality, natural beauty and unique scientific values, recreational values, and the quality of life generally;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

C. preservation of the public rights in the public waters of the state and to provide the public use of the lake consistent with the preservation of environmental values;

D. ensuring local involvement in the project and a commitment to future lake management;

E. conformity with federal, state, regional, and local laws, rules, and water and related land management policies; and

F. fair and objective resolution of conflicts between competing lake related interests in and around the district.

Statutory Authority: *MS s 378.41*

Posted: *June 11, 2008*

6115.0950 ELIGIBILITY FOR LAKE IMPROVEMENT DISTRICTS.

The types of lake improvements in items A to H are eligible for the creation of a lake improvement district:

A. studying the sources of and solutions to lake problems;

B. preserving and improving water quality by means of water and related land management, excluding land use zoning authority; and in-lake water treatment;

C. sedimentation and siltation control;

D. shoreline erosion control;

E. aquatic nuisance control;

F. preserving and improving fish and wildlife habitat;

G. preserving and improving recreational potential of the lake; and

H. any other purposes approved by the county board pursuant to Minnesota Statutes, sections 103B.551, subdivision 3; 103G.605; and 103G.621.

Statutory Authority: *MS s 103B.511; 378.41*

Posted: *June 11, 2008*

6115.0960 CRITERIA AND STANDARDS FOR ESTABLISHMENT OF LAKE IMPROVEMENT DISTRICTS.

Subpart 1. **In general.** Proposals for the establishment of lake improvement districts shall be evaluated based on the extent to which they demonstrate the following.

Subp. 2. **Local need for district.** The proposal shall demonstrate the need for the district and why another unit of government with similar powers, or a voluntary lake association, cannot or will not satisfactorily accomplish the district's proposed purposes.

Subp. 3. **Appropriateness of proposed boundaries.** The proposed boundaries shall be consistent with district boundaries as defined in part 6115.0920. The proposed boundaries shall include all lands and waters within the lake's direct drainage basin, unless justification is provided for including a lesser area and approved in writing by the commissioner. The proposed boundaries shall include a sufficient amount of

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

the lake's watershed and related land to develop and implement feasible solutions to the identified problems. The proposed boundaries shall include those lands and waters which can reasonably be considered adversely affected by the proposed actions of the district. The proposed boundaries shall be delineated so as to provide appropriate public representation and the equitable distribution of benefits and levying of costs.

Subp. 4. **Appropriateness of proposed purposes.** The proposed purposes shall be consistent with existing state, federal, regional, and local laws, policies, objectives, and plans pertaining to water and related land management, fish and wildlife habitat, surface and ground water quality, natural beauty and unique scientific values, economic and recreation values, and the quality of life. The proposed purposes shall be consistent with the public rights in the public waters of the state. When a district is proposed for the purpose of conducting a feasibility study of the sources of and solutions to lake problems, the proposal shall demonstrate an understanding that subsequent lake restoration measures may require modification of the district's boundaries and statement of purposes, pursuant to part 6115.0980, subpart 1, and Minnesota Statutes, section 103B.575.

Subp. 5. **Technical feasibility of proposed plans and programs.** The proposal shall demonstrate the technical feasibility of the proposed plans and programs, or provide for the determination of technical feasibility.

Subp. 6. **Adequacy of proposed means of financing.** The proposal shall demonstrate capability of raising sufficient funds to meet district purposes, to ensure continuity of district operations, and to meet the requirements of these parts.

Subp. 7. **Adequacy of procedures for planning, decision-making, and public involvement.** The proposal shall assure consideration of the interests of concerned citizens both within and outside the boundaries of the proposed district. The proposal shall include the identification of varying and often conflicting interests regarding water and related land management in and around the proposed district, and procedures to assure the consideration of such diverse interests so that decisions are made in the best overall interests of fairness and public health, safety, and welfare.

Subp. 8. **Public access.** The proposed plan shall provide for public access when adequate public access consistent with size of the lake, the extent of public interest in using the lake, and the combined uses of the lake is unavailable. Service charges may not be imposed on the use of a public access if other units of government cost share the acquisition, development, or maintenance of the public access.

Subp. 9. **Adequacy of long-range monitoring of environmental effects of district programs.** The proposed plan shall demonstrate an understanding of potential environmental effects of the proposed district plans and programs, and provide for a long-range monitoring of such effects.

Subp. 10. **Coordination with other special purpose districts.** The proposal shall demonstrate how the proposed district programs will be coordinated with existing special purpose districts formed for water and related land management. Examples of such units of government are watershed districts, sanitary districts, drainage and conservancy districts, lake conservation districts, and soil and water conservation districts. Lake improvement districts shall not be established where a special purpose unit of government for water and related land management exists which can implement the purposes of the proposed lake improvement district, unless written approval is acquired from such unit of government or

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

from the commissioner. The proposal should demonstrate efforts in good faith to resolve at the local level any conflicts between an existing special purpose district and the proposed lake improvement district.

Statutory Authority: *MS s 103B.511; 378.41*

Posted: *June 11, 2008*

6115.0970 CREATION OF LAKE IMPROVEMENT DISTRICT.

Subpart 1. **Petition or county board document.** A county board document proposing the creation of, or a petition to create, a lake improvement district shall contain the following elements:

A. A written statement of lake problems and objectives.

B. The proposed type or types of water and related land resource management programs to be undertaken by the proposed district. This shall include a detailed statement of intended studies, management programs, remedial actions, and construction projects.

C. A statement of the means by which the programs will be financed.

D. A map showing the boundaries of the proposed lake improvement district. The map shall show the number and location of permanent homes and seasonal dwellings in the district. The scale of the map, and basic geographical information, such as range, township, and section numbers, shall be clearly indicated on the map.

E. The number of directors proposed for the district.

F. Copies of local ordinances which regulate use of the lake or any public access.

G. Any information indicating the degree of local interest and commitment to future management.

H. The identification of any lands and waters which may be adversely affected by the implementation of district purposes, and a preliminary assessment of these adverse effects.

I. A statement outlining the adequacy and ownership of public accesses, including public lands and beaches.

J. An estimate of the total equalized valuation of the property within the district.

K. Any other information demonstrating accordance with the criteria and standards for establishment as contained in part 6115.0960.

Subp. 2. **Submission of petition or resolution.** Initial submittal of petition or resolution to county board, the commissioner, and the agency for:

A. Creation by petition. No later than five days after the official filing of a petition for the establishment of a lake improvement district with the county board, the citizens or organization sponsoring the petition shall provide a certified copy of the petition to the commissioner and the agency. This is necessary in order to facilitate preliminary review of the proposed district boundaries prior to the notification of the public hearing.

B. Creation by resolution. At least 40 days prior to the public hearing, the county board shall provide a certified copy of the document containing the information required by this part to the commissioner and the agency. This is necessary to facilitate preliminary review of the proposed district boundaries prior to notification of the public hearing.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 3. **Notification of public hearing.** At least 21 days prior to the public hearing, the county board shall give notice of the public hearing to the commissioner and the agency, and make a reasonable attempt to notify every resident and every resident owner within the proposed district of the pending resolution or petition and the public hearing. A reasonable attempt to notify shall consist of mailing notice to the last known address of each landowner within the proposed district, publication of notice in two successive issues of a newspaper widely circulated in the proposed district, and posting notice in public buildings and several leading commercial establishments in or near the proposed district, as appropriate and reasonable. All local and regional units of government, special purpose districts, and development commissions within and adjacent to the boundaries of the proposed district shall be given notice of the public hearing. All corporations and utilities owning real estate or corporate property within the proposed district shall be given notice of the public hearing.

As part of the notification procedure, a statement shall accompany the notice setting forth the following:

A. a description of the proposed purposes, programs, funding, and boundaries of the proposed district, and the name proposed for the district;

B. the time and place of the public hearing; and

C. the following paragraph shall be included:

"The establishment of the proposed lake improvement district requires review by the commissioner of natural resources and the approval of the (as appropriate) county board(s) (and/or city governing body). Concerned citizens may submit evidence at a public hearing to be held prior to the passage of any resolution establishing the proposed lake improvement district. Concerned citizens may also submit evidence and opinions to the commissioner of natural resources. A copy of the petition (or document, as appropriate) for the establishment of the lake improvement district is available for public review at the (as appropriate) county courthouse (or other appropriate public building; give address and telephone number where interested citizens can review the document)."

If the establishment of the lake improvement district is proposed by the county board pursuant to subpart 2, item B and Minnesota Statutes, section 103B.515, the following paragraph shall be included in the notice of the public hearing:

"Citizens may call for a referendum on the question of whether or not to establish a lake improvement district by filing a petition requesting such a referendum. The petition shall be signed by 25 percent of the land owners within the territory of the proposed district, who are Minnesota residents.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Upon receipt of such a petition prior to the effective date of creation of the district, the county board shall hold the creation in abeyance pending the referendum vote of all qualified voters residing within the boundaries of the proposed district."

Subp. 4. **Public review of petition or resolution.** The county board shall make the petition or document containing the information required by this part available for review by concerned citizens, at the county courthouse or other appropriate public building.

Subp. 5. **Review by commissioner and agency.** Upon receipt of a copy of the petition or document, the commissioner shall:

A. Review the petition or document and any evidence presented by the agency or concerned citizens pertaining to the establishment of the proposed district. This review shall include an evaluation of the statement of district purposes and its relation to existing laws, rules, and regulations, units of government, water and related land management programs and policies. The proposed district boundaries shall be examined to assess their consistency with these parts. When one or more of the stated purposes of the proposed district relate to pollution control, this review shall be conducted with the assistance of the agency.

B. Prepare an advisory report stating findings as to whether the proposed lake improvement district should be established. The commissioner shall set forth in the report any matters pertaining to the district which should be further investigated and evaluated. On determining that the establishment of the proposed district is not in the public interest, the commissioner shall so report the specific reasons and inadequacies. The commissioner may request additional time for review of the proposed district in such cases where additional time can be shown to be necessary for proper evaluation. The commissioner's report may contain reports by the agency.

Subp. 6. **Request for continuance or postponement of hearing.** The county board may grant requests by citizens, the commissioner, or the agency for postponement or continuance of the public hearing to a time more than 30 days after receipt of the petition and verification of the signatures thereon. Such requests may be granted if the county board determines that the additional time requested is appropriate and reasonable in order for the requesting organization or citizens to adequately prepare for the public hearing, and consistent with the goals of promptness and fairness in the proceedings.

Subp. 7. **Advisory report.** The commissioner's advisory report shall be publicly read into the record at the public hearing.

Subp. 8. **Modification of findings.** The commissioner may modify findings based on evidence presented during and subsequent to the public hearing.

Subp. 9. **Formal meeting to approve or disapprove district.** No sooner than ten days but within 30 days following the holding of the public hearing, the county board shall formally convene to approve or disapprove the establishment of the proposed lake improvement district. At least ten working days' notice shall be given to the commissioner of the time and place where the board will formally convene for this purpose. If the commissioner or the commissioner's representative does not appear, any modifications of the commissioner's advisory report shall be publicly read into the record.

Statutory Authority: *MS s 103B.511; 378.41*

History: *17 SR 1279*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Posted: *June 11, 2008*

6115.0980 ADMINISTRATION OF LAKE IMPROVEMENT DISTRICTS.

Subpart 1. **Modification.** No program, remedial action, project, or change of district boundaries which is not specified in the resolution creating a lake improvement district may be undertaken, except by modifying the appropriate items listed in part 6115.0970, subpart 1, items A to E.

For an established district, any of the items listed in part 6115.0970, subpart 1, items A to E may be modified by petition to or resolution by the county board, in the same manner that a district is created.

Subp. 2. **Legal responsibilities and liabilities of lake improvement districts.** Nothing in these parts shall be construed to relieve a lake improvement district of the legal duties, obligations, or liabilities incident to the programs, plans, or actions of the district.

The lake improvement district shall assume all legal risks and liabilities, including those for damages or any injury to persons or property, arising from the construction, operation, maintenance, alteration, or abandonment of its programs, plans, or actions.

In the event of termination of the district, or failure of the district to meet its obligations, these responsibilities and liabilities shall fall upon the unit or units of government which established the lake improvement district.

Subp. 3. **Limited state liabilities.** The establishment of a lake improvement district shall not impose any liability upon the state of Minnesota, its officers, employees, agents, or consultants, for any damage or injury to any persons or property resulting from the activities of the lake improvement district.

Subp. 4. **Rights of lake improvement districts.** Nothing in these parts shall be construed to deprive any lake improvement district of such recourse to the courts as it may be entitled to under the laws of this state.

Subp. 5. **Inspections.** The commissioner shall be given prompt access to and inspection of all records, structures, facilities, and operations at all reasonable times as may be necessary to monitor compliance with the terms of existing permit and to ensure protection of the public health, safety, and welfare. The commissioner's inspections shall not relieve the lake improvement district from the full responsibility of providing adequate inspection and supervision for all programs and projects undertaken by the district.

Subp. 6. **Compliance with other laws and water management policies.** Lake improvement districts shall conform to federal, state, regional, and local laws, rules, and fish and wildlife, water, and related land management policies. Lake improvement districts shall obtain all necessary permits, as required by law, prior to implementing district purposes and programs.

Subp. 7. **Compliance by preexisting lake improvement districts.** Within one year following promulgation of these parts, lake improvement districts in existence prior to the promulgation of these rules shall submit to their county board and to the commissioner a certified copy of a document containing the

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

information required by part 6115.0970. This document shall also contain a report on the past and current activities and financial condition of the district.

The commissioner shall review the document and prepare an advisory report stating findings as to whether the district is consistent with these parts. The report may contain such recommendations as the commissioner determines is necessary to bring the district into compliance with these parts.

Within 60 days following the official filing of the commissioner's report with the county board, the board shall formally convene to consider the report. The county board shall give ten working days' notice to the commissioner of the time and place where it will convene to consider the commissioner's report. If the commissioner or the commissioner's representative does not appear, the report shall be publicly read into the record.

Statutory Authority: *MS s 378.41*

History: *17 SR 1279*

Posted: *June 11, 2008*

6115.1000 MR 1997 [Obsolete, MS s 14.47, subd. 6, paragraph (b)]

Posted: *June 11, 2008*

6115.1010 MR 1997 [Obsolete, MS s 14.47, subd. 6, paragraph (b)]

Posted: *June 11, 2008*

6115.1020 MR 1997 [Obsolete, MS s 14.47, subd. 6, paragraph (b)]

Posted: *June 11, 2008*

6115.1030 MR 1997 [Obsolete, MS s 14.47, subd. 6, paragraph (b)]

Posted: *June 11, 2008*

6115.1040 MR 1997 [Obsolete, MS s 14.47, subd. 6, paragraph (b)]

Posted: *June 11, 2008*

6115.1050 MR 1997 [Obsolete, MS s 14.47, subd. 6, paragraph (b)]

Posted: *June 11, 2008*

6115.1060 MR 1997 [Obsolete, MS s 14.47, subd. 6, paragraph (b)]

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Posted: *June 11, 2008*

6115.1070 MR 1997 [Obsolete, MS s 14.47, subd. 6, paragraph (b)]

Posted: *June 11, 2008*

6115.1080 MR 1997 [Obsolete, MS s 14.47, subd. 6, paragraph (b)]

Posted: *June 11, 2008*

6115.1090 MR 1997 [Obsolete, MS s 14.47, subd. 6, paragraph (b)]

Posted: *June 11, 2008*

6115.1100 MR 1997 [Obsolete, MS s 14.47, subd. 6, paragraph (b)]

Posted: *June 11, 2008*

6115.1150 [Repealed by amendment, L 1979 c 199]

Posted: *June 11, 2008*

STATE WATER BANK PROGRAM

6115.1200 STATUTORY AUTHORITY AND PURPOSE.

These parts are promulgated under the authority of Minnesota Statutes, sections 103F.601, subdivisions 1 and 2, and 103G.315, subdivision 15. Their purpose is to implement and make specific the state water bank program and the indemnification process established by Minnesota Statutes, sections 103G.211 and 103G.221, for the purpose of compensating farmers for not converting certain kinds of wetlands to cropland.

Statutory Authority: *MS s 103F.601; 103G.315; 105.392; 105.415*

Posted: *June 11, 2008*

6115.1210 DEFINITIONS.

Subpart 1. **Adjacent land.** "Adjacent land" means any lands abutting a basin that is eligible for inclusion in the state water bank program.

Subp. 2. **Commissioner.** "Commissioner" means the commissioner of the Department of Natural Resources or designated agents.

Subp. 3. **Drain.** "Drain" means to conduct drainage activities that will remove or reduce the surface water from the basin. Acts constituting draining include, but are not limited to pumping, lowering the outlet, enlarging the outlet, tiling, or reducing the amount of water entering the basin. (Drainage does not include temporary water level reduction for conservation purposes.)

Subp. 4. **Fair market value.** "Fair market value" is an estimate of a property's value based upon standard and accepted land appraisal methods. The appraisal for eligible wetlands will estimate the potential value of the area as agricultural cropland less the cost of drainage.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 5. **Less than 50 acres in area.** "Less than 50 acres in area" means the area of a plane bounded by the ordinary high water mark which is a mark delineating the highest water level which has been maintained for a sufficient period of time to leave evidence upon the landscape. The ordinary high water mark is commonly that point where the vegetation changes from predominantly aquatic to predominantly terrestrial.

Subp. 6. **Professional soil classifier.** "Professional soil classifier" is a person who qualifies as a professional soil classifier on the basis of criteria specified by the Minnesota Association of Professional Soil Classifiers. The requirements are a bachelor of science degree in soil science or adequate credits (15 semester or 23 quarter hours) in soil science, and four years of field experience in mapping soils.

Subp. 7. **Public waters.** "Public waters" for the purposes of these rules means waters of the state so designated in a county by the process described in Minnesota Statutes, section 103G.201, and those waters that have been determined to be public waters or navigable waters by the district court or if appealed, by the state or federal Supreme Court.

Statutory Authority: *MS s 103F.601; 103G.315; 105.392; 105.415*

History: *17 SR 1279*

Posted: *June 11, 2008*

6115.1220 PROCEDURES.

Subpart 1. **Permit applications.** Application for a permit to drain basins that are potentially eligible for compensation from the department because of being declared public waters shall be made on such forms as the commissioner may provide and shall include all data specified by the form and any required application fees.

The applicant shall include the following information to enable the commissioner to determine the

feasibility, practicality, and lawfulness of the proposed drainage:

A. a statement by the owner that there are no burdens on the property or agreements which drainage would violate;

B. a demonstration by the owner that the right to use the outlet can be obtained;

C. a description of the proposed drainage project;

D. a demonstration of the project costs, showing how the costs were estimated, together with an explanation of why the investment would be profitable; and

E. a statement by a professional soil classifier that the basin would be high quality cropland. The determination shall be based on the following criteria. The kinds of soils that will that will qualify as high quality cropland are based on the following method arranged from best to poorest.

Rating Value	Soil Properties

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

1. Loamy or clayey mineral soils (loamy or clayey average particle size in the control section.)
2. Deep organic soils (Typic subgroups,) and shallow organic soils with a loamy or clayey substratum (Terric subgroups with loamy or clayey particle size.)
3. Shallow organic soils with a sandy or gravelly substratus (Terric subgroups with sandy or sandy skeletal particle size.)
4. Sandy or gravelly mineral soils (Aquents, aquepts, and Aquolls with sandy or sandy skeletal average particle size in the control section.)
5. Other soils (mostly soils with limnic materials dominating the control section.)

Growing degree days (GDD) will be used as a climatic parameter to use for accessing soil quality.

The groups from best to poorest are:

Rating Value	Climate Parameter
1.	More than 4400 GDD
2.	3400 - 4400 GDD
4.	Less than 3400 GDD

The following counties fall within the individual climate parameters:

More than 4400 GDD

Anoka	Lac Qui Parle	Rice
Big Stone	Le Sueur	Rock
Blue Earth	Lincoln	Scott
Brown	Lyon	Sibley
Carver	McLeod	Steele
Chippewa	Martin	Stevens
Cottonwood	Meeker	Swift
Dakota	Mower	Traverse
Dodge	Murray	Wabasha
Faribault	Nicollet	Waseca

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Fillmore	Nobles	Washington
Freeborn	Olmsted	Watonwan
Goodhue	Pipestone	Wilkin
Hennepin	Ramsey	Winona
Houston	Redwood	Wright
Jackson	Renville	Yellow Medicine
Kandiyohi		

3400 - 4400 GDD

Aitkin	Hubbard	Otter Tail
Becker	Isanti	Pennington
Beltrami	Itasca	Pine
Benton	Kanabec	Polk
Carlton	Kittson	Pope
Cass	Koochiching	Red Lake
Chisago	Lake of the Woods	Roseau
Clay	Mahnomen	Sherburne
Clearwater	Marshall	Stearns
Crow Wing	Mille Lacs	Todd
Douglas	Morrison	Wadena
Grant	Norman	

Less than 3400 GDD

Cook	Lake	St. Louis

To arrive at a value, an index is determined by multiplying the soil property rating by the GDD rating. A value of four or less shall be considered high quality cropland.

The determination of soil properties shall be done by a professional soil classifier with at least one observation of soil properties to depths of 50 inches for each ten acres of the wetland. Points of

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

observations should be located systematically in the wetland, recorded on a map, and a log of soil made for each observation. The information shall be included with the permit application.

Subp. 2. **Eligible water basins.** If the public water basin is eligible for compensation the commissioner shall mail to the applicant, within 60 days of receipt of an application for a permit to drain, the various choices of indemnification, to include:

A. An offer:

(1) to place the basin in the state water bank program, together with a sample water bank agreement;

(2) to acquire the basin and such interest as is necessary to make entry upon the acquired area available to the public;

(3) to acquire an easement in the nature of a conservation restriction as described by Minnesota Statutes, sections 84.64 and 84.65, together with a sample of such an easement; or

(4) to acquire a lease on the basin, together with a sample lease agreement.

B. A statement:

(1) If such be the case, that the wetland appears to be eligible for the federal water bank program and who the landowner should contact. The state program, however, does not incur any obligations on the federal program and if the landowner chooses to select this option the landowner will be subject to the federal program's priorities and procedures.

(2) That the landowner may suggest any other appropriate indemnification method, along with the proposed terms and conditions that the landowner would like to have included.

(3) That the landowner and commissioner may agree to include adjacent property in the terms of the agreements.

(4) That the landowner may choose any one of the indemnification offers or any other method of indemnification that the commissioner will agree to.

C. An explanation of the balance of these procedures in order to establish the dollar amount of each offer as soon as the landowner specifies what adjacent land, if any, the landowner would like to have included.

Subp. 3. **Ineligible areas.** If the area is ineligible for compensation the commissioner will so inform the applicant and advise the applicant that a Minnesota Statutes, section 103G.311 hearing on the issue of eligibility may be demanded.

Subp. 4. **Right to drain basin.** If within 60 days of receipt of an application for a permit to drain, the commissioner does not mail the landowner a choice of indemnification, the landowner is entitled to drain the basin.

Subp. 5. **Adjacent land.** Upon receipt of an offer of indemnification, the landowner shall inform the commissioner of the amount, if any, and location of adjacent land that the landowner would like to have included in the agreement, and what alternative, if any, methods of indemnification the landowner would like the commissioner to consider.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 6. **Certification.** Within 60 days of receiving the above information the commissioner shall complete an appraisal of the property and submit it to the Department of Administration for certification. If it is not so submitted within the 60-day period, the landowner may drain the basin.

Subp. 7. **Negotiations.** When an appraisal has been certified, the commissioner shall inform the landowner of the dollar amount of each offer, and begin negotiations. The outcome of the negotiations can be either:

A. the landowner accepts one of the offers made or agreed to by the commissioner;

B. the landowner places the basin in a federal water bank program;

C. the landowner signs a consent to condemnation pursuant to Minnesota Statutes, section 84.027, subdivision 9, specifying which of the methods of indemnification offered or agreed to by the commissioner that the landowner has selected; or

D. the landowner does none of the above, in which case the basin cannot be drained unless and until a new application for a permit to drain is submitted and the commissioner does not make an offer of indemnification.

Subp. 8. **Sale of basin to commissioner.** If the landowner chooses to sell the basin and access area to the commissioner the landowner shall obtain from the county board of commissioners the approval to sell the property as required by Minnesota Statutes, section 97A.145. The commissioner must be supplied with a copy of the board's resolution and if the county board refuses approval, the applicant must select from among those options not requiring county board approval. This procedure does not apply in those counties where blanket approval to sell the property to the state has been granted to those landowners who are eligible for compensation under Minnesota Statutes, section 105.391, subdivision 3.

Subp. 9. **Recording and indexing documents.** Water bank, lease, and easements obtained on an area shall be recorded and indexed in the office of the county recorder in the county where the basin lies.

Statutory Authority: *MS s 103F.601; 103G.315; 105.392; 105.415*

History: *L 1986 c 386 art 1 s 28; 17 SR 1279*

Posted: *June 11, 2008*

6115.1230 EFFECTIVE DATE.

These parts apply to applications for permits to drain received after the water basin involved has been designated a public water pursuant to Minnesota Statutes, section 103G.201, or has been identified as public waters or navigable waters by a district court or if appealed, by the state or federal Supreme Court.

Statutory Authority: *MS s 103F.601; 103G.315; 105.392; 105.415*

Posted: *June 11, 2008*

6115.1240 PAYMENT RATES.

Subpart 1. **Water bank program.** Annual payment rates for the state water bank program will be determined by multiplying the fair market value of the water basin and any adjacent lands by five percent.

Subp. 2. **Water basin and adjacent lands.** Annual lease payments for the water basin and any adjacent lands will be based on a fair market rental rate.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 3. **Easements.** Conservation restrictions in the form of easements will be established by an appraisal and their lengths will be subject to negotiation.

Subp. 4. **Other method of indemnification.** The rate for any other method of indemnification that is agreed to will be negotiated with the landowner and judged on its merits based upon the proposed restrictions and their relationship to the other payment rates.

Statutory Authority: *MS s 103F.601; 103G.315; 105.392; 105.415*

Posted: *June 11, 2008*

6115.1250 TERMS FOR WATER BANK AND LEASE AGREEMENTS.

Subpart 1. **Agreement period and beginning date.** Agreement period and beginning date:

A. Eligible basins are placed in the state water bank program for a period of ten calendar years and under a lease agreement for, not to exceed, 20 calendar years.

B. The lease agreement is continuous and shall transfer with the property if ownership changes during the time of the lease agreement.

C. A water bank or lease agreement finalized during the current calendar year shall be effective January 1 of that year. Exception: in cases where compliance with the terms of agreement cannot be rendered during the current calendar year, the beginning date of the agreement shall be January 1 of the following year.

D. Water bank or lease payments for the first year of an agreement will be made as soon as possible after an agreement has been finalized. Payments for the duration of a water bank or lease agreement will be made on or about August 1 of each continuous year thereafter.

Subp. 2. **Terms.** Terms:

A. Waterbasins. In return for receipt of an annual payment the landowner must agree not to adopt any practice which would tend to defeat the purposes of the agreement. At a minimum, the designated basin may not be:

(1) Drained, burned, filled, clipped, or otherwise used in such a manner that would effect its wetland character. Exception: noxious weeds may be controlled by the landowner by spot clipping and spot spraying. If cutting is used the area should not be clipped closer than six inches so as to protect nesting wildlife.

(2) Harvested for agricultural purposes.

(3) Grazed.

(4) Used as a source of irrigation water.

(5) Used as a receptacle for draining other wetlands.

Exception: the commissioner may approve designated acreage to receive limited drainage waters if such use is in keeping with sound wetlands management and prescribed in a mutually agreed upon conservation plan.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. Adjacent lands. On finding it desirable the commissioner may mutually agree with the landowner upon the amount and location of adjacent lands to include in the agreement. Up to one acre of adjacent land may be obtained for each acre of water basin. The commissioner may negotiate and outline a conservation plan for the water basin and adjacent lands. Upon signing the agreement, the landowner shall agree to effectuate the wetland conservation and development plan. Terms that may be included are:

(1) development of food and/or cover plots;

(2) specified planting and harvesting dates;

(3) areas desirable for permanent cover;

(4) habitat improvement methods such as: clearing, tilling, reestablishment of former wetlands or the creation of new wetlands, fencing to protect the area;

(5) advice on conservation and development practices; and

(6) any other mutually agreed upon practice that would effectuate wetland conservation and development.

Subp. 3. **Signatures.** The agreement shall be on forms provided by the commissioner and shall be signed by the owner of the designated acreage, and the commissioner.

Statutory Authority: *MS s 103F.601; 103G.315; 105.392; 105.415*

History: *17 SR 1279*

Posted: *June 11, 2008*

6115.1260 MODIFICATIONS OF WATER BANK AND LEASE AGREEMENTS.

Subpart 1. **In general.** The commissioner and the landowner may mutually agree to any modification of agreement terms that may be desirable to carry out the purposes of the program or facilitate its administration. Exception: no changes in payment rates for acreage under agreement is authorized during the term of the water bank or lease agreement.

Subp. 2. **Change in ownership of lands underlying public waters.** All landowners shall notify the commissioner of the sale of property that is covered by the water bank or lease agreement. Upon transfer of an individual's right and interest in lands subject to a water bank agreement during the agreement period, the former landowner forfeits all rights to further payments under the agreement and refunds to the state all payments received thereunder during that year of the transfer. Forfeiture of payments is not required for those participating in a lease agreement nor if the transferee of any such land agrees with the commissioner to assume all obligations of the former owner.

The new landowner may choose not to participate in the water bank program; however, any water declared public shall not be drained. If an alternative form of indemnification is desired, or if the new owner wishes to have payment rates adjusted on the existing water bank agreement, a permit application will have to be submitted to the commissioner to initiate the procedures in these parts. The requirement for

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

soils information and borings shall be waived on those basins that have been determined eligible for the water bank program by previous permit applications.

When two or more farms are combined that share mutual public waters the landowner who is adding property shall have the option of adding the new property to the original agreement, continuing the former owners' agreement, or decide not to participate in the program and not be able to drain the basin.

When a transfer of ownership occurs on or before August 1 of the current calendar year and the new owner agrees to continue the former owner's obligation, payments due will be made to the new owner.

Subp. 3. **Registration of modification.** All modifications will be completed on amendment forms provided by the commissioner. Modifications will be noted on the original agreement and the original amendment forms will be retained by the commissioner.

Statutory Authority: *MS s 103F.601; 103G.315; 105.392; 105.415*

History: *17 SR 1279*

Posted: *June 11, 2008*

6115.1270 AGREEMENT TERMINATIONS.

Subpart 1. **Forfeit of rights to further payments.** Upon termination of an agreement the landowner shall forfeit all rights to further payments.

Subp. 2. **Termination by mutual consent.** The commissioner may terminate any agreement with mutual consent of the landowner if the commissioner determines that termination would be in the public interest. If such be the case, no refund of payments made under the agreement is required.

Subp. 3. **Refund of payments.** The landowner must refund to the state all payments, partial or in full, received under the agreement upon any violation of the agreement terms during the time that the landowner has control of the property.

A. Subject to the commissioner's determination that the violation is material and of the nature that warrants termination of the agreement the landowner shall:

(1) refund to the state all payments received;

(2) forfeit all rights to further payments;

(3) not be entitled to drain the affected basin; and

(4) not have the basin considered for a permit to drain or be allowed compensation under Minnesota Statutes, sections 103G.211 and 103G.221, until a transfer of ownership has taken place.

B. Subject to determining that the violation does not warrant termination of the agreement, the commissioner may require partial refunds or make payment adjustments as the commissioner deems appropriate.

Subp. 4. **Termination action.** The commissioner shall notify each party to the agreement of the termination:

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

A. the reason for termination;

B. the amount of payment refund due;

C. that the landowner is no longer required to comply with the agreement terms and that the public waters cannot be drained; and

D. that the landowner may challenge the termination by demanding a hearing under Minnesota Statutes, section 103G.311.

Statutory Authority: *MS s 103F.601; 103G.315; 105.392; 105.415*

History: *17 SR 1279*

Posted: *June 11, 2008*

6115.1280 EXTENSION OF WATER BANK OR LEASE AGREEMENT.

At the end of an agreement period the commissioner shall offer the landowner the landowner's choice of the five indemnification offers without requiring a new application for a permit to drain. The landowner has 60 days to notify the commissioner, in writing, if the landowner will be:

A. continuing the former agreement terms, subject to any rate redetermination; or

B. dissolving the former agreement; and

C. changing to another form of indemnification; or

D. deciding not to participate in the program with the knowledge that the basin cannot be drained.

If the landowner chooses to select another indemnification method, the choice must be specified in the landowner's notice to the commissioner.

If the notification of the landowner's intent to continue in the program is not given, the landowner will be required to submit an application for a permit to drain the basin to establish future eligibility to the water bank program.

Upon receipt of the landowner's choice, the commissioner shall conduct an appraisal to establish the fair market value of the property. Once completed, the agreement may be finalized.

Statutory Authority: *MS s 103F.601; 103G.315; 105.392; 105.415*

History: *17 SR 1279*

Posted: *June 11, 2008*

AGRICULTURAL DIKE CONSTRUCTION ALONG THE

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

RED RIVER OF THE NORTH AND BOIS DE SIOUX RIVERS

6115.1300 PURPOSE.

The purpose of these parts is to provide for the orderly and consistent review of permit applications to construct, relocate, rebuild, or alter agricultural dikes along the Red River of the North and Bois de Sioux Rivers in order to assure that the granting of such permits would be in the best interests of the people of Minnesota and North Dakota. These parts are mutually applicable in both states. The authority to establish these joint criteria is granted to the commissioner of Natural Resources in Minnesota Statutes, sections 103G.105, 103G.245, and 471.59 and to the North Dakota State Water Commission by Sections 61-02-24 and 61-16-15 of the North Dakota Century Code. The two states recognize that establishment of these parts governing the issuance, review, and denial of permits to construct, relocate, rebuild, or alter agricultural dikes along the boundary rivers is but the first step in the exercise of joint control over those activities which could contribute to an increased flood potential of these rivers. The two states further recognize the need to exercise this joint control in that water management decisions which appear logical in a local or statewide context may have negative interstate and international impacts.

These parts are being established at this time because there is a current need to provide a basis for the review of existing, unauthorized agricultural dikes and permit applications for the construction of additional agricultural dikes along the boundary waters. Local land owners view such dikes as interim solutions to local flood problems.

Statutory Authority: *MS s 103G.105; 103G.315; 105.415; 105.49; 471.59*

Posted: *June 11, 2008*

6115.1310 SCOPE.

These parts governing the review, issuance, and denial of permits to construct, relocate, rebuild, or alter agricultural dikes along the boundary rivers pertain to all such dikes located within the floodplains of the Red River of the North and the Bois de Sioux Rivers. Floodplain areas of the Red River of the North are defined by Appendix O, Volume 8, of the Souris-Red-Rainy Basins Comprehensive Study as Red River of the North Main Stem Regional Floodplain Area, and the floodplain of the Bois de Sioux River is defined by the U.S. Geological Survey one percent chance of recurrence area flood quadrangles. These rules apply to dikes constructed on tributaries within the floodplains of these boundary rivers. These parts shall be superseded by local authority adoption of commissioner approved floodplain ordinances which include agricultural diking provisions as conditional uses.

Statutory Authority: *MS s 103G.105; 103G.315; 105.415; 105.49; 471.59*

Posted: *June 11, 2008*

6115.1320 DEFINITIONS.

Subpart 1. **Scope.** For the purposes of these parts certain terms or words used herein shall be interpreted as follows.

Subp. 2. **Boundary rivers.** "Boundary rivers" means the Red River of the North and the Bois de Sioux River as they form a natural boundary between the states of Minnesota and North Dakota.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 3. **Dike.** "Dike" means an embankment constructed of earth and/or other suitable materials to protect agricultural lands.

Subp. 4. **Farmstead.** "Farmstead" means a farm dwelling and/or associated farm buildings.

Subp. 5. **Flood frequency.** "Flood frequency" means the average frequency, statistically determined, for which it is expected that a specific flood stage or discharge may be equalled or exceeded. This frequency is usually expressed as having a probability of occurring, on the average, once within a specified number of years.

Subp. 6. **Flood waters.** "Flood waters" means those waters which temporarily inundate normally dry areas adjoining a watercourse. This inundation results from an overflow of the watercourse caused by excessive amounts of rainfall and/or snowmelt which exceed its capacity.

Subp. 7. **Public waters.** "Public waters" means all natural and altered natural watercourses with a total drainage area greater than two square miles, except that trout streams officially designated by the commissioner shall be public regardless of the size of their drainage area.

Subp. 8. **Watercourse.** "Watercourse" means a channel in which a flow of water occurs either continuously or intermittently in a definite direction. The term applies to either natural or artificially constructed channels.

Statutory Authority: *MS s 103G.105; 103G.315; 105.415; 105.49; 471.59*

Posted: *June 11, 2008*

6115.1330 SEVERABILITY.

The provisions of these rules shall be severable, and the invalidity of any paragraph, subparagraph, or subdivision thereof shall not make void any other paragraph, subparagraph, subdivision, or any other part.

Statutory Authority: *MS s 103G.105; 103G.315; 105.415; 105.49; 471.59*

Posted: *June 11, 2008*

6115.1340 DESIGN CRITERIA.

Subpart 1. **Dike setbacks and elevation.** Dikes are to be constructed at a location and elevation so as not to cause an increase in elevation of the 100-year frequency flood of more than one-half foot at any point along the river. Calculation of the effects of the dikes shall be based on an assumed equal degree of encroachment along the opposite side of the river. If mutual agreement has been reached between persons on both sides of the river, dikes on one side may utilize up to the entire increase in flood elevation allowable. In all instances the applicants maintain the liability for damages resulting from any and all activities.

Subp. 2. **Dike dimensions.** Dike top width shall not be less than six feet. Side slopes shall not be steeper than 3:1, except where slope stability analysis and slope erosion control can justify steeper slopes. No organic soil or material shall be allowed in the foundation of the fill of dikes.

Subp. 3. **Vegetative cover and riprap.** A protective cover of grasses shall be established on all exposed surfaces of the dike. Riprap shall be used where required for control of erosion.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 4. **Interior drainage.** Dikes shall have provisions for interior drainage. The design shall include plans to handle the discharge from the drainage area based on drainage design requirements for the local area.

Statutory Authority: *MS s 103G.105; 103G.315; 105.415; 105.49; 471.59*

Posted: *June 11, 2008*

6115.1350 HYDROLOGIC DATA FOR DESIGN.

The North Dakota State Water Commission and the Minnesota Department of Natural Resources shall provide the discharges and corresponding elevations of the various frequency floods (and other available flood data), in relation to known historic floods, for use in dike design.

Statutory Authority: *MS s 103G.105; 103G.315; 105.415; 105.49; 471.59*

Posted: *June 11, 2008*

6115.1360 DIKES ACROSS NATURAL WATERWAYS AND LEGAL DRAINS.

Dikes shall not be constructed across public waters or watercourses without permit from the commissioner of natural resources, under Minnesota Statutes, section 103G.245. Dikes constructed across legal drains or public ditch systems shall require the approval of the appropriate local authority (watershed district, county, city, etc.).

Statutory Authority: *MS s 103G.105; 103G.315; 105.415; 105.49; 471.59*

Posted: *June 11, 2008*

6115.1370 FARMSTEAD DIKING.

Within an existing dike system, ring dikes around individual farmsteads shall not require dike permits if they are not provided with tiebacks to existing roadways or dikes. Ring dikes provided with tiebacks shall be considered part of the overall dike system and will be required to secure diking permits. Outside the dike system there shall be no limitations on tiebacks of dikes around farmsteads. However, appropriate authorization must be obtained from the local land use authority consistent with adopted codes or ordinances.

Statutory Authority: *MS s 103G.105; 103G.315; 105.415; 105.49; 471.59*

Posted: *June 11, 2008*

6115.1380 PERMIT APPLICATION.

Subpart 1. **Forms; plans and specifications.** All applications submitted by the owner to construct, to relocate, rebuild, or alter dikes shall be made on forms provided by the commissioner and shall be accompanied by two complete sets of plans and specifications. Such plans and specifications shall include the following:

A. a general location map with a minimum scale of 1" = 800' showing the following: location of the dike with respect to the watercourse; location of field inlets to provide for internal drainage; and location of legal drains and natural channels tributary to the main river channel;

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. detailed cross-sections of the dike showing elevation, in relation to mean sea level, and side slopes; and

C. other data as deemed appropriate by the commissioner to properly evaluate the application for permit.

Subp. 2. **Cross-sections.** After review of the information required above and other available data, the state agency to which the application is made shall determine the location and number of required cross-sections of the river channel and overland areas. These locations shall be provided to the applicant who shall then provide the required cross-section data. The applicant shall undertake and agree to pay the expenses incurred in securing these cross-sections.

Subp. 3. **Joint permit applications.** Joint permit applications involving two or more landowners or a permit application on behalf of two or more landowners will be accepted by the state agencies. These permit applications, taken together, must meet the above rules.

Subp. 4. **Joint administration.** A copy of each application for a permit shall be forwarded by the state agency receiving the initial application to the other state for comment and recommendation before final approval is granted. If no response is received within 30 days, the commissioner shall process the permit without such comments or recommendations.

Subp. 5. **Permit revocation.** The applicant shall provide for certification by a licensed land surveyor, engineer, or other qualified person or agency that the finished dike elevations are not higher than those approved by the commissioner. The permit will be revoked for failure to provide this certification. The permit may be revoked for failure to construct the dike in accordance with the plans and specifications submitted. Structural alteration of the dike without permission of the appropriate state agency will also result in having the permit revoked.

Subp. 6. **Reconstruction; maintenance.** Reconstruction of any authorized dike may be performed after notification to the commissioner of the repair needed. Permittee shall again certify the repair concurrent with this section. The maintenance of dikes must include periodic removal of woody vegetation (for example, trees and shrubs) which may become established on the embankment.

Subp. 7. **General administration.** All applicants for permit to construct dikes shall be subject to the provisions of parts 6115.0240 to 6115.0260.

Statutory Authority: *MS s 103G.105; 103G.315; 105.415; 105.49; 471.59*

History: *L 1998 c 324 s 9*

Posted: *June 11, 2008*

6115.1390 EXCEPTION TO CRITERIA.

Under special circumstances, exceptions to the dike rules may be authorized on an individual basis but they must have the concurrent approval of the North Dakota state engineer, local water management board in North Dakota, Minnesota Department of Natural Resources, and local watershed district in Minnesota. Factors that will be considered include but shall not be limited to dike setback line, location of farmsteads, property lines, existing roads, stream velocity, environmental effects, and acquisition of flowage rights. Request for exceptions must be accompanied by a plan satisfactory to all agencies.

Statutory Authority: *MS s 103G.105; 103G.315; 105.415; 105.49; 471.59*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

6115.1400 APPLICATION OF RULES TO EXISTING DIKES.

These parts shall apply to all unauthorized dikes constructed in the past for the protection of those agricultural lands located within the floodplains of the Red River of the North and the Bois de Sioux, as defined in part 6115.1310. Exceptions are farmstead dikes if they meet the provisions of part 6115.1370.

The commissioner shall have the authority to order removal, modification, or reconstruction of dikes not conforming to these parts.

Statutory Authority: *MS s 103G.105; 103G.315; 105.415; 105.49; 471.59*

Posted: *June 11, 2008*

CONSOLIDATED CONSERVATION AREAS DRAINAGE PROJECTS

6115.1500 PURPOSE.

The purpose of parts 6115.1500 to 6115.1550 is to establish criteria and procedures for determining drainage benefits to state-owned lands in consolidated conservation (con-con) areas administered under Minnesota Statutes, chapter 84A. Con-con areas are found in parts of Aitkin, Beltrami, Koochiching, Lake of the Woods, Mahnomen, Marshall, and Roseau Counties.

Statutory Authority: *MS s 84A.55*

History: *32 SR 1697*

Posted: *June 11, 2008*

6115.1510 DEFINITIONS.

Subpart 1. **Scope.** The terms used in parts 6115.1500 to 6115.1550 have the meanings given in this part.

Subp. 2. **Commissioner.** "Commissioner" means the commissioner of natural resources or the commissioner's designated representative.

Subp. 3. **Department.** "Department" means the Department of Natural Resources.

Subp. 4. **Drainage.** "Drainage" means any method for removing or diverting waters from wetlands. The methods include, but are not limited to, excavating an open ditch, installing subsurface drainage tile, filling, diking, or pumping.

Subp. 5. **Drainage authority.** "Drainage authority" has the meaning given under Minnesota Statutes, section 103E.005, subdivision 9.

Subp. 6. **Drainage project.** "Drainage project" means a new drainage system, an improvement of a drainage system, an improvement of an outlet, a lateral, a repair, or a redetermination of benefits involving state-owned lands in consolidated conservation areas administered under Minnesota Statutes, chapter 84A, where:

A. the drainage authority will make assessments to state-owned lands; or

B. the commissioner will be asked or must consider whether to participate in the project through assessments or a lump sum, by joining the petition, by consent, or by approval.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Subp. 7. **Drainage system.** "Drainage system" has the meaning given under Minnesota Statutes, section 103E.005, subdivision 12.

Subp. 8. **Improvement.** "Improvement" means the tiling, enlarging, extending, straightening, or deepening of an established and constructed drainage system, including construction of ditches to reline or replace tile and construction of tile to replace a ditch.

Subp. 9. **Lateral.** "Lateral" has the meaning given under Minnesota Statutes, section 103E.005, subdivision 15.

Subp. 10. **Public waters.** "Public waters" has the meaning given in Minnesota Statutes, section 103G.005, subdivision 15.

Subp. 11. **Public waters wetlands.** "Public waters wetlands" has the meaning given in Minnesota Statutes, section 103G.005, subdivision 15a.

Subp. 12. **Repair.** "Repair" means to restore all or a part of a drainage system as nearly as practicable to the same condition as originally constructed and subsequently improved, including resloping of ditches and leveling waste banks if necessary to prevent further deterioration, realignment to original construction if necessary to restore the effectiveness of the drainage system, and routine operations that may be required to remove obstructions and maintain the efficiency of the drainage system. "Repair" also includes:

A. incidental straightening of a tile system resulting from the tile-laying technology used to replace tiles; and

B. replacement of tiles with the next larger size that is readily available, if the original size is not readily available.

Statutory Authority: *MS s 84A.55*

History: *32 SR 1697*

Posted: *June 11, 2008*

6115.1520 DRAINAGE PROJECTS.

Subpart 1. **Notification and documentation.** For the commissioner to consider participating in a drainage project that would have assessments within a consolidated conservation area, the drainage authority must follow the procedures described in this subpart. The drainage authority must notify the commissioner, in writing and as soon as practicable, with specifics about the proposed project. The specifics must describe the purpose of the project and what kind of project it is. The drainage authority must show the extent of the project on a map. The drainage authority must provide the commissioner with copies of all written documents, including any petition and engineer's report that have been filed or used in connection with the drainage project proceedings, as they are available.

Subp. 2. **Investigation.** After receiving notification and all documentation required under subpart 1, the commissioner must complete an investigation to determine whether the proposed drainage project benefits state-owned lands for the purposes for which they were established. In the investigation, the commissioner must:

A. determine, which, if any, state-owned lands are positively impacted by the proposed drainage project according to subpart 3; and

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

B. determine which, if any, state-owned lands are negatively impacted by the proposed drainage project according to subpart 4.

Subp. 3. **Positive impacts.** Positive impacts to state-owned lands occur when a proposed drainage project allows the department or department's lessee to continue to use or enhances its ability to use drainage to achieve management purposes as provided in Minnesota Statutes, section 84A.55. The following criteria are evidence that the department uses drainage to achieve a management purpose:

A. the department utilizes a drainage system to outlet water into a public ditch from agricultural cropland it manages;

B. the department leases the land for commercial purposes such as agriculture, agro-forestry, aquaculture, wild rice paddies, peat mining, or mineral extraction, and the lessee utilizes a drainage system to outlet water into a public ditch from the leased lands;

C. the department petitions for a drainage project;

D. the department outlets water from state-owned lands into a public ditch from an impoundment that is designed and used exclusively for wildlife management purposes;

E. timber production is improved by the project; or

F. wildlife habitat is improved by the project.

Subp. 4. **Negative impacts.** Negative impacts to state-owned lands occur when a drainage project adversely affects the management of the land for its intended purposes. The following criteria are evidence that a drainage project negatively impacts state-owned lands. The drainage project:

A. degrades public waters, public waters wetlands, or wetlands on state-owned lands;

B. causes direct physical disturbance to rare species or significant natural communities through project activities such as, but not limited to, ditching and depositing soils;

C. causes an alteration of the hydrology that disturbs rare species, natural communities, or peatland features;

D. causes an alteration of the hydrology that degrades designated peatland scientific and natural areas;

E. restricts management options for state-owned lands; or

F. results in the reduction or elimination of access to state-owned lands.

Statutory Authority: *MS s 84A.55*

History: *32 SR 1697*

Posted: *June 11, 2008*

6115.1530 DETERMINING BENEFIT AND PARTICIPATION.

Subpart 1. **Commissioner's determination.** Following the investigation under part 6115.1520, for all drainage projects except those classified as repairs, the commissioner must determine whether the drainage project benefits state-owned lands and whether to participate in the project. In making the determination, the commissioner shall evaluate state-owned lands, on a parcel-by-parcel basis, with each parcel consisting of no more than 40 acres. A drainage project benefits a parcel of state-owned land only when the investigation shows that the positive impacts outweigh the negative impacts to that

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

parcel of state-owned land. Where the commissioner determines that the project results in a net benefit to state-owned lands, the commissioner shall participate in the project. Having determined to participate, the commissioner shall authorize the imposition of assessments for the project on the lands in any amounts the commissioner determines or may make lump sum contributions to the county or other public funds established for the payment of the cost of the project. The commissioner may also set conditions to modify the project before approving or joining a petition. Before cooperating in a project by joining in the petition or consenting to or approving it, the commissioner may identify conditions that must be satisfied or modifications that must be made in the proposed project if such conditions or modifications are necessary to ensure that the project will benefit state-owned lands in con-con areas.

Subp. 1a. **Commissioner's determination for repairs.** Following the investigation under part 6115.1520, for drainage projects considered repairs, the commissioner must determine whether the repair project benefits state-owned lands and whether to participate in the project. In making the determination, the commissioner, following consultation with drainage authorities, shall develop a table that identifies the benefits for each 40-acre parcel. A repair project benefits a parcel of state-owned land only when the investigation shows that the positive impacts outweigh the negative impacts to that parcel of state-owned land. Where the commissioner determines the project results in a net benefit to state-owned lands, the commissioner shall participate in the project. Having determined to participate, the commissioner shall authorize the imposition of assessments for the projects on the lands in any amounts the commissioner determines or may make lump sum contributions to the county or other public funds established for the payment of the cost of the project. The commissioner may also set conditions to modify the project before approving or joining the petition. Before cooperating in a project by joining in the petition or consenting to or approving it, the commissioner may identify conditions that must be satisfied or modifications that must be made in the proposed project if such conditions or modifications are necessary to ensure that the project will benefit state-owned lands in con-con areas.

Subp. 2. **Routine repair exception.** If a drainage authority's notification and documentation made under part 6115.1520, subpart 1, shows that the total cost of a proposed drainage repair under Minnesota Statutes, section 103E.705, is less than $20,000 and the commissioner has previously determined the benefits to the state-owned lands within that drainage system, the commissioner may, without investigation, authorize the imposition of assessments for the proposed repair proportionate to the overall benefits to the state-owned lands as previously determined by the commissioner. If the commissioner authorizes assessments under this subpart, the commissioner need not issue the findings and report required under part 6115.1540. Where the commissioner does not authorize an assessment for a repair under this subpart, the commissioner shall issue the findings and report as set forth in part 6115.1540.

Statutory Authority: *MS s 84A.55*

History: *32 SR 1697*

Posted: *June 11, 2008*

6115.1540 FINDINGS AND REPORT.

Upon completion of the table described in part 6115.1530, subpart 1a, for repairs and following the investigation under part 6115.1520, the commissioner must provide the drainage authority with findings within 60 days after the commissioner has received all notifications and documentation required under part 6115.1520, subpart 1. For repairs over $20,000, and upon completion of the table described in part 6115.1530, subpart 1a, the commissioner must provide the drainage authority with findings within 60 days.

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

The findings must convey the results of the investigation, state whether the commissioner will participate in the project, and state the reasons for the commissioner's decisions. The findings must identify which state-owned lands are benefited and which are not and set forth any conditions the commissioner attaches to the project and the amount of the contribution if the commissioner will participate.

Statutory Authority: *MS s 84A.55*

History: *32 SR 1697*

Posted: *June 11, 2008*

6115.1550 APPEAL.

The findings and report of the commissioner under part 6115.1540 may be reviewed by a declaratory judgment action in the district court of the county wherein the proposed project, or any part thereof, would be undertaken. Judicial review under this part must be initiated within 60 days after receipt of the findings by the drainage authority.

Statutory Authority: *MS s 84A.55*

History: *32 SR 1697*

Posted: *June 11, 2008*

Copyright ©2008-2010 by the Revisor of Statutes, State of Minnesota. All Rights Reserved.

Minnesota Water Statutes and Rules

What are Statutes?

Statutes are laws that apply to all citizens and cover a variety of topics. Laws refer to all laws passed by the Legislature, which are subsequently bound in the Session Laws of that year. Statutes are a codification of those laws, which are compiled and published every year as Minnesota Statutes. By codifying laws into Minnesota Statutes, the laws are placed into context of statutes that have been on the books in previous years.

What are Rules?

Administrative rules are not actually enacted by the Legislature. Rather, the Legislature merely gives the state agency or unit the authority to establish its own rules. These administrative rules have the force and effect of law.

An agency may adopt a rule only after the legislature has enacted a law granting this authority to the agency. An agency rule that is adopted under the rulemaking provisions of **Minnesota Statutes, chapter 14**, has the force and effect of law. ***Rulemaking in Minnesota: A Guide*** explains each step of the rulemaking process in Minnesota.

Statutes and Rules Relating to DNR Waters Programs

Subject	Statute	Rule
Public Waters and Public Waters Wetlands	103G	6115
Water Appropriation	103G	6115
Dam Safety	103G	6115
Floodplain Management	103F	6120
Shoreland Management	103F	6120
Lake Improvement Districts	103B	6115
Wild and Scenic Rivers	103F	6105
Pollution Sensitivity	103H	No rule

- **Search statutes by key word or phrase**
- **Search rules by key word or phrase**

General Water Statutes and Rules Information

- **Minnesota Statutes**
  - **Index of State Water-Related Statutes: Chapters 103A thru 114**
  - **Table of Contents for Chapter 103G: *Waters of the State***
- **Minnesota Rules**
  - **Index of Minnesota Department of Natural Resources Rules: Chapter 6100 through 6290**
- **Links to Other State, Federal, and Local Law References**
  - **Minnesota Legislative Reference Library: *Links to the World***

Other Resources

- ***Water Law Basics***
- **Wetlands Regulation in Minnesota** PDF (410 Kb)
- **Questions and Answers About Water Laws in Minnesota** PDF (413 Kb)

DISCLAIMER

These web page references or links are provided as a service to our customers. These references to statutes and rules are important to understanding the programs that DNR Waters implements. DNR and DNR Waters are not responsible for publishing, maintaining or correcting these web pages. The content of the pages will be reviewed periodically for correctness and corrections will be sent to the webmaster in the office of the Legislative Revisor of Statutes.

E.23. Mississippi



GUIDANCE FOR THE DESIGN OF DAMS

PLANS, SPECIFICATIONS & ENGINEERING REPORTS

TABLE OF CONTENTS

CHAPTER

10 **GENERAL**
- 10. Introduction
- 11. Plans
- 12. Specifications
- 13. Operation During Construction
- 14. Record Drawings
- 15. Storm Water Permitting Requirements
- 16. Other Requirements

20 **HYDROLOGIC/HYDRAULIC ANALYSIS**
- 21. Hydrological Analysis
- 22. Hydraulic Analysis
- 23. Breach Analysis
- 24. Inundation Mapping

30 **SITE INVESTIGATION/ GEOTECHNICAL ANALYSIS**
- 31. Site Investigation
- 32. Embankment Design
- 33. Seismic Stability
- 34. Embankment Design for Small Dams

40 **STRUCTURAL COMPONENTS**
- 41. Spillways
- 42. Drains
- 43. Stilling Basins
- 44. Miscellaneous

50 **INSTRUMENTATION/OPERATION/MAINTENANCE**

CHAPTER 10
GENERAL

10. INTRODUCTION

10.1 Acknowledgment

The technical guidance in this document has primarily been taken from Design of Small Dams, 3rd Edition, U.S. Bureau of Reclamation, Earth Dams and Reservoirs TR-60, NRCS, Earth and Rockfill Dams – General Design and Construction Considerations, EM 1110-2-2300, U.S. Army Corps of Engineers, Technical Manual: Conduits through Embankment Dams, FEMA.

10.2 Applicability

This document, Guidance for the Design of Dams in Mississippi ("Guidance"), should be used as a guide in the design and preparation of plans, specifications and engineering reports for dams, insofar as this guidance is applicable to normal situations for an individual project. Plans, specifications, contract documents and engineering reports required by regulation shall conform to the applicable items in this Guidance.

This document is not a regulation or a standard and has therefore not been adopted by the Commission on Environmental Quality. However, owners, consulting engineers, and other parties involved in the construction of any dam in the State should be aware of, and must comply with, the Commission's "Dam Safety Regulations LW-4", and all other applicable laws and regulations. This guidance does not supersede any existing laws, ordinances, regulations, or standards. If such conflicts arise, the designer should contact the Division of Dam Safety and the other appropriate agencies for instruction on how to proceed.

It should be recognized that simply complying with the items herein does not ensure that a design is correct, or even adequate, but only minimally acceptable to the Department. High quality projects will routinely exceed the minimum standards stipulated herein, and such quality will likely be reflected in the performance, value and satisfaction obtained from such a design.

There are some differing requirements depending on the hazard classification (Low, Significant or High), **the dam height** (Small dams are those less than 25 feet in height, Medium dams are greater than 25 feet and less than 50 feet in height and Large dams are greater than 50 feet in height), and **the storage volume** (Small lakes are less than 150 acre-feet maximum storage, Medium lakes are greater than 150 acre-feet maximum storage and less than 1,000 acre-feet maximum storage and Large lakes are greater than 1,000 acre-feet maximum storage).

Currently, the Dam Safety Regulations LW-4 do not require Low Hazard dams be designed by a registered professional engineer (state law or local ordinances may have different requirements, see previous paragraph). However, owners should consider having the spillway of their Low Hazard dam designed to High Hazard standards. This will help the owner avoid the risk of having to upgrade their dam if the hazard classification changes due to downstream development. Further, the Office of Land and Water, Division of Dam Safety neither warrants

nor assumes any responsibility for any design of any project governed by this Guidance. It is the owner's and/or design engineer's responsibility to ensure that such project designs and specifications are correct and adequate. Should anything contained herein appear to conflict with good design practice, such instance should be brought to the Division of Dam Safety's attention immediately for resolution.

Plans, specifications and engineering reports that vary from this guidance may be submitted and approved (as specified by applicable regulations) when properly justified by the consulting engineer and/or supported by reference to Design of Small Dams 3rd Edition, NRCS technical releases, U.S. Army Corps of Engineers engineering manuals, or other appropriate publications. Although the words "shall" and "must" are used extensively, they are to be interpreted in the context of this section (10.2 Applicability) of the Guidance.

It is recognized that this Guidance does not completely address every conceivable situation concerning the design, inspection, testing, or contracting of dam construction. Therefore, when any issue arises which is not explicitly covered by the Guidance, the Division of Dam Safety may require additional documentation or justification of the reasonableness or adequacy of the plans, specifications and engineering reports. The Division of Dam Safety may withhold completion of review or approval until such documentation, justification, or document changes are submitted and determined acceptable.

Any revisions, changes, addenda, etc. to reviewed and/or approved plans or specifications shall also be made in accordance with this section. Such revisions shall be submitted to the Division of Dam Safety for review and approval. Record drawings (As-built) clearly showing such alterations shall be submitted to the Division of Dam Safety at the completion of the work.

11. PLANS

11.1 General

___ All plans shall bear a suitable title block showing the name of the project, the name of the owner and a clear indication whether the owner is a state agency, municipality, district, association, institution, or private individual. The plans shall be signed, sealed, and dated by the Mississippi Registered Professional Engineer responsible for their development in a manner consistent with the requirements of the State Board of Registration for Professional Engineers and Land Surveyors, as they apply generally to the practice of engineering. Nothing herein is to be construed as allowing any such work to be performed other than by or under the direct supervision of a Registered Mississippi Professional Engineer.

___ The plans shall be of professional quality, clear and legible (suitable for microfilming). They shall be drawn to a scale that will permit all necessary information to be plainly shown. They shall show the scale in feet, a graphical scale, the north point, and date. Datum used shall be indicated. Locations and data of test borings and wells, when made, should be shown on the plans or reference made to their location in the geotechnical report. Generally, the plans should be full size, but not larger than 30 inches x 42 inches.

Submittal of draft plans for review may be legal size (8.5 x 14) or the AutoCAD project file may be sent in for review. Final submittal of plans shall consist of two (2) complete sets.

___ The plans for dams shall include a site plan which shows the surrounding property, all property lines, and ownership information as recorded in the tax assessor's record. The plans shall include the location, orientation and outline of the lake and dam relative to its surroundings. The drainage direction and receiving stream shall be shown.

___ Detail plans shall consist of: plan views, elevations, sections and supplementary views which, together with the specifications and general layouts, provide the working information for the contract and construction of the dam and its appurtenances. Plans shall also include: dimensions and relative elevations of the spillways / outlet structures, the location and outline form of monitoring equipment / wells, location, size and type of piping for outlets or drains, water levels, location and description of benchmarks used and ground elevations.

11.2 Plans of Dams

11.2.1 General Plan

A complete plan of existing and/or proposed dams shall be submitted for projects involving new dams and/or additions to existing dams. This plan shall show the following:

11.2.1.1 Geographical Features

___ a. Topography and elevations - Existing or proposed streets and all ditches, streams, rivers and water surfaces shall be clearly shown. Contour lines at suitable intervals should be included. Location and description of benchmark used.

___ b. Boundaries - The boundary lines of the subdivision or the dam owner's property and the surrounding landowners shall be shown.

11.2.2 Detail Plans

___ Detail plans shall be submitted. Profiles should have a horizontal scale of not more than 100 feet to the inch and a vertical scale of not more than 10 feet to the inch. Plan views should be drawn to a corresponding horizontal scale and preferably be shown on the same sheet. Plans and profiles shall show:

___ a. Location of primary and emergency spillway.

___ b. Profile and plan drawings of spillways with elevations.

___ c. Embankment zones, cutoff trench, soil borings, borrow areas.

___ d. Special detail drawings, drawn to a scale that clearly shows the nature and details of the design of all joints, connections, thrust blocks, re-bar placement, instrumentation, drains, filters, etc.

12. SPECIFICATIONS

___ Complete technical specifications for the construction of the dam and all appurtenances, shall accompany the plans.

___ The specifications shall be signed, sealed, and dated by the Mississippi Registered Professional Engineer responsible for their development in a manner consistent with the requirements of the State Board of Registration for Professional Engineers and Land Surveyors, as they apply generally to the practice of engineering. Nothing herein is to be construed as allowing any such work to be performed other than by or under the direct supervision of a Mississippi Registered Professional Engineer.

___ The specifications accompanying construction drawings shall include, but not be limited to, all construction information not shown on the drawings which is necessary to inform the builder in detail of the design requirements for the quality of materials, workmanship and fabrication of the project. They shall also include: the type, size, strength, operating characteristics, and rating of equipment; earthwork and compaction; the complete requirements for all mechanical and electrical equipment, including piping, and joining of pipe, machinery, valves, corrosion protection; electrical apparatus, wiring, instrumentation, and meters; operating tools, construction materials; special filter materials, such as filter fabric, stone, sand, or gravel; miscellaneous appurtenances; chemicals when used; instructions for testing materials and equipment as necessary to meet design standards; and performance tests for the completed works and component units. It is suggested that these performance tests be conducted at design load conditions wherever practical.

13. OPERATION DURING CONSTRUCTION

___ Plans and specifications shall contain provisions for routing stream flow and runoff during the entire period of dam construction.

14. RECORD DRAWINGS

___ The owner shall ensure that written notification of completion of the dam is provided to this office within 30 days of completion of the dam. The completion notice shall be accompanied by a set of “as-built” plans (marked as record drawings or as-built) with the engineer’s certification that the project was completed in substantial compliance with the approved plans and specifications and any approved revisions.

15. STORM WATER PERMITTING REQUIREMENTS

Has the applicant fulfilled the storm water permitting requirements as outlined below?

( ) Yes ( ) No ( ) NA

a. Construction activities where less than one (1) acre of land is disturbed. **(No Permit Required)** ( ) Yes ( ) No ( ) NA

b. Construction activities where *more than one (1) acre but less than (5) acres* of land is disturbed. **A "Small Construction General Permit" is required.** The dam safety engineer checks to see if the applicant has obtained a copy of: (a) Small Construction Storm Water General Permit (which includes the notice of intent (NOI)); and, (b) Construction Guidance Manual (for the storm water pollution prevention plan (SWPPP)).

( )Yes ( )No ( ) NA

All of these items are also available to the applicant for download on the MDEQ website www.deq.state.ms.us. Click "permits" under "Key Topics", then click "Storm water", then scroll down and look for Small Construction for the two forms listed above.
NOTE: None of the above listed items for small construction general permits need be submitted to MDEQ unless specifically requested.

c. Construction activities where *(5) acres or more* of land is disturbed. **A "Large Construction General Permit" is required.** The dam safety engineer checks to see if the applicant has obtained a copy of: (a) Large Construction Storm Water General Permit; (b) Large Construction Storm Water NOI; and, (c) Construction Guidance Manual (for the storm water pollution prevention plan (SWPPP)).

( )Yes ( )No ( ) NA

All of these items are also available to the applicant for download on the MDEQ website www.deq.state.ms.us.
NOTE: All the above listed items are required to be submitted to the Environmental Permitting Division (EPD) at MDEQ. Coverage will be granted under the large construction general permit once these submittals are determined acceptable by MDEQ Environmental Permitting Division.

16. OTHER

a. Has the appropriate U. S. Army Corps of Engineers District Office been notified to see if a 404 Permit is required?

( ) Yes ( )No ( )NA

NOTE: If "yes" then a copy of the Corps' correspondence, application, or authorization letter shall be submitted.

b. Has the applicant obtained a groundwater withdrawal permit from the Office of Land and Water for wells used to augment lake water levels?

( ) Yes ( ) No ( ) NA

CHAPTER 20
HYDROLOGIC AND HYDRAULIC ANALYSIS

20. INTRODUCTION

The technical guidance for this chapter has primarily been taken from Applied Hydrology by Chow, Maidment and Mays, Hydrologic Analysis and Design by Richard McCuen, Handbook of Hydraulics 7th Edition by Brater, King, Lindell and Wei, Open Channel Hydraulics by Terry Sturm, assorted technical papers by Arthur Miller, Ph.D., P.E. on hydrologic analysis and assorted technical papers by Danny Fread, Ph.D. on dam failure analysis.

21. HYDROLOGY REPORT

A hydrology report shall be submitted for the construction of all new high and significant hazard dams as well as evaluation of existing high and significant hazard dams to meet dam safety program requirements during a formal inspection (if a report hasn't already been prepared). The report shall contain the following:

___ The report shall be signed, sealed, and dated by the Mississippi Registered Professional Engineer responsible for its development in a manner consistent with the requirements of the State Board of Registration for Professional Engineers and Land Surveyors, as they apply generally to the practice of engineering. The hydrologic analysis and report may also be done by a registered professional hydrologist, however all design and recommendations that affect public safety must be performed by or under the direct supervision of a Mississippi Registered Professional Engineer.

___ A description of the drainage basin which includes the name of the stream impounded and/or discharged to, the county the basin is located in, a physical description of the basin's characteristics as they affect runoff, soil type(s) using SCS names, SCS hydrologic group(s) and curve number(s), the amount of urban development present as well as a 5 year projection of urban development, size of the drainage area in square miles or acres and average slope of the basin.

___ A topographical map showing scale, name of USGS quadrangle map from which it was produced, outline of drainage area and sub-basins (if any), longest flow path from basin boundary to point of concentration (used for calculating time of concentration), the dam, the area that will be submerged at normal pool, outline of area submerged at maximum pool if dam is a flood control structure with low normal pool, downstream area and any development, section, range and township where lake is located and name and outline of stream impounded and/or discharged to.

___ A description of the design storm(s) used with the amount of inches of rainfall in a 24 hour period shown (refer to Dam Safety Regulation LW-4, Section IV, A, B, and D). For analysis of the principal spillway capacity of High Hazard dams, the 100-year, 24 hour storm event must be modeled using the SCS Type II or Type III dimensionless design

storm distribution. Analysis of the Probable Maximum Precipitation (PMP) design storm must use the dimensionless design storm distribution as shown in the regulations (SCS Emergency Spillway Hydrograph) or SCS Type II or Type III dimensionless design storm distribution. If the drainage area is larger than 10 square miles then the areal adjustments may be used. (See Page 6 & 7)

___ The method and calculations used to calculate time of concentration must be shown.

___ The program used to do the hydrologic analysis shall be named and all inputs and assumptions listed as well as the outputs. The equation method used to determine the peak discharge shall be stated (Note – the Rational Method shall not be accepted). A summary shall be included which states the peak inflow for each design storm, the time to peak, the volume of inflow to the reservoir, the volume of available storage, the capacity of the principal spillway when the auxiliary spillway activates as well as the maximum capacity of the principal spillway, the capacity of the auxiliary spillway and the maximum elevation of the pool for each design storm evaluated.

___ The runoff flow (in cfs) into the proposed impoundment versus time shall be plotted and the volume under the curve stated.

___ The storage volume and surface area of the impoundment versus elevation shall be plotted with the elevation of the dam toe (where zero storage occurs), the normal pool elevation, the auxiliary spillway crest elevation and the crest of the dam shown on the chart.

___ If augmentation for dry years or initial filling is considered in the design then the primary source shall be from surface water source(s). Groundwater augmentation to fill and/or maintain water levels shall be reviewed on a case by case basis and only allowed for special circumstances.

22. HYDRAULIC REPORT

The hydraulic analysis is usually done using the same program that is used for the hydrologic analysis. Required information may be provided in the same report as the hydrologic analysis and is acceptable where provided on the same output printout as the hydrologic analysis. The report shall contain the following:

___ A description of the principal and auxiliary spillways.

___ A plan and profile sketch of the principal and auxiliary spillways showing dimensions and elevations of the invert, outlet, control section, slope of spillway, crest of the dam and toe of the dam. The sketch shall show the location of the spillways in relation to the dam and the outlet channel.

___ The hydraulic equations (weir, orifice, culvert or gate) used for determining discharge shall be shown along with all coefficients used. If the spillway is a culvert(s) then the governing flow condition assumed shall be stated.

___ The stage-storage-discharge or stage-discharge relationship shall be plotted. If principal spillway is a riser and conduit configuration, then the elevation where full conduit flow develops shall be shown.

___ The velocity for open channel spillways (chute spillways and vegetated earthen spillways) shall be computed and shown as well as where flow transitions from sub-critical to critical to super-critical. Control section shall be placed where flow passes through critical depth.

___ Exit velocity or tractive forces for vegetated earthen spillways shall be computed. Type of vegetation shall be described. Earthen spillways should be cut through natural ground around the abutment of the dam. Earthen spillways that must go through fill or easily erodible soils shall be armored. Exit velocity for a vegetated earthen spillway shall not exceed the permissible velocities shown on the attached table from the USDA-SCS Engineering Field Manual.

___ Froude number shall be calculated for exit velocity at end of spillway(s) (flow entering hydraulic jump) for large dams (see Section 10.2). The depth after the jump shall be calculated and the stilling basin sized based on calculated depth (USBR recommends that length be approximately 6 times the calculated depth). A description of the stilling basin and a sketch showing dimensions and elevations shall be provided. For small and medium dams standard stilling basin guidelines (NRCS, COE, DEQ planning manual for storm water, etc.) are acceptable.

23. BREACH ANALYSIS

A breach analysis and inundation mapping shall be done for all high and significant hazard dams.

___ The method of breach analysis shall be based on lake size (see Section 10.2) unless special circumstances dictate otherwise. For small lakes breach analysis shall be by overtopping. For medium lakes breach analysis shall be by overtopping and sunny day failure (piping) at normal pool. For large lakes the breach analysis shall be sunny day failure at crest of auxiliary spillway.

___ The report shall be signed, sealed, and dated by the Mississippi Registered Professional Engineer responsible for its development in a manner consistent with the requirements of the State Board of Registration for Professional Engineers and Land Surveyors, as they apply generally to the practice of engineering. Nothing herein is to be construed as allowing any such work to be performed other than by or under the direct supervision of a Mississippi Registered Professional Engineer.

___ A description of the reservoir and downstream area which includes the name of the stream impounded and/or discharged to, the volume of the reservoir, the dam and the material (soil type) that it is constructed of, whether or not there is a core in the dam, the height of the dam and elevations for the toe, normal pool and crest, the county (and municipality if reservoir will impact a municipality) the reservoir is located in and a physical description of the downstream area including the amount and type of development present and key elevations shall be provided.

___ The method and calculations used to determine the breach formation factors (time of breach, size of breach) must be shown.

___ The program used to do the breach analysis shall be named and all inputs and assumptions listed as well as the outputs. A map shall be included showing and identifying the downstream cross sections (identify by labeling with the same number as in the program). An electronic copy of the project file shall be submitted along with the written report.

___ Comprehensive surveys of the downstream area for the purposes of establishing cross sections, unless the breach analysis is for the purpose of requesting a lower hazard classification, are at the discretion of the engineer preparing the analysis as to whether they are necessary. Elevations for cross sections may generally be obtained from U.S.G.S. quadrangle maps. More accurate data, such as GIS mapping from LIDAR data with 1 or 2 foot contours, or survey data, if easily obtainable, is recommended.

24. INUNDATION MAPPING

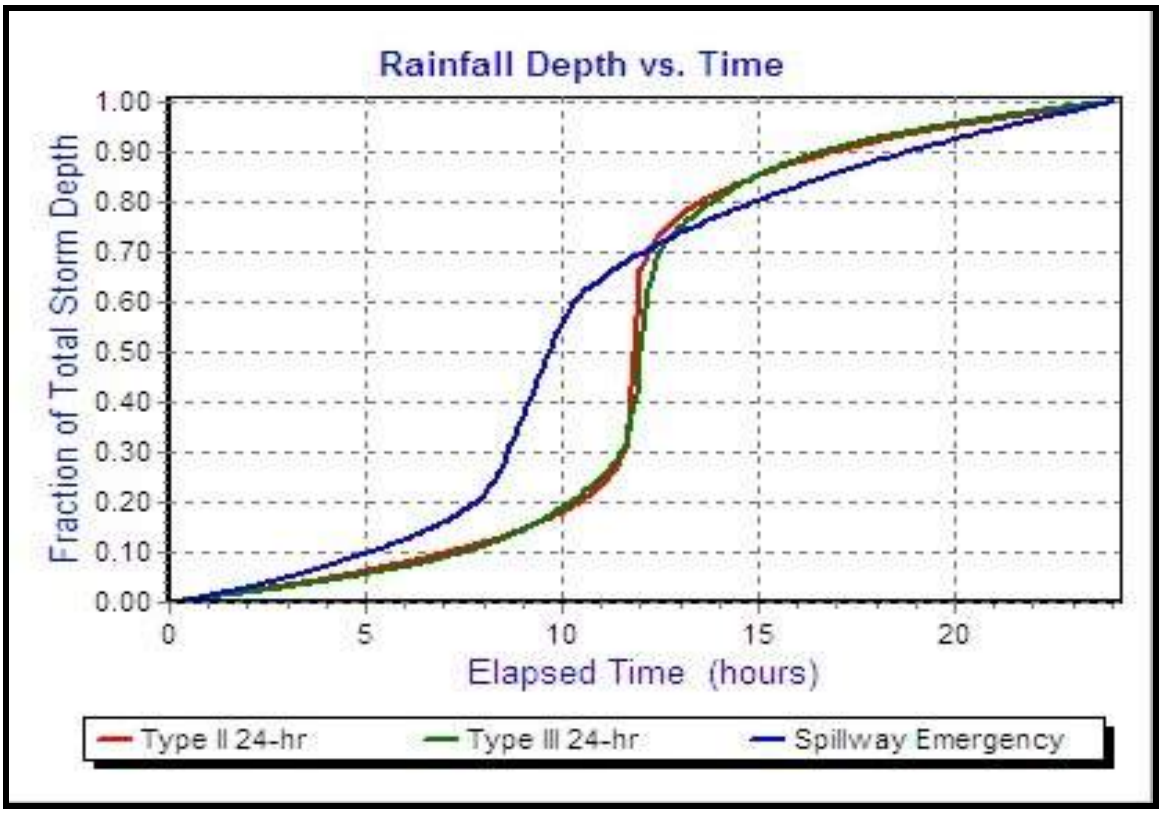
An inundation map shall be provided along with the breach analysis *unless* the breach analysis is for the purpose of proving that the dam is not a high or significant hazard.

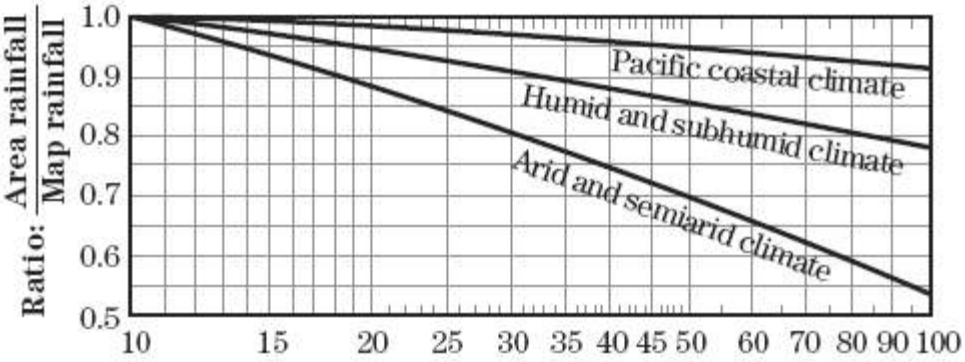
___ Map shall be in color and shall be at a scale where lake and impacted structures downstream may be clearly seen. If inundation area is too large to be shown on one map then an index map shall be included which shows the full extent of the inundation area and the outline of the detailed maps with an identifier for each map sheet. Outline of inundation area shall be marked in permanent ink in a color that is easily distinguishable. If inundation area is marked with hatching, then hatching will be done in such a manner as to not obscure impacted structures, roads and identifying labels.

___ Identifying features shall be clearly labeled (main roads, subdivisions, commercial complexes, etc.) so as to aid emergency responders in quickly locating impacted areas and conducting evacuations.

___ Suggested evacuation routes should be included and be marked with a direction arrow so as to assist emergency responders in directing evacuees to safety.

___ Travel times shall be marked on the map with increments no less than 20 minutes. Dams where everything downstream that will be impacted, will be impacted within the first hour, do not require travel times to be marked on the map.





Areal precipation adjustments for drainage areas 10 to 100 square miles

SCS Emergency Spillway Distribution

Time (hrs)	0	0.5	1	1.5	2	2.5	3	3.5	4
Fraction of Total Depth	0	0.004352	0.012838	0.021543	0.030535	0.04	0.050158	0.061078	0.072761
	4.5	5	5.5	6	6.5	7	7.5	8	8.5
	0.085207	0.098416	0.112387	0.127209	0.143542	0.16215	0.184215	0.215628	0.276613
	9	9.5	10	10.5	11	11.5	12	12.5	13
	0.369615	0.466104	0.556392	0.616503	0.646957	0.673827	0.697429	0.718308	0.737594
	13.5	14	14.5	15	15.5	16	16.5	17	17.5
	0.755792	0.772899	0.788923	0.804083	0.818563	0.832469	0.84583	0.858646	0.870918
	18	18.5	19	19.5	20	20.5	21	21.5	22
	0.882657	0.893946	0.904816	0.915348	0.925576	0.935579	0.945364	0.954931	0.964281
	22.5	23	23.5	24					
	0.973412	0.982367	0.991213	1					

Mississippi Commission on Environmental Quality

DAM SAFETY REGULATION
LW-4

Adopted by the Commission on Environmental Quality June 24, 2004
Revised by the Commission on Environmental Quality August 25, 2005

TABLE OF CONTENTS

Chapter Page Number
I. Definitions 3
II. Authorization 5
A. Applicability 5
B. Exceptions 6
C. Limitations 6
III. Application Content and Procedure 7
IV. Design and Safety Requirements 8 V. General Conditions of Authorization 11
VI. Inspection and Reporting 12
VII. Confidential Information 13
VIII. Enforcement 13
IX. Correspondence and Adequacy of Notice 13
X. Hearings and Appeals 14
Appendix A Hydrologic Design Criteria 15

DAM SAFETY REGULATION (LW-4)

I. Definitions - The words and phrases used in this regulation shall have the meanings set forth in this section:

A. Adverse Effects –Negative impacts that may occur at the site of the dam, upstream, downstream, or at locations remote from the site of the dam. The primary concerns are loss of human life, economic loss (including property damage), lifeline disruptions (such as damage to roads, bridges, or utilities), and adverse environmental impact.

B. Abutment—That part of the undisturbed valley side or a constructed concrete wall against which the dam is constructed. Right and left abutments are identified from the perspective of an observer standing on the dam looking downstream.

C. Alter or Repair— Any change in the surface or cross-section of existing dams and/or appurtenant works or any modification to appurtenant structures, other than minor grading and fill associated with routine slope and turf maintenance activities. Examples of alterations or repairs include such work as adding significant amounts of material to, or removing material from, the cross-section of a dam; changing the dimensions or elevations of an emergency or overflow spillway; replacing pipe or in any other way altering a principal spillway; making any repairs of erosion or undermining associated with seepage through the dam; building a roadway on or across any part of a dam; burying pipelines; or in any way altering the approved operational features of a dam.

D. Appurtenant Works – This term includes, but is not limited to; spillways, either in the dam or separate therefrom; the reservoir and its rim or shoreline; low level outlet works; and water conduits such as tunnels, pipelines, or penstocks, either through the dam or its abutments.

E. Breach—Partial removal of a dam by creating a channel through the dam to the original stream bed elevation, so that no water is impounded by the breached structure.

F. Commission**---** The Mississippi Commission on Environmental Quality, or its designee.

G. Dam—Any artificial barrier, including appurtenant works, constructed to impound or divert water, waste-water, liquid borne materials, or solids that may flow if saturated. All structures necessary to maintain the water level in an impoundment or to divert a stream from its course will be considered one dam.

H. Days—Calendar days including Saturdays, Sundays, and Holidays; unless specifically indicated otherwise in the body of this regulation.

I. Department or MDEQ--- The Mississippi Department of Environmental Quality.

J. Emergency Action Plan--- A formal written document identifying the area that would be inundated in the event of a dam failure and setting forth the plans and procedures for notifying the individuals, agencies, and public officials that would mobilize resources to respond to the emergency.

K. Emergency –This term includes, but is not limited to, uncontrolled breach of a dam; or any conditions leading to, or causing, a breach, overtopping, or any other condition in the dam and/or its appurtenant works that may lead to failure of the dam or otherwise pose a threat to life or property.

L. Enlarge –Any change in, or addition to, an existing dam or reservoir, which raises, or may raise the water storage elevation or storage volume of the water, waste-water, or liquid-borne material impounded by the dam.

M. High Hazard–A class of dam in which failure may cause loss of life, serious damage to residential, industrial, or commercial buildings; or damage to, or disruption of, important public utilities or transportation facilities such as major highways or railroads. Dams which meet the statutory thresholds for regulation that are proposed for construction in established or proposed residential, commercial, or industrial areas will be assigned this classification, unless the applicant provides convincing evidence to the contrary.

N. Impoundment or Reservoir — A man-made dammed, leveed, or diked area or basin designed to store water or other liquids above surface levels that would occur under natural conditions.

O. Low Hazard—A class of dam in which failure would at the most result in damage to agricultural land, farm buildings (excluding residences), or minor roads.

P. Permit Board or Board --- The Mississippi Environmental Quality Permit Board.

Q. Person—The state or other agency or institution thereof, any municipality, political subdivision, public or private corporation, individual, partnership, association or other entity, and including any officer or governing or managing body of any municipality, political subdivision, or public or private corporation, or the United States or any officer or employee thereof.

R. Probable Maximum Precipitation (PMP) **—**The rainfall event used for hydraulic design of dams and appurtenant spillways in Mississippi. The Probable Maximum Precipitation (PMP) varies by location within the state and the event used in design shall be as defined for the proposed construction location by Hydrometeorological Reports published by the Office of Hydrology, National Weather Service.

S. Professional Engineer**—**An engineer with experience in the design of dams who is registered with the State of Mississippi Board of Registration for Professional Engineers and Land Surveyors.

T. Professional Geologist---A geologist with experience in determining and analyzing geologic conditions

affecting the siting of dams who is registered with the Mississippi State Board of Registered Professional Geologists.

U. Removal—Complete elimination of the dam embankment or structure to restore the approximate original topographic contours of the area.

V. Significant Hazard—A class of dam in which failure poses no threat to life, but may cause significant damage to main roads, minor railroads, or cause interruption of use or service of public utilities.

W. Water Storage Elevation—The maximum surface elevation of water that can be maintained by a dam or reservoir.

X. Written Authorization**---** Official written correspondence or permit document from the Board, or its designee, authorizing construction, enlargement, repair, or alteration of a dam; including any specified conditions or limitations under which the work is to be performed by the person to whom the approval is granted.

II. Authorization

A. Applicability

1. Except as otherwise provided in this section, any person or entity proposing to construct, enlarge, repair, or alter a dam or reservoir in the state of Mississippi must obtain written authorization from the Permit Board, or its designee, prior to commencement of any site work related to the project. For high hazard and significant hazard dams, the written authorization will be in the form of a permit document. Application for such permits shall be made on a form prescribed by the Board and will be processed by the Board in accordance with Mississippi Code Annotated, Section 49-17-29.

2. The Board may require submittal of any information deemed necessary to evaluate a proposal to construct, enlarge, repair, or alter a dam or reservoir. Once the Board has authorized the project, the applicant shall not modify the approved design, plans, specifications, or construction methods, or act according to such modified documents, without the prior written authorization of the Permit Board.

3. Any person intending to acquire the right to store or use water from a reservoir formed by a dam, regardless of whether or not written construction authorization is required under this regulation, shall submit an application for a surface water use permit to MDEQ in accordance with Mississippi Code Annotated, Sections 51-3-5 and 51-3-7, and the regulations of the Commission promulgated thereunder.

B. Exceptions

1. Prior written authorization is not required for emergency repairs to a dam which is in imminent danger of failing. However, the dam owner shall report such emergency repairs to MDEQ by close of business on the next business day following the incident and file a written report with MDEQ within five (5) days of the incident.

2. Written construction authorization shall not be required for:

a.) a peripheral dam or levee eight (8) feet or less in height, measured from the point of lowest elevation of its toe, regardless of the impounded storage volume; or

b.) a dam that impounds twenty-five (25) acre-feet or less at maximum storage volume; or

c.) a dam that does not impound a watercourse with a continuous flow of water, as determined by the Commission;

Any person or entity proposing to construct, enlarge, repair, or alter any dam or reservoir in reliance upon the provisions of paragraphs II.B.2.(a.-c.) to exempt the project from the requirement to obtain

written authorization must submit a notification of the planned project to MDEQ prior to the onset of construction. If, upon review of such notification, the Commission determines that the proposed dam poses a potential threat to downstream lives and property; the person or entity proposing the project may be required to comply with design and safety requirements contained in Section IV of this regulation. The Commission may enforce compliance with such design and safety standards in the interest of public safety, notwithstanding the fact that written authorization may not be required for the project. The pre-construction notification shall be submitted on a form prescribed by the Permit Board.

3. Prior written authorization is not required for recurring routine maintenance activities including but not limited to mowing, grading or filling ruts in roadways that cross the dam, filling ruts or repairing other surface damage caused by vehicles or animals on the slopes, filling eroded areas in the surface of an embankment to establish or maintain the turf, or other similar activities.

C. Limitations

1. The Board's receipt, comment, or approval of any design, construction, or modification does not relieve the dam's owner, consulting engineer, consulting Geologist, contractor, equipment supplier, attorney, or any other party of any liabilities or responsibilities. Board and/or MDEQ approval of, or comment on, any document does not establish or convey any liability or responsibility to the Board and/or MDEQ, nor does such approval or comment represent any assurances that the project will comply with any authorization requirements or otherwise perform as intended by the owner, consulting engineer, consulting Geologist, contractor, equipment supplier, attorney or other parties. The dam owner and/or any person responsible for constructing, enlarging, repairing, or altering a dam or reservoir shall comply with all conditions of the Board's authorization to construct and ensure that all construction, operation, and maintenance activities achieve such compliance. It is the responsibility of the dam owner/applicant to obtain all other approvals, permits, clearances, easements, and/or agreements for the construction and/or operation of the dam which may be required by federal, state, or local law or regulation.

2. Written authorizations by the Board expire one (1) year from the date of issuance if work has not commenced on the project. If the work cannot be commenced within the one-year period, the dam owner or any other person responsible for the project must request a time extension from the Board, in writing, at least thirty (30) days prior to the expiration of the one-year authorization period. The written request shall provide an explanation of project delays and an estimated construction commencement date. The Board will normally grant a time extension, on proper application therefor, unless the Board determines that circumstances surrounding the project have so changed that the construction and operation of the dam as originally proposed would violate state or federal laws or regulations. If the applicant allows the authorization to expire, a new application must be submitted and approved prior to the onset of construction.

3. The hazard classification assigned to a dam by the Board is subject to change based on future developments that may increase the potential threat to life and property in the event of a dam failure. The dam owner and/or any person responsible for the construction and/or operation of a dam or reservoir assume all risks associated with designing and constructing the dam to meet less than the most stringent design criteria for high-hazard dams, including the risk of having to make modifications to the dam to meet future heightened regulatory requirements associated with a change in classification.

III. Application Content and Procedure

A. Any person or entity proposing to construct, enlarge, repair, or alter a dam or reservoir shall submit either an application or a pre-construction notification (if the provisions of paragraph II. B. apply) to the Board, on forms prescribed by the Board, at least thirty (30) days prior to the anticipated commencement of construction. The submittal must have a United States Geologic Survey (USGS) topographic map, or portion thereof, attached to it showing the location of the proposed dam and reservoir including a clearly marked access route to the site and marked locations and general descriptions of all buildings, drainage

structures or culverts, roads, railroads, bridges, and utility lines within two-miles downstream of the site of the proposed dam.

B. If the provisions of paragraph II. B. do not apply, and the potential threat to life or potential property damage that would result from failure of the proposed dam rises to the level of significance characteristic of a high hazard or significant hazard classification, the application package also must include two complete sets of design documents prepared in accordance with the following requirements:

1. Engineering drawings, specifications, and engineering reports shall be prepared, signed, and sealed by a professional engineer.

2. Drawings shall be prepared to a scale that provides sufficient detail for review of all project components.

3. Specifications shall include detailed descriptions of all work to be performed and materials to be used in the construction.

4. Engineering reports shall include, but not be limited to, hydrologic calculations, hydraulic calculations, geotechnical investigation, stability analysis, dewatering plan, and provisions for internal drainage. Portions of the investigation at the site of the dam and within the catchment area including, but not limited to, characterization of geologic formations, assessment of groundwater conditions, and/or other geologic conditions, factors, and processes which may impact the design of the dam may be performed by a professional geologist. If a professional geologist produces documents in support of the design of a project, the work products must be signed and sealed by the professional geologist.

5. If a professional geologist produces documents in support of the design of a project, the work products must be signed and sealed by the professional geologist.

C. The Board may require the applicant to supply any additional information necessary to evaluate an application, including the following:

1. Whether the proposed dam will provide adequate safety for lives and property; and/or

2. Whether the proposed dam will adversely affect riparian or other beneficial water uses, or plans for the proper utilization of the water resources of the state, and/or

3. Any other information the Board deems appropriate.

IV. Design and Safety Requirements

A. Any modification, alteration, enlargement, or major repair of an existing dam, whether requested by the owner or directed by the Commission, will be subject to the current design standards for the appropriate hazard classification as set forth in this regulation.
.

B. The owner of any existing dam, regardless of its condition, that poses an unacceptable threat to downstream lives or property may be required by the Commission either to bring the dam into compliance with current standards or take the dam out of service by draining the impoundment and removing the dam.

C. High Hazard dams must be capable of safely passing the runoff from a 100-year rainfall event through the principal spillway without activating the emergency spillway. The 100-year rainfall event is established by the National Weather Service and varies for different areas of the state. The proper design rainfall event for the county where the proposed dam is located can be obtained from MDEQ or from the nearest Natural Resources Conservation Service (NRCS) office. The runoff from one hundred percent (100%) of the Probable Maximum Precipitation (PMP), as defined in paragraph 1.R. of this regulation, must be passed

through the principal and emergency spillway and/or stored in the reservoir without overtopping the dam. The appropriate PMP for each county as obtained from the National Weather Service Bulletins and the rainfall distribution curve to be used in design routings are provided at Appendix A to this regulation. The Commission may require the owner or operator of a high hazard dam that does not meet this requirement to take remedial action to bring the dam into compliance with all current dam safety requirements or to breach the dam.

D. Within thirty (30) days after completion of a high hazard dam, the owner shall submit one (1) complete set of as-built plans and specifications to the Board. The submittal also shall include a letter signed by the professional engineer responsible for the project, certifying that the dam was constructed in accordance with the Board approved plans and specifications.

E. Significant hazard dams shall be designed to control the contributory watershed runoff from at least fifty percent (50%) of the PMP without overtopping the dam. The owner and any other persons responsible for the construction and operation of the dam shall assume all risks for future costs to upgrade a dam in the event the hazard classification changes. Applicants for authorization to construct significant hazard dams must comply with the document submittal requirements set forth for high hazard dams in paragraph III.B. Within thirty (30) days after completion of a significant hazard dam, the owner shall submit one (1) complete set of as-built plans and specifications to the Board accompanied by a letter signed by the professional engineer responsible for the project, certifying that the dam was constructed in accordance with the Board approved plans and specifications.

F. Low hazard dams shall be designed to control the contributory watershed runoff from at least thirty-five percent (35%) of the PMP without overtopping the dam. The owner and any other persons responsible for the construction and operation of the dam shall assume all risks for future costs to upgrade a dam in the event the hazard classification changes. Drawings to be submitted with the application for a low hazard dam shall include, but not be limited to, a plan view of the dam (including all appurtenant works) and sections through the dam at the centerline of the principal spillway and at the centerline of the emergency spillway if it is located in the dam. The applicant shall provide written notification of completion of the dam to the Board, within thirty (30) days after the dam has been constructed, and either certify that the dam was constructed as shown in the drawings previously submitted or submit new as-built drawings.

G. Because the size and type of pipe used for the principal spillway is one of the most critical elements in the design of high hazard and significant hazard dams, the professional engineer responsible for the project shall provide the Board with detailed hydraulic, hydrologic, and structural computations supporting selection of the size and type of pipe to be used. Detailed drawings and specifications relating to the installation of the pipe shall include, but not be limited to, construction measures that adequately address critical loading, bedding, backfill, compaction, and seepage precautions related to installation of the pipe.

H. The Freeboard Hydrograph shall be used to determine the top of dam elevation and the size and crest elevation of the emergency spillway for high hazard dams.

I. The soils in an earthen emergency spillway shall be capable of withstanding the water velocities generated when the emergency spillway is activated without experiencing excessive erosion.

J. Side slopes of all dams shall be a minimum of three horizontal to one vertical (3:1).

K. The owner or operator of a high hazard dam shall develop an Emergency Action Plan (EAP) for the dam. The Board may direct the owner or operator of a significant hazard dam to develop an Emergency Action Plan (EAP). The EAP shall be submitted to the Board for approval. Once approved, a copy of the EAP will be maintained on file by the Board. The owner or operator of the dam shall review the EAP on an annual basis to assure that the information contained therein is current. Revisions to the EAP, as necessary, shall be furnished to the Board and all other persons involved in the implementation of the EAP. The owner or operator also shall be responsible for conducting or coordinating periodic training and exercises to assure that personnel involved in the implementation of the EAP are properly prepared to carry out their responsibilities in the event of an emergency.

V. General Conditions of Authorization

A. No materials shall be placed in a watercourse that will impede or block the natural flow of water without prior written authorization from the Permit Board and other appropriate federal, state, and local authorities. Additionally, any activity involving the discharge of dredged or fill material or any other construction in any state waters that are also subject to federal regulation under Section 404 of the 1972 Clean Water Act and/or Section 10 of the Rivers and Harbors Appropriation Act of 1899 shall be conducted in accordance with appropriate provisions of those federal statutes.

B. A permit or written authorization issued by the Permit Board does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of federal, State, or local laws or regulations. No impoundment may be constructed that will adversely affect riparian or other beneficial water uses or plans for the proper utilization of state waters, or that will cause flooding of upstream property unless the owner of the proposed dam has legally aquired the right to do so. The Commission may prescribe minimum flow releases from any dam or reservoir, as necessary, to protect downstream uses or otherwise prudently manage available surface water.

C. Any dam that impounds a watercourse with a continuous flow shall be designed so that the established minimum flow for the stream (as established by the Commission) is maintained.
D. The owner and/or any person responsible for the construction, enlargement, repair, or alteration of a dam on a watercourse lying, in whole or in part, within a levee district duly constituted under the laws of the State of Mississippi, shall first obtain permission for the work from the board of the levee district and shall provide proof of such permission with the application to the Board.

E. Owners of earthen dams covered under this regulation shall establish and maintain a healthy turf on the exposed faces of the dam to prevent erosion, and shall mow frequently enough to prevent the encroachment of woody vegetation into the slopes of the dam embankment.

F. Owners of High Hazard or Significant Hazard dams will be required to prohibit livestock grazing on the dam in order to prevent damage to the turf and to prevent erosion associated with establishment of animal trails

G. In addition to the general conditions contained herein, the Board may place special conditions on any authorization to construct or modify a dam.

H. The Commission may order the removal of a dam after it has been constructed or modified when it is determined that the dam does not meet criteria and/or standards established by the Board or the Commission and/or otherwise fails to adequately protect lives and property.

I. A Surface Water Use Permit may also be required for any person to impound and store water behind a dam.

J. The owners or operators of high hazard or significant hazard dams shall maintain records and documents related to the original construction, recurring inspections, maintenance, repairs, and alterations of the dam for the life of the project. Such records shall be made available for inspection, or copies of such records furnished, upon request by the Department.

VI. Inspection and Reporting

A. The owner and the operator of a dam shall be responsible for the proper operation and maintenance as well as the structural integrity of the dam. In order to fulfill this responsibility, the owner and/or the operator should perform a visual inspection of the dam at least every sixty (60) days and after every major rainfall event over the watershed. Any symptoms of dam failure observed during such visual inspections shall be immediately reported

to MDEQ.

B. The owner or operator of a high hazard or significant hazard dam shall have a detailed inspection of the dam performed by a registered professional engineer with experience in the design and construction of dams not later than March 1, 2006, and thereafter at such recurring intervals as may be directed by the Department. A checklist form prescribed and furnished by MDEQ shall be used to record observations during the inspection. The report on findings of scheduled detailed inspections (including the completed MDEQ prescribed checklist and an evaluation of the operation, maintenance, and the structural integrity of the dam), bearing the signature and seal of the professional engineer performing the inspection, shall be submitted to the Board within sixty (60) days after completion of the inspection.

C. MDEQ employees are authorized to make inspections at any time to evaluate the operation, maintenance, and structural integrity of dams and reservoirs. The owner or operator shall be required to perform, at the owner's or operator's expense, such work as may be necessary to correct deficiencies in maintenance and operation or accomplish necessary repairs identified by such inspections. If deficiencies are not corrected or repairs are not made as specified in the inspection report, the Commission may order owners or operators to take remedial action or remove the dam in order to safeguard lives and property.

D. If, upon inspection, the Board or the Commission determines that:

1. A dam was constructed without obtaining required prior written authorization from the Permit Board;

2. A dam was not constructed in accordance with the plans and specifications upon which the Board based its written authorization;

3. The dam may not provide adequate safety for lives and property;

4. The dam may adversely affect riparian or other beneficial water uses, or plans for the proper utilization of the water resources of the state; or

5. The owner and/or operator of the dam has allowed the dam to deteriorate and remain in an unsafe condition after having been ordered to make the necessary repairs or modifications, the Board or the Commission may:

a.) cause the dam to be removed or breached;

b.) require the owner and/or operator to take remedial action;

c.) revoke or modify any authorization pertaining thereto; or

d.) take other action the Commission deems appropriate, within its jurisdiction.

VII. Confidential Information

Procedures for declaring submitted information confidential and for agency handling of such information are found in Miss. Code Ann. Section 49-17-39, Section 51-3-44, and the Commission's Regulations Regarding the Review and Reproduction of Public Records (MCEQ-2).

VIII. Enforcement

A. Any person who allows a dam to deteriorate to an unsafe condition may be ordered to make necessary repairs to restore it to a safe condition. If appropriate repairs are not made, the Commission may take action to correct unsafe conditions, or to require removal of the dam, and the Board may revoke or modify any written authorization pertaining thereto.

B. Enforcement of this regulation shall be governed by Miss. Code Ann. Sections 49-17-31, 49-17-

33, 49-17-35, 49-17-37, 49-17-41, and Sections 51-3-49, 51-3-51, and 51-3-55.

IX. Correspondence and Adequacy of Notice

A. General -- All regulated dam owners shall inform MDEQ of any address changes, changes in ownership, or changes in the designated agent of the owner within fifteen (15) days of any such changes, and must readily accept all mail sent to them from the Commission, MDEQ, or the Permit Board.

B. Registered or certified mail -- Registered or Certified Mail sent with proper postage and to the last address provided to MDEQ by the dam owner of record shall be considered adequate notification of notice served if MDEQ is notified that the mail was delivered and accepted or if the mail is returned as rejected or unclaimed by the addressee.

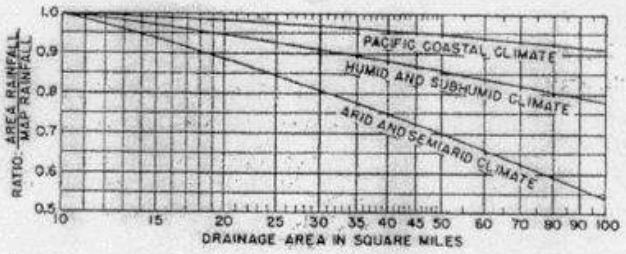
C. Refusal to accept mail -- Refusal to accept mail from the Commission, the Permit Board, the Department, or its designee, shall be considered a violation of this regulation.

X. Hearings and Appeals

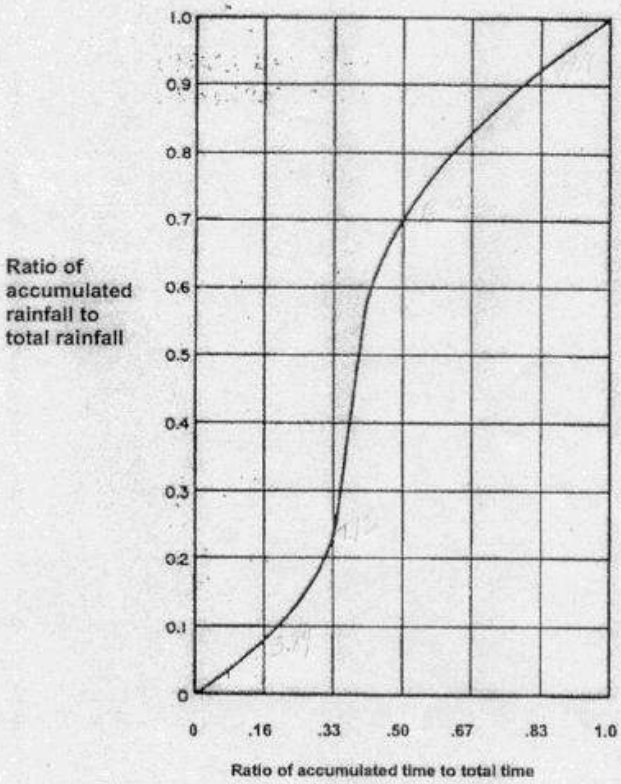
Any person aggrieved by any initial action of the Permit Board to issue, deny, transfer, modify or revoke a permit or written authorization may request an evidentiary hearing before the Permit Board regarding the decision. Procedures for hearings and further appeals of Permit Board decisions are set forth in Mississippi Code Annotated Section 49-17-29.

APPENDIX A

HYDROLOGIC DESIGN CRITERIA



Areal Adjustment



Dimensionless Design Storm Distribution

A-1

PMP (24 hour duration) for MS Counties

COUNTY	PMP (in.)	COUNTY	PMP (in.)	COUNTY	PMP (in.)
Adams	46.1	Itawamba	41.3	Perry	47.0
Alcorn	40.2	Jackson	47.8	Pike	46.9
Amite	46.7	Jasper	45.3	Pontotoc	41.5
Attala	43.4	Jefferson	45.7	Prentiss	40.7
Benton	40.4	Jeff Davis	46.1	Quitman	41.4
Bolivar	42.1	Jones	46.1	Rankin	44.8
Calhoun	42.0	Kemper	44.0	Scott	44.6
Carroll	42.8	Lafayette	41.2	Sharkey	43.6
Chickasaw	42.1	Lamar	46.8	Simpson	45.5
Choctaw	43.0	Lauderdale	44.6	Smith	45.3
Claiborne	45.3	Lawrence	46.2	Stone	47.6
Clarke	45.3	Leake	44.0	Sunflower	42.4
Clay	42.5	Lee	41.3	Tallahatchie	41.9
Coahoma	41.4	Leflore	42.6	Tate	40.7
Copiah	45.5	Lincoln	46.2	Tippah	40.4
Covington	46.1	Lowndes	42.8	Tishomingo	40.4
DeSoto	40.4	Madison	44.2	Tunica	40.7
Forrest	47.0	Marion	46.8	Union	41.0
Franklin	46.2	Marshall	40.5	Walthall	46.9
George	47.5	Monroe	42.1	Warren	44.6
Greene	46.9	Montgomery	42.7	Washington	43.0
Grenada	42.3	Neshoba	44.0	Wayne	46.0
Hancock	48.3	Newton	44.6	Webster	42.5
Harrison	48.0	Noxubee	43.4	Wilkinson	46.7
Hinds	44.7	Oktibbeha	42.8	Winston	43.4
Holmes	43.3	Panola	41.2	Yalobusha	41.8
Humphreys	43.3	Pearl River	47.6	Yazoo	43.8
Issaquena	43.8				

Note – These data interpolated or extrapolated from Figure 20 of Hydrometeorological Report No. 51, Probable Maximum Precipitation Estimates, United States East of 105th Meridian, Office of Hydrology, National Weather Service, U.S. Department of Commerce, NOAA, June 1978. Consideration shall be given to updated National Weather Service references applicable to the location of the dam site as data becomes available.

A-2

E.24. Missouri



Dam Safety Publication No. 3

Rules and Regulations of the Missouri Dam and Reservoir Safety Council



MISSOURI DEPARTMENT OF NATURAL RESOURCES
Geological Survey and Resource Assessment Division
Dam and Reservoir Safety Program

Cover photo: Jamesport City lake dam in Daviess County, Missouri.
Dam and Reservoir Safety Program file photo.

Dam Safety Publication No. 3

RULES AND REGULATIONS OF THE MISSOURI DAM AND RESERVOIR SAFETY COUNCIL

DAM AND RESERVOIR SAFETY COUNCIL

CHAIRMAN
Mary Hagerty

VICE-CHAIRMAN
Dean E. Freeman

MEMBERS
Jeffrey Cawlfield
John Boyer
Zoretta Schoonover
Barbara Adelman
Richard Frueh



MISSOURI DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY AND RESOURCE ASSESSMENT DIVISION
Mimi R. Garstang, Director and State Geologist
P.O. Box 250, Rolla, MO 65402-0250
(573) 368-2175

COPYRIGHT INFORMATION

This copy of the Dam and Reservoir Safety Council rules has been reprinted for use by the Dam and Reservoir Safety Program. It is reprinted, by permission, from the copyrighted Code of State Regulations in accordance with a letter dated October 21, 1981 from James C. Kirkpatrick, Secretary of State. Subscriptions to the Missouri Register and copies of the Code of State Regulations are available through the Secretary of State's Office, State Information Center, Jefferson City, Missouri 65101. These reprinted rules may not be used as evidence in a court of law and copies for that purpose must be obtained from the office of the Secretary of State. Duplication of the rules is not permitted without permission from the Secretary of State.

All other material in this publication, including the statutes, are not copyrighted and may be copied.

TABLE OF CONTENTS

Page		Legal Reference
ii	Copyright Information	
iii	Table of Contents	
vii	Introduction	

CODE OF STATE REGULATIONS – RULES

Chapter 1 – Organization, Definitions, and Immunity

1	General Organization	10 CSR 22-1.010
1	Council	10 CSR 22-1.010 (1)
1	Purpose and Powers of Council	10 CSR 22-1.010 (2)
1	Administration by Department of Natural Resources	10 CSR 22-1.010 (3)
1	Department of Natural Resources	10 CSR 22-1.010 (4)
1	Location	10 CSR 22-1.010 (5)
1	Definitions	10 CSR 22-1.020
5	Immunity of Officers	10 CSR 22-1.030

Chapter 2 – Permits

6	Who Needs a Permit	10 CSR 22-2.010
6	Types of Permits	10 CSR 22-2.020
6	Registration Permit	10 CSR 22-2.020 (2)
7	Construction Permit	10 CSR 22-2.020 (3)
7	Safety Permit	10 CSR 22-2.020 (4)
7	Types of Dams and Reservoirs	10 CSR 22-2.030
7	Conventional Dams	10 CSR 22-2.030 (2)
7	Industrial Water Retention Dams	10 CSR 22-2.030 (3)
8	Classes of Downstream Environment	10 CSR 22-2.040
8	Issuing First Permit	10 CSR 22-2.050
9	Issuing Permit Renewals	10 CSR 22-2.060
9	Revoking Permit	10 CSR 22-2.080
9	Unauthorized Modifications	10 CSR 22-2.080 (1)
10	Failure to Act When Given Directive	10 CSR 22-2.080 (2)
10	Transferring Permit	10 CSR 22-2.090
10	Appeal of Action on Permits	10 CSR 22-2.100

Page		Legal Reference
	Chapter 3 – Permit Requirements	
11	General Information	10 CSR 22-3.010
11	General Requirements	10 CSR 22-3.020
11	Permit Application	10 CSR 22-3.020 (1)
11	Environmental Classification	10 CSR 22-3.020 (2)
12	Quality of Work	10 CSR 22-3.020 (3)
12	Slope Stability	10 CSR 22-3.020 (4)
12	Seismic Analysis – Liquefaction	10 CSR 22-3.020 (5)
12	Seismic Analysis – Slope Stability	10 CSR 22-3.020 (6)
12	Spillway Design Flood	10 CSR 22-3.020 (7)
12	Registration Permit Requirements	10 CSR 22-3.030
12	Conventional Dams	10 CSR 22-3.030 (1)
12	Inspection	10 CSR 22-3.030 (1) (A)
16	Maintenance and Monitoring	10 CSR 22-3.030 (1) (B)
16	Right of Entry	10 CSR 22-3.030 (1) (C)
16	Intent of Permit	10 CSR 22-3.030 (1) (D)
16	Industrial Water Retention Dams	10 CSR 22-3.030 (2)
16	Inspection	10 CSR 22-3.030 (2) (A)
16	Maintenance and Monitoring	10 CSR 22-3.030 (2) (B)
17	Phased Construction	10 CSR 22-3.030 (2) (C)
17	Right of Entry	10 CSR 22-3.030 (2) (D)
17	Phased Construction Supervision	10 CSR 22-3.030 (2) (E)
17	Special Permit Considerations	10 CSR 22-3.030 (2) (F)
17	Intent of Permit	10 CSR 22-3.030 (2) (G)
17	Construction Permit Requirements	10 CSR 22-3.040
17	Conventional Dams	10 CSR 22-3.040 (1)
17	Information Required	10 CSR 22-3.040 (1) (A)
18	Additional Information That May Be Required	10 CSR 22-3.040 (1) (B)
19	Right of Entry	10 CSR 22-3.040 (1) (C)
19	Industrial Water Retention Dams	10 CSR 22-3.040 (2)
19	Consideration of Phased Construction	10 CSR 22-3.040 (2) (A)
20	Records and Supervision of Phased Construction	10 CSR 22-3.040 (2) (B)
21	Information Required	10 CSR 22-3.040 (2) (C)
21	Additional Information That May Be Required	10 CSR 22-3.040 (2) (D)
22	Right of Entry	10 CSR 22-3.040 (2) (E)
22	Changed Drawings	10 CSR 22-3.040 (2) (F)
22	Safety Permit Requirements	10 CSR 22-3.050
22	Conventional Dams	10 CSR 22-3.050 (1)
22	Industrial Water Retention Dams	10 CSR 22-3.050 (2)
22	Right of Entry	10 CSR 22-3.050 (3)
	Chapter 4 – Action Taken by Council and Chief Engineer	
23	Emergency Action	10 CSR 22-4.010
23	Enforcement Orders	10 CSR 22-4.020

REVISED STATUTES OF MISSOURI

CHAPTER 236 – DAMS, MILLS, AND ELECTRIC POWER

24	Definitions	236.400, RSMo (1986)
25	Dam and Reservoir Safety Program	236.405, RSMo (1986)
25	Program Created	236.405 (1), RSMo (1986)
25	Employment of Staff	236.405 (2), RSMo (1986)
25	Employment of Chief Engineer	236.405 (3), RSMo (1986)
25	Records	236.405 (4), RSMo (1986)
25	Dam and Reservoir Safety Council	236.410, RSMo (1986)
25	Non-Partisan Council Created	236.410 (1), RSMo (1986)
25	Council Composition, Structure, and Operation	236.410 (2), RSMo (1986)
26	Council Duties and Powers	236.415, RSMo (1986)
26	Rules Adoption, Violations, and Hearings	236.415 (1), RSMo (1986)
26	Hearings Criteria	236.415 (2), RSMo (1986)
26	Issuing Permits and Delegating Authority	236.415 (3), RSMo (1986)
26	Rules Adoption Criteria	236.415 (4), RSMo (1986)
26	Required Inspections	236.420, RSMo (1986)
27	Chief Engineer's Duties and Powers	236.425, RSMo (1986)
27	Recommend Rules	236.425 (1), RSMo (1986)
27	Recommend Action on Permits	236.425 (2), RSMo (1986)
27	Make Investigations	236.425 (3), RSMo (1986)
27	Right of Entry	236.425 (4), RSMo (1986)
27	Council Employment of Consultants	236.430, RSMo (1986)
27	Construction Permit	236.435, RSMo (1986)
27	Dam Owner Must Obtain	236.435 (1), RSMo (1986)
27	Application Requirements	236.435 (2), RSMo (1986)
27	Consulting with Chief Engineer	236.435 (3), RSMo (1986)
28	Time Frame for Permit Action	236.435 (4), RSMo (1986)
28	Application Rejection	236.435 (5), RSMo (1986)
28	Agricultural Dam Exclusion	236.435 (6), RSMo (1986)
28	Design by Conservation Agency Engineers	236.435 (7), RSMo (1986)
28	Safety, Registration, and Construction Permit	236.440, RSMo (1986)
28	Notification of Construction Completed and Application for Safety Permit	236.440 (1), RSMo (1986)
28	Safety Permit Procedures	236.440 (2), RSMo (1986)
28	Registration Permit Procedures	236.440 (3), RSMo (1986)
28	Additional Registration Permit Procedures	236.440 (4), RSMo (1986)
29	Conditional Registration Permits	236.440 (5), RSMo (1986)

Page		Legal Reference
29	Removal of Dam Under Construction Permit	236.440 (6), RSMo (1986)
29	Safety Permits for Conservation Agency	
29	Engineered Dams	236.440 (7), RSMo (1986)
29	Safety or Registration Permit Renewal	236.440 (8), RSMo (1986)
29	Water Barrier Becomes Dam	236.440 (9), RSMo (1986)
29	Violation for Lack of or Non-Compliance with Permit	236.440 (10), RSMo (1986)
29	Dam Condition Unsafe	236.445, RSMo (1986)
29	Suspend Permit and Require Repairs	236.445 (1), RSMo (1986)
30	Violation for Failure to Act	236.445 (2), RSMo (1986)
30	Abandoned Unsafe Dams	236.450, RSMo (1986)
30	Emergency Action Authorized	236.455, RSMo (1986)
30	Transfer of Ownership	236.460, RSMo (1986)
30	Industrial Water Retention Structures	236.465, RSMo (1986)
30	Additional Permit Requirements	236.465 (1), RSMo (1986)
30	Enlargement Does Not Require New Permit	236.465 (2), RSMo (1986)
30	Safety and Registration Permit with Enlargement	236.465 (3), RSMo (1986)
30	Engineer Requirements	236.465 (4), RSMo (1986)
31	Inspection for Permit Renewal	236.465 (5), RSMo (1986)
31	Inspection by Chief Engineer	236.465 (6), RSMo (1986)
31	Dams Regulated by Other Agencies	236.465 (7), RSMo (1986)
31	Hearings	236.470, RSMo (1986)
31	Testimony, Recording, Availability	236.470 (1), RSMo (1986)
31	Hearing Officer Powers and Duties	236.470 (2), RSMo (1986)
31	Attendance Requirements for Rules	236.470 (3), RSMo (1986)
31	Attendance Requirements for Other Matters	236.470 (4), RSMo (1986)
31	Approval of Final Orders	236.470 (5), RSMo (1986)
31	Immunity of Officers	236.475, RSMo (1986)
31	Judicial Review	236.480, RSMo (1986)
31	Water Rights Preserved	236.485, RSMo (1986)
32	Enforcement of Act	236.490, RSMo (1986)
32	Legal Actions Available	236.495, RSMo (1986)
32	Subpoena Powers	236.495 (1), RSMo (1986)
32	Injunctive Relief and Penalties	236.495 (2), RSMo (1986)
32	Penalties	236.500, RSMo (1986)
32	Willful Violation of Law	236.500 (1), RSMo (1986)
32	Continued Violation	236.500 (2), RSMo (1986)
32	Willful Obstruction or Resistance	236.500 (3), RSMo (1986)
32	Willful Violation of Permit Requirements	236.500 (4), RSMo (1986)

INTRODUCTION

The Dam and Reservoir Safety Council and the Dam and Reservoir Safety Program within the Missouri Department of Natural Resources were established by House Committee Substitute for House Bill 603 as passed by the first regular session of the 80th General Assembly. The bill was signed by the governor and subsequently became law on September 28, 1979. This law is Sections 236.400 through 236.500 in the Revised Statutes of Missouri as printed in the 1986 Supplement. The Dam and Reservoir Safety Program was assigned to the Geological Survey and Resource Assessment Division within the Department of Natural Resources for administration.

The Governor began appointment of the first Council during April of 1980. Employment of the Chief Engineer and initiation of recruitment for the additional authorized staff commenced in July 1980. A working Council with a quorum of four members had been appointed by September 1980.

From September 1980 to August 1981 the Council, with help from the Chief Engineer and his staff, promulgated the first set of rules. These rules provide the information that is necessary in order to implement the law. These rules became effective on August 13, 1981 and are contained in the Code of State Regulations under Title 10, Division 22, Chapters 1 through 3.

In June 1984, the seventh member of the Council was appointed by the Governor, and the first full seven member council meeting was held in July 1984. From January 1984 to December 1984, the Council, with help from the Chief Engineer and his staff, made extensive revisions to the August 13, 1981 edition of the rules. These revisions became effective on January 1, 1985 and are contained in the Code of State Regulations under Title 10, Division 22, Chapters 1 through 4. The Council has taken action on four other occasions to make minor modifications to the rules. These revisions became effective on January 1, 1987; January 1, 1989; January 1, 1991; and June 9, 1994.

The Dam and Reservoir Safety Council is a non-paid policy-making body appointed by the Governor with the consent of the Senate. Communication with the Council is normally handled through the paid staff, which is directed by the Chief Engineer. Questions, comments, requests, and other inquiries should be addressed to the Chief Engineer for action or referral to the Council. The Chief Engineer may be contacted at the following address or telephone number.

Chief Engineer
Dam & Reservoir Safety Program
Missouri Department of Natural Resources
PO Box 250
Rolla, MO 65402-0250
573/ 368-2175

CODE OF STATE REGULATIONS – RULES
TITLE 10 – DEPARTMENT OF NATURAL RESOURCES
DIVISION 22 – DAM AND RESERVOIR SAFETY COUNCIL

CHAPTER 1 – ORGANIZATION, DEFINITIONS AND IMMUNITY

10 CSR 22-1.010 General Organization

PURPOSE: The purpose of this rule is to comply with section 536.023, RSMo (1978) which requires each agency to adopt as a rule a description of its operation and the methods whereby the public may obtain information or make submissions or requests.

(1) Section 236.410, RSMo (1986) establishes a Dam and Reservoir Safety Council of the state of Missouri. The council consists of seven (7) members appointed by the governor with the advice and consent of the Senate. The council holds a minimum of four (4) regular meetings each year and such special meetings and hearings as the council chairman may deem necessary.

(2) The Missouri dam and reservoir safety law and rules, regulations, guidelines and standards provide for the construction, management and operation of dams and reservoirs in a manner which will provide adequate protection of public safety, life or property. To achieve this purpose the council has statutory powers as listed in sections 236.405 and 236.415, RSMo (1986) for policy making, adopting rules, regulations, standards and guidelines and issuing of permits.

(3) The Department of Natural Resources is authorized under section 236.405, RSMo (1986) to administer and enforce all rules, regulations, standards and guidelines adopted by the council and assist the council in achieving its statutory duties. The department has designated the dam and reservoir safety program as the agency within the department responsible for administering the dam and reservoir safety law. The director of the Department of Natural Resources appoints a chief engineer who is the dam and reservoir safety program director and a staff as provided in section 236.405, RSMo (1986). The chief engineer and staff provide day-to-day operation of the dam and reservoir safety program.

(4) Among its operations, the dam and reservoir safety program performs administrative and technical functions including: review permit applications and recommend approval or denial of such applications; inspect dams and reservoirs; enforce the law and all rules, regulations, standards and guidelines adopted pursuant to Chapter 236, RSMo (1986); employ necessary staff, develop facts as may be required by the council; recommend rules, regulations, standards and guidelines required by Chapter 236, RSMo (1986); mitigate or eliminate unsafe dam or reservoir conditions; and other functions as described in section 236.420 to 236.500, RSMo (1986).

(5) Requests for permit applications, requirements or other permit information, copies of these rules and the dam and reservoir safety law, dam inspections, technical information and assistance, requests for public hearings and any other submissions are to be made to the Department of Natural Resources, Dam and Reservoir Safety Program, PO Box 250, Rolla, MO 65402-0250.

Auth: chapter 236.RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981.

10 CSR 22-1.020 Definitions

PURPOSE: The following terms when used in rules, regulations, standards and guidelines adopted by the Dam and Reservoir Safety Council pursuant to the "dam safety law" shall have the meaning respectively ascribed to them by this section.

Editors note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expansive. The entire text of the rule has been filed with the secretary of state. The entire text of the rule may be found at the headquarters of the agency and is available to any interested person at a cost not more than the actual cost of reproduction.

(1) **"Agency engineer"** means an experienced engineer, not necessarily registered as a professional engineer in Missouri, who works for an engineering division of a state or federal agency regularly engaged in dam and reservoir design and construction for soil and water conservation or irrigation or relating to wildlife conservation.

(2) **"Agricultural dam"** means any dam, the primary use of which is to impound water for use in irrigation, livestock watering, or commercial fish rearing and sale.

(3) **"Alterations", "repairs",** or either means such alterations or repairs as affect the safety of a dam or reservoir, or public safety, life or property.

(4) "**Appurtenant works**" means the structures or materials incident to or annexed to dams that are built or maintained in connection with such dams and which are used primarily in connection with their proper operation, maintenance or functioning. This includes, without limitation, such structures as spillways, either in the dam or separate therefrom; the reservoir rim; low level outlet works; and water conduits such as tunnels, pipelines or penstocks, either through a dam or its abutments.

(5) **"Area capacity curves"** means graphic curves, which show the relationship between reservoir surface area and the storage capacity of the reservoir at given elevations.

(6) **"Chief engineer"** means the head of the dam and reservoir safety program of the Department of Natural Resources or his representative.

(7) **"Commercial Fish Rearing"** reservoir means a reservoir which was designed specifically for fish rearing purposes and the primary use is to provide water for commercial fish rearing and sale to other parties in a "for profit" venture. This does not include activities such as sport fishing.

(8) **"Construction permit"** means a written authorization issued by the council giving the owner the right to construct, alter, enlarge, reduce, repair or remove a dam or reservoir or appurtenances thereto, with such conditions as are necessary to adequately protect the public safety, life, property, the dam or reservoir.

(9) **"Conventional dam"** means any dam other than an industrial water retention dam.

(10) **"Council delegate"** or **"authorized representative"** means an individual, usually the chief engineer, authorized by the council to act in its behalf.

(11) **"Crest"** or **"dam crest"** means the top surface of the dam.

(12) **"Crest elevation"** or **"dam crest elevation"** means the lowest elevation of the crest exclusive of the spillway(s).

(13) **"Dam"** means any artificial or man-made barrier which does or may impound water, and which impoundment has or may have a surface area of fifteen (15) or more acres of water at the water storage elevation or which is thirty-five feet (35') or more in height measured either from the natural bed of the stream or watercourse or lowest point on the toe of the dam (whichever is lower) up to the crest elevation, together with appurtenant works. Sections 236.400 and 236.500 shall not apply to any dam which is not or will not be in excess of thirty-five feet (35') in height or to any dam or reservoir licensed and operated under the Federal Power Act.

(14) **"Dam and Reservoir Safety Council"** referred to as the "council" means seven (7) members appointed by the governor for purposes of implementing the dam safety law.

(15) **"Dangerous Dam or Reservoir"** is a dam or reservoir which is in an advanced state of deterioration such that if deterioration continues, the threat of dam failure and flooding would be imminent and substantial.

(16) **"Department"** means the Department of Natural Resources.

(17) **"Downstream environment zone"** means the area downstream from a dam that would be affected

by inundation in the event the dam failed when filled to the emergency spillway crest elevation, or to the dam crest elevation, in the absence of an emergency spillway.

(18) **"Earthquake Intensity"** means Modified Mercalli intensity which is used to describe the degree of shaking a dam will experience.

(19) **"Enforcement Order"** means a written directive issued by the council or the chief engineer to the owner of a dam for correction of defects in the dam or reservoir which have been determined to make the structure a threat to public safety, life or property. The order will contain specific actions with which the owner must comply to remove the threat the dam or reservoir poses to public safety, life or property.

(20) **"Enlargement"** means any change in or addition to an existing dam or reservoir, which raises the height of the dam, increases the watershed for the reservoir or raises the water storage elevation of the water impounded by the dam or reservoir.

(21) **"Environmental class"** means classification of the downstream environment zone based on the contents of that zone (see 10 CSR 22.2.040(1)). Class I represents the most severe threat to public safety, life or property and Class III represents the least threat.

(22) **"Factor of safety"** means the resultant of the summation of the forces resisting failure divided by the summation of the driving forces tending to cause failure.

(23) **"Freeboard"** means the difference in elevation between the dam crest elevation and the water storage elevation in the reservoir.

(24) **"Height"** or **"height of dam"** means the difference in the elevation of either the natural bed of the stream or watercourse or the lowest point on the toe of the dam (whichever is lower) and the dam crest elevation.

(25) **"Industrial building"** means a permanent, enclosed structure used by groups of workers usually involved in some type of manufacturing, processing or industrial related process.

(26) **"Industrial water retention dam"** means a dam used to retain the solids transported as waterborne industrial byproducts and the associated water. This includes, but is not limited to, tailings dams, slime impoundments and settling ponds.

(27) **"Inundation"** means water, two feet (2') or more deep, over the general level of the submerged ground affected outside the stream channel.

(28) **"Inspection"** means scheduled and unscheduled examinations of a dam and reservoir with the primary objective of making safety observations and recording them in a written description.

(29) **"Irrigation Reservoir"** means a reservoir whose primary use is to provide water for the irrigation of agricultural lands for the production of grains, hay, pasture, fruits, vegetables and animal feeds which are for sale or to be used by the owner.

(30) **"Law"** means the dam and reservoir safety law, as contained in chapter 236, RSMo, and all rules, regulations, standards and guidelines adopted thereto.

(31) **"Liquefaction"** is a condition where a soil will undergo continued deformation at a constant low residual stress or with low residual resistance, due to the build-up and maintenance of high pore water pressures, which reduce the effective confining pressure to a very low value.

(32) **"Livestock Water Reservoir"** means a reservoir whose primary use is to provide water for livestock that are raised for breeding or marketing purposes.

(33) **"Maintenance"** means the proper keeping of all aspects of a dam or reservoir and appurtenances thereto, that pertain to safety, in a state of repair and working order as necessary to comply with the law and any permit issued thereunder and to protect public safety, life or property.

(34) **"Modification"** or **"modifications"** means changes or revisions to the design, construction, maintenance, operation or repair or the alteration, enlargement, reduction, removal or natural physical change that may occur to a dam or reservoir that were not included in the approved plans for the construction permit, or such changes or revisions to a dam or reservoir where a registration or safety permit is in effect or required hereunder, if such changes or revisions would endanger public safety, life or property as a result of creating a potential

failure in the dam or reservoir, except that modification or modifications do not mean or include approved anticipated enlargements, outlined by design plans and specifications submitted and approved with the original application for a construction, safety or registration permit for industrial water retention dams and reservoirs.

(35) **"Observable defects"** are those defects which would be detectable by an experienced professional engineer making an on-site visual inspection of the dam in accordance with current engineering, geologic and construction practices.

(36) **"Owner"** or **"dam owner"** means a person who owns, controls, operates, maintains, manages or proposes to construct a dam or reservoir including: the state and its departments, institutions, agencies, and political subdivisions, but not the United States government; a municipal or quasi-municipal corporation; a district; a public utility; a natural person, firm, partnership, association, corporation, political subdivision or legal entity; the duly authorized agents of leasees, or trustees of any of the foregoing; or receivers or trustees appointed by any court for any of the foregoing.

(37) **"Permanent dwelling"** means a dwelling occupied at least ninety (90) days a year.

(38) **"Permit"** means construction, safety or registration permit.

(39) **"Permit application"** or **"applicant"** means an owner who applies for a construction, safety or registration permit.

(40) **"Probable maximum acceleration"** means the horizontal acceleration developed at a dam as a result of an earthquake with a probability of occurrence similar to the probable maximum precipitation. The probable maximum acceleration is readily available from a Corps of Engineers Report entitled "Earthquake Potential of the St. Louis District – Ground Motion Supplement" which is on file with the chief engineer of the Dam and Reservoir Safety Program. *(See Editors Note.)*

(41) **"Probable maximum precipitation"** or **"PMP"** means the precipitation that may be expected from the most severe combination of critical meteorological conditions that are reasonably possible in an area. The probable maximum precipitation (PMP) is readily available from the National Weather Service in Hydrometeorological Report 51, *"Probable Maximum Precipitation Estimates, United States East of the 105h Meridian." (See Editors Note.)*

(42) **"Public building"** means a permanent, enclosed structure used by the general public but not necessarily owned by the public.

(43) **"Registration Permit"** means a permit issued for a period not to exceed five (5) years by the council to the owner of a dam or reservoir in existence or in the progress of construction on August 13, 1981 or which becomes subject to the law for such dams and reservoirs by a change in factors or circumstances subsequent to that date. Such permits shall only be issued for dams which are in properly maintained condition or which have made and complied with recommendations for corrections of observed defects of the dam or reservoir and have been examined and approved in accordance with the law.

(44) **"Reservoir"** means any basin, including the water, which contains or will contain the maximum amount of water impounded by a dam.

(45) **"Safety Permit"** means a permit issued to the owner of a dam for a period of five (5) years, or less if safety considerations so require, by the council indicating that the dam meets the requirements of the law, and containing such conditions as to operations, maintenance and repair as are necessary to adequately protect public safety, life and the dam or reservoir.

(46) **"Seepage"** means the migration of water though a dam or foundation.

(47) **"Significant Modification"** means changes, alterations, or modifications to an existing dam or reservoir or changes to the construction documents for a new dam. These include but are not limited to: changes in the location of the dam or reservoir, changes in the storage capacity or drainage area, changes in the capacity of the spillway system, modification of the embankment slopes, changes in the height of the dam or structure or the use of different construction methods or procedures than those submitted with the permit application.

(48) **"Spillway"** means any passageway, channel, or structure, open or closed, or both, designed expressly or primarily to discharge excess water from a reservoir after the water storage elevation has been reached.

(49) **"Spillway design flood"** or **"SDF"** means the specified flood discharge that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in an area and for which the dam and reservoir are designed. The "SDF" is derived from the rainfall values given in Table 5.

(50) **"Stability"** means the properties of a dam or reservoir that cause it, when disturbed from a condition of equilibrium, to develop forces or moments that restore the original condition.

(51) **"Starter dam"** means a pervious or impervious dam constructed as the first phase in the building of an industrial water retention dam and reservoir.

(52) **"Storage"** means the volumetric capacity of the reservoir below the water storage elevation or other selected reference on the dam.

(53) **"Stream"** means any river, creek or channel, having well-defined banks, in which water flows for substantial periods of the year to drain a given area.

(54) **"Tailings"** means the material generated by a mining/milling operation, which is deposited in slurry form in an impoundment for storage and/or disposal or both.

(55) **"Tailings dam"** means an existing dam or reservoir used for the impoundment or retention of tailings or a proposed, existing or newly constructed dam and reservoir for which the anticipated or contemplated use is the impoundment or retention of tailings.

(56) **"Toe"** or **"toe of slope"** means the line of the fill (dam embankment) slope where it intersects the natural ground.

(57) **"Water"** means water, other liquids or tailings.

(58) **"Watercourse"** means a valley, swale, depression, or other low place in the topography occupied by flowing water during conditions of runoff.

(59) **"Water storage elevation"** means that elevation of water surface at the principal spillway, which could be obtained by the dam or reservoir were there no outflow and were the reservoir full of water.

(60) **"Watershed"** means the area that contributes or may contribute surface water to a reservoir.

Auth: sections 236.405 and 236.415, RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985. Amended: Filed September 7, 1993, effective May 9, 1994.

10 CSR 22-1.030 Immunity of Officers

PURPOSE: The purpose of this rule is to restate the immunity from damages provided in section 236.475, RSMo (1986)

(1) In the absence of willful and wanton misconduct, no action shall be brought against the council, the chief engineer or his agents, or department employees or private individuals employed as consultants by the department for the recovery of damages caused by the partial or total failure of any dam or reservoir or through the use of operation of any dam or reservoir upon the ground that such person is liable by virtue of any of the following: the approval of a dam or reservoir or permits therefore; the issuance or enforcement or orders relating to maintenance, operation or repair of a dam or reservoir; control or regulation of a dam or reservoir; measures taken to protect against failure during an emergency; or denial of a permit.

Auth: sections 236.475, RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981.

TITLE 10 – DEPARTMENT OF NATURAL RESOURCES
DIVISION 22 – DAM AND RESERVOIR SAFETY COUNCIL

CHAPTER 2 – PERMITS

10 CSR 22-2.010 Who Needs a Permit

PURPOSE: The purpose of this rule is to identify those persons who need to obtain a permit for their dam and reservoir and to identify those persons who do not need to obtain a permit for their dam and reservoir.

(1) The owner of a proposed new dam thirty-five feet (35') or more in height is required to obtain a construction permit and a safety permit for his dam and reservoir. The owner of an existing dam thirty-five feet (35') or more in height is required to obtain a registration permit within the time set forth in 10 CSR 22-2.020(2).

(2) By definition, the United States government is not considered an owner. Therefore, no federal dam and reservoir is regulated by section 236.400 to 236.500, RSMo (1986), and no permits are required.

(3) Agricultural dams are exempted from all permit requirements as long as the agricultural dam and reservoir continue to be used primarily for agricultural purposes, (see 10 CSR 22-1.020(2)). The owners of agricultural dams and reservoirs over thirty-five feet (35') in height must notify the council of their reliance on this exemption and their basis for application of this exemption to their dams. If an agricultural dam and reservoir is constructed after the effective date of the law, but subsequently becomes subject to the provisions of the law, the owner shall, prior to obtaining a registration permit, provide evidence that the dam meets the construction permit criteria in effect at the time the dam was constructed.

(4) Dams and reservoirs licensed and operated under the Federal Power Act are exempted from all permit requirements.

(5) Dams and reservoirs that were designed by and the construction monitored by an agency engineer (see 10 CSR 22-1.020(1)) do not need a construction permit but a set of plans shall be filed with the chief engineer prior to the initiation of the construction activity. These dams and reservoirs are required to have a registration or safety permit subsequent to construction.

(6) Industrial water retention dams (see 10 CSR 22-1.020(26)) and reservoirs regulated by another state agency or federal agency are exempted from all permit requirements. For the exemption to apply the industrial water retention dam and reservoir must be subject to safety inspections by the other state agency or federal agency and standards used must be at least as stringent as those required by the law. In addition the owner must notify the council that another agency is regulating his dam and reservoir and explain the basis for the exemption to apply.

Auth: sections 236.400, 236.405, 236.415, 236.435, 236.440, and 236.465, RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985. Amended: Filed September 7, 1993, effective May 9, 1994.

10 CSR 22-2.020 Types of Permits

PURPOSE: The purpose of this rule is to describe the three (3) types of permits and their uses that the Dam and Reservoir Safety Council will issue.

(1) There are three (3) types of permits – registration permits, construction permits and safety permits and each one is intended to regulate a separate and distinct type of activity. A dam and reservoir will have only one (1) type of permit in effect at any given time although they may have more than one type of permit during their existence.

(2) Registration permits (see 10 CSR 22-1.020(43)) apply to and are required for the continued operation of a dam and reservoir that was in existence on the effective date of this paragraph, August 13, 1981. A registration permit also applies to and is required for structures which become subject to the provisions of the dam and reservoir safety law that were in existence prior to the date that they became sub-

ject to the law. Registration permits may be issued for a time period up to five (5) years. The owner of a dam and reservoir on the effective date of the law shall obtain his first registration permit in accordance with the height of his dam. For dam heights of thirty-five feet (35') to less than fifty feet (50'), fifty feet to seventy feet (50'-70'), and over seventy feet (70'+), the maximum time to obtain the first registration permit is respectively within nine (9) years, four (4) years, and two (2) years from the effective date of this section, August 13, 1981.

(3) Construction permits (see 10 CSR 22-1.020(8)) apply to the construction of a new dam and reservoir, or the alteration, enlargement, reduction, repair, or removal of a new or existing dam, reservoir or appurtenances. New dams are dams for which construction commences after the effective date of this section, August 13, 1981. For dams that were under construction on August 13, 1981, construction must be completed by August 13, 1987 or the owner will be required to obtain a construction permit. If completed prior to August 13, 1987, the owner will be required to obtain a registration permit as outlined in 10 CSR 22-2.020(2). A construction permit may be issued for any reasonable length time period required to complete construction and it may contain appropriate restrictions placed on the owner for construction and operation of the dam and reservoir during that period. At the conclusion of construction, a safety or registration permit shall be obtained by the owner.

(4) Safety permits (see 10 CSR 22-1.020(45)) apply to the operation of a dam and reservoir constructed pursuant to a construction permit. The safety permit is not a guarantee of the dam and reservoir's safety and does not alter the owner's liability; it is simply an operating permit. If a dam and reservoir were not subject to the provisions of the law when they were constructed but subsequently become subject to the provisions of the law, the owner shall obtain a registration permit, not a safety permit. Safety permits may be issued for a time period up to five (5) years, and they may contain appropriate conditions for the operation and safety of the dam and reservoir.

Auth: sections 236.400, 236.405, 236.415, 236.435, 236.440 and 236.465, RSMo (1986). Original rules filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985. Amended: Filed May 15, 1987, effective September 15, 1987.

10 CSR 22-2.030 Types of Dams and Reservoirs

PURPOSE: The purpose of this rule is to describe the two (2) fundamentally different types of dams and reservoirs that will be required to obtain permits from the Dam and Reservoir Safety Council.

(1) There are two (2) types of dams and reservoirs, conventional dams and reservoirs and industrial water retention dams and reservoirs. The two (2) types of dams and reservoirs are distinguished on the basis of their reservoir contents and the length of the time period during which active dam building occurs.

(2) Conventional dams and reservoirs (see 10 CSR 22-1.020(9)) are dams and reservoirs used for purposes other than tailings, slime, settling or other similar industrial water retention purposes. A conventional dam is constructed in one relatively continuous operation over a short time span (compared to the design life of the reservoir). Filling and use of the reservoir occurs after construction is completed.

(3) Industrial water retention dams and reservoirs (see 10 CSR 22-1.020(26)) are dams and reservoirs used for the purpose of storing solids and the water associated with the particular industrial process such as tailings, slime and other similar industrial materials. An industrial water retention dam may be constructed in phases and steps or continuously, over a long period of time (compared to the design life of the reservoir). Filling and use of the reservoir may occur during most phases of construction. An industrial water retention dam and reservoir in existence or under construction on the effective date of 10 CSR 22-2.020(2), August 13, 1981, shall obtain a registration permit which may include approval to make enlargements. The owner of any such dam and reservoir shall apply for and obtain new construction and/or registration permits for any modifications to that dam and reservoir other than enlargements covered by an existing permit. A construction permit is required and shall be obtained by the owner, for the initial construction phase of any new industrial water retention dam and reservoir built after the effective date of 10 CSR 22-2.020(3), August 13, 1981. Upon completion of the initial construction phase, the owner shall apply for a safety permit for the operation and enlargement of the new dam and reservoir.

Auth: sections 236.405, 236.415, 236.435, 236.440, and 236.465, RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985.

10 CSR 22-2.040 Classes of Downstream Environment

PURPOSE: The purpose of this rule is to describe the three (3) environmental classes for the downstream environmental zone that will be used by the Dam and Reservoir Safety Council when considering permits.

(1) The downstream environment zone is the area downstream from a dam that would be affected by inundation in the event the dam failed. Inundation is defined as water, two feet (2') or more deep over the general level of the submerged ground affected outside the stream channel. Based on the content of the downstream environment zone, three (3) environmental classes are defined. They are: class I, which contains ten (10) or more permanent dwellings or any public building; class II, which contains one (1) to none (9) permanent dwellings, or one (1) or more campgrounds with permanent water, sewer and electrical services or one (1) or more industrial buildings; and class III, which is everything else.

(2) Spillway design standards are based on the environmental class of the downstream environment zone of a dam and reservoir. The standards become more stringent for lower environmental class numbers. If conditions change in the downstream environment zone and it becomes necessary to change the environmental class of the dam and reservoir, the owner must then meet the standards and criteria for the new environmental class of the dam and reservoir. A dam and reservoir may be in only one (1) environmental class at any given time.

(3) Inundation, the downstream environment zone and the associated environmental class are analyzed assuming the dam fails with the reservoir at the emergency spillway crest elevation or the dam crest elevation in the absence of an emergency spillway. If the spillway standards for class I are used, the failure analysis does not have to be performed. If a failure analysis is made, the contents of the downstream environment zone used to determine the environmental class are only the features that would be inundated by the flooding resulting from the dam failure.

Auth: sections 236.405, 236.415, 236.435, 236.440 and 236.465, RSMo (1986). Original rules filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985.

10 CSR 22-2.050 Issuing First Permit

PURPOSE: The purpose of this rule is to describe the procedure for issuing the first permit to a dam and reservoir owner for a particular dam and reservoir.

(1) A permit will be issued or a letter will be sent to the owner with comment within forty-five (45) days after the receipt of a properly prepared application or after the completion of any hearings or record period conducted by the council in connection with such application, whichever is later. The council, upon hearing the recommendations of the chief engineer, shall approve or deny the permit application.

(2) A permit will be issued if a complete and proper application has been submitted and the dam and reservoir comply with the law.

(A) A registration permit may be denied if it is determined that the owner has not complied with the experienced professional engineer's or agency engineer's inspection recommendations.

(B) A construction permit may be denied if there is insufficient information to determine that the proposed construction, alteration, enlargement, reduction or removal of a dam or reservoir would not endanger public safety, life or property.

(C) A safety permit may be denied if it is determined that there are violations of the construction permit or the law.

(D) If revisions have been made which vary substantially from the provisions of the construction permit, the owner must show that the revisions do not endanger public safety, life or property before a safety permit will be issued.

(3) Conditions contained in a construction permit shall include that the construction work must be under the responsible charge of an experienced professional engineer and that records be kept and made available as required by the chief engineer including, without limitation, for the foundation excavation and inspection and placement of backfill in the core trench. It is not necessary for the engineer in responsible charge to be on site continuously. During construction, the council or its del-

egate, or the chief engineer, may make periodic site inspections for the purpose of inspecting for and securing conformity of construction with the approved plans and specifications, and the owner shall, upon reasonable notice, permit such person entry upon its property to make such inspections. The owner may be required to perform, at their own expense, reasonable work or tests as are necessary to provide sufficient information to enable the council to determine that there is such conformity. Usually, such testing will be limited to verification of embankment compaction, concrete strengths and other similar requirements. It is expected that such tests will be required where the owner's inspection records are lacking.

(4) Any significant modifications from construction permit or approved plans makes the permit void and requires the owner to obtain a new permit. Significant modifications to the plans and specifications must be prepared by an experienced professional engineer. The council or its delegate will follow the same evaluation procedures for the modifications as used with issuance of the original construction permit. Special attention will be given to these modification requests to provide a quick decision.

(5) The owner of a dam and reservoir that is removed under a construction permit must notify the council or its delegate when this work is completed and in conformity with the provisions of the construction permit. The council or its delegate will then issue a final approval to relieve the owner of the requirement to have a permit upon a showing that the requirements of the law for removal have been satisfied.

(6) Approval by the council for a construction permit becomes invalid within one (1) year unless work on the construction has begun within that period, except that the owner may be excused from beginning work for such period of time that the work is prevented by flood, shortage of materials or regulation of government which cannot be met for reasons over which the owner has no control or other causes beyond the owner's control. The same applies to construction of approved modifications contained in the conditions of a registration or safety permit for industrial water retention dams unless the conditions specify a different time schedule.

Auth: sections 236.400, 236.405, 236.415, 236.435, 236.440 and 236.465, RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985.

10 CSR 22-2.060 Issuing Permit Renewals

PURPOSE: The purpose of this rule is to describe the procedure for renewing a permit.

(1) The owner of a permitted dam and reservoir must apply for the renewal of the permit not less than sixty (60) days prior to expiration of that permit. Before any permit may be renewed, the chief engineer must determine that the dam and reservoir are essentially as described in the latest permit and approved plans; they satisfy the law; and that no inspection conducted in connection with the permit renewal reveals any defect which would threaten public safety, life or property. The council or its delegate will issue another permit within forty-five (45) days of the receipt of a complete and proper application unless it is determined that the dam and reservoir are not as described in the latest permit and approved plans; not properly maintained; do not satisfy the law; or that the defects are not corrected.

(2) The council may require the owner to furnish a certification by an experienced professional engineer or an agency engineer that the dam and reservoir are as described in the latest permit and approved plans; are properly maintained, satisfy the law; and have all the defects corrected.

Auth: sections 236.405, 236.415, 236.440 and 236.465, RSMO (1986). Original rule filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985.

10 CSR 22-2.080 Revoking Permit

PURPOSE: The purpose of this rule is to describe the reasons for revoking a permit.

(1) Approval of the council or its delegate, the chief engineer, shall be obtained for modifications that substantially alter or adversely affect the safety or stability of the dam or reservoir. Such modifications, without the approval of the council or its delegate, the chief engineer, are cause for suspension or revocation of any permit. It the chief engineer finds that the condition of the dam and reservoir has deteriorated substantially from those conditions present when the permit was issued, or that has defects which adversely affect the safety or sta-

bility of the dam and reservoir or threatens public safety, life or property, he shall suspend or revoke the permit. It a permit is suspended or revoked, the dam owner will be in violation of the law and may be subject to prosecution for a misdemeanor.

(2) If the chief engineer determines that a dam or reservoir constitutes a threat to public safety, life or property, he may order its removal or take any other actions necessary to reduce or eliminate such threat. Failure of a dam owner to alter or remove his dam and reservoir, as directed, when it is found to be a threat to public safety, life or property will result in revocation of the permit and, if necessary, removal of the dam or any other action necessary to reduce or eliminate the threat to public safety, life or property by the state at the owner's expense.

Auth: sections 236.405, 236.415, 236.445, 236.495 and 236.500, RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985.

10 CSR 22-2.090 Transferring Permit

PURPOSE: The purpose of this rule is to describe the procedure for transferring a permit with ownership changes.

(1) Permits issued pursuant to 10 CSR 22-2.050 and 10 CSR 22-2.060 are transferable only as provided in section 236.460 RSMo (1986). If ownership or other transfer of interest in the dam and reservoir changes, the former owner must notify the chief engineer of the sale or transfer and the permit will be transferred to the new owner after determination that such transfer will not endanger the public safety, life, property, the dam or reservoir. The permit holder of record will be held responsible for maintaining compliance with these rules and standards. If the former owner does not have the permit transferred, the new owner may submit the appropriate application and documents necessary to obtain a new permit. The new owner must, in this case, also show proof of ownership. The old owner's responsibilities of ownership under the law will not be extinguished until the permit is transferred to an eligible owner. Nothing in these regulations shall be construed to eliminate the liability of the previous owner for injuries caused by a dam failure, nor a new operator who has not obtained a permit nor had an existing permit transferred to his name.

Auth: sections 236.405, 236.415, and 236.460, RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985.

10 CSR 22-2.100 Appeal of Action on Permits

PURPOSE: The purpose of this rule is to describe the procedure for appealing the results of any action taken with regard to a permit.

(1) Permits revoked or denied are subject to council appeal. All parties shall be afforded an opportunity for hearing before the council for review of denial or revocations decisions, if request is made within thirty (30) days after notice is served personally or by certified or registered mail upon such parties or their agents. Except for emergency action, further legal action shall not be taken until after such hearing and council decision.

(2) The record of hearing shall include all written testimony, data, records, etc. as well as all oral proceedings recorded stenographically or by such other means that will preserve the testimony. Rules of discovery, evidence and privilege as applied in civil cases in the circuit courts shall be followed.

(3) A final decision will be in writing, and the party or their agents will be notified personally or by registered or certified mail of the final decision. A copy of any opinion in support of this decision will be furnished upon request. Such decisions are subject to judicial review pursuant to provisions of section 236.480, RSMo (1986).

Auth: sections 236.405, 236.415, 236.425, 236.440, 236.445, 236.470 and 236.480, RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985.

TITLE 10 – DEPARTMENT OF NATURAL RESOURCES
DIVISION 22 – DAM AND RESERVOIR SAFETY COUNCIL

CHAPTER 3 – PERMIT REQUIREMENTS

10 CSR 22-3.010 General Information

PURPOSE: The purpose of this rule is to provide general information about permit requirements.

(1) Requirements for existing or proposed dams and reservoirs must allow for variations in conditions and materials from site to site. Therefore, this rule and rules 10 CSR 22-3.020 to 10 CSR 22-3.050 describe the minimum general requirements which are consistent with current engineering, geologic, construction, operation and maintenance practices, necessary to obtain permits from the Dam and Reservoir Safety Council.

(2) These rules are not intended to define the only requirements for a dam and reservoir to comply with the law, or the only engineering, geologic and construction practices to be used in detailed site investigation or in the specific design and construction of individual dams. The detailed and specific information that outlines current and prudent engineering, geologic and construction practices is available in technical literature. Determinations by the Dam and Reservoir Safety Council, after hearing the recommendations of the chief engineer of the acceptability of a design and adequacy of plans, specifications and construction must, by necessity, be made on a case by case basis. Therefore, it is recommended that applicants unfamiliar with the way these rules are applied contact the council or the chief engineer prior to commencing extensive work or plan development.

(3) Adherence to the law does not guarantee the safety of any dam or reservoir or relieve the owner of any liability in the event of dam failure.

(4) A permit application form along with a copy of the laws, rules, standards, and guidelines relating to dam and reservoir safety can be obtained free from the Department of Natural Resources, Geological Survey and Resource Assessment Division, Dam Safety Program, PO Box 250, Rolla, MO 65402-0250. Persons seeking this and/or other information on dams in Missouri should address their inquiry to the chief engineer.

Auth: sections 236.400, 236.405, 236.415, 236.435, 236.440 and 236.465, RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985.

10 CSR 22-3.020 General Requirements

PURPOSE: The purpose of this rule is to itemize the basic requirements and standards that apply to all permits.

(1) The permit application must contain information required by the council and the chief engineer including, but not limited to, the following information: type of permit being applied for; name of owners; mailing address of owners; telephone number(s) of owners; name of dam; name of reservoir; coordinate location of the dam centerline at the maximum section; purpose or use of dam and reservoir; name, address and telephone number of the experienced professional engineer or agency engineer who has provided or will provide required technical assistance; and the downstream environment zone environmental class for the dam and reservoir. The owners must complete applicable investigations required in 10 CSR 22-3.020 to 10 CSR 22-3.050 before filing a permit application. All permit applications must be filed with the chief engineer at the address listed in 10 CSR 22-3.010 (4).

(2) The owner must provide a determination of an environmental class for each dam and reservoir. The method, data, and assumptions used by the owner to determine environmental class shall conform to practices reputable and in current use in the engineering, geologic and construction profession or the chief engineer may reject the owner's classification. If an owner chooses not to have this done by an experienced professional engineer or an agency engineer, the chief engineer will assign the dam and reservoir to environmental class I or he may assign the dam and reservoir to the appro-

priate environmental class if he has justification to do so.

(3) The anticipated consequences of a dam failure with respect to public safety, life and property damage are important considerations in establishing acceptable methods for specific investigations and sites. Methods used in exploration, design, construction and maintenance must be in accordance with good engineering practices reputable and in current use in the engineering, geologic and construction professions.

(4) When the owner is applying for a construction permit, the required design factors of safety for slope stability for earth and rock conventional dams which are given in Table 1 shall be met. The required design factors of safety for concrete conventional dams are given in Table 2. The required design factors of safety for slope stability for industrial water retention dams are given in Table 3. Owners shall meet these requirements in the design of new dams prior to the issuance of the permit. Owners shall also meet these requirements when substantial changes are proposed to the height or slope of an existing conventional dam or structure prior to the issuance of the construction permit. (see following tables)

(5) For new dams constructed wholly or partially of cohesionless materials (such as sands and silts) or having a foundation of cohesionless materials, earthquake loading may result in the build-up of pore water pressures and a loss of strength. Engineers shall take this pore pressure increase and loss of strength into account when performing their stability analysis, but the degree to which liquefaction may affect the factor of safety for slope stability shall be left up to the engineer's best judgement. Bedrock accelerations and earthquake intensities are listed in Table 4.

(6) New dams constructed wholly of cohesive materials (such as clays) and having a foundation of cohesive materials or bedrock, can be expected to withstand significant earthquake shaking if it can be shown that other required design factors of safety for slope stability are met. Therefore, only new dams located in Bollinger, Butler, Cape Girardeau, Dunklin, Mississippi, New Madrid, Pemiscot, Ripley, Scott, Stoddard and Wayne counties must meet the requirements for slope stability during earthquake loading while dams located in other counties do not unless 10 CSR 22-3.020(5) applies to them. Bedrock accelerations and earthquake intensities are listed in Table 4.

(7) The required spillway design flood, which shall allow for flood storage in the reservoir, is to be derived by using the precipitation values given in Table 5 and shall apply to both new and existing dams.

Auth: sections 236.400, 236.405, 236.435, 236.440 and 236.465, RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985.

10 CSR 22-3.030 Registration Permit Requirements

PURPOSE: The purpose of this rule is to itemize the requirements for a registration permit.

(1) In addition to the basic requirements for all permits listed in 10 CSR 22-3.020(1),(2),(3) and (7), the registration permit application for a conventional dam and reservoir must include certification by an experienced professional engineer or an agency engineer that the dam and reservoir have been inspected in accordance with the law and that the owner has complied with the engineer's recommendations to correct observed defects and an inspection report, as required by the law. The engineer must further show that the spillway can safely pass the spillway design flood derived from Table 5 and submit a report describing the correction of all observed defects and the description of an operation and maintenance program to be followed while the registration permit is in effect.

(A) The inspection of a dam and reservoir for a registration permit is intended to detect observable defects. The procedure to determine observable defects normally will be a surface examination by an experienced professional engineer or an agency engineer. The inspection must include all surface examinations necessary to determine if observable defects exist that affect the stability of the dam and reservoir or the adequacy of the spillway. Judgement of the structural stability and an evaluation of the spillway capacity must be made. Judgement shall be based upon the engineer's experience, training and knowledge of similar dams and in accordance with practices reputable and in current use in the engineering, geologic and construction professions.

1. Observed defects which may require correction, evaluated on the basis of current engineer-

TABLE 1

Required Design Factors of Safety for Slope Stability
Earth and Rock Conventional Dams

Loading Condition	Factor of Safety
End of construction, full reservoir*	1.4
Steady seepage, full reservoir*	1.5
Steady seepage, maximum reservoir*	1.3
Sudden drawdown, from full to empty reservoir (if applicable)	1.2
Earthquake***, steady seepage, full reservoir*	1.0

* Full reservoir means water level is at the water storage elevation
** Maximum reservoir means water level is at maximum water level attained during the spillway design flood or at the dam crest elevation, whichever is lower.
*** Earthquake loading will vary according to dam location in relation to seismic source zones and downstream environmental zones. See Table 4.

TABLE 2

Required Design Factors of Safety
Concrete Conventional Dams

Failure Mode	Loading Condition	Factor of Safety
Overturning	full reservoir*	1.5
	maximum reservoir**	1.3
Sliding	full reservoir*	1.5
	maximum reservoir**	1.3
Structural integrity	full reservoir*	1.5
	maximum reservoir**	1.3
Earthquake*** - any mode	full or maximum reservoir* & **	1.0

* Full reservoir means water level is at the water storage elevation.
** Maximum reservoir means water level is at maximum level attained during the spillway design flood.
*** Earthquake loading will vary according to dam location in relation to seismic source zones and downstream environmental zones. See Table 4.

TABLE 3

Required Design Factors of Safety for Slope Stability
Industrial Water Retention Dams

Loading Condition	Factor of Safety
Starter dam, end of construction, full reservoir*	1.4
Any other stage of construction, full reservoir*, steady seepage	1.3
Any other stage of construction, maximum reservoir**, steady seepage	1.0
Completed dam, full reservoir*, steady seepage	1.5
Completed dam, maximum reservoir**, steady seepage	1.3
Earthquake***, steady seepage, full reservoir*	1.0

* Full reservoir means water level is at the water storage elevation.
** Maximum reservoir means water level is at maximum water level attained during the spillway design flood or at the dam crest elevation, whichever is lower.
*** Earthquake loading will vary according to dam location in relation to seismic source zones and downstream environmental zones. See Table 4.

TABLE 4

Required Design Acceleration for Earthquake Design

Dam Type	Stage of Construction	Special Descriptions	Environmental Class I	II	III
Conventional or Industrial	Completed	New dams less than 50 feet in height	.75PMA*	.5PMA*	.25PMA*
		New dams greater than 50 feet in height**	.75PMA*	.5PMA*	.4PMA*
Industrial	Starter Dam	New Dams**	.5PMA*	.2PMA*	.1PMA*
	After starter dam is finished and before final dam is completed	New Dams**	.75PMA*	.5PMA*	.2PMA*

Zone:	A	B	C	D	E	F
PMA*:	0.31g	0.28g	0.26g	0.23g	0.20g	0.17g
Intensity***:	IX-X	IX	VIII-IX	VIII	VII-VIII	VII

* PMA is Probable Maximum Acceleration of bedrock which is determined by the zones as a fraction of the acceleration of gravity (g-32.2fps^2) for six zones in Missouri (See 10 CSR 22-1.010(40)).
** See 10 CSR 22-2.020(3) for clarification.
*** Modified Mercalli Intensity.

TABLE 4 (cont.)

ZONE A
Dunklin
Mississippi
New Madrid
Pemiscot

ZONE B
Bollinger
Butler
Cape Girardeau
Ripley
Scott
Stoddard
Wayne

ZONE C
Carter
Howell
Iron
Madison
Oregon
Perry
Reynolds
St. Francois
Ste. Genevieve
Shannon

ZONE D
Crawford
Dent
Douglas
Franklin
Jefferson
Ozark
Phelps
Pulaski
St. Louis
St. Louis City
Taney
Texas
Washington
Wright

ZONE E
Audrain
Barry
Barton
Bates
Benton
Boone
Caldwell
Callaway
Camden
Carroll
Cass
Cedar
Chariton
Christian
Clark
Cole
Cooper
Dade
Dallas
Gasconade
Greene
Henry
Hickory
Howard
Jackson
Jasper
Johnson
Knox
Laclede
Lafayette
Lawrence
Lewis
Lincoln
Linn
Livingston
McDonald
Macon
Maries
Marion
Miller
Moniteau
Monroe
Montgomery
Morgan
Newton
Osage
Pettis
Pike
Polk
Ralls
Randolph
Ray
St. Charles
St. Clair
Saline
Scotland
Shelby
Stone
Vernon
Warren
Webster

ZONE F
Adair
Andrew
Atchison
Buchanan
Clay
Clinton
Daviess
Dekalb
Gentry
Grundy
Harrison
Holt
Mercer
Nodaway
Platte
Putnam
Schuyler
Sullivan
Worth

TABLE 5

Required Spillway Design Flood Precipitation Values

Dam Type	Stage of Construction	Special Descriptions	Environmental Class I	II	III
Conventional or Industrial	Completed	Any existing dam**	.75PMP*	.5PMP*	100 Yr****
		New dams less than 50 feet in height**	.75PMP*	.5PMP*	100 Yr****
		New dams greater than 50 feet in height**	.75PMP*	.5PMP*	100 Yr****
Industrial	Starter Dam	Any	.5PMP*	.2PMP*	.1PMP*
	After starter dam is finished and before final dam is completed	Any	.75PMP*	.5PMP*	.2PMP*

* PMP is Probable Maximum Precipitation.
** Existing dam means a dam which was completed by August 13, 1981 or which was started prior to August 13, 1981 and completed by August 13, 1987.
*** See 10 CSR 22-2.020(3) for clarification.
**** 100 Yr is the 100-year frequency rainfall event.

ing, geologic and construction practices, include but are not limited to: slides; slopes as steep as or steeper than those on similar types of dams and constructed of similar materials which have experienced slope stability problems; piping of fines; seepage that exits in an uncontrolled fashion on the downstream slope of or from the downstream foundation of the dam; unusual zones of softness and irregular settlement; erosion on the upstream or downstream slope of the dam; spillways that are calculated to be inadequate for the design flood; spillways that are eroded or otherwise in poor condition; and cracks in the embankment or structure.

2. Observed defects that are in an advanced state of deterioration must be immediately reported by the inspecting engineer to the owner and to the chief engineer.

(B) Proper maintenance and operation of a dam and reservoir are critical to the continuing safety of a dam and reservoir and to public safety, life and property. A maintenance program shall be required and shall include the following items: erosion control on the embankment; monitoring emergency spillway flow rates; vegetation control; spillway maintenance; emergency action plans; maintenance and monitoring of seepage observation devices, if any; and maintenance and monitoring of instruments used, if any, to observe the stability of the dam.

(C) Visits for the purpose of observation of maintenance and operation may be made by the council, the chief engineer or a member of the chief engineer's staff. Such visits will be at any reasonable time following reasonable notice, except that in the case of an emergency threatening public safety, life or property no such notice shall be required, and inspection may be at any time. Owners shall permit entry to its property for such persons to perform such inspections.

(D) The application need not state, nor is it necessary to show, that the dam is a safe dam. The intent of the registration permit is to show that the dam is performing adequately and that there are no observable indications that the dam is unsafe.

(2) In addition to the basic requirements for all permits listed in 10 CSR 22-3.020(1),(2),(3), and (7), the registration permit application for an industrial water retention dam and reservoir shall include certification by an experienced professional engineer or an agency engineer that the dam and reservoir have been inspected in accordance with the law and that the owner has complied with the engineer's recommendations to correct observed defects and an inspection report, as required by the law. The engineer must further show that the spillway can safely pass the spillway design flood derived from Table 5 and submit a report describing the correction of any observed defects, the operation and maintenance program to be made a part of the registration permit, and the phased, stepped, and/or continuous construction of the dam.

(A) The inspection of an industrial water retention dam and reservoir for a registration permit is intended to detect observable defects. The procedure to determine observable defects normally will be a surface examination by an experienced professional engineer or an agency engineer. The inspection must include all surface examinations necessary to determine if observable defects exist that affect the stability of the dam and reservoir or the adequacy of the spillway. Judgement of the structural ability and an evaluation of the spillway capacity must be made. Judgement shall be based upon the engineer's experience, training, and knowledge of similar dams and in accordance with practices reputable and in current use in the engineering, geologic and construction professions.

1. Observed defects which may require correction, evaluated on the basis of current engineering, geologic and construction practices, include but are not limited to: slides, slopes as steep as or steeper than those on similar types of dams and constructed of similar materials which have experienced slope stability problems; piping of fines; seepage that exits in an uncontrolled fashion on the downstream slope of or from the downstream foundation of the dam; unusual zones of softness and irregular settlement; erosion on the upstream or downstream slope of the dam; spillways that are calculated to be inadequate for the design flood; spillways that are eroded or otherwise in poor condition; and cracks in the embankment or structure.

2. Observed defects that are in an advanced state of deterioration must be immediately reported by the inspecting engineer to the owner and to the chief engineer.

(B) Proper maintenance and operation of a dam and reservoir are critical to the continuing safety of a dam and reservoir and the protection of public safety, life and property. A maintenance and operation program shall be required and shall include the following items: erosion control on the embankment; monitoring of storm runoff; vegetation control spillway maintenance; emergency action plans; maintenance and monitoring of seepage observation devices, if any; and maintenance and monitoring of instruments used, if any, to observe the stability of the dam.

(C) The council or chief engineer may require the owner to submit a report describing the phased, stepped and/or continuous construction of an industrial water retention dam and reservoir, containing information on the materials used, method of transport and placement of materials, the sequence and placement location of materials, spillway changes to be made, the anticipated final dimensions and configuration of the dam and the name, address and telephone number of the person(s) in responsible charge of this work.

(D) Visits for the purpose of inspecting during construction or enlargement or observation of maintenance and operation may be made by the council, the chief engineer or a member of the chief engineer's staff. Such visits will be at any reasonable time following reasonable notice, except that in the case of an emergency threatening public safety, life or property, no such notice shall be required, and inspection may be made at any time. Owners shall permit entry to its property for such persons to perform such inspection.

(E) It shall not be necessary for the owner to retain an experienced professional engineer or an agency engineer continuously during the entire permit period unless there is modification(s) in the construction method described in the permit application. However, personnel with adequate supervision and training in methods of safe construction, maintenance and operation of dams must be provided to insure that the construction, maintenance and operation of the dam and reservoir are carried out as described.

(F) The registration permit will be the only permit required for an industrial water retention dam and reservoir that was in existence prior to the effective date listed in 10 CSR 22-2.020(2) unless it is to be reduced and removed. If the dam or reservoir is to be reduced or removed, a construction permit will be required. Other changes will require the owner to obtain a new registration permit.

(G) The application need not state, nor is it necessary to show, that the dam is a safe dam. The intent of the registration permit is to show that the dam is performing adequately and that there are no readily observable indications that the dam is unsafe, and that phased, stepped and/or continuous construction of the dam will meet the requirements of the law.

Auth: sections 236.400, 236.405, 236.415, 236.420, 236.425, 236.440 and 236.465, RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985.

10 CSR 22-3.040 Construction Permit Requirements

PURPOSE: The purpose of this rule is to itemize the requirements for a construction permit.

(1) In addition to the basic requirements for all permits listed in 10 CSR 22-3.020, the construction permit application for a conventional dam and reservoir shall be prepared by or under the direction of and certified by an experienced professional engineer and shall be in accordance with practices reputable and appropriate in the engineering, geologic and construction professions.

(A) The following requirements shall apply to, and the following information shall be provided by the owner:

1. Up-to-date topographic map(s) showing the location of the proposed or existing dam, the upstream watershed, the reservoir, and the downstream environment zone. The topographic map(s) of the project area must be at a scale appropriate to the size of the project area. An up-to-date US Geological Survey topographic map is considered a minimum;

2. Exploration records and results including the location of all exploration, especially in the area of the core trench, the method(s) used to explore the site, a record of what was found, the method(s) used to obtain samples and the number of samples taken;

3. Testing records and results including information on the care and treatment of samples, types of tests performed on samples or in situ, reference(s) to or the procedures used in testing, and the test results. Physical and mechanical properties of foundation and construction materials must include the information source for these values especially if they are not the results of testing;

4. The geotechnical design procedures or method(s) shall be identified and referenced or described so that they may be reviewed and their applicability verified. This shall include all assumptions made. The geotechnical procedure(s) or design results shall include the minimum computed factors of safety and they must meet or exceed the required design factors of safety (see 10 CSR 22-3.020(4)). The geotechnical design information shall be presented for the foundation, core trench, and dam embankment. Earthquake loading must be analyzed as outlined in 10 CSR 22-3.020(5) and (6);

5. The structural design procedure(s) or method(s) shall be identified and referenced or described so that they may be reviewed and their applicability verified. Design results for concrete dams and concrete structures appurtenant to embankment dams shall provide for and show an adequate factor of safety for normal and maximum loading conditions of compression, tension, shear, torsion, buckling, sliding, and overturning;

6. Hydrologic information used to evaluate the watershed, reservoir, spillway, and downstream environment zone including the watershed area, rainfall rate and duration, antecedent moisture conditions, time of concentration, area capacity curves, description of spillway elevation(s), type(s) dimensions, locations, cross-sections and profiles, dam crest elevation and the downstream valley cross-sections;

7. The hydrologic/hydraulic design procedure(s) or method(s) used shall be identified and referenced or described so that they may be reviewed and their applicability verified. This shall include all assumptions made. The hydrologic/hydraulic procedure(s) or design results shall include the reservoir inflow hydrograph, the reservoir outflow hydrograph, the spillway discharge capacity, the freeboard at the maximum water storage elevation and the environmental class of the dam. The dam shall be capable of safely containing or discharging the required design flood (see 10 CSR 22-3.020(7)).

8. Location and design of diversion channels or other structures to control stream flow during or after construction shall be provided if failure of these channels or other structures would affect hydrologic conditions of the dam. Stream diversion systems used during construction shall be designed to provide protection to the dam and the safety of the public.

9. Construction control and inspection procedures shall be used during the construction of a new dam and reservoir or modification of an existing dam and reservoir. Construction control and inspection procedures should include compaction testing and density testing;

10. Procedures shall be used for record keeping and monitoring throughout the construction or modification process to provide information about any construction progress and conditions that may cause difficulties during construction;

11. The location of and protective measures used in conjunction with all drain lines, sewer lines, utilities or other structures that pass through or under the dam;

12. Topographic surveys showing the location of baselines, centerlines, and other horizontal and vertical control points sufficiently accurate to locate the proposed construction and to define the volume of storage in the reservoir.

13. Two (2) sets of plans and specifications including:

A. Graphic scales shall be provided for all scaled drawings;

B. The title, which shall be identical on the plans and the specifications, shall include: the name of the dam; the name of the owner; whether the work shows an existing dam, a proposed dam or an enlargement, repair or alteration of the dam or reservoir; the county or counties the dam and reservoir are in; the location of the dam by quarter section, section, township, and range or by geodetic coordinates; and each sheet shall have in an appropriate title block the name of the dam as well as the sheet number in relation to the total, e.g. sheet 1 of 12; and

C. Certifications by the experienced professional engineer and the owner shall be placed near the lower right hand corner of the title sheet (first sheet) of the drawings. The certifications shall be similar to those presented in figures 1 and 2 (see figs. 1 and 2).

14. If a construction permit is requested to convert a dam to a retaining or retarding structure, the procedure to be followed in making the conversion shall be described by the owner; and

15. The procedures set up for regular inspection by the owner. The owner shall develop an emergency action plan, inspect his dam regularly and as necessary to protect public safety, life and property. A list of items to be inspected, a time schedule for these inspections and a form for reporting the results shall be established.

(B) The council or chief engineer may require the following action and information from the owner:

1. Procedures set up to provide regular maintenance and minor repairs to the dam and reservoir after construction and to continue or start record keeping and monitoring work so that the dam and reservoir are maintained in a safe condition and a complete history of its performance is available;

2. Location and types of instrumentation; drainage and/or seepage control facilities. Monitoring equipment and drainage control facilities are recommended for all dams and reservoirs; however, depending on conditions, they may be mandatory items if necessary to accomplish the purposes of the law;

3. The downstream environment zone warning procedure to be used if dam failure is a threat. A downstream environment zone warning system is recommended for all dams and reservoirs; however, depending on conditions, it may be necessary to accomplish the purposes of the law. This would consist of the current name(s) of the dam and reservoir owner's representative(s) responsible for giving notification of a threat and the current phone numbers of appropriate local police and other persons having emergency assistance authority;

4. Upstream slope protection from wave action; and

5. Additional actions or information as required to protect public safety, life and property and to accomplish the purposes of the law.

(C) Visits for the purpose of inspecting during or after construction or observation of operation and maintenance may be made by the council, the chief engineer or a member of the chief engineer's staff. Such visits will be at any reasonable time following reasonable notice, except that in the case of an emergency threatening public safety, life or property, no such notice shall be required and inspection may be made at any time. Owner shall permit entry to their property for such persons to perform such inspections.

(2) In addition to the basic requirements for all permits listed in 10 CSR 22-3.020, the construction permit application for an industrial water retention dam and reservoir shall be prepared by or under the direction of and certified by an experienced professional engineer and shall be in accordance with practices reputable and appropriate in the engineering, geologic and construction professions.

(A) The engineer who plans and designs an industrial water retention dam and reservoir or its modification shall assess the sequence, timing, method of placement and stability control program during construction from the beginning of the starter dam or modification through the life of the structure and after operation ceases or until the dam and reservoir no longer need a permit.

(B) Adequate records, as required by good practices in the geologic and engineering professions, shall be kept and made available to the council or chief engineer for the construction, maintenance, and operation procedures. Adequate instrumentation and monitoring of seepage water shall be provided where necessary. Any significant settling or movement in the foundation of the dam should be measured if possible. Trained personnel and adequate supervision shall be provided to insure the construction and operation of the dam and reservoir are carried out to specifications.

FIGURE 1

Certification by Experienced Professional Engineer

I hereby certify that these plans for the (insert the correct word or words choosing from: existing, construction of the, repair of the, enlargement of the, or alteration of the) _____ Dam were prepared by me (or under my direct supervision) for the owners thereof.
Name of Dam

_____
Firm Name

_____
Registered Engineer

FIGURE 2

Certification by Owner

I, _____, owner, whose Post Office Address is

_____, Zip _____, do hereby accept and approve these plans.

_____
Owner

(C) The following requirements shall apply to, and the following information shall be provided by the owner:

1. A description of the system used to deposit tailings on the dam;

2. Up-to-date topographic map(s) showing the location of the proposed dam, the upstream watershed, the reservoir and the downstream environment zone. The topographic map(s) of the project area must be at a scale appropriate to the size of the project area. An up-to-date U.S. Geological Survey topographic map is considered a minimum;

3. The location(s) of surface and underground mine workings if these workings would cause, would contribute to the cause, or would be affected in the event of failure;

4. Exploration records and results including the location of all exploration, especially in the area of the core trench, the method(s) used to explore the site, a record of what was found, the method(s) used to obtain samples and the number of samples taken;

5. Testing records and results including information on the care and treatment of samples, types of tests performed on samples or in situ, reference(s) to or the procedures used in testing, and the test results. Physical and mechanical properties of foundation and construction materials must include the information source for these values especially if they are not the results of testing;

6. The geotechnical design procedure(s) or method(s) shall be identified and referenced or described so that they may be reviewed and their applicability verified. This shall include all assumptions made. The geotechnical procedure(s) or design results shall include the minimum computed factors of safety and they must meet or exceed the required design factors of safety (see 10 CSR 22-3.020(4)). The geotechnical design information shall be presented for the foundation core trench and dam embankment. Earthquake loading must be analyzed as outlined in 10 CSR 22-3.020(5) and (6);

7. Type and physical properties of the liquid and solid materials to be used in construction of the dam and contained in the reservoir;

8. The changes created in the downstream environment zone as the dam and reservoir become incrementally larger;

9. The embankment changes and new factors of safety for stability as the dam and reservoir become incrementally larger;

10. If a starter dam is used, whether it will be pervious or impervious;

11. The expected crest elevation, dam configuration, spillway elevation, and the size and configuration of each successive stage of the dam shall be included;

12. Anticipated storage volume of solid or semi-solid materials and of liquids at the completion of the dam;

13. The structural design procedure(s) or method(s) shall be identified and referenced or described so that they may be reviewed and their applicability verified. Design results for concrete dams and concrete structures appurtenant to embankment dams shall provide for and show an adequate factor of safety for normal and maximum loading conditions of compression, tension, shear, torsion, buckling, sliding and overturning;

14. Hydrologic information used to evaluate the watershed, reservoir, spillway, and downstream environment zone including the watershed area, rainfall rate and duration, antecedent moisture conditions, time of concentration, area capacity curves, description of spillway elevation(s), type(s), dimensions, locations, cross-sections and profiles, dam crest elevation, and the downstream valley cross-sections;

15. Hydrologic/hydraulic design procedure(s) or method(s) used shall be identified and referenced or described so that they may be reviewed and their applicability verified. This shall include all assumptions made. The hydrologic/hydraulic procedure(s) or design results shall include the reservoir inflow hydrograph, the reservoir outflow hydrograph, the spillway discharge capacity, the freeboard at the maximum water storage elevation and the environmental class of the dam. The dam shall be capable of safely containing or discharging the required design flood (see 10 CSR 22-3.020(7)).

16. The hydrologic changes, the spillway alterations proposed and the freeboard changes as the dam becomes incrementally larger;

17. Location and design of diversion channels or other structures to control stream flow during or after construction shall be provided if failure of these channels or other structures would affect the stability or hydrologic conditions of the dam. Stream diversion systems used during construction shall be designed to provide protection to the dam and to protect public safety, life and property;

18. Location and design of any diversion channels or other structures to control runoff or reclaimed water;

19. Construction control and inspection procedures shall be determined by the engineer and used during the construction of a new dam and reservoir or modification of an existing dam and reservoir. Construction control and inspection procedures shall include compaction testing, density testing, and any other quality control measures used to insure compliance with the construction specifications;

20. Procedures shall be used for record keeping and monitoring throughout the construction, enlargement or modification process to provide information about construction progress and any conditions that may cause difficulties during construction.

21. The location of and protective measures used in conjunction with all drain lines, sewer lines, utilities or other structures that pass through or under the dam;

22. Topographic surveys showing the location of baselines, centerlines and other horizontal and vertical control points sufficiently accurate to locate the proposed construction and to define the volume of storage in the reservoir at each planned stage of construction.

23. Two (2) sets of plans and specifications including:

A. Graphic scales shall be provided for all scaled drawings;

B. The title, which shall be identical on the plans and the specifications shall include: the name of the owner; whether the work shows an existing dam, a proposed dam, or an enlargement, repair or alteration of the dam and reservoir; the county or counties the dam and reservoir are in; the location of the dam by quarter section, section, township and range or by geodetic coordinates; and each sheet shall have in an appropriate title block the name of the dam as well as the sheet number in relation to the total, e.g., sheet 1 of 12; and

C. Certification by the experienced professional engineer and the owner shall be placed near the lower right hand corner of the title sheet (first sheet) of the drawings. The certifications shall be similar to those presented in figures 1 and 2 (see figs. 1 and 2 preceding).

24. If a construction permit is requested to convert a dam to a retaining or retarding structure, the procedure to be followed in making the conversion shall be described by the owner; and

25. The procedure set up for regular inspection by the owner. The owner shall develop an emergency action plan, inspect his dam and reservoir regularly and as necessary to protect public safety, life and property. A list of items to be inspected, a time schedule for these inspections and a form for reporting the results shall be established by the council or chief engineer. Items that shall receive maintenance to and/or inspections on a daily basis during periods of active dam enlargement include: the spigots or cyclones; the decant lines; the position of the water pool in relation to the spillway, decant intake and crest of the tailings dam; drain lines checked for quantity of water and sediment; the embankment observed for visual defects such as slides or significant seepage changes; the spillway shall be checked to verify that it has not become blocked.

(D) The council or chief engineer may require the following action and information from the owner:

1. Procedures set up to provide regular maintenance and minor repairs to the dam and reservoir during construction and enlargement so that the dam and reservoir are maintained in a safe condition and a complete history of its performance is available;

2. Location and types of instrumentation, drainage, and/or seepage control facilities. Monitoring equipment and drainage and seepage control facilities are recommended for all dams and reservoirs; however, depending on conditions, they may be mandatory items if necessary to accomplish the purposes of the law;

3. The downstream environment zone warning procedure to be used if dam failure is a threat. A downstream environment zone warning system is recommended for all dams and reservoirs; however, depending on conditions, it may be necessary to accomplish the purposes of the law. This would consist of the current name(s) of the dam and reservoir owners representative(s) responsible for giving notification of a threat of failure and the current phone numbers of appropriate local police and other persons having emergency assistance authority;

4. Upstream slope protection from wave action; and

5. Additional actions or information as required to protect public safety, life and property and to accomplish the purposes of the law.

(E) Visits for the purpose of inspecting during or after construction or observation of operation and maintenance may be made by the council, the chief engineer, or a member of the chief engineer's staff. Such visits will be at any reasonable time following reasonable notice, except that in the case of an

emergency threatening public safety, life or property, no such notice shall be required and inspection may be made at any time. Owners shall permit entry to their property for such persons to perform such inspections.

(F) Drawings to show changes shall be submitted when such changes are made to the original plans including, without limitation, changes in incremental dam crest heights, spillway locations, and cross-sections.

Auth: sections 236.400, 236.405, 236.415, 236.420, 236.425, 236.435, 236.440 and 236.465, RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985.

10 CSR 22-3.050 Safety Permit Requirements

PURPOSE: The purpose of this rule is to itemize the requirements for a safety permit.

(1) In addition the basic requirements for all permits listed in 10 CSR 22-3.020, the safety permit application for a conventional dam and reservoir shall include:

(A) Notification of the completion of construction and application for the first safety permit for the dam and reservoir shall be provided by the owner. The experienced professional engineer or agency engineer who was in responsible charge of the construction work shall certify that the construction was substantially in accordance with the approved plans and specifications. If revisions have been made which vary considerably from the provisions of the construction permit, it must be shown that the revisions do not endanger public safety, life or property. This subsection shall not be construed to excuse any person from the requirement to notify the council or chief engineer of modifications or revisions prior to commencing such actions and to obtain the required permits or authorization therefore;

(B) Notification of completion shall be within two (2) month's time after completion of construction; and

(C) As built drawings shall be submitted.

(2) In addition to the basic requirements for all permits listed in 10 CSR 22-3.020, the application for a safety permit for an industrial water retention dam and reservoir shall include:

(A) Notification of completion of the starter dam or the initial phase of construction shall be prepared by or under the supervision of an experienced professional engineer in accordance with the provisions of the construction permit;

(B) Notification of the completion of construction and application for the first safety permit for the dam and reservoir shall be provided by the owner or the experienced professional engineer who was in responsible charge of the construction work. The engineer shall certify that the construction was substantially in accordance with the approved plans and specifications. If revisions have been made which vary considerably from the provisions of the construction permit, it must be shown that the revisions do not endanger public safety, life or property. This subsection shall not be construed to excuse any person from the requirement to notify the council or chief engineer of modifications or revisions prior to commencing such actions and to obtain the required permits or authorization therefore;

(C) Notification of completion shall be within two (2) month's time after completion of construction; and

(D) As built drawings shall be submitted.

(3) Visits for the purpose of observation of operation and maintenance procedures may be made by the council, the chief engineer or member of their staff. Such visits will be at any reasonable time following reasonable notice, except that in the case of an emergency threatening public safety, life or property, no such notice shall be required, and inspection may be made at any time. Owners shall permit entry to their property for such persons to perform such inspections.

Auth: sections 236.400, 236.405, 236.415, 236.420, 236.425, 235.440, and 236.465, RSMo (1986). Original rule filed April 14, 1981, effective August 13, 1981. Amended: Filed June 14, 1984, effective January 1, 1985.

TITLE 10 – DEPARTMENT OF NATURAL RESOURCES
DIVISION 22 – DAM AND RESERVOIR SAFETY COUNCIL

CHAPTER 4 – ACTION TAKEN BY COUNCIL AND CHIEF ENGINEER

10 CSR 22-4.010 Emergency Action

PURPOSE: The purpose of this rule is to define the way emergency action is taken.

(1) In performing his duties, the chief engineer shall determine by inspection whether a dam or reservoir constitutes a threat to public safety, life or property. If it is determined that a dam is in an advanced state of deterioration and in such condition that continued deterioration could cause failure of the dam, the chief engineer may classify the dam as dangerous to public safety, life or property. If the chief engineer or council further determines that there is not sufficient time to issue an enforcement order to the owner to correct the hazard, or to take other legal action, the chief engineer or council may take any appropriate action necessary for emergency protection of public safety, life or property. The type of action depends upon the state of progression of the deterioration, the physical layout of the dam, reservoir and inundation zone below the dam, and the resources available to the chief engineer or council at the time of the emergency.

(2) The chief engineer or council, upon determining that a dam or reservoir is dangerous and constitutes a substantial threat of failure may request the attorney general or a prosecuting attorney to take any legal steps necessary for the protection of public safety, life or property. Such action may be brought in any county where the defendant or defendant's principal place of business is located or where the dam or reservoir is located. Nothing in this section shall preclude the chief engineer or council from taking immediate action under 10 CSR 22-4.010(1) above with respect to any dam or reservoir he has classified as dangerous to public safety, life or property.

Auth: sections 236.400, 236.405, 236.420, 236.425 and 236.455, RSMo. Original rule filed June 14, 1984, effective January 1, 1985.

10 CSR 22-4.020 Enforcement Orders and Enforcement Procedures

PURPOSE: The purpose of this rule is to identify the procedure to be taken for the issuance of enforcement orders.

(1) Enforcement orders shall be prepared by the chief engineer or council in cases where a dam or reservoir contains serious defects that pose a threat to public safety, life or property. Enforcement orders shall be sent to a dam owner by certified mail or served personally.

(2) If an owner does not initiate corrective actions to his dam and reservoir within thirty (30) days of the issuance of an enforcement order by the chief engineer or council, the council may request the attorney general or a prosecuting attorney to apply to the circuit court having jurisdiction to enforce compliance. Nothing in this section shall preclude the chief engineer from taking immediate action under 10 CSR 22-4.010(1) above with respect to any dam or reservoir he has classified as dangerous to public safety, life or property.

Auth: sections 236.400, 236.405, 236.410, 236.415, 236.445 and 236.450, RSMo. Original rule filed June 14, 1984, effective January 1, 1985.

REVISED STATUTES OF MISSOURI
CHAPTER 236
DAMS, MILLS, AND ELECTRIC POWER

Dam and Reservoir Safety

236.400. Definitions. As used in sections 236.400 to 236.500, standards, rules, and regulations promulgated hereunder, unless the context otherwise requires the following words and terms mean:

(1) **"Agricultural dam"**, any dam constructed to impound water for use in irrigation, livestock watering, or commercial fish rearing and sale;

(2) **"Alterations", "repairs",** or either of them, such alterations or repairs as affect the safety of a dam or reservoir, or public safety, life or property.

(3) **"Chief engineer"**, the head of the dam and reservoir safety program of the department of natural resources or his representative;

(4) **"Construction permit"**, a written authorization issued by the council giving the owner the right to construct, alter, enlarge, reduce, repair, or remove a dam or reservoir or appurtenances thereto, with such conditions as are necessary to adequately protect the public safety, life, property, the dam or reservoir;

(5) **"Dam"**, any artificial or manmade barrier which does or may impound water, and which impoundment has or may have a surface area of fifteen or more acres of water at the water storage elevation, or which is thirty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or dam, if it is not across a streambed or watercourse, together with appurtenant works. Sections 236.400 to 236.500 shall not apply to any dam which is not or will not be in excess of thirty-five feet in height or to any dam or reservoir licensed and operated under the Federal Power Act.

(6) **"Dam and reservoir safety council"**, as designed by sections 236.400 to 236.500 and referred to as the "council" shall consist of seven members appointed by the governor according to the provisions of sections 236.400 to 236.500;

(7) **"Director"**, the director of the department of natural resources of the state of Missouri;

(8) **"Enlargement"**, any change in or addition to an existing dam or reservoir which raises the height of a dam, increases the watershed for a reservoir, or raises the water storage elevation of the water impounded by a dam or reservoir;

(9) **"Experienced professional engineer"**, an engineer registered in the state of Missouri and experienced in hydraulics, hydrology and civil engineering as applied to dam design and construction;

(10) **"Maintenance"**, the proper keeping of all aspects of a dam or reservoir and appurtenances thereto, that pertain to safety, in a state of repair and working order as necessary to comply with sections 236.400 to 236.500, any permit hereunder, and protect public safety, life and property;

(11) **"Natural physical changes"**, those changes not directly or indirectly caused by man which affect the safety of the dam or reservoir.

(12) **"Operation"**, the physical changes, natural or manmade that occur or are made to a dam or reservoir, or operation of the mechanisms or appurtenances of the dam or reservoir which affect or may affect public safety, life or property;

(13) **"Owner"**, a person who owns, controls, operates, maintains, manages, or proposes to construct a dam or reservoir including:

(a) The state and its departments, institutions, agencies, and political subdivisions, but not the United States government;

(b) A municipal or quasi-municipal corporation;

(c) A district;

(d) A public utility;

(e) A natural person, firm, partnership, association, corporation, political subdivision, or legal entity;

(f) The duly authorized agents, lessees, or trustees of any of the foregoing;

(g) Receivers or trustees appointed by any court for any of the foregoing;

(14) **"Permit"**, a construction, safety, or registration permit;

(15) **"Permit applicant"**, an owner who applies for a construction, safety or registration permit.

(16) **"Reduction"**, any decrease in the height of a dam, watershed size, or watershed storage elevation of the water impounded by a dam or reservoir;

(17) **"Registration permit"**, a permit issued for a period not to exceed five years by the council to the owner of a dam and reservoir in existence on September 28, 1979, or which becomes subject to 236.500 for such dams and reservoirs which are in a properly maintained condition or which have made and complied with recommendations for corrections of observed defects of the dam or reservoir and have been* examined and approved in accordance with sections 236.400 to 236.500 and standards, rules and regulations and guidelines issued pursuant to sections 236.400 to 236.500.

(18) **"Reservoir"**, any impoundment which results from a dam as defined in sections 236.400 to 236.500;

(19) **"Safety permit"**, a permit issued to the owner for a period of five years, or less if safety considerations so require, by the council indicating that the dam meets the requirements of sections 236.400 to 236.500 and the guidelines, standards, rules and regulations issued pursuant to sections 236.400 to 236.500, and containing such conditions as to operations, maintenance and repair as are necessary to adequately protect public safety, life and the dam or reservoir.

(20) **"Water"**, water, other liquid or tailings.

(21) **"Water storage elevation"**, that elevation of water surface at the principal spillway which could be obtained by the dam or reservoir were there no outflow and were the reservoir full of water;

(22) **"Watershed"**, the area usually expressed in acres of square miles, that contributes or may contribute surface water to a reservoir.

(L. 1979 H.B. 603 § 1)

*Words "have been" not in original rolls.

236.405. Employment of engineer and assistants-records.- -1. There is hereby created a dam and reservoir safety program in the department of natural resources. The council shall promulgate rules, regulations, guidelines, and standards relating to the determination of whether a dam or reservoir constitutes a danger to public safety, life or property to be effective upon approval by the director.

2. The director of the department of natural resources shall employ an experienced professional engineer as chief engineer and assistants to administer the activities of the dam and reservoir safety program.

3. The chief engineer shall be selected under the state merit system on the basis of professional experience directly related to the design and construction of dams and reservoirs.

4. The findings, opinions, and orders of the council and the chief engineer shall be kept as permanent public records in the offices of the department of natural resources.

(L 1979 H.B. 603 § 2)

236.410. Council established-members, terms, qualifications, officers-meetings-quorum-compensation.- -1. There is hereby created a "Dam and Reservoir Safety Council" whose domicile for the purposes of sections 236.400 to 236.500 shall be the department of natural resources of the state of Missouri, for the regulation of dam and reservoir safety. The council shall consist of seven members, no more than four of whom shall be members of the same political party, appointed by the governor with the advice and consent of the senate.

2. The members of the council shall have a background of academic training or professional experience directly related to the design of dams and reservoirs. At least two members of the council shall

be professional engineers registered in the state of Missouri, one of whom shall represent the general public; at least one member shall be an engineering geologist; at least one member, in addition to the professional engineer, shall be a representative of the general public, and two members shall be from industry, one of whom shall be an earthmoving contractor; and one member shall be the owner of a dam or reservoir. The members shall serve for a term of two years; except, of the first appointments three shall be appointed for one year. The governor shall fill any vacancy on the council and may remove any appointed member for cause. The council shall annually elect a chairman and vice-chairman from among its members. The council shall meet regularly but not less than quarterly. Special meetings and hearings may be called upon delivery of written notice to each member of the council signed by the director, the chief engineer, the council chairman, or four of the council members. Four members of the council shall constitute a quorum to transact the business of the council. The council shall decide all questions by a majority vote of those present and constituting a quorum. The members of this council shall not receive any compensation other than for actual travel and subsistence when acting officially as members of the council.

(L. 1979 H.B. 603 § 3)

236.415. Council's powers and duties-public hearings required-adoption of rules and regulations, procedure-suspension and reinstatement, procedure.- -1. The council considering recommendations of the chief engineer shall, subsequent to a public meeting, adopt, subject to the approval of the director, the general technological guidelines and the standards, guidelines, rules and regulations applicable to permits, the design, construction, maintenance, operation, alteration, repair, enlargement, reduction, removal or natural physical changes that may occur to a dam or reservoir. Violations of guidelines, standards, rules and regulations are violations of sections 236.400 to 236.500 permitting the revocation, suspensions, or refusal to issue any permit required by sections 236.400 to 236.500. No standards, guidelines, rules or regulations shall be adopted, or any amendment or repeal thereof shall be effective, except after a public hearing to be held after thirty days prior notice by advertisement or press release, and publication as required in chapter 536, RSMo, of the date, time and place of the hearing and opportunity given to the public to be heard.

2. At the hearing, opportunity to be heard by the council with respect to the subject thereof shall be afforded any interested person upon written request to the council, addressed to the chief engineer, received not later than seven days prior to the hearing and may be afforded to other persons if convenient. In addition, any interested person, whether or not heard, may submit, within seven days subsequent to the hearings, a written statement of his views. The council may solicit the views, in writing, of persons who may be affected by, or interested in, proposed rules and regulations, standards or guidelines. Any person heard or represented at any hearing or making written request for notice shall be given written notice of the action of the council with respect to the subject thereof.

3. The council upon hearing the recommendations of the chief engineer and reviewing the application for a construction or registration permit shall approve or deny the permit application. The council may delegate authority to approve or deny permit applications to the chief engineer, whose actions shall be subject to appeal to the council as provided in subsection 2 of section 236.425.

4. No standard, rule or regulation or guideline, or amendment or repeal thereof, adopted by the council shall be in force and effect until it has been approved in writing by the director and the requirements of chapter 536, RSMo, are satisfied. The affirmative vote of at least four members of the council shall be required for adoption. Any rule or portion of a rule promulgated pursuant to sections 236.400 to 236.500 may be suspended by the joint committee on administrative rules if after hearing thereon the committee finds that such rule or portion of the rule is beyond or contrary to the statutory authority of the agency which promulgated the rule, or is inconsistent with the legislative intent of the authorizing statute. The general assembly may reinstate such rule by concurrent resolution signed by the governor.

(L 1979 H.B. 603 § 4)

236.420. Inspection of dams and reservoirs, when-report on conditions.- -The council, with the advice and assistance of the chief engineer, shall carry out a state program of inspection of dams and reservoirs in accordance with regulations adopted by the council. All dams and reservoirs in this state shall be inspected on a periodic basis to determine if they constitute a threat to public safety, life or property. The chief engineer shall submit reports to the

director and the council concerning the condition of each dam or reservoir inspected, and the recommendations as to any alterations or repairs needed.
(L 1979 H.B. 603 § 5)

236.425. Chief engineer's duties-search warrants-council to hear certain appeals.- -1. The chief engineer shall administer the provisions of sections 236.400 to 236.500 by:

(1) Recommending general technological guidelines that pertain to the design, construction, maintenance, operation, use alteration, repair, enlargement, reduction, or natural physical changes of, or that may occur to, a dam or reservoir including their removal; except that, detailed technical specifications shall not be promulgated to regulate the design, construction, operation, maintenance, use, alteration, repair or removal of a dam or reservoir. Such guideline shall not be effective until adopted by the council and approved by the director at a public meeting, after notice requirements set forth in subsection 1 of section 236.415 herein have been satisfied;

(2) Making* recommendations concerning the issuing, continuing in effect, revoking, modifying suspending, or denying, under such conditions as prescribed by sections 236.400 to 236.500 and such rules as may be adopted to protect public safety, life, property, dams and reservoirs, construction permits for the construction, alteration, enlargement reduction, repair or removal of dams or appurtenances thereto, and safety and registration permits to insure continuing protection of public safety, life, property, dams and reservoirs, for all dams subject to the provisions of sections 236.400 to 236.500.

(3) Making such investigations, including hearings, as are proper to protect public safety, life and property from an unsafe dam or reservoir, and to determine whether any permits should be issued, continued, revoked, modified, suspended, or denied or whether any violations of sections 236.400 to 236.500, standards, or rules or regulations have occurred or are occurring;

(4) Entering, at any reasonable time, any private or public premises as necessary to make an investigation or inspection of a dam or reservoir, or records kept, pertaining thereto, and such inspection shall follow reasonable notice to the owner given prior to such investigation or inspection except in the case of an emergency threatening public safety, life or property, in which case such inspection or investigation may be made without prior notice. A suitably restricted search warrant, upon a showing of probable cause in writing and upon oath, shall be issued by any judge or magistrate having jurisdiction, to the chief engineer or his representative for the purpose of enabling him to make the inspection.

2. The council shall meet with or hear the appeal of a permit application and his representative upon request of the permit applicant if the chief engineer has rejected the application for a construction, safety, or registration permit.
(L 1979 H.B. 603 § 6)
*Words "To Make" appear in original rolls.

236.430. Employees, council to provide for.- -The council shall retain, employ, provide for and compensate within appropriations available therefore, such consultants, assistants, and other employees on a full-or part-time basis as may be necessary to carry out the provisions of sections 236.400 to 236.500 and prescribe the times at which they shall be appointed and their powers and duties.
(L 1979 H.B. 603 § 7)

236.435. Permits required, when, procedure to obtain-chief engineer to make recommendation-exemptions-plans to be filed.- -1. Prior to the commencement of the construction, alteration, enlargement, reduction or removal of a dam or reservoir, the owner shall apply to the council and upon satisfying the requirements of sections 236.400 to 236.500 and the rules, regulations and standards promulgated pursuant hereto, obtain a construction permit.

2. The application for a construction permit shall bear the seal and signature of an experienced professional engineer registered in Missouri or employed by a qualified engineering division of a state or federal agency regularly engaged in dam construction for soil and water conservation, or irrigation or relating to wildlife conservation and shall be accompanied by the design report and plans and specifications of the proposed design, alteration, enlargement, reduction, repair or removal of the dam or reservoir.

3. Any person constructing or owning a dam or reservoir, or living or owning property in an area affected, or whose safety may be affected by such dam or reservoir may consult with the chief engineer concerning such dam or reservoir.

4. The council upon hearing the recommendations

of the chief engineer shall approve or deny an application for a construction permit within forty-five days after its receipt or the completion of any hearings in connection with such application, whichever is later. The permit shall be issued upon the receipt of the application if, in the judgement of the council, requirements of sections 236.400 to 236.500 and all standards, rules and regulations hereunder are satisfied and the design will be adequate to protect the public safety, life and property.

5. The council upon hearing the recommendation of the chief engineer may reject the application if it decides that there is insufficient information to determine the safety of the proposed construction, alteration, enlargement, reduction or removal of the dam or reservoir would endanger public safety, life or property, or otherwise not comply with sections 236.400 to 236.500 and any rules, standards, guidelines and regulations adopted hereunder.

6. A landowner that now owns or proposes to construct an agricultural dam or reservoir, which will be used primarily for agricultural purposes, will be exempt from all provisions of sections 236.400 to 236.500. If the council, with the advice of the chief engineer, determines that the dam or reservoir is no longer used primarily for agricultural services, it shall become subject to the provisions of sections 236.400 to 236.500.

7. Dams or their construction, alterations, enlargements, reductions or removals designed by, and their construction, alteration, enlargement, reduction or repair or removal monitored by, a qualified engineer regularly engaged in dam construction for soil and water conservation or irrigation or relating to wildlife conservation are for the purposes of such construction or other listed actions exempt from the provisions of this section except that the plans for the dam shall be filed with the chief engineer prior to construction, or other listed action. Amended plans shall be filed at the completion of construction or other listed action if there have been significant deviations from the previously filed plans.

(L 1979 H.B. 603 § 9)

236.440. Owner to notify council, when-council to issue safety permit-registration of existing dams, when-violations.- -1. The owner shall notify the council upon completion of construction, alteration, enlargement, or reduction of the dam and reservoir. This notification shall bear the seal and signature of an experienced professional engineer and shall be accompanied by an application for a safety permit. The owner of any dam or reservoir subject to the provisions of sections 236.400 to 236.500 shall obtain a safety permit following completion of construction.

2. Upon receipt of complete and proper application for a safety permit, including notification of completion by the owner and certification by an experienced professional engineer that the new construction, alteration, enlargement or reduction has been completed in accordance with the provisions of the construction permit and sections 236.400 to 236.500, the council shall upon receipt of the application issue a safety permit. The council upon advice of the chief engineer may deny the application if it determines that violations of the construction permit or sections 236.400 to 236.500 exist. If revisions have been made which vary substantially from the provisions of the construction permit, it must be shown that the revisions do not endanger public safety, life or property. The safety permit for dams constructed pursuant to a construction permit issued under sections 236.400 to 236.500, may contain conditions the council upon advice of the chief engineer determines are necessary for the protection of public safety, life or property and a schedule and timetable for the dam and reservoir to achieve compliance with the construction permit and provisions of sections 236.400 to 236.500, standards, rules and regulations promulgated hereunder, but such conditions shall not be more stringent or restrictive than those contained in the construction permit.

3. Owners of dams and reservoirs in existence on September 28, 1979, shall obtain registration permits for dams of fifty to seventy feet in height within four years, and for dams up to fifty feet in height within six years of September 28, 1979, or as otherwise required by the provisions of sections 236.400 to 236.500 and rules and regulations adopted hereunder. A registration permit shall be issued by the council upon the advice of the chief engineer for dams and reservoirs only after it is determined that the dam meets the standards of sections 236.400 to 236.500 and rules and regulations hereunder, and any recommendations made by the inspecting engineer pursuant thereto.

4. Upon complete and prior application for a registration permit, on forms provided by the department of natural resources, by the owner of a dam in existence upon September 28, 1979, including a cer-

tification by an experienced professional engineer or an engineering division of state or federal agency regularly engaged in dam construction for soil or water conservation, irrigation, or relating to wildlife conservation, that the dam has been inspected in accordance with sections 236.400 to 236.500, standards, rules and regulations and guidelines promulgated hereunder, and that the owner has complied with the inspecting engineer's or agency's recommendations necessary to correct observed defects of the dam or reservoir, the council shall, upon receipt of the application, issue a registration permit. The council upon hearing the recommendations of the chief engineer may deny the application if it determines that the owner has not complied with the inspecting engineer's or agency's recommendations.

5. For dams for which construction was completed prior to the effective date of the construction permit requirements hereunder, the registration permit may contain conditions the council upon hearing recommendations of the chief engineer determines to be necessary to bring the dam and reservoir into compliance with sections 236.400 to 236.500 and standards, rules and regulations promulgated hereunder.

6. If a dam or reservoir has been removed by the owner, the council shall issue a final approval upon notification by the owner and receipt of certification by an experienced professional engineer that the removal has been carried out in accordance with the provisions of the construction permit issued for such removal. Failure to obtain final approval shall be a violation of sections 236.400 to 236.500.

7. The council shall issue safety permits for dams or their construction, alterations, enlargements reductions or removals designed by, and their construction or other listed actions monitored by, a state or federal agency engaged in dam construction for soil and water conservation, irrigation or relating to wildlife conservation provided the owners obtain from such agency and file with the chief engineer a statement upon completion of the construction or other listed actions and at not greater than five year intervals, and with every application for renewal of a safety permit, that the dam conforms to the plans on file with the chief engineer and is in a safe, properly maintained condition.

8. The owner shall apply for renewal of a safety or registration permit not less than sixty days prior to expiration of the previously issued permit. The chief engineer shall determine if the dam and reservoir are essentially as described in the latest permit issued for that dam and reservoir, whether they satisfy the requirements of sections 236.400 to 236.500 and any rules, regulations, standards and guidelines adopted pursuant to sections 236.400 to 236.500 and whether any inspections conducted in connection with the permit renewal reveals any defect in the dam or reservoir which would threaten public safety, life or property. Unless the chief engineer determines that the dam and reservoir are not properly maintained, do not satisfy the requirements of the permit, act* of rules, regulations, standards and guidelines promulgated hereunder, or that defects revealed by the inspection are not corrected, the council upon hearing the recommendations of the chief engineer shall issue or renew the safety or registration permit upon forty-five days of the receipt of a complete and proper application. The council may require the owner to furnish a certification, as a part of an application to renew a permit hereunder, by an experienced professional engineer or a qualified engineering division of a state or federal agency regularly engaged in dam construction for water conservation, irrigation or relating to wildlife conservation that the dam is in a properly maintained condition and that any recommendation for correction of defects which violate sections 236.400 to 236.500, guidelines, rules, regulations and standards hereunder or which threaten public safety, life or property have been complied with and that the engineer detected no other such defects which have not been corrected.

9. If a barrier or water impoundment becomes a dam or reservoir through alteration or enlargement as defined herein, it shall be subject to the provisions of sections 236.400 to 236.500.

10. Failure to obtain and comply with a permit as required in this section is a violation of sections 236.400 to 236.500.

(L. 1979 H.B. 603 § 9)

* Word "act" apparently refers to "this act," now 236.400 to 236.500.

236.445. Permit may be suspended-alteration or removal may be required-violation.- -1. If it is found that a dam or reservoir presents a threat to public safety, life or property, or that the safety of the dam or reservoir is threatened, the permit for

the dam or reservoir shall be suspended and shall be reinstated only when the owner at his expense has completed the necessary alteration or has established such operational procedures as the council upon hearing the recommendations of the chief engineer deems necessary for the protection of the public safety, life, property, the dam or reservoir. If necessary for such protection, the council may require the owner at his expense to remove the dam or reservoir, or if the owner refuses or neglects to act, the state may alter or remove the dam or reservoir, and the chief engineer may recover the costs of such action as provided in section 236.450.

2. If the owner refuses to alter or remove a dam or reservoir as directed when found to be a threat as set forth in sections 236.400 to 236.500, he shall be in violation of sections 236.400 to 236.500 and the permit requirements hereunder and such action shall subject the owner to the enforcement provisions contained herein and revocation of the permit.

(L. 1979 H.B. 603 § 10)

236.450. Removal or repair of abandoned dam-recovery of expenses.- -An existing dam or reservoir which the chief engineer determines to be abandoned and considered to be a threat to public safety, life, or property may be altered, repaired, or removed upon such determination at the expense of the state of Missouri, and the chief engineer may request either the attorney general or a prosecuting attorney to bring an action in the name of the people of the sate of Missouri to recover such expenses from the owner through appropriate legal processes. Such action may be brought in any county where the defendant or defendant's principal place of business is located or where the dam or reservoir is located.

(L. 1979 H.B. 603 § 11)

236.455. Emergency action authorized.- -If it is determined at any time that the condition of a dam or reservoir is an imminent and substantial threat, and so dangerous to public safety, life or property as not to permit time for issuance of an enforcement order to correct the hazard, the chief engineer may take any appropriate action not prohibited by the constitution or laws of the state he deems necessary for emergency protection of public safety, life or property and may request the attorney general or a prosecuting attorney to take any legal steps necessary to accomplish such action and to recover the cost of such measures from the owner by appropriate legal action.

(L. 1979 H.B. 603 § 12)

236.460. Transfer of ownership, notice required.- -The owner shall notify the chief engineer upon the sale or other transfer or interest in a dam or reservoir, either existing or under construction, alteration or removal. The construction, safety or registration permit shall be transferred to the successive owner upon receipt of this notification and upon determination that such transfer will not endanger public safety, life, property, the dam or reservoir.

(L. 1979 H.B. 603 § 13)

236.465. Industrial water retention structures subject to provisions of sections 236.400 to 236.500-inspection-changes.- -Irrespective of any other provisions of sections 236.400 to 236.500, the following provisions shall apply to the construction, alteration or enlargement of tailing, slime and settling ponds and to other similar industrial water retention structures included within the definitions of dam or reservoir in section 236.400:

(1) Applications for construction, safety or registration permits shall be submitted as provided in section 236.435 and section 236.440 except that design plans and specifications which outline any anticipated enlargement of the industrial water retention structure shall be included;

(2) It shall not be necessary to reapply for a permit each time the structure is enlarged if the enlargement plans have been submitted in and approved with the original application, and the provision of subdivision (3) of this section have been satisfied.

(3) Upon notification of the chief engineer, bearing the seal and signature of an experienced professional engineer, that the initial phase of construction has been completed in accordance with the provisions of the construction permit and sections 236.400 to 236.500, or if a registration permit has been issued as provided in subdivision (1) of this section, and before any enlargement is begun, and if no violation of sections 236.400 to 236.500 can be shown, a safety permit or a registration permit with special provisions that authorize the planned enlargement to the initially constructed structure shall be issued, on application, if enlargement plans were included and approved in the original application;

(4) It is not necessary to retain continuously a professional engineer after the initial stage of construction;

(5) The dam shall be inspected by an experienced professional engineer registered in the state of Missouri as required to renew the safety permit or registration permit at five-year intervals unless safety or the public, life and property require a shorter period of time;

(6) The chief engineer shall make inspections of these structures as necessary to insure adequate protection for public safety, life and property;

(7) Where it is shown that a tailings, slime and settling pond, or other similar water retention structure is subject to inspection for safety, using standards at least as stringent as those required under sections 236.400 to 236.500, by a federal or state agency and the owner notifies the council that the structure is subject to such inspection, such structures shall be exempt from the provisions of sections 236.400 to 236.500.

(L. 1979 H.B. 603 § 14)

236.470. Conduct of hearings subpoenas-approval of final orders.- -1. At any public hearing all testimony taken before the council, or a hearing officer appointed by the council chairman, shall be under oath and recorded stenographically. The transcript so recorded shall be made available to any person upon payment of the usual charge therefore;

2. In any such hearing, any member of the council or the hearing officer shall issue in the name of the council notice of hearing and subpoenas. Subpoenas shall be issued and enforced as provided in section 536.077, RSMo. The rules of discovery that apply in any civil case apply to hearings held by the council.

3. All hearings to approve, amend or repeal guidelines, standards or rules and regulations shall be held before at least four members of the council.

4. All other hearings may be held before one council member designated by the council chairman or a hearing officer who shall be a member of the Missouri bar and appointed by the council chairman. The hearing officer or council member shall preside at the hearing and hear all evidence and rule on the admissibility of evidence. The hearing officer or council member shall make recommended findings of fact and may make recommended conclusions of law to the council.

5. All final orders or determinations or other final actions by the council shall be approved in writing by at least four members of the council. Any council member approving in writing any final order or* determination or other final action, who did not attend the hearing, shall do so only after reviewing all exhibits and reading the entire transcript.

(L. 1979 H.B. 603 § 15)

* Word "of" appears in original rolls.

236.475. Immunity of officers.- -In the absence of willful and wanton misconduct, no action shall be brought against the council, the chief engineer or his agents, or department employees or private individuals employed as consultants by the department for the recovery of damages caused by the partial or total failure of any dam or reservoir or through the use or operation of any dam or reservoir upon the ground that such person is liable for virtue of any of the following:

(1) The approval of a dam or reservoir or permits therefore;

(2) The issuance or enforcement of orders relating to maintenance, operation, or repair of a dam or reservoir;

(3) Control and regulation of a dam or reservoir;

(4) Measures taken to protect against failure during an emergency.

(L. 1979 H.B. 603 § 16)

236.480. Judicial review of actions-administrative review required-interpretation of administrative actions.- -1. All final decisions, orders, actions or determinations made pursuant to the provisions of sections 236.400 to 236.500 are subject to judicial review pursuant to the provisions of chapter 536, RSMo. No judicial review shall be available, however, until all administrative remedies are exhausted.

2. In any suit filed pursuant to section 236.400 to 236.500, RSMo, concerning the validity of the standards, rules, guidelines and regulations promulgated hereunder, the court shall review the record made pursuant to their adoption to determine the validity and reasonableness of such standards, rules, guidelines and regulations and may hear such additional evidence as it deems necessary.

(L. 1979 H.B. 603 § 17)

236.485. Water rights preserved.- -The provisions of sections 236.400 to 236.500 do not grant or diminish any right to that water entering, discharged from or impounded by a dam or contained in a reservoir.

(L. 1979 H.B. 603 § 18)

236.490. Enforcement of act.- -All duly constituted officers of the law of this state or any political subdivision thereof shall aid in the enforcement of the provision of sections 236.400 to 236.500.

(L. 1979 H.B. 603 § 19)

236.495. Legal actions for enforcement available, procedure.- -1. In carrying out the provisions of sections 236.400 to 236.500 and to the extent not inconsistent with chapter 491, RSMo, the chief engineer or council may subpoena witnesses and compel their attendance, and may also require the submission of books, papers, documents or other pertinent data in any hearing or enforcement proceedings hereunder or in any case wherein a violation of this chapter is alleged. Upon failure or refusal to comply with such order or upon failure to honor a subpoena, as herein provided, the council may request the attorney general or a prosecuting attorney to apply to the circuit court having jurisdiction to enforce compliance.

2. The council may request the attorney general or a prosecuting attorney, in the name of the state, to institute a suit for injunctive relief to stop or prevent violations of the provisions of sections 236.400 to 236.500,permits, standards, orders and rules and regulations promulgated hereunder, which shall be violations of sections 236.400 to 236.500, or to restrain any violation thereof, or after written notification of violation by the council, and a reasonable time to correct such violation, for the assessment of a penalty of up to one thousand dollars per day, for each day or part thereof the violation continues to occur after such notice. Such action may be brought in any county where the defendant's principal place of business is located, where the dam or reservoir is located, or the violation does or may occur.

(L. 1979 H.B. 603 § 20)

236.500. Penalties.- -1. Any person who willfully violates any of the provisions of section 236.400 to 236.500 is guilty of a misdemeanor and, upon conviction, shall be punished by a fine of not less than five hundred dollars nor more than ten thousand dollars, or by confinement in the county jail for a term of not less than thirty days nor more than one year, or by both such fine and confinement.

2. In the event of a continuing violation, each day that the violation continues shall constitute a separate and distinct offense.

3. Any person who willfully obstructs, hinders or prevents the council, the chief engineer or his agents or employees from performing the duties imposed by sections 236.400 to 236.500 and rules and regulations promulgated hereunder or who willfully resists the council, the chief engineer, or his agents in the performance of the duties imposed on them by sections 236.400 to 236.500 and rules and regulations promulgated hereunder is guilty of a misdemeanor and, upon conviction, shall be punished as provided in subsection 1 of this section.

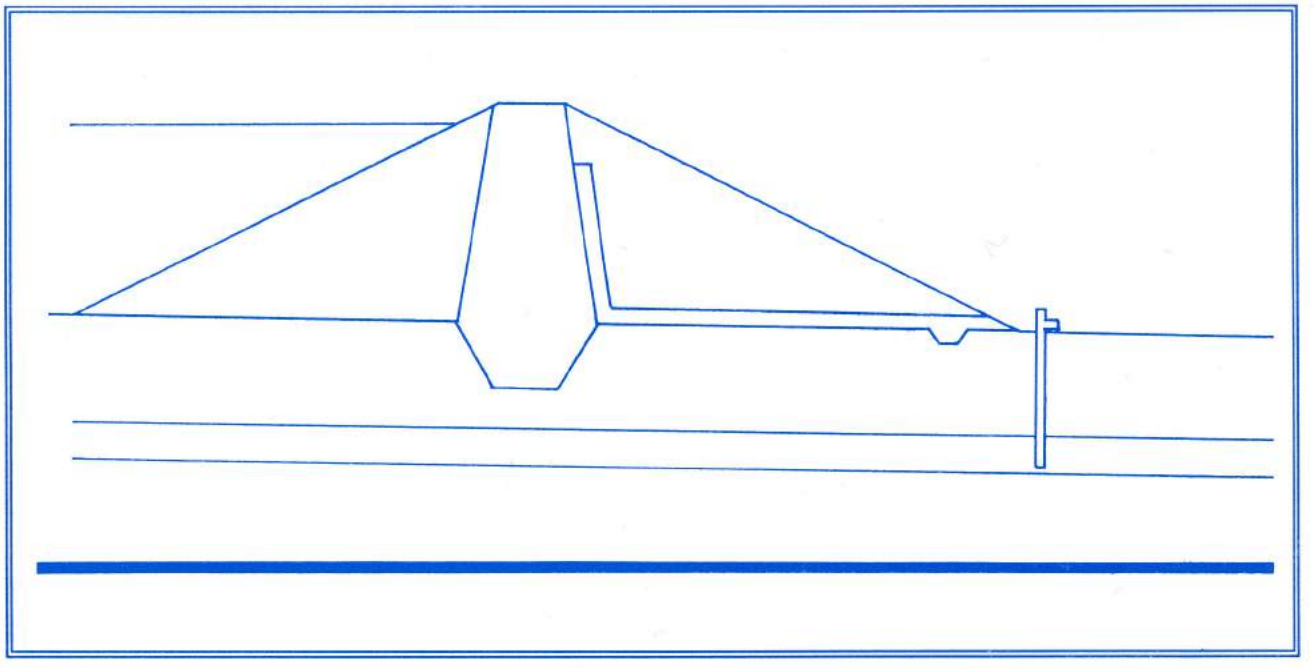
4. Any owner who willfully engages in the construction, repair, alteration or removal of any dam or reservoir without a construction permit or in violation of a construction permit or willfully violates the requirements of or for a safety or registration permit is guilty of a misdemeanor and, upon conviction, shall be punished as provided in subsection 1 of this section.

(L. 1979 H.B. 603 § 21)

ENGINEERING ANALYSIS

OF

DAMS



BY
BRIAN J. SWENTY

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY
DAM AND RESERVOIR SAFETY PROGRAM

AUGUST 1989

FOREWORD

The first state legislation aimed at regulating dams was passed in 1889 and was called the Dams, Mills, and Electric Power Law. That law was concerned only with damages caused by construction and lake formation. It did not address the engineering aspects of design or safety of dams.

During the period 1977-81, the Corps of Engineers conducted a nationwide inventory and inspection of dams. The results indicated that Missouri ranked fourth in the United States in total number of dams and first in the total number of unsafe dams. Of 613 dams inspected, approximately 75% were considered unsafe. The final report submitted to Congress by the Corps cited Missouri as having inadequate legislation, regulatory procedures, technical staff, and funding.

In September 1979, the Governor signed House Bill 603 into law. The bill became sections 236.400 through 236.500 RSMo and is known as the dam safety law. It authorized the creation of a Dam and Reservoir Safety Council appointed by the Governor and a staff within the Department of Natural Resources to implement the law. Regulations were approved in August 1981 and Missouri began the process of upgrading unsafe dams.

Only dams 35 feet or greater in height are regulated by the Natural Resources' Division of Geology and Land Survey, dam and reservoir safety program. Exemptions to the dam safety law include:

- dams owned and operated by the federal government
- dams licensed by the Federal Energy Regulatory Commission
- dams impounding water used primarily for agricultural purposes

During the past eight years, numerous owners have had their dams inspected in accordance with the law. As these dams were evaluated and analyzed, it became clear that an engineering analysis manual was needed to provide engineers with a technical reference to perform their computations. An abundance of engineering text books, design manuals, and construction guidelines have been written which pertain to the design of dams, but there are few booklets dedicated to the subject of dam safety analysis.

Dam Safety is a complex issue. To determine whether a dam is safe requires a knowledge of hydrology, hydraulic engineering, geotechnical engineering, geology, seismology, surveying, and structural analysis. This manual is intended to provide engineers with a description of analytical techniques that can be used to evaluate the safety of dams.

Two of the goals of the dam safety law are to ensure that new dam construction meets minimum safety standards and defects at older unsafe dams are eliminated. It is my hope that this manual will provide the technical assistance necessary to accomplish these goals.

G. Tracy Mehan III
Director, Missouri Department of Natural Resources

ENGINEERING ANALYSIS OF DAMS

By Brian J. Swenty, Ph.D., P.E.
Chief Engineer
Dam and Reservoir Safety Program

Department of Natural Resources
Division of Geology and Land Survey
P.O. Box 250, Rolla, MO 65401

ACKNOWLEDGEMENTS

This booklet was prepared under the direction of Dr. James H. Williams, Director of the Division of Geology and Land Survey, Missouri Department of Natural Resources, and the Missouri Dam and Reservoir Safety Council. The council is a non-paid policy making body appointed by the Governor with the consent of the Senate. Members of the council include Dr. John D. Rockaway, Jr., chairman; Charles I. Mansur, vice-chairman; Carol Eichling; Terry Perkins; Dean E. Freeman; Donald W. Laraway; and Stanfred L. Hilty.

This booklet was printed with funding by a grant from the Association of State Dam Safety Officials (ASDSO) and the Federal Emergency Management Agency (FEMA). The support of these two organizations and their interest in dam safety is acknowledged and deeply appreciated.

Within the Missouri Department of Natural Resources, Division of Geology and Land Survey, there were several individuals who made significant contributions to the manual's development. James L. Alexander, Russell C. Adams, Robert A. Clay, and Ralph P. Hess of the Dam and Reservoir Safety Program staff reviewed the entire manuscript and made many helpful suggestions. Mr. Alexander and Mr. Clay also assisted in the preparation of many of the illustrations. Dr. Robert H. Hansman, Editor for the Division of Geology and Land Survey, edited the booklet and was especially helpful in developing and organizing the list of references. Dr. James H. Williams, State Geologist and Division Director, reviewed the chapter on geology. Robert E. Myers, State Land Surveyor, reviewed several chapters including the chapter on engineering surveys. Special thanks to Marge Paulsmeyer, Dam and Reservoir Safety Program Secretary, who assisted in typing the booklet and making necessary revisions.

The booklet was reviewed by several professional engineers in private practice, in government, and at the University of Missouri-Rolla. Among those reviewing all or parts of the booklet include Hugh A. Curry, Jerry Edwards, William F. Lueckenhoff, Albert B. Becker, Richard H. Frueh, Dr. Jerome A. Westphal, Dr. Richard W. Stephenson, J. Larry Hubbard, and Gene C. Bowen. Numerous comments were received and several changes and additions were made to the final draft.

Many state and federal agencies provided information on the subjects covered in this booklet. The use of references and other information is appreciated.

TABLE OF CONTENTS

		Page
LIST OF ILLUSTRATIONS		v
LIST OF TABLES		v
I	INTRODUCTION	1
II	PERMITS	2
	A. Construction Permits	2
	B. Safety Permits	2
	C. Registration Permits	2
III	HYDROLOGIC CONSIDERATIONS	4
	A. Downstream Environmental Zone	4
	B. Spillway Design Flood Precipitation Values	6
	C. Watershed Data	7
	D. Initial Abstraction and Infiltration	9
	E. Unit Hydrographs	9
	F. Time of Concentration	14
	G. Rainfall Hyetographs	16
	H. Inflow Hydrograph Computation	16
IV	HYDRAULIC CONSIDERATIONS	19
	A. Closed Conduit Hydraulics	19
	1. Design Considerations for Conduit Spillways	19
	2. Shaft Spillways	19
	3. Culvert Spillways	23
	4. Flow under Bridges	23
	B. Open Channel Hydraulics	23
	1. Water Surface Profiles	25
	2. Critical Flow Computations	28
	C. Reservoir Routing	29
V	GEOTECHNICAL CONSIDERATIONS	32
	A. Soil Classification	33
	B. Foundation Cutoffs	33
	C. Foundation and Embankment Drainage	33
	1. Chimney Drains	35
	2. Blanket Drains	35
	3. Trench Drains	35
	4. Relief Wells	35
	D. Structural Stability	36
	1. End of Construction Case	38
	2. Steady Seepage Cases	38
	3. Sudden Drawdown	39
	4. Earthquake	39
	E. Protection of Upstream Slopes	40

Page

F. Instrumentation 40
1. Seepage and Leakage 40
2. Embankment Movements 40
3. Piezometric Pressures 41
VI ANALYSIS OF CONCRETE GRAVITY STRUCTURES 42
A. Forces Acting on the Dam 42
1. External Water Pressure 43
2. Internal Water Pressure 44
3. Silt Pressure 44
4. Ice Pressure 44
5. Earthquake 44
a. Horizontal Earthquake Force 45
b. Vertical Earthquake Force 46
6. Weight of Structure 46
B. Requirements for Stability 46
1. Overturning 46
2. Sliding 47
3. Structural Integrity 47
VII GEOLOGICAL CONSIDERATIONS 48
A. Core Trench Requirements 48
B. Spillways 49
VIII ENGINEERING SURVEYS 50
A. Site Selection Survey 50
B. Construction Surveying 51
C. Analyzing Existing Dams 51
REFERENCES 53
APPENDICES
APPENDIX A: PERMIT FORMS 55
APPENDIX B: INVENTORY FORMS 63
APPENDIX C: RAINFALL DATA FOR MISSOURI 67

LIST OF ILLUSTRATIONS

Figures Page

3.1 Topographic Map of Downstream Environmental Zone 5
3.2 Method of Computing PMP values for Drainage Areas Greater than 10 Square Miles 6
3.3 Topographic Map of Drainage Area 7
3.4 Soil Map of Drainage Area 8
3.5 SCS Dimensionless Unit Hydrograph 13
3.6 Gray's (1961) Method of Computing Channel Slope 14
4.1 Profile of a Drop Inlet Spillway 20
4.2 Combined Spillway Rating Curve for a Conduit Spillway 21
4.3 Conduit Spillway Calculation Form 22
4.4 Flow Through a Rectangular Orifice 23
4.5 Plan View of an Earth Dam and Spillways 25
4.6 Energy in Gradually Varied Open Channel Flow 26
4.7 Storage versus Outflow Curve for a Reservoir 30
4.8 $S + O\Delta t/2$ versus Outflow Curve for a Reservoir 31
5.1 Types of Dams in Missouri 32
5.2 Methods of Constructing Tailings Dams 33
5.3 Unified Soil Classification Chart (ASTM-2487) 34
5.4 Types of Drains 35
5.5 Circular Failure Surface in an Earthfill Dam 36
5.6 Free Body Diagram - Simplified Bishop Method 37
5.7 Phreatic Surface in an Earthfill Dam 39
6.1 Forces Acting on a Concrete Gravity Dam (From Design of Small Dams) 43
6.2 Water Pressure on an Overflow Concrete Dam (From Design of Small Dams) 44
6.3 Coefficient for Pressure Distribution for Constant Sloping Surfaces (From Design of Small Dams) 45
6.4 Foundation Base Pressures for a Concrete Gravity Dam (From Design of Small Dams) 46

LIST OF TABLES

Tables Page

3.1 Runoff Curve Numbers - Urban Areas 10
3.2 Runoff Curve Numbers - Agricultural Lands[1] 11
3.3 Runoff Curve Numbers - Noncultivated Agricultural Lands 12
3.4 Average Time Distribution of Heavy Rainfall at a Point 17
3.5 Procedure for Computing an Inflow Hydrograph 18
4.1 Geometric Elements of Trapezoidal Channels 24
4.2 Standard Step Method of Computation 27

CHAPTER I

INTRODUCTION

The purpose of this booklet is to provide engineers with information regarding the analysis of dams in Missouri. This booklet does not represent and should not be considered a comprehensive step-by-step set of requirements for dam design and analysis. It should be used simply as a technical reference. No discussions were included regarding the preparation of plans and specifications for new dams. Other agencies, such as the Soil Conservation Service, the U. S. Army Corps of Engineers, and the Bureau of Reclamation, have publications which deal with this topic.

There are many acceptable methods that can be used to perform an engineering analysis of a dam and spillway. Suggested standards are listed in this booklet along with recommended methods and references. When a permit application is submitted to the Dam and Reservoir Safety Program, the engineering computations are reviewed by the Chief Engineer and his staff on a case-by-case basis. Engineers may use methods of analysis and design which differ from those presented in this manual. Latitude is provided to engineers who use other methods which produce a product that meets the minimum safety criteria in the regulations and the dam safety law.

A typical analysis includes all or part of the following aspects of engineering:

- Hydrological
- Hydraulic
- Geotechnical
- Structural Stability
- Seismic
- Geological

In this manual the word "dam" refers to any artificial or manmade barrier which is 35 feet or more in height measured either from the natural bed of the stream or watercourse or lowest point on the toe of the dam (whichever is lower) up to the crest elevation, together with appertenant works. Dams less than 35 feet in height are not regulated by the Dam and Reservoir Safety Program.

The objective of the Missouri Department of Natural Resources, Dam and Reservoir Safety Program is to insure that dams in Missouri are safely constructed, operated, and maintained. The Code of State Regulations contain minimum safety criteria for both new and existing dams. New dams are those constructed after August 13, 1981.

There are several differences between the criteria for new and existing dams. For example, engineers do not have to show that existing dams meet the stability criteria unless significant modifications are made to the height, slope, or water storage elevation. The seismic criteria apply only to new dams. For a complete description of the applicable criteria, see 10 CSR 22-3.020.

Geological considerations are very important in the analysis and design of new dams. A short discussion of geology and its relationship to dams is included in this booklet. More detailed information, such as geological maps, bore logs, and publications on Missouri geology, can be obtained from the Department of Natural Resources, Division of Geology and Land Survey.

New construction and the analysis of existing dams require field surveys of the embankment and spillways. A chapter on engineering surveying has been provided in this manual. Under Missouri law, engineering surveys can be performed by a registered professional engineer; however, boundary and property surveys must be performed by a registered land surveyor.

The appendices contain copies of permit applications and certification forms for engineers. For more information, contact:

Chief Engineer
Dam and Reservoir Safety Program
Department of Natural Resources
P.O. Box 250
Rolla, Missouri 65401
Phone (314) 364-1752

CHAPTER II

PERMITS

The owner of a proposed new dam 35 feet or more in height is required to obtain a construction permit to build the dam and a safety permit to operate the dam and reservoir. Owners of existing dams 35 feet or more in height are required to obtain registration permits in accordance with the schedule in 10 CSR 22-2.020(2). Significant modifications to existing dams also require a construction permit. Significant modifications are defined in 10 CSR 22-1.020(50). Exemptions from these permit requirements have been provided in the dam safety law for the federal government and owners of agricultural dams which were constructed in accordance with 10 CSR 22-2.010(3).

A. Construction Permits

In order to show that a dam will meet the minimum safety criteria in the code of state regulations, an engineering report must be submitted with the permit application, plans, and specifications. In most cases, hydrologic, hydraulic, geotechnical, and structural computations must be performed. Sufficient detail must be included in the report for the analysis to be verified. The staff of the Dam and Reservoir Safety Program does not perform a comprehensive check of the engineer's computations. Instead, data is taken from the engineers report and an independent analysis is performed to insure that the minimum safety standards are met. If a discrepancy is found between the results of the staff analysis and the engineer's report, the engineer's computations are examined in more detail to resolve the problem.

When a construction permit is issued to build or modify a dam, the owner is required to notify the Chief Engineer when construction begins. An engineer from the Dam and Reservoir Safety Program normally inspects new dam sites during three key activities; the construction of the core trench, construction of internal drains, and installation of pipes through the embankment. It is important for the owner to maintain communication with his engineer, the contractor, and the Dam and Reservoir Safety Program staff throughout construction. Inspections during critical construction activities provide information needed to prepare as-built drawings and safety permit applications following construction.

Construction permits are normally issued for a period of one year to start construction and one additional year to complete construction.

B. Safety Permits

A safety permit is basically an operating permit for dams that were constructed after August 13, 1981. A copy of the permit application and the checklist used to review the applications are included in Appendix A. The owner's engineer must submit a certification that the dam was built substantially in accordance with the approved plans and specifications. Safety permit applications must include as-built drawings if significant modifications were made to the original design drawings during construction. Appropriate engineering computations should accompany the application if as-built drawings are submitted.

Safety permits are usually issued for a period of 5 years. During this time, the owner must maintain the dam in accordance with an approved maintenance and operation plan. The Missouri Department of Natural Resources (1986) published the booklet, Maintenance, Inspection, and Operation of Dams in Missouri which is a good reference for developing a maintenance and operation plan.

Sixty days prior to the expiration of the safety permit, the owner should contact the staff of the Dam and Reservoir Safety Program and request a permit renewal inspection. The permit renewal inspection includes visual observations of the dam, a review of maintenance records, and a site visit to the area downstream of the dam. Assuming no observable defects are found and the downstream hazard zone is unchanged, the permit is renewed for an additional five year period. If changes in the downstream hazard zone require spillway or dam crest modifications, a construction permit must be obtained to perform the work.

Safety permits for tailings dams constructed after August 13,1981 include provisions for phased, stepped, or continuous construction. They must be renewed at five year intervals or whenever major changes are made to the plans and specifications on file with the Dam and Reservoir Safety Program. Safety permits are required for tailings dams after closure of the mining and milling operation unless the dams meet the retaining/retarding structure exemption criteria listed in 10 CSR 22-2.010(7).

C. Registration Permits

There are approximately 640 dams in Missouri that are regulated by the Dam and Reservoir Safety Council. Over 95% of these dams were constructed prior to August 13, 1981. These older dams must be operated under the provisions of a registration permit. Like safety permits, registration permits are operating permits for dams that have been shown to meet the minimum safety criteria in the dam safety law.

Before a registration permit can be issued, the dam must be inspected and analyzed to show that it meets the

minimum safety standards in the Rules and Regulations of the Dam and Reservoir Safety Council. Dams must have sufficient spillway capacity to pass the design flood without overtopping and all observable defects must be corrected or monitored. Observable defects are described in 10 CSR 22-3.030(1)(A)1. Stability calculations are not required unless significant modifications are made to the height of the dam, the slopes, or the water storage elevation. Hydrologic and hydraulic calculations should be included in the inspection report or in a separate engineering report. If the dam must be modified to correct observable defects, a construction permit may be required depending on the extent of the modifications.

In addition to the spillway calculations, two certifications, a statement concerning the stability of the dam, and a maintenance and operation plan must be submitted prior to issuance of the first registration permit. A blank registration permit application, a review checklist, and a standard certification form are included in Appendix A. The booklet, Maintenance, Inspection, and Operation of Dams in Missouri is a good reference for developing a maintenance and operation plan.

Sixty days prior to the expiration of the registration permit, the owner should contact the staff of the Dam and Reservoir Safety Program and request a permit renewal inspection. Assuming no observable defects are found and the downstream hazard zone is unchanged, the permit is renewed for an additional five year period. If changes in the downstream hazard zone require spillway or dam crest modifications, a construction permit must be obtained to perform the work.

Registration permits for tailings dams in existance before August 13,1981 can include provisions for phased, stepped, or continuous construction. They must be renewed at five year intervals or whenever major changes are made to the plans and specifications on file with the Dam and Reservoir Safety Program. Registration permits are required for tailings dams after closure of the mining and milling operation unless the dams meet the retaining/retarding structure exemption criteria in 10 CSR 22-2.010(7).

CHAPTER III

HYDROLOGIC CONSIDERATIONS

The analysis of an existing dam and the design of a new dam includes the hydrological analysis of the watershed and a hydraulic analysis of the spillways. Generally the hydrologic computations conclude with the computation of the inflow hydrograph to the reservoir. Parameters used in the hydrologic analysis include the watershed area, unit hydrograph parameters, lag time, total rainfall, rainfall distribution (hyetograph), infiltration characteristics of the watershed, and initial abstraction. In the case of kinematic and dynamic wave modeling and breach analysis, channel routing will also be included in the definition of hydrological computations.

Hydraulic computations involve reservoir routing and rating open channel and closed conduit spillways. This differentiation, although not universal in the field of civil engineering, will nonetheless be used throughout this booklet.

The flood used for design to prevent the failure of the dam is termed the "spillway design flood" (SDF). As defined in 10 CSR 22-1.020 (52), the spillway design flood is the specified flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in an area and for which the dam and reservoir are designed. Determination of the spillway design flood is based on a rational consideration of the chances of the simultaneous occurrence of several elements or conditions which contribute to the flood. A major aspect of the spillway design flood computation is the determination of the runoff that would result from an occurrence of a percentage of the probable maximum precipitation. This hydrometeorological approach is necessary because contemporaneous site-specific meteorologic and streamflow data do not exist for most small watersheds in Missouri. If actual streamflow records of considerable length are available for the general region in which the dam is located, this data should be used in the determination of the SDF. This chapter, however, is primarily concerned with synthetic hydrology and techniques used to simulate the rainfall runoff process on a watershed.

A. Downstream Environment Zone

The downstream environment zone is defined as an area downstream from a dam that would be affected by inundation in the event the dam failed with the reservoir at the emergency spillway crest elevation or the dam crest elevation, in the absence of an emergency spillway. This is typically termed a "sunny-day" failure. Inundation is defined as a minimum of 2 feet of water over the first floor elevation of affected structures. Three environmental classes are defined in 10 CSR 22-2.040(1). Class I is high hazard, Class II is significant hazard, and Class III is low hazard. If a sufficient number of homes are located downstream of a dam, a breach analysis is required to justify a Class II or Class III downstream environmental zone designation. It may be advantageous to the engineer performing the computations to meet with the staff of the Dam and Reservoir Safety Program before a breach analysis is conducted. In many cases, a downstream enviornmental zone classification can be agreed upon without computations.

A dam breach analysis involves a specific analytical approach rather than the use of procedures described for spillway design. There are many models available for performing a breach analysis. The two most widely used models in Missouri are DAMBRK and HEC-1. Recently, private engineers have modified the input structure to the National Weather Service's DAMBRK program, originally developed by Fread (1984). These changes are an attempt to make the model more user friendly and add attractive graphics capabilities. The DAMBRK model considers rapidly varying, unsteady flow in channels and includes off channel storage. It provides an engineer with the most accurate method of simulating a dam failure and routing the flood wave downstream. Despite the capabilities of DAMBRK, the staff of the Dam and Reservoir Safety Program have found that the U.S. Army Corps of Engineers (1981) Hydrologic Engineering Center (HEC) Flood Hydrograph Model (HEC-1) produces reasonable results for dam break analyses.

In order to use HEC-1 to conduct a breach analysis and consider the effects of off-channel storage, the engineer must first rate the channel(s) downstream by performing a backwater analysis. The Corps of Engineers (1985) Water Surface Profile Model (HEC-2) is typically used to perform these computations. As a first estimate, the engineer can use cross sections derived from USGS topographic maps. However, these sections produce results only as reliable as the degree of accuracy of the map. This is normally 10 feet for maps with twenty foot contours and 5 feet for maps with ten foot contours. If additional accuracy is required, surveyed cross sections of the valley must be obtained.

When the channel has been rated for a range of flowrates, the engineer must select the dam failure criteria. The final breach geometry and the time to failure are the two most significant parameters to select. According to Fread (1984), the final breach width should be selected in the range of one to three times the height of the dam, the side slope of the breach should vary from 0-2 horizontal to 1

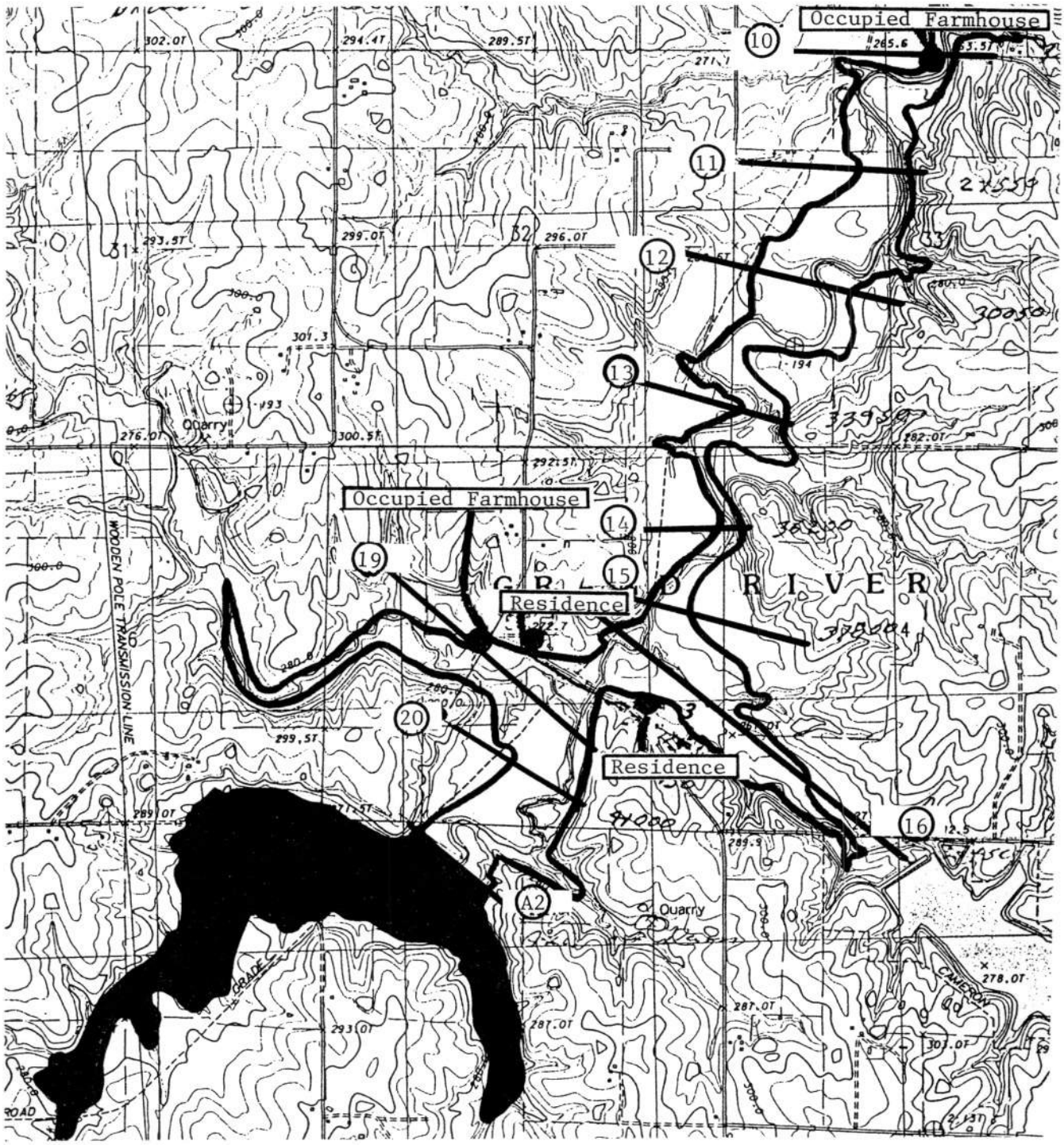


Figure 3.1 Topographic Map of Downstream Environmental Zone

vertical, and the time to breach should be in the range of 0.5 to 4 hours. For concrete gravity and arch dams, the time to breach is typically considered to be 10 minutes or nearly instantaneous. For earth dams, a breach width equal to the height of the dam and a sideslope of 1 horizontal to 1 vertical are normally used unless the dam contains observable geotechnical defects.

Upon completion of the breach analysis, a water surface profile should be drawn of the flood wave created by the failure of the dam. The profile should include the elevation of all homes that would be inundated by the flood wave. When topographic cross sections are used, the profile should also include the estimated elevations of all homes according to the degree of accuracy of the map.

Finally, a topographic map should be submitted as shown in Figure 3.1. It should include the location of the

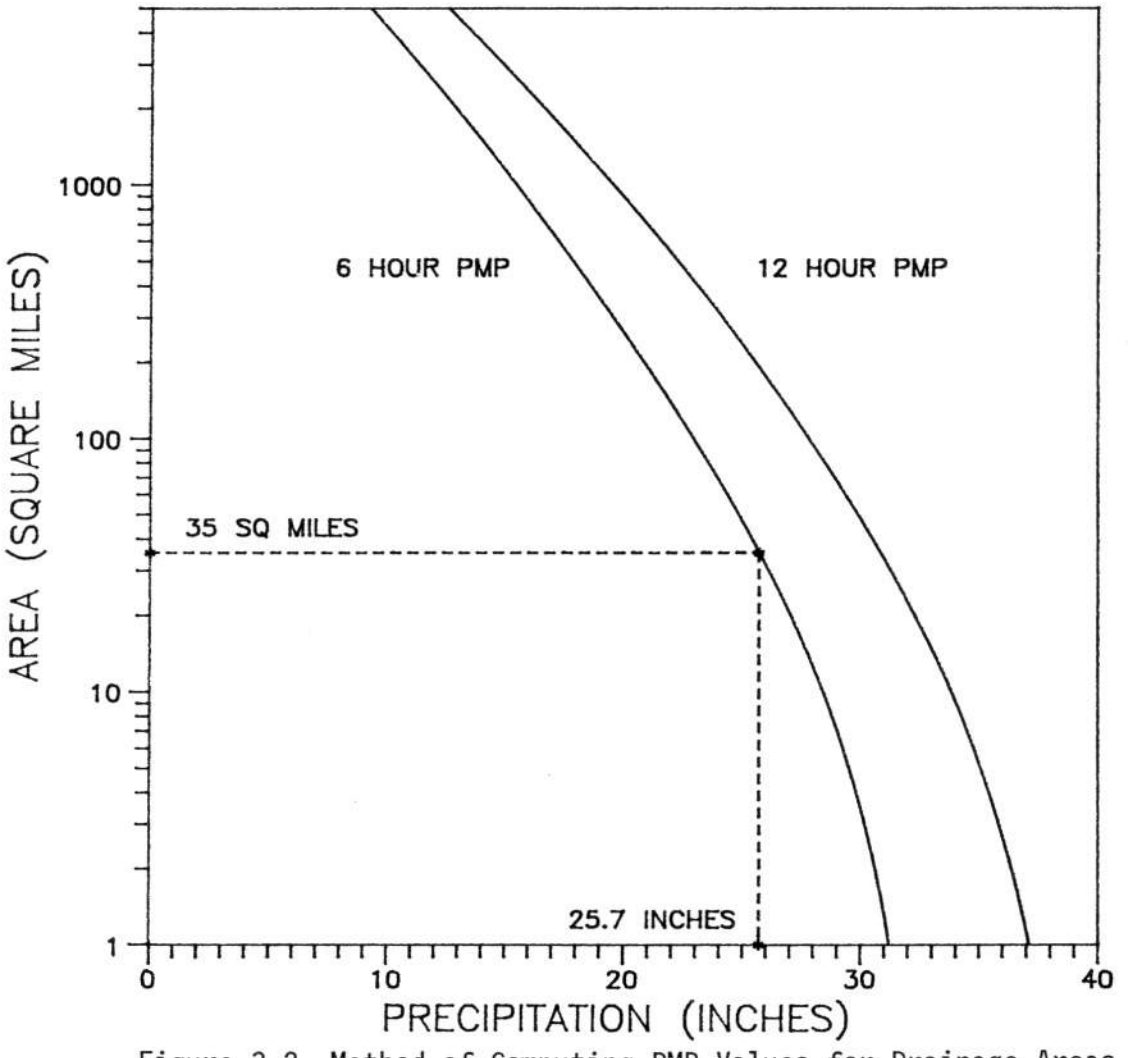


Figure 3.2 Method of Computing PMP Values for Drainage Areas

dam and reservoir, the location of stream cross sections used in the breach analysis, the boundary of the breach floodplain, and verified locations of permanent dwellings, campgrounds, industrial buildings, and public buildings within the breach floodplain. Because the cultural data shown on topographic maps may be several years old, field verification of the information on the map is essential.

B. Spillway Design Flood Precipitation Values

The precipitation values listed in Table 5, 10 CSR 22-3.020, must be used to determine the spillway design flood for both new and existing dams. After the downstream environmental class has been determined, the precipitation value to be used in the hydrologic computations can be selected. The probable maximum precipitation (PMP) can be obtained from Hydrometeorological Report 51, Probable Maximum Precipitation Estimates, United States East of the 105th Meridian, published by the U.S. Department of Commerce (1978). This publication contains PMP values for watersheds east of the 105th meridian that range in size from 10 to 20,000 square miles. Rainfall durations range from 6 to 72 hours. The National Weather Service states that "point" PMP values are likely to be greater than the 10 square mile values; however, in performing dam safety analyses, it is acceptable to use the 10 square mile PMP values rather than deriving a PMP value for a smaller area. This procedure is allowed to compensate for the unliklihood that a small watershed will receive the most intense rainfall in any storm. For drainage areas greater than 10 square miles, the engineer has the option of determining the PMP value for the area being considered by using the method shown in Figure 3.2. This method is explained in more detail in Hydrometeorological Report 51.

Several different duration rainfall events must be ana-

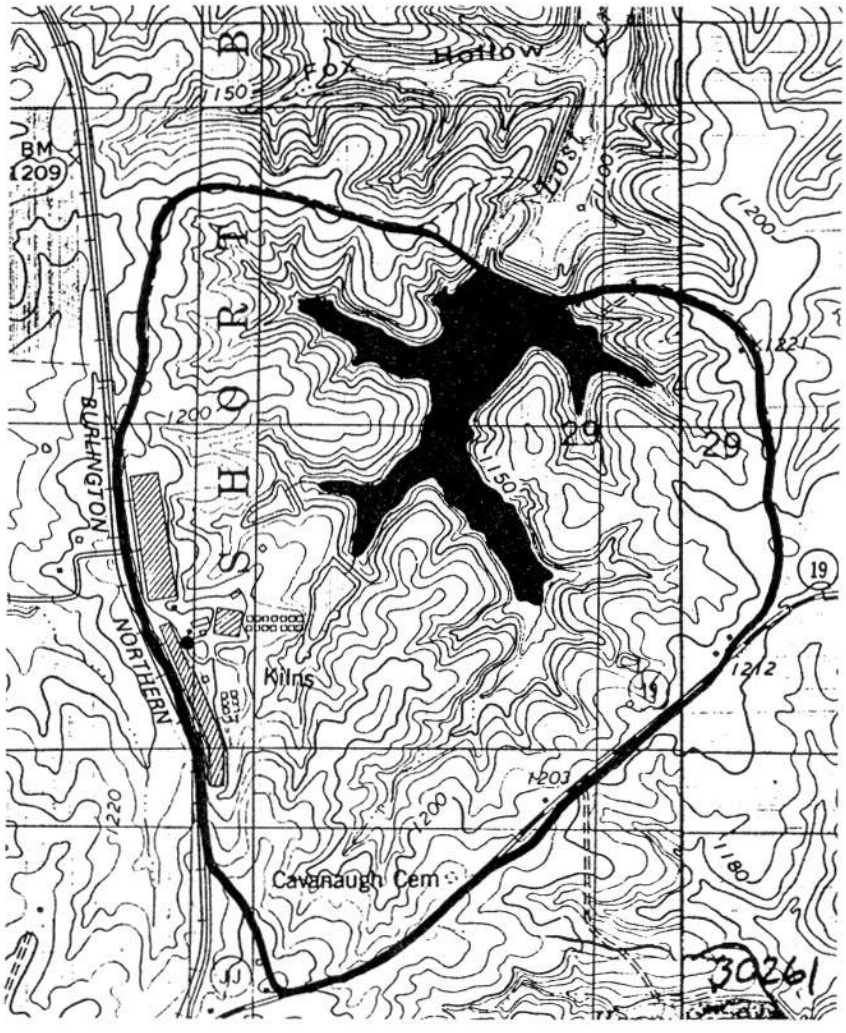


Figure 3.3 Topographic Map of Drainage Area

lyzed. The duration that produces the highest reservoir elevation in the overtopping analysis is termed the critical duration rainfall event. The search for this event is limited to the durations listed in Hydrometeorological Report 51 (6, 12, 24, 48 and 72 hour events). For watersheds less than 1 square mile in size the critical duration event is normally the 6 or 12 hour event.

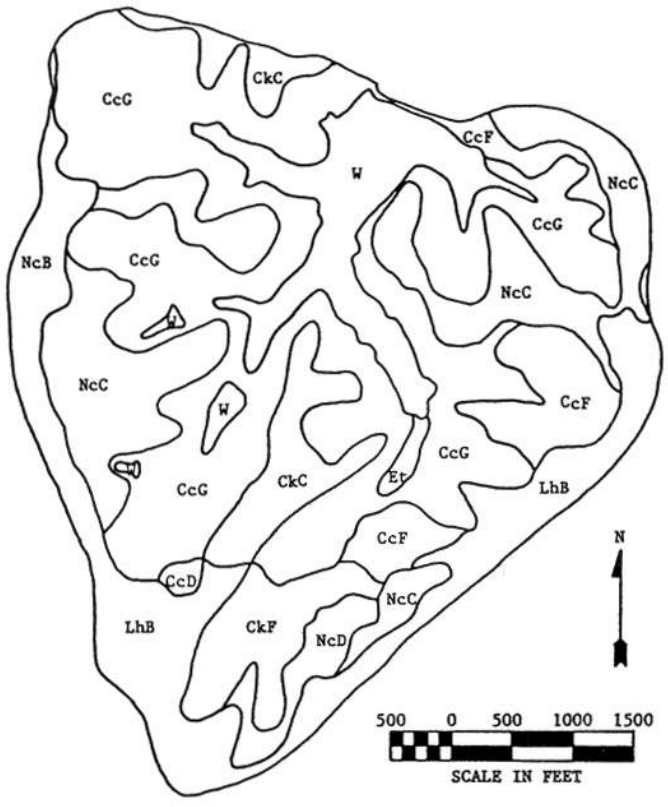
If a grass lined emergency spillway is proposed for a new dam or the modification of an existing dam, it is advisable to design it so that it will only be used for rainfall events in excess of the 50 or 100-year events. Values for these frequency based rainfall events can be found in Technical Paper 40, Rainfall Frequency Atlas of the United States, published by the U.S. Department of Commerce (1961).

Appendix C contains total rainfall values, by county, for 6-hour, 12-hour, and 24-hour frequency based and PMP events in Missouri. The PMP values are for 10 square mile areas only. For other durations, areas, and return periods, engineers should consult Hydrometeorological Report 51 and Technical Paper 40.

C. Watershed Data

All available information concerning watershed characteristics should be assembled. As shown in Figure 3.3, a map of the drainage area should be prepared showing the drainage system, contours, drainage boundaries, and locations of any precipitation stations and streamflow gaging stations. Available data on soil types, cover, and land usage provide valuable guides to judgement and should also be assembled. If the Soil Conservation Service (SCS) has published a soil survey booklet for the county in which the drainage area is located, a soil map can be developed as shown in Figure 3.4. Engineers are advised to contact the county SCS office for a copy of the soil survey booklet.

Land use, such as woodland, pasture, farmland, and



SYMBOL	SOIL TYPE	SLOPE
CcD	Clarksville Cherty Silt Loam	9-14%
CcF	Clarksville Cherty Silt Loam	14-30%
CcG	Clarksville Cherty Silt Loam	30-50%
CkC	Coulstone and Clarksville Cherty Soil	2-9%
CkF	Coulstone and Clarksville Cherty Soil	14-30%
Et	Elsah Certy Loam	1-2%
LhB	Lebanon and Hobson Silt Loam	2-5%
NcB	Nixa-Clarksville Cherty Loam	2-5%
NcC	Nixa-Clarksville Cherty Loam	5-9%
NcD	Nixa-Clarksville Cherty Loam	9-14%
W	Water	

Figure 3.4 Soil Map of Drainage Area

residential can be determined from several sources such as topographic maps, tax reassessment photographs, and Agricultural Stabilization and Conservation Service (ASCS) aerial photographs.

For large watersheds, it is advisable to divide the drainage area into subbasins on the basis of size, drainage pattern, existing and proposed facilities, vegetation, and soil and cover types. The subbasin hydrographs are channel routed downstream to the reservoir. Upstream dams and reservoirs may be included in the analysis. Any upstream dam that is found to overtop during the spillway design flood must either be considered to breach or omitted from the analysis. Breaching is assumed to commence when the reservoir exceeds the lowest elevation on the crest of the dam. The breach hydrograph is then routed downstream and added to the inflow hydrograph at the next reservoir. It is advisable to calibrate the spillway design flood results to historical flood events where adequate stream gage data are available. However, most small watersheds in Missouri are not gaged.

The USGS now has 7 1/2 minute topographic maps for the entire state of Missouri. These can be purchased from commercial businesses or ordered from Department of Natural Resources, Maps and Publications, P.O. Box 250, Rolla Missouri 65401; Phone (314) 364-1752. Watershed and subbasin areas should be determined by use of mechanical planimeters or electronic digitizers. Several area measurements should be taken to determine the value to use in the hydrological computations.

D. Initial Abstraction and Infiltration

Initial abstraction consists of the sum of interception, depression storage, and infiltration which occurs prior to runoff. After runoff begins, infiltration continues throughout the duration of the rainfall event.

Interception and depression storage are intended to represent the surface storage of water by trees, grass, and local depressions in the ground surface. These important hydrologic processes must be carefully considered in models which are used to describe the hydrology of a watershed.

Several empirical infiltration models have been developed but few include procedures for estimating interception and depression storage losses. Recognizing this problem, the SCS (1972) developed the curve number method which can be used to estimate runoff from small agricultural watersheds. In view of the general lack of available data pertaining to abstractions during storm events, the SCS curve number method is used by the staff of the Dam and Reservoir Safety Program to determine both initial abstraction and infiltration losses. If other infiltration models are used, the engineer should estimate the interception and depression storage losses based on a review of available soil and cover data.

In order to use the SCS curve number method to estimate the initial abstraction for a subbasin, an area weighted runoff curve number, CN, should be computed. The factors that determine the runoff curve number are the hydrologic soil group, land use, hydrologic condition and the antecedent moisture condition (AMC).

Hydrologic soil groups have been defined by the Soil Conservation Service (1986) for each of the soils in Missouri. They range from A (most permeable) to D (least permeable). The land use addresses the type of development in the subbasin. Typical values for CN for various land uses are shown in Tables 3.1, 3.2, and 3.3 (SCS, 1986). The hydrologic condition takes into account the effect of cover and is generally estimated from density and type of plant growth. The reservoir area can either be considered as an impervious area in the model or included in the weighted runoff curve number computations.

The antecedent moisture condition (AMC) is classified into three categories by the SCS (1972) depending on the available moisture capacity of the soil. Antecedent moisture condition II is used by the staff of the Dam and Reservoir Program to determine the weighted runoff curve number for a watershed. The values of CN in Tables 3.1, 3.2, and 3.3 are for AMC II conditions.

When the SCS curve number method is used in the HEC-1 model, the initial abstraction is computed for each subbasin by using the empirical relationship (SCS, 1972):

$$I_a = 0.2\left(\frac{1000}{CN} - 10\right) \qquad (3.1)$$

This relationship was developed by the SCS to estimate initial abstraction and is an approximation based upon a scattering of rainfall-runoff data for watersheds less than 10 acres in size.

Infiltration is defined as the entry of water from the surface into the soil profile. It is an important hydrologic process which must be carefully considered in the hydrology of a watershed. Several factors affect infiltration. These include soil properties, the initial water content, rainfall rates, surface sealing and crusting, layered soils, and the porosity of the soil. Many empirical and physical models are available to estimate the infiltration rate.

The SCS method is typically used to determine the infiltration rate after the initial abstraction has been satisfied. Direct runoff is computed by the HEC-1 model in the following manner:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}, \qquad (3.2)$$

where

Q = incremental direct runoff in inches;
P = incremental storm rainfall, in inches; and
S = (1000/CN) - 10.

The actual infiltration in any increment of time is equal to $P - I_a - Q$.

E. Unit Hydrographs

Unit hydrographs are used in the planning and design of water control structures. Chow (1964) defined the unit hydrograph of a drainage basin as a hydrograph of direct runoff resulting from 1 inch of effective rainfall generated uniformly over the basin area at a uniform rate during a specified period of time or duration.

Because most watersheds are ungaged, the use of synthetic unit hydrographs is an accepted procedure in the computation of inflow hydrographs into a reservoir. Synthetic unit hydrographs are based on the assumption that watersheds within a homogeneous region have similar rainfall-runoff characteristics. Although this is not the most accurate procedure to use, the lack of gaged data makes the use of synthetic unit hydrographs necessary.

The two most commonly used synthetic unit hydrograph methods in Missouri are the SCS dimensionless unit hydrograph and Gray's (1961) unit hydrograph. The SCS method is shown in Figure 3.5 and is included in many of the commonly used computer models. It is typically used on small watersheds. According to Technical Release 60 (SCS, 1985), the SCS unit hydrograph is valid on watersheds up to 50 square miles in size. Larger watersheds should be divided into subbasins with areas less than 20 square miles. Gray's method was developed using data for the midwestern United States. This unit hydrograph is applicable for watersheds up to 94 square miles. Both methods are acceptable for dam safety analysis.

TABLE 3.1

Runoff Curve Numbers - Urban Areas

Cover Description Cover type and hydrologic condition[1]	Ave % Impervious[2]	Curve Numbers[3] for Hydrologic Soil Group A	B	C	D
Open space (lawns, parks, golf courses, cemeteries, etc):					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved streets, roads, parking lots, roofs, driveways, etc.	100	98	98	98	98
Paved; open ditches (including right of way)		83	89	92	93
Gravel (including right of way)		76	85	89	91
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82

[1]Average runoff condition, and $I_a = 0.2S$.

[2]The average percent impervious area shown was used to develop the composite CN's.

[3]AMC II conditions.

TABLE 3.2

Runoff Curve Numbers - Agricultural Lands[1]

Land use	Treatment or Practice[2]	Hydrologic Condition[3]	Curve Numbers[4] for Hydrologic Soil Group A	B	C	D
Fallow	Bare soil	----	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
	Crop residue cover (CR)	Good	74	83	88	90
Row Crops	Straight row	Poor	72	81	88	91
	Straight row	Good	67	78	85	89
	Straight row & CR	Poor	71	80	87	90
	Straight row & CR	Good	64	75	82	85
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Contoured + CR	Poor	69	78	83	87
	Contoured + CR	Good	64	74	81	85
	Contoured + terraces	Poor	66	74	80	82
	Contoured + terraces	Good	62	71	78	81
	Contoured + terraces + CR	Poor	65	73	79	81
	Contoured + terraces + CR	Good	61	70	77	80
Small Grain	Straight row	Poor	65	76	84	88
	Straight row	Good	63	75	83	87
	Straight row & CR	Poor	64	75	83	86
	Straight row & CR	Good	60	72	80	84
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	73	81	84
	Contoured + CR	Poor	62	73	81	84
	Contoured + CR	Good	60	72	80	83
	Contoured + terraces	Poor	61	72	79	82
	Contoured + terraces	Good	59	70	78	81
	Contoured + terraces + CR	Poor	60	71	78	81
	Contoured + terraces + CR	Good	58	69	77	80

[1]Average runoff condition, and $I_a = 0.2S$.

[2]Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3]Hydrologic condition is based on combination of factors that affect infiltration and runoff, including (a) density and canopy of vegetation, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes in rotations, (d) percent of residue cover on the land surface (good $\geq$ 20%), and (e) degree of surface roughness.

Poor:Factors impair infiltration and tend to increase runoff.

Good:Factors encourage average and better than average infiltration and tend to decrease runoff.

[4]AMC II conditions

TABLE 3.3

Runoff Curve Numbers - Noncultivated Agricultural Lands

Cover Type	Hydrologic Condition[1]	Curve Numbers[2] for Hydrologic Soil Group A	B	C	D
Pasture, grassland, or range-continuous forage for grazing[3]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow--continuous grass, protected from grazing and generally mowed for hay	----	30[4]	58	71	78
Brush--brush-weed-grass mixture with brush the major element.[5]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30	48	65	73
Woods--grass combination (orchard or tree farm)[6]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.[7]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77
Farmsteads-buildings, lanes, driveways, and surrounding lots.	----	59	74	82	86

[1]Average runoff condition, and $I_a = 0.2S$.

[2]AMC II conditions

[3]Poor; <50% ground cover or heavily grazed with no mulch.
Fair; 50% to 75% ground cover and not heavily grazed.
Good; >75% ground cover and lightly or only occasionally grazed.

[4]Actual curve number is less than 30; use CN=30 for runoff computations.

[5]Poor; <50% ground cover.
Fair; 50% to 75% ground cover.
Good; >75% ground cover.

[6]CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[7]Poor; Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair; Woods are grazed but not burned, and some forest litter covers the soil.
Good; Woods are protected from grazing, and litter and brush adequately cover the soil.

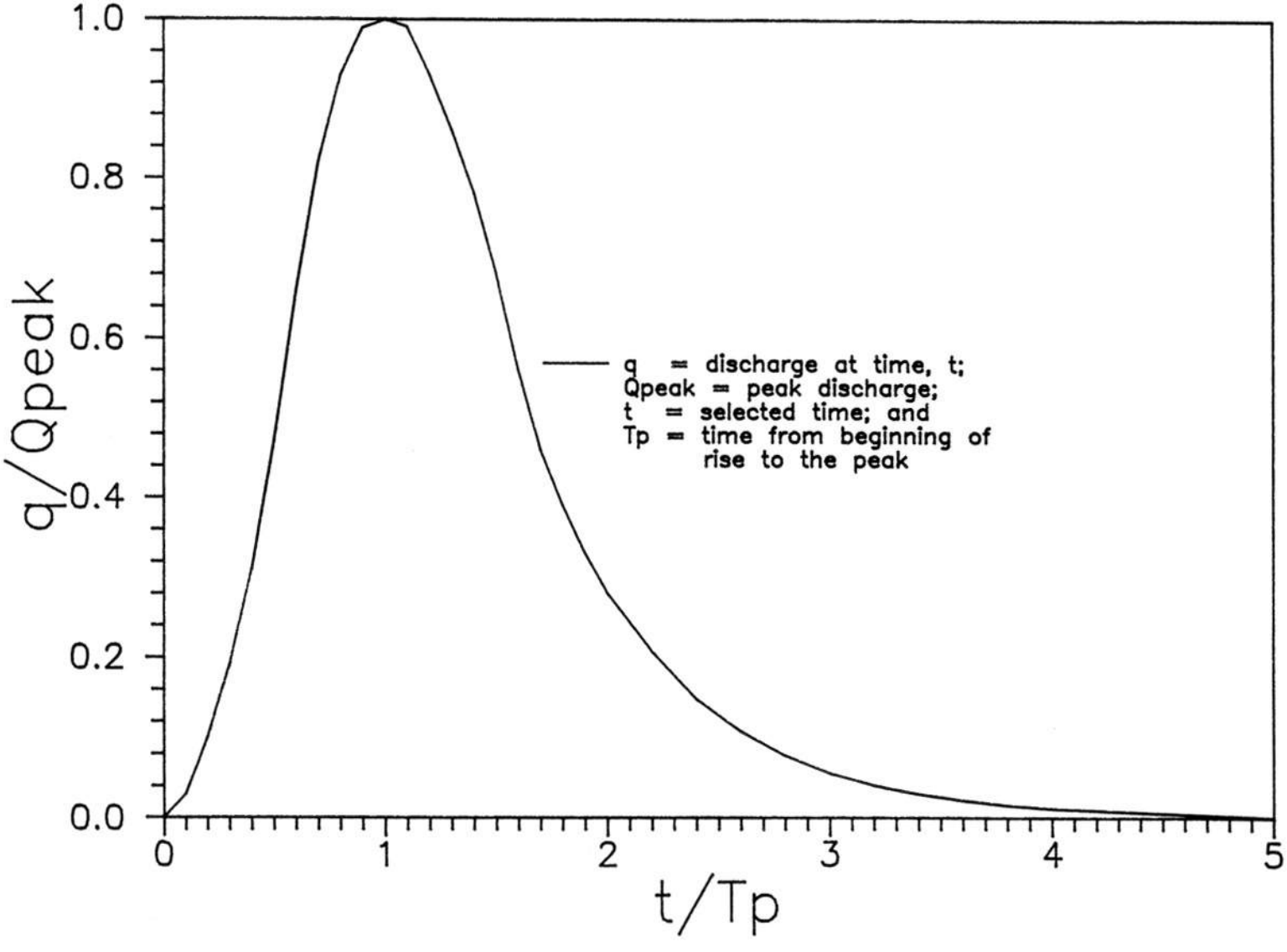


Figure 3.5 SCS Dimensionless Unit Hydrograph

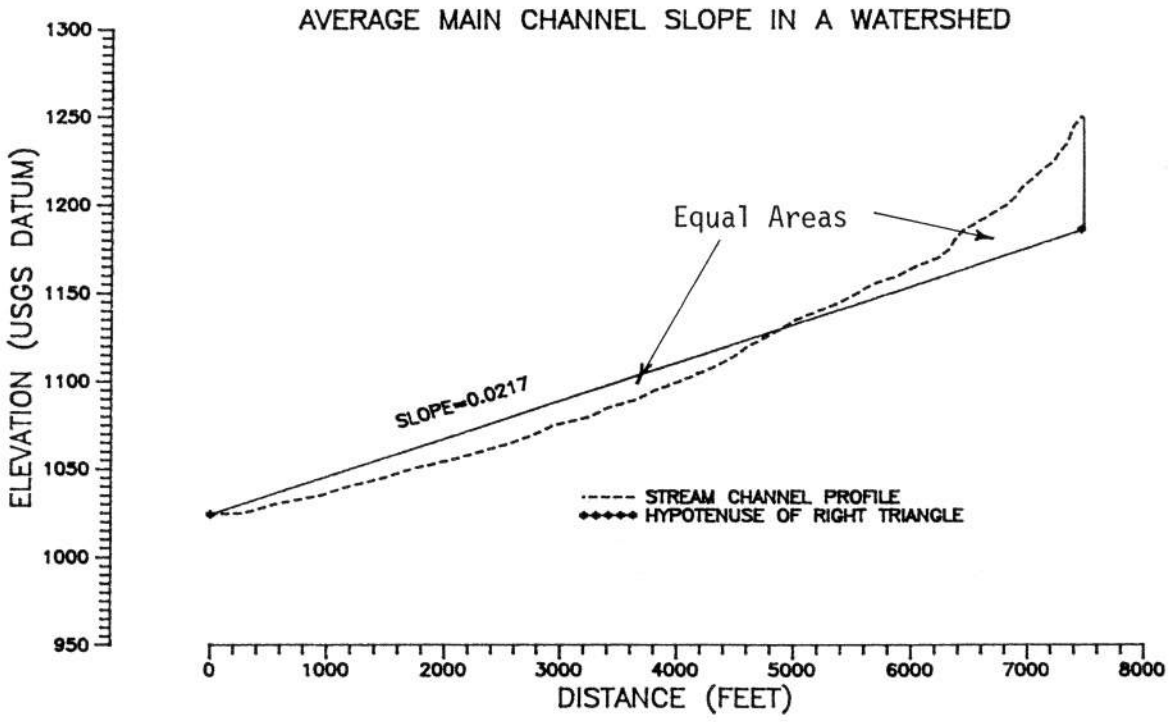


Figure 3.6 Gray's (1961) Method of Computing Channel Slope

The SCS dimensionless unit hydrograph is based upon empirical observations of how natural watersheds "typically" respond to rainfall in excess of the rate at which it can infiltrate. A good description of the method is included in the SCS (1972) National Engineering Handbook, Section 4, Hydrology. The basic input parameters needed to develop a synthetic unit hydrograph for a watershed include the basin lag time, basin area, and the duration of the unit hydrograph. Time to peak, T_P, and the peak flow, Q_{peak}, for each increment of rainfall are computed from these three parameters.

The basin lag time, T_L, should be computed before the unit hydrograph duration, ΔD, is specified. The SCS dimensionless unit hydrograph is based on the relationship, $\Delta D = 0.22 T_L$. According to the SCS, a small variation in ΔD is permissible, however, ΔD should not be greater than 0.25 T_P. This SCS guideline lead the Corps of Engineers to recommend the relationship in Equation 3.3 for selecting the HEC-1 computation interval, Δt.

$$\Delta t \leq .29 T_L, \qquad (3.3)$$

where

Δt = HEC-1 computation interval in minutes; and

T_L = basin lag time in minutes.

Selection of the HEC-1 computation interval is very important because it is also the duration of the SCS dimensionless unit hydrograph.

In Gray's unit hydrograph, a gamma distribution is used to describe a dimensionless unit hydrograph. The length and slope of the main channel upstream of the reservoir and the watershed area are the parameters used to develop the synthetic unit hydrograph. These parameters can easily be obtained from a topographic map. Channel slope is determined as shown in Figure 3.6. The area beneath the channel profile is set equal to the area of a right triangle with the hypotenuse crossing the origin at the elevation of the reservoir. The slope of the hypotenuse is the average channel slope. Gray's unit hydrograph can be computerized to solve for the Unit Hydrograph Ordinates based on an input of watershed area, channel length, and channel slope. A good description of the method is presented by Viessman, Harbaugh, and Knapp (1972).

F. Time of Concentration

The use of synthetic unit hydrographs requires a characterization of watershed response time. This characteristic time is usually taken to be either time of concentration or basin lag time. Both are commonly assumed to be constant and lag time is often considered to be a fraction

of time of concentration so that one is easily converted to the other. Lag time must be computed in order to use the SCS dimensionless unit hydrograph. With Gray's unit hydrograph, the time of concentration is implicitly computed in the determination of the hydrograph ordinates.

The SCS (1972) defined lag time as the time interval between the centroid of effective rainfall and the peak of direct runoff. When used with the SCS unit hydrograph, this definition assumes that lag time is stable and is constant regardless of rainfall duration or intensity. This assumption of linearity is made to simplify computations. Based on their experience on small watersheds, the SCS estimates lag time as

$$T_L = 0.6T_c, \tag{3.4}$$

where

T_C = time of concentration in minutes.

A number of empirical approaches to estimating basin response time have come to be accepted in the field of hydrology for dam safety. Among the most common are the Kirpich formula (1940), the Kerby-Hathaway formula (Kerby, 1959), the SCS Upland method, and the SCS Lag method (SCS, 1985). The SCS methods and the Kerby-Hathaway method consider surface roughness and all four methods recognize the importance of length and slope of the flow path. None of these methods, however, reflect the influence of rainfall characteristics such as rainfall duration and intensity.

The Kirpich formula was developed from data gathered by Ramser (1927) from experiments conducted on a single 112 acre agricultural watershed in Tennessee. The equation is

$$T_c = 0.00013L^{.77}S^{-.385}, \tag{3.5}$$

where

T_C = time of concentration in hours;
L = length of the watershed in feet; and
S = slope in feet/feet.

A version of the Kirpich formula is printed in the U. S. Department of of the Interior (1974) manual entitled Design of Small Dams.

The SCS Lag method is shown in Equation 3.6 and is based on the assumption that the time of concentration equals 1.67 times the lag time. It can be used on watersheds up to 2000 acres in size.

$$T_c = 0.000879L^{.8}\left(\frac{1000}{CN} - 9\right)^{.7}Y^{-.5}, \tag{3.6}$$

where

T_C = time of concentration in hours;
L = hydraulic length of the watershed in feet;
CN = hydrologic soil cover complex no.; and
Y = average watershed land slope, %.

The slope in Equation 3.6 is the average land slope, not the channel slope. It is typically computed from topographic maps and SCS soil survey maps. Horton (1932) published three methods of computing overland slope which are frequently used. These include the contour area method, the mean slope method, and the intersection line method.

The contour area method requires that areas be planimetered between each successive pair of contour lines in a subbasin. Each area is divided by the average contour length for the interval being considered to compute the average distance between contours as shown in Equation 3.7.

$$L_i = \frac{A_i}{\frac{L_1 + L_2}{2}}, \tag{3.7}$$

where

L_i = average distance between contours;
A_i = intermediate area;
L_1 = length of first contour; and
L_2 = length of second contour.

The overland slope of the subbasin is then computed as

$$S_o = \sum \frac{(A_i D)}{A_T L_i}, \tag{3.8}$$

where

S_O = overland flow slope;
D = contour interval; and
A_T = subbasin area.

The mean slope method is a simplified form of the contour area method because it considers the subbasin as a whole. The total length of contours in the subbasin is determined and the mean slope is computed by Equation 3.9.

$$S_o = \frac{D\sum L}{A_T}, \tag{3.9}$$

where

$\sum L$ = total length of contours.

According to Horton (1932), the mean slope method gives good results if the relief is moderate and contours are spaced uniformly.

An average watershed slope can also be computed by weighting the average slopes from the SCS soil map shown in Figure 3.4.

The SCS (1985) Upland Method, shown in Equation 3.10, was developed primarily for flow in upland areas which include overland flow and flow through grassed waterways, paved areas, and small upland gullies.

$$T_c = \frac{L}{3600V}, \qquad (3.10)$$

where

T_C = time of concentration in hours;
L = channel length in feet; and
V = velocity of full bank flow in feet/second.

Travel times for each mode of upland flow and land use are computed from a graph of experience curves (SCS, 1972) showing velocity versus slope for various ground cover conditions. The summation of these travel times equals the time of concentration in the watershed. This method is limited to watersheds less than 2000 acres.

Huggins and Burney (1982) suggested computing time of concentration by adding the channel travel time from the Kirpich equation and the overland flow travel time from the Kerby-Hathaway equation. The basis for the Kerby-Hathaway formula, shown in Equation 3.11, is a study conducted by Hathaway (1945) on overland flow for airfield design and construction.

$$T_c = 0.01377 L_o^{.47} n^{.47} S_o^{-.235}, \qquad (3.11)$$

where

T_C = time of concentration in hours;
L_O = overland flow length;
n = roughness factor; and
S_O = overland flow slope in feet/feet.

When using this method, overland flow lengths should be limited to 500 feet. The roughness factor, n, has the same meaning for overland flow as it does for channel flow, but it is typically higher (0.1 - 0.4) due to the combined resistance effects of the overland flow surface. Kerby (1959) suggested the following values:

TYPE OF SURFACE	n
Smooth impervious surface	.02
Smooth, bare, packed soil	.10
Poor grass, cultivated row crops, or moderately rough bare surface	.20
Pasture or average grass	.40
Deciduous timberland	.60
Conifer timberland, deciduous timberland with deep forest litter, or dense grass	.80

Engman (1986) analyzed data from experimental plots and recommended roughness coefficients of 0.13 for range grass, 0.24 for dense grass, 0.41 for Bermuda grass and 0.45 for bluegrass sod.

This last method, which combines the time of concentration values obtained from the Kirpich and Kerby-Hathaway formulas, is the method generally used by the staff of the Dam and Reservoir Safety Program.

All four methods are acceptable for dam safety analysis, but none of them consider the affects of rainfall. Swenty (1989) conducted a study which showed that lag time is affected by rainfall duration, depth, and intensity. He concluded that the traditional approach of combining the overland and channel flow lag times from the Kerby-Hathaway and Kirpich equations yields reasonable estimates of basin lag time for 100% PMP events on basins less than 1 square mile in size. All four methods were found to underestimate basin lag time for 6-hour and 12-hour rainfall events, less than the 100% PMP.

G. Rainfall Hyetographs

In order to compute an inflow hydrograph, the spillway design flood precipitation value must be distributed over the duration of the rainfall event. Methods are included in the SCS (1974) National Engineering Handbook No. 4 (NEH-4), the U. S. Department of the Interior (1974) Design of Small Dams, and the U. S. Army Corps of Engineers (1987) Flood Hydrograph Package, HEC-1, but the distributions used by the Dam and Reservoir Safety Program are those developed by Huff (1980). Huff published four rainfall distributions for various duration rainfall events. The data used to derive these rainfall distributions were acquired from gaging stations in the state of Illinois. Because of Missouri's close proximity to Illinois, these distributions are acceptable for dam safety projects in Missouri.

The average time distribution of heavy rainfall at a point is shown in Table 3.4 (Huff, 1980). Huff recommended that the point time-distribution relationships shown in Table 3.4 be used with PMP rains extending from a point to 50 square miles.

First and second quartile rainfall distributions should be used for rainfall events less than 12 hours, third quartile rainfall distributions should be used for rainfall durations of 12 to 24 hours and fourth quartile rainfall distributions would be used for rainfall durations greater than 24 hours. Distributions for areas from 50 to 400 square miles were also derived by Huff (1980).

Huff's distributions can also be used to distribute the 50-year and 100-year rainfall events. These rainfall events are typically used to design emergency spillways and to analyze the affect of proposed spillway modifications on discharge rates.

H. Inflow Hydrograph Computation

The inflow design flood hydrograph represents direct runoff from precipitation in the form of rain over a watershed. If hand computations are performed, the procedure outlined in Table 3.5 is recommended.

This procedure should be followed for each duration rainfall event that is analyzed. For a typical small watershed, both a 6-hour and a 12-hour inflow hydrograph will have to be computed. Larger watersheds will require the analysis of longer duration events.

TABLE 3.4 Median Time Distributions of Heavy Storm Rainfall at a Point

Cumulative storm rainfall (percent) for given storm type

Cumulative storm time (percent)	First-quartile	Second-quartile	Third-quartile	Fourth-quartile
5	16	3	3	2
10	33	8	6	5
15	43	12	9	8
20	52	16	12	10
25	60	22	15	13
30	66	29	19	16
35	71	39	23	19
40	75	51	27	22
45	79	62	32	25
50	82	70	38	28
55	84	76	45	32
60	86	81	57	35
65	88	85	70	39
70	90	88	79	45
75	92	91	85	51
80	94	93	89	59
85	96	95	92	72
90	97	97	95	84
95	98	98	97	92

TABLE 3.5

Procedure for Computing an Inflow Hydrograph

Step 1	Determine the size of the drainage area of each basin for which an inflow hydrograph is to be computed.
Step 2	For watersheds less than 10 square miles, determine the PMP values for 6-hour, 12-hour and 24-hour events. For larger watersheds, adjust the PMP value as described in Section B and include 48-hour and 72-hour duration events.
Step 3	Compute the time of concentration for the drainage basin and convert to lag time.
Step 4	Using the lag time, compute the computational time interval, Δt, where $\Delta t \leq 0.29$(lag time).
Step 5	Determine the downstream environmental zone and select the appropriate design precipitation value from Table 5, 10 CSR 22-3.020.
Step 6	Determine the rainfall hyetograph by using Huff's Quartile distributions in Table 3.3. Sum the ordinates to compute an accumulative design rainfall table.
Step 7	Determine the initial abstraction and construct an infiltration model for the watershed. Compute the amount of excess rainfall at each time step. If the SCS curve number method is used, determine the hydrologic soil cover complex number, CN, of the watershed and perform steps 8 and 9.
Step 8	Determine the accumulative direct runoff from Equation 3.2.
Step 9	Convert the accumulative direct runoff table to an incremental table of direct runoff.
Step 10	Construct a synthetic unit hydrograph for the basin.
Step 11	Compute hydrographs for each time increment using the synthetic unit hydrograph (step 10) and either the excess rainfall at each time step (step 7) or the incremental table of direct runoff (step 9). Overlay hydrographs and add ordinates at each time increment. The summation of all ordinates produces the inflow hydrograph to the reservoir.

ERRATA SHEET FOR "ENGINEERING ANALYSIS OF DAMS MANUAL"
November 14, 1991

Page 18, Table 3.5, Step 6, should read,

Determine the rainfall hyetograph by using Huff's Quartile distributions in Table 3.4. Sum the ordinates to compute an accumulative design rainfall table.

Page 20, definition of term D_{rc} in second column should read,

D_{rc} = diameter of riser in ft.

Page 24, Table 4.1 should read,

TABLE 4.1

Geometric Elements of Trapezoidal Channels

Geometric Element	Symbol	Definition	Equation
Water Area	A	Cross sectional area of the flow normal to the direction of flow	$(b + zy)y$
Wetted Perimeter	P	Length of the line of intersection of the channel wetted surface with a cross sectional plane normal to the direction of flow.	$b + 2y\sqrt{1 + z^2}$
Hydraulic Radius	R	Ratio of the water area to its wetted perimeter.	$\frac{(b+zy)y}{b+2y\sqrt{1+z^2}}$
Top Width	T	Width of the channel section at the free surface.	$b + 2zy$
Hydraulic Depth	D	Ratio of the water area to the top width.	$\frac{(b+zy)y}{b+2zy}$
Section Factor	Z	Product of the water area and the square root of the hydraulic depth.	$\frac{[(b+zy)y]^{1.5}}{\sqrt{b+2zy}}$

Note y = depth of flow in channel

b = channel base width.

z = sideslope of channel, z:1.

Page 29, the conic method equation in column two should read,

The conic method can be used to compute reservoir volume from surface area versus elevation data as follows:

$$\Delta Vol = \frac{(E_{n+1} - E_n)}{3}(A_n + A_{n+1} + \sqrt{A_n A_{n+1}})$$

Page 35, Figure 5.4

"Relief wall" should be "Relief well"

CHAPTER IV

HYDRAULIC CONSIDERATIONS

The hydraulic calculations that are performed in a dam safety analysis involve the principles of fluid mechanics, and the laws of continuity, conservation of momentum, and specific energy. Many dams have a combination of closed conduit spillways, open channel spillways, and gates and valves for water supply and other uses. It is important that the engineer be familiar with the principles of hydraulic engineering in order to determine the capacity of these spillways.

After the spillways are rated, an overtopping analysis can be conducted. In order to perform an overtopping analysis, the inflow hydrograph must be routed through the reservoir to determine the maximum water surface elevation during the spillway design flood (SDF). This information not only determines whether a dam can safely pass the SDF; it also defines the maximum reservoir loading condition for the slope stability analysis. The purpose of this section is to provide the engineer with the techniques commonly employed by the staff of the Dam and Reservoir Safety Program to perform these computations.

A. Closed Conduit Hydraulics

Closed conduit spillways can either be single structures, such as culverts, or systems consisting of an inlet structure, a closed discharge pipe and an outlet structure. One advantage of this type of spillway is that near maximum capacity is attained at relatively low heads. This characteristic makes the spillway ideal for use where the maximum spillway outflow is to be limited. A disadvantage of conduit spillways is that there is little increase in capacity at higher reservoir levels.

1. Design Considerations for Conduit Spillways

On new dams and modifications to existing dams, the inlet structure should be designed to establish full pipe flow at as low a head as practical and to operate without excessive surging, vibration, or vortex action. This requires the inlet to have a larger cross-sectional area than the main conduit or ventilation.

Trash racks should be placed on inlet risers to exclude trash too large to pass freely through the spillway and outlet structure. General criteria for trash racks is included in the booklet, Maintenance, Inspection, and Operation of Dams in Missouri.

Conduits under earth embankments must support the external loads with an adequate factor of safety. They must withstand the internal hydraulic pressure without leakage under full external load and settlement and convey water at the design velocity without damage to the interior surface of the conduit. The material used for the conduit should be determined by the size of the dam, the economic life of the dam, and the relative ease of replacement.

Conduits should be designed and constructed to remain watertight under maximum anticipated hydrostatic head and maximum joint extension. The analysis should include the effects of joint deflection caused by settlement of the embankment. Corrugated metal pipes are not recommended for use in dams because banded joints are not designed for high pressure flow.

Piping and seepage control around the conduit is an important consideration. For many years, anti-seep collars were required on conduits passing through earth embankment dams. Although no longer used in all dams, anti-seep collars are still an acceptable method for seepage control. When used, the anti-seep collars should be designed to extend the seepage path by 15 percent through the saturated zone. The major disadvantage of anti-seep collars is that it is difficult to compact soil directly against the concrete structure. A large amount of hand compaction is required. An alternative to anti-seep collars is a granular diaphram (sand filter) around a section of conduit downstream of the core. This method is frequently used by the SCS (1986) and is becoming widely accepted by private engineers.

When spillway flows drop from the reservoir pool level to the downstream outlet channel level, the static head is converted to kinetic energy. This energy manifests itself in the form of high velocities, which, if not impeded, results in erosion. Means of returning the flow to the river without serious scour or erosion to the toe of the dam or damage to adjacent structures must be provided. Types of outlet structures include cantilever outlets combined with plunge pools, Saint Anthony Falls (SAF) basins, and impact basins.

2. Shaft Spillways

A shaft spillway is an uncontrolled spillway in which the water enters over a weir and drops through a vertical or sloping shaft into a conduit which discharges into the downstream channel.

The drop-inlet and the morning-glory are the two most common shaft spillways. The drop-inlet spillway is normally a concrete cast-in-place box or a circular sharp crested weir constructed from precast concrete pipe. Figure 4.1 shows a profile of a drop inlet spillway. The morning-glory spillway is a special case of the circular sharp crested weir in which the shape of the weir crest and the upper portion of the shaft are designed to follow the trajectory of the lower nappe.

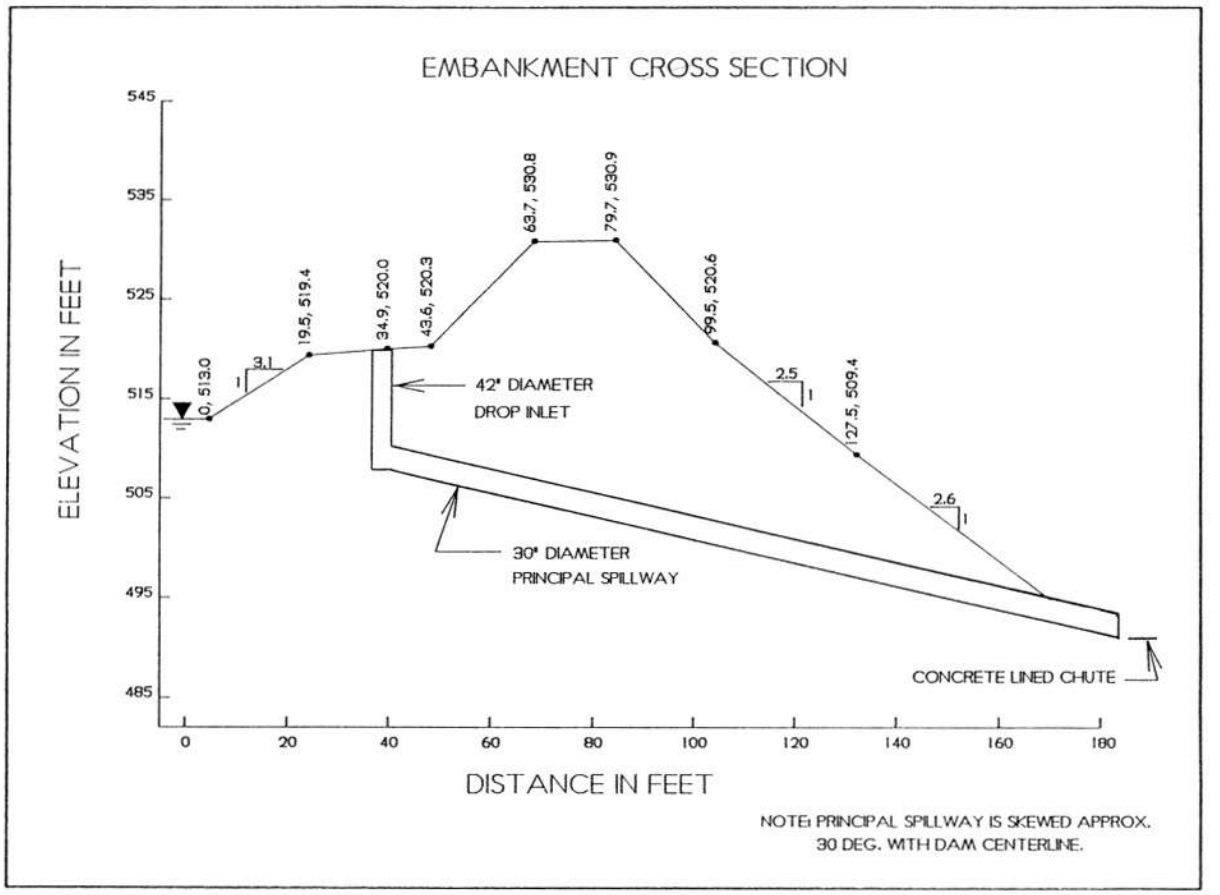


Figure 4.1 Profile of a Drop Inlet Spillway

This section discusses the hydraulic characteristics and the design for a drop-inlet spillway. A discussion of the morning-glory spillway can be found in Design of Small Dams.

The discharge characteristics of a shaft spillway are determined by that portion of the structure which is controlling the discharge. It can be seen in Figure 4.2 that there is the potential for as many as three separate controls and thus three distinct sections in the elevation discharge curve.

The first form of control is weir flow which is described by the weir equation:

$$Q = C_w L_w H^{1.5}, \qquad (4.1)$$

where

Q = discharge in cfs;
C_W = weir coefficient;
L_W = perimeter length of weir in ft.; and
H = depth of water over the weir in ft.

The Portland Cement Association (1964) list the following equations for determining the weir coefficient, C_W, for rectangular drop inlets as a function of the level of the reservoir and the diameter of the outlet pipe:

$$C_w = 3.38\left(1 - \frac{1}{250\frac{H}{D}}\right)^{1.5} \quad for \ \frac{Q}{D^{2.5}} < 4, \qquad (4.2)$$

$$C_w = 4.1\left(1 - \frac{1}{16.7\frac{H}{D}}\right)^{1.5} \quad for \ \frac{Q}{D^{2.5}} > 4, \qquad (4.3)$$

where

H = headwater depth above the inlet in ft.; and
D = diameter of the outlet pipe in ft.

The weir coefficient, C_W, for circular drop inlets is given in Equation 4.4:

$$C_w = 3.60\left(1 - \frac{0.013}{H/D_{rc}}\right)^{1.5}, \qquad (4.4)$$

where

D_{rc} = diameter or riser in ft.

The transition point between weir and orifice flow occurs when the contraction of the flow is fully developed

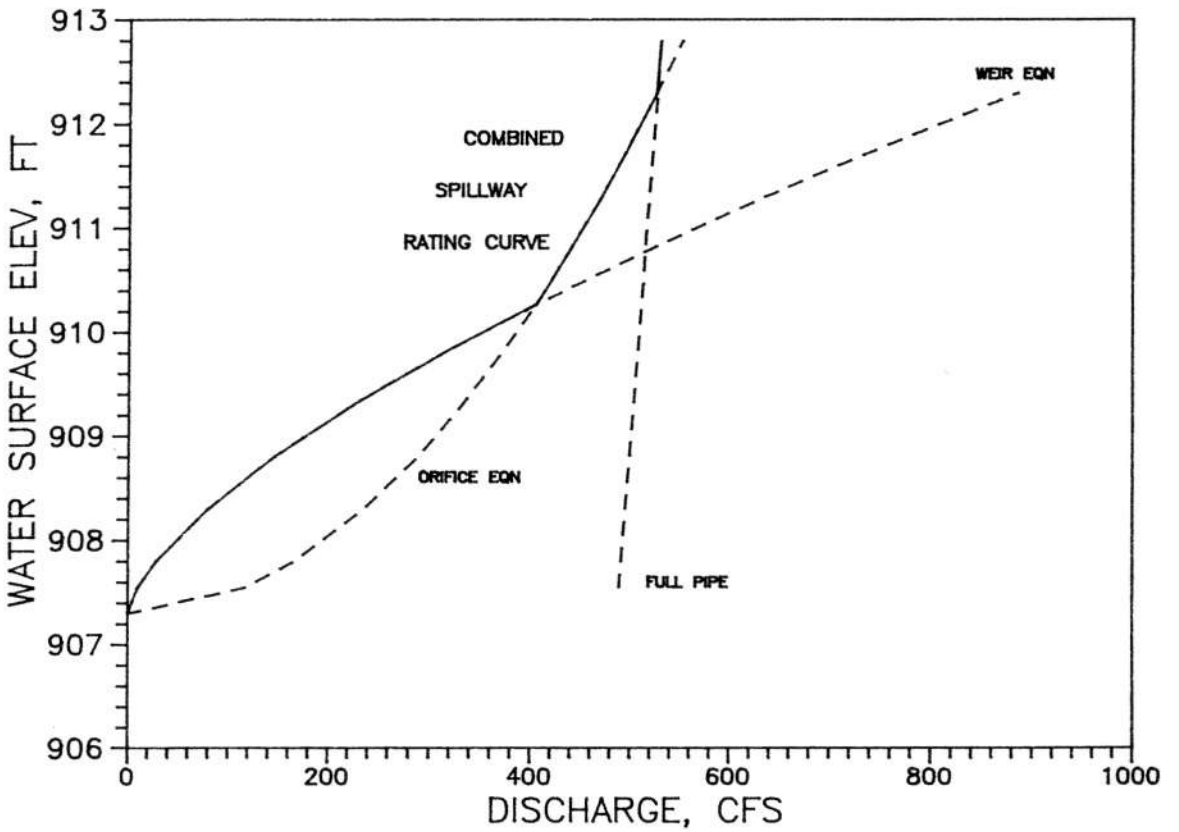


Figure 4.2 Combined Spillway Rating Curve for a Conduit Spillway

at the inlet. The second form of control that must be considered is orifice flow which is discribed in Equation 4.5:

$$Q_o = C_o A\sqrt{(2gH)}, \qquad (4.5)$$

where

Q_O = discharge in cfs;
C_O = contraction coefficient;
A = cross sectional area of inlet in ft^2; and
H = head in feet.

The head is normally taken to be the elevation difference between the top of the inlet and the reservoir surface.

When the depth of water in the vertical riser is above the critical depth for weir flow, the drop inlet will be submerged. Flow is then determined by the relationship in Equation 4.6:

$$Q_p = A_p\sqrt{\frac{2gH_t}{K_c + K_o + \frac{fL}{D}}}, \qquad (4.6)$$

where

Q_p = discharge through pipe in cfs;
A_p = cross sectional area of pipe in square ft;
H_t = total head measured from the headwater surface in the riser to the crown of the pipe outlet in ft;
K_C = total entrance losses, dimensionless coefficient;
K_O = total outlet losses, dimensionless coefficient;
f = Darcy-Weisbach friction factor;
L = length of pipe in feet; and
D = diameter of pipe in feet.

This equation ignores the effect of friction in the riser which, for short risers, is insignificant. Loss coefficients for expansions, contractions, bends, gates, and trashracks are contained in Design of Small Dams. Simon (1986) also provided a good discussion of various loss coefficients.

Figure 4.3 contains a form that can be used to tabulate flow rates under weir, orifice, and full pipe flow conditions. Q_{TOTAL} is determined at each elevation bt taking the minimum of Q_W, Q_O, and Q_P.

This section has not included siphon flow. Unless properly designed to withstand negative pressures, a conduit can be severely damaged by repeated occurrences of siphon flow. A brief explanation of siphon flow follows.

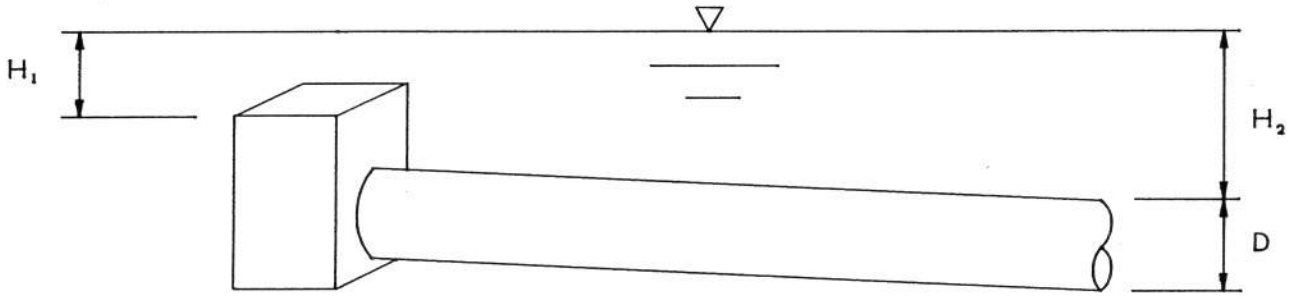
When air is purged from the discharge conduit, large, nearly instantaneous increases in the discharge occur. As the inlet becomes submerged, the high turbulence at the base entrains air and removes portions of the trapped air from the inlet. The pressure inside the inlet becomes negative and creates a pressure differential across the inlet. This is turn increases the discharge through the inlet. The

NAME OF DAM _____ DATE _____

(MO) COUNTY _____ ENGR _____

PIPE CALCULATIONS

ELEV.	H_1	Q_w	Q_o	H_2	Q_p	Q_{Total}



Weir Flow

$$Q_w = C_w L_w H_1^{1.5}$$

Orifice Flow

$$Q_o = C_o A_o \sqrt{2gH_1}$$

Full Pipe Flow

$$Q_p = A_p \sqrt{\frac{2gH_2}{\sum k + \frac{fL}{D}}}$$

C_w = _____ weir coefficient
L_w = _____ weir length of inlet, ft.
H_1 = _____ reservoir elev - inlet elev, ft
C_o = _____ orifice coefficient
A_o = _____ cross sectional area of inlet, ft^2
H_2 = _____ total head at pipe outlet, ft
$\sum k$ = _____ summation of inlet, bend and outlet losses
f = _____ Darcy Weisbach friction factor
A_p = _____ cross sectional area of pipe, ft^2
D = _____ diameter of pipe, ft^2
L = _____ length of pipe, ft

VALUES USED IN ANALYSIS

C_w =	
L_w =	
H_1 =	
C_o =	
A =	
H_2 =	
K =	
f =	
A_p =	
D =	
L =	

Figure 4.3 Conduit Spillway Calculation Form

increased discharge causes the driving head (the depth of water in the inlet) to increase and increases the discharge through the outlet conduit. During this process the unsteady nature of the flow causes waves to travel down the conduit. Usually a wave will seal the conduit. The large negative pressure created by the wave will cause the system to siphon and flow full. The discharge increases abruptly as the flow jumps from inlet to outlet control. Dynamic pressures are created throughout the system. Unless the reservoir rises rapidly, vortexes and other disturbances at the inlet will bring air into the system, break the siphon, and start the cycle over.

Sometimes the siphon action only partially occurs. As the system begins to siphon, the driving head is drawn down in the inlet. The wave, which had sealed the conduit, allows air back up the conduit. The driving head quickly rises and forces the trapped air in the inlet up and through the top "belching" out into the atmosphere. The water at the inlet quickly replaces the belched air as it passes out, and falls into the inlet as a slug causing dynamic pressure surges. These surges can cause damaging vibration throughout the system. Measures must be taken to avoid this problem and insure the proper operation of the system.

3. Culvert Spillways

A culvert spillway ordinarily consists of a simple culvert conduit placed through the dam or along the abutment, generally on a uniform grade with the entrance placed vertically or inclined. The culvert cross section may be round, rectangular, square, or some other shape. Usually, prefabricated pipe materials such as concrete or PVC are utilized.

The factors which combine to determine the nature of flow in a culvert spillway include slope, size, shape, length, roughness of the conduit barrel, and the inlet and outlet geometry. The combined effect of these factors determines the location of the control which in turn determines the discharge characteristics of the conduit. The location of the control dictates whether the conduit flows partly full or full and thereby establishes the head-discharge relationship.

Many nomographs and graphs have been developed for standard size pipe and box culverts. The staff of the Dam and Reservoir Safety Program uses Hydraulic Engineering Circular No. 10 published by the U.S. Department of Transportation (1972) to rate most culverts. Another good reference is Hydraulic Engineering Circular No. 5 published by the U.S. Department of Transportation (1965). Nomographs for determining flow in circular pipes are also included in the appendix of Design of Small Dams.

4. Flow under Bridges

In most cases, flow under bridges should be determined by performing a backwater analysis of the channel over which the bridge is located. However, in some cases, a single span bridge will pass flow as an orifice under low heads.

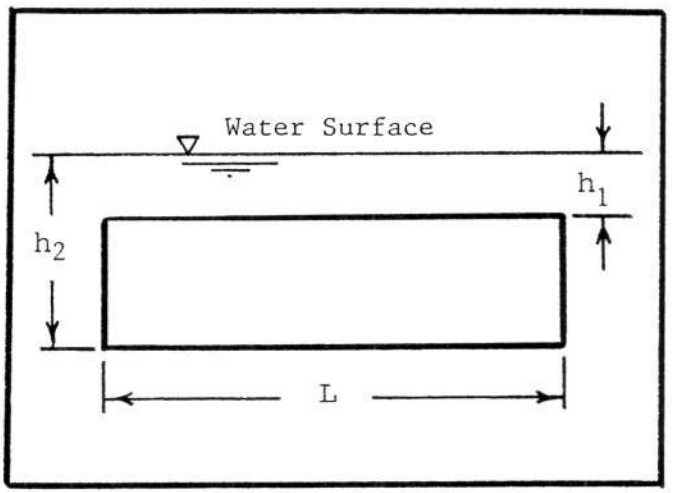


Figure 4.4 Flow Through a Rectangular Orifice

When the head on a vertical orifice is small in comparison with the height of the orifice, there is an appreciable difference between the theoretical discharge and the discharge given by Equation 4.5. Figure 4.4 shows a rectangular orifice of width L and height H. The respective heads on the upper and lower edges of the orifice are h_1 and h_2. Equation 4.7 gives the theoretical discharge for rectangular orifices.

$$Q_t = \frac{2}{3} L\sqrt{2g}(h_2^{1.5} - h_1^{1.5}) \qquad (4.7)$$

When Equation 4.5 is employed for orifices discharging under low heads, the deviation from the theoretical form of the formula must be corrected in the contraction coefficient. Equation 4.7 provides a better means of deriving the rating curve and does not require the estimation of a contraction coefficient.

B. Open Channel Hydraulics

Most dams have open channel principal spillways or emergency spillways which carry the majority of the flow during the design flood. It is important to know how to analyze the capacity of an open channel to determine if a dam will be overtopped. Many open channels have gentle slopes to prevent excessive erosion, but gentle slopes can cause backwater conditions in the channel. Depending on the flow rate, the control can move up or down the channel. Therefore, backwater analyses have to be be performed at several flow rates to determine the capacity of the channel.

TABLE 4.1

Geometric Elements of Trapezoidal Channels

Geometric Element	Symbol	Definition	Equation
Water Area	A	Cross sectional area of the flow normal to the direction of flow	$(b + zy)y$
Wetted Perimeter	P	Length of the line of intersection of the channel wetted surface with a cross sectional plane normal to the direction of flow.	$b + 2y\sqrt{1 + z^2}$
Hydraulic Radius	R	Ratio of the water area to its wetted perimeter.	$\frac{(b+zy)y}{b+2y\sqrt{1+z^2}}$
Top Width	T	Width of the channel section at the free surface.	$b + 2zy$
Hydraulic Depth	D	Ratio of the water area to the top width.	$\frac{(b+zy)y}{b+2zy}$
Section Factor	Z	Product of the water area and the square root of the hydraulic depth.	$\frac{[(b+zy)y]^{1.5}}{\sqrt{b+2zy}}$

Note y = depth of flow in channel

b = channel base width.

z = sideslope of channel, z:1.

An open channel is a conduit in which the flow has a free surface at all times. This contrasts with closed conduit or pipe flow in which the flow is completely enclosed. The free surface is subject to local atmospheric pressure, thus, the hydraulic grade line of a channel coincides with the water surface. This also has the effect of determining the location of the energy grade line since it is one velocity head $V^2/2g$ above the hydraulic grade line. The driving force which causes water to flow in open channels is the action of gravity along the slope of the channel.

Open channel flow may be classified and described in several ways. One such classification uses time as the criterion. Flow is considered to be steady if a parameter such as velocity or depth of flow at a point does not change over some time interval. The flow is unsteady if there is a change with respect to time.

Table 4.1 illustrates some of the common concepts used in open channel hydraulics. Channel sections are taken perpendicular to the direction of flow. The depth of flow, y, is the vertical distance from the lowest point of a channel section to the free surface. The water area, A, is the cross-sectional area of the flow normal to the direction of flow. The top width, T, is the width of the channel section at the surface. The wetted perimeter, P, is the length of the boundary in contact with the bottom and sides of the channel. The hydraulic radius, R, is the area divided by the wetted perimeter. The hydraulic depth, D, is the area divided by the top width, and is the characterictic length in open channels. Equations for these parameters are listed in Chow (1959) for various channel cross sections.

If space is used as the criterion, the flow is uniform if there is no change in velocity or depth along the length of a reach of channel. If a change does occur the flow is varied. Varied flow may be described as gradually or rapidly varied flow. In gradually varied flow, the rate of change of depth and velocity with respect to distance is relatively small so that some of the assumptions of uniform flow can be used for hydraulic calculations. Flow profiles caused by the backwater effect of a reservoir and changes in channel slope are examples of gradually varied flow.

A channel is prismatic if it has constant cross-section and slope over a reach; otherwise it is nonprismatic.

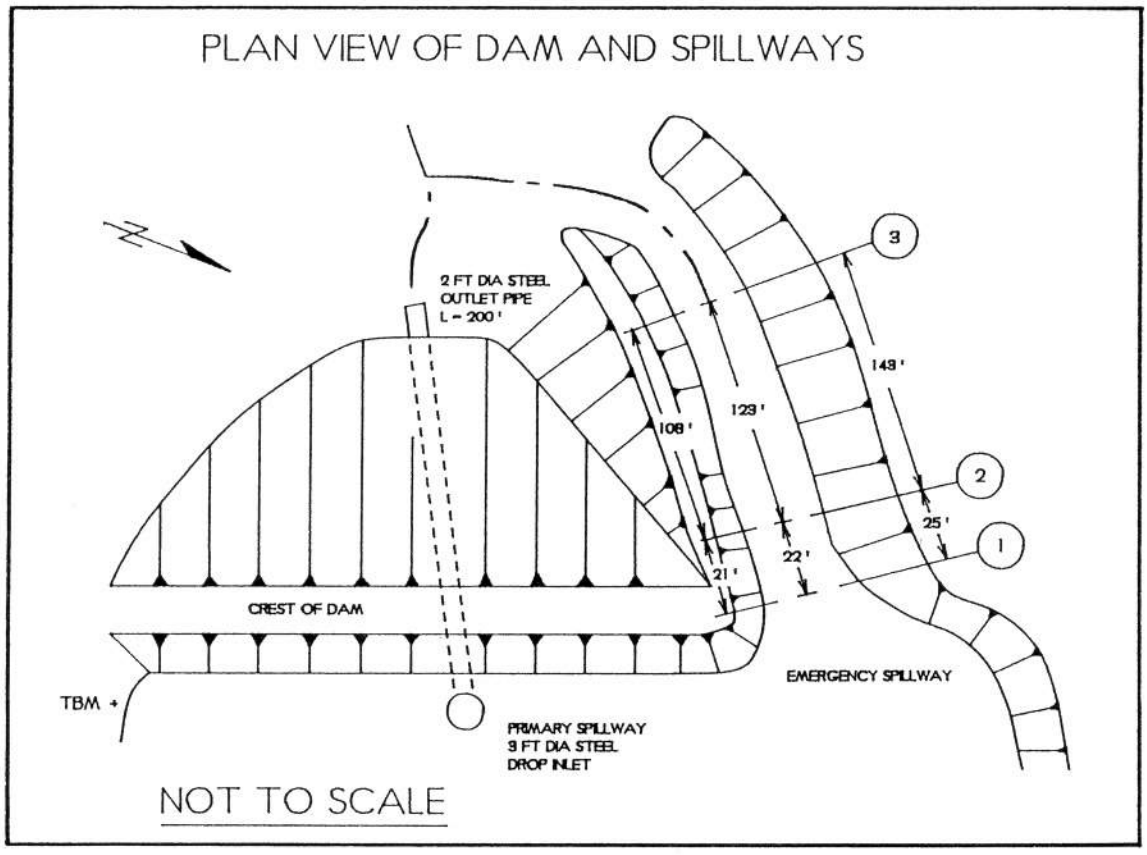


Figure 4.5 Plan View of an Earth Dam and Spillways

1. Water Surface Profiles

When water surface profiles are determined in an open channel spillway, the reservoir surface is assumed to be the elevation of the energy grade line at the upstream most cross section. In surveying an open channel spillway, the engineer should obtain cross sections at several locations both upstream and downstream of the assumed control section. This will ensure that sufficient information will be available to determine the approximate location of the control section. The results of a backwater analysis also allow the engineer to determine if the velocities in the channel are too high and if the training berm is high enough to prevent water from flowing outside the channel. Figure 4.5 shows a typical series of cross sections needed to perform backwater computations.

There are many methods available to compute water surface profiles in an open channel. The staff of the Dam and Reservoir Safety Program utilizes the U.S. Army Corps of Engineers (1982) HEC-2 Water Surface Profiles computer program to perform these calculations. The program calculates water surface profiles for steady gradually varied flow in natural or man-made channels. Both subcritical and supercritical flow profiles can be computed. The effects of various obstructions such as bridges, culverts, weirs, and structures in the channel may be considered in the computations. The computational procedure is based on the solution of the one-dimensional energy equation with energy loss due to friction evaluated with Manning's equation. The computational precedure is generally known as the Standard Step Method.

Figure 4.6 illustrates a short channel reach of length Δx which will be used to explain the basis of the standard step method. Equating the total heads at the two end sections 1 and 2, Equation 4.8 is produced:

$$S_o \Delta x + y_1 + \alpha_1 \frac{V_1^2}{2g} = y_2 + \alpha_2 \frac{V_2^2}{2g} + S_f \Delta x, \qquad (4.8)$$

where

S_O = slope of the channel bottom;
Δx = increment of channel reach;
y = depth of flow;
V = velocity of flow;
g = acceleration of gravity, 32.2 fps^2;
α = energy coefficient; and
S_f = energy gradient.

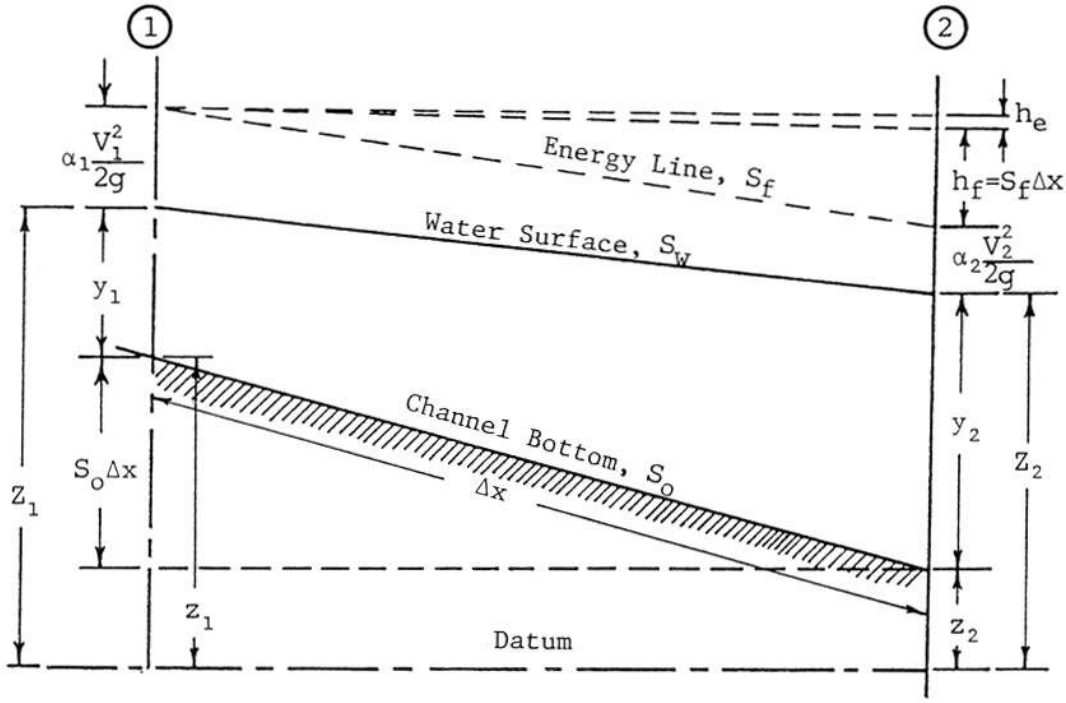


Figure 4.6 Energy in Gradually Varied Open Channel Flow

The water surface elevations at the two end sections are referenced to a horizontal datum as

$$Z_1 = S_o \Delta x + y_1 + z_2 \qquad (4.9)$$

and

$$Z_2 = y_2 + z_2 \qquad (4.10)$$

The friction loss is

$$h_f = S_f \Delta x = \frac{1}{2}(S_{f1} + S_{f2})\Delta x. \qquad (4.11)$$

For ease of computation, the friction slope, S_f, is taken as the average of the slopes at the two end sections, or $\overline{S}_f$. Substituting Equations 4.9, 4.10, and 4.11 into Equation 4.8 yields

$$Z_1 + \alpha_1 \frac{V_1^2}{2g} = Z_2 + \alpha_2 \frac{V_2^2}{2g} + h_f + h_e, \qquad (4.12)$$

where

α = energy coefficient; and
h_e = eddy losses.

The eddy loss depends mainly on the velocity head change and may be expressed as a part of it, or $k\left(\Delta\alpha \frac{V^2}{2g}\right)$ where k is a coefficient. For gradually converging and diverging reaches, k = 0 to 0.1 and 0 to 0.2, respectively. For abrupt expansions and contractions, k is about 0.5.

The total heads at the two end sections are

$$H_1 = Z_1 + \alpha_1 \frac{V_1^2}{2g} \qquad (4.13)$$

$$H_2 = Z_2 + \alpha_2 \frac{V_2^2}{2g} \qquad (4.14)$$

Substituting into Equation 4.12 yields

$$H_1 = H_2 + h_f + h_e \qquad (4.15)$$

Equation 4.15 is the basic equation which is used to develop the procedure used in the standard step method. The standard step computation can be arranged in tabular form and solved as shown in Table 4.2.

The backwater computations must always be carried upstream if the flow is subcritical and downstream if it is supercritical. In computing a flow profile, the following information is generally required:

- The discharge for which the flow profile is desired.
- The water surface elevation at the control section. If this is not available, the comutation may start from an

TABLE 4.2

Standard Step Method of Computation

Station (1)	Z (2)	y (3)	A (4)	V (5)	$\alpha\frac{V^2}{2g}$ (6)	H (7)	R (8)	$R^{\frac{4}{3}}$ (9)	S_f (10)	$\overline{S}_f$ (11)	Δx (12)	h_f (13)	h_e (14)	H (15)

Before the computations begin, the flow rate must be specified as well as the channel roughness, n; slope, S_o; and energy coefficient, α.

Col. 1: Identify channel cross section by station number

Col. 2: Water surface elevation at the station. A trial value is first entered in this column; this will be verified or rejected on the basis of the computations made in the remaining columns of the table. For the first step, this elevation must be given or assumed. When the trial value in the second step has been verified, it becomes the basis for the verification of the trial value in the next step, and so on.

Col. 3: Depth of flow in feet, corresponding to the water surface elevation in column 2.

Col. 4: Water area corresponding to y in column 3.

Col. 5: Mean velocity equal to the given discharge, Q, divided by the water area in column 4.

Col. 6: Velocity head in feet, corresponding to the velocity in column 5.

Col. 7: Total head computed by Equation 4.13, equal to the sum of Z in column 2 and the velocity head in column 6.

Col. 8: Hydraulic radius in feet, corresponding to y in column 3.

Col. 9: Four-thirds power of the hydraulic radius.

Col. 10: Friction slope computed by $S_f = \frac{n^2V^2}{2.22R^{4/3}}$ with V from column 5 and $R^{4/3}$ from column 9.

Col. 11: Average friction slope through the reach between the sections in each step, approximately equal to the arithmetic mean of the friction slope just computed in column 10 and that of the previous step.

Col. 12: Length of the reach between the sections, equal to the difference in station numbers between the stations.

Col. 13: Friction loss in the reach, equal to the product of the values in columns 11 and 12.

Col. 14: Eddy loss in the reach, equal to zero.

Col. 15: Elevation of the total head in feet. This is computed by Equation 4.15, that is, by adding the values of h_f and h_e in columns 13 and 14 to the elevation at the lower end of the reach, which is found in column 15 of the previous reach. If the value so obtained does not agree closely with that entered in column 7, a new trial value of the water-surface elevation is assumed, and so on, until agreement is obtained. The value that leads to agreement is the correct water-surface elevation. The computation may then proceed to the next step.

assumed elevation at a section far enough away from the initial section through which the profile is desired.

- The geometric elements at various channel sections along the reach for all depths of flow within the range expected. Cross sections and reach length between are the two primary elements.

- The channel roughness and losses at each section.

Chow (1959) and Henderson (1966) provide an excellent discussion of the standard step method and procedures to compute backwater profiles.

One of the most difficult assessments that an engineer must make in the performance of a backwater analysis is the estimation of the surface roughness of the channel. Manning's n is a measure of surface roughness and is largely dependent on the material of which the channel boundaries are composed. There are several other factors which affect the value of n, including vegetation, channel irregularity, alignment, silting, scouring, obstructions, size and shape of channel, and depth of flow. Values of n are usually selected from tables for various materials or from pictures of channel for which values of n have been determined empirically. Chow (1959) and the United States Geological Survey (1967) are excellent references which should be used in estimating channel roughness. The following table can be used to estimate roughnesses for channels and closed conduits.

SURFACE	Min. n	Max. n
PVC Pipe	.010	.012
Concrete Pipe	.012	.015
Cast Iron Pipe	.013	.017
Grass Lined Channels	.020	.040
Rock Cut Channels, Smooth	.025	.040
Rock Cut Channels, Irreg.	.030	.045
Natural Streams	.025	.150

Vegetated open channel spillways usually consist of an inlet channel, a control section, and an exit channel. Subcritical flow occurs in the inlet channel and the flow is usually supercritical in the exit channel. Vegetated open channel spillways are typically trapezoidal in cross-section and are protected from erosion by a grass cover. While erosion damage is normally considered to be a maintenance related deficiency, it becomes a safety problem in cases where failure of the discharge channel will cause the flow to impinge on the toe or slopes of the embankment. As a general guideline, channels can be expected to suffer erosion damage when velocities exceed 8 fps.

The amount of erosion that will occur in a channel depends upon the characteristics of the soil, the type and density of the vegetation cover, the discharge velocity, and the duration and frequency of use. To minimize erosion, vegetated open channel spillways should be designed with horizontal or adverse sloped inlet channels and control sections that are located away from the dam. The anticipated average use of a vegetated open channel spillway should be kept to a minimum; it is preferable that the spillway be designed to carry flows only in excess of the 100-year event. In highly erodible soils, concrete sills or weirs should be constructed to stop headward erosion and prevent failure of the spillway.

All spillway flows should be confined to the channel with training berms or levees. Training berms must be high enough to contain the peak flow during the spillway design flood.

2. Critical Flow Computations

When an ogee spillway or a weir is located adjacent to the reservoir, the spillway rating curve can be determined by analyzing critical flow in an open channel. Critical flow is defined as the state of flow at which the specific energy, $y + \frac{V^2}{2g}$, is a minimum for a given discharge, Q. Using Equation 4.16, discharge rates can be computed at various values of critical depth.

$$Q = \sqrt{\frac{A^3 g}{T}}, \qquad (4.16)$$

where

Q = flow rate in cfs;
A = area of flow at critical depth in ft^2;
g = acceleration of gravity, 32.2 ft/sec^2; and
T = top width of water surface.

In order to develop a spillway rating curve, the reservoir elevation, $ELEV_{res}$, must be computed at each value of critical depth, y_c. This can be accomplished using Equation 4.17:

$$ELEV_{res} = ELEV_{sp} + y_c + \frac{V_c^2}{2g}, \qquad (4.17)$$

where

$ELEV_{res}$ = Elevation of the reservoir;
$ELEV_{sp}$ = Spillway crest elevation;
y_c = critical depth in feet; and
$\frac{V_c^2}{2g}$ = velocity head.

The only unknown parameter in Equation 4.17 is the velocity head, $\frac{V_c^2}{2g}$. It can be determined by using the continuity equation to compute the velocity at each value of critical depth, $V_c = \frac{Q}{A}$

Equation 4.16 should only be used to rate control structures such as weirs that will not become submerged by downstream conditions. It is always advisable to perform a backwater analyses of the discharge channel when there are questions about the channel's capacity and erosion resistance, or if training berms must be evaluated.

C. Reservoir Routing

Reservoirs can be routed by any number of level pool techniques. The basic requirements include reservoir elevation-storage information and a spillway rating curve. The beginning reservoir elevation should be the water storage elevation (normal pool) as defined by 10 CSR 22-1.020(62).

After the inflow hydrograph has been computed, the storm hydrograph must be routed through the reservoir. The staff of the Dam and Reservoir Safety Program uses the modified Puls routing method described by Chow (1964). This method assumes an invariable discharge-storage relationship and neglects the variable slope occurring during the passage of a flood wave. It is a satisfactory method for reservoir routing but should not be used for channel routing when unsteady flow conditions exist.

Modified Puls routing requires the solution of the continuity equation which can be expressed as

$$I - O = \frac{\Delta S}{\Delta t}, \qquad (4.18)$$

where

I = inflow into the reservoir;
O = outflow from the reservoir; and
S = water stored in the reservoir.

Equation 4.18 is exact but its application to practical problems involves approximations. The basic assumptions are that the water surface in the reservoir is level at all times and that the average of the inflow and outflow at the beginning and ending of a routing period are equal to the average flow during the period. Using subscripts 1 and 2 to denote the beginning and ending of a routing period gives

$$\frac{I_1 + I_2}{2} - \frac{O_1 + O_2}{2} = \frac{S_2 - S_1}{\Delta t} \qquad (4.19)$$

Arranging Equation 4.19 so that all known values are on the left yields

$$\frac{I_1 + I_2}{2}\Delta t + S_1 - \frac{O_1 \Delta t}{2} = S_2 + \frac{O_2 \Delta t}{2} \qquad (4.20)$$

The assumption that $(I_1 + I_2) / 2$ equals the average inflow during a routing period implies that the inflow hydrograph varies linearly over the time step, Δt. Thus the controlling factor in selecting the routing period Δt is that it be sufficiently short so that this assumption is not seriously violated. The routing period should never be greater than the time of travel through the reservoir and should be chosen to ensure that the peak of the inflow hydrograph will be considered. As a rule of thumb, the routing period should be long enough to consider at least four inflows on the rising limb of the inflow hydrograph.

The two relationships that must be developed to solve Equation 4.20 involve the outflow from the reservoir and storage within the reservoir. This section will consider only storage in the reservoir. The previous sections in this chapter addressed the issue of outflow, which is determined by rating both closed conduit and open channel spillways.

Like basin area, reservoir areas can be determined from a topographic map using a planimeter. The reservoir's water surface area should be determined at each successive contour from the toe to the top of the dam. For dams that have been in existence several years, contour lines may not extend below the normal pool elevation. In this case, only reservoir volumes above normal pool can be computed. Hydrographic surveys are useful to determine the amount of silt in the reservoir but they are not required to perform reservoir routing.

The volume between successive contours can be determined by either of two methods: the average end area method or the conic method. The average end area method averages the area between two successive contours and multiplies the result times the change in elevation as shown in Equation 4.21

$$\Delta Vol = \left(\frac{A_n + A_{n+1}}{2}\right)(E_{n+1} - E_n), \qquad (4.21)$$

where

ΔVol = volume of storage between elevations E_n and E_{n+1};
A_n = water surface area at elevation E_n;
A_{n+1} = water surface area at elevation E_{n+1}; and
E = elevation.

The conic method can be used to compute reservoir volume from surface area versus elevation data as follows:

$$\Delta Vol = (E_{n+1} - E_n)(A_n + A_{n+1} + \sqrt{A_n A_{n+1}})$$

After the reservoir volumes have been computed, a graph of elevation versus storage is developed. Using this graph and the spillway rating curve, a graph of discharge versus storage is created as shown in Figure 4.7. Each point on the curve represents reservoir storage and outflow at a given elevation. Figure 4.8 is a plot of outflow, O, versus $\left(S + \frac{1}{2}O\Delta t\right)$. This graph is obtained by adding to the abscissa of the storage curve, Figure 4.7, one half of the value of $(O\Delta t)$. At the beginning of a routing period, the known values are the inflows for periods 1 and 2 and the outflow at period 1. The goal is to determine the outflow for period 2.

The modified Puls routing procedure involves the following steps:

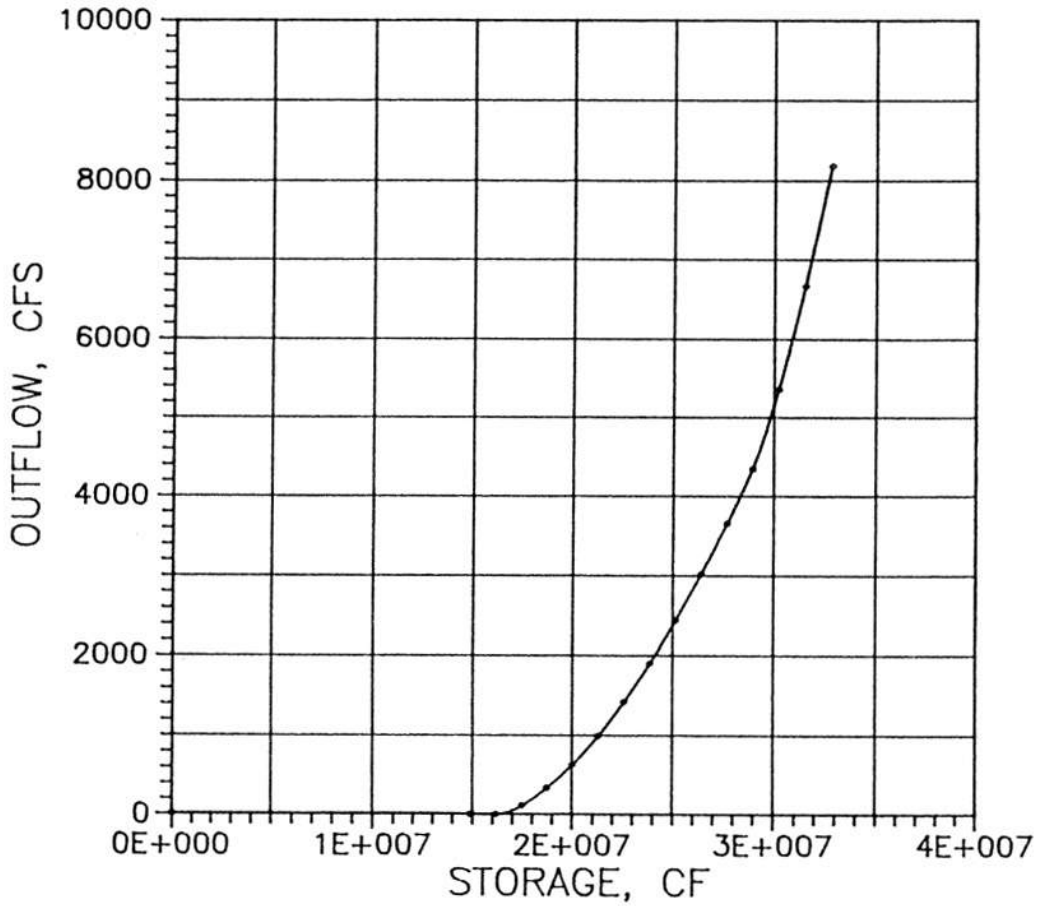


Figure 4.7 Storage Versus Outflow Curve for a Reservoir

Step 1 Compute $(I_1 + I_2)/2$, the average inflow.

Step 2 For an initial outflow, O_1, the storage S_1 is obtained from the storage versus outflow curve, Figure 4.7.

Step 3 Compute the quantity $\left(S_1 - \frac{1}{2}O_1\Delta t\right)$.

Step 4 Using Equation 4.18, determine the quantity $\left(S_2 + \frac{1}{2}O_2\Delta t\right)$ by adding the average inflow plus the quantity $\left(S_1 + \frac{1}{2}O_1\Delta t\right)$.

Step 5 Determine the outflow O_2 corresponding to $\left(S_2 + \frac{1}{2}O_2\Delta t\right)$ from Figure 4.8.

Several iterations of these computations are performed to construct the outflow hydrograph which is a plot of time versus outflow, O_2. The maximum water surface elevation during the design flood is then determined from the peak rate of outflow.

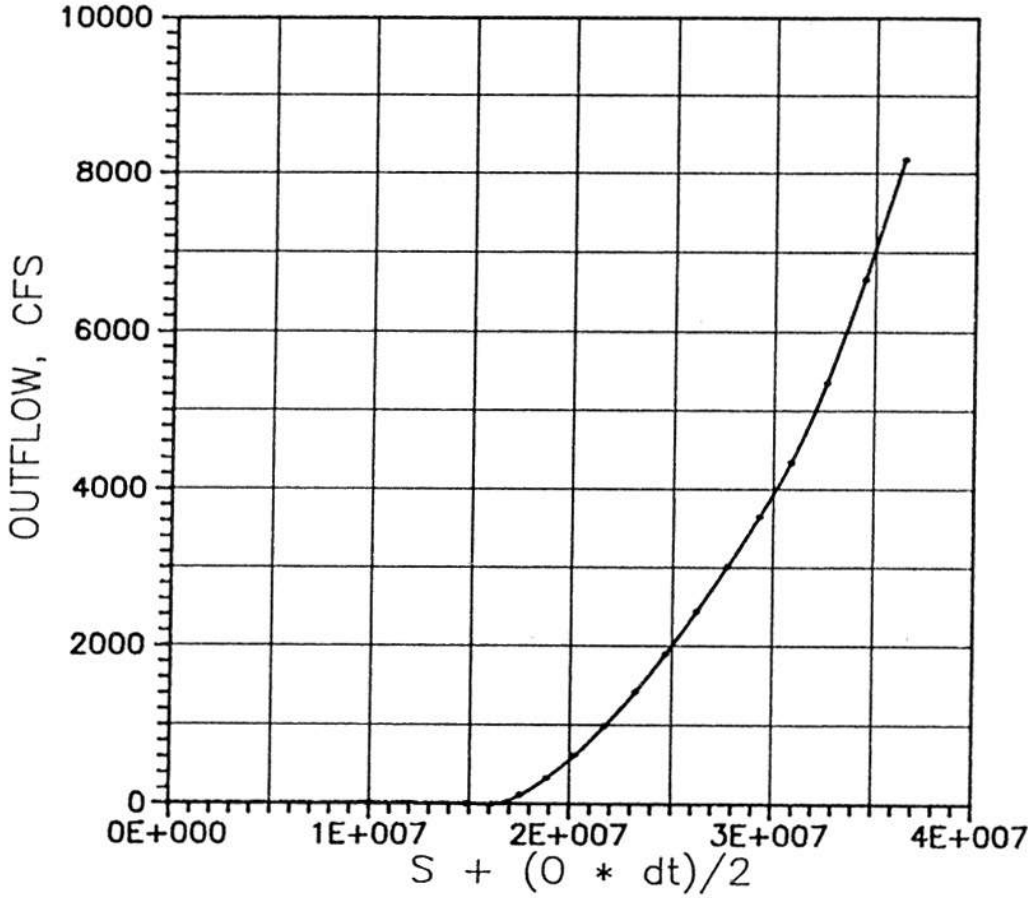


Figure 4.8 S + (O · dt)/2 Versus Outflow Curve for A Reservoir

CHAPTER V

GEOTECHNICAL CONSIDERATIONS

The geotechnical considerations in this chapter will focus on earth, rockfill and tailings dams. Figure 5.1 illustrates the differences between the three types of dams.

Rolled earthfill dams are constructed in successive mechanically compacted layers. They can be constructed as homogeneous embankments or as zoned dams with an impervious core. Homogeneous dams are constructed entirely or almost entirely of a single embankment material. They are so named to distinguish them from zoned dams, which contain different materials in different parts of the embankment. The downstream slope of a homogeneous dam on an impervious foundation will theoretically develop seepage to a height of roughly one-third the depth of the reservoir pool. Sometimes, homogeneous and zoned embankments are constructed with internal drains to control seepage. Chimney, blanket and trench drains are three of the more common types of internal drains used in Missouri. Internal drains serve two important purposes. They control seepage and reduce the pore pressure in the downstream portion of the dam thereby improving the stability of the dam.

Rockfill dams usually have an impervious core which is flanked by zones of material considerably more pervious. The pervious zones enclose, support, and protect the impervious core; the upstream pervious zone affords stability against rapid drawdown; and the downstream pervious zone acts as a drain to control the line of seepage. To prevent internal erosion of the impervious core, a filter is placed between the core and the downstream rock shell.

Tailings or industrial water retention dams are used by mining companies to store waste rock from mining. All tailings dams greater than 35 feet in height are regulated under the dam safety law. The three types of tailings dams currently in existence in Missouri are lead, barite, and iron tailings. Each of these dams typically includes a clay starter dam which is normally constructed as a homogeneous earthfill embankment.

Lead tailings used in dam construction are typically ground limestone and dolomite. The silty sand tailings have a gradation ranging from a #40 to a #200 sieve. On-dam cycloning (Vick, 1983) is the primary method used to disposit lead tailings in Missouri. Underflow sand from each hydro-cyclone is discharged toward the embankment face, and overflow slimes are discharged into the impoundment. A wide zone of slimes adjacent to the upstream slope of the dam helps restrict the flow of seepage through the dam.

Barite tailings used in dam construction consist of well graded gravel. Barite slimes have low permeability and consist of red and dark brown clay.

Iron tailings dams are built with crushed rock that ranges in size from 1/4 to 5/8 inch. In order for iron tailings dams to retain water, a clay blanket or an impermeable liner must be placed on the upstream slope.

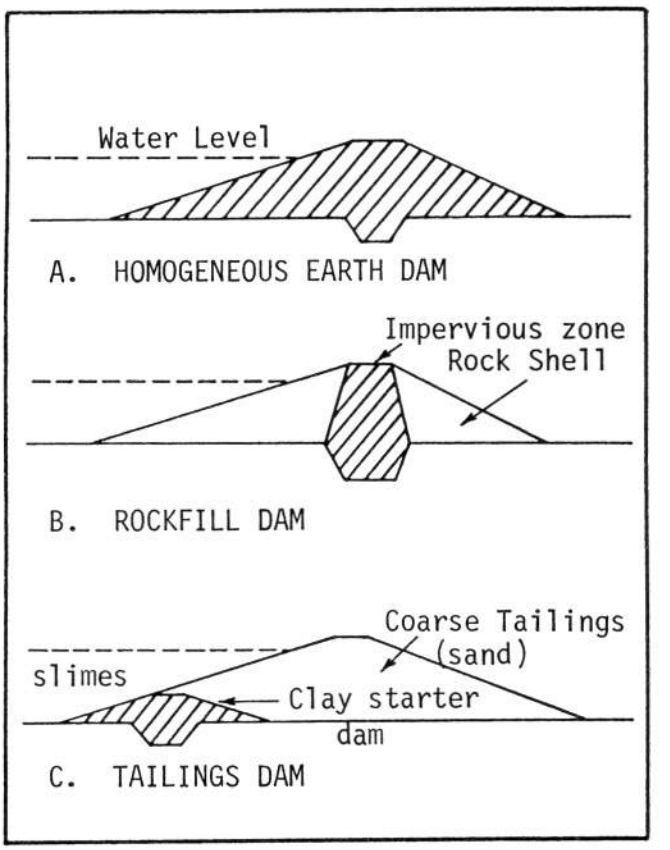


Figure 5.1 Types of Dams in Missouri

Tailings dams can be constructed by the upstream, centerline and downstream methods as shown in Figure 5.2.

The geotechnical analysis of industrial water retention dams involve seepage, slope stability and seismic response computations. The design for all new dams built in Missouri after August 13, 1981 must include a geotechnical analysis to show that the dam will meet the criteria in 10 CSR 22-3.020. A geotechnical analysis is not required for dams that were in existence prior to August 13, 1981 unless the height, slope or reservoir elevation is being modified.

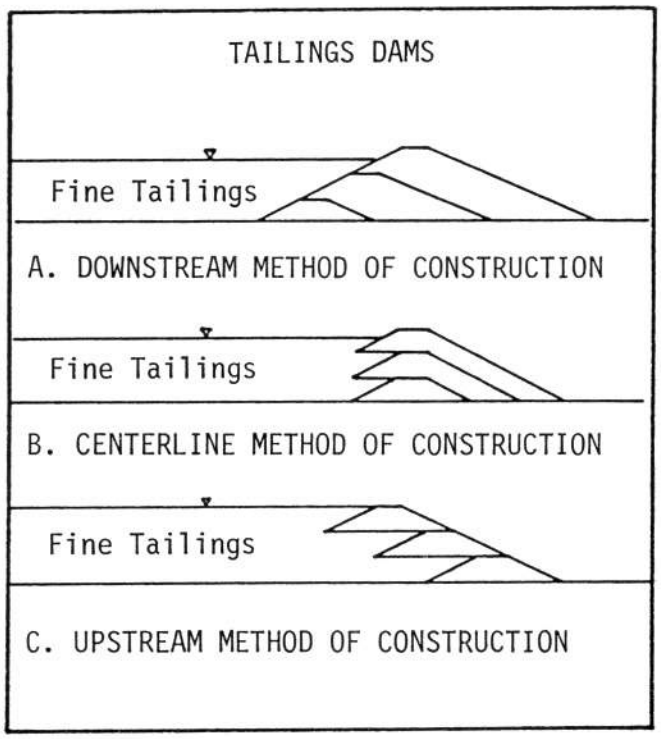


Figure 5.2 Methods of Constructing Tailings Dams

A. Soil Classification

Knowledge of soil classification, including typical engineering properties of soil groups, is essential when investigating earth materials or foundations for structures. Soil classification can be used to estimate engineering characteristics of soils for use in the analysis of small dams.

The Unified Soil Classification System is recommended for use in the classification of soils. Figure 5.3, the Unified Soil Classification Chart, is the basis for soil classification under this system.

In addition to proper classification, it is important to include an adequate description of the soil in reports or logs of explorations. The classification chart contains the information required for describing soils, citing several examples.

B. Foundation Cutoffs

Many dam sites have a foundation consisting of alluvial deposits of permeable sand and gravel, silt, or weathered rock at or near the surface with an impervious (less permeable) stratum of rock, clay, or shale at a greater depth. For these sites, a positive cutoff is recommended to assure a successful and stable dam. The cutoff should intersect the impervious stratum and be an extension of the core of the embankment. A positive cutoff is particularly important where the water in storage is used for irrigation or water supply.

Where a positive cutoff is impractical because of the depth to an impervious stratum, a partial cutoff may provide foundation stability and reduce seepage losses to acceptable levels. Regardless of the foundation conditions, the only way to determine the economical feasibility of a positive cutoff or partial cutoff is to make a seepage analysis and water balance.

C. Foundation and Embankment Drainage

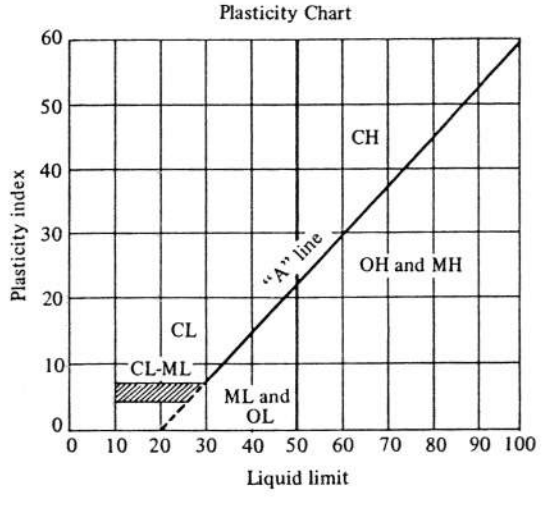
The impervious portion of an earthfill dam provides resistance to seepage, which creates the reservoir. Soils vary in permeability, and even the tightest clays can transmit seepage. Therefore, seepage control is a major concern in dam design. Filter and drainage systems must have adequate capacity but still control the movement of fine grained soil particles through the embankment. Internal erosion of fine grained soil can lead to a condition known as "piping" in which a conduit or pipe forms within the embankment. If allowed to continue, the erosion can eventually migrate upstream to the reservoir and cause a total failure of the dam.

The movement of reservoir water through the dam depends on the reservoir level, the degree of permeability of the embankment material in the horizontal and vertical directions, the amount of remaining pore-water pressures caused by compressive forces during construction, and the distance over which the seepage travels. The upper surface of seepage is called the phreatic surface; in a cross section, it is referred to as a phreatic line. Although the soil may be saturated by capillarity above this line, giving rise to a "line of saturation," seepage is limited to the portion below the phreatic line.

Drains are included in embankments and foundations for two basic reasons: to prevent piping by controlling migration of soil particles under seepage flow; and to control pressure build-up by allowing free drainage of seepage flow. There are no hard and fast rules for selecting a margin of safety for the capacity of internal drains. Cedergren (1977), recommends that drains be designed to carry at least ten times as much seepage as expected due to difficulty in estimating permeability of the drain material and seepage rates. Judgement is required and should be related to past experience with similar materials and an evaluation of the data obtained during the site investigation and testing program.

In recent years, many engineers have opted to use geotextiles as filters for granular drains. Geotextiles can be either woven or nonwoven. They are used in subsurface drainage systems as a permeable separator to keep soil

Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria	
Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 per cent: GW, GP, SW, SP. More than 12 per cent: GM, GC, SM, SC. 5 to 12 per cent: *Borderline* cases requiring dual symbols[b]	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW
		Gravels with fines (Appreciable amount of fines)	GM[a] d / u	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits below "A" line with P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW
		Sands with fines (Appreciable amount of fines)	SM[a] d / u	Silty sands, sand-silt mixtures	Atterberg limits above "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7	
Fine-grained soils (More than half material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
			OL	Organic silts and organic silty clays of low plasticity		
	Silts and clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity, organic silts		
	Highly organic soils		Pt	Peat and other highly organic soils		



[a]Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterberg limits; suffix d used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u used when L.L. is greater than 28.
[b]Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC, well-graded gravel-sand mixture with clay binder.

Figure 5.3 Unified Soil Classification Chart (ASTM D-2487)

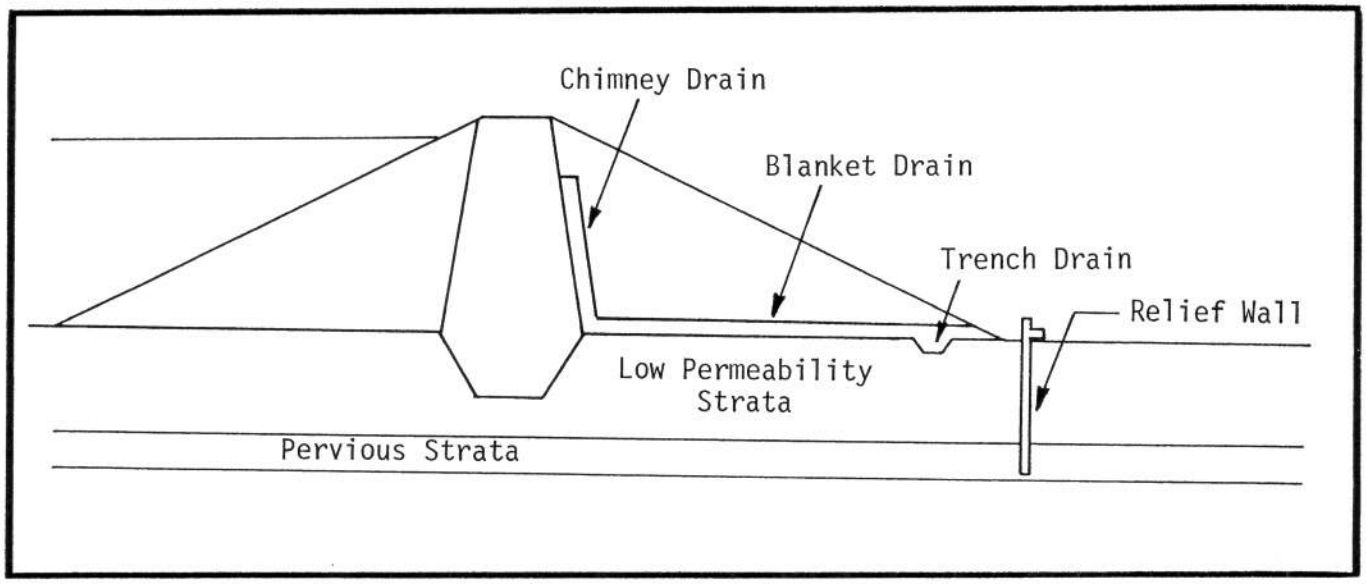


Figure 5.4 Types of Drains

out of the drainage media and permit water to pass freely. Permittivity (capacity to pass water) and pore size (opening size) are critical characteristics of geotextiles. Nonwoven geotextiles are frequently used in dam construction because of their high flow capacity and small pore size. Care should always be taken to assure an effective installation.

Four types of drains will be discussed: chimney drains, blanket drains, trench drains and relief wells. These are shown in Figure 5.4. It should be noted that the selection of the drainage media is a very important consideration. Crushed limestone should not be used. Instead, river run gravel or sand (quartz and chert material) should be selected to ensure the long term success of the drain.

1. Chimney Drains

Chimney drains are primarily interceptors that provide positive control of embankment seepage. With a chimney drain, water that percolates through the soil is intercepted to prevent seepage in the materials downstream from the drain. Chimney drains are applicable where the downstream embankment material cannot be allowed to become saturated and where the horizontal permeability of the fill is significantly higher than the vertical permeability. It may be more economical to place poor materials in a "random fill" zone downstream from a chimney drain than to waste them. Chimney drains are also applicable where embankment materials are susceptible to cracking.

2. Blanket Drains

Horizontal blanket drains occasionally are used in new dams in Missouri. They are primarily used to intercept foundation seepage and prevent saturation of the dam. Horizontal blanket drains are applicable where there is no significant difference between the vertical and horizontal permeability of the embankment or the foundation; where bedrock is pervious (if the drain is placed directly on bedrock); or where a good bond cannot be obtained between bedrock and the embankment and underseepage is a problem.

3. Trench Drains

Trench drains are used more frequently then the other drain types in both new dams and modifications to existing dams. They can be used to provide drainage to the foundation, embankment or abutments. Trench drains are typically excavated with a back hoe and lined with geotextile filter fabric. River run gravel works well as a drainage medium.

Prefabricated drainage composites can also be used as a trench drain, especially in modifications to existing dams. They provide consistent in-place drainage and can reduce the material cost, installation time, and design complexity in some applications. Prefabricated drainage composites typically are two-component materials consisting of a three-dimensional drain core or net with a fabric attached. Water passes through the fabric and into the core. The core acts as a collector and transporter of seepage while the fabric acts as a filtering medium.

4. Relief Wells

Relief wells are generally located near the downstream toe of an embankment. They are particularly adapted for control of pressures from confined and alluvial aquifers

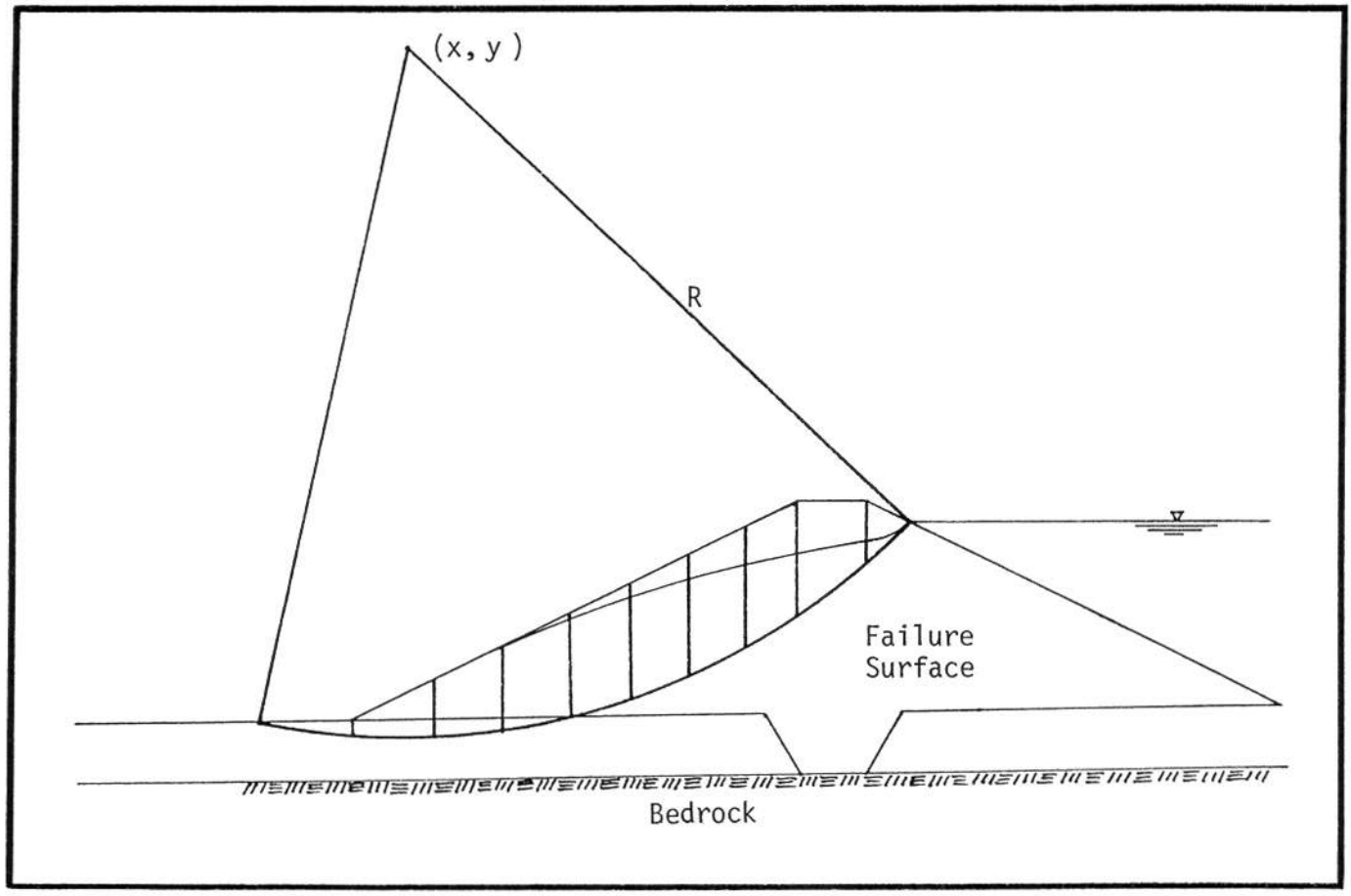


Figure 5.5 Circular Failure Surface in an Earthfill Dam

that are too deep to be drained with foundation drains. They are often used in conjunction with other types of drains.

Drain outlets are needed to conduct the accumulated seepage from all internal drains to a controlled discharge point. PVC pipe works well and provides the dam owner with a outlet location at which to measure the seepage rate.

Two excellent discussions on the subject of internal drains and filters were written by Sherard, Dunnigan, and Talbot (1984).

D. Structural Stability

The potential for failure from sliding, sloughing and rotation must be analyzed, documented and incorporated in the design of all new dams. Embankment and foundation design and geotechnical exploration should be consistent with the complexity of the site and the potential for failure. Anticipated settlement, seepage, and cracking should be considered and documented.

The slope stability criteria used in this manual is that contained in 10 CSR 22-3.020, Tables 1, 3, and 4. Various procedures are available for calculating the factors of safety of embankment sections. The basic methods include the circular arc and the sliding wedge methods.

The staff of the Dam and Reservoir Safety Program use the ICES LEASE and STABL computer programs to perform slope stability analyses. Both programs employ the simplified Bishop Method which divides potential failure surfaces into slices for analysis. Figure 5.5 depicts a circular failure surface in an embankment dam. The factor of safety is the ratio of the moment of shear strength (resisting forces) along the failure surface to the moment of the weight of the failure mass (driving forces). To determine the minimum factor of safety for a dam requires the analysis of several failure surfaces.

The simplified Bishop Method uses a basic moment equilibrium equation for the summation of forces on each

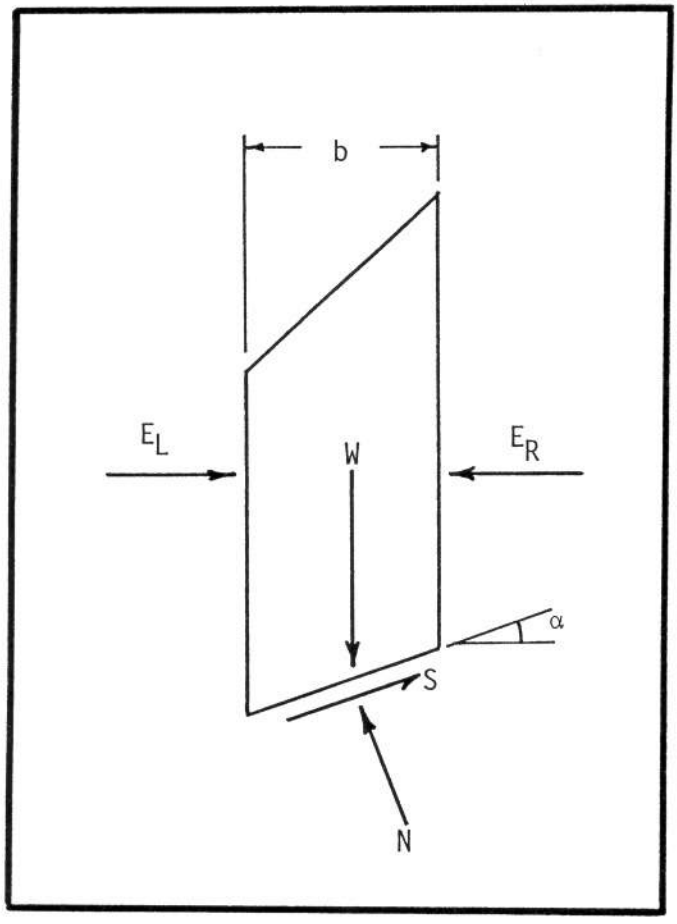


Figure 5.6 Free Body Diagram - Simplified Bishop Method

slice as shown in Figure 5.6. Symbols and definitions are given below.

W = total weight of slice, soil plus water;
b = width of slice;
E_L = Force acting on left boundary of slice;
E_R = Force acting on right boundary of slice;
S = resultant of friction and cohesion forces;
N = effective normal force;
α = angle between the base of each slice and horizontal.

The method sums the vertical components of the forces. The side forces are assumed to be equal, horizontal, and colinear. The factor of safety is computed by Equation 5.1:

$$F = \frac{\sum\left[c + \left(\frac{W}{b} - u\right)\tan\phi\right]b\left(\frac{1}{M_\alpha}\right)}{\sum(W\sin\alpha)}, \qquad (5.1)$$

where

c = cohesion of soil at the bottom of the slice;
W = total weight of slice, soil plus water;
b = width of slice;
u = hydrostatic pressure on the bottom of the slice;
ϕ = angle of frictional resistance of soil;
$M_\alpha = f(F) = \left[1 + \frac{\tan\alpha\tan\phi}{F}\right]\cos\alpha$; and
α = angle between the base of each slice and horizontal.

Except for M_α, all of the parameters in Equation 5.1 are based on the physical characteristics of the failure surface and the soil. Once these parameters are determined, Equation 5.1 can be solved iteratively. This is necessary because the factor of safety term, F, is on both sides of the equation.

A trial factor of safety value can be computed from Equation 5.2:

$$F_1 = \frac{\sum(cb + W\tan\phi)}{\sum(W\sin\alpha)} \qquad (5.2)$$

The parameter, F_1, is used to calculate M_α and solve Equation 5.1. The result of Equation 5.1 is used in the next iteration and the process is repeated until convergence occurs. Lambe and Whitman (1969), Perloff and Baron (1976), and Huang (1983) have provided a good description of the simplified Bishop procedure in detail.

Analyses are to be made for the loading conditions that are most critical during the design life of the structure. For new dams, the following conditions must be considered: (1) end of construction; (2) steady seepage - full reservoir; (3) steady seepage - maximum reservoir; (4) sudden drawdown; and (5) earthquake. When modifications are made to the slopes, height or water storage elevation of dams built before August 13, 1981, only the steady seepage and sudden drawdown cases must be analyzed.

Selection of the soil strength parameters is the most important facet of the slope stability analysis. Unlike steel and concrete, soil strengths vary widely, depending on the type and location of the soil. When testing a soil, the soil strength depends upon consolidation (effective confining) pressure, drainage during shear, volumetric history, disturbance, and strain rate. In most cases, the strength of a soil can be expressed by Equations 5.3 and 5.4:

$$\bar{\tau} = \bar{c} + (\sigma - u)\tan\bar{\phi}, \qquad (5.3)$$

where

$\bar{\tau}$ = effective shear stress on the surface at failure;
$\bar{c}$ = cohesion intercept based on effective stresses;
σ = total normal stress acting on the failure surface;
u = pore water pressure;
$\bar{\phi}$ = friction angle based on effective stresses;

and

$$\tau = c + \sigma \tan\phi, \qquad (5.4)$$

where

τ= shear stress on the surface at failure;

c= cohesion intercept;

σ= total normal stress acting on the failure surface; and

ϕ= friction angle.

As depicted in Equations 5.3 and 5.4, two basically different approaches to the stability problem can be used by the engineer: the effective stress method and the total stress method. Drained strength parameters are used in an effective stress analysis while undrained strength parameters are used in a total stress analysis. According to Sherard et. al. (1963), there are two advantages of the effective stress method: the analysis is carried out with a somewhat more fundamental definition of the shear strength; and pore pressures assumed in the design can later be compared with those which develop in the dam and foundation as measured by piezometers.

In preparation for performing the stability analysis, the engineer should develop a cross section of the dam at the maximum section. The cross section should show all soil zones and their respective properties. Internal drains should be clearly delineated. The phreatic surface must be estimated using analytical methods or piezometric data. The estimated phreatic surface should be depicted on the cross section.

1. End of Construction Case

In the end of construction case, both the upstream and downstream slopes of a dam must be examined for stability. The most conservative condition assumes that the compacted soil does not consolidate under the weight of the soil layers above it and is sheared before drainage can occur. In reality, some dissipation of pore pressures occurs, with an increase in strength of the soil. Estimation of such dissipation of pressure with gain in strength is inexact. A pore pressure instrumentation system may be installed to verify the dissipation of pressures; however this is generally not economically feasible for small to medium sized dams. Soil strength values for the instantaneous end of construction condition can be obtained from the unconsolidated-undrained (UU) triaxial test.

In analyzing the end of construction factor of safety for the downstream slope, the staff of the Dam and Reservoir Safety Program examines all failure surfaces that would result in the release of water from the reservoir. The upstream slope is analyzed by examining all failure surfaces that intercept the crest.

2. Steady Seepage Cases

The two steady seepage conditions that must be analyzed are characterized by the completion of two processes. First, the soil in the dam has been consolidated by the overlying soil and second, all pore pressures have dissipated to values determined by the position of the phreatic surface. These cases are normally critical for the downstream slope because the seepage forces act in the downstream direction and the reservoir supports the upstream slope.

To determine the shear strength parameters, a representative soil sample is compacted to the design density, consolidated under a representative overburden stress, and fully saturated. It is then sheared under fully drained conditions. An alternative is to use the results of a consolidated-undrained (CU) triaxial test with pore pressure measurements. With either method, drained strength parameters are determined. Pore pressures within the dam are estimated from a flow net or as a function of the depth below the phreatic surface. The phreatic surface for a homogeneous dam on an impervious foundation can be estimated as shown in Figure 5.7.

Following Casagrande's (1937) procedure, it is assumed that the theoretical line of seepage starts from the pool level at a distance of $0.3\triangle$ from the dam, where $\triangle$ is the horizontal distance from the upstream toe to the point where the reservoir elevation meets the upstream slope of the dam. Utilizing an x,y coordinate system with the origin at the downstream toe, the exit point of the phreatic surface can be computed from the known values of h and d in Figure 5.7. As an approximation, the y coordinate of the exit point can be taken as 0.33h and the phreatic surface can be drawn as a smooth curve between the entrance and exit points. The phreatic surface is thus assumed to be a parabola tangent to the downstream slope.

Huang (1983) developed tables to compute the exit and mid points as a function of d and h for downstream slopes ranging from s = 1.5 to 5.0. Huang's method can be used in embankment sections on an impervious base and without internal drains. Other methods of approximating the shape of the phreatic surface must be used when internal drains are located in the dam. In most cases, the staff of the Dam and Reservoir Safety Program estimates the shape of the phreatic surface in Figure 5.7 as 2-3 chords which connect the entrance and exit points.

Piezometric data from an existing embankment can also be used to develop the phreatic surface for use in the stability analysis.

In analyzing the steady seepage cases, the staff of the Dam and Reservoir Safety Program examines all failure surfaces that would result in the release of water from the reservoir. The cross section of the dam at the maximum section is analyzed. For the steady seepage-maximum reservoir case, the phreatic surface is assumed to be in the same location as the steady seepage-full reservoir condition unless the dam has an upstream pervious zone.

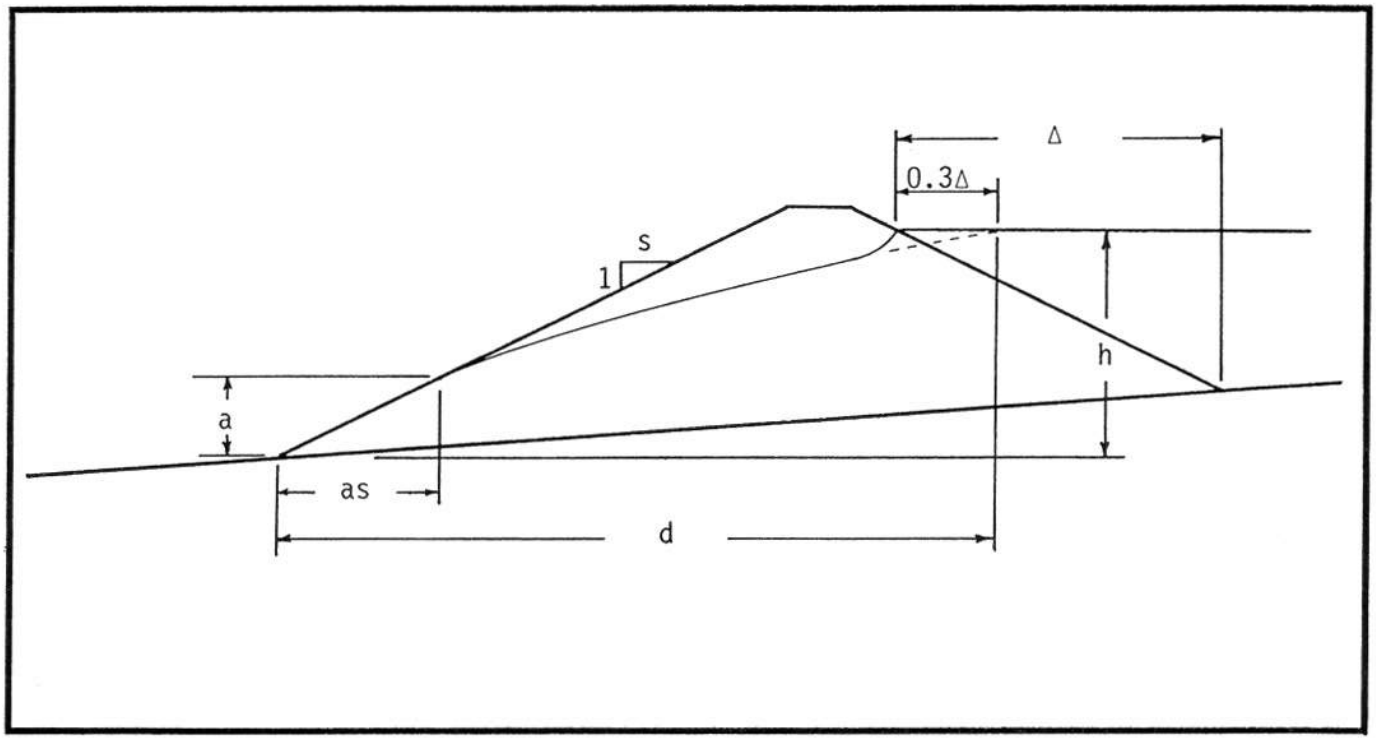


Figure 5.7 Phreatic Surface in an Earthfill Dam

3. Sudden Drawdown

The sudden, or rapid drawdown condition can be critical for the upstream slope of any dam where the reservoir elevation can be drawn down by a lake drain pipe or by other means. If the reservoir level cannot be drawn down quickly, this condition does not have to be analyzed.

In the sudden drawdown case, the soil is fully consolidated under the weight of the overlying material, and saturation with a static water level or a steady seepage condition is established. As the drawdown occurs, buoyancy forces are eliminated in the soil zone above the lowered reservoir elevation. The soil is sheared under undrained conditions by the increased weight of the saturated soil above the lowered reservoir elevation. The shear strength, however, is still governed by the consolidation that occurred before drawdown. The effective normal stress before drawdown should be used to calculate frictional resistance at the assumed failure surface.

The information and shear strength parameters required for the sudden drawdown analysis are obtained from the consolidated, undrained (CU) triaxial tests. The cross section of the dam at the maximum section should be used and the phreatic surface assumed to be in the same location as the steady seepage-full reservoir condition. The staff of the Dam and Reservoir Safety Program examines all failure surfaces that intercept the crest of the dam.

4. Earthquake

The required accelerations for earthquake design are listed in Table 4, 10 CSR 22-3.020. They are termed the Probable Maximum Acceleration and are dependent upon the location of the dam and the downstream hazard classification. These accelerations should be used with the cross section analyzed in the steady-seepage, full reservoir condition to determine the seismic stability of the embankment. The acceleration imparts a horizontal force to each slice which increases the moment of weight of the failing mass. As in the steady seepage cases, effective stress parameters should be used in the analysis.

Earthquake loading may result in the build-up of pore water pressures and a loss of strength for new dams constructed wholly or partially of cohesionless materials (such as sand and silt) or having a foundation of cohesionless materials. Engineers shall take this pore pressure increase and loss of strength into account when performing their stability analysis. The degree to which liquefaction may affect the factor of safety for slope stability is left up to the engineer's best judgement. Dynamic analyses of earth embankments are not required. Typically, a pseudo-static

analysis can be conducted to determine the likelihood of failure. In conductin g the analysis, very low strength parameters are assumed for the liquefaction zones.

E. Protection of Upstream Slopes

It is generally necessary to protect the upstream face of a dam from wave erosion. The orientation and length of the permanent pool, the purpose of the reservoir, and the duration of stages in flood control pools all affect the need for and the type of embankment protection. Embankments in northern Missouri that are constructed of friable, or loessial, soils are particularly susceptible to upstream slope erosion. Minor water level fluctuations lift soil particles from exposed surfaces and leave vertical banks along the water line.

Upstream slope protection usually consists of rock riprap, either dumped or handplaced. As a minimum, rock riprap should consist of hard durable rock, well graded, placed at a minimum thickness of 18 inches on 6 inches of well-graded gravel or a layer of geotextile (filter cloth). On dams with small reservoirs, a properly designed beaching slope can be used instead of riprap.

Judgement is required in the design of the vertical height of riprap. Protection should be provided both above and below the water storage elevation. The protection below the normal pool elevation is dependent upon several factors including the purpose of the reservoir and the base flow of the inflow stream. A water supply reservoir will generally have a wide range of stages during the year due to withdrawals. A recreation dam on a stream with a year round base flow normally only requires a minimal amount of riprap below the normal pool elevation. Maximum protection can be obtained by placing riprap on the upstream face of the dam from the toe to the crest; however, this is expensive and is normally not justified on smaller dams. As a general rule, riprap should be placed a few feet above and below the water storage elevation.

A recommended reference for the design of riprap slope protection is Riprap for Slope Protection Against Wave Action, (SCS, 1983).

F. Instrumentation

Instrumentation can significantly improve the overall safety of a dam by providing continuous surveillance of the structure. Instrumentation is normally associated with large high hazard dams, but it is also used in dams with unusual design features.

Instrumentation refers to the method and equipment used to make physical measurements of dams. Instrumentation is not, however, a substitute for inspection. It is a supplement to visual observations and inspections. Visual examinations are aided by monitoring instruments that measure seepage and leakage through and around the embankment, movements of the embankment and foundation, and water levels and pressures within the embankment and the foundation. Where instrumentation exists, adequate records of measurements, along with the visual observations, should be maintained. To be effective, these records should be continuous and periodically reviewed by a professional engineer experienced in the design and operation of embankment structures. Any change in behavior of the dam would signal a need for further review and analysis.

There are three general types of instruments used to monitor dams. These include seepage monitoring instruments, embankment movement instruments and water pressure instruments (piezometers). An excellent discussion of instrumentation is included in the Training Aids for Dam Safety (TADS) module entitled, Instrumentation for Embankment and Concrete Dams.

1. Seepage and Leakage

All dams seep to varying degrees and all seepage should be monitored and recorded. If there is visible flow, the quantity of water should be measured by channelizing the seepage and installing a pipe, weir, or a flume. A record should be kept of the discharge rate, the temperature of the seepage, and the reservoir elevation. Toe and/or foundation drains should also be monitored and data recorded along with the reservoir elevation. Any wet spots should be noted and the location, size, and condition recorded.

2. Embankment Movements

Considerable movement of embankment dams can be anticipated during and immediately after construction. Much of the movement may be attributed to foundation settlement under the load of the embankment. The embankment will also move as the reservoir is filled for the first time and may periodically experience cyclic movements as the reservoir is emptied and filled in succeeding seasons. Movements are determined by periodic measurements of monuments placed in or on the structure and abutments. For existing dams, monumentation to measure movements is usually limited to the crest and downstream slopes. The monuments are anchored in the embankment below the depth of normal seasonal volume change. Abutment monuments usually consist of steel rods or surveyor's markers embedded in concrete and placed in excavations in the abutments. Differences in elevation and location of the monuments are measured by transit and level surveys of the monuments.

Measurements of the locations of monuments on the surface of the embankment should be such that changes in both vertical and horizontal locations are measured. The measurements should be reduced to graphical displays of changes in vertical location, changes in horizontal

location along the axis of the embankment, and changes in horizontal location transverse to the axis of the embankment (upstream and downstream). The water surface elevation in the reservoir at the time of measurement of the monument is important and should be recorded along with the monument location data. The monuments should be tied to a bench mark that is outside the influence of the dam and reservoir. Monuments should be located in areas where they will not be damaged by normal traffic or operations.

3. Piezometric Pressures

A primary indicator of the performance of an embankment is the pore pressure distribution within the structure and its foundation. Pore pressures in embankments are measured by piezometers. There are basically three types of piezometers in common usage: (1) a hydraulic piezometer (open system) in which the water pressure is obtained directly by measuring the elevation of water standing in a pipe or vertical tube; (2) an electronic piezometer (closed system) in which the water pressure deflects a calibrated membrane and the deflection is measured electronically to give the water pressure; and (3) a gas pressure unit (diaphragm system) in which the water pressure is measured by balancing it with pressurized gas in a calibrated unit.

In large high hazard dams, piezometers should be installed to determine the location of the phreatic line and the pressure distribution along a potential failure surface. Piezometers should be installed so that the porous tip is located in the zone of interest within the dam. The line of piezometers should be perpendicular to the longitudinal axis of the embankment. In large structures, there may be several lines of piezometers, while in smaller structures and existing dams perhaps one line of 3-5 piezometers would be adequate.

CHAPTER VI

ANALYSIS OF CONCRETE GRAVITY STRUCTURES

This section applies only to small concrete gravity dams, overflow weirs, sills, and walls on the crest of a dam. It does not apply to concrete gravity dams greater than 50 feet in height, arch dams, or buttress dams. These topics are beyond the scope of this booklet.

A concrete gravity dam is a structure that is designed so that its own weight provides the major resistance to the forces exerted upon it. If the foundation is adequate, and the dam is properly designed and constructed, a solid concrete dam is a permanent structure which requires little maintenance. It is generally constructed of unreinforced blocks of concrete with flexible seals in the joints between the blocks. The most common types of concrete gravity dam failure are overturning or sliding on the foundation.

The foundation for a gravity dam must be capable of resisting the applied forces without overstressing the dam. The horizontal forces on the dam tend to make it slide in a downstream direction, which results in horizontal stresses at the base of the dam. These in turn may try to induce shear failure in the concrete at the base, along the concrete-foundation contact, or within the foundation. Overturning moments result in stresses which may cause crushing of the rock along the toe.

Table 2, 10 CSR 22-3.020 lists stability criteria for conventional concrete dams. The failure mechanisms that must be analyzed include overturning, sliding, structural integrity, and seismic.

A. Forces Acting On The Dam

To analyze the safety of gravity dams, it is necessary to determine the forces which may be expected to affect the stability of the structure. The forces which must be considered are those due to:

1) external water pressure (reservoir and tailwater);
2) internal water pressure (pore pressure or uplift) in the dam and foundation;
3) silt pressure;
4) ice pressure;
5) earthquake;
6) weight of the structure; and
7) forces from gates and other appurtenant structures.

When analyzing the crest of an overflow section, the possibility of subatmospheric pressure developing between the overflowing sheet of water and concrete should be considered. This phenomenon is known as cavitation and can cause serious damage to concrete.

Figure 6.1 shows a nonoverflow concrete section loaded with reservoir water and tailwater. Symbols and definitions for this loading are given below.

Ψ = angle between face of element and the vertical.

T = horizontal distance from upstream edge to downstream edge of section.

I = moment of inertia of base of section 1-foot wide about its center of gravity, equal to $T^3/12$.

w_c = unit weight of concrete.

w = unit weight of water.

h or h' = vertical distance from reservoir water or tailwater, respectively , to base of section.

P or P' = reservoir water or tailwater pressure, respectively, at base of section. It is equal to wh or wh'.

W_o = dead load weight above base of section under consideration including the weight of the concrete, w_c, plus such appurtenances as gates and bridges.

W_w or W'_w = vertical component of reservoir water or tailwater load, respectively, on face above base of section.

M_o = moment of W_o, about center of gravity of base of section.

M_w or M'_w = moment of W_w or W_w' about center of gravity of base of section.

V or V' = horizontal component of reservoir water or tailwater load, respectively, on face above base of section. This is equal to $\frac{wh^2}{2}$ for V and $\frac{w(h')^2}{2}$ for V'.

M_p or M'_p = moment of V or V' about center of gravity of base of section, equal to $\frac{wh^3}{6}$ for M_p and $\frac{w(h')^3}{6}$ for M'_p.

$\sum W$ = resultant vertical force above base of section.

$\sum V$ = resultant horizontal force above base of section.

$\sum M$ = resultant moment of forces above base of section about center or gravity of base of section.

e = distance from midpoint of base of section to point where resultant

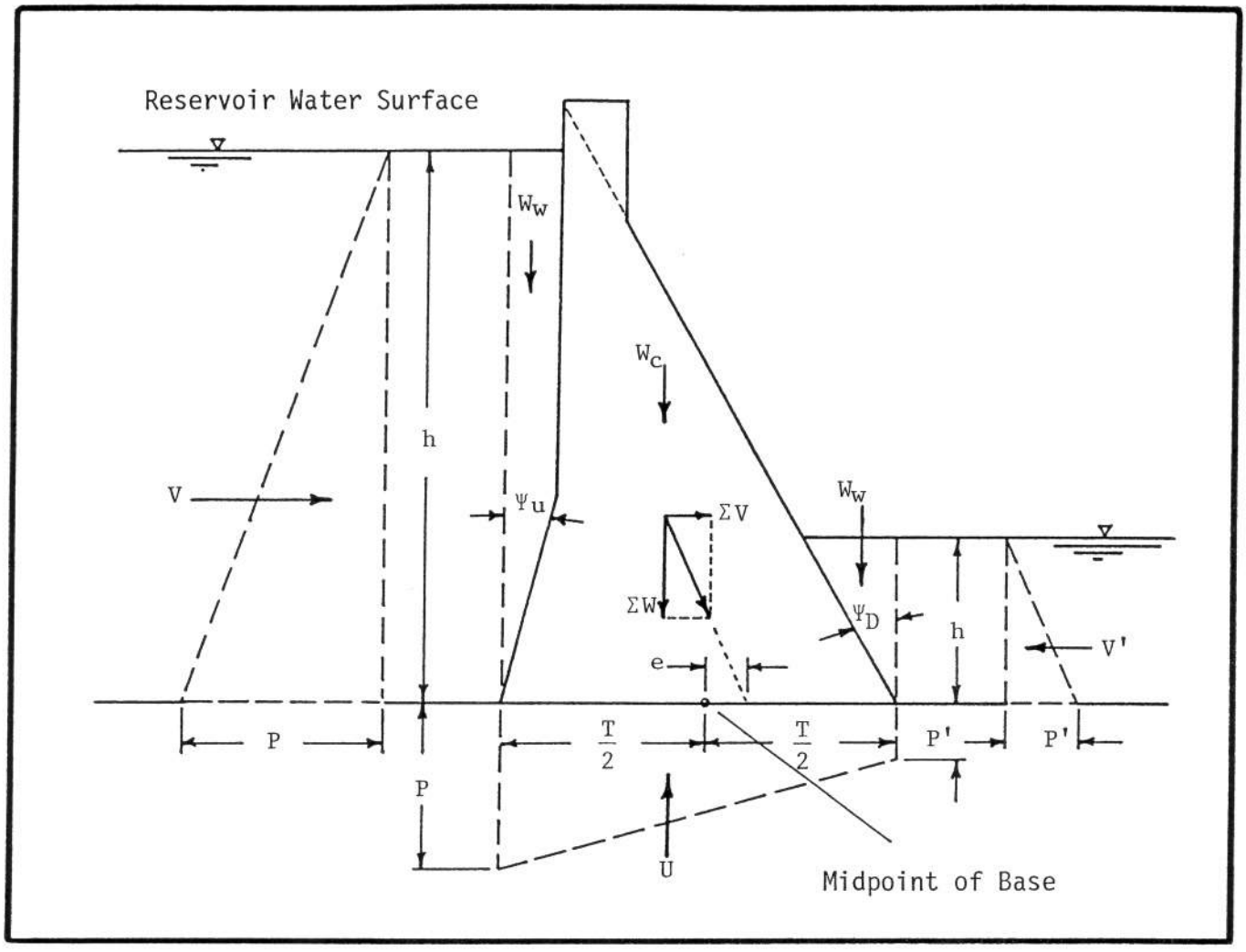


Figure 6.1 Forces Acting on a Concrete Gravity Dam (From Design of Small Dams)

of $\sum W$ and $\sum V$ intersects base of section. It is equal to $\sum M / \sum W$.

U = total uplift force on horizontal section, equal to $T\left(\frac{P+P'}{2}\right)$

The loadings have been summed into horizontal and vertical components, which implies that the foundation or potential failure plane is horizontal or nearly horizontal. If the foundation or potential failure plane is substantially sloped, the loads should be resolved into components normal and parallel to that plane.

1. External Water pressure

External water pressure must be considered on both overflow and nonoverflow sections. Figure 6.1 illustrates water pressure on a nonoverflow section. On the upstream face, the horizontal force is **V** and the vertical force is $\mathbf{W_W}$. The weight of water is generally accepted as 62.4 pounds per cubic foot.

On overflow dams without control features, the total horizontal water pressure on the upstream face is represented by the trapezoid abcd in Figure 6.2. The unit pressures at the top and at the bottom are $62.4h_1$ and 62.4h, respectively. The resultant force passes through the center of gravity of the trapezoid.

The vertical pressure component of water flowing over the top of the spillway is not used in the analysis because most of the total head has changed to velocity head. The sheet of water flowing on the downstream face generally does not exert enough pressure on the dam to warrant consideration. Where tailwater or backwater ponds against the downstream face, it is treated in the same manner as the tailwater in Figure 6.1. The only exception is during major flows when the tailwater pressures are

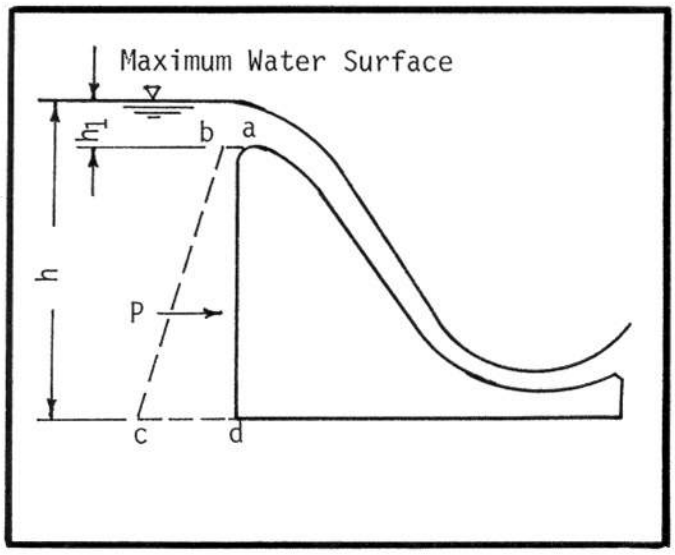


Figure 6.2 Water Pressure on an Overflow Concrete Dam (From Design of Small Dams)

involved in dissipating energy. During this condition, they may contribute only minor stabilizing forces on the dam.

2. Internal Water Pressure

Internal water pressure is an important factor which must be considered on both rock and soil foundations. The intensity of uplift pressure under a concrete dam on a rock foundation is difficult to determine. If the base of the concrete section is not instrumented, it is generally assumed that pore pressures in rock or concrete act over the entire base of the section. It is evident that under sustained loading the uplift pressure at the upstream face is equal to the full reservoir pressure. Its distribution approaches a straight-line variation from this point to the tailwater pressure at the downstream face, or zero if there is no tailwater. This is true not only at the contact between the dam and foundation but within the body of the dam itself. Even if drains are provided to relieve excess hydrostatic pressure, it is still common practice to assume a straight-line pressure distribution from the upstream to downstream toe.

Uplift pressures under a concrete dam on a pervious foundation are related to seepage through permeable materials. Water percolating through pore spaces in the foundation material is affected by frictional resistance in much the same way as water flowing through a pipe. The magnitude and distribution of seepage pressures in the foundation and the amount of underseepage for a given coefficient of permeability can be obtained from a flow net. An excellent reference for flow net construction is given by Cedergren (1977). The intensity of the uplift can be controlled by construction of properly placed aprons, cutoffs, and other devices.

3. Silt pressure

Nearly all streams carry an appreciable amount of silt during flood flows. This is especially true in northern and western Missouri. Where silt is present in a stream on which a concrete dam is built, it will eventually find its way to the reservoir and be deposited adjacent to the dam. If allowed to accumulate against the upstream face of the dam, the saturated silt exerts pressure greater than the hydrostatic pressure of water due to its heavier unit weight. In the absence of reliable test data, a rather common assumption of the magnitude of saturated silt pressure is to consider the horizontal pressure as equivalent to that of a fluid weighing 85 pounds per cubic foot and the vertical weight as 120 pounds per cubic foot.

Many small gravity dams and spillway structures have been designed without regard to silt load. In general, the silt load against storage dams will be a small factor. Against diversion dams, however, it is likely to be more important. In either case there is some basis for neglecting the silt load, especially in the design of concrete spillway weirs and sills.

4. Ice Pressure

Ice pressure is produced by thermal expansion in the ice sheet and by wind drag. The necessary allowance to be made for ice load in the design of a concrete dam is difficult to determine. Data concerning the physical characteristics of ice such as its crushing strength, its modulus of elasticity, and the effects of plastic flow are inadequate and approximate. The thrust exerted by expanding ice depends on the thickness of the sheet, the rate of temperature rise in the ice, fluctuations in the water surface, character of the reservoir shore line, wind drag, and other factors. The rate of temperature rise in the ice is a function of rate of rise of the air temperature and the amount of snow cover on the ice. Lateral restraint of the ice sheet depends on the character of the reservoir shore line.

Because of all these variables, the engineer is faced with a difficult task in estimating the amount of ice pressure acting against a structure. Rose (1947) developed several charts to analyze ice pressure. His charts were reprinted by the U. S. Department of the Interior (1974) in Design of Small Dams and show the thrust in kips for ice thicknesses up to 4 feet and for air temperature rises of 5°, 10°, or 15° F. per hour.

5. Earthquake

Earthquakes impart accelerations to the dam which usually increase the effective loadings on the dam. An allowance for earthquake effects must therefore be made in the analysis of concrete gravity dams and appurtenant structures.

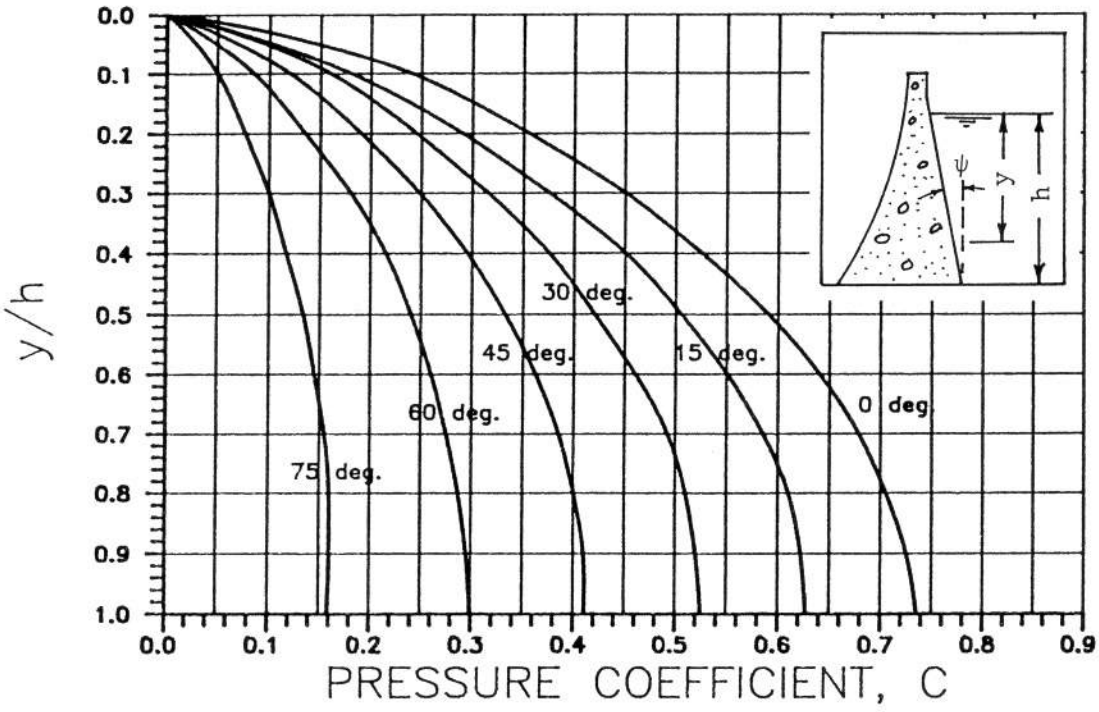


Figure 6.3 Coefficient for Pressure Distribution for Constant Sloping Surfaces

Both vertical and horizontal earthquake loads should be applied in the direction which produces the least stable structure. For the condition of full reservoir this will be a foundation movement in the upstream direction and a foundation movement downward. The upstream movement increases the downstream force of the water and silt loads and produces a downstream inertial force from the mass concrete in the dam. The downward movement decreases the effective weight of the water above a sloping face and of the concrete in the dam. Increasing the horizontal loads in a downstream direction and decreasing the effective weights tend to decrease the stability of the structure. In order to determine the total forces due to an earthquake, the earthquake acceleration must be determined from Table 4, 10 CSR 22-3.020. Table 4 contains horizontal accelerations. Vertical accelerations should be approximated as 50% of the horizontal acceleration.

a. Horizontal Earthquake Force

The effect of inertia on the concrete should be applied at the center of gravity of the mass, regardless of the shape of the cross section. For dams with vertical or sloping upstream faces, the increase in water pressure, P_e, in pounds per square foot, at any elevation due to horizontal earthquake loading is given by Equation 6.1:

$$P_e = C\lambda w h, \qquad (6.1)$$

where

C = a dimensional coefficient giving the distribution and magnitude of pressures;

λ = earthquake intensity (% of gravity);

w = unit weight of water, pcf; and

h = total depth of reservoir at section being studied in feet.

Values of C for various degrees of slope and relations of h and the vertical distance from the reservoir surface to the elevation in question may be obtained from Figure 6.3. The total horizontal force, V_e, above any elevation y distance below the reservoir surface is given by Equation 6.2:

$$V_e = 0.726 P_e y, \qquad (6.2)$$

where

y = the vertical distance from the reservoir surface to the elevation in question in feet.

The total overturning moment, M_e, above elevation y is determined by Equation 6.3:

$$M_e = 0.299 P_e y^2 \qquad (6.3)$$

For dams and structures with a combination vertical and sloping face, the procedure to be used is governed by the relation of the height of the vertical portion to the total height of the dam. If the height of the vertical portion of the upstream face of the dam is equal to or greater than one-half the total height of the dam, it should be analyzed as if it is vertical throughout. If the height of the vertical portion of the upstream face of the dam is less than one-half of the total height of the dam, the pressures should be determined on a sloping line connecting the point of intersection of the upstream face of the dam and reservoir surface with the point of intersection of the upstream face of the dam and the foundation.

b. Vertical Earthquake Force

On sloping faces of dams the weight of the water above the slope should be modified by the appropriate acceleration factor. The weight of the concrete also should be modified by this acceleration factor.

6. Weight of Structure

The weight of the structure includes the weight of the concrete plus appurtenances such as gates and bridges. For most low dams and other concrete structures, only the dead load due to the weight of the concrete is used in the analysis. The unit weight of concrete is considered to be 150 pounds per cubic foot. The total weight acts vertically through the center of gravity of the cross section.

B. Requirements for Stability

A concrete gravity structure must be designed to resist, with ample factor of safety, three failure conditions: overturning, sliding, and overstressing.

1. Overturning

There is a tendency for a gravity structure to overturn about the downstream toe at the foundation or about the downstream edge of any horizontal section. If the vertical stress at the upstream edge of any horizontal section computed without uplift exceeds the uplift pressure at that point, the dam is considered safe against overturning. The most critical condition for inducing overturning is when, at the upstream face, the uplift pressure exceeds the vertical stress at any horizontal section. To perform an analysis of this condition, a combined pressure diagram must be developed.

Under stable conditions the resultant of the horizontal and vertical loads on the structure will be balanced by an equal and opposite force which constitutes the reaction of the foundation. The vertical reaction of the foundation, computed without uplift, is represented by the trapezoid A12B in Figure 6.4B. The vertical normal stresses A1 and B2 are determined by the use of eccentric loading formulas as shown in Equations 6.4 and 6.5:

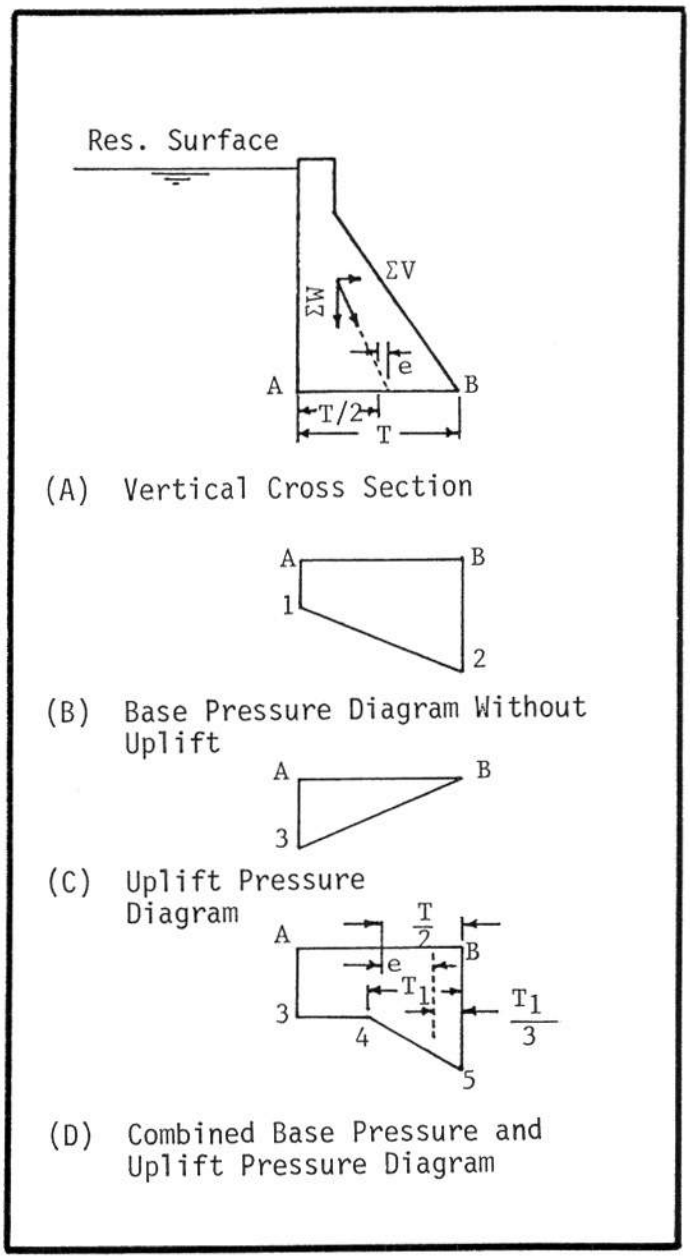


Figure 6.4 Foundation Base Pressures for a Concrete Gravity Dam (From Design of Small Dams)

$$A1 = \frac{\sum W}{T}\left(1 - \frac{6e}{T}\right) \qquad (6.4)$$

$$B2 = \frac{\sum W}{T}\left(1 + \frac{6e}{T}\right) \qquad (6.5)$$

When uplift is introduced and the uplift pressure at the upstream face is less than A1, compression exists on the

upstream face. When the uplift at A is greater then A1, the upstream face is in tension and cracking will occur. To analyze this condition, the foundation pressure diagram must be revised. The following procedure is used:

(1) A horizontal crack is assumed to exist and extend from the upstream face toward the downstream face to a point where the vertical stress of the adjusted diagram is equal to the uplift pressure at the upstream face. This is point 4 in Figure 6.4D.
(2) Taking moments about the center of gravity of the base, the following equations are obtained:

$$e' = \frac{\sum M}{\sum W - A3 \cdot T}, \qquad (6.6)$$

$$T_1 = 3\left(\frac{T}{2} - e'\right), \qquad (6.7)$$

$$B5 = \frac{2(\sum W - A3 \cdot T)}{T_1} + A3, \qquad (6.8)$$

where

e' = eccentricity of the stress diagram after cracking;
$\sum M$ = summation of moments of all forces;
$\sum W$ = summation of vertical forces;
$A3$ = internal hydrostatic pressure at the upstream face;
T = thickness of section at base; and
T_1 = remaining uncracked portion of the structure.

If B5 is less than the allowable stress for the concrete in any horizontal section or less than the allowable stress in the concrete and foundation for a horizontal section at the foundation, the dam is considered to be safe against overturning.

2. Sliding

The horizontal force, $\sum V$, in Figure 6.4A tends to displace the dam in a horizontal direction. This tendency is resisted by the shear resistance of the concrete or the foundation.

The shear friction factor of safety is the sliding stability criterion for all concrete dams and should generally be used for other structures on rock foundations. The shear friction factor of safety, Q, is shown in Equation 6.9:

$$Q = \frac{cA + (\sum W - U)\tan\phi}{\sum V}, \qquad (6.9)$$

where

c = cohesion value of concrete or foundation;
A = area of base considered; and
$\tan\phi$ = coefficient of internal friction of concrete or foundation.

The values of cohesion and internal friction of the rock or rock-concrete contact must generally be determined by special laboratory tests. For certain rock types, free from adverse geologic structures, cohesion and internal friction can be estimated from published test data. Rock with infilled jointing or lamination and other adverse geologic structures require investigation and testing of the properties of the rock surfaces and infilling material.

3. Structural Integrity

The unit stresses in the concrete and foundation must be kept within prescribed maximum values. Normally, the stresses in the concrete of small gravity dams will be so low that a concrete mix designed to meet other requirements such as durability and workability will attain sufficient strength to insure a reasonable factor of safety.

The foundation should be investigated and the maximum allowable stress established. When the foundation consists of soils, the engineering properties of the material should be determined along with the allowable bearing pressure. If there is any doubt as to the proper classification and adequacy of the foundation materials, laboratory tests should be made to determine the allowable bearing pressures.

CHAPTER VII

GEOLOGICAL CONSIDERATIONS

Careful evaluation of geologic conditions at potential lake sites and sound design and construction practices can greatly enhance lake development. It can also save the owner money during the life of the dam.

All dams seep, and below normal rainfall, combined with a high rate of seepage can cause wide fluctuations in lake levels at some reservoirs. When dams are constructed without any borings or consideration for the geological conditions of the lake site, the likelihood that the dam will experience seepage and safety problems increases dramatically. Unfortunately, many owners discover that a geological investigation should have been performed after the dam is built. Seepage and stability problems are frequently linked to geologic conditions. To reduce seepage, it is sometimes necessary to grout the abutments or foundation, construct a new cutoff trench, or construct an impermeable earthern blanket in the reservoir basin. These are all expensive options, particularly if the work is done after the dam is built.

A surface geological evaluation of the proposed lake site should be made by a qualified geologist. The purpose of the visual investigation is to observe geologic conditions that are not evident from maps or reports of previous studies. At the same time, observations can be made of the presence or absence of springs or seeps, the type and thickness of soil, the characteristics of exposed bedrock outcrops, the presence of karst features, and whether the stream is losing or gaining. An excellent source of information for evaluating potential lake sites in Missouri is a booklet entitled, A guide for the geologic and hydrologic evaluation of small lake sites in Missouri, written by Dean, Barks, and Williams (1976).

The Rules and Regulations of the Missouri Dam and Reservoir Safety Council require engineers to submit exploration records and test results for all new dams that will be regulated under the dam safety law. The exploration records are normally in the form of boring logs which detail the strata and composition of the foundation and abutments at the lake site. The regulations do not specify the type or number of borings.

Typically, an owner will request his engineer to obtain borings at 100-200 foot intervals along the proposed dam centerline across the valley. The actual interval will depend on local conditions and the length of the proposed dam. There should be at least one hole in each abutment and two of the valley holes should extend 10 to 20 feet into bedrock. Backhoe pits can be excavated in potential borrow areas to determine the type and quantity of material available to construct the dam. Care must be taken in obtaining samples from the borrow areas to determine the strength of the soil that will be used in the dam. As pointed out in Chapter V, soil does not have predictable strength properties like concrete or steel. It must be tested at the density at which it will be placed to determine its strength. Construction permits issued by the Dam and Reservoir Safety Program require that density testing of the fill be performed during construction. This requirement is made to insure that the material is placed in accordance with the design specifications.

A. Core Trench Requirements

It is common practice to construct a core trench to control seepage beneath new dams. Subsurface borings give the engineer an indication of how deep the core trench will have to be and how much material must be removed. If the core trench extends to bedrock, the engineer should evaluate the rock strata to insure that the trench has penetrated all weathered rock and the underlying material is free from undesirable geological features.

An understanding of the weathering process is important. Rock at the earth's surface is continually being broken down by weathering. One of the most common weathering processes is the freezing of water in cracks accompanied by expansion of the ice and subsequent fracturing of the rock. Numerous cycles of freezing and thawing can produce extensive weathering.

The flow of water through rock can weaken some minerals and leave the remainder susceptible to wind or water erosion. The broken particles resulting from the weathering process are often transported by air, ice, water, or gravity and redeposited. The modes of deposition can be extremely variable and can cause considerable differences in the successive layers of the deposited or sedimentary material. Hence, sedimentary rocks are often characterized by the great variety in the material in the successive layers. Except for the St. Francois mountain region, Missouri's surface bedrock is almost exclusively sedimentary rock.

There are several types of defects that exist in bedrock. Some of the potential defects in a rock foundation include faults, joints, fractures, and bedding planes. An inspection of the core trench during construction can identify problems and insure that they are corrected before the trench is backfilled.

Faults are common in Missouri, but few are active. Faults are ruptures in rock formations and are caused by high-magnitude tectonic forces. Joints in sedimentary

rock are formed as a result of weathering. The primary difference between faults and joints is the method by which they are formed. When portions of a formation move with respect to each other, the discontinuity produced is termed a fault. If there is a discontinuity but no movement has occurred, the break would be called a joint or fracture. The term fracture can refer to a joint or a fault but always denotes a discontinuity in the rock mass.

Water percolating through fractures can alter the mineral of the adjacent rock and in some cases actually dissolve portions of it. This process occurs in many of the carbonate rock formations in southern Missouri and results in a weak, altered material. The solution joint that is produced can be open, closed, or filled with some type of secondary material. In many cases, the secondary material found in the joint is weak clay. Joints generally tend to be more weathered and open near the surface and narrow with increasing depth. Regardless of whether the joints are filled, it is necessary to identify them during the core trench inspection. Foundation leakage can be reduced by washing and then grouting the joints and fractures. Large clay seams and sand zones in the bedrock need to be excavated and backfilled with compacted clay.

Separations between bedding planes are a type of joint primarily associated with sedimentary rock. The shale and sandstone region of west central Missouri has distinct bedding planes. During construction of the core trench, all weathered shale should be removed.

Faulting and jointing in carbonate rocks may contribute to the development of karst conditions. Deposited clay material along such discontinuities may be washed away with increased head. A severe increase in abutment seepage can sometimes occur during the initial filling of the reservoir. This can be associated with the erosion of clay in abutment joints. It is therefore important to construct a good core trench up the abutment walls as well as along the base of the valley.

Glacial materials deposited by Pleistocene continental ice sheets are prevalent in northern Missouri. Varying thicknesses of till and loess characterize this area. The soils are highly erodible and contribute to siltation problems. Common core trench problems include sand-gravel alluvium and buried channels. Unconsolidated, permeable drift soils in foundations and in reservoir areas are likely to create defects in a dam and must be removed. Because of wide variations in the glacial deposits, proposed dam sites should be thoroughly investigated.

Depending on the region of the state, many different types of soil and bedrock may be encountered. It is important to review detailed published geologic and soil maps before beginning an exploration program or excavating a core trench. Maps and other published reports on Missouri geology are available from the Division of Geology and Land Survey, 111 Fairgrounds Road, P.O. Box 250, Rolla, Missouri 65401.

B. Spillways

Open channel spillways can be located in rock or soil. Borings should be conducted to determine the extent of bedrock and soil in the proposed spillway location. Rock cut spillways are generally erosion resistant and require less maintenance than grass lined soil spillways. Excavation of the rock frequently requires the use of explosives. A well trained, experienced blasting contractor should be retained to perform all blasting at new dams and to enlarge rock cut spillways at existing dams. Overblasting can result in the creation of new joints in the underlying bedrock which can lead to seepage and weathering problems during the life of the dam. An experienced blasting contractor can produce rock from the spillway excavation that can be used as riprap for slope protection, discharge channel erosion protection, and toe berms.

A pre-blast and post-blast survey should be conducted when using explosives at an existing dam when homes and other structures are located nearby. In addition, the staff of the Dam and Reservoir Safety Program requires the owner of an existing dam to monitor slope movement and seepage as part of any construction permit which authorizes blasting.

Where bedrock is deep, the spillway channel should either be lined, retaining walls should be constructed, or the soil cut slopes should be designed to be stable. Many different types of soil can be encountered. Soils may be classified by their origin or mode of deposition. The broadest divisions are residual soils and transported soils. Residual soils are formed by in place chemical and physical decomposition of parent rock or soil material. The deeply weathered clays in southern Missouri are an example of residual soils. Transported soils are moved from their original site of deposition by water, gravity, wind, or ice. They can be deposited in water or on land. The loess soils in northern and western Missouri were transported and deposited by wind. Loess is highly erodible and care should be exercised when designing open channel spillways in it.

Colluvium is soil that has been transported downslope on hillsides primarily by the influence of gravity. In addition to gravity, movement of the soil is aided by ice heave, overturning of tree roots, and water. Abutments that are characterized by bent tree trunks, hummocky or irregular slopes, landslide scars, or heterogeneous soil mixtures likely have colluvial materials at their base. Colluvium can be particularly hazardous to existing dams where landsliding may impact the reservoir, spillways, or other appurtenant structures. This is especially true in open channel spillways.

A stability analysis should be conducted of all spillway cut slopes in soil. A slope failure can result in a spillway becoming blocked by slide debris.

CHAPTER VIII

ENGINEERING SURVEYS

Engineering surveys for dam safety include the study and selection of sites for new dams, construction surveying, and the procurement of data for design and analysis. For new construction, engineering surveying is closely allied to the various stages of project development. The American Society of Civil Engineers (1985) published a manual on engineering surveys, which includes a chapter on dam construction. It is a good reference for practicing engineers to use in planning preliminary and design surveys.

A. Site Selection Survey

An engineering survey program for a dam generally originates as a preliminary or reconnaissance study of one or more sites. The preliminary study does not determine the feasibility of a project; it does, however, provide an important source of data for planners and designers of the project to use in making siting and preliminary design determinations.

The preliminary survey and siting procedure begins with the best available contour maps, such as the U.S. Geological Survey 1 in. = 2000 ft (1:24000) scale quadrangle maps. If the maps used are from two or more sources, care must be taken to insure that the vertical datums are compatible. Possible site locations can then be noted on these maps and a limited amount of field work performed to verify the accuracy of the maps at the published scale. Any changes which have taken place subsequent to development of the maps can be noted during a field reconnaisance.

Care must be exercised when using old maps. Several years are involved in the compilation of mass-produced maps, and many years may pass before the maps are revised. Significant changes may have taken place in the area since the maps were compiled, which could seriously impair the accuracy and usefulness of the maps.

10 CSR 22-3.040(1)(A)12 requires engineers to submit topographic surveys with the construction permit application. Once a site has been selected, additional exploration and testing will usually be performed. Unless the project is very small in scope, photogrammetric mapping probably will be the most economical and expedient means for obtaining the necessary large scale, detailed topographic maps for the engineering design and construction operations. The optimum time for obtaining the photography for mapping is the time interval from January through early April. This is primarily due to the better sun angle and absence of foliage on the trees. The project may have areas obscured by dense tree or underbrush cover in the summer and early fall. Information derived from the geological investigation of the site should be plotted on the photogrammetric map. This includes the location of borings and test pits for future reference.

It is important to establish baselines and temporary benchmarks at an early stage of the design. A horizontal and vertical control survey net should control all five survey programs: preliminary, engineering design, property acquisition, construction, and post-construction. Adequate horizontal and vertical control survey monumentation should be provided to carry the project through the construction stage. Vertical control should be based on the North American Vertical Datum of 1929 where possible. Location of the monumentation on or near the final right-of-way lines generally will serve best to preserve them from disturbance or destruction during construction. In addition, the monumentation should be designed to accommodate post-construction maintenance and control needs such as monitoring the performance or movement of the structure throughout its useful life.

Information obtained from the engineering design survey will be used to layout the core trench, the dam, the spillways, and all appurtenant works in the drawings and during construction staking. Borrow pit location, access roads, material and equipment storage areas, and diversion channels will be delineated on the plans and tied to established baselines. Suitable map scales for reservoir areas and large dam sites will vary with the size of the reservoir areas and roughness of the terrain. Maps for design drawings and structural details may be needed at scale ratios of 1 in. = 10 ft. (1:120) to 1 in. = 100 ft. (1:600). Aerial photography of these particular structural design areas, at the proper altitude for the desired special photogrammetric mapping, should be obtained at the same time as the photography for the overall mapping.

In planning the survey program for the engineering and design phase of project development, consideration must also be given to property acquisition, construction, and post-construction survey programs. This will avoid expensive resurveys or even more costly redesign or correction of already completed portions of the project.

The Rules and Regulations of the Dam and Reservoir Safety Council do not require owners to submit boundary surveys of the reservoir or the dam site. Flood easements are the sole responsibility of the owner. Before building a dam, it is advisable for the owner to obtain the written consent of all persons, agencies, or authorities owning property which may be inundated by the dam on a temporary or permanent basis. This will require a determination

of the impoundment area below the top of dam elevation.

B. Construction Surveying

Upon completion of the engineering design for the project, location and construction surveys and monumentation will be required. Dam site centerlines are usually staked for the convenience of the design engineers, but offset reference monuments will be needed to reestablish the centerline location as construction proceeds. These offset reference monuments should carry both horizontal and vertical positions.

If the area is heavily wooded, the control reference line may be located along a roadway, railway, or electric power transmission line clearing which roughly parallels the stream. Offset traverses to the reference line can then be computed in the office and surveyed in the field. Construction control requirements usually involve more than the basic establishment of centerlines and strategically located bench marks. Supplemental control may also be required at many locations around and on a structure for activities such as setting concrete forms and aligning pipes.

Before the embankment is started, original and final excavated topography of the foundation and the core trench should be obtained to prepare as-built drawings following construction. During construction, survey checks should be made from time to time of monuments to detect any horizontal or vertical disturbance which may have been caused by construction equipment.

The execution of the construction surveys may be the responsibility of the owner, the contractor, or it may be a divided responsibility in accordance with the specifications. In some cases, the owner may establish and maintain principal centerline and grade references while the construction contractor performs required layout work and detailed referencing of the construction.

The reference line monumentation should be preserved for use in postconstruction maintenance and control surveys. The location of the core trench, all internal drains, and pipes should be tied to a reference line. The design may include provisions for the contractor to install monitoring instruments in the dam to detect internal changes and horizontal and vertical movement.

Another aspect of construction surveys is height data. Vertical control must be established to determine the elevation of the crest of the dam and the toe. Because the dam safety law only applies to dams that are over 35 feet in height, care must taken to establish the elevation of the toe of the dam for future reference. This is especially true at sites where the owner plans to build a dam less than 35 feet in height. Post-construction grading can obscure the toe and old creekbed after the dam is complete.

In order to obtain a construction permit to build a dam greater than 35 feet in height, hydrological information must be analyzed and submitted. This includes the flow elevation of all spillways, channel profiles and cross sections, the water storage elevation, inlet and outlet works elevations, and stage-storage information for the reservoir. This information is normally included on the plans. It is necessary to know the topography of the dam site to design a spillway system that will keep the dam from being overtopped during the design flood.

C. Analyzing Existing Dams

Dam safety inspections include an engineering survey to obtain data to perform a hydrologic and hydraulic analysis of the dam and to determine the slope of the embankment faces. The survey includes a profile of the crest, a cross section of the embankment at the maximum section, invert elevations of pipes, cross sections of open channel spillways, location and top elevation of dikes along the discharge channel, and dimensions of inlet and outlet structures.

The two most common methods employed by the staff of the Dam and Reservoir Safety Program are stadia surveys and level and tape surveys. The primary benefit of performing a stadia survey is to develop a plan of the dam and spillways. The location of observable defects such as slides, uncontrolled seepage exit points, and cracks can be determined and plotted on a plan view. It also gives the engineer analyzing the dam additional information concerning the location of the spillways and discharge channels in relation to the dam. With the widespread use of electronic distance measuring equipment, this information can be determined in a few hours. Level and tape surveys are adequate for most dams. Because elevations are the most important data for the hydrologic and hydraulic analysis, a level traverse should be completed and closed on the beginning benchmark.

Stationing for the crest profile must be close enough to determine the lowest elevation on the dam. This elevation is the location where water will first overtop the crest. Stations should extend far enough to include all spillways, except in the case of tailings dams where spillways are typically located several hundred feet upstream. Elevations should be rounded off to the nearest 0.05 ft. A higher degree of accuracy is not needed because the results of the overtopping analysis are normally rounded off to the nearest .1 ft. If the crest is crowned or if the crest slopes from one shoulder to the other, the elevations should be taken at the highest point.

The engineer should attempt to tie the survey to a National Geodetic Vertical Datum (NGVD) but that is not always possible. When an assumed elevation is used, a temporary benchmark should be established near the dam at a location that will remain undisturbed if modifications are required. A nail or spike in a tree near the dam works well. All references to the benchmark should be labeled "local datum". Because the stage-storage curve will be derived from USGS maps, the survey should include the local normal pool elevation which can be related to a reservoir elevation on the map. It is good practice to include an

equation in the inspection report for converting local survey elevations to the elevations on the topographic map.

The engineer should obtain a cross section of the embankment at the maximum section to establish the height of the dam and determine the upstream and downstream slopes. At dams where the old steambed has been covered, it may be necessary to take several elevations along the toe to determine the lowest point in accordance with 10 CSR 22-1.020(59). The station of the embankment cross section should be noted and the engineer should obtain enough points to plot the cross section in the inspection report.

The invert elevations or flow lines of all pipes, inlet structures, and outlet structures should be determined. This information will be used to rate the spillways and establish the water storage (normal pool) elevation. Dimensions and elevations of inlet structures are very important. It may be necessary to make soundings in a deep drop inlet structure to determine the upstream flow line of the discharge pipe.

The final phase of the engineering survey involves open channel spillways. Figure 4.5 shows a plan of a typical open channel emergency spillway. In order to determine the capacity of the channel and derive the water surface profile, a backwater analysis is required. The purpose of the backwater analysis is to rate the channel, determine the location of the control, determine the velocities expected in the channel, and compute the depth of water throughout the channel during the design flood. The term "control" applies to the channel section that regulates discharge. This cannot be determined visually. In fact, the location of the control can change with increasing discharge. Therefore, enough cross sections must be obtained to rate the channel at several discharges.

After the highest elevation in the channel is determined, cross sections should be laid out on the ground. Elevations should be taken at every break in slope and distances measured between each point. The left bank, right bank, and center of channel distances must be determined between each cross section. The bank elevations should extend to the top of dam elevation or to the top of training berms and dikes. The training berm information will be used to determine if it will be overtopped during the spillway design flood.

The survey notes should include information about the type of surface in the spillway. The information should be sufficient to estimate the roughness of the channel at each cross section.

REFERENCES

American Society of Civil Engineers, 1985, Engineering surveying manual: American Society of Civil Engineers Manuals and Reports on Engineering Practice No. 64, New York, N.Y.

Casagrande, A., 1937, Seepage through dams: Journal of New England Water Works Association, June, p. 295-336.

Cedergren, H. R., 1977, Seepage, drainage, and flow nets: John Wiley and Sons, Inc, New York, N.Y.

Chow, V. T., 1959, Open channel hydraulics: McGraw-Hill, New York, N.Y.

Chow, V. T., 1964, Handbook of Applied Hydrology: McGraw-Hill, New York, N.Y.

Cowan, W. L., 1956, Estimating hydraulic roughness coefficients: Agricultural Engineering, v. 37, no. 7, p. 473-475.

Dean, T. J., Barks, J. H., and Williams, J. H., 1976, A guide for the geologic and hydrologic evaluation of small lake sites in Missouri: Water Resources Report no. 31, Missouri Department of Natural Resources, Division of Geology and Land Survey, Rolla, Missouri.

Eagleson, P. E., 1970, Dynamic hydrology: McGraw-Hill, New York, N.Y.

Engman, E. T., 1986, Roughness coefficients for routing surface runoff: Journal of Irrigation and Drainage Engineering, American Society of Civil Engineers, v. 112, n. 1, p. 39-53.

Fread, D. L., 1984, DAMBRK: The NWS dam-break flood forecasting model: U. S. Department of Commerce, National Weather Service, Office of Hydrology, Silver Spring, Maryland.

Gray, D. M., 1961, Synthetic unit hydrographs for small drainage areas: Journal of the Hydraulics Division, American Society of Civil Engineers, v. 87, n. 4.

Hathaway, G. A., 1945, Design of drainage facilities: Transactions, American Society of Civil Engineers, v. 110, p. 697-730.

Henderson, F. M., and Wooding, R. A., 1964, Overland flow and groundwater flow from a steady rainfall of finite duration: Journal of Geophysical Research, v. 69, n. 8, p. 1531-1540.

Henderson, F. M., 1966, Open channel flow: Macmillan Publishing Company, Inc., New York, N.Y.

Hjelmfeldt, A. T., and Cassidy, J. J., 1976, Hydrology for engineers and planners: Iowa State University Press, Ames, Iowa.

Horton, R. E., 1932, Drainage-basin characteristics: Transactions, American Geophysical Union, p. 350.

Huang, Y. H., 1983, Stability analysis of earth slopes: Van Nostrand Reinhold Company, New York, N.Y.

Huff, F. A., 1980, Precipitation relations for use in dam safety project: Illinois State Water Survey, Urbana, Illinois.

Huggins, L. F. and Burney J. R., 1982, Surface runoff, storage, and routing: American Society of Agricultural Engineers, Hydrological Modeling of Small Watersheds, Chapter 5, St. Joseph, Michigan.

Kerby, W. S., 1959, Time of concentration for overland flow: Civil Engineering, v. 29, n. 3, p. 174.

Kirpich, Z. P., 1940, Time of concentration of small agricultural Watersheds: Civil Engineering, v. 10, n. 6, p. 362.

Lambe, T. L. and Whitman, R. V., 1969, Soil mechanics: John Wiley and Sons, Inc, New York, N.Y.

Missouri Department of Natural Resources, 1986, Maintenance, inspection, and operation of dams in Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey, Dam and Reservoir Safety Program.

Missouri Department of Natural Resources, 1989, Rules and regulations of the Missouri dam and reservoir safety council: Missouri Department of Natural Resources, Division of Geology and Land Survey, Dam and Reservoir Safety Program.

Munger, D. F., Bartholomew, C. L., Marshall, G. S., Miller, D.G., Tanner, D. T., and James, R. L., 1989, Instrumentation for embankment and concrete dams: Training Aids for Dam Safety, United States Government Printing Office.

National Research Council, 1985, Safety of dams - flood and earthquake criteria: National Academy Press, Washington, D.C.

Perloff, W. H. and Baron, W., 1976, Soil mechanics principals and applications: Ronald Press Company, New York, N.Y.

Portland Cement Association, 1964, Handbook of concrete culvert pipe hydraulics: Portland Cement Association, Skokie, Illinois.

Ramser, C. E., 1927, Runoff from small agricultural watersheds: Journal of Agricultural Research, v. 34, n. 9.

Rose, E., 1947, Thrust exerted by expanding ice sheet: Transactions, American Society of Civil Engineers, v. 112, p. 871.

Sherard, J. L., Woodward, R. J., Gizienski, S. F., and Clevenger, W. A., 1963, Earth and earth-rock dams: John Wiley and Sons, Inc., New York, N.Y.

Sherard, J. L., Dunnigan, L. P., and Talbot, J. R., 1984, Basic properties of sand and gravel filters: Journal of Geotechnical Engineering, American Society of Civil Engineers, v. 110, n. 6.

Sherard, J. L., Dunnigan, L. P., and Talbot, J. R., 1984, Filters for silts and clays: Journal of Geotechnical Engineering, American Society of Civil Engineers, v. 110, n. 6.

Simon, A. L., 1986, Hydraulics: Third Edition, John Wiley and Sons, Inc., New York, N.Y.

Singh, V. P., 1988, Hydrologic systems, rainfall-runoff modeling: v. 1, Prentice Hall, Engelwood Cliffs, New Jersey.

Snyder, F. F., 1938, Synthetic unit graphs: Transactions, American Geophysical Union, v. 19, p. 447-454.

Soil Conservation Service, 1972, National engineering handbook: U. S. Department of Agriculture, Soil Conservation Service, Section 4, Hydrology, Washington, D.C.

Soil Conservation Service, 1983, Riprap for slope protection against wave action: U. S. Department of Agriculture, Soil Conservation Service, Technical Release n. 69, Washington D.C.

Soil Conservation Service, 1985, Earth dams and reservoirs: U. S. Department of Agriculture, Soil Conservation Service, Technical Release n. 60, Washington, D.C.

Soil Conservation Service, 1986, Urban hydrology for small watersheds: U. S. Department of Agriculture, Soil Conservation Service, Technical Release n. 55, Washington, D.C.

Swenty, B. J., 1989, Time characteristics of small watersheds in response to the probable maximum precipitation: Dissertation presented to the University of Missouri-Rolla in partial fulfillment of the requirements of the degree Doctor of Philosophy.

Taylor, A. B., and Schwartz, H. E., 1952, Unit hydrograph lag and peak flow related to basin characteristics: Transactions, American Geophysical Union, v. 33, p. 235-246.

U. S. Army Corps of Engineers, 1982, National program of inspection of non-federal dams, Final Report to Congress: U. S. Army Corps of Engineers, Office of the Chief of Engineers, Washington, D. C.

U. S. Army Corps of Engineers, 1985, HEC-2 water surface profile model: U. S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California.

U. S. Army Corps of Engineers, 1987, HEC-1 flood hydrograph package - users manual: U. S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California.

U. S. Department of Commerce, 1961, Rainfall frequency atlas of the United States: Weather Bureau, Technical paper 40, Washington, D.C.

U. S. Department of Commerce, 1978, Probable maximum precipitation estimates, United States East of the 105th Meridian: National Oceanic and Atmospheric Administration, Hydrometeorological Report No. 51, Washington, D.C.

U. S. Department of the Interior, 1974, Design of small dams: Bureau of Reclamation, Washington, D.C.

U. S. Department of Transportation, 1965, Hydraulic charts for the selection of highway culverts: Federal Highway Administration, Hydraulic engineering circular n. 5, Washington, D.C.

U. S. Department of Transportation, 1972, Capacity charts for the hydraulic design of highway culverts: Hydraulic engineering circular n. 10, Federal Highway Administration, Washington, D.C.

U. S. Geological Survey ,1967, Roughness characteristics of natural channels: Water Supply Paper n. 1849, U. S. Department of the Interior, Washington, D.C.

Vick, S. G., 1983, Planning, design, and analysis of tailings dams: John Wiley and Sons, Inc, New York, N.Y.

Viessman, W, Harbaugh, T. E., and Knapp, J. W., 1972, Introduction to hydrology: Intex Educational Publishers, New York, N.Y.

APPENDIX A

PERMIT FORMS

APPLICATION FOR CONSTRUCTION PERMIT

DATE_____

PART I: GENERAL INFORMATION

Owner(s) Name: _____

Address: _____

_____ Zip_____

Phone: _____

Name of Dam: _____I.D. No. MO_____

County _____

Location of Dam Centerline at Maximum Section: _____

Sect._____, Twp._____North, Rg._____;

Approximate UTM Coordinates_____N _____E

Dam Height:_____ Reservoir Area:_____

Owner's Engineer_____Reg. No._____

Address: _____

_____Zip:_____

Phone: _____

ATTACHED DOCUMENTS (Note: This Application is Not Complete Without Parts II and III)

PART II: DESIGN REPORT CONSIDERATIONS*

PART III CONSTRUCTION DOCUMENTS*

SUBMIT TO: Dam and Reservoir Safety Program
Division of Geology & Land Survey
Department of Natural Resources
P.O. Box 250
Rolla, Missouri 65401

* See Rules and Regulations for Clarification

APPLICATION FOR SAFETY PERMIT

DATE_____ _____

PART I: GENERAL INFORMATION

Owner(s) Name: _____

Address: _____

_____ Zip: _____

Phone: _____

Name of Dam: _____ I.D. No. MO_____

County _____

Location of Dam Centerline at Maximum Section:

Sect._____, Twp._____ North, R_____;

Approximate UTM Coordinates_____

Dam Height:_____ Reservoir Area:_____

Owner's Engineer_____Reg.No._____

Address:_____

_____Zip_____

Phone: _____

ATTACHED DOCUMENTS: (Note - This Application is Not Complete Without Addressing Part II)

PART II: AS-BUILT PLANS*.

SUBMIT TO: Dam and Reservoir Safety Program
Division of Geology and Land Survey
Department of Natural Resources
P.O. Box 250
Rolla, Missouri 65401

* See Rules and Regulations for Clarification

APPLICATION FOR REGISTRATION PERMIT

DATE_____

PART I: GENERAL INFORMATION

Owner(s) Name: _____

Address: _____

_____ Zip _____

Phone: _____

Name of Dam: _____ I.D. No. MO _____

County _____

Location of Dam Centerline at Maximum Section: _____

Sect. _____, Twp. _____ North, Rg. _____;

Approximate UTM Coordinates _____ N _____ E

Dam Height: _____ Reservoir Area: _____

Owner's Engineer _____ Reg. No. _____

Address: _____

_____ Zip: _____

Phone: _____

ATTACHED DOCUMENTS (Note: This Application is Not Complete Without Parts II thru VI)

PART II: REQUIRED CERTIFICATIONS BY ENGINEER*

PART III INSPECTION REPORT*

PART IV REPORT ON CORRECTION OF DEFECTS (if applicable)*

PART V PROPOSED OPERATION AND MAINTENANCE PLAN*

PART VI REPORT ON CONSTRUCTION SEQUENCE**

SUBMIT TO: Dam and Reservoir Safety Program
Division of Geology & Land Survey
Department of Natural Resources
P.O. Box 250
Rolla, Missouri 65401

* See Rules and Regulations for Clarification
** For Industrial Water Retention Dams only

ATTACHMENT

CONSTRUCTION PERMIT APPLICATION

DAM NAME _____ **ID #** MO _____

COUNTY _____ **DATE** _____

OWNER CERTIFICATION

I, the undersigned, owner, whose Post office Address is _____ _____, Zip _____, do hereby accept and approve these plans.

_____

Owner

ENGINEER CERTIFICATION

I hereby certify that these plans for the (construction of, or alteration of) the _____ _____(Name of Dam) were prepared by me or under my direct supervision for the owners thereof.

_____

(Name of Firm)

_____

(Registered Engineer and P.E. #)

(Engineer's Seal)

ATTACHMENT

SAFETY PERMIT APPLICATION

DAM NAME _____ **ID #** MO _____

COUNTY _____ **DATE** _____

☐ **ENGINEER CERTIFICATION**

I hereby certify that the construction of the _____ _____(Name of Dam) was substantially in accordance with the approved plans and specifications on file with the Missouri Dam and Reservoir Safety Program.

_____

(Name of Firm)

_____

(Registered Engineer and P.E. #)

(Engineer's Seal)

ATTACHMENT

REGISTRATION PERMIT APPLICATION

DAM NAME _____ ID # MO _____

COUNTY _____ DATE _____

☐ **ENGINEER CERTIFICATION**

I hereby certify that I have inspected the _____ _____(Name of Dam) on _____ (Date) in accordance with the law.

☐ **ENGINEER CERTIFICATION**

I hereby certify that the owner of the _____ _____(Name of Dam) has complied with my recommendations to correct observed defects as required by law.

☐ **JUDGEMENT OF STABILITY**

At the time of my inspection, there were no observable indications that the dam was unsafe.

_____

(Name of Firm)

_____

(Registered Engineer and P.E. #)

(Engineer's Seal)

APPENDIX B

INVENTORY FORMS

DAM INVENTORY QUESTIONNAIRE

I.D. # MO _ _ _ _ _

1. NAME OF DAM: _____

2. OWNER: _____

OWNER'S ASSOCIATION: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

PHONE: _____

. LOCATION OF DAM: COUNTY: _____

Township: _____N; Range: _____East/West; Section: _____1/4 _____1/4 ____

. NAME OF ENGINEER: _____

. NAME OF BUILDER OR CONTRACTOR: _____

. TYPE OF DAM: (CHECK BOXES THAT APPLY)

☐ EARTH ☐ ROCK OR ROCK FILL ☐ CONCRETE OR MASONRY ☐ TAILINGS

. USE OF LAKE: (CHECK BOXES THAT APPLY)

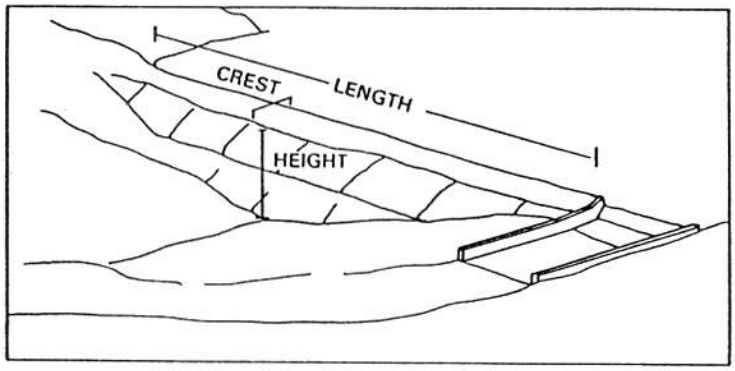
☐ RECREATION (FISHING,SWIMMING, ETC.) ☐ LIVESTOCK WATERING ☐ WATER SUPPLY

☐ CROP IRRIGATION ☐ INDUSTRIAL

. YEAR DAM WAS BUILT: _____

. SURFACE AREA OF LAKE: _____ ACRES

. DIMENSIONS OF DAM: (FILL IN BLANKS ON SKETCH)



HEIGHT: _____

WIDTH OF CREST: _____

LENGTH OF DAM: _____

. PRIMARY SPILLWAY? ☐ YES ☐ NO

. EMERGENCY SPILLWAY? ☐ YES ☐ NO

. NAME OF PERSON FILLING OUT QUESTIONNAIRE:

_____

DATE: _____

AGRICULTURAL EXEMPTION INFORMATION SHEET

MISSOURI DAM & RESERVOIR SAFETY PROGRAM

NAME OF DAM: _____ ID# (MO_____)

OWNER: _____

ADDRESS: _____

CITY: _____ STATE: ____ ZIP: _____ PHONE ___/_____

TYPE OF DAM: ☐ EARTH ☐ ROCK FILL ☐ CONCRETE/MASONRY

☐ OTHER _____

USE OF LAKE: (Check all boxes that apply)

☐ RECREATION (FISHING, SWIMMING, ETC.) ☐ LIVESTOCK WATERING

☐ WATER SUPPLY ☐ FISH REARING ☐ CROP IRRIGATION ☐ INDUSTRIAL

CURRENT NUMBER OF LIVESTOCK ON FARM THAT RECEIVE WATER FROM LAKE:

HORSES ____ HOGS ____ CATTLE ____ SHEEP ____ OTHER ____

METHOD OF WATERING LIVESTOCK:

☐ DIRECT ACCESS TO LAKE ☐ WATERING TANK ☐ OTHER

FARM SIZE (acres): TOTAL ____ PASTURE ____ HAY ____ WOODLAND ____ CROP ____

NUMBER OF FISH RAISED AND SOLD LAST YEAR:

CATFISH _____ TROUT _____ CARP _____ OTHER _____

ARE FISH RAISED IN CONFINEMENT CAGES? ☐ OR HARVESTED BY SEINING? ☐

NUMBER OF ACRES IRRIGATED AND TYPE OF CROPS:

CORN ____ AC. SOYBEANS ____ AC. MILO ____ AC. HAY ____ AC.

OTHER _____

TYPE OF IRRIGATION EQUIPMENT: TRAVELING GUN ☐ CENTER PIVOT ☐

STATIONARY SPRINKLER ☐ FLOOD IRRIGATION ☐

PUMPING FROM LAKE ☐ GRAVITY WITHDRAWAL FROM LAKE ☐

NAME OF PERSON FILLING OUT THIS QUESTIONNAIRE: _____

_____

DATE: _____ COMMENTS: _____

_____

APPENDIX C

RAINFALL DATA FOR MISSOURI

TABLE C.1

Precipitation Values for Counties in Missouri

County	6-Hour Duration			12-Hour Duration			24-Hour Duration		
	50-Year	100-Year	PMP*	50-Year	100-Year	PMP*	50-Year	100-Year	PMP*
Adair	4.8	5.2	27.1	5.5	6.3	32.0	6.4	7.0	33.5
Andrew	5.0	5.4	27.0	5.9	6.6	32.0	6.6	7.3	33.8
Atchison	4.9	5.3	26.7	5.9	6.4	31.6	6.4	7.1	33.2
Audrain	4.8	5.2	27.7	5.6	6.3	32.9	6.5	7.2	34.5
Barry	5.5	6.0	28.9	6.5	7.2	34.4	7.6	8.4	37.8
Barton	5.4	6.0	28.4	6.4	7.1	33.9	7.4	8.2	36.5
Bates	5.3	5.8	28.0	6.2	7.0	33.3	7.2	8.0	35.6
Benton	5.1	5.7	28.1	6.0	6.8	33.4	7.0	7.7	35.6
Bollinger	4.8	5.2	28.7	5.6	6.2	34.0	6.6	7.2	36.5
Boone	4.9	5.3	27.7	5.7	6.4	33.0	6.6	7.3	34.7
Buchanan	5.0	5.5	27.2	6.0	6.7	32.2	6.7	7.4	34.0
Butler	4.9	5.4	28.9	5.8	6.4	34.5	6.7	7.4	37.3
Caldwell	5.0	5.4	27.3	5.9	6.6	32.3	6.7	7.4	34.1
Callaway	4.9	5.3	27.8	5.7	6.4	33.1	6.6	7.3	34.8
Camden	5.0	5.6	28.2	6.0	6.7	33.6	7.0	7.7	36.0
Cape Girardeau	4.8	5.1	28.6	5.5	6.1	34.0	6.5	7.1	36.2
Carroll	5.0	5.4	27.4	5.8	6.6	32.7	6.7	7.4	34.3
Carter	5.0	5.5	28.8	5.8	6.5	34.3	6.8	7.5	37.0
Cass	5.2	5.7	27.8	6.1	6.9	33.1	7.1	7.9	35.0
Cedar	5.3	5.9	28.3	6.3	7.0	33.8	7.3	8.0	36.3
Chariton	4.9	5.3	27.4	5.7	6.4	32.5	6.6	7.3	34.2
Christian	5.3	5.9	28.8	6.3	7.0	34.3	7.3	8.0	37.4
Clark	4.6	5.1	27.0	5.4	6.0	31.8	6.2	6.8	33.2
Clay	5.1	5.6	27.4	6.0	6.7	32.7	6.8	7.6	34.4
Clinton	5.0	5.5	27.3	5.9	6.7	32.3	6.7	7.4	34.1
Cole	4.9	5.4	28.0	5.8	6.5	33.3	6.8	7.4	35.2
Crawford	5.9	5.3	28.3	5.7	6.4	33.6	6.6	7.4	35.9
Cooper	5.0	5.4	27.7	5.9	6.6	33.1	6.8	7.5	35.0
Dade	5.3	5.9	28.5	6.3	7.0	33.9	7.4	8.1	36.7
Dallas	5.2	5.7	28.4	6.1	6.8	33.8	7.1	7.8	36.5
Daviess	4.9	5.4	27.1	5.8	6.5	32.0	6.5	7.2	33.8
Dekalb	5.0	5.4	27.1	5.9	6.6	32.1	6.6	7.3	33.8
Dent	4.9	5.4	28.5	5.8	6.5	33.9	6.7	7.5	36.3
Douglas	5.2	5.8	28.8	6.2	6.9	34.3	7.1	7.9	37.5
Dunklin	4.9	5.4	29.1	5.8	6.4	34.8	6.8	7.5	38.0
Franklin	4.8	5.2	28.0	5.6	6.3	33.3	6.5	7.2	35.1
Gasconade	4.8	5.3	28.0	5.7	6.3	33.3	6.6	7.3	35.1
Gentry	4.9	5.3	26.9	5.8	6.5	31.8	6.5	7.2	33.5
Greene	5.3	5.9	28.6	6.3	7.0	34.0	7.3	8.0	37.0
Grundy	4.9	5.3	27.1	5.7	6.4	32.0	6.5	7.1	33.6
Harrison	4.9	5.3	26.9	5.7	6.4	31.8	6.4	7.1	33.3
Henry	5.2	5.7	28.0	6.1	6.9	33.3	7.1	7.8	35.5
Hickory	5.2	5.7	28.2	6.1	6.8	33.7	7.1	7.8	36.0
Holt	5.0	5.4	26.9	5.9	6.5	31.9	6.5	7.2	33.5

TABLE C.1

Precipitation Values for Counties in Missouri

County	6-Hour Duration			12-Hour Duration			24-Hour Duration		
	50-Year	100-Year	PMP*	50-Year	100-Year	PMP*	50-Year	100-Year	PMP*
Howard	4.9	5.3	27.6	5.7	6.5	32.9	6.7	7.4	34.5
Howell	5.1	5.7	28.9	6.0	6.8	34.5	7.0	7.8	37.5
Iron	4.9	5.3	28.5	5.7	6.3	33.8	6.6	7.3	36.2
Jackson	5.1	5.7	27.5	6.1	6.8	33.0	6.9	7.7	34.8
Jasper	5.5	6.0	28.5	6.5	7.2	34.0	7.5	8.3	37.0
Jefferson	4.8	5.2	28.1	5.5	6.1	33.3	6.4	7.1	35.2
Johnson	5.1	5.6	27.8	6.0	6.8	33.1	7.0	7.7	35.0
Knox	4.7	5.2	27.1	5.4	6.2	32.0	6.3	7.0	33.5
Laclede	5.1	5.7	28.4	6.0	6.7	33.8	7.0	7.7	36.4
Lafayette	5.1	5.6	27.6	6.0	6.7	32.9	6.9	7.6	34.8
Lawrence	5.4	6.0	28.6	6.4	7.1	34.1	7.4	8.2	37.1
Lewis	4.7	5.1	27.2	5.4	6.1	32.0	6.2	6.9	33.6
Lincoln	4.7	5.1	27.7	5.5	6.1	32.9	6.4	7.0	34.4
Linn	4.9	5.3	27.2	5.7	6.4	32.2	6.5	7.2	33.9
Livingston	4.9	5.4	27.5	5.8	6.5	32.2	6.6	7.3	34.0
McDonald	5.5	6.1	28.9	6.6	7.4	34.4	7.7	8.5	37.9
Macon	4.8	5.2	27.2	5.6	6.3	32.3	6.4	7.1	33.9
Madison	4.8	5.3	28.6	5.6	6.2	33.9	6.6	7.3	36.2
Maries	4.9	5.4	28.2	5.8	6.5	33.5	6.8	7.5	35.7
Marion	4.7	5.1	27.3	5.4	6.1	32.2	6.3	7.0	33.9
Mercer	4.8	5.3	26.9	5.6	6.3	31.8	6.4	7.0	33.3
Miller	5.0	5.5	28.1	5.9	6.6	33.5	6.9	7.5	35.8
Mississippi	4.8	5.1	28.9	5.5	6.1	34.2	6.5	7.1	37.0
Moniteau	5.0	5.4	27.9	5.9	6.6	33.2	6.8	7.5	35.0
Monroe	4.8	5.2	27.5	5.6	6.3	32.6	6.4	7.1	34.1
Montgomery	4.8	5.2	27.7	5.6	6.3	33.0	6.5	7.1	34.7
Morgan	5.0	5.5	28.0	6.0	6.7	33.3	6.9	7.6	35.5
New Madrid	4.8	5.3	29.0	5.6	6.2	34.5	6.6	7.2	37.2
Newton	5.5	6.1	28.7	6.5	7.3	34.2	7.6	8.4	37.5
Nodaway	4.9	5.3	26.8	5.8	6.5	31.6	6.4	7.1	33.3
Oregon	5.0	5.6	28.9	6.0	6.7	34.5	6.9	7.7	37.6
Osage	4.9	5.4	28.0	5.7	6.4	33.3	6.7	7.4	35.2
Ozark	5.2	5.8	28.9	6.2	6.9	34.5	7.2	7.9	37.8
Pemiscot	4.9	5.3	29.2	5.7	6.4	34.8	6.7	7.4	38.0
Perry	4.8	5.1	28.5	5.5	6.1	33.7	6.4	7.1	36.0
Pettis	5.0	5.6	27.8	6.0	6.7	33.2	7.0	7.6	35.0
Phelps	4.9	5.4	29.3	5.8	6.5	33.7	6.8	7.5	36.0
Pike	4.7	5.1	27.6	5.4	6.1	32.7	6.3	7.0	34.0
Platte	5.1	5.6	27.3	6.0	6.7	32.5	6.8	7.6	34.3
Polk	5.2	5.8	28.4	6.2	6.9	33.9	7.2	7.9	36.5
Pulaski	5.0	5.5	28.3	5.9	6.6	33.8	6.9	7.6	36.1
Putnam	4.8	5.2	26.9	5.5	6.2	31.8	6.3	7.0	33.2
Ralls	4.7	5.1	27.5	5.4	6.1	32.6	6.3	7.0	34.0
Randolph	4.8	5.3	27.5	5.7	6.4	32.7	6.5	7.2	34.2

TABLE C.1

Precipitation Values for Counties in Missouri

County	6-Hour Duration			12-Hour Duration			24-Hour Duration		
	50-Year	100-Year	PMP*	50-Year	100-Year	PMP*	50-Year	100-Year	PMP*
Ray	5.0	5.5	27.4	5.9	6.7	32.7	6.8	7.5	34.4
Reynolds	4.9	5.4	28.7	5.8	6.4	34.0	6.7	7.4	36.5
Ripley	5.0	5.5	28.9	5.9	6.6	34.5	6.8	7.5	37.5
St. Charles	4.7	5.1	27.8	5.5	6.1	33.0	6.4	7.0	34.7
St. Clair	5.2	5.8	28.2	6.2	6.9	33.5	7.2	7.9	36.0
St. Francois	4.8	5.2	28.4	5.6	6.2	33.6	6.5	7.2	35.9
St. Louis	4.7	5.1	27.9	5.4	6.1	33.1	6.3	7.0	34.8
St. Louis City	4.7	5.1	27.9	5.4	6.0	33.0	6.3	7.0	34.8
Ste. Genev	4.8	5.1	28.3	5.5	6.1	33.6	6.5	7.1	35.8
Saline	5.0	5.4	27.6	5.9	6.6	33.0	6.8	7.5	34.6
Schuyler	4.7	5.2	26.9	5.5	6.2	31.8	6.3	6.9	33.2
Scotland	4.7	5.1	26.9	5.4	6.1	31.8	6.2	6.9	33.2
Scott	4.8	5.2	28.8	5.6	6.1	34.1	6.5	7.1	36.6
Shannon	5.0	5.5	28.7	5.9	6.6	34.2	6.8	7.6	37.0
Shelby	4.8	5.2	27.3	5.5	6.2	32.3	6.4	7.0	33.9
Stoddard	4.8	5.3	28.9	5.7	6.3	34.3	6.6	7.3	37.0
Stone	5.4	6.0	28.9	6.4	7.1	34.5	7.5	8.2	37.7
Sullivan	4.8	5.3	27.0	5.6	6.3	32.0	6.4	7.1	33.5
Taney	5.3	5.9	28.9	6.3	7.0	34.5	7.4	8.1	37.8
Texas	5.0	5.6	28.6	6.0	6.7	34.0	6.9	7.6	37.0
Vernon	5.4	5.9	28.2	6.3	7.1	33.6	7.3	8.1	36.0
Warren	4.8	5.2	27.9	5.5	6.2	33.1	6.5	7.2	34.8
Washington	4.8	5.3	28.3	5.6	6.3	33.6	6.6	7.3	35.8
Wayne	4.9	5.3	28.7	5.7	6.3	34.1	6.7	7.4	36.8
Webster	5.2	5.8	28.6	6.2	6.9	34.0	7.2	7.9	37.0
Worth	4.9	5.3	26.8	5.7	6.4	31.6	6.4	7.0	33.3
Wright	5.1	5.7	28.6	6.1	6.8	34.0	7.1	7.8	37.0

* Probable Maximum Precipitation (PMP) values were taken from the National Weather Service publication, Hydrometeorological Report 51. All PMP values in Table C.1 are for 10 square mile areas.

ERRATA - October 16, 1989

CORRECTED TABLE C.1 Ray through Wright Counties

Rules of
Department of Natural Resources
Division 22—Dam and Reservoir Safety Council
Chapter 1—Organization, Definitions and Immunity

Title		Page
10 CSR 22-1.010	General Organization	3
10 CSR 22-1.020	Definitions	3
10 CSR 22-1.030	Immunity of Officers	5

Title 10—DEPARTMENT OF NATURAL RESOURCES
Division 22—Dam and Reservoir Safety Council
Chapter 1—Organization, Definitions and Immunity

10 CSR 22-1.010 General Organization

PURPOSE: This rule complies with section 536.023, RSMo which requires each agency to adopt as a rule a description of its operation and the methods where the public may obtain information or make submissions or requests.

(1) Section 236.410, RSMo established a Dam and Reservoir Safety Council of Missouri. The council consists of seven (7) members appointed by the governor with the advice and consent of the senate. The council holds a minimum of four (4) regular meetings each year and special meetings and hearings as the council chairman may deem necessary.

(2) The Missouri dam and reservoir safety law, rules, regulations, guidelines and standards provide for the construction management and operation of dams and reservoirs in a manner which will provide adequate protection of public safety, life or property. To achieve this purpose the council has statutory powers as listed in sections 236.405 and 236.415, RSMo for policy making, adopting rules, standards and guidelines and issuing of permits.

(3) The Department of Natural Resources is authorized under section 236.405, RSMo to administer and enforce all rules, standards and guidelines adopted by the council and to assist the council in achieving its statutory duties. The department has designated the dam and reservoir safety program as the agency within the department responsible for administering the dam and reservoir safety law. The director of the Department of Natural Resources appoints a chief engineer who is the dam and reservoir safety program director and a staff, as provided in section 236.405, RSMo. The chief engineer and staff provide day-to-day operation of the dam and reservoir safety program.

(4) The dam and reservoir safety program performs administrative and technical functions including: review permit applications and recommend approval or denial of applications; inspect dams and reservoirs; enforce the law and all rules, standards and guidelines adopted pursuant to Chapter 236, RSMo; employ necessary staff; develop facts as may be required by the council; recommend rules, standards and guidelines required by Chapter 236, RSMo; mitigate or eliminate unsafe dam or reservoir conditions; and other functions as described in sections 236.420 to 236.500, RSMo.

(5) Requests for permit applications, requirements or other permit information, copies of these rules and the dam and reservoir safety law, dam inspections and technical information and assistance, requests for public hearings and any other submissions are to be made to the Department of Natural Resources, Dam and Reservoir Safety Program, P.O. Box 250, Rolla, MO 65401.

AUTHORITY: Chapter 236, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981.

Original authority: 236.405, RSMo 1979 and 236.415, RSMo 1979.

10 CSR 22-1.020 Definitions

PURPOSE: The following terms when used in rules, standards and guidelines adopted by the Dam and Reservoir Safety Council pursuant to the dam safety law shall have the meaning respectively ascribed to them by this section.

PUBLISHER'S NOTE: The secretary of state has determined that the publication of the entire text of the material which is incorporated by reference as a portion of this rule would be unduly cumbersome or expensive. Therefore, the material which is so incorporated is on file with the agency who filed this rule, and with the Office of the Secretary of State. Any interested person may view this material at either agency's headquarters or the same will be made available at the Office of the Secretary of State at a cost not to exceed actual cost of copy reproduction. The entire text of the rule is printed here. This note refers only to the incorporated by reference material.

(1) Agency engineer means an experienced engineer, not necessarily registered as a professional engineer in Missouri, who works for an engineering division of a state or federal agency regularly engaged in dam and reservoir design and construction for soil and water conservation or irrigation or relating to wildlife conservation.

(2) Agricultural dam means any dam, the primary use of which is to impound water for use in irrigation, livestock watering or commercial fish rearing and sale.

(3) Alterations, repairs, or either means alterations or repairs as affect the safety of a dam or reservoir, or public safety, life or property.

(4) Appurtenant works means the structures or materials incident to or annexed to dams which are built or maintained in connection with dams and which are used primarily in connection with their proper operation, maintenance or functioning. This includes, without limitation, structures as spillways, either in the dam or separate therefrom; the reservoir rim; low level outlet works; and water conduits such as tunnels, pipelines or penstocks, either through a dam or its abutments.

(5) Area capacity curves means graphic curves which show the relationship between reservoir surface area and the storage capacity of the reservoir at given elevations.

(6) Chief engineer means the head of the dam and reservoir safety program of the Department of Natural Resources or his/her representative.

(7) Commercial fish rearing reservoir means a reservoir which was designed specifically for fish rearing purposes and the primary use is to provide water for commercial fish rearing and sale to other parties in a for profit venture. This does not include activities such as sport fishing.

(8) Construction permit means a written authorization issued by the council giving the owner the right to construct, alter, enlarge, reduce, repair or remove a dam or reservoir or appurtenances thereto, with conditions that are necessary to adequately protect the public safety, life, property, the dam or reservoir.

(9) Conventional dam means any dam other than an industrial water retention dam.

(10) Council delegate or authorized representative means an individual, usually the chief engineer, authorized by the council to act in its behalf.

(11) Crest or dam crest means the top surface of the dam.

(12) Crest elevation or dam crest elevation means the lowest elevation of the crest exclusive of the spillway(s).

(13) Dam means any artificial or man-made barrier which does or may impound water and which impoundment has or may have a surface area of fifteen (15) or more acres of water at the water storage elevation or which is thirty-five feet (35') or more in height from the natural bed of the stream or watercourse or lowest point on the toe of the dam (whichever is lower) up to the crest elevation, together with appurtenant works. Sections 236.400 to 236.500 shall not apply to any dam which is not or will not be in excess of thirty-five feet (35') in height or to any dam or reservoir licensed and operated under the Federal Power Act.

(14) Dam and Reservoir Safety Council referred to as the council means seven (7) members appointed by the governor for purposes of implementing the dam safety law.

(15) Dangerous dam or reservoir is a dam or reservoir which is in an advanced state of deterioration so that if deterioration continues, the threat of dam failure and flooding would be substantial.

(16) Department means the Department of Natural Resources.

(17) Downstream environment zone means the area downstream from a dam that would be affected by inundation in the event the dam failed when filled to the emergency spillway crest elevation or to the dam crest elevation, in the absence of an emergency spillway.

(18) Earthquake intensity means Modified Mercalli intensity which is used to describe the degree of shaking a dam will experience.

(19) Enforcement order means a written directive issued by the council or the chief engineer to the owner of a dam for correction of defects in the dam or reservoir which have been determined to make the structure a threat to public safety, life or property. The order will contain specific actions with which the owner must comply to remove the threat the dam or reservoir poses to public safety, life or property.

(20) Enlargement means any change in or addition to an existing dam or reservoir, which raises the height of the dam, increases the watershed for the reservoir or raises the water storage elevation of the water impounded by the dam or reservoir.

(21) Environmental class means a classification of the downstream environment zone based on the contents of that zone (see 10 CSR 22-2.040(1)). Class I represents the most severe threat to public safety, life or property and Class III represents the least threat.

(22) Factor of safety means the resultant of the summation of the forces resisting failure divided by the summation of the driving forces tending to cause failure.

(23) Freeboard means the difference in elevation between the dam crest elevation and the water storage elevation in the reservoir.

(24) Height or height of dam means the difference in the elevation of either the natural bed of the stream or watercourse or the lowest point on the toe of the dam (whichever is lower) and the dam crest elevation.

(25) Industrial building means a permanent, enclosed structure used by groups of workers usually involved in some type of manufacturing, processing or industrial related process.

(26) Industrial water retention dam means a dam used to retain the solids transported as water-borne industrial byproducts and the associated water. This includes, but is not limited to, tailings dams, slime impoundments and settling ponds.

(27) Inundation means water, two feet (2') or more deep, over the general level of the submerged ground affected outside the stream channel.

(28) Inspection means scheduled and unscheduled examinations of a dam and reservoir with the primary objective of making safety observations and recording them in a written description.

(29) Irrigation reservoir means a reservoir whose primary use is to provide water for the irrigation of agricultural lands for the production of grains, hay, pasture, fruits, vegetables and animal feeds which are for sale or to be used by the owner.

(30) Law means the dam and reservoir safety law, as contained in Chapter 236, RSMo and all rules, standards and guidelines adopted thereto.

(31) Liquefaction is a condition where a soil will undergo continued deformation at a constant low residual stress or with low residual resistance, due to the build-up and maintenance of high pore water pressures, which reduce the effective confining pressure to a very low value.

(32) Livestock watering reservoir means a reservoir whose primary use is to provide water for livestock which are raised for breeding or marketing purposes.

(33) Maintenance means the proper keeping of all aspects of a dam or reservoir and appurtenances thereto, that pertain to safety, in a state of repair and working order as necessary to comply with the law and any permit issued thereunder and to protect public safety, life or property.

(34) Modification(s) means changes or revisions to the design, construction, maintenance, operation or repair or the alteration, enlargement, reduction, removal or natural physical changes that may occur to a dam or reservoir that were not included in the approved plans for the construction permit, or changes or revisions to a dam or reservoir where a registration or safety permit is in effect or required hereunder, if the changes or revisions would endanger public safety, life or property as a result of creating a potential failure in the dam or reservoir; except that modification(s) do not mean or include approved anticipated enlargements, outlined by design plans and specifications submitted and approved with the original application for a construction, safety or registration permit for industrial water retention dams and reservoirs.

(35) Observable defects are those defects which would be detectable by an experienced professional engineer making an on-site visual inspection of the dam in accordance with current engineering, geologic and construction practices.

(36) Owner or dam owner means a person who owns, controls, operates, maintains, manages or proposes to construct a dam or reservoir including: the state and its departments, institutions, agencies and political subdivisions, but not the United States government; a municipal or quasi-municipal corporation; a district; a public utility; a natural person, firm, partnership, association, corporation, political subdivision or legal entity; the duly authorized agents or leasees, or trustees of any of the foregoing; or receivers or trustees appointed by any court for any of the foregoing.

(37) Permanent dwelling means a dwelling occupied at least ninety (90) days a year.

(38) Permit means construction, safety or registration permit.

(39) Permit applicant or applicant means an owner who applies for a construction, safety or registration permit.

(40) Probable maximum acceleration means the horizontal acceleration developed at a dam as a result of an earthquake with a probability of occurrence similar to the probable maximum precipitation. The probable maximum acceleration is readily available from a Corps of Engineers Report entitled Earthquake Potential of the St. Louis District—Ground Motion Supplement which is on file with the chief engineer of the Dam and Reservoir Safety Program.

(41) Probable maximum precipitation or PMP means the precipitation that may be expected from the most severe combination of critical meteorologic conditions that are reasonably possible in an area. The PMP is readily available from the National Weather Service in Hydrometeorological Report 51, Probable Maximum Precipitation Estimates, United States East of the 105th Meridian.

(42) Public building means a permanent, enclosed structure used by groups of the general public but not necessarily owned by the public.

(43) Registration permit means a permit issued for a period not to exceed five (5) years by the council to the owner of a dam or reservoir in existence or in the progress of construction on August 13, 1981 or which becomes subject to the law for the dams and reservoirs by a change in factors or circumstances subsequent to that date. Permits shall only be issued for dams which are in a properly maintained condition or which have made and complied with recommendation for corrections of observed defects of the dam or reservoir and have been examined and approved in accordance with the law.

(44) Reservoir means any basin, including the water, which contains or will contain the maximum amount of water impounded by a dam.

(45) Safety permit means a permit issued to the owner of a dam for a period of five (5) years, or less if safety considerations so require, by the council indicating that the dam meets the requirements of the law, and containing conditions as to operations, maintenance and repair as are necessary to adequately protect public safety, life and the dam or reservoir.

(46) Seepage means the migration of water through a dam or foundation.

(47) Significant modification means changes, alteration or modifications to an existing dam or changes to the construction documents for a new dam. Those include, but are not limited to: changes in the location of the dam or reservoir, changes in the storage capacity or drainage area, changes in the capacity of the spillway system, modification of the embankment slopes, changes in the height of the dam or structure, or the use of different construction methods or procedures than those submitted with the permit application.

(48) Spillway means any passageway, channel or structure, open or closed or both, designated expressly or primarily to discharge excess water from a reservoir after the water storage elevation has been reached.

(49) Spillway design flood or SDF means the specified flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in an area and for which the dam and reservoir are designed. The SDF is derived from the rainfall values given in Table 5.

(Editor's Note: For Table 5 see 10 CSR 22-3.020)

(50) Stability means the properties of a dam or reservoir that cause it when disturbed from a condition of equilibrium to develop forces or moments that restore the original condition.

(51) Starter dam means a pervious or impervious dam constructed as the first phase in the building of an industrial water retention dam and reservoir.

(52) Storage means the volumetric capacity of the reservoir below the water storage elevation or other selected reference on the dam.

(53) Stream means any river, creek or channel, having well-defined banks, in which water flows for substantial periods of the year to drain a given area.

(54) Tailings means the material generated by a mining/milling operation which is deposited in slurry form in an impoundment for storage, disposal, or both.

(55) Tailings dam means an existing dam or reservoir used for the impoundment or retention of tailings or a proposed, existing or newly constructed dam and reservoir for which the anticipated or contemplated use is the impoundment or retention of tailings.

(56) Toe or toe of slope means the line of the fill (dam embankment) slope where it intersects the natural ground.

(57) Water means water, other liquids or tailings.

(58) Watercourse means a valley, swale, depression or other low place in the topography occupied by flowing water during conditions of runoff.

(59) Water storage elevation means that elevation of water surface at the principal spillway which could be obtained by the dam or reservoir were there no outflow and were the reservoir full of water.

(60) Watershed means the area that contributes or may contribute surface water to a reservoir.

AUTHORITY: sections 236.405, RSMo Supp. 1993 and 236.415, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective Jan. 1, 1985. Amended: Filed Sept. 1, 1993, effective May 9, 1994.*

**Original authority: 236.405, RSMo 1979, amended 1933 and 236.415, RSMo 1979.*

10 CSR 22-1.030 Immunity of Officers

PURPOSE: The purpose of this rule is to restate the immunity from damages provided in section 236.475, RSMo (1986).

(1) In the absence of willful and wanton misconduct, no action shall be brought against the council, the chief engineer or his/her agents, department employees or private individuals employed as consultants by the department for the recovery of damages caused by the partial or total failure of any dam or reservoir or through the use or operation of any dam or reservoir upon the ground that the person is liable by virtue of any of the following: the approval of a dam or reservoir or permits therefore; the issuance or enforcement of orders relating to maintenance, operation or repair of a dam or reservoir; control or regulation of a dam or reservoir; measures taken to protect against failure during an emergency; or denial of a permit.

AUTHORITY: section 236.475, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981.*

**Original authority: 236.475, RSMo 1979.*

Rules of
Department of Natural Resources
Division 22—Dam and Reservoir Safety Council
Chapter 2—Permits

Title		Page
10 CSR 22-2.010	Who Needs a Permit	3
10 CSR 22-2.020	Types of Permits	3
10 CSR 22-2.030	Types of Dams and Reservoirs	4
10 CSR 22-2.040	Classes of Downstream Environment	4
10 CSR 22-2.050	Issuing First Permit	4
10 CSR 22-2.060	Issuing Permit Renewals	5
10 CSR 22-2.070	Modifications not Requiring Permit Changes (Rescinded January 1, 1985)	5
10 CSR 22-2.080	Revoking Permit	5
10 CSR 22-2.090	Transferring Permit	5
10 CSR 22-2.100	Appeal of Action on Permits	6

Title 10—DEPARTMENT OF NATURAL RESOURCES
Division 22—Dam and Reservoir Safety Council
Chapter 2—Permits

10 CSR 22-2.010 Who Needs a Permit

PURPOSE: This rule identifies those persons who need to obtain a permit for their dam and reservoir and to identify those persons who do not need to obtain a permit for their dam and reservoir.

(1) The owner of a proposed new dam thirty-five feet (35') or more in height is required to obtain a construction permit and a safety permit for his/her dam and reservoir. The owner of an existing dam thirty-five feet (35') or more in height is required to obtain a registration permit within the time set forth in 10 CSR 22-2.020(2).

(2) By definition, the United States government is not considered an owner. Therefore, no federal dam and reservoir is regulated by sections 236.400—236.500, RSMo and no permits are required.

(3) Agricultural dams are exempted from all permit requirements as long as the agricultural dam and reservoir continue to be used primarily for agricultural purposes (see 10 CSR 22-1.020(2)). The owners of agricultural dams and reservoirs over thirty-five feet (35') in height must notify the council of their reliance on this exemption and their basis for application of this exemption to their dams. If an agricultural dam and reservoir is constructed after the effective date of the law, but subsequently becomes subject to the provisions of the law, the owner shall provide, prior to obtaining a registration permit, evidence that the dam meets the construction permit criteria in effect at the time the dam was constructed.

(4) Dams and reservoirs licensed and operated under the Federal Power Act are exempted from all permit requirements.

(5) Dams and reservoirs that were designed by and the construction monitored by an agency engineer (see 10 CSR 22-1.020(1)) do not need a construction permit but a set of plans shall be filed with the chief engineer prior to the initiation of any construction activity. These dams and reservoirs are required to have a registration or safety permit subsequent to construction.

(6) Industrial water retention dams (see 10 CSR 22-1.020(27)) and reservoirs regulated by another state agency or federal agency are exempted from all permit requirements. For the exemption to apply, the industrial water retention dam and reservoir must be subject to safety inspections by the other state agency or federal agency and standards used must be at least as stringent as those required by the law. In addition, the owner must notify the council that another agency is regulating his/her dam and reservoir and explain the basis for the exemption to apply.

AUTHORITY: sections 236.400, 236.415, 236.435, 236.440 and 236.465, RSMo 1986 and 236.405, RSMo Supp. 1993. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective Jan. 1, 1985. Amended: Filed Sept. 1, 1993, effective May 9, 1994.*

**Original authority: 236.400, 236.415, 236.435, 236.440 and 236.465, RSMo 1979 and 236.405, RSMo 1979, amended 1993.*

10 CSR 22-2.020 Types of Permits

PURPOSE: This rule describes the three types of permits and their uses that the Dam and Reservoir Safety Council will issue.

(1) There are three (3) types of permits—registration permits, construction permits and safety permits and each one is intended to regulate a separate and distinct type of activity. A dam and reservoir will have only one (1) type of permit in effect at any given time although they may have more than one (1) type of permit during their existence.

(2) Registration permits (see 10 CSR 22-1.020(44)) apply to and are required for the continued operation of a dam and reservoir that was in existence or in the process of being constructed on the effective date of this section, August 13, 1981. A registration permit also applies to and is required for structures which become subject to the provisions of the dam and reservoir safety law that were in existence prior to the date that they became subject to the law. Registration permits may be issued for a time period up to five (5) years. The owner of a dam and reservoir on the effective date of the law shall obtain his/her first registration permit in accordance with the height of his/her dam. For dam heights of thirty-five feet (35') to less than fifty feet (50'), fifty feet to seventy feet (50'–70') and over seventy feet (70 + '), the maximum time to obtain the first registration permit is respectively within nine (9) years, four (4) years and two (2) years from the effective date of this section, August 13, 1981.

(3) Construction permits (see 10 CSR 22-1.020(8)) apply to the construction of a new dam and reservoir, the alteration, enlargement, reduction, repair or removal of a new or existing dam, reservoir or appurtenances. New dams are dams for which construction commences after the effective date of this section, August 13, 1981. For dams which were under construction on August 13, 1981, construction must be completed by August 13, 1987 or the owner will be required to obtain a construction permit. If completed prior to August 13, 1987, the owner will be required to obtain a registration permit as outlined in 10 CSR 22-2.020(2). A construction permit may be issued for any reasonable length time period required to complete construction and it may contain appropriate restrictions placed on the owner for construction and operation of the dam and reservoir during that period. At the conclusion of construction, a safety or registration permit shall be obtained by the owner.

(4) Safety permits (see 10 CSR 22-1.020(48)) apply to the operation of a dam and reservoir constructed pursuant to a construction permit. The safety permit is not a guarantee of the dam and reservoir's safety and does not alter the owner's liability; it is simply an operating permit. If a dam and reservoir were not subject to the provisions of the law when they were constructed but subsequently become subject to the provisions of the law, the owner shall obtain a registration permit, not a safety permit. Safety permits may be issued for a time period up to five (5) years, and they may contain appropriate conditions for the operation and safety of the dam and reservoir.

AUTHORITY: sections 236.400, 236.415, 236.435, 236.440 and 236.465, RSMo 1986 and 236.405, RSMo Supp. 1993. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective Jan. 1, 1985. Amended: Filed May 15, 1987, effective Sept. 15, 1987.*

**Original authority: 236.400, 236.415, 236.435, 236.440 and 236.465, RSMo 1979 and 236.405, RSMo 1979, amended 1993.*

10 CSR 22-2.030 Types of Dams and Reservoirs

PURPOSE: This rule describes the two fundamentally different types of dams and reservoirs that will be required to obtain permits from the Dam and Reservoir Safety Council.

(1) There are two (2) types of dams and reservoirs, conventional dams and reservoirs and industrial water retention dams and reservoirs. The two (2) types of dams and reservoirs are distinguished on the basis of their reservoir contents and the length of the time period during which active dam building occurs.

(2) Conventional dams and reservoirs (see 10 CSR 22-1.020(9)) are dams and reservoirs used for purposes other than tailings, slime, settling or other similar industrial water retention purposes. A conventional dam is constructed in one (1) relatively continuous operation over a short time span (compared to the design life of the reservoir). Filling and use of the reservoir occurs after construction is completed.

(3) Industrial water retention dams and reservoirs (see 10 CSR 22-1.020(27)) are dams and reservoirs used for the purpose of storing solids and the water associated with the particular industrial process such as tailings, slime and other similar industrial materials. An industrial water retention dam may be constructed in phases and steps or continuously, over a long period of time (compared to the design life of the reservoir). Filling and use of the reservoir may occur during most phases of construction. An industrial water retention dam and reservoir in existence or under construction on the effective date of 10 CSR 22-2.020(2), August 13, 1981, shall obtain a registration permit which may include approval to make enlargements. The owner of any such dam and reservoir shall apply for and obtain new construction and/or registration permits for any modifications to that dam and reservoir other than enlargements covered by an existing permit. A construction permit is required and shall be obtained by the owner, for the initial construction phase of any new industrial water retention dam and reservoir built after the effective date of 10 CSR 22-2.020(3), August 13, 1981. Upon completion of the initial construction phase, the owner shall apply for a safety permit for the operation and enlargement of the new dam and reservoir.

AUTHORITY: sections 236.405, RSMo Supp. 1993 and 236.415, 236.435, 236.440 and 236.465, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective Jan. 1, 1985.*

**Original authority: 236.405, RSMo (1979), amended 1993 and 236.415, 236.435, 236.440 and 236.465, RSMo (1979).*

10 CSR 22-2.040 Classes of Downstream Environment

PURPOSE: This rule describes the three environmental classes for the downstream environmental zone that will be used by the Dam and Reservoir Safety Council when considering permits.

(1) The downstream environment zone is the area downstream from a dam that would be affected by inundation in the event the dam failed. Inundation is defined as water, two feet (2') or more deep over the general level of the submerged ground affected outside the stream channel. Based on the content of the downstream environment zone, three (3) environmental classes are defined. They are: class I, which contains ten (10) or more permanent dwellings or any public building; class II, which contains one to nine (1–9) permanent dwellings, or one (1) or more campgrounds with permanent water, sewer and electrical services or one (1) or more industrial buildings; and class III, which is everything else.

(2) Spillway design standards are based on the environmental class of the downstream environment zone of a dam and reservoir. The standards become more stringent for lower environmental class numbers. If conditions change in the downstream environment zone and it becomes necessary to change the environmental class of the dam and reservoir, the owner must then meet the standards and criteria for the new environmental class of the dam and reservoir. A dam and reservoir may be in only one (1) environmental class at a given time.

(3) Inundation, the downstream environmental zone and the associated environmental class are analyzed, assuming the dam fails with the reservoir at the emergency spillway crest elevation or the dam crest elevation in the absence of an emergency spillway. If the spillway standards for class I are used, the failure analysis does not have to be performed. If a failure analysis is made, the contents of the downstream environment zone used to determine the environmental class are only the features that would be inundated by the flooding resulting from the dam failure.

AUTHORITY: sections 236.405, RSMo Supp. 1993 and 236.415, 236.435, 236.440 and 236.465, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective Jan. 1, 1985.*

**Original authority: 236.405, RSMo 1979, amended 1993 and 236.415, 236.435, 236.440 and 236.465, RSMo 1979.*

10 CSR 22-2.050 Issuing First Permit

PURPOSE: This rule describes the procedure for issuing the first permit to a dam and reservoir owner for a particular dam and reservoir.

(1) A permit will be issued or a letter will be sent to the owner with comments within forty-five (45) days after the receipt of a properly prepared application or after the completion of any hearings or record period conducted by the council in connection with the application, whichever is later. The council, upon hearing the recommendations of the chief engineer, shall approve or deny the permit application.

(2) A permit will be issued if a complete and proper application has been submitted and the dam and reservoir comply with the law.

(A) A registration permit may be denied if it is determined that the owner has not complied with the experienced professional engineer's or agency engineer's inspection recommendations.

(B) A construction permit may be denied if there is insufficient information to determine that the proposed construction, alteration, enlargement, reduction or removal of a dam or reservoir would not endanger public safety, life or property or otherwise would comply with the law.

(C) A safety permit may be denied if it is determined that there are violations of the construction permit or the law.

(D) If revisions have been made which vary substantially from the provisions of the construction permit, the owner must show that the revisions do not endanger public safety, life or property before a safety permit will be issued.

(3) Conditions contained in a construction permit shall include that the construction work must be under the responsible charge of an experienced professional engineer and the records be kept and made available as

required by the chief engineer including, without limitation, for the foundation excavation and inspection and placement of backfill in the core trench. It is not necessary for the engineer in responsible charge to be on-site continuously. During construction, the council or its delegate, the chief engineer, may make periodic site inspections the purpose of inspecting and securing conformity of construction with the approved plans and specifications and the owner shall permit, upon reasonable notice, the person entry upon its property to make such inspections. The owner may be required to perform, at its own expense, reasonable work or tests as are necessary to provide sufficient information to enable the council to determine that there is conformity. Usually, testing will be limited to verification of embankment compaction, concrete strengths and other similar requirements. It is expected that the tests will be required where the owner's inspection records are lacking.

(4) Any significant modifications from a construction permit or approved plans makes the permit void and requires the owner to obtain a new permit. Significant modification to the plans and specifications must be prepared by an experienced professional engineer. The council or its delegate will follow the same evaluation procedures for the modifications as used with issuance of the original construction permit. Special attention will be given to these modification requests to provide a quick decision.

(5) The owner of a dam and reservoir that is removed under a construction permit must notify the council or its delegate when this work is completed and in conformity with the provisions of the construction permit. The council or its delegate will then issue a final approval to relieve the owner of the requirement to have a permit upon a showing that the requirements of the law for removal have been satisfied.

(6) Approval by the council for a construction permit becomes invalid within one (1) year, unless work on the construction has begun within that period, except that the owner may be excused from beginning work for a period of time that the work is prevented by flood, shortage of materials or regulation of government which cannot be met for reasons over which the owner has no control or other causes beyond the owner's control. The same applies to construction of approved modifications contained in the conditions of a registration or safety permit for industrial water retention dams unless the conditions specify a different time schedule.

AUTHORITY: sections 236.400, 236.415, 236.435, 236.440 and 236.465, RSMo 1986 and 236.405, RSMo Supp. 1993. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective Jan. 1, 1985.*

**Original authority: 236.400, 236.415, 236.435, 236.440 and 236.465, RSMo 1979 and 236.405, RSMo 1979, amended 1993.*

10 CSR 22-2.060 Issuing Permit Renewals

PURPOSE: This rule describes the procedure for renewing a permit.

(1) The owner of a permitted dam and reservoir must apply for the renewal of the permit not less than sixty (60) days prior to expiration of that permit. Before any permit may be renewed, the chief engineer must determine that the dam and reservoir are essentially as described in the latest permit and approved plans; they satisfy the law; and that no inspection conducted in connection with the permit renewal reveals any defect which would threaten public safety, life or property. The council, or its delegate will issue another permit within forty-five (45) days of the receipt of a complete and proper application unless it is determined that the dam and reservoir are not as described in the latest permit and approved plans; not properly maintained; do not satisfy the law; or that the defects are not corrected.

(2) The council may require the owner to furnish a certification by an experienced professional engineer or an agency engineer that the dam and reservoir are as described in the latest permit and approved plans; are properly maintained; satisfy the law; and have all defects corrected.

AUTHORITY: sections 236.405, RSMo Supp. 1993 and 236.415, 236.440 and 236.465, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective Jan. 1, 1985.*

**Original authority: 236.405, RSMo 1979, amended 1993 and 236.415, 236.440 and 236.465, RSMo 1979.*

10 CSR 22-2.070 Modifications not Requiring Permit Changes
(Rescinded January 1, 1985)

AUTHORITY: sections 236.405, 236.415, 236.435, 236.440, and 236.465, RSMo Supp. 1980. Original rule filed April 14, 1981, effective Aug. 13, 1981. Rescinded: Filed June 14, 1984, effective Jan. 1, 1985.

10 CSR 22-2.080 Revoking Permit

PURPOSE: This rule describes the reasons for revoking a permit.

(1) Approval of the council or its delegate, the chief engineer, shall be obtained for modifications that substantially alter or adversely affect the safety or stability of the dam or reservoir. Modifications, without the approval of the council or its delegate, the chief engineer, are cause for suspension or revocation of any permit. If the chief engineer finds that the condition of the dam and reservoir has deteriorated substantially from those conditions present when the permit was issued, or that has defects which adversely affect the safety or stability of the dam and reservoir or threatens public safety, life or property, s/he shall revoke the permit. If a permit is suspended or revoked, the dam owner will be in violation of the law and may be subject to prosecution for a misdemeanor.

(2) If the chief engineer determines that a dam or reservoir constitutes a threat to public safety, life or property, s/he may order its removal or take any other actions necessary to reduce or eliminate the threat. Failure of a dam owner to alter or remove his/her dam and reservoir as directed, when it is found to be a threat to public safety, life or property, will result in revocation of the permit and, if necessary, removal of the dam or any other action necessary to reduce or eliminate the threat to public safety, life or property by the state at the owner's expense.

AUTHORITY: sections 236.405, RSMo Supp. 1993 and 236.415, 236.445, 236.495 and 236.500, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective Jan. 1, 1985.*

**Original authority: 236.405, RSMo 1979, amended 1993 and 236.415, 236.445, 236.495 and 236.500, RSMo 1979.*

10 CSR 22-2.090 Transferring Permit

PURPOSE: This rule describes the procedure for transferring a permit when ownership changes.

(1) Permits issued pursuant to 10 CSR 22-2.050 and 10 CSR 22-2.060 are transferable only as provided in section 236.460, RSMo.

If ownership or other transfer of interest in the dam and reservoir changes, the former owner must notify the chief engineer of the sale or transfer and the permit will be transferred to the new owner after determination that the transfer will not endanger the public safety, life, property, the dam or reservoir. The permit holder of record will be held responsible for maintaining compliance with these rules and standards. If the former owner does not have the permit transferred, the new owner may submit the appropriate application and documents necessary to obtain a new permit. The new owner, in this case, must also show proof of ownership. The old owner's responsibilities of ownership under the law will not be extinguished until the permit is transferred to an eligible owner. Nothing in these regulations shall be construed to eliminate the liability of the previous owner for damages or injuries caused by a dam failure, nor a new operator who has not obtained a permit nor had an existing permit transferred to his/her name.

AUTHORITY: sections 236.405, RSMo Supp. 1993 and 236.415, and 236.460, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective, Jan. 1, 1985.*

**Original authority: 236.405, RSMo 1979, amended 1993 and 236.415 and 236.460, RSMo 1979.*

10 CSR 22-2.100 Appeal of Action on Permits

PURPOSE: This rule describes the procedure for appealing the results of any action taken with regard to a permit.

(1) Permits revoked or denied are subject to council appeal. All parties shall be afforded an opportunity for hearing before the council for review of denial or revocation decisions, if request is made within thirty (30) days after notice is served personally or by certified or registered mail upon the parties or their agents. Except for emergency action, further legal action shall not be taken until after the hearing and council decision.

(2) The record of hearing shall include all written testimony, data, records, etc., as well as all oral proceedings recorded stenographically or by other means that will preserve the testimony. Rules of discovery, evidence and privilege as applied in civil cases in the circuit courts shall be followed.

(3) A final decision will be in writing, and the party or its agents will be notified personally or by registered or certified mail of the final decision. A copy of any opinion in support of this decision will be furnished upon request. Decisions are subject to judicial review pursuant to provisions of section 236.480, RSMo.

AUTHORITY: sections 236.405, RSMo Supp. 1993 and 236.415, 236.425, 236.440, 236.445, 236.470 and 236.480, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective Jan. 1, 1985.*

**Original authority: 236.405, RSMo 1979 amended 1993 and 236.415, 236.425, 236.440, 236.445, 236.470 and 236.480, RSMo 1979.*

Rules of
Department of Natural Resources
Division 22—Dam and Reservoir Safety Council
Chapter 3—Permit Requirements

Title		Page
10 CSR 22-3.010	General Information	3
10 CSR 22-3.020	General Requirements	3
10 CSR 22-3.030	Registration Permit Requirements	7
10 CSR 22-3.040	Construction Permit Requirements	8
10 CSR 22-3.050	Safety Permit Requirements	11

Title 10—DEPARTMENT OF NATURAL RESOURCES
Division 22—Dam and Reservoir Safety Council
Chapter 3—Permit Requirements

10 CSR 22-3.010 General Information

PURPOSE: The purpose of this rule is to provide general information about permit requirements.

(1) Requirements for existing or proposed dams and reservoirs must allow for variations in conditions and materials from site-to-site. Therefore, this rule and 10 CSR 22-3.020—10 CSR 22-3.050 describe the minimum general requirements which are consistent with current engineering, geologic, construction, operation and maintenance practices, necessary to obtain permits from the Dam and Reservoir Safety Council.

(2) These rules are not intended to define the only requirements for a dam and reservoir to comply with the law or sound engineering, geologic and construction practices, to be used in detailed site investigation or in the specific design and construction of individual dams. The detailed and specific information that outlines current and prudent engineering, geologic and construction practices is available in technical literature. Determinations by the Dam and Reservoir Safety Council, after hearing the recommendations of the chief engineer of the acceptability of a design and adequacy of plans, specifications and construction must be made, by necessity, on a case-by-case basis. Therefore, it is recommended that applicants unfamiliar with the way these rules are applied contact the council or the chief engineer prior to commencing extensive work or plan development.

(3) Adherence to the law does not guarantee the safety of any dam or reservoir or relieve the owner of any liability in the event of dam failure.

(4) A permit application form along with a copy of the laws, rules, standards and guidelines relating to dam and reservoir safety can be obtained free from the Department of Natural Resources, Division of Geology and Land Survey, Dam Safety Program, P.O. Box 250, Rolla, MO 65401. Persons seeking this and/or other information on dams in Missouri should address their inquiry to the chief engineer.

AUTHORITY: sections 236.400, 236.405, 236.415, 236.435, 236.440 and 236.465, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981.*

**Original authority: 246.400, RSMo 1979; 236.405, RSMo 1979, amended 1993, 1995; 236.415, RSMo 1979, amended 1995; 236.435, RSMo 1979; 236.440, RSMo 1979; and 236.465, RSMo 1979.*

10 CSR 22-3.020 General Requirements

PURPOSE: The purpose of this rule is to itemize the basic requirements and standards that apply to all permits.

(1) The permit application must contain information required by the council and the chief engineer including, but not limited to, the following information: type of permit being applied for; name of owners; mailing address of owners; telephone number(s) of owners; name of dam; name of reservoir; coordinate location of the dam centerline at the maximum section; purpose or use of dam and reservoir; name, address and telephone number of the experienced professional engineer or agency engineer who has provided or will provide required technical assistance; and the downstream environment zone environmental class for the dam and reservoir. The owners must complete all applicable investigations required in 10 CSR 22-3.0202–10 CSR 22-3.050 before filing a permit application. All permit applications must be filed with the chief engineer at the address listed in 10 CSR 22-3.010(4).

(2) The owner must provide a determination of an environmental class for each dam and reservoir. The method, data and assumptions used by the owner to determine environmental class shall conform to practices reputable and in current use in the engineering, geologic and construction professions or the chief engineer may reject the owner's classification. If an owner chooses not to have this done by an experienced professional engineer or an agency engineer, the chief engineer will assign the dam and reservoir to environmental class I or s/he may assign the dam and reservoir to another environmental class if s/he has justification to do so.

(3) The anticipated consequences of a dam failure with respect to public safety, life and property damage are important considerations in establishing acceptable methods for specific investigations and sites. Methods used in exploration design, construction and maintenance must be in accordance with good engineering practices reputable and in current use in the engineering, geologic and construction professions.

(4) When the owner is applying for a construction permit, the required design factors of safety for slope stability for earth and rock conventional dams which are given in Table 1 shall be met. The required design factors of safety for concrete conventional dams are given in Table 2. The required design factors of safety for slope stability for industrial water retention dams are given in Table 3. Owners shall meet these requirements in the design of new dams prior to the issuance of the permit. Owners shall also meet these requirements when substantial changes are proposed to the height or slope of an existing conventional dam or structure prior to the issuance of the construction permit (see the following tables).

(5) For new dams constructed wholly or partially of cohesionless materials (such as sands and silts) or having a foundation of cohesionless materials, earthquake loading may result in the build-up of pore water pressures and a loss of strength. Engineers shall take this pore pressure increase and loss of strength into account when performing their stability analysis, but the degree to which liquefaction may affect the factor of safety for slope stability shall be left up to the engineer's best judgment. Bedrock accelerations and earthquake intensities are listed in Table 4.

(6) New dams constructed wholly of cohesive materials (such as clays) and having a foundation of cohesive materials or rock, can be expected to withstand significant earthquake shaking if it can be shown that other required design factors of safety for slope stability are met. Therefore, only new dams located in Bollinger, Butler, Cape Girardeau, Dunklin, Mississippi, New Madrid, Pemiscot, Ripley, Scott, Stoddard and Wayne Counties must meet the requirements for slope stability during earthquake loading while dams located in other counties do not unless 10 CSR 22-3.030(5) applies to them. Bedrock accelerations and earthquake intensities are listed in Table 4.

Table 1—Required Design Factors of Safety for Slope Stability Earth and Rock Conventional Dams

Loading Condition	Factor of Safety
End of construction, full reservoir*	1.4
Steady seepage, full reservoir*	1.5
Steady seepage, maximum reservoir**	1.3
Sudden draw down, from full to empty reservoir (if applicable)	1.2
Earthquake***, steady seepage, full reservoir*	1.0

*Full reservoir means water level is at the water storage elevation.

**Maximum reservoir means water level is at maximum water level attained during the spillway design flood or at the dam crest elevation, whichever is lower.

***Earthquake loading will vary according to dam location in relation to seismic source zones and downstream environmental zones. (See Table 4).

Table 2—Required Design Factors of Safety Concrete Conventional Dams

Failure Mode	Loading Condition	Factor of Safety
Overturning	full reservoir*	1.5
	maximum reservoir**	1.3
Sliding	full reservoir*	1.5
	maximum reservoir**	1.3
Structural integrity	full reservoir*	1.5
	maximum reservoir**	1.3
Earthquake*** any mode	full or maximum reservoir* & **	1.0

*Full reservoir means water level is at the water storage elevation.

**Maximum reservoir means water level is at maximum level attained during the spillway design flood.

***Earthquake loading will vary according to dam location in relation to seismic source zones and downstream environmental zones. (See Table 4).

Table 3—Required Design Factors of Safety for Slope Stability Industrial Water Retention Dams

Loading Condition	Factor of Safety
Starter dam, end of construction, full reservoir*	1.4
Any other stage of construction, full reservoir*, steady seepage	1.3
Any other stage of construction, maximum reservoir*, steady seepage	1.0
Completed dam, full reservoir*, steady seepage	1.5
Completed dam, maximum reservoir**, steady seepage	1.3
Earthquake***, steady seepage, full reservoir*	1.0

*Full reservoir means water level is at the water storage elevation.

**Maximum reservoir means water level is at the maximum level attained during the spillway design flood or at the dam crest elevation, whichever is lower.

***Earthquake loading will vary according to dam location in relation to seismic source zones and downstream environmental zones. (See Table 4).

(7) The required spillway design flood, which shall allow for flood storage in the reservoir, is to be derived by using the precipitation values given in Table 5 and shall apply to both new and existing dams.

Table 4—Required Design Acceleration For Earthquake Design

Dam Type	Stage of Construction	Special Descriptions	Environmental Class I	II	III
Conventional or Industrial	Completed	New dams less than 50 feet in height	.75PMA*	.5PMA*	.25PMA*
		New dams greater than 50 feet in height**	.75PMA*	.5PMA*	.4PMA*
Industrial	Starter dam	New dams**	.5PMA*	.2PMA*	.1PMA*
	dam is completed	After starter dam is finished and before final New dams**	.75PMA*	.5PMA*	.2PMA*

Zone	PMA*	Intensity**
A	0.31 g	IX—X
B	0.28 g	IX
C	0.26 g	VIII—IX
D	0.23 g	VIII
E	0.20 g	VII—VIII
F	0.17 g	VII

ZONE A	ZONE B	ZONE C	ZONE D	ZONE E	ZONE E (cont.)	ZONE F
Dunklin	Bollinger	Carter	Crawford	Audrain	Lewis	Adair
Mississippi	Butler	Howell	Dent	Barry	Lincoln	Andrew
New Madrid	Cape Girardeau	Iron	Douglas	Barton	Linn	Atchison
Pemiscot	Ripley	Madison	Franklin	Bates	Livingston	Buchanan
	Scott	Oregon	Jefferson	Benton	McDonald	Clay
	Stoddard	Perry	Ozark	Boone	Macon	Clinton
	Wayne	Reynolds	Phelps	Caldwell	Maries	Davis
		St. Francois	Pulaski	Callaway	Marion	Dekalb
		Ste. Genevieve	St. Louis	Camden	Miller	Gentry
		Shannon	St. Louis City	Carroll	Moniteau	Grundy
			Taney	Cass	Monroe	Harrison
			Texas	Cedar	Montgomery	Holt
			Washington	Chariton	Morgan	Mercer
			Wright	Christian	Newton	Nodaway
				Clark	Osage	Platte
				Cole	Pettis	Putnam
				Cooper	Pike	Schuyler
				Dade	Polk	Sullivan
				Dallas	Ralls	Worth
				Gasconade	Randolph	
				Greene	Ray	
				Henry	St. Charles	
				Hickory	St. Clair	
				Howard	Saline	
				Jackson	Scotland	
				Jasper	Shelby	
				Johnson	Stone	
				Knox	Vernon	
				Laclede	Warren	
				Lafayette	Webster	
				Lawrence		

* PMA is Probable Maximum Acceleration of bedrock which is determined as a fraction of the acceleration of gravity (g = 32.2 fps2) for the six zones in Missouri (see 10 CSR 22-1.020(41)).

** See 10 CSR 22-2.020(3) for clarification.

*** Modified Mercalli Intensity.

Table 5—Required Spillway Design Flood Precipitation Values

Dam Type	Stage of Construction	Special Descriptions	Environmental Class I	II	III
Conventional or Industrial	Completed	Any existing dam**	.75PMP*	.5PMP*	100 Yr.****
	New dam less than 50 feet in height***		.75PMP*	.5PMP*	100 Yr.****
	New dam greater than 50 feet in height		.75PMP*	.5PMP*	100 Yr.*****
Industrial	Starter dam	Any	.5PMP*	.2PMP*	.1PMP*
	After starter dam is finished and before final dam is completed	Any	.75PMP*	.5PMP*	.2PMP*

*PMP is Probable Maximum Precipitation.

**Existing dam means a dam which was completed by August 13, 1981 or which was started prior to August 13, 1981 and completed by August 13, 1987.

***See 10 CSR 22-2.020(3) for clarification.

****100 Yr. is the 100 year frequency rainfall event.

AUTHORITY: sections 236.400, 236.405, 236.415, 236.435, 236.440 and 236.465, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective Jan. 1, 1985. Amended: Filed Aug. 15, 1988, effective Jan. 1, 1989. Amended: Filed May 15, 1990, effective Nov. 30, 1990.*

**Original authority: 236.400, RSMo 1979; 236.405, RSMo 1979, amended 1993, 1995; 236.415 RSMo 1979, amended 1995; 236.435, RSMo 1979; 236.440, RSMo 1979; and 236.465, RSMo 1979.*

10 CSR 22-3.030 Registration Permit Requirements

PURPOSE: The purpose of this rule is to itemize the requirements for a registration permit.

(1) In addition to the basic requirements for all permits listed in 10 CSR 22-3.020(1), (2), (3) and (7), the registration permit application for a conventional dam and reservoir must include certification by an experienced professional engineer or an agency engineer that the dam and reservoir have been inspected in accordance with the law and that the owner has compiled engineer's recommendations to correct the observed defects and an inspection report, as required by the law. The engineer must further show that the spillway can safely pass the spillway design flood derived from Table 5 and submit a report describing the correction of all observed defects and the description of an operation and maintenance program to be followed while the registration permit is in effect.

(A) The inspection of a dam and reservoir for a registration permit is intended to detect observable defects. The procedure to determine observable defects normally will be a surface examination by an experienced professional engineer or an agency engineer. The inspection must include all surface examinations necessary to determine if observable defects exist that affect the stability of the dam and reservoir or the adequacy of the spillway. Judgment of the structural stability and an evaluation of the spillway capacity must be made. Judgment shall be based upon the engineer's experience, training and knowledge of similar dams and in accordance with practices reputable and in current use in the engineering, geologic and construction professions.

1. Observed defects which may require correction, evaluated on the basis of current engineering, geologic and construction practices, include but are not limited to: slides; slopes as steep as or steeper than those on similar types of dams and constructed of similar materials which have experienced slope stability problems; piping of fines; seepage that exits in an uncontrolled fashion on the downstream slope of or from the downstream foundation of the dam; unusual zones of softness and irregular settlement; erosion on the upstream or downstream slope of the dam; spillways that are calculated to be inadequate for the design flood; spillways that are eroded or otherwise in poor condition and cracks in the embankment or structure.

2. Observed defects that are in an advanced state of deterioration must be immediately reported by the inspecting engineer to the owner and to the chief engineer.

(B) Proper maintenance and operation of a dam and reservoir are critical to the continuing safety of a dam and reservoir and to public safety, life and property. A maintenance program shall be required and shall include the following items: erosion control on the embankment; monitoring emergency spillway flow rates; vegetation control; spillway maintenance; emergency action plans; maintenance and monitoring of seepage observation devices, if any; and maintenance and monitoring of instruments used, if any, to observe the stability of the dam.

(C) Visits for the purpose of observation of maintenance and operation may be made by the council, the chief engineer or a member of the chief engineer's staff. Visits will be at any reasonable time following reasonable notice, except that in the case of an emergency threatening public safety, life or property, no notice shall be required and inspection may be at any time. Owners shall permit entry to its property for persons to perform the inspections.

(D) The application need not state, nor is it necessary to show, that the dam is a safe dam. The intent of the registration permit is to show that the dam is performing adequately and that there are no observable indications that the dam is unsafe.

(2) In addition to the basic requirements for all permits listed in 10 CSR 22-3.020(1), (2), (3) and (7), the registration permit application for an industrial water retention dam and reservoir shall include certification by an experienced professional engineer or an agency engineer that the dam and reservoir have been inspected in accordance with the law and that the owner has complied with the engineer's recommendations to correct observed defects and an inspection report, as required by the law. The engineer must further show that the spillway can safely pass the spillway design flood derived from Table 5 and submit a report describing the correction of any observed defects, the operation and maintenance program to be made a part of the registration permit and the phased, stepped and/or continuous construction of the dam.

(A) The inspection of an industrial water retention dam and reservoir for a registration permit is intended to detect observable defects. The procedure to determine observable defects normally will be a surface examination by an experienced professional engineer or an agency engineer. The inspection must include all surface examinations necessary to determine if observable defects exist that affect the stability of the dam and reservoir or the adequacy of the spillway. Judgment of the structural stability and an evaluation of the spillway capacity must be made. Judgment shall be based upon the engineer's experience, training and knowledge of similar dams and in accordance with practices reputable and in current use in the engineering, geologic and construction professions.

1. Observed defects which may require correction, evaluated on the basis of current engineering, geologic and construction practices, include but are not limited to slides; slopes as steep as or steeper than those on similar types of dams and constructed of similar materials which have experienced slope stability problems; piping of fines; seepage that exits in an uncontrolled fashion on the downstream slope of or from the downstream foundation of the dam; unusual zones of softness and irregular settlement; erosion on upstream or downstream slope of the dam; spillways that are calculated to be inadequate for the design flood; spillways that are eroded or otherwise in poor condition and cracks in the embankment or structure.

2. Observed defects that are in an advanced state of deterioration must be immediately reported by the inspecting engineer to the owner and to the chief engineer.

(B) Proper maintenance and operation of a dam and reservoir are critical to the continuing safety of a dam and reservoir and the protection of public safety, life and property. A maintenance program shall be required and shall include the following items: erosion control on the embankment; monitoring of storm runoff; vegetation control; spillway maintenance; emergency action plans; maintenance and monitoring of seepage observation devices, if any; and maintenance and monitoring of instruments used, if any, to observe the stability of the dam.

(C) The council or chief engineer may require the owner to submit a report describing the phased, stepped and/or continuous construction of an industrial water retention dam and reservoir, containing information on

the materials used, method of transport and placement of materials, the sequence and placement location of materials, spillway changes to be made, the anticipated final dimensions and configuration of the dam and the name, address and telephone number of the person(s) in responsible charge of this work.

(D) Visits for the purpose of inspecting during construction or enlargement or observation of maintenance and operation may be made by the council, the chief engineer or a member of the chief engineer's staff. Visits will be at any reasonable time following reasonable notice, except that in the case of an emergency threatening public safety, life or property, no such notice shall be required and inspection may be made at any time. Owners shall permit entry to its property for persons to perform inspection.

(E) It shall not be necessary for the owner to retain an experienced professional engineer or an agency engineer continuously during the entire permit period unless there is modification(s) in the construction method described in the permit application. However, personnel with adequate supervision and training in methods of safe construction, maintenance and operation of dams must be provided to insure that the construction maintenance and operation of the dam and reservoir are carried out as described.

(F) The registration permit will be the only permit required for an industrial water retention dam and reservoir that was in existence prior to the effective date listed in 10 CSR 22-2.020(2) unless it is to be reduced or removed. If the dam or reservoir is to be reduced or removed, a construction permit will be required. Other changes will require the owner to obtain a new registration permit.

(G) The applicant need not state, nor is it necessary to show, that the dam is a safe dam. The intent of the registration permit is to show that the dam is performing adequately and that there are no readily observable indications that the dam is unsafe and that phased, stepped and/or continuous construction of the dam will meet the requirements of the law.

AUTHORITY: sections 236.400, 236.405, 236.415, 236.420, 236.425, 236.440 and 236.465, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective Jan. 1, 1985.*

**Original authority: 236.400, RSMo 1979; 236.405, RSMo 1979, amended 1993, 1995; 236.415, RSMo 1979, amended 1995; 236.420, RSMo 1979; 236.425, RSMo 1979; 236.440, RSMo 1979; and 236.465, RSMo 1979.*

10 CSR 22-3.040 Construction Permit Requirements

PURPOSE: The purpose of this rule is to itemize the requirements for a construction permit.

(1) In addition to the basic requirements for all permits listed in 10 CSR 22-3.030, the construction permit application for a conventional dam and reservoir shall be prepared under the direction of and certified by an experienced professional engineer and shall be in accordance with practices reputable and appropriate in the engineering, geologic and construction professions.

(A) The following requirements shall apply to and the following information shall be provided by the owner:

1. Up-to-date topographic map(s) showing the location of the proposed or existing dam, the upstream watershed, the reservoir and the downstream environment zone. The topographic map(s) of the project area must be at a scale appropriate to the size of the project area. An up-to-date United States Geological Survey topographic map is considered a minimum;

2. Exploration records and results including the location of all exploration, especially in the area of the core trench, the method(s) used to explore the site, a record of what was found, the method(s) used to obtain samples and the number of samples taken;

3. Testing records and results including information on the care and treatment of samples, types of tests performed on samples or in situ, reference(s) to or the procedures used in testing and the test results. Physical and mechanical properties of foundation and construction materials must include the information source for these values especially if they are not the results of testing;

4. The geotechnical design procedure(s) or method(s) shall be identified and referenced or described so that they may be reviewed and the applicability verified. This shall include all assumptions made. The geotechnical procedure(s) or design results shall include the minimum computed factors of safety and they must meet or exceed the required design factors of safety (see 10 CSR 22-3.020(4)). The geotechnical design information shall be presented for the foundation, core trench and dam embankment. Earthquake loading must be analyzed as outlined in 10 CSR 22-3.020(5) and (6);

5. The structural design procedure(s) or method(s) shall be identified and referenced or described so that they may be reviewed and their applicability verified. Design results for concreted dams and concrete structures appurtenant to embankment dams shall provide for and show an adequate factor of safety for normal and maximum loading conditions of compression, tension, shear, torsion, buckling, sliding and overturning;

6. Hydrologic information used to evaluate the watershed, reservoir, spillway and downstream environment zone including the watershed area, rainfall rate and duration, antecedent moisture conditions, time of concentration, area capacity curves, description of spillway elevation(s), type(s), dimensions, locations, cross section and profiles, dam crest elevation and the downstream valley cross sections;

7. The hydrologic/hydraulic design procedure(s) or method(s) used shall be identified and referenced or described so that they may be reviewed and their applicability verified. This shall include all assumptions made. The hydrologic/hydraulic procedure(s) or design results shall include the reservoir inflow hydrograph, the reservoir outflow hydrograph, the spillway discharge capacity, the freeboard at the maximum water storage elevation and the environmental class of the dam. The dam shall be capable of safely containing or discharging the required design flood (see 10 CSR 22-3.020(5));

8. Location and design of diversion channels or other structures to control stream flow during or after construction shall be provided if failure of these channels or other structures would affect hydrologic conditions of the dam. Stream diversion systems used during construction shall be designed to provide protection to the dam and the safety of the public;

9. Construction control and inspection procedures shall be used during the construction of a new dam and reservoir or modification of an existing dam and reservoir. Construction control and inspection procedures should include compaction testing and density testing;

10. Procedures shall be used for recordkeeping and monitoring throughout the construction or modification process to provide information about any construction progress and conditions that may cause difficulties during construction;

11. The location of and protective measures used in conjunction with all drain lines, sewer lines, utilities or other structures that pass through or under the dam;

12. Topographic surveys showing the location of baselines, centerlines and other horizontal and vertical control points sufficiently accurate to locate the proposed construction and to define the volume of storage in the reservoir;

13. Two (2) sets of plans and specifications including—

A. Graphic scales shall be provided for all scaled drawings;

B. The title, which shall be identical on the plans and the specifications, shall include: the name of the dam; the name of the owner; whether the work shows an existing dam, a proposed dam or an enlargement, repair or alteration of the dam or reservoir; the county(ies) the dam and reservoir are in; the location of the dam by quarter section, section, township and range or by geodetic coordinates; and each sheet shall have in an appropriate title block the name of the dam as well as the sheet number in relation to the total, for example, sheet one (1) of twelve (12); and

C. Certifications by the experienced professional engineer and the owner shall be placed near the lower right-hand corner of the title sheet (first sheet) of the drawings. The certifications shall be similar to those presented in figures 1 and 2 (see figures 1 and 2); and

Figure 1

Certification by Experienced Professional Engineer

I hereby certify that these plans for the (insert the correct word or words choosing from: existing; construction of the; repair of the; enlargement of the; or alteration of the

_____ Dam were prepared by me (or under my
Name of Dam
direct supervision) for the owners thereof.

_____
Firm Name

_____
Registered Engineer

(Seal)

Figure 2

Certification by Owner

I,_____, owner, whose Post Office Address is
Name of Owner
_____ , Zip _____ , do
Owner's Address

hereby accept and approve these plans.

_____
Owner

14. If a construction permit is requested to convert a dam to a retaining or retarding structure, the procedure to be followed in making the conversion shall be described by the owner; and

15. The procedures set up for regular inspection by the owner. The owner shall develop an emergency action plan, inspect his/her dam regularly and as necessary to protect public safety, life and property. A list of items to be inspected, a time schedule for these inspections and a form for reporting the results shall be established.

(B) The council or chief engineer may require the following action and information from the owner:

1. Procedures set up to provide regular maintenance and minor repairs to the dam and reservoir after construction and to continue or start recordkeeping and monitoring work so that the dam and reservoir are maintained in a safe condition and a complete history of its performance is available;

2. Location and types of instrumentation, drainage and/or seepage control facilities. Monitoring equipment and drainage and seepage control facilities are recommended for all dams and reservoirs, however, depending on conditions, they may be mandatory items if necessary to accomplish the purposes of the law;

3. The downstream environment zone warning procedure to be used if dam failure is a threat. A downstream environment zone warning system is recommended for all dams and reservoirs, however, depending on conditions, it may be necessary to accomplish the purposes of the law. This would consist of the current name(s) of the dam and reservoir owners representative(s) responsible for giving notification of a threat of failure and the current phone numbers of appropriate local police and other persons having emergency assistance authority;

4. Upstream slope protection from wave action; and

5. Additional actions or information as required to protect public safety, life and property and to accomplish the purposes of the law.

(C) Visits for the purpose of inspecting during or after construction or observation of operation and maintenance may be made by the council, the chief engineer or a member of the chief engineer's staff. Visits will be at any reasonable time following reasonable notice, except that in the case of an emergency threatening public safety, life or property, no notice shall be required and inspection may be made at any time. Owners shall permit entry to their property for persons to perform inspections.

(2) In addition to the basic requirements for all permits listed in 10 CSR 22-3.020, the construction permit application for an industrial water retention dam and reservoir shall be prepared under the direction of and certified by an experienced professional engineer and shall be in accordance with practices reputable and appropriate in the engineering, geologic and construction professions.

(A) The engineer who plans and designs an industrial water retention dam and reservoir or its modification shall assess the sequence, timing, method of placement and stability control program during construction from the beginning of the starter dam or modification through the life of the structure and after operation ceases or until the dam and reservoir no longer need a permit.

(B) Adequate records, as required by best practices in the geologic and engineering professions, shall be kept and made available to the council or chief engineer for the construction, maintenance and operation procedures. Adequate instrumentation and monitoring of seepage water shall be provided where necessary. Any significant settling or movement in the foundation of the dam should be measured if possible. Trained personnel and adequate supervision shall be provided to insure the construction and operation of the dam and reservoir are carried out to specifications.

(C) The following requirements shall apply to and the following information shall be provided by the owner:

1. A description of the system used to deposit tailings on the dam;

2. Up-to-date topographic map(s) showing the location of the proposed dam, the upstream watershed, the reservoir and the downstream environment zone. The topographic map(s) of the project area must be at a scale appropriate to the size of the project area. An up-to-date United States Geological Survey topographic map is considered minimum;

3. The location(s) of surface and underground mine workings if these workings would cause, would contribute to the cause or would be affected in the event of failure;

4. Exploration records and results including the location of all exploration, especially in the area of the core trench, the method(s) used to explore the site, a record of what was found, the method(s) used to obtain samples and the number of samples taken;

5. Testing records and results including information on the care and treatment of samples, types of tests performed on samples or in situ, reference(s) to or the procedures used in testing and the test results. Physical and mechanical properties of foundation and construction materials must include the information source for these values especially if they are not the results of testing;

6. The geotechnical design procedure(s) or method(s) shall be identified and referenced or described so that they may be reviewed and their applicability verified. This shall include all assumptions made. The geotechnical procedure(s) or design results shall include the minimum computed factors of safety and they must meet or exceed the required design factors of safety (see 10 CSR 22-3.020(4)). The geotechnical design information shall be presented for the foundation core trench and dam embankment. Earthquake loading must be analyzed as outlined in 10 CSR 22-3.020(5) and (6).

7. Type and physical properties of the liquid and solid materials to be used in construction of the dam and contained in the reservoir;

8. The changes created in the downstream environment zone as the dam and reservoir become incrementally larger;

9. The embankment changes and new factors of safety for stability as the dam and reservoir become incrementally larger;

10. If a starter dam is used, whether it will be pervious or impervious;

11. The expected crest elevation, dam configuration, spillway elevation and the size and configuration of each successive stage of the dam shall be included;

12. Anticipated storage volume of solid or semisolid materials and of liquids at the completion of the dam;

13. The structural design procedure(s) or method(s) shall be identified and referenced or described so that they may be reviewed and their applicability verified. Design results for concrete dams and concrete structures appurtenant to embankment dams shall provide for and show an adequate factor of safety for normal and maximum loading conditions of compression, tension, shear, torsion, buckling, sliding and overturning;

14. Hydrologic information used to evaluate the watershed, reservoir, spillway and downstream environment zone including the watershed area, rainfall rate and duration, antecedent moisture conditions, time of concentration, area capacity curves, description of spillway elevation(s), type(s), dimensions, locations, cross sections and profiles, dam crest elevation and the downstream valley cross sections;

15. Hydrologic/hydraulic design procedure(s) or method(s) used shall be identified and referenced or described so that they may be reviewed and their applicability verified. This shall include all assumptions made. The

hydrologic/hydraulic procedure(s) or design results shall include the reservoir inflow hydrograph, the reservoir outflow hydrograph, the spillway discharge capacity, the freeboard at the maximum water storage elevation and the environmental class of the dam. The dam shall be capable of safely containing or discharging the required design flood (see 10 CSR 22-3.020(5));

16. The hydrologic changes, the spillway alterations proposed and the freeboard changes as the dam becomes incrementally larger;

17. Location and design of diversion channels or other structures to control stream flow during or after construction shall be provided if failure of these channels or other structures would affect the stability or hydrologic conditions of the dam. Stream diversion systems used during construction shall be designed to provide protection to the dam and to protect public safety, life and property;

18. Location and design of any diversion channels or other structures to control runoff or reclaimed water;

19. Construction control and inspection procedures shall be determined by the engineer and used during the construction of a new dam and reservoir or modification of an existing dam and reservoir. Construction control and inspection procedures shall include compaction testing and density testing and any other quality control measures used to insure compliance with the construction specifications;

20. Procedures shall be used for recordkeeping and monitoring throughout the construction, enlargement or modification process to provide information about any construction progress and conditions that may cause difficulties during construction;

21. The location of and protective measures used in conjunction with all drain lines, sewer lines, utilities or other structures that pass through or under the dam;

22. Topographic surveys showing the location of baselines, centerlines and other horizontal and vertical control points sufficiently accurate to locate the proposed construction and to define the volume of storage in the reservoir at each planned stage of construction;

23. Two (2) sets of plans and specifications including:

A. Graphic scales shall be provided for all scaled drawings;

B. The title, which shall be identical on the plans and the specifications, shall include: the name of the dam; the name of the owner; whether the work shows an existing dam, a proposed dam or an enlargement, repair or alteration of the dam and reservoir; the county(ies) the dam and reservoir are in; the location of the dam by quarter section, section, township and range or by geodetic coordinates; and each sheet shall have in an appropriate title block the name of the dam as well as the sheet number in relation to the total, for example, sheet one (1) of twelve (12); and

C. Certification by the experienced professional engineer and the owner shall be placed near the lower right-hand corner of the title sheet (first sheet) of the drawing. The certifications shall be as presented in figures 1 and 2 (see figures 1 and 2 preceding);

24. If a construction permit is requested to convert a dam to a retaining or retarding structure, the procedure to be followed in making the conversion shall be described by the owner; and

25. The procedure set up for regular inspection by the owner. The owner shall develop an emergency action plan, inspect his/her dam and reservoir regularly and as necessary to protect public safety, life and property. A list of items to be inspected, a time schedule for these inspections and a form for reporting the results shall be established by the council or chief engineer. Items that shall receive maintenance to and/or inspections on a daily basis during periods of active dam enlargement include: the spigots or cyclones; the decant lines; the position of the water pool in relation to the spillway, decant intake and crest of the tailings dam; drain lines checked for quantity of water and sediment; the embankment observed for visual defects such as slides or significant seepage changes; the spillway shall be checked to verify that it has not become blocked.

(D) The council or chief engineer may require the following action and information from the owner:

1. Procedures set up to provide regular maintenance and minor repairs to the dam and reservoir during construction and enlargement so that the dam and reservoir are maintained in a safe condition and a complete history of its performance is available;

2. Location and types of instrumentation, drainage and/or seepage control facilities. Monitoring equipment and drainage and seepage control facilities are recommended for all dams and reservoirs, however, depending on conditions they may be mandatory items if necessary to accomplish the purposes of the law; a list of items to be inspected, a time schedule for these inspections and a form for reporting the results shall be established by the council or chief engineer;

3. The downstream environment zone warning procedure to be used if dam failure is a threat. A downstream environment zone warning system is recommended for all dams and reservoirs, however, depending on conditions, it may be necessary to accomplish the purposes of the law. This would consist of the current name(s) of the dam and reservoir owners representative(s) responsible for giving notification of a threat of failure and the current phone numbers of appropriate local police and other persons having emergency assistance authority;

4. Upstream slope protection from wave action; and

5. Additional actions or information as required to protect public safety, life and property and to accomplish the purposes of the law.

(E) Visits for the purpose of inspecting during or after construction or observation of operation and maintenance may be made by the council, the chief engineer or member of the chief engineer's staff. Visits will be at any reasonable time following reasonable notice, except that in the case of an emergency threatening public safety, life or property, no notice shall be required and inspection may be made at any time. Owners shall permit entry to their property for the persons to perform inspections.

(F) Drawings to show changes shall be submitted when changes are made to the original plans including, without limitation, changes in incremental dam crest heights, spillway locations and cross sections.

AUTHORITY: sections 236.400, 236.405, 236.415, 236.420, 236.425, 236.435, 236.440 and 236.465, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective Jan. 1, 1985.*

**Original authority: 236.400, RSMo 1979; 236.405, RSMo 1979, amended 1993, 1995; 236.415, RSMo 1979, amended 1995; 236.420, RSMo 1979; 236.425, RSMo 1979; 236.435, RSMo 1979; 236.440, RSMo 1979; and 236.465, RSMo 1979.*

10 CSR 22-3.050 Safety Permit Requirements

PURPOSE: The purpose of this rule is to itemize the requirements for a safety permit.

(1) In addition to the basic requirements for all permits listed in 10 CSR 22-3.020, the safety permit application for a conventional dam and reservoir shall include:

(A) Notification of the completion of construction and application for the first safety permit for the dam and reservoir shall be provided by the owner. The experienced professional engineer or agency engineer who was

in responsible charge of the construction work shall certify that the construction was substantially in accordance with the approved plans and specifications. If revisions have been made which vary considerably from the provisions of the construction permit, it must be shown that the revisions do not endanger public safety, life or property. This subsection shall not be construed to excuse any person from the requirement to notify the council or chief engineer of modifications or revisions prior to commencing the actions and to obtain the required permits or authorization thereof;

(B) Notification of completion shall be within two (2)-months' time after completion of construction; and

(C) As-built drawings shall be submitted.

(2) In addition to the basic requirements for all permits listed in 10 CSR 22-3.020, the application for a safety permit for an industrial water retention dam and reservoir shall include:

(A) Notification of completion of the starter dam or the initial phase of construction shall be prepared by or under the supervision of an experienced professional engineer and shall indicate that construction was performed in accordance with the provisions of the construction permit.

(B) Notification of the completion of construction and application for the first safety permit for the dam and reservoir shall be provided by the owner. The experienced professional engineer who was in responsible charge of the construction work shall certify that the construction was substantially in accordance with the approved plans and specifications. If revisions have been made which vary considerably from the provisions of the construction permit, it must be shown that the revisions do not endanger public safety, life or property. This subsection shall not be construed to excuse any person from the requirement to notify the council or chief engineer or modifications or revisions prior to commencing the actions and to obtain the required permits or authorization therefore;

(C) Notification of completion shall be within two (2)-months time after completion of construction; and

(D) As-built drawings shall be submitted.

(3) Visits for the purpose of observation of operation and maintenance procedures may be made by the council, the chief engineer or a member of their staff. Visits will be at any reasonable time following reasonable notice, except that in the case of an emergency threatening public safety, life or property, no notice shall be required and inspection may be made at any time. Owners shall permit entry to their property for such persons to perform the inspections.

AUTHORITY: sections 236.400, 236.405, 236.415, 236.420, 236.425, 236.440 and 236.465, RSMo 1986. Original rule filed April 14, 1981, effective Aug. 13, 1981. Amended: Filed June 14, 1984, effective Jan. 1, 1985.*

**Original authority: 236.400, RSMo 1979; 236.405, RSMo 1979, amended 1993, 1995; 236.415, RSMo 1979, amended 1995; 236.420, RSMo 1979; 236.425, RSMo 1979; 236.440, RSMo 1979; and 236.465,RSMo 1979.*

Rules of
Department of Natural Resources
Division 22—Dam and Reservoir Safety Council
Chapter 4—Action Taken by Council and Chief Engineer

Title		Page
10 CSR 22-4.010	Emergency Action	3
10 CSR 22-4.020	Enforcement Orders and Enforcement Procedures	3

Title 10—DEPARTMENT OF NATURAL RESOURCES
Division 22—Dam and Reservoir Safety Council
Chapter 4—Action Taken by Council and Chief Engineer

10 CSR 22-4.010 Emergency Action

PURPOSE: The purpose of the rule is to define the way emergency action is taken.

(1) In performing his/her duties, the chief engineer shall determine by inspection whether a dam or reservoir constitutes a threat to public safety, life or property. If it is determined that a dam is in an advanced state of deterioration and in such condition that continued deterioration could cause failure of the dam, the chief engineer may classify the dam as dangerous to public safety, life or property. If the chief engineer or council further determines that there is not sufficient time to issue an enforcement order to the owner to correct the hazard, or to take other legal action, the chief engineer may take any appropriate action necessary for emergency protection of public safety, life or property. The type of action depends upon the state of progression of the deterioration, the physical layout of the dam, reservoir and inundation zone below the dam, and the resources available to the chief engineer or council at the time of the emergency.

(2) The chief engineer or council, upon determining that a dam or reservoir is dangerous and constitutes a substantial threat of failure and flooding, may request the attorney general or a prosecuting attorney to take any legal steps necessary for the protection of public safety, life or property. Action may be brought in any county where the defendant or defendant's principal place of business is located or where the dam or reservoir is located. Nothing in this section shall preclude the chief engineer or council from taking immediate action under 10 CSR 22-4.010(1) with respect to any dam or reservoir that has been classified as dangerous to public safety, life or property.

AUTHORITY: sections 236.400, 236.405, 236.420, 236.425 and 236.455, RSMo 1986. Original rule filed June 14, 1984, effective Jan. 1, 1985.*

**Original authority: 236.400, RSMo 1979; 236.405, RSMo 1979, amended 1993, 1995; 236.420, RSMo 1979; 236.425, RSMo 1979; and 236.455, RSMo 1979.*

10 CSR 22-4.020 Enforcement Orders and Enforcement Procedures

PURPOSE: The purpose of this rule is to identify the procedure to be taken for the issuance of enforcement orders.

(1) Enforcement orders shall be prepared by the chief engineer or council in cases where a dam or reservoir contains serious defects which pose a threat to public safety, life or property. Enforcement orders shall be sent to a dam owner by certified mail or served personally.

(2) If an owner does not initiate corrective actions to his/her dam and reservoir within thirty (30) days of the issuance of an enforcement order by the chief engineer or council, the council may request the attorney general or a prosecuting attorney to apply to the circuit court having jurisdiction to enforce compliance. Nothing in this section shall preclude the chief engineer from taking immediate action under 10 CSR 22-4.010(1) with respect to any dam or reservoir s/he has classified as dangerous to public safety, life or property.

AUTHORITY: sections 236.400, 236.405, 236.410, 236.415, 236.445 and 236.450, RSMo 1986. Original rule filed June 14, 1984, effective Jan. 1, 1985.*

**Original authority: 236.400, RSMo 1979; 236.405, RSMo 1979, amended 1993, 1995; 236.410, RSMo 1979, amended 1992; 236.415, RSMo 1979, amended 1995; 236.445, RSMo 1979; and 236.450, RSMo 1979.*

Missouri Revised Statutes

Chapter 236
Dams, Mills and Electric Power

August 28, 2010

Dams across nonnavigable streams--who may erect.

236.010. Any person or corporation chartered and organized to construct, operate and maintain mills, electric power and light works, or other machinery, may erect a dam across any watercourse, not being a navigable stream, if such person or corporation is the proprietor of the land through which the watercourse runs at the point where it is proposed to erect such dam, by proceeding as herein provided.

(RSMo 1939 § 10286)

Prior revisions: 1929 § 9157; 1919 § 7399; 1909 § 5456

Owner of land on one side of stream may erect dam.

236.020. Any person or corporation chartered and organized to construct, operate and maintain mills, electric power and light works, or other machinery, being the owner, in fee simple, of the land on one side of such watercourse, including a part of the bed of the stream, at a point where it is proposed to erect a dam, may, nevertheless, erect such dam by proceeding as herein provided.

(RSMo 1939 § 10287)

Prior revisions: 1929 § 9158; 1919 § 7400; 1909 § 5457

Petition to be filed in circuit court--contents.

236.030. In the case supposed in section 236.010, the person or corporation proposing to erect a dam shall file a petition in the circuit court of the county in which it is proposed to erect such mill, electric power and light works, or other machinery, in connection with the dam, and shall therein set forth:

(1) A description of the land and an abstract of the title thereto;

(2) The name of the watercourse, and a description of the point at which it is proposed to erect such dam;

(3) The altitude of the dam which it is proposed to erect; and

(4) The kind of mill, electric power and light works, or other machinery, which it is proposed to connect with the dam.

(RSMo 1939 § 10288)

Prior revisions: 1929 § 9159; 1919 § 7401; 1909 § 5458

Additional information to be set out.

236.040. In the case supposed in section 236.020, the person or corporation proposing to erect a dam shall file a petition as provided in section 236.030, and in addition thereto shall set forth:

(1) The name and place of residence of the owner of the land on the other side of the watercourse whereon to abut such dam;

(2) On what side of the watercourse it is proposed to erect such mill, electric power and light works, or other machinery in connection with the dam; and

(3) A prayer that the title to one acre of the land on the opposite side of such watercourse, to include the place where to abut such dam, may be decreed to such person or corporation, and that the same may be set apart by metes and bounds.

(RSMo 1939 § 10289)

Prior revisions: 1929 § 9160; 1919 § 7402; 1909 § 5459

Petition, where filed.

236.050. Such petition shall be filed in the circuit court of the county within which the petitioner proposes to erect such mill, electric power and light works, or other machinery.

(RSMo 1939 § 10290)

Prior revisions: 1929 § 9161; 1919 § 7403; 1909 § 5460

Writ of ad quod damnum.

236.060. Upon filing the petition, it shall be the duty of the court to cause a writ of ad quod damnum to be issued, under the seal of the court, directed to the sheriff, commanding him to summon twelve fit persons of his county to meet at the place where it is proposed to erect a dam, on a day to be named in the writ, then and there to inquire, by the said jury, touching the matters contained in the petition a copy of which shall accompany the writ.

(RSMo 1939 § 10291)

Prior revisions: 1929 § 9162; 1919 § 7404; 1909 § 5461

Duty of sheriff in executing writ.

236.070. The sheriff shall attend the jury on the day and at the place appointed, and upon full examination, inquire by such jury:

(1) What damage each proprietor will sustain by reason of inundation consequent upon the erection of the dam, as proposed;

(2) Whether the mansion house of any such proprietor, or the outhouses, curtilages or gardens thereto

immediately belonging, or orchard, will be overflowed thereby;

(3) Whether and to what extent ordinary navigation and the passage of fish will be obstructed by such erection, and whether and by what means the same may be prevented or diminished; and

(4) Whether the health of the neighborhood will be materially affected in consequence of such erection.

(RSMo 1939 § 10292)

Prior revisions: 1929 § 9163; 1919 § 7405; 1909 § 5462

Acre of ground to be set apart, when.

236.080. In the case supposed in section 236.020, the sheriff shall further inquire by the jury the value of the acre of land mentioned in the prayer of the petition, and set apart the same by metes and bounds.

(RSMo 1939 § 10293)

Prior revisions: 1929 § 9164; 1919 § 7406; 1909 § 5463

Proprietor to be notified of the inquest.

236.090. In such case the sheriff shall give the proprietor of the land whereof one acre is prayed for, a reasonable notice of the time and place when and where he will take the inquest of the jury, if such proprietor be in his county, and if not, he shall set up notice at the house of the tenant of such land, and if there be no actual tenant thereof, he shall set up such notice at some conspicuous place on the land.

(RSMo 1939 § 10294)

Prior revisions: 1929 § 9165; 1919 § 7407; 1909 § 5464

Sheriff and jury may act in adjoining county.

236.100. The sheriff and jury may enter and act in an adjoining county when necessary to the discharge of their duties.

(RSMo 1939 § 10295)

Prior revisions: 1929 § 9166; 1919 § 7408; 1909 § 5465

Inquest to be in writing.

236.110. The inquest of the jury shall be reduced to writing, signed by each of the jurors, and returned by the sheriff, together with the writ and a statement of the manner in which he executed it, into the court whence it issued, without delay.

(RSMo 1939 § 10296)

Prior revisions: 1929 § 9167; 1919 § 7409; 1909 § 5466

Proceedings on return of inquest.

236.120. Upon the return of such inquest and writ, any person aggrieved by the verdict of the jury may file his objections to the proceedings under such writ, and to the verdict, and show cause why the proceedings should be quashed and the verdict set aside.

(RSMo 1939 § 10297)

Prior revisions: 1929 § 9168; 1919 § 7410; 1909 § 5467

Issues to be tried as in civil cases.

236.130. The court may thereupon direct issues to be made up and tried as in other civil cases, and if good cause be shown therefor, the court shall quash the proceedings and set aside the verdict.

(RSMo 1939 § 10298)

Prior revisions: 1929 § 9169; 1919 § 7411; 1909 § 5468

Costs, how adjudged.

236.140. The costs attending the trial of such issues shall be adjudged against the unsuccessful party, as in other civil cases.

(RSMo 1939 § 10299)

Prior revisions: 1929 § 9170; 1919 § 7412; 1909 § 5469

Court may order new writ.

236.150. The court, on motion, may order a new writ of ad quod damnum to issue, for the purpose of having the damages assessed according to law.

(RSMo 1939 § 10300)

Prior revisions: 1929 § 9171; 1919 § 7413; 1909 § 5470

Court may enter order to erect dam, when.

236.160. If no objections be filed to the proceedings under the writ or to the verdict of the jury, and it shall appear to the court, upon a view of the inquest, that the mansion house of any proprietor, or the outhouse, curtilages or gardens thereto belonging, or orchard, will not be overflowed, and that the health of the neighborhood will not be materially affected by the stagnation of water consequent upon the proposed erection, the court shall thereupon grant or refuse the permission prayed for, according to its judgment of what would be most reasonable and just under all circumstances.

(RSMo 1939 § 10301)

Prior revisions: 1929 § 9172; 1919 § 7414; 1909 § 5471

Court shall include in its order, what.

236.170. When the party petitioning prays for an acre of land whereon to abut his dam, the court shall include in its order, if the petition is granted, a judgment vesting the title of such acre of land in the party petitioning, his heirs and assigns forever.

(RSMo 1939 § 10302)

Prior revisions: 1929 § 9173; 1919 § 7415; 1909 § 5472

Privilege to erect subject to certain conditions.

236.180. The judgment and order authorized by sections 236.160 and 236.170, and the rights and privileges thereby granted, shall, in all cases, be upon and subject to the conditions following:

(1) Such conditions in reference to the obstructions to the passage of fish and ordinary navigation, as the court shall think proper to impose;

(2) That all damages and valuations assessed and made by the jury shall be paid;

(3) That the dam and mills, electric power and light works, or other machinery, shall be commenced within one year, and finished and ready for business within three years from the date of the order of permission;

(4) That whenever the dam or mill, electric power and light works, or other machinery, shall be destroyed or materially impaired, the same shall be built or repaired within three years thereafter; but if the owner of such dam or mill, electric power and light works, or other machinery, shall be an infant, or of unsound mind, or imprisoned at the time such dam or mill, electric power and light works, or other machinery, shall be destroyed or materially impaired, then within three years after such disability is removed.

(RSMo 1939 § 10303, A. 1949 S.B. 1080)

Prior revisions: 1929 § 9174; 1919 § 7416; 1909 § 5473

CROSS REFERENCE:

Dam owners to maintain fishways--fish hatchery in lieu of fishway, 252.150

Land decreed for mill privileges to revert, when.

236.190. In case of noncompliance with any of the conditions concerning the building, rebuilding or repairing, where the land of another shall have been adjudged by the court for the purpose of an abutment, the same shall revert to and revest in the original owner, his assigns or legal representatives.

(RSMo 1939 § 10304)

Prior revisions: 1929 § 9175; 1919 § 7417; 1909 § 5474

Height of dam, how increased.

236.200. Any owner of any dam or mill, electric power and light works, or other machinery, erected by virtue of this or any previous law, may increase the altitude of his dam by permission of the court, under and by the same proceedings, regulations and conditions herein provided.

(RSMo 1939 § 10305)

Prior revisions: 1929 § 9176; 1919 § 7418; 1909 § 5475

Inquest not to bar right of action, when.

236.210. The inquest of the jury, or the order and permission of the court founded thereupon, shall not bar any prosecution or action for injuries caused by the erections herein contemplated, except such as were actually foreseen and estimated by the jury.

(RSMo 1939 § 10306)

Prior revisions: 1929 § 9177; 1919 § 7419; 1909 § 5476

Power of court to prevent erection of dam.

236.220. The circuit court of the proper county shall have power, upon petition, to prevent the erection or raising of any dam, stoppage, or obstruction across any stream which shall operate as a nuisance and be injurious to any mill, electric power and light works, or other machinery erected, or which shall dam up and render impure or unwholesome or unhealthy the waters of said stream at any point where water is or may be taken from said stream to supply the inhabitants of any city or town or village in the state with water, or of any dam, the erection of which has been authorized by the order of any competent tribunal, of a date earlier than that permitting the erection and raising of such first mentioned dam, stoppage or obstruction; and such court may, upon a final hearing of such petition, order and adjudge that such dam, stoppage or obstruction be abated by the sheriff of the proper county.

(RSMo 1939 § 10308)

Prior revisions: 1929 § 9179; 1919 § 7421; 1909 § 5478

Dams without chutes declared nuisances.

236.230. Every person who shall erect or maintain, or cause to be erected or maintained, in or across any of the waters of this state, unless said waters be wholly upon his own premises, any dam or other obstruction, no matter for what purpose, and shall not place and maintain thereon an apron or chute not less than fifteen feet wide, and sloping from each side to the center, so that the center shall be at least six inches lower than either edge, and having an inclination of not more than forty-five degrees, and so situated that the main current of water, impeded in its natural flow by the dam or other obstruction, shall pass over the same, or who shall not so construct or arrange such dam or other obstruction that it shall be lowest at the point where the apron or chute shall be placed, and low enough for the free passage of fish over the same each way, whenever the stream in which the same shall be situate shall be swollen beyond its ordinary size, shall be guilty of a misdemeanor, and shall be held to be guilty of a distinct offense each day he shall be in default as aforesaid; and every dam or other obstruction erected or maintained in violation of this section, shall be a public nuisance, and may be abated as such.

(RSMo 1939 § 10312)

Prior revisions: 1929 § 9183; 1919 § 7425; 1909 § 5482

Dams deemed public nuisances, when.

236.240. All dams, stoppages and obstructions not made according to law shall be deemed to be public nuisances, and may be dealt with as such.

(RSMo 1939 § 10309)

Prior revisions: 1929 § 9180; 1919 § 7422; 1909 § 5479

Forfeiture of rights, when.

236.250. If any person or corporation, or his or its legal representatives, to whom permission to erect a dam by virtue hereof shall have been given, shall fail to build, rebuild or repair the same, together with the mill, electric power and light works, or other machinery connected therewith, according to the requirements of law or the conditions of the permission, it shall be lawful for any person owning the land on one side of the watercourse, at the point where such dam is erected, or below, to build a dam and mill, electric power and light works, or other machinery thereon, as if no such permission had been given, without incurring any liability on account of backing the water on such dam.

(RSMo 1939 § 10310)

Prior revisions: 1929 § 9181; 1919 § 7423; 1909 § 5480

Dam reconstructed and maintained when used for other purposes.

236.255. In any case where a dam has been erected for a period of thirty years or more, and property above the dam within one mile of the point where the dam is situated has been developed for use of the impounded waters above the dam, the owner of the land on either side of the stream at the point where the dam is located shall have the right and authority to repair, maintain or reconstruct the dam, even though the dam is not used for the operation of any mill, electric power and light works, or other machinery.

(L. 1953 p. 669)

Privilege to construct dam to cease, when.

236.260. If the improvement of the navigation of any stream shall be undertaken by the state, or by any county, or other lawful authority under the state, then the privilege of keeping any dam across such stream, the right to construct which may be hereafter granted, shall cease, if the same would prevent or obstruct the making of such improvement; and it shall be the duty of the owner or owners of such dam, either to remove it or to make such change in the same as will render the navigation safe and convenient, according to the plan of such improvement; said change or alteration in such dam shall be so constructed as to be approved of by the proper officers or agents who shall have the superintendence of the improvement of such stream.

(RSMo 1939 § 10311)

Prior revisions: 1929 § 9182; 1919 § 7424; 1909 § 5481

Penalty for building without permission.

236.270. Any person who shall build or heighten any dam, or any other stoppage or obstruction on or across any watercourse, without first obtaining permission from the court of the proper county, according to law, and shall thereby work any injury to any other person, shall forfeit to the party injured double damages for such injury, to be recovered by civil action.

(RSMo 1939 § 10307)

Prior revisions: 1929 § 9178; 1919 § 7420; 1909 § 5477

Right to divert stream through tunnel--conditions.

236.280. Any person or persons, firm or firms, corporation or corporations, owning lands extending across the neck of any bend in any of the rivers of this state where a tunnel through such bends would create a waterfall to create electric power, that such owner or owners shall have the right to tunnel through such bends in such neck, on his or their or its own land or lands, and take up and divert and transmit and use the waters of said river (leaving enough water in said river at the point where said diversion shall be made to meet the wants of stock and the families below such point of diversion), and use the waters so diverted to create electric power for transmission and sale to the public, and then return such waters to said river again, without the consent of the riparian owners thereof owning shore lands on the inside and outside of said bend, between the intake and output points of said tunnel, by the use of the usual condemnation proceedings in the circuit court of the county of this state in which said lands, or a part thereof, are, or may be situated, to ascertain and establish the damage that will accrue to such owner or owners of said riparian rights by reason of the use and license aforesaid, and after this has been established and decreed, and that the judgment so awarded shall be paid before diverting and using said waters.

(RSMo 1939 § 10313)

Prior revisions: 1929 § 9184; 1919 § 7426; 1909 § 5483

Definitions.

236.400. As used in sections 236.400 to 236.500, standards, rules and regulations promulgated hereunder, unless the context otherwise requires the following words and terms mean:

(1) "Agricultural dam", any dam constructed to impound water for use in irrigation, livestock watering, or commercial fish rearing and sale;

(2) "Alterations", "repairs", or either of them, such alterations or repairs as affect the safety of a dam or reservoir, or public safety, life or property;

(3) "Chief engineer", the head of the dam and reservoir safety program of the department of natural resources or his representative;

(4) "Construction permit", a written authorization issued by the council giving the owner the right to construct, alter, enlarge, reduce, repair or remove a dam or reservoir or appurtenances thereto, with such conditions as are necessary to adequately protect the public safety, life, property, the dam or reservoir;

(5) "Dam", any artificial or manmade barrier which does or may impound water, and which impoundment has or may have a surface area of fifteen or more acres of water at the water storage elevation, or which is thirty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or dam, if it is not across a streambed or watercourse, together with appurtenant works. Sections 236.400 to 236.500 shall not apply to any dam which is not or will not be in excess of thirty-five feet in height or to any dam or reservoir licensed and operated under the Federal Power Act;

(6) "Dam and reservoir safety council", as designated by sections 236.400 to 236.500 and referred to as the "council" shall consist of seven members appointed by the governor according to the provisions of sections 236.400 to 236.500;

(7) "Director", the director of the department of natural resources of the state of Missouri;

(8) "Enlargement", any change in or addition to an existing dam or reservoir which raises the height of a dam, increases the watershed for a reservoir, or raises the water storage elevation of the water impounded by a dam or reservoir;

(9) "Experienced professional engineer", an engineer registered in the state of Missouri and experienced in hydraulics, hydrology and civil engineering as applied to dam design and construction;

(10) "Maintenance", the proper keeping of all aspects of a dam or reservoir and appurtenances thereto, that pertain to safety, in a state of repair and working order as necessary to comply with sections 236.400 to 236.500, any permit hereunder, and protect public safety, life and property;

(11) "Natural physical changes", those changes not directly or indirectly caused by man which affect the safety of the dam or reservoir;

(12) "Operation", the physical changes, natural or manmade that occur or are made to a dam or reservoir, or operation of the mechanisms or appurtenances of the dam or reservoir, which affect or may affect public safety, life or property;

(13) "Owner", a person who owns, controls, operates, maintains, manages, or proposes to construct a dam or reservoir including:

(a) The state and its departments, institutions, agencies, and political subdivisions, but not the United States government;

(b) A municipal or quasi-municipal corporation;

(c) A district;

(d) A public utility;

(e) A natural person, firm, partnership, association, corporation, political subdivision, or legal entity;

(f) The duly authorized agents, lessees, or trustees of any of the foregoing;

(g) Receivers or trustees appointed by any court for any of the foregoing;

(14) "Permit", a construction, safety or registration permit;

(15) "Permit applicant", an owner who applies for a construction, safety or registration permit;

(16) "Reduction", any decrease in the height of a dam, watershed size, or water storage elevation of the water

impounded by a dam or reservoir;

(17) "Registration permit", a permit issued for a period not to exceed five years by the council to the owner of a dam or reservoir in existence on September 28, 1979, or which becomes subject to the provisions of sections 236.400 to 236.500 for such dams and reservoirs which are in a properly maintained condition or which have made and complied with recommendations for corrections of observed defects of the dam or reservoir and have been* examined and approved in accordance with sections 236.400 to 236.500 and standards, rules and regulations and guidelines issued pursuant to sections 236.400 to 236.500;

(18) "Reservoir", any impoundment which results from a dam as defined in sections 236.400 to 236.500;

(19) "Safety permit", a permit issued to the owner for a period of five years, or less if safety considerations so require, by the council indicating that the dam meets the requirements of sections 236.400 to 236.500 and the guidelines, standards, rules and regulations issued pursuant to sections 236.400 to 236.500, and containing such conditions as to operations, maintenance and repair as are necessary to adequately protect public safety, life and the dam or reservoir;

(20) "Water", water, other liquid or tailings;

(21) "Water storage elevation", that elevation of water surface at the principal spillway which could be obtained by the dam or reservoir were there no outflow and were the reservoir full of water;

(22) "Watershed", the area, usually expressed in acres of square miles, that contributes or may contribute surface water to a reservoir.

(L. 1979 H.B. 603 § 1)

*Words "have been" not in original rolls.

Employment of engineer and assistants--records--rulemaking, procedure.

236.405. 1. There is hereby created a dam and reservoir safety program in the department of natural resources. The council shall promulgate rules, regulations, guidelines, and standards relating to the determination of whether a dam or reservoir constitutes a danger to public safety, life or property to be effective upon approval by the director.

2. The director of the department of natural resources shall employ an experienced professional engineer as chief engineer and assistants to administer the activities of the dam and reservoir safety program.

3. The chief engineer shall be selected under the state merit system on the basis of professional experience directly related to the design and construction of dams and reservoirs.

4. The findings, opinions, and orders of the council and the chief engineer shall be kept as permanent public records in the offices of the department of natural resources.

5. No rule or portion of a rule promulgated under the authority of sections 236.400 to 236.500 shall become effective unless it has been promulgated pursuant to the provisions of section 536.024.

(L. 1979 H.B. 603 § 2, A.L. 1993 S.B. 52, A.L. 1995 S.B. 3)

Council established--members, terms, qualifications, officers--meetings--quorum--

compensation.

236.410. 1. There is hereby created a "Dam and Reservoir Safety Council", whose domicile for the purposes of sections 236.400 to 236.500 shall be the department of natural resources of the state of Missouri, for the regulation of dam and reservoir safety. The council shall consist of seven members, no more than four of whom shall be members of the same political party, appointed by the governor with the advice and consent of the senate.

2. The members of the council shall have a background of academic training or professional experience directly related to the design of dams and reservoirs. At least two members of the council shall be professional engineers registered in the state of Missouri, one of whom shall represent the general public; at least one member shall be an engineering geologist; at least one member, in addition to the professional engineer, shall be a representative of the general public; two members shall be from industry, one of whom shall be earthmoving contractors; and one member shall be the owner of a dam or reservoir. The members shall serve for a term of two years; except, of the first appointments three shall be appointed for one year. The governor shall fill any vacancy on the council and may remove any appointed member for cause. The council shall annually elect a chairman and vice chairman from among its members. The council shall meet regularly but not less than quarterly. Special meetings and hearings may be called upon delivery of written notice to each member of the council signed by the director, the chief engineer, the council chairman or four of the council members. Four members of the council shall constitute a quorum to transact the business of the council. The council shall decide all questions by a majority vote of those present and constituting a quorum. The members of this council shall not receive any compensations other than for actual travel and subsistence when acting officially as members of the council.

(L. 1979 H.B. 603 § 3, A.L. 1992 H.B. 1634)

Council's powers and duties--public hearings required--adoption of rules and regulations, procedure.

236.415. 1. The council considering recommendations of the chief engineer shall, subsequent to a public meeting, adopt, subject to the approval of the director, the general technological guidelines and the standards, guidelines, rules and regulations applicable to permits, the design, construction, maintenance, operation, alteration, repair, enlargement, reduction, removal or natural physical changes that may occur to a dam or reservoir. Violations of guidelines, standards, rules and regulations are violations of sections 236.400 to 236.500 permitting the revocation, suspension, or refusal to issue any permit required by sections 236.400 to 236.500. No standards, guidelines, rules, or regulations shall be adopted, or any amendment or repeal thereof shall be effective, except after a public hearing to be held after thirty days' prior notice by advertisement or press release, and publication as required in chapter 536 of the date, time and place of the hearing and opportunity given to the public to be heard.

2. At the hearing, opportunity to be heard by the council with respect to the subject thereof shall be afforded any interested person upon written request to the council, addressed to the chief engineer, received not later than seven days prior to the hearing and may be afforded to other persons if convenient. In addition, any interested person, whether or not heard, may submit, within seven days subsequent to the hearings, a written statement of his views. The council may solicit the views, in writing, of persons who may be affected by, or interested in, proposed rules and regulations, standards or guidelines. Any person heard or represented at the hearing or making written request for notice shall be given written notice of the action of the council with respect to the subject thereof.

3. The council upon hearing the recommendations of the chief engineer and reviewing the application for a construction or registration permit shall approve or deny the permit application. The council may delegate authority to approve or deny permit applications to the chief engineer, whose actions shall be subject to appeal to the council as provided in subsection 2 of section 236.425.

4. No standard, rule or regulation or guideline, or amendment or repeal thereof, adopted by the council shall be in force and effect until it has been approved in writing by the director and the requirements of chapter 536 are satisfied. The affirmative vote of at least four members of the council shall be required for adoption.

(L. 1979 H.B. 603 § 4, A.L. 1995 S.B. 3)

Inspection of dams and reservoirs, when--report on conditions.

236.420. The council, with the advice and assistance of the chief engineer, shall carry out a state program of inspection of dams and reservoirs in accordance with regulations adopted by the council. All dams and reservoirs in this state shall be inspected on a periodic basis to determine if they constitute a threat to public safety, life or property. The chief engineer shall submit reports to the director and the council concerning the condition of each dam or reservoir inspected, and recommendations as to any alterations or repairs needed.

(L. 1979 H.B. 603 § 5)

Chief engineer's duties--search warrants--council to hear certain appeals.

236.425. 1. The chief engineer shall administer the provisions of sections 236.400 to 236.500 by:

(1) Recommending general technological guidelines that pertain to the design, construction, maintenance, operation, use, alteration, repair, enlargement, reduction, or natural physical changes of, or that may occur to, a dam or reservoir including their removal; except that, detailed technical specifications shall not be promulgated to regulate the design, construction, operation, maintenance, use, alteration, repair or removal of a dam or reservoir. Such guidelines shall not be effective until adopted by the council and approved by the director at a public meeting, after notice requirements set forth in subsection 1 of section 236.415 herein have been satisfied;

(2) Making* recommendations concerning the issuing, continuing in effect, revoking, modifying, suspending, or denying, under such conditions as prescribed by sections 236.400 to 236.500 and such rules as may be adopted to protect public safety, life, property, dams and reservoirs, construction permits for the construction, alteration, enlargement, reduction, repair or removal of dams or appurtenances thereto, and safety and registration permits to insure continuing protection of public safety, life, property, dams and reservoirs, for all dams subject to the provisions of sections 236.400 to 236.500;

(3) Making such investigations, including hearings, as are proper to protect public safety, life and property from an unsafe dam or reservoir, and to determine whether any permits should be issued, continued, revoked, modified, suspended, or denied or whether any violations of sections 236.400 to 236.500, standards, or rules or regulations have occurred or are occurring;

(4) Entering, at any reasonable time, any private or public premises as necessary to make an investigation or inspection of a dam or reservoir, or records kept, pertaining thereto, and such inspection shall follow reasonable notice to the owner given prior to such investigation or inspection except in the case of an emergency threatening public safety, life or property, in which case such inspection or investigation may be made without prior notice. A suitably restricted search warrant, upon a showing of probable cause in writing and upon oath, shall be issued by any judge having jurisdiction, to the chief engineer or his representative for the purpose of enabling him to make the inspection.

2. The council shall meet with or hear the appeal of a permit applicant and his representative upon request of the permit applicant if the chief engineer has rejected the application for a construction, safety or registration permit.

(L. 1979 H.B. 603 § 6)

*Words "To make" appear in original rolls.

Employees, council to provide for.

236.430. The council shall retain, employ, provide for and compensate within appropriations available therefor, such consultants, assistants, and other employees on a full- or part-time basis as may be necessary to carry out the provisions of sections 236.400 to 236.500 and prescribe the times at which they shall be appointed and their powers and duties.

(L. 1979 H.B. 603 § 7)

Permits required, when, procedure to obtain--chief engineer to make recommendation--exemptions--plans to be filed.

236.435. 1. Prior to the commencement of the construction, alteration, enlargement, reduction or removal of a dam or reservoir, the owner shall apply to the council and upon satisfying the requirements of sections 236.400 to 236.500 and the rules, regulations and standards promulgated pursuant hereto, obtain a construction permit.

2. The application for a construction permit shall bear the seal and signature of an experienced professional engineer registered in Missouri or employed by a qualified engineering division of a state or federal agency regularly engaged in dam construction for soil and water conservation, or irrigation or relating to wildlife conservation and shall be accompanied by the design report and plans and specification of the proposed design, alteration, enlargement, reduction, repair or removal of the dam or reservoir.

3. Any person constructing or owning a dam or reservoir, or living or owning property in an area affected, or whose safety may be affected by such dam or reservoir may consult with the chief engineer concerning such dam or reservoir.

4. The council upon hearing the recommendation of the chief engineer shall approve or deny an application for a construction permit within forty-five days after its receipt or the completion of any hearings in connection with such application, whichever is later. The permit shall be issued upon the receipt of the application if, in the judgment of the council, requirements of sections 236.400 to 236.500 and all standards, rules and regulations hereunder are satisfied and the design will be adequate to protect the public safety, life and property.

5. The council upon hearing the recommendation of the chief engineer may reject the application if it decides that there is insufficient information to determine the safety of the proposed construction, alteration, enlargement, reduction or removal of the dam or reservoir or that the construction, alteration, enlargement, reduction or removal of the dam or reservoir would endanger public safety, life or property, or otherwise not comply with sections 236.400 to 236.500 and any rules, standards, guidelines and regulations adopted hereunder.

6. A landowner who now owns or proposes to construct an agricultural dam or reservoir which will be used primarily for agricultural purposes will be exempt from all provisions of sections 236.400 to 236.500. If the council with the advice of the chief engineer, determines that the dam or reservoir is no longer used primarily for agricultural services, it shall become subject to the provisions of sections 236.400 to 236.500.

7. Dams or their construction, alterations, enlargements, reductions or removals designed by, and their construction, alteration, enlargement, reduction or repair or removal monitored by, a qualified engineer regularly engaged in dam construction for soil and water conservation or irrigation or relating to wildlife conservation are for the purposes of such construction or other listed actions exempt from the provisions of this section except that the plans for the dam shall be filed with the chief engineer prior to construction, or other listed action. Amended plans shall be filed at the completion of construction or other listed action if there have been significant

deviations from the previously filed plans.

(L. 1979 H.B. 603 § 8)

Owner to notify council, when--council to issue safety permit--registration of existing dams, when--violations.

236.440. 1. The owner shall notify the council upon completion of construction, alteration, enlargement, or reduction of the dam or reservoir. This notification shall bear the seal and signature of an experienced professional engineer and shall be accompanied by an application for a safety permit. The owner of any dam or reservoir subject to the provisions of sections 236.400 to 236.500 shall obtain a safety permit following completion of construction.

2. Upon receipt of complete and proper application for a safety permit, including notification of completion by the owner and certification by an experienced professional engineer that the new construction, alteration, enlargement or reduction has been completed in accordance with the provisions of the construction permit and sections 236.400 to 236.500, the council shall upon receipt of the application issue a safety permit. The council upon advice of the chief engineer may deny the application if it determines that violations of the construction permit or sections 236.400 to 236.500 exist. If revisions have been made which vary substantially from the provisions of the construction permit, it must be shown that the revisions do not endanger public safety, life or property. The safety permit for dams constructed pursuant to a construction permit issued under sections 236.400 to 236.500, may contain conditions the council upon advice of the chief engineer determines are necessary for the protection of public safety, life and property and a schedule and timetable for the dam and reservoir to achieve compliance with the construction permit and provisions of sections 236.400 to 236.500, standards, rules and regulations promulgated hereunder, but such conditions shall not be more stringent or restrictive than those contained in the construction permit.

3. Owners of dams and reservoirs in existence on September 28, 1979, shall obtain registration permits for dams of fifty to seventy feet in height within four years, and for dams up to fifty feet in height within six years of September 28, 1979, or as otherwise required by the provisions of sections 236.400 to 236.500 and rules and regulations adopted hereunder. A registration permit shall be issued by the council upon the advice of the chief engineer for dams and reservoirs only after it is determined that the dam meets the standards of sections 236.400 to 236.500 and rules and regulations hereunder, and any recommendations made by the inspecting engineer pursuant thereto.

4. Upon complete and proper application for a registration permit, on forms provided by the department of natural resources, by the owner of a dam in existence upon September 28, 1979, including a certification by an experienced professional engineer or an engineering division of a state or federal agency regularly engaged in dam construction for soil or water conservation, irrigation, or relating to wildlife conservation, that the dam has been inspected in accordance with sections 236.400 to 236.500, standards, rules and regulations and guidelines promulgated hereunder, and that the owner has complied with the inspecting engineer's or agency's recommendations necessary to correct observed defects of the dam or reservoir, the council shall, upon receipt of the application, issue a registration permit. The council upon hearing the recommendations of the chief engineer may deny the application if it determines that the owner has not complied with the inspecting engineer's or agency's recommendations.

5. For dams for which construction was completed prior to the effective date of the construction permit requirements hereunder, the registration permit may contain conditions the council upon hearing recommendations of the chief engineer determines to be necessary to bring the dam and reservoir into compliance with sections 236.400 to 236.500 and standards, rules and regulations promulgated hereunder.

6. If a dam or reservoir has been removed by the owner, the council shall issue a final approval upon notification by the owner and receipt of certification by an experienced professional engineer that the removal has been

carried out in accordance with the provisions of the construction permit issued for such removal. Failure to obtain final approval shall be a violation of sections 236.400 to 236.500.

7. The council shall issue safety permits for dams or their construction, alterations, enlargements, reductions or removals designed by, and their construction or other listed actions monitored by, a state or federal agency engaged in dam construction for soil and water conservation, irrigation or relating to wildlife conservation provided the owners obtain from such agency and file with the chief engineer a statement upon completion of the construction or other listed actions and at not greater than five year intervals, and with every application for renewal of a safety permit, that the dam conforms to the plans on file with the chief engineer and is in a safe, properly maintained condition.

8. The owner shall apply for renewal of a safety or registration permit not less than sixty days prior to expiration of the previously issued permit. The chief engineer shall determine if the dam and reservoir are essentially as described in the latest permit issued for that dam and reservoir, whether they satisfy the requirements of sections 236.400 to 236.500 and any rules, regulations, standards and guidelines adopted pursuant to sections 236.400 to 236.500 and whether any inspection conducted in connection with the permit renewal reveals any defect in the dam or reservoir which would threaten public safety, life or property. Unless the chief engineer determines that the dam and reservoir are not properly maintained, do not satisfy the requirements of the permit, act* or rules, regulations, standards and guidelines promulgated hereunder, or that defects revealed by the inspection are not corrected, the council upon hearing the recommendations of the chief engineer shall issue or renew the safety or registration permit upon forty-five days of the receipt of a complete and proper application. The council may require the owner to furnish a certification, as a part of an application to renew a permit hereunder, by an experienced professional engineer or a qualified engineering division of a state or federal agency regularly engaged in dam construction for water conservation, irrigation or relating to wildlife conservation that the dam is in a properly maintained condition and that any recommendation for correction of defects which violate sections 236.400 to 236.500, guidelines, rules, regulations and standards hereunder or which threaten public safety, life or property have been complied with and that the engineer detected no other such defects which have not been corrected.

9. If a barrier or water impoundment becomes a dam or reservoir through alteration or enlargement as defined herein, it shall be subject to the provisions of sections 236.400 to 236.500.

10. Failure to obtain and comply with a permit as required in this section is a violation of sections 236.400 to 236.500.

(L. 1979 H.B. 603 § 9)

*Word "act" apparently refers to "this act", now §§ 236.400 to 236.500.

Permit may be suspended--alteration or removal may be required--violation.

236.445. 1. If it is found that a dam or reservoir presents a threat to public safety, life or property, or that the safety of the dam or reservoir is threatened, the permit for the dam or reservoir shall be suspended and shall be reinstated only when the owner at his expense has completed the necessary alteration or has established such operational procedures as the council upon hearing the recommendations of the chief engineer deems necessary for protection of the public safety, life, property, the dam or reservoir. If necessary for such protection, the council may require the owner at his expense to remove the dam or reservoir, or if the owner refuses or neglects to act, the state may alter or remove the dam or reservoir, and the chief engineer may recover the costs of such action as provided in section 236.450.

2. If the owner refuses to alter or remove a dam or reservoir as directed when found to be a threat as set forth in sections 236.400 to 236.500, he shall be in violation of sections 236.400 to 236.500 and the permit requirements hereunder, and such action shall subject the owner to the enforcement provisions contained herein and revocation

of the permit.

(L. 1979 H.B. 603 § 10)

Removal or repair of abandoned dam--recovery of expenses.

236.450. An existing dam or reservoir which the chief engineer determines to be abandoned and considered to be a threat to public safety, life, or property may be altered, repaired, or removed upon such determination at the expense of the state of Missouri, and the chief engineer may request either the attorney general or a prosecuting attorney to bring an action in the name of the people of the state of Missouri to recover such expenses from the owner through appropriate legal processes. Such action may be brought in any county where the defendant or defendant's principal place of business is located or where the dam or reservoir is located.

(L. 1979 H.B. 603 § 11)

Emergency action authorized.

236.455. If it is determined at any time that the condition of a dam or reservoir is an imminent and substantial threat, and so dangerous to public safety, life or property as not to permit time for issuance of an enforcement order to correct the hazard, the chief engineer may take any appropriate action not prohibited by the constitution or laws of this state he deems necessary for emergency protection of public safety, life or property, and may request the attorney general or a prosecuting attorney to take any legal steps necessary to accomplish such action and to recover the cost of such measures from the owner by appropriate legal action.

(L. 1979 H.B. 603 § 12)

Transfer of ownership, notice required.

236.460. The owner shall notify the chief engineer upon the sale or other transfer of interest in a dam or reservoir, either existing or under construction, alteration or removal. The construction, safety or registration permit shall be transferred to the successive owner upon receipt of this notification and upon determination that such transfer will not endanger public safety, life, property, the dam or reservoir.

(L. 1979 H.B. 603 § 13)

Industrial water retention structures subject to provisions of sections 236.400 to 236.500--inspection--changes.

236.465. Irrespective of any other provisions of sections 236.400 to 236.500, the following provisions shall apply to the construction, alteration or enlargement of tailing, slime and settling ponds and to other similar industrial water retention structures included within the definitions of dam or reservoir in section 236.400:

(1) Applications for construction, safety or registration permits shall be submitted as provided in section 236.435 and section 236.440 except that design plans and specifications which outline any anticipated enlargement of the industrial water retention structure shall be included;

(2) It shall not be necessary to reapply for a permit each time the structure is enlarged if the enlargement plans

have been submitted in and approved with the original application, and the provisions of subdivision (3) of this section have been satisfied;

(3) Upon notification of the chief engineer, bearing the seal and signature of an experienced professional engineer, that the initial phase of construction has been completed in accordance with the provisions of the construction permit and sections 236.400 to 236.500, or if a registration permit has been issued as provided in subdivision (1) of this section, and before any enlargement is begun, and if no violation of sections 236.400 to 236.500 can be shown, a safety permit or a registration permit with special provisions that authorize the planned enlargement to the initially constructed structure shall be issued, on application, if enlargement plans were included and approved in the original application;

(4) It is not necessary to retain continuously a professional engineer after the initial stage of construction;

(5) The dam shall be inspected by an experienced professional engineer registered in the state of Missouri as required to renew the safety permit or registration permit at five-year intervals unless safety of the public, life and property require a shorter period of time;

(6) The chief engineer shall make inspections of these structures as necessary to insure adequate protection for public safety, life and property;

(7) Where it is shown that a tailings, slime and settling pond, or other similar water retention structure is subject to inspection for safety, using standards at least as stringent as those required under sections 236.400 to 236.500, by a federal or state agency and the owner notifies the council that the structure is subject to such inspection, such structures shall be exempt from the provisions of sections 236.400 to 236.500.

(L. 1979 H.B. 603 § 14)

Conduct of hearings--subpoenas--approval of final orders.

236.470. 1. At any public hearing all testimony taken before the council, or a hearing officer appointed by the council chairman, shall be under oath and recorded stenographically. The transcript so recorded shall be made available to any person upon payment of the usual charge therefor.

2. In any such hearing, any member of the council or the hearing officer shall issue in the name of the council notice of hearing and subpoenas. Subpoenas shall be issued and enforced as provided in section 536.077. The rules of discovery that apply in any civil case apply to hearings held by the council.

3. All hearings to approve, amend or repeal guidelines, standards or rules and regulations shall be held before at least four members of the council.

4. All other hearings may be held before one council member designated by the council chairman or a hearing officer who shall be a member of the Missouri bar and appointed by the council chairman. The hearing officer or council member shall preside at the hearing and hear all evidence and rule on the admissibility of evidence. The hearing officer or council member shall make recommended findings of fact and may make recommended conclusions of law to the council.

5. All final orders or determinations or other final actions by the council shall be approved in writing by at least four members of the council. Any council member approving in writing any final order or* determination or other final action, who did not attend the hearing, shall do so only after reviewing all exhibits and reading the entire transcript.

(L. 1979 H.B. 603 § 15)

*Word "of" appears in original rolls.

Immunity of officers.

236.475. In the absence of willful and wanton misconduct, no action shall be brought against the council, the chief engineer or his agents, or department employees or private individuals employed as consultants by the department for the recovery of damages caused by the partial or total failure of any dam or reservoir or through the use or operation of any dam or reservoir upon the ground that such person is liable by virtue of any of the following:

(1) The approval of a dam or reservoir or permits therefor;

(2) The issuance or enforcement of orders relating to maintenance, operation or repair of a dam or reservoir;

(3) Control and regulation of a dam or reservoir;

(4) Measures taken to protect against failure during an emergency.

(L. 1979 H.B. 603 § 16)

Judicial review of actions--administrative review required--interpretation of administrative actions.

236.480. 1. All final decisions, orders, actions or determinations made pursuant to the provisions of sections 236.400 to 236.500 are subject to judicial review pursuant to the provisions of chapter 536. No judicial review shall be available, however, until all administrative remedies are exhausted.

2. In any suit filed pursuant to section 536.050 concerning the validity of the standards, rules, guidelines and regulations promulgated hereunder, the court shall review the record made pursuant to their adoption to determine the validity and reasonableness of such standards, rules, guidelines and regulations and may hear such additional evidence as it deems necessary.

(L. 1979 H.B. 603 § 17)

Water rights preserved.

236.485. The provisions of sections 236.400 to 236.500 do not grant or diminish any right to that water entering, discharged from or impounded by a dam or contained in a reservoir.

(L. 1979 H.B. 603 § 18)

Enforcement of act.

236.490. All duly constituted officers of the law of this state or any political subdivision thereof shall aid in the enforcement of the provisions of sections 236.400 to 236.500.

(L. 1979 H.B. 603 § 19)

Legal actions for enforcement available, procedure.

236.495. 1. In carrying out the provisions of sections 236.400 to 236.500 and to the extent not inconsistent with chapter 491, the chief engineer or council may subpoena witnesses and compel their attendance, and may also require the submission of books, papers, documents or other pertinent data in any hearing or enforcement proceedings hereunder or in any case wherein a violation of this chapter is alleged. Upon failure or refusal to comply with such order or upon failure to honor a subpoena, as herein provided, the council may request the attorney general or a prosecuting attorney to apply to the circuit court having jurisdiction to enforce compliance.

2. The council may request the attorney general or a prosecuting attorney, in the name of the state, to institute a suit for injunctive relief to stop or prevent violations of the provisions of sections 236.400 to 236.500, permits, standards, orders and rules and regulations promulgated hereunder, which shall be violations of sections 236.400 to 236.500, or to restrain any violation thereof, or after written notification of violation by the council, and a reasonable time to correct such violation, for the assessment of a penalty of up to one thousand dollars per day, for each day or part thereof the violation continues to occur after such notice. Such action may be brought in any county where the defendant's principal place of business is located, where the dam or reservoir is located, or the violation does or may occur.

(L. 1979 H.B. 603 § 20)

Penalties.

236.500. 1. Any person who willfully violates any of the provisions of sections 236.400 to 236.500 is guilty of a misdemeanor and, upon conviction, shall be punished by a fine of not less than five hundred dollars nor more than ten thousand dollars, or by confinement in the county jail for a term of not less than thirty days nor more than one year, or by both such fine and confinement.

2. In the event of a continuing violation, each day that the violation continues shall constitute a separate and distinct offense.

3. Any person who willfully obstructs, hinders or prevents the council, the chief engineer or his agents or employees from performing the duties imposed by sections 236.400 to 236.500 and rules and regulations promulgated hereunder or who willfully resists the council, the chief engineer or his agents in the performance of the duties imposed on them by sections 236.400 to 236.500 and rules and regulations promulgated hereunder is guilty of a misdemeanor and, upon conviction, shall be punished as provided in subsection 1 of this section.

4. Any owner who willfully engages in the construction, repair, alteration or removal of any dam or reservoir without a construction permit or in violation of a construction permit or willfully violates the requirements of or for a safety or registration permit is guilty of a misdemeanor and, upon conviction, shall be punished as provided in subsection 1 of this section.

(L. 1979 H.B. 603 § 21)

© Copyright

E.25. Montana





Is Your Dam Above Homes, Highways, or Other Structures?

Do you own or plan to build a dam above homes, highways, or other structures?

If you own or plan to build a dam, it's important to know whether the dam presents a hazard to the people and property downstream. A high hazard dam is any dam that impounds 50 acre-feet of water or more and could cause loss of life downstream in the event of a dam failure. "High-hazard" is not a description of the dam's condition. "High-hazard" refers to the potential for the loss of life downstream if the dam were to fail.

There are over 3,500 dams in Montana that impound 50 acre-feet of water or more. Of these dams, approximately 150 are classified as high-hazard.

Montana's Dam Safety Law

In 1985, Montana became one of 48 states to adopt regulations for high-hazard dams. The Montana Dam Safety Act implements a permitting process requiring that construction, maintenance, and operation of high-hazard dams be conducted in a safe manner.

It is beneficial for a high-hazard dam to be in compliance with Montana's Dam Safety Act. If a high-hazard dam is permitted under the act, a dam owner is not, in the absence of negligence, liable for damages resulting from discharges from the dam or reservoir that

continued...

exceed the 100 year flow. This provision reduces the risk of liability to a high- hazard dam owner.

Exempt from the Dam Safety Act are:

- Dams that are owned by the federal government,
- Dams inspected by the Federal Energy Regulatory Commission,
- Dams included in a mine operating permit issued by the Montana Department of Environmental Quality,
- Dams associated with facilities certified under the Major Facility Siting Act.
- Private dams on federal property, including dams on U.S. Forest Service property.

These dams are already required to meet safety standards established by other state or federal law and are exempt to prevent instances of dual jurisdiction or conflicting standards.

Hazard Classification

Construction of a new dam or alteration of an existing dam, with an impoundment capacity of 50 acre-feet or more, requires an application to the Department of Natural Resources and Conservation (DNRC) Dam Safety Program for a hazard classification. The ***impoundment capacity*** is measured to the maximum normal operating pool, which is usually the crest of the spillway. The requirements for hazard classification also apply to flood control structures that have the potential for impounding 50 acre-feet or more.



Construction Work on Deadman's Basin Dam

Construction Permit

If determination is reached that a high-hazard potential exists downstream from a dam, a construction permit is necessary before construction. ***Construction*** includes construction of a new high-hazard dam or major repair, alteration, enlargement, or removal of an existing high-hazard dam. An application for a construction permit must be accompanied by construction plans and specifications as well as an engineering design report.

The plans, specifications, and report must be prepared by a licensed professional engineer experienced in dam design and construction. Within 60 days of receiving a completed application, DNRC will issue or deny a construction permit. There is no fee associated with a construction permit application.

A construction permit is not required for performing minor and routine repairs, maintenance, or emergency repairs on a high-hazard facility.

The determination of hazard involves an evaluation of the area downstream from the dam that would be flooded in the event of dam failure. If the flood would have the potential to cause a loss of life, the dam is classified as a high-hazard structure. The hazard classification is based on the potential loss of life downstream; ***it is not an assessment of the safety of the structure.*** DNRC will make a hazard classification determination within 60 days after a complete application is received. The cost of the hazard classification determination is $125.



Painted Rocks Dam

Operation Permit

It may be necessary to obtain an operation permit from DNRC if you own or plan to own a high-hazard dam. An operation permit application must include an operation plan and an engineer's inspection report. The permit is effective for a period of no longer than 5 years. After 5 years renewal of the permit is required. The ***operation plan*** consists of reservoir operation procedures, maintenance procedures for the dam and appurtenant works, and the emergency procedures. The plan must be updated whenever the permit is renewed. Preparation of and adherence to the plan will aid in the safe operation and maintenance of the high-hazard dam. A more detailed description of an operation plan can be found in Administrative Rules of Montana Chapter 36.14.101-803. A sample of an operation plan is available from DNRC.

A periodic inspection of the high-hazard dam is necessary when the operation permit is first applied for or renewed. The minimum frequency for inspection is stated in the operation permit and is at least once every five years. The inspection must be arranged by the dam owner and conducted by a licensed professional engineer. A report of the inspection must accompany the permit application.

If, after reviewing the application, operation plan, and inspection report, DNRC determines that the high-hazard dam meets or exceeds minimum safety standards and can be safely operated and maintained, an operation permit is issued. There is no fee associated with an operation permit application. DNRC will issue or deny the permit within 90 days after receiving a complete application.

Civil Penalty

A civil Penalty of up to $1,000 per day can be assessed against a dam owner, for non-compliance with the Montana Dam Safety Act.



Eureka Dam Failure

Emergency

If a dam is in danger of failing due to structural deficiencies or severe flood conditions and poses a life threatening emergency, a dam owner may proceed with the necessary repairs or breaching without the previously described construction permit. ***DNCR must be notified immediately of any proposed emergency repairs or breaching.*** If a dam owner fails to act, DNRC may take any action necessary to safeguard downstream life and property. Costs incurred by DNRC's action during an emergency must be paid by the owner of the dam.

Complaints - Unsafe Dam or Reservoir

If you have a concern that life or property is being endangered by a dam, regardless of the capacity of the reservoir, a complaint may be filed by submitting an affidavit to DNRC. DNRC may then inspect or order an inspection of the dam unless the data, records, and inspection reports are adequate to determine that the complaint has no merit.

If the inspection discloses defects in the dam or reservoir that, in the judgment of DNRC, constitute an immediate hazard to life or property, DNRC can order the reservoir be drained, limiting its use, or taking other steps to ensure the safety of the dam. DNRC may require the owner to pay all or part of the inspection expenses.



Toston Dam



Ackley Dam

Laws, Rules and Forms

For copies of the Montana Dam Safety Act, the administrative rules, or application forms, you may write or call DNRC at the address below.

Other Information

Numerous publication are available concerning inspection guidelines, emergency and early warning plans, and other areas that may be of interest or assistance to owners of dams. Contact DNRC for more information.

Montana Department of
Natural Resources and Conservation
Water Resource Division
Dam Safety Program
1424 9th Avenue
PO Box 201601
Helena, MT 59620-1601
406-444-6613

TECHNICALLY SPEAKING… MONTANA'S TECHNICAL NOTES FOR RISK-BASED DAM SAFETY ANALYSES

Gary Fischer, P.E., Hydrometrics, Inc. and Carroll College
and
Michele Lemieux, P.E., Montana Dam Safety Program, Montana Department of Natural Resources and Conservation

Introduction

In 1999, the Montana Dam Safety Program adopted spillway design standards based on risk-based criteria and moved away from standards based on percentages of the probable maximum flood (PMF) keyed only to dam height and reservoir volume. This propelled the program into an era where spillway standards are determined by the risk of loss of life (LOL) due to dam failure, instead of just the size of the impounded reservoir. This was a good thing for some dam owners who were penalized for owning a large dam even though the dams were located in rural areas with sparse population where the chance for LOL due to failure was rare. However, since the new standards are based on breach inundation modeling and runoff hydrology of storms with very low exceedance probabilities, they have also required engineers to have a thorough understanding of storm hydrology and to be adept at computer modeling of storm routing and breach failures. The myriad of data available to engineers to conduct such modeling can be overwhelming and it is sometimes hard for engineers to stay abreast of the latest techniques and available information. In response to this relatively new approach to dam safety analyses, the Montana Dam Safety Program has contracted with Hydrometrics, Inc. to initially develop three Technical Notes designed to assist and provide guidance to professionals for dam safety analyses. This paper provides a description of the first two Technical Notes, with a look ahead at the anticipated features of the third.

What Would Washington State Do?

The Montana Dam Safety Program has long held a close working relationship with the Washington Dam Safety Office. The two states share similar geographical features, both having mountainous terrain in the western third of each state with the eastern two-thirds comprised of mostly high elevation plains. While Washington experiences roughly 2 to 3 times the annual precipitation and much higher population in the western third of their state compared to Montana, the eastern plains areas of both states are similar in meteorology and population. Holding similar philosophies in terms of risk-based standards, Montana in the late 1990s developed spillway standards using Washington's risk-based standards as examples. Montana's state-specific extreme storm studies were conducted using the same statistical analyses as Washington. Similar in concept to the Washington State Dam Safety Office Guidance Documents (1), the Montana Dam Safety Program is in the process of developing technical notes that provide information for professionals and engineers to conduct spillway capacity analyses, LOL determinations, and simplified evacuation mapping.

The Evolution of Spillway Standards in Montana

In Montana, a dam is regulated as “high hazard” if its failure has the potential for causing LOL. The original Dam Safety Rules established spillway hydrologic standards for high hazard dams based on reservoir volume and dam height. It became evident that in many cases the required spillway size was disproportionate to the level of downstream development. This was particularly true for large dams located in rural areas or, on the other end of the scale, for smaller dams that had dense downstream development but still posed significant threats to downstream populations.

To help address this discrepancy, the Montana Dam Safety Program within DNRC in 1999 developed new hydrologic standards that provide a uniform level of downstream protection by relating the required spillway size to the consequences of a dam failure, or estimated LOL, rather than to the size of the dam. The minimum inflow design flood, or IDF, is the storm runoff that enters a reservoir impounded by a dam and is routed through the spillway. The magnitude, or relative size, of the IDF is determined by LOL, which in turn dictates the spillway capacity to safely pass the routed IDF.

Current standards require that an IDF for LOL of 0.5 or less must have a minimum recurrence interval of 500-years. For LOL greater than 0.5 and less than or equal to 5, the minimum recurrence interval used for calculating the IDF is determined by multiplying the LOL by 1,000. In other words, for a dam with LOL potential of 3, the IDF would have a recurrence interval of 3,000 years. For LOL greater than 5 and less than 1,000, the minimum IDF is based upon the amount of runoff that is predicted to occur from an amount of precipitation calculated using equations that interpolate rainfall depths between the 5,000-year event (LOL = 5) and the probable maximum precipitation (PMP). The full PMP is used to determine the IDF, called the PMF, when the LOL is greater than or equal to 1,000. (2)

Montana-Specific Hydrologic Data

Since the new standards require estimates of runoff for precipitation storms having recurrence intervals up to 5,000 years, it was important to obtain meteorological and hydrological data to match. In anticipation of the new risk-based spillway standards, the Montana Dam Safety Program initiated two studies that provided methods for determining precipitation depths and temporal hyetograph development up to a recurrence interval of 5,000 years. Both studies were conducted by the U.S. Geological Survey (USGS) Water Science Center in Helena, Montana. The first study, completed in 1997, uses precipitation gage data from three meteorologically similar regions in Montana to develop procedures for estimating precipitation depths for 2-, 6- and 24-hour duration storms having recurrence intervals up to 5,000 years (3). The second study, completed in 1998, provides methodologies to construct synthetic rainfall hyetographs using precipitation depths estimated by the 1997 report (4). In the 1998 report, storm temporal characteristics are estimated from Montana precipitation gage data using the same three homogeneous regions as the 1997 study.

A third USGS study provides procedures for estimating unit hydrographs for large runoff events in Montana at ungaged sites (5). Based on Montana stream gage data, this report provides methodologies for estimating unit hydrographs using Clark’s Method and the Soil Conservation Service (SCS) Dimensionless Unit Hydrograph Method.

The three USGS studies described above can be used for spillways whose dams have the potential for LOL equal to or less than five. For LOL greater than 5, spillway IDF will

determined either by runoff produced by the PMP or an interpolated precipitation amount between the 5,000-year depth and the PMP. In Montana, PMP estimates are determined by two National Oceanic and Atmospheric Administration (NOAA) reports: Hydrometeorological Report (HMR) 55a (6) for areas east of the Continental Divide; and HMR 57 (7) for areas west of the Continental Divide.

Armed with these studies, Montana engineers and hydrologists have the ability to reasonably estimate precipitation and runoff events for very large and infrequent storms.

Technical Note 1 – Analysis of Spillway Capacity in Montana

Even with the wealth of information available to conduct hydrologic analyses in Montana, professionals are still faced with the complicated task of piecing together both relatively new spillway hydrologic standards and technical information provided by the USGS and NOAA. The Montana Dam Safety Program provided a spillway adequacy decision tree (8), shown in Figure 1, to help in determining steps needed in conducting a spillway analysis. The procedures shown in Figure 1 reflect the risk-based spillway hydrological standards for Montana. Technical Note 1 (TN1), *Analysis of Spillway Capacity in Montana* (9) was developed to expand the procedures in Figure 1, providing a logical, comprehensive guide for determining spillway capacity for Montana high hazard dams. TN1 incorporates the technical references specific to Montana with guidance on developing a hydrologic model using the computer program HEC-HMS (Hydrological Modeling System) (10) for spillway analysis. TN1 is a guidance document for professionals with at least some knowledge of spillways and hydrological modeling. While other references and procedures are accepted by the Dam Safety Program, TN1 references and procedures are recommended because of their direct applicability to Montana dams and because of the experience gained by the Dam Safety Program in dealing with spillway analyses.

Technical Note 2 – Loss of Life Determination

Since Montana spillway hydrologic standards are risk-based, or dependent on the estimated LOL due to dam failure, it was necessary for the Montana Dam Safety Program to develop more standardized guidance for the determination of LOL. To do this, the Dam Safety Program contracted with Hydrometrics, Inc. to develop Technical Note 2 (TN2), *Loss of Life Determination for Spillway Capacity Analysis* (11). TN2 is currently in draft form and is in the process of Dam Safety Program review. TN2 is intended as a dynamic publication that will be modified as necessary to incorporate the latest and best references for estimating LOL from dam failures. At this time, the Montana Dam Safety Program recommends procedures developed by Graham of the U.S. Bureau of Reclamation (12) for determining LOL from dam failures. Graham studied data from “every U.S. dam failure that resulted in more than 50 fatalities and every dam failure that occurred after 1960 resulting in any fatalities” (ibid). Data was evaluated with regard to warning time, population at risk (PAR) and LOL. Graham concluded LOL from dam failures is greatly influenced by three main factors: the PAR or population occupying the area inundated by a dam failure flood; the warning time given to PAR exposed to the failure flood; and the severity of the flooding. Graham provides procedures and empirical equations to estimate LOL for various combinations of the three factors mentioned previously. In general, LOL is much less than PAR, particularly in low force areas, where flood depth and flow velocity are relatively low, and with sufficient warning time.

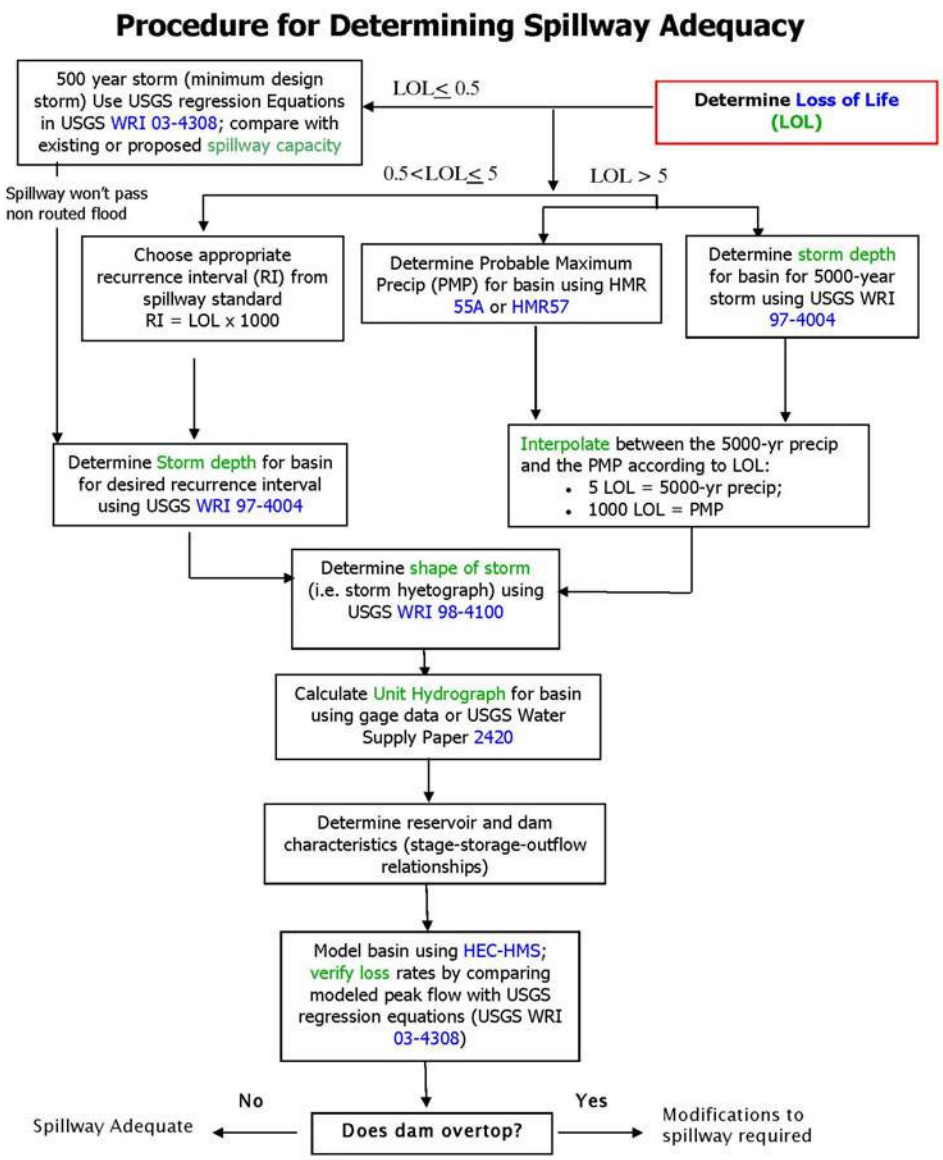


Figure 1. Procedure for Determining Spillway Adequacy for Montana Dams (8).

The Montana spillway hydrologic standards specify that the LOL determination be conducted using a simulated “spillway failure” flood (2). The Montana Dam Safety Program interprets spillway failure as the point where the spillway has exceeded its ability to discharge outflow, i.e. the spillway fails when the reservoir has reached a level at the low point of the dam crest. The modeled failure flood for an LOL determination is a result of a dam breach with the reservoir level at the crest of the dam. The failure flow does not include spillway discharge. PAR within the failure flood boundary is determined by the number of structures, roads, recreational areas and other features where humans could congregate and assigning average numbers for human occupancy. LOL is estimated using the PAR estimates, warning time, and judgment on flood severity. Flood severity according to Graham can be categorized in three levels: low severity occurs when no buildings are washed off their foundations; medium severity occurs when homes are destroyed but trees or mangled homes remain for people to seek refuge in or on; and high severity occurs when the flood sweeps the area clean and nothing remains. Obviously, professional judgment is required in assigning a severity rating. Graham recommends assigning low severity if “most of the structures will be exposed to depths of less than 10 feet and medium severity if most of the structures will be exposed to depths of 10 feet or more” (12). A final factor recommended by Graham in determining LOL is flood severity understanding. Flood severity understanding can fall within one of two categories: vague, where the issuers give the warning prior to dam failure or they are not truly aware of its potential for damage; or precise, where issuers of warnings have either seen the flooding or have relayed accurate information from others who are aware of the flooding. Figure 2 contains Graham’s table for estimating LOL based on the factors described above.

Technical Note 3 – Simplified Breach Analysis

With the need for standardizing guidance for technical evaluations using the risk-based spillway standards in Montana, the Montana Dam Safety Program also realized the need for consistent evacuation mapping and breach modeling. According to an informal survey of emergency and disaster response personnel in Montana, many emergency action plan evacuation maps tend to be confusing, especially during an emergency or emergency simulation. Evacuation maps contain at least two flood inundation boundaries, one for a clear-weather (piping) breach, and another for a storm-induced (overtopping) breach.

While these boundaries differed significantly in some cases, it was left to the emergency responder to decifer the correct boundary on the map to match the type of failure. In true emergencies, time used to read and understand maps could be time better used in issuing warnings and conducting evacuations. Other information often placed on maps, such as peak discharge travel time and flood wave height, was either ignored or misunderstood much of the time.

In an attempt to simplify evacuation maps and the engineering required to develop them, the Dam Safety Program has encouraged simplified evacuation mapping and procedures. To better explain how simplified mapping is accomplished, the Dam Safety program has tasked Hydrometrics, Inc. with developing Technical Note 3 (TN3), *Simplified Evacuation Mapping for Emergency Action Planning*. At this time, a draft version of TN3 has been written (13) and is currently being reviewed by the Dam Safety Program.

Table 7 Recommended Fatality Rates for Estimating Loss of Life Resulting from Dam Failure				
Flood Severity	Warning Time (minutes)	Flood Severity Understanding	Fatality Rate (Fraction of people at risk expected to die)	
			Suggested	Suggested Range
HIGH	no warning	not applicable	0.75	0.30 to 1.00
	15 to 60	vague	Use the values shown above and apply to the number of people who remain in the dam failure floodplain after warnings are issued. No guidance is provided on how many people will remain in the floodplain.	
		precise		
	more than 60	vague		
		precise		
MEDIUM	no warning	not applicable	0.15	0.03 to 0.35
	15 to 60	vague	0.04	0.01 to 0.08
		precise	0.02	0.005 to 0.04
	more than 60	vague	0.03	0.005 to 0.06
		precise	0.01	0.002 to 0.02
LOW	no warning	not applicable	0.01	0.0 to 0.02
	15 to 60	vague	0.007	0.0 to 0.015
		precise	0.002	0.0 to 0.004
	more than 60	vague	0.0003	0.0 to 0.0006
		precise	0.0002	0.0 to 0.0004

Figure 2. From Graham, Table for Estimating Loss of Life Resulting from Dam Failure (12)

TN3 defines the procedures to develop simplified evacuation maps. One breach flood boundary will be placed on the map to avoid confusion by emergency response personnel. The breach model will begin with a breach of the dam with the reservoir level at the low point of the dam crest. Maps will be developed in consultation with local emergency personnel in order to identify affected structures, escape routes and potential areas of backwater where additional boundaries may be added to the breach boundary. The Montana Dam Safety Program recommends breach routing modeled with the computer program HEC-HMS (10) because of its ease of use and adequate accuracy for evacuation map purposes. HEC-HMS uses pseudo-unsteady flow computational methods for flood routing, such as kinematic wave or Muskingum-Cunge, which are simplified but computationally robust. Other computer models may be used that are more sophisticated unsteady flow models, such as HEC-RAS (14) and FLDWAV (15), but to date these models can be difficult to refine in order to maintain computational consistency without program errors. The Dam Safety Program has concluded HEC-HMS provides results well within the accuracy bounds of any breach flood model, especially with the potential for uncertainty of large flood waves that may verge on non-Newtonian flow by carrying large percentages of debris and mud. HEC-HMS also tends to take less time for engineers to develop a breach model as compared to HEC-RAS or FLDWAV, reducing the cost to owners for engineering analysis.

Summary

Since the introduction of risk-based spillway standards for Montana high-hazard dams, the Montana Dam Safety Program has searched for methods to provide guidance for professionals to conduct analyses related to spillway adequacy. In 2008, the Dam Safety Program developed Technical Note 1, *Analysis of Spillway Capacity in Montana*, which is available for use by engineers and professionals, engaged in spillway analyses. Technical Note 2, *Loss of Life Determination for Spillway Capacity Analysis*, is currently in draft form and should be ready for use by professionals by mid-2010. A draft of Technical Note 3, *Simplified Evacuation Mapping for Emergency Action Planning*, has been developed and is in the process of being reviewed by the Dam Safety Program.

References

1. Washington State Dam Safety Office, 2010. Guidance Documents found on the website http://www.ecy.wa.gov/programs/wr/dams/GuidanceDocs.html.
2. Administrative Rules of Montana (ARM), 1999. Chapter 36.14.502, Hydrologic Standard for Emergency and Principal Spillways.
3. U.S. Department of the Interior, U.S. Geological Survey. 1997. Regional Analysis of Annual Precipitation Maxima in Montana, Water-Resources Investigations Report 97-4004.
4. U.S. Department of the Interior, U.S. Geological Survey. 1998. Characteristics of Extreme Storms in Montana and Methods for Constructing Synthetic Storm Hyetographs, Water-Resources Investigations Report 98-4100.
5. U.S. Department of the Interior, U.S. Geological Survey. 1996. Procedures for Estimating Unit Hydrographs for Large Floods at Ungaged Sites in Montana, Water-Supply Paper 2420.

6. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. 1988. Hydrometeorological Report No. 55A, Probable Maximum Precipitation Estimates – United States Between the Continental Divide and the 103rd Meridian. June.
7. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. 1994. Hydrometeorological Report No. 57, Probable Maximum Precipitation – Pacific Northwest States, Columbia River (including portions of Canada), Snake River and Pacific Coastal Drainages. October.
8. Montana Department of Natural Resources and Conservation, 2009. Procedure for Determining Spillway Adequacy. Available at http://www.dnrc.mt.gov/wrd/water_op/dam_safety/technical_ref/procedure_determining_spillway_adequacy.pdf.
9. Hydrometrics, Inc., 2008. Technical Note 1, Analysis of Spillway Capacity in Montana. For the Montana Dam Safety Program, Montana Department of Natural Resources and Conservation. October.
10. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center. 2009. HEC-HMS, Hydrologic Modeling System, Version 3.4. August.
11. Hydrometrics, Inc., 2010. Technical Note 2, Loss of Life Determination for Spillway Capacity Analysis. For the Montana Dam Safety Program, Montana Department of Natural Resources and Conservation. Draft.
12. U.S. Department of the Interior, Bureau of Reclamation. 1999. A Procedure for Estimating Loss of Life Caused by Dam Failure. DSO-99-06. Dam Safety Office. By Wayne J. Graham. September.
13. Hydrometrics, Inc., 2010. Draft Technical Note 3, Simplified Evacuation Mapping for Emergency Action Planning. For the Montana Dam Safety Program, Montana Department of Natural Resources and Conservation. July.
14. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center. 2010. HEC-HMS, Hydrologic Modeling System, Version 4.1. January.
15. U.S. Department of Commerce, National Weather Service, Fread, D. L., Lewis, Janice M. 1988. FLDWAV: A Generalized Flood Routing Model, Proceedings of the National Conference on Hydraulic Engineering and International Symposium on Model - Prototype Correlation of Hydraulic Structures, (DLF Publication #58). August.

36.14.502 HYDROLOGIC STANDARD FOR EMERGENCY AND PRINCIPAL SPILLWAYS

(1) Spillway conveyance for high-hazard dams will be based on estimated loss of life downstream from the dam caused by spillway failure.

(2) The minimum inflow design flood for an estimated loss of life of 0.5 or less shall be the 500-year recurrence interval flood.

(3) The minimum inflow design flood recurrence interval for estimated loss of life greater than 0.5 and less than or equal to 5 shall be determined by multiplying the estimated loss of life by 1,000.

(4) The minimum inflow design flood for estimated loss of life greater than 5 and less than 1,000 shall be determined from the design precipitation derived using the following equations:

$$P_s = P_{5,000}\ (10^{rd}) \text{ where}$$

$$r = -0.304 + .435 \log_{10} (lol)$$

$$d = \log_{10} (PMP) - \log_{10} (P_{5,000})$$

lol = estimated loss of life

PMP = probable maximum precipitation

$P_{5,000}$ = 5,000-year recurrence interval precipitation

P_s = design precipitation to meet spillway standard

(5) The minimum inflow design flood for estimated loss of life greater than or equal to 1,000 shall be the probable maximum flood.

(6) The reservoir and spillway must safely store and pass the runoff resulting from the minimum inflow design flood.

(7) As a minimum, the reservoir will be assumed at normal operation pool before the minimum inflow design flood begins.

(8) The spillway capacity may be smaller if an analysis shows that there is no additional loss of life expected from the dam failure flood than that observed for the minimum inflow design flood.

History: 85-15-110, MCA; IMP, 85-15-210, MCA; NEW, 1988 MAR p. 2489, Eff. 11/24/88; AMD, 1995 MAR p. 541, Eff. 4/14/95; AMD, 1999 MAR p. 2573, Eff. 11/5/99.

Dam Safety Program

Technical Note 1

Analysis of Spillway Capacity in Montana

Prepared for:

Montana Department of Natural Resources and Conservation
Water Resources Division
Water Operations Bureau
Dam Safety Program
PO Box 201601
Helena, MT 59620-1601

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

October 2008

TABLE OF CONTENTS

LIST OF TABLES iv

LIST OF APPENDICES v

1.0 INTRODUCTION 1-1

1.1 PURPOSE 1-2

1.2 FOCUS AND LIMITATIONS 1-2

1.3 TARGET AUDIENCE 1-3

2.0 DESIGN STANDARDS AND PROCEDURES 2-1

2.1 HISTORY OF SPILLWAY STANDARDS 2-1

2.2 DETERMINING REQUIRED INFLOW DESIGN FLOOD 2-3

2.2.1 Estimated Loss of Life Determination 2-3

2.2.2 Inflow Design Flood Determination 2-3

2.2.2.1 Design Storm Frequency or Return Period for LOL ≤ 5 2-4

2.2.2.2 Design Storm Precipitation Interpolation for LOL > 5 2-5

3.0 BASIN CHARACTERISTICS 3-1

3.1 PHYSICAL ATTRIBUTES 3-1

3.1.1 Area 3-1

3.1.2 Subbasins 3-1

3.1.3 Soils 3-1

3.1.3.1 NRCS Web Soil Survey 3-2

3.1.3.2 NRCS Soil Surveys 3-2

3.1.3.3 Other Data Sources 3-2

3.1.4 Land Use and Ground Cover 3-2

3.1.5 Hydrologic Condition and Antecedent Moisture Condition 3-3

3.2 UNIT HYDROGRAPH ESTIMATION 3-3

3.2.1 Hydrograph Analysis 3-4

3.2.2 Synthetic Unit Hydrograph Development 3-4

3.2.2.1 Montana Procedures (USGS WSP 2420) 3-4

3.2.2.2 Other Methods 3-6

3.3 RAINFALL LOSSES 3-7

3.3.1 Initial Abstraction 3-7
3.3.2 Infiltration 3-8
3.3.2.1 NRCS Curve Number 3-9
3.3.2.2 Constant Loss Rate 3-10
3.3.2.3 Other Methods 3-10
3.3.3 Percent Impervious Area 3-11
4.0 CHANNEL ROUTING METHODS 4-1
4.1 BASEFLOW 4-2
4.1.1 Considerations for Snow Melt and Rain-on-Snow 4-2
4.2 HEC-HMS ROUTING METHODS 4-3
4.3 OTHER ROUTING METHODS 4-5
5.0 PRECIPITATION ESTIMATES FOR MONTANA 5-7
5.1 RAINFALL BASED ON OCCURRENCE PROBABILITY 5-7
5.1.1 Storm Depth and Duration Determination (*USGS WRIR 97-4004*) 5-7
5.1.2 Temporal Distribution (*USGS WRIR 98-4100*) 5-8
5.1.3 Areal Distribution 5-8
5.1.4 Areal Reduction Factors 5-9
5.2 PROBABLE MAXIMUM PRECIPITATION (NWS HMR 55A AND 57) 5-9
5.2.1 Storm Duration 5-9
5.2.2 Storm Depth Determination 5-10
5.2.3 Temporal Distribution 5-11
5.2.4 Areal Distribution 5-11
5.2.5 Areal Reduction Factors 5-11
5.3 DESIGN PRECIPITATION DEPTH 5-12
6.0 RESERVOIR AND SPILLWAY CHARACTERISTICS 6-1
6.1 RESERVOIR STAGE-AREA/VOLUME 6-1
6.2 DAM CREST ELEVATION AND WIDTH 6-2
6.3 OUTLET CONDUIT DISCHARGE 6-3
6.3.1 Discharge Estimation 6-3
6.4 SPILLWAY STAGE-DISCHARGE 6-4

7.0 MODELING SURFACE RUNOFF AND FLOOD ROUTING....7-1
7.1 HEC-HMS PROCEDURES....7-1
7.1.1 Basin Model....7-2
7.1.2 Meteorological Model....7-2
7.1.3 Control Specifications....7-2
7.1.4 Time Series Data....7-4
7.1.5 Paired Data....7-5
7.1.6 Grid Data....7-5
7.1.7 Simulation Runs and Results....7-6
7.2 SUGGESTED PHASE APPROACH....7-6
8.0 MODEL VERIFICATION....8-1
8.1 MODEL UNCERTAINTY....8-1
8.2 MODEL CONSERVATISM....8-2
8.3 VERIFICATION METHODS....8-3
8.3.1 Model Parameters....8-4
8.3.2 Gage Data....8-5
8.3.3 USGS Regression Equations (USGS WRIR 03-4308)....8-5
8.4 CONFIDENCE IN VERIFICATION AND MODEL CONSERVATISM....8-6
9.0 REFERENCES....9-1

LIST OF TABLES

TABLE 7-1. BASIN MODEL PARAMETERS FOR HEC-HMS....7-3
TABLE 7-2. METEOROLOGICAL MODEL PARAMETERS FOR HEC-HMS....7-4

LIST OF APPENDICES

APPENDIX A	FLOWCHART PROCEDURE FOR DETERMINING COMPLIANCE WITH MONTANA SPILLWAY DESIGN STANDARDS
APPENDIX B	MINIMUM INFLOW DESIGN FLOOD FOR HIGH HAZARD DAMS
APPENDIX C	NRCS CURVE NUMBER TABLES FROM CHAPTER 9, HYDROLOGIC – SOIL COVER COMPLEXES OF THE NRCS NATIONAL ENGINEERING HANDBOOK, TITLE 210

DAM SAFETY PROGRAM TECHNICAL NOTE 1 (TN1)
ANALYSIS OF SPILLWAY CAPACITY IN MONTANA

Overview

Technical Note 1 (TN1) provides guidance to engineers and professionals engaged in the analysis and design of spillways for Montana high hazard dams. TN1 is intended for analyses related to high hazard dams regulated by the Montana Dam Safety Program, but the guidance provided can be used on other dams. The appropriate guidelines for specific dams are typically determined by the dam's regulating agency. The procedures in TN1 are intended for analyzing spillway capacity using the hydrologic computer model HEC-HMS (Hydrologic Modeling System). TN1 addresses only spillway capacity analysis. It does not provide guidance on armoring or erosion control design, energy dissipation, or maintenance and operation procedures.

TN1 is organized to lead the user through logical steps of spillway capacity analysis. TN1 first provides a clear explanation of spillway hydrologic standards according to Montana Dam Safety rules. Then the user is led through analysis methods to estimate factors that are used to develop a hydrologic model, such as basin characteristics, routing techniques, precipitation estimates, and reservoir and spillway characteristics. Next, TN1 provides information for the user to model precipitation and runoff with HEC-HMS as well as methods to verify the model is providing reasonable results. Finally, the appendices of TN1 provide valuable information such as design standards and flowcharts to properly analyze a spillway, model input factors and an example of a spillway capacity analysis.

TN1 is not a regulatory requirement for spillway analysis. Other methods may be used by engineers and professionals. But the guidance provided in TN1 is accepted by the Montana Dam Safety Program and the methods suggested are common in engineering practice.

We welcome comments on TN1 and contact information is provided in Section 1. We hope you find TN1 helpful and that it will serve as a reasonable approach to spillway capacity analysis.

DAM SAFETY PROGRAM
TECHNICAL NOTE 1
ANALYSIS OF SPILLWAY CAPACITY IN MONTANA

1.0 INTRODUCTION

The **Montana Dam Safety Program** is pleased to provide this **Technical Note 1 (TN1), Analysis of Spillway Capacity in Montana**. We hope this publication is helpful in providing technical guidance to professionals engaged in the analysis and design of spillways for high hazard dams in Montana. Our intent is to make available relevant and up-to-date information, references and procedures, much of which is unique to Montana, which will aid engineers and professionals in conducting spillway analyses.

This is the first Technical Note developed by the Montana Dam Safety Program and, as such, we are interested in making it the best we possibly can. We welcome and encourage your feedback on its contents. Please send your comments to:

Montana Dam Safety Program
Department of Natural Resources and Conservation (DNRC)
PO Box 201601
Helena, MT 59620-1601
mlemieux@mt.gov

The Montana Dam Safety Program operates within the DNRC Water Resources Division's Water Operations Bureau.

DNRC would like to acknowledge Hydrometrics, Inc. of Helena, Montana for the development and preparation of Technical Note 1 and Mr. Rob Kingery of the DNRC State Water Projects Bureau for his review and technical guidance.

TN1 will be revised as updated technical references are made available.

1.1 PURPOSE

The purpose of TN1 is to assist and provide guidance to engineers and professionals engaged in the analysis and design of spillways for Montana high hazard dams. TN1 is not a regulatory document and the references and procedures provided can be modified to suit the needs of the user. TN1 references technical resources that are recognized as applicable to Montana dams and most often used by the Dam Safety Program in analyzing and designing spillways. The Dam Safety Program intends for TN1 to provide a consistent means of conducting spillway analyses, but recognizes that professionals may prefer other technical resources that are not used in TN1.

1.2 FOCUS AND LIMITATIONS

TN1 is intended for use on high hazard dams regulated by the Montana Dam Safety Program. Several of the technical references are specific to Montana hydrology. Guidance for federal dams may come from other sources developed for their appropriate regulations.

TN1 provides a methodology for analyzing spillway capacity using the HEC-HMS (Hydrologic Modeling System) (USACOE, 2008) rainfall-runoff model, for which data collection and input are accomplished manually. Other methods can be used to come to similar results. Where digital data is available, the use of geographical information systems (GIS) is becoming an increasingly popular and useful tool in conducting a multi-element spatial runoff model, and several available software packages and models can be used in this application.

TN1 is applicable to larger, undeveloped drainage areas, usually at least one square mile. Smaller watersheds and urban watersheds can best be modeled using other methods.

TN1 assists in evaluation of spillway capacity, but does not provide guidance on armoring or erosion control design. It also does not address energy dissipation of flows or maintenance and operation procedures.

1.3 TARGET AUDIENCE

TN1 is for use by engineers and professionals experienced in hydrologic analyses and familiar with design and rehabilitation of spillways and dams. Professional judgment is required and expected regardless of guidance provided by TN1. Users of TN1 are expected to be familiar with common hydrologic and hydraulic computer programs and their appropriate use. DNRC and the Dam Safety Program are not responsible for the use and interpretation of TN1 contents.

2.0 DESIGN STANDARDS AND PROCEDURES

Montana Dam Safety Administrative Rules govern the design, operation and maintenance of high hazard dams (dam safety rules are part of the Administrative Rules of Montana (ARM) and can be viewed at h*ttp://dnrc.mt.gov/wrd/water_op/dam_safety/*.)As described in this section, standards for Montana dams came about through a growing awareness of the potential danger of dams and the need for regular maintenance and operation procedures. This awareness started at the federal level and has become the responsibility of state agencies. The Dam Safety Program currently maintains spillway hydrologic standards based on the estimated loss of life downstream of a dam.

2.1 HISTORY OF SPILLWAY STANDARDS

The development of current spillway hydrologic standards began as an organized effort to identify potentially hazardous dams and to implement appropriate design, maintenance and operation procedures to protect downstream citizens. In the United States, the first federally-funded effort to address the safety of dams was initiated in 1972 by the National Dam Inspection Act, Public Law 92-367, which authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-federal dams throughout the United Sates. The Corps of Engineers developed guidelines for safety inspections of dams in 1975. The guidelines recommended a two-phased study for investigating and evaluating dams. Phase 1 inspections of high hazard and other significant dams were conducted in the late 1970s and early 1980s. Results of the Phase 1 inspections were presented to state agencies responsible for dams and reservoirs. States were responsible for implementing Phase I recommendations. Phase II of the study consisted of more detailed investigations and evaluations of dams to better identify specific safety concerns. Except in special cases, the Phase II investigations were the responsibility of states.

In response to the Phase 1 reports for Montana dams, the Montana Legislature passed the Montana Dam Safety Act in 1985. The Act is currently part of the Montana Code Annotated (MCA), Title 85 (Water Use), Chapter 15 (Dam Safety Act). The Act

authorizes the DNRC to administer and implement dam safety rules and regulations. In 1988, DNRC developed the Dam Safety Rules in the Administrative Rules of Montana (ARM) Chapter 36.14.

The original Dam Safety Rules established spillway hydrologic standards for high hazard dams based on reservoir volume and dam height. The minimum inflow design flood for an existing dam impounding less than 100 acre-feet and less than 20 feet in height was the 100-year flood. The inflow design flood increased in magnitude for larger impoundments by fractions of the Probable Maximum Flood (PMF) to a maximum of the full PMF for dams impounding 50,000 acre-feet or greater and with heights of 100 feet or higher.

It became evident that in many cases the required spillway size was disproportionate to the level of downstream development. This was particularly true for large dams located in rural areas or for smaller dams that had dense downstream development. In response, DNRC searched for new hydrologic standards that would provide a uniform level of downstream protection by relating the required spillway size to the consequences of a dam failure, rather than to the size of the dam.

DNRC organized a Montana Spillway Standards Committee to develop risk-based hydrologic standards for spillways of high hazard dams and in 1999 the Committee released *Technical Decisions for Minimum Design Inflow for High Hazard Dams (Appendix B)*. The Committee recommendations were incorporated into the current Dam Safety Rules in 1999. The hydrologic standards generally require spillway capacity for high-hazard dams to be based on an estimate of the number of lives that may be lost downstream from the dam due to a spillway failure, which is called the estimated loss of life or LOL. The minimum inflow design flood, or IDF, is the storm runoff that enters a reservoir impounded by a dam and is routed through the spillway. The magnitude, or relative size, of the IDF is determined by LOL, which in turn dictates the capacity of the spillway. The IDF for an LOL of 0.5 or less must have a minimum recurrence interval of 500-years. For an LOL greater than 0.5 and less than or equal to 5, the minimum

recurrence interval used for calculating the IDF is determined by multiplying the LOL by 1,000. For an LOL greater than 5 and less than 1,000, the minimum IDF is based upon the amount of runoff that is predicted to occur from an amount of precipitation calculated using equations that interpolate rainfall depths between the 5,000-year event and the probable maximum precipitation (PMP). The full PMP is used to determine the IDF, called the probable maximum flood (PMF), when the LOL is greater than or equal to 1,000. Details of calculating IDF magnitudes are given in the following sections.

2.2 DETERMINING REQUIRED INFLOW DESIGN FLOOD

Central to the evaluation of spillways is the determination of LOL and its impact on the determination of IDF and spillway size.

2.2.1 Estimated Loss of Life Determination

One of the most subjective and misunderstood components of dam safety is the determination of LOL from dam failure. Yet this determination is the deciding factor in determining the size of the IDF for spillway design in Montana. Because of the varying approaches to calculating LOL, the Montana Dam Safety Program has provided **Technical Note 2 (TN2), Estimated Loss of Life Determination for Spillway Design**. Procedures from TN2 should be used to estimate LOL from a dam failure prior to continuing with the analysis procedures in this technical note.

2.2.2 Inflow Design Flood Determination

The method of determining the IDF for spillway adequacy depends on whether the LOL is greater, equal to or less than 5. For an LOL less than or equal to 5, the spillway IDF magnitude is calculated as a return interval, or exceedance probability of occurrence. An LOL greater than 5 requires the IDF magnitude to be calculated by equations that interpolate precipitation depths between the 5,000-year recurrence interval and the PMP.

2.2.2.1 Design Storm Frequency or Return Period for LOL ≤ 5

If the estimated LOL is equal to or less than 0.5, the minimum IDF is the 500-year recurrence interval. (Yes, LOL can be a fraction! This is part of the reason for some of the misunderstanding surrounding LOL and the need for using the procedures in TN2.)

If the LOL is greater than 0.5 and less than or equal to 5, the minimum IDF recurrence interval is determined by multiplying the LOL by 1,000.

The general equation for the return interval of the minimum IDF for LOL ≤ 5 is:

Inflow Design Flood (IDF) Return Interval = LOL x 1,000

The IDF is usually determined by applying precipitation that corresponds to the appropriate return interval to a rainfall-runoff model. Methods of determining this precipitation are described in Section 5.0. It is also feasible to determine a hydrograph for the IDF with the required return interval by conducting statistical analyses on stream gage data. However two conditions have to be met: 1) the reservoir must exist on a stream that has a nearby gage with a long-term record; and 2) the gage record must be long enough to statistically estimate peak discharges for the return interval required for dam safety purposes. For dams with LOL less than or equal to 0.5, an inflow hydrograph could be developed for the 500-year flood by first estimating the peak flood discharge using regional regression equations for ungaged basins (USGS, 2003).

Use caution when calculating the IDF based upon runoff from precipitation of a given return interval. The precipitation event with a given return interval rarely produces a flood of the same return interval. Even if two precipitation storms have identical total rainfall depths, they rarely produce equal runoff hydrographs because of differences in the temporal and spatial distribution of precipitation and variability in other basin parameters. Therefore, the user should verify rainfall-runoff model results, to the extent

possible, with established runoff statistical estimates or regional regression equations for equal return interval estimates. Section 8.0 discusses this issue in greater detail.

2.2.2.2 Design Storm Precipitation Interpolation for LOL > 5

If the LOL is greater than 5 and less than 1,000, the precipitation depth for determining the IDF is calculated with equations that effectively interpolate between depths for the 5,000-year storm and the PMP. The equations are found in the Dam Safety Administrative Rules of Montana, but are provided here also:

$$P_S = P_{5,000}\left(10^{rd}\right) \text{ where}$$

$$r = -0.304 + 0.435\log_{10}\left(LOL\right)$$

$$d = \log_{10}\left(PMP\right) - \log_{10}\left(P_{5,000}\right)$$

PMP = probable maximum precipitation depth (inches)

$P_{5,000}$ = 5,000-year return interval precipitation depth (inches)

P_s = design precipitation depth for the spillway standard (inches)

The IDF for an LOL greater than or equal to 1,000 is the probable maximum flood, or PMF. The PMF is runoff produced by the PMP.

3.0 BASIN CHARACTERISTICS

Basin characteristics include all physical features of the rainfall watershed contributing to the reservoir on which the dam and spillway are located. These characteristics affect the volume and timing of the resulting hydrograph from a precipitation event, and must be defined in a rainfall runoff model.

3.1 PHYSICAL ATTRIBUTES

Each drainage basin has unique physical attributes. The following sections provide insight and sources of data for each of the attributes that affect runoff.

3.1.1 Area

The area of the drainage basin is measured along the watershed boundaries or divides. A watershed is the catchment for rainfall from which runoff will flow into the reservoir. For input to HEC-HMS, the area is measured in units of square miles.

3.1.2 Subbasins

If the drainage basin has sub-areas with distinctly different characteristics or which contain separate tributaries leading to a main drainage, it can be divided into subbasins. Each subbasin can be treated as a separate rainfall-runoff unit, but the connection of each subbasin to successive subbasins or routing channels must be done in a proper sequence to model as close as possible the actual runoff flow patterns.

3.1.3 Soils

Accurate identification of soil types in the basin is essential to accurately predicting runoff. In most cases it is impractical to conduct comprehensive physical soil sampling and testing to determine soil types. If soil data are not available, some soil sampling and testing, including infiltration measurements, may be warranted as verification of estimated parameters. Soil data may not be available, especially in mountainous terrain. However, the USDA Forest Service may have unpublished data for some areas of National Forests. We advise you contact the soil scientist for the National Forest where

the drainage basin resides. For much of Montana, including state, federal and private land, there are Soil Surveys produced and published by the USDA Natural Resources Conservation Service (NRCS). The following sections describe some of the sources available for soil data.

3.1.3.1 NRCS Web Soil Survey

The NRCS provides a *Web Soil Survey* site to assist in determining soil properties for a specified "area of interest", which is in this case is a drainage basin or subbasin. The link for accessing the *Web Soil Survey* is http://websoilsurvey.nrcs.usda.gov. This site contains most of the available soil survey information for the state and is a convenient way to determine composite hydrologic soil groups. The site includes most federal land in its inventory.

3.1.3.2 NRCS Soil Surveys

NRCS Soil Surveys are published for most counties in Montana and are available. A listing of soil surveys and their availability is shown on the following web site: http://soils.usda.gov/survey/printed_surveys/state.asp?state=Montana&abbr=MT.

3.1.3.3 Other Data Sources

Soil data can be obtained from a variety of sources. It is up to the user to determine the best available data. Common sources include counties, federal and state land management agencies, colleges and agricultural research centers.

3.1.4 Land Use and Ground Cover

While soil is important in determining infiltration rates and water holding capacity, it is equally important to determine the predominant plant cover and land uses for the subject basin. These factors greatly influence precipitation loss parameters, as in determining an appropriate NRCS curve number (see Section 3.3.2.1). Commonly, thick vegetation and healthy forests create abstractions that either trap rainfall or effectively delay the runoff response, creating runoff hydrographs that have relatively low peak discharges and runoff volumes. Conversely, urbanization and human development produce impervious areas

that prevent or delay infiltration, resulting in more runoff than in a natural setting. The general effect is to produce higher runoff volumes and peak discharges in a basin.

3.1.5 Hydrologic Condition and Antecedent Moisture Condition

Hydrologic condition, according to the NRCS, refers to the factors that affect infiltration and runoff, including density of vegetative areas and surface toughness. Poor hydrologic condition indicates impaired infiltration and increased runoff, while good hydrologic condition is the opposite. Antecedent moisture condition is a measure of the soil moisture just prior to a storm event. Estimating hydrologic condition and antecedent moisture of a drainage basin depends on how much conservatism the user intends for the rainfall-runoff model. Hydrologic condition of a basin can typically be estimated based on the factors listed above. However, soil moisture constantly changes and predicting the water holding capacity of a soil just prior to a given precipitation event is not usually possible. If a basin is relatively dry, and has not experienced rainfall for a period of time, there will typically be a fairly high capacity for infiltration and the ability to retain or retard rainfall for the design storm. High soil moisture or saturated soils may be present if antecedent storms have occurred prior to the design storm. If the basin is already wet and the soil has little additional water holding capacity, more precipitation will become runoff and the resulting hydrograph will be larger than dry antecedent conditions. Hydrologic condition and antecedent moisture condition are typically accounted for in a hydrologic model by infiltration variables, which are discussed in Section 3.3.

3.2 UNIT HYDROGRAPH ESTIMATION

The most common method to define the unique shape and timing of a direct runoff hydrograph for a given drainage basin is to determine its unit hydrograph. As a review, unit hydrograph theory will be briefly described. First introduced by Sherman (1932), the unit hydrograph is defined as a hydrograph of 1 inch of rainfall excess or direct runoff (the portion of rainfall that is available for runoff after losses) for a specified rainfall duration. It is also assumed that the rainfall is distributed uniformly over the entire basin. The unit hydrograph is considered to be a function of basin characteristics. The theory of a unit hydrograph is that runoff is linearly related to rainfall excess. Therefore, direct

runoff from complex storms of any duration with sequential increments varying in depth can be estimated by superimposing and adding unit hydrographs. There are numerous hydrology reference texts available to assist the user with further details on the theory and application of unit hydrographs.

3.2.1 Hydrograph Analysis

For a reservoir on a watershed with streamflow and rainfall gage records, a unit hydrograph can be derived by a trial-and-error procedure that involves analyzing recorded runoff hydrographs and rainfall hyetographs. Users are encouraged to follow standard published methodologies if this situation applies to their project.

3.2.2 Synthetic Unit Hydrograph Development

Most applications in dam safety will involve developing a synthetic unit hydrograph on an ungaged basin. Many methods have been developed for estimating synthetic unit hydrographs, but because of the work accomplished by the USGS specifically for Montana, this technical note will focus on two related methods and include just a brief discussion of other common methods.

3.2.2.1 Montana Procedures (USGS WSP 2420)

USGS published *Water-Supply Paper 2420, Procedures for Estimating Unit Hydrographs for Large Floods at Ungaged Sites in Montana* (1996). This paper presents procedures for determining unit hydrograph parameters for two methods: the Clark unit hydrograph and the dimensionless unit hydrograph. The USGS study was initiated because of the subjectivity in determining unit hydrographs in dam safety applications. The Dam Safety Program recognizes *WSP 2420* as a reliable source for unit hydrograph development for dams in Montana.

WSP 2420 presents procedures derived from Montana streamflow and rainfall records. Unit hydrographs are developed for physiologically similar regions of the state. Examples in *WSP 2420* provide procedures for unit hydrograph development. Unit hydrograph parameters can be easily input into HEC-HMS for rainfall-runoff modeling.

Clark (1945) developed a method to define unit hydrographs using three components: the time of concentration (Tc); a basin storage coefficient (R); and a time-area curve. Using regression analysis of rainfall and runoff gage data, the USGS developed equations to calculate the Tc and R for the Clark unit hydrograph. Although the time-area curve may be developed independently, it is most common to utilize the default time-area curve from Figure 3 of *WSP 2420*.

The dimensionless unit hydrograph is a versatile tool when comparing drainage basins with varying characteristics. In the USGS study, unit hydrographs were made dimensionless by dividing the discharge at each time step by the "standard lag" time, as defined by Snyder (1938). This is the same procedure developed by Cudworth (1989) for the U.S. Bureau of Reclamation.

The tables and equations for using *WSP 2420* dimensionless unit hydrograph methods to calculate unit hydrographs are too extensive for this technical note, however DNRC has available a spreadsheet that will perform the calculations. This spreadsheet is available from the Dam Safety Program.

It is necessary for the user to become familiar with the concepts and procedures presented in *WSP 2420* to properly use the publication for dam safety applications. While the parameters for determining unit hydrographs were developed from Montana hydrological data, there is scatter in the data used to derive the variable regression equations and the user is encouraged to review and understand the reliability of the equations prior to unit hydrograph development. *WSP 2420* fully explains the limitations and design considerations of the study. Several limitations are as follows:

- Unit hydrograph characteristics were generally derived from general (or long duration) rainfall events instead of local (thunderstorm) events. These were some of the largest storms recorded in Montana, so they should represent the "worst-case" conditions.

- Lag time estimates in the report are not valid for use in other dimensionless unit hydrographs, such as those of the U.S. Bureau of Reclamation.
- The unit hydrograph duration needs to be small enough to reasonably estimate the peak discharge. Rules for calculating the unit duration are given in the study.
- The methods are applicable for basins small enough that variations in areal runoff do not affect the hydrograph shape. If the calculated unit duration is greater than 7 hours, the basin may require subdividing with separate unit hydrographs for each subbasin. Likewise, it is recommended that basins over 500 square miles be subdivided for the same reasons.
- Equations for adjusting the peak and shape of dimensionless unit hydrographs are invalid when the desired dimensionless peak discharge is less than 8.0.
- The study estimation methods are valid only within the range of variables used. Figures 15-19 should be reviewed to insure that the basin parameters are within the range of data used in *WSP-2420*.
- The methods are intended for use at ungaged sites where no site-specific information is available.

3.2.2.2 Other Methods

Hydrology texts describe various other methods for determining synthetic unit hydrographs. Here are brief descriptions of several of the most common methods, whose reference citations are included in the text by Viessman and Lewis (2003):

Gamma Distribution – Because the shapes of most hydrographs closely match a two-parameter gamma function, this method can be used to develop synthetic unit hydrographs. The advantage of this method is the volume under the curve can be determined to exactly equal one inch of runoff from a basin, plus it produces a line that is continuous rather than relying on the calculation of only several points to draw a curve.

Snyder's Method – Commonly employed by the US Army Corps of Engineers, this method is used in the USGS dimensionless unit hydrograph procedure to determine

standard lag time. But the full use of the method results in calculations of lag time, time base, unit hydrograph duration, peak discharge, and hydrograph time widths at 50 and 75 percent of peak flow to construct a unit hydrograph. Some coefficients vary according to types and locations of streams and drainage basins.

Espey-Altman Method – For use in primarily urban settings, this method uses a set of regression equations developed from a regional analysis of relatively small watersheds to calculate seven points on a 10-minute unit hydrograph.

NRCS Dimensionless Unit Hydrograph – Using the same general concept as in WSP 2420, the NRCS used the results of an analysis on a large number of natural unit hydrographs to develop dimensionless time and discharge coordinates for a dimensionless unit hydrograph. In order to determine the unit hydrograph coordinates, the method requires calculations of the hydrograph time from the beginning of rainfall to peak discharge and the peak discharge.

3.3 RAINFALL LOSSES

Not all rainfall becomes surface runoff. Understanding how rainfall infiltrates, is intercepted, or is stored in small ground depressions is key to determining the volume and timing of runoff. Reasonably accurate estimates of rainfall losses are difficult to determine and are probably the most subjective parameters in surface hydrology. The following sections provide guidance on some of the methods for determining rainfall losses.

3.3.1 Initial Abstraction

As defined by the NRCS, initial abstraction is the portion of rainfall that is lost before it becomes excess rainfall or surface runoff. Initial abstraction includes interception (rainfall that is held by vegetation or structures before reaching the ground), infiltration (rainfall lost into the soil before becoming saturated and reaching a point where rainfall intensity is greater than the soil infiltration rate), and depression storage (surface storage

areas that do not release trapped water during the rainfall event). Initial abstraction can be estimated by several different methods.

The most common equation for determining initial abstraction is empirical and used in conjunction with the NRCS curve number method (2007) (see Section 3.3.2.1of this technical note), which is

$I_a = 0.2S$ where I_a = initial abstraction, inches

S = potential maximum retention after runoff begins, inches = 1000/CN -10

CN = soil complex curve number

HEC-HMS offers many different methods of determining rainfall loss and initial abstractions are generally included with each method. Note that when using the NRCS curve number method (see section 3.3.2.1), if an initial abstraction of zero is entered, HEC-HMS automatically calculates an initial abstraction based on the curve number. The user is encouraged to estimate initial abstraction with whatever method is familiar, but to justify the parameters chosen.

Initial infiltration loss is included with methods on infiltration (Section 3.3.2). Other resources are available for estimating interception, such as Horton (1919) and Woodall (1984). Depression storage can be estimated from other sources as well, including Chin (2006).

Initial abstraction can be a useful tool in calibrating a surface runoff model such as HEC-HMS. Please refer to Section 8.0 of this technical note for a discussion on model verification.

3.3.2 Infiltration

Infiltration in this application refers to rainfall lost to the soil after initial abstraction, once surface runoff has started. Infiltration rates vary with soil texture. In general terms,

infiltration rates in coarse grained or sandy soils are much higher than fine grained or clayey soils. Infiltration rates for a given soil are not linear over time when water is continuously ponded at the surface. Given enough time with water ponded over the soil column, infiltration will approach a steady, constant rate. Infiltration rates can be estimated by several different methods, briefly described below:

3.3.2.1 NRCS Curve Number

The USDA Natural Resources Conservation Service (NRCS) developed the curve number model through empirical research on a broad range of soil types and cover combinations. It is probably the most popular method of determining excess rainfall, or direct surface runoff, because of its ease of application and extensive database of parameters. The curve number model divides rainfall into three components: rainfall excess (runoff), initial abstraction, and retention. Through a series of computational relationships between all three components, the NRCS developed hydrologic soil-cover complexes. Each complex was assigned a curve number, or CN, which indicates the runoff potential of a complex during periods when the soil is not frozen. High curve numbers indicate high potential for runoff. The highest possible CN is 100, which means that all rainfall becomes runoff and there are no abstractions.

In order to use the CN method, the user has to know the soil and cover types for the basin being considered. The user also has to determine the hydrologic condition of the cover vegetation (whether it is thick or sparse), and assume an antecedent soil moisture condition. Appendix C of this technical note contains tables for estimating CN for a basin.

While this method is empirically-based and has been shown to be less accurate than some physically-based infiltration models, it is one of the most widely used methods. It provides a relatively easy method to estimate rainfall losses, especially over large basins, and it is backed by the NRCS, who use this method extensively. To the extent possible, the user should verify the results of a rainfall-runoff model based on the CN method with

an independent analysis of peak discharge values and adjust CN values appropriately, as described in Section 8.0 of this technical note.

Note that curve numbers can give a quick estimate of direct runoff volume from a basin using the following NRCS equation:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

Where Q = direct runoff in inches (which can be converted to volume by multiplying by the basin area)

P = total precipitation in inches

S = potential maximum retention of precipitation = (1000 – CN)/10

CN = curve number

3.3.2.2 Constant Loss Rate

The constant loss rate for infiltration is used when the assumption is that the soil is saturated and infiltration has reached a minimum, steady value. Use of this method also indicates that initial infiltration abstractions are zero. Various tables are available with estimated constant loss rate values for different soil types. The Technical Reference Manual for HEC-HMS has such a table with ranges of constant loss values for soil types used for CN estimations.

3.3.2.3 Other Methods

Other infiltration models are appropriate and, when properly used, provide very accurate estimates of rainfall infiltration. There are general input parameters available for these methods, but most require actual infiltration data to be effective. Data collection may be cumbersome in most applications, but these methods can precisely predict infiltration if data are available. References for the following infiltration models are included in the HEC-HMS Technical Reference Manual.

Horton Model – Derived empirically but based on physical relationships, the Horton Model is an exponential relationship that defines infiltration rate over time assuming water is continuously ponded over the soil. Infiltration declines exponentially until it asymptotically approaches a minimum constant rate.

Green-Ampt Model – Also called the delta function model, it was derived as both a physical and empirical model that assumes water is constantly ponded on the soil surface and that as the water moves downward in the soil, there is a sharp interface where wet soil meets dry soil. Infiltration is affected by soil hydraulic conductivity, wetting front suction head and porosity.

3.3.3 Percent Impervious Area

If a basin contains areas that prevent infiltration, such as frozen ground, open water bodies, pavement, rock, etc., these surfaces are accounted for in the model as "percent impervious area". This factor is used in conjunction with CN or other loss methods to estimate runoff in a storm event. Greater percentages of impervious areas produce higher runoff volumes. Therefore, if the user desires conservative (high) runoff values, then high percent impervious values are used. Percent imperious area can also be used as a calibration parameter when verifying model results.

4.0 CHANNEL ROUTING METHODS

If there is a component to the hydrologic model that requires flow of runoff in an established channel, such as a stream, river, or prismatic channel, the model will need a method specified to route the hydrograph. Channel routing is a means of transporting flow in a channel and adjacent floodplain overbanks. Routing starts with a runoff hydrograph determined from overland flow of excess rainfall, or direct surface runoff, from a subbasin. The upstream hydrograph is routed down the channel by a specified method to a known downstream point, resulting in a downstream hydrograph. Travel time through the specified reach is an indication of the hydrograph translation. Attenuation of the hydrograph (reduction of peak discharge and flattening of the hydrograph curve) occurs because of energy loss and storage as it travels downstream.

As described in Section 4.2, there are several models available for computing a downstream hydrograph using a program such as HEC-HMS. Each of these models solves, in various degrees of simplification, the fundamental equations of open channel flow: the continuity and momentum equations. Combined, the two equations are known as the St. Venant, or unsteady (dynamic wave), equations. HEC-HMS methods are simplified to the point of approximating unsteady flow using simplified approximations. These approximations typically combine the continuity equation with a simplified momentum equation that includes only relevant and significant terms. The justification for not using the solution of the full unsteady equations in HEC-HMS is that approximations of the full equations are adequate for typical flood routing needs and the approximations provide faster and more stable computational processes.

It may be necessary for some problems to use the full unsteady equations. Section 4.3 provides a brief summary of some of the models available for this application.

4.1 BASEFLOW

A runoff hydrograph is generally separated into two types of flow: direct runoff from excess precipitation and baseflow. Baseflow is usually the "normal" flow of a water course, consisting of runoff from prior precipitation or groundwater inflow that was stored temporarily in the watershed. Baseflow can also be the delayed subsurface runoff from the current storm. Some modelers try to account for the contribution of snow melt by approximating it as baseflow.

Some models of watersheds use extensive computations to account for baseflow storage and subsurface flow. This approach is appropriate for long-term watershed modeling and hydrologic budgeting. However the impact of baseflow on a short-term flood event, such as for dam safety applications, may be not as significant. HEC-HMS uses three methods for estimating baseflow, each with simplified approximations that are more appropriate for storm runoff applications:

- Constant, monthly-varying value
- Exponential recession model
- Linear-reservoir volume accounting model

Selection of the appropriate method is left to the user.

4.1.1 Considerations for Snow Melt and Rain-on-Snow

While most extreme runoff events are triggered by and modeled for only rainfall, there is the potential for significant runoff caused by snowmelt in Montana. Spring and early summer storms may occur on snowpack, creating rain-on-snow events that have the potential to be severe. Mostly notably, the June 1964 storm along the northern Rocky Mountain front that caused nearly 20 fatalities and several dam failures was a rain-on-snow event. Given the right meteorological conditions, high elevation watersheds have the potential for significant runoff from only snowmelt.

However, effective and accurate modeling of snowmelt is difficult and tends to be very data intensive. HEC-HMS offers two methods for predicting snowmelt: the gridded temperature index and the temperature index. Both methods use atmospheric conditions to determine snow accumulation and snowmelt rates. Runoff is the result of availability of liquid water at the soil surface.

Snow's contribution in hydrologic modeling can be simplified to at least estimate that portion of runoff resulting from snowmelt. If some data are available to determine reasonable estimates of runoff by snowmelt, they can be used to enhance the rainfall runoff. A typical method is to account for the snowmelt by increasing base flow by an average snowmelt discharge. Total discharge would combine the rainfall runoff and the enhanced base flow.

The NRCS maintains SNOTEL sites, which are remote, high mountain snow data collection locations, for providing snowpack runoff data that is transmitted telemetrically. SNOTEL stands for SNOwpack TELemetry. In addition to providing data that may be used to determine average or typical rates snowmelt runoff for a basin, SNOTEL sites may provide data that can be used to confirm that a spillway is sized adequately to handle the largest snowmelt event of record in addition to the spillway design inflow. For some small, high mountain dams, this maximum snowmelt rate may be larger than the spillway design inflow calculated from precipitation events.

4.2 HEC-HMS ROUTING METHODS

As mentioned previously, HEC-HMS offers routing methods that provide approximations of full unsteady flow equations. Methods should be selected based on specific uses and conditions of the routing channel and parameters of the project, and familiarity of the user with a specific method. The following are brief descriptions of the methods offered in Version 3.2 of HEC-HMS and, for some of the following methods, their applicability for routing hydrographs along channels:

Kinematic Wave Routing – This process ignores the inertial and pressure forces of the full unsteady flow equations. It is better suited for relatively steep streams and channels

that can be approximated by regular shapes and slopes, such as man-made channels. Five options are provided for determining the channel cross sectional shape: circle (for open channel flow in circular channels – not for pressure flow in a pipe), deep (for shapes where depth is approximately equal to width), rectangle, trapezoid, and triangle.

Lag Routing – This method is used only for the translation of a flood wave, or hydrograph. It does not account for attenuation or diffusion of the flood wave. It can be effectively used in short stream segments where travel time and flow depth are known and do not vary. The only input parameter for lag routing is lag time, which is the travel time for the hydrograph to move from the upstream end to the downstream end of the stream segment. It is best suited to short stream segments with a predicable travel time that doesn't vary with flow depth. This method may be overly conservative, as some attenuation always occurs.

Modified Puls Routing – Also called storage or level pool routing, this method uses a relationship between water storage in a stream reach and discharge from the reach to route flow. It is through calculated storage and delayed release of retained water that attenuation is determined. It can be used to calculate backwater from channel constrictions, as long as the backwater is contained in the stream reach. The process requires input of a storage-discharge function for each reach. This can be obtained from hydrograph analysis or by conducting a HEC-RAS analysis of the reach to determine a storage-discharge relationship. The user also determines an initial flow condition by one of three options: initial discharge; outflow equals inflow; and an elevation-discharge relationship.

Muskingum Routing – Using a basic conservation of mass computation, this method determines a water surface that is linear but is not level. By this approximation, Muskingum routing accounts for increased water storage in the rising limb of the hydrograph and decreased storage in the falling limb. By adding a travel time component, K, and an X variable that expresses the weighting between inflow and outflow in the specified reach, this method approximates hydrograph attenuation.

Muskingum-Cunge Routing – This method combines the conservation of mass and an approximation of diffusion in the conservation of momentum equation. Sometimes referred to as the variable coefficient method, it recalculates parameters at each time step with new depth and channel properties. It is sometimes referred to as a variable coefficient method because the routing parameters are recalculated every time step based on channel properties and the flow depth. It represents attenuation of flood waves and can be used in reaches with a mild slope. The user has a choice of five types of cross sections to enter into the routing procedure: rectangular, trapezoidal, triangular, circular or an eight-point section. The eight-point section makes this method useful for natural channels and is based on an average stream and floodplain cross section for the selected reach. Reaches should be determined on the basis of each having similar cross sectional properties. Manning's 'n' values for channel and left and right overbanks are to be input by the user. Manning's 'n' values should be average numbers for each reach. Note that when using HEC-HMS it often is necessary to include a baseflow when using the Muskingum-Cunge method, in order for the computations to work.

Straddle Stagger Routing – This method uses empirical representations of translation and attenuation to route flow through a specified reach. Two parameters are entered into the model: lag and duration. Lag is the approximate travel time of the hydrograph through the reach; duration defines the amount of spread in the hydrograph peak, or the amount of attenuation.

4.3 OTHER ROUTING METHODS

For more precise estimation of hydrograph routing in a channel reach, it is recommended that a hydraulic model be used to incorporate the full solution of St. Venant's equations. At this time, the most widely used and accessible computer program for accomplishing this is HEC-RAS (River Analysis System, USACOE, 2008). The advantage of unsteady flow estimation in HEC-RAS is that the physically-based equations more accurately represent floodplain storage and energy dissipation while a flood wave travels in a natural channel and floodplain corridor, as well as defining backwater profiles at channel

constrictions. At this time, HEC-RAS computational modeling of unsteady flow tends to be somewhat unstable in cases of rapidly varied flow, such as a flood wave, and the user is required to make model adjustments based on professional judgment to overcome the program instability.

The National Weather Service (NWS) developed two computational models to help forecast hydrograph routing in rivers. The first, DWOPER (Dynamic Wave Operation Model) (1984), was intended as a tool to model unsteady flow in major rivers where mild bottom slopes and backwater created problems in hydrologic routing models. The second is DAMBRK (Dam Break Model) (1988), used primarily to predict flood wave routing specifically for dam failures. Each model has limitations unique to their intended function. The NWS sought to combine features of each into one model, called FLDWAV (Generalized Flood Wave Routing Model) (1998), but at this time, access to the program is limited and utilization is primarily for NWS projects.

The United States Geological Survey (USGS) has available for public use a program titled Full Equations Model (FEQ) (1996), which is a computer model for simulation of one-dimensional unsteady flow in open channels and through control structures. According to the USGS, FEQ can be applied to simulate a wide range of stream configurations including loops and lateral-inflow conditions.

All of the programs mentioned above are one-dimensional unsteady flow models. Applications of flood flow simulation in wide, flat floodplains where flow occurs in two directions may require the use of two-dimensional models such as FLO-2D® (FLO-2D, 2007) or MIKE FLOOD® (DHI, 2008). Both models are approved by the Federal Emergency Management Agency (FEMA) for floodplain modeling and use dynamic computations for complex flow interaction. Use of these models requires a technical understanding of the two-dimensional flow regime.

5.0 PRECIPITATION ESTIMATES FOR MONTANA

For use in rainfall-runoff modeling, precipitation is the catalyst for runoff. While basin characteristics have a significant effect on the timing and volume of runoff, precipitation plays a more important role, especially with very large storms that easily saturate soil and fill small depression storage areas. Four components of precipitation need to be determined in order to fully define how runoff will occur: depth, duration, temporal distribution and spatial distribution. Depth and duration are linked by the premise that severe storms of short duration typically have higher rainfall intensities than longer duration storms. Publications specific to Montana have been developed by both the USGS and NWS to assist in precipitation estimates.

In response to the effort by DNRC to base spillway IDF on LOL from dam failure, and move away from standards based solely on reservoir size, the USGS developed methods for determining storm depth and temporal distribution up to a return interval of 5,000 years for the state of Montana. For larger storms, rainfall depths are interpolated between the 5,000-year storm and the probable maximum flood (PMF). As described earlier in this technical note, a PMF is produced by PMP estimates, which in turn are computed by methods developed by the NWS.

5.1 RAINFALL BASED ON OCCURRENCE PROBABILITY

For dams having LOL less than or equal to 5 (determined from a dam breach evaluation), and subsequently a storm return interval of between 500 and 5,000 years, the rainfall storm depth is calculated using methods developed by the U.S. Geological Survey (USGS) for extreme precipitation events. The following sections provide guidance on use of the appropriate references.

5.1.1 Storm Depth and Duration Determination (*USGS WRIR 97-4004*)

The USGS published *Water-Resources Investigations Report (WRIR) 97-4004, Regional Analysis of Annual Precipitation Maxima in Montana* (1997). This document provides methods for determining precipitation depths in Montana for extreme storms having

exceedance probabilities up to one-in-five thousand, or return intervals to 5,000 years. The study utilized statistical procedures that effectively combine record lengths of multiple rainfall gages to make depth estimates for relatively long return intervals. Dimensionless frequency curves for three homogeneous regions within Montana were developed based on physiography and climate. Precipitation depths can be computed for storm durations of 2-, 6-, and 24-hours. Mean storm depth regression equations use site mean annual precipitation, latitude and longitude as variables. The user is encouraged to follow the publication examples in *WRIR 97-4004* to determine storm depths for various applications.

5.1.2 Temporal Distribution (*USGS WRIR 98-4100*)

Following *WRIR 97-4004*, the USGS published *Water Resources Investigations Report 98-4100, Characteristics of Extreme Storms in Montana and Methods for Constructing Synthetic Storm Hyetographs* (1998), which identifies temporal distributions of incremental storm depths for 2-, 6-, and 24-hour duration storms, and their application to analyses or design. The study uses the same homogeneous regions as *WRIR 97-4004*. Starting with total storm depths determined from *WRIR 97-4004*, incremental depths are calculated and distributed to construct hyetographs according to regional statistical analyses. Peak incremental depths are temporally distributed based on historical occurrences within a specified region and the level of conservatism desired. *WRIR 98-4100* offers examples of hyetograph construction for various applications in the homogeneous regions of the state.

5.1.3 Areal Distribution

Specific spatial, or areal, distribution recommendations are not given in *WRIR 97-4004* or *WRIR 98-4100*. Spatial distribution is left to the user. It is possible to use the areal distribution procedures for some PMP estimates, discussed in Section 5.2.4. Section 5.2.4 also provides a brief discussion on the use of areal distribution within a drainage basin.

5.1.4 Areal Reduction Factors

WRIR 98-4100 provides depth-area reduction curves that are adapted from NOAA Atlas-2 (1973). These curves should be utilized to compute a basin-wide areal reduction factor for rainfall depth values derived from *WRIR 97-4004*.

5.2 PROBABLE MAXIMUM PRECIPITATION (NWS HMR 55A AND 57)

The National Oceanic and Atmospheric Administration (NOAA) conducted a nation-wide study of precipitation events mainly to address the need to develop data in support of the growing concern over dam safety issues in the late 1970's. Because of the potentially catastrophic results of dam failures, NOAA developed methods to estimate rainfall events that potentially create the most severe precipitation possible, given optimum meteorological conditions. These storms are defined as probable maximum precipitation, or PMP, events. NOAA conducted PMP studies for specific regions throughout the United States. The PMP studies are called Hydrometeorological Reports, or HMR's. Two HMR's cover the state of Montana: HMR No. 55A (1988), which was developed for the area of the United States between the Continental Divide and the 103rd Meridian (the longitudinal line just east of the Montana-North Dakota border); and HMR No. 57 (1994), which is for the Pacific Northwest States of Idaho, Oregon, Montana and Washington between the Continental Divide and the Cascade Mountains.

5.2.1 Storm Duration

PMP estimates were developed for both short duration ("local") and long duration ("general") events. General storms are defined as a major synoptic weather features that are longer than 6 hours duration and can cover large drainage areas. Local storms are generally shorter than 6 hours in duration (often only 1 or 2 hours long), are separate from general storm patterns, and are confined to smaller drainage areas. Local storms are often related to thunderstorm events.

HMR procedures typically apply to general storms having durations between 1 and 72 hours over areas between 10 and 10,000 square miles, and local storms having durations between ¼ and 6 hours over areas between 1 and 500 square miles. NOAA recommends

that for drainage areas less than 500 square miles, both the general and local storms should be considered.

The goal of estimating IDF for dams is to determine the worst case, or most conservative, scenario if options are available for a given storm event. In general, local storms will produce higher peak discharges and less runoff volume than general storms. Therefore, professional judgment may be needed to determine if a local storm or a general storm will produce the largest routed flood for spillway capacity analysis. Many times both storms need to be routed to determine which is the most severe. Often, spillways for reservoirs on small drainages will experience higher outflows from local storms than from general storms. The opposite is often the case with spillways on reservoirs with large upstream drainage areas. There are exceptions, however, and the user is cautioned to explore all plausible cases because other factors play a role in determining the worst-case scenario for spillway analysis, such as reservoir volume, dam height and drainage basin characteristics

5.2.2 Storm Depth Determination

Each HMR contains step procedures and examples for determining total and incremental depths for a specified storm. Time increments are determined by total storm duration, with shorter increments associated with shorter durations. There are some steps that require user decisions, such as the use of all-season or seasonal PMP estimates, depending on the application. The user is responsible for understanding the appropriateness of such factors.

Other factors in the step procedures will affect the calculated storm depth, such as areal reduction factors that are used to account for spatial variability of storms over larger drainage areas.

5.2.3 Temporal Distribution

HMR publications provide guidance on determining the sequential order of PMP increments. The sequence combinations provided are options for the user to determine the critical distribution for a specific drainage.

Another option is to use the temporal distributions found in *WRIR 98-4100* (described in Section 5.1.2 of this technical note), which are specific to Montana regional extreme storms. Options for determining sequences that fit with the intended purpose of the storm synthesis can allow the user flexibility in computing conservative hyetographs for dam safety purposes.

5.2.4 Areal Distribution

Procedures for areal distribution of the PMP over a basin are only provided for western Montana in HMR No. 57 for local, short-duration storms. If this method is used, the user can then eliminate rainfall adjustments for duration and basin area.

No other specific areal distribution procedures are given in HMR publications for Montana.

Use of areal distributions in a hydrologic model such as HEC-HMS requires special considerations on how the model is set up and developed. For synthetically produced precipitation, the HEC-HMS model distributes rainfall uniformly over the area of an identified subbasin. Areally distributed rainfall can be simulated by use of gage weights, gridded precipitation data or treatment of rainfall on specifically delineated subbasins within the entire drainage area.

5.2.5 Areal Reduction Factors

Both HMR 55A and HMR 57 provide depth area reduction curves which should be utilized to adjust PMP depths based upon total basin area.

5.3 DESIGN PRECIPITATION DEPTH

In Section 2.2 of this Technical Note, descriptions were given of how to compute an IDF for spillway capacity analysis. In general, the size of the IDF is dependent on the LOL downstream of the dam. For LOL less than and equal to 5, the IDF is computed by precipitation based on occurrence probability. For LOL equal to or greater than 1000, the IDF is computed by precipitation based on full PMP estimates. However, it is the case where LOL is between 5 and 1000 that computation of precipitation for the IDF becomes more complicated. The equation for calculating these precipitation depths are given in Section 2.2.2.2.

Provided in this section are three suggested methods for calculating precipitation depths for LOL between 5 and 1000: 1) The Non Areal Reduced Approximate Method, 2) The Areal Reduced Approximate Method and 3) The Incremental Precipitation method.

The Non Areal Reduced Approximate Method for calculating precipitation depths for LOL between 5 and 1000 is as follows:

1. Through previous analyses, determine the storm duration that produces the most severe routed spillway flow from an IDF. If this has not been done, then the steps that follow should be repeated, once for a short duration storm (usually no greater than 6 hours) and again for a long duration storm (usually 24 hours or longer).
2. At the selected storm duration, determine total precipitation depths for two events:
    a. A 5,000-year event using the references and procedures given in Section 5.1 of this Technical Note, without including the aerial reduction factor.
    b. A full PMP event using the references and procedures given in Section 5.2 of this Technical Note, without including the areal reduction factor.
3. Use the equation for Section 2.2.2.2 to compute an interpolated depth. Note that the areal reduction factors in WRIR 97-4004 differ from those utilized for development of the PMP. Leaving the areal reduction factors out of the 5,000

year and PMP precipitation values, avoids combining apples and oranges, so to speak. Note that the interpolated depth is not areally reduced.

4. Use procedures in WRIR 98-4100 (Section 5.2 of this Technical Note) to distribute the interpolated precipitation depth temporally. An areal reduction factor is applied at this time.

The Areal Reduced Approximate Method for calculating precipitation depths for LOL between 5 and 1000 is as follows:

1. Through previous analyses, determine the storm duration that produces the most severe routed spillway flow from an IDF. If this has not been done, then the steps that follow should be repeated, once for a short duration storm (usually no greater than 6 hours) and again for a long duration storm (usually 24 hours or longer).
2. At the selected storm duration, determine total precipitation depths for two events:
    a. A 5,000-year event using the references and procedures given in Section 5.1 of this Technical Note, including the aerial reduction factor.
    b. A full PMP event using the references and procedures given in Section 5.2 of this Technical Note, including the aerial reduction factor.
3. Use the equation for Section 2.2.2.2 to compute an interpolated depth. Since both the 5000 year storm and the PMP are aerial reduced, the interpolated depth is considered to be areally reduced.
4. Use procedures in WRIR 98-4100 (Section 5.2 of this Technical Note) to distribute the interpolated precipitation depth temporally. Since the precipitation is already areal reduced, the areal reduction factor is neglected (assigned a value of 1).

The Incremental Precipitation Method for calculating precipitation depths for LOL between 5 and 1000 is more technically accurate, but significantly more complicated than either Approximate Method. The procedure is as follows:

1. Develop areally reduced depth-duration curves for both the 5,000 year event and the PMP following the procedures given in WRIR 97-4004 and the appropriate HMR, respectively. Note that the areal reduction factors in WRIR 97-4004 differ from those utilized for development of the PMP. The reduction factors will also differ for each incremental duration.
2. Use the equation from Section 2.2.2.2 to compute an interpolated cumulative depth for each duration in the two depth-duration curves. The resulting interpolated depth-duration curve will be the design depth-duration curve.
3. Use procedures in *WRIR 98-4100* to develop a temporal distribution of incremental precipitation depths from the design depth-duration curve.

6.0 RESERVOIR AND SPILLWAY CHARACTERISTICS

Characteristics of the reservoir and spillway are important to identify the reservoir storage volume and spillway outflow characteristics for routing the IDF. Unless the reservoir has a relatively small volume in relation to the upstream drainage area, the reservoir pool is typically effective, at least to a certain degree, attenuating the peak discharge of the inflow design hydrograph. The extent of attenuation is also dependent on the required spillway IDF magnitude.

The term "spillway" in this section refers to a reservoir's principal and auxiliary spillways which are designed to safely convey flood waters past the dam. The capacity of the low-level outlet should typically be ignored in the flood-routing analysis since it is typically much smaller than the spillway capacity. Additionally, flood events often occur unexpectedly and may impair access to the dam, thus making it difficult to operate the gates. There are cases, however, where analysis of the outlet capacity is necessary and methods to assist in determining its stage-discharge relationship are given below.

6.1 RESERVOIR STAGE-AREA/VOLUME

One of the most difficult data features to obtain, the reservoir volume is often approximated unless a recent detailed bathymetric survey has been completed. Often the only reservoir volume information is from original design data, which may be outdated because of sedimentation in the reservoir. However, original design data may be the only reasonable information available. The user may need to exercise judgment or use other available data to determine actual reservoir volume.

As an alternative to existing volume data, there are two relatively easy methods to approximate reservoir volume. The first is to estimate volume using the simplified equation found in ARM 36.14.102, which is

Reservoir volume = 0.4 times the vertical height in feet from the downstream toe of the dam to the crest of the dam times the water surface area at that level in acres.

The above equation more closely approximates volume if the reservoir is fairly circular in surface area.

Another relatively simple method for reservoirs in natural basins is to approximate volume by interpolating an elevation-area relationship of the basin above the normal storage level for the reservoir. This can usually be accomplished with USGS 7.5 minute quadrangle topographic maps. The method involves the following steps:

1. Determine the area for several elevation contours above the normal water level of the reservoir. Assume the dam's location does not change.
2. Plot the contour elevations versus area on graph paper or using a spreadsheet graphing feature.
3. Also plot the elevation of the reservoir outlet, or known low point of the reservoir, at the zero area point.
4. Interpolate the line through the elevation zone of the reservoir, from the normal water surface elevation to zero, using the same shaped curve as for the plotted points, or by using a fitted-curve function of a spreadsheet.
5. Use the interpolated points to calculate volume by the elevation-area method.

6.2 DAM CREST ELEVATION AND WIDTH

The elevation of the low point on the dam crest and the width of the crest can be measured easily in the field, if the information is not already published. It is important to obtain the low-point elevation of the crest to understand when overtopping might occur. The crest width can be used to estimate flow over the dam if overtopping occurs during model routing. Overtopping flow can be approximated by appropriate broad-crested weir equations.

6.3 OUTLET CONDUIT DISCHARGE

For a conservative method of determining the spillway capacity, ignore the low-level outlet flow contribution during flood routing. For most small to medium sized earthen dams, the outlet capacity is much smaller than the spillway capacity, and it is reasonable to ignore outlet flow contribution. This is particularly true since it should not be assumed that the dam operators will be able to access the dam in a timely fashion during an extreme flood event.

6.3.1 Discharge Estimation

Three HEC-HMS methods can be used to estimate elevation-discharge relationships for the outlet if it is used in flood routing. The first method is to choose the 'Outflow Curve' option and calculate the elevation-discharge curve using established hydraulic equations. In HEC-HMS, the outflow curve can be entered as a paired data function. Calculated flow through a gated outlet with a pipe culvert should include the following:

- Discharges at several reservoir levels, accounting for the hydrostatic head above the outlet pipe
- Entrance and exit head losses and any head loss through gates
- Friction loss in the outlet pipe, accounting for pipe length, material on the inside of the pipe, the pipe's age and its condition
- Tailwater levels in the downstream outlet channel for the range of possible discharges

The second method available in HEC-HMS is to choose the 'Outflow Structures' option, which allows the model to compute outlet flow given a standard set of parameters. There are two methods available: orifice and culvert outlets. The orifice method applies to outlets without a culvert pipe, while the culvert method is used for low-level outlets where friction head loss would affect the outflow characteristics. The outflow structures option also computes emergency spillway flow, which is discussed in Section 6.4.

The third method is identified as 'Specified Release' in HEC-HMS. This option is used if actual outflow data has been measured and the gage information is used instead of an outflow curve. The measured flow is entered as a time-series gage and should represent actual measured outflows for time periods in the past and estimated outflows for any time periods in the future.

6.4 SPILLWAY STAGE-DISCHARGE

In most cases, the spillway is used only during runoff events. Also, spillways are typically open channels with relatively prismatic cross sections, or weir structures that have various crest configurations (such as broad-crested or ogee).

As discussed in Section 6.3 for outlets, HEC-HMS offers three ways to defined emergency spillway outflow characteristics: outflow curve; outflow structures; or specified release.

An 'Outflow Curve' is determined by independent calculation of spillway discharge for a range of reservoir elevations. Commonly, this is accomplished by use of a surface water profile model, such as HEC-RAS. Other methods to calculate the open-channel flow is by manual calculations using Manning's equation or by programmed software, such as FlowMaster® (Bentley, 2005), which can estimate flow in prismatic channels. The elevation-discharge or storage-discharge relationship is entered as a paired-data file.

The 'Outflow Structures' option has three methods available for calculating spillway discharges: broad-crested spillway; ogee spillway; or a specified spillway. Broad-crested and ogee methods will prompt the user to input parameters that define the chosen spillway. The specified spillway method is the same as entering an outflow curve, as described in the above paragraph, as a paired-data file.

'Specified Release' is essentially the same as described for principal spillway outlets in Section 6.3, except that flow data is measured for the emergency spillway. The measured data is entered as a time-series gage in HEC-HMS.

7.0 MODELING SURFACE RUNOFF AND FLOOD ROUTING

As indicated previously in this technical note, the most common runoff and flood routing model currently in use is HEC-HMS. While some of its limitations have been pointed out, HEC-HMS is relatively user-friendly and provides reliable results. The model is versatile in being able to route floods through reservoirs and spillways. It is a useful tool for dam safety evaluations to effectively determine spillway adequacy.

HEC-HMS is made available to the public at no cost. However, the Corps of Engineers does not provided technical support to the public and it is up to the user to understand the applicability and limitations of the model. The user is also responsible for upgrading the model as new versions become available.

In this section, we have provided a brief overview on how HEC-HMS is organized and important features that are needed to conduct a spillway capacity analysis. This is not a replacement for the HEC-HMS User's Manual or Technical Reference Manual and the user is responsible for becoming familiar with the program and its use.

7.1 HEC-HMS PROCEDURES

HEC-HMS is separated into components that contain data for use in the model. The components are:

Basin Model	Time-Series Data
Meteorological Model	Paired Data
Control Specifications	Grid Data

The Basin Model is shown graphically and allows the user to place icons for each basin component in the order of flow. Once data is entered into the model, the user prompts the model to perform computations that estimate runoff and routing. Results of the computations are available in tabular or graphical form.

Model features are described below.

7.1.1 Basin Model

All basin, subbasin, channel (or reach, as defined in HEC-HMS), and reservoir information are entered into the Basin Model. Options are also available for junctions on more complex basins, diversions, sources and sinks. The Basin Model is organized with the parameters shown in Table 7-1. Typical information for entering data for spillway capacity models is contained in Sections 3.0, 4.0 and 6.0 of this technical note. Each feature within the basin is connected in order of flow direction. Separate subbasins can be connected at confluence points with the Junction feature in HEC-HMS. There are also options to model diversions, water inflow sources and sinks where no outflow occurs.

7.1.2 Meteorological Model

All rainfall, snowmelt and evapotranspiration information are entered into the Meteorological Model. The Meteorological Model is organized with the parameters shown in Table 7-2. Typical information for entering meteorological data for spillway capacity models is contained in Section 5.0 of this technical note.

7.1.3 Control Specifications

The Control Specifications allow the user to specify the time period of the model. The user is asked to enter a starting date and time and an ending date and time, as well as a model time interval. The time interval usually corresponds to the interval used in time series data, such as precipitation or discharge gages.

TABLE 7-1. BASIN MODEL PARAMETERS FOR HEC-HMS

Component	Method	Parameter
Subbasin	Loss Method	Green and Ampt
		Gridded Deficit Constant
		Gridded SCS Curve Number
		Gridded Soil Moisture Accounting
		Initial and Constant
		SCS Curve Number
		Smith Parlange
		Soil Moisture Accounting
	Transform Method	Clark Unit Hydrograph
		Kinematic Wave
		ModClark
		SCS Unit Hydrograph
		Snyder Unit Hydrograph
		User-Specified S-graph
		User-Specified Unit Hydrograph
	Baseflow Method	Bounded Recession
		Constant Monthly
		Linear Reservoir
		Nonlinear Boussinesq
		Recession
Reach (Channel Routing)	Routing Method	Kinematic Wave
		Lag
		Modified Puls
		Muskingum
		Muskingum-Cunge
		Straddle Stagger
	Loss/Gain Method	Constant
		Percolation
Reservoir	Outflow Method	Outflow Curve
		Outflow Structures
		Specified Release
	Storage Method	Elevation-Area-Discharge
		Elevation-Storage-Discharge
Junction		
Diversion	Type	Inflow Function
		Lateral Weir
		Pump Station
Source	Type	Constant Flow
		Discharge Gage
Sink		

TABLE 7-2. METEOROLOGICAL MODEL PARAMETERS FOR HEC-HMS

Component	Method
Precipitation	Frequency Storm
	Gage Weights
	Gridded Precipitation
	Inverse Distance
	SCS Storm
	Specified Hyetograph
	Standard Project Storm
Evapotranspiration	Gridded Priestley-Taylor
	Monthly Average
	Priestley-Taylor
Snowmelt	Gridded Temperature Index
	Temperature Index

7.1.4 Time Series Data

Time series data includes the following type of information:

Precipitation Gages

Discharge Gages

Stage Gages

Temperature Gages

Solar Radiation Gages

Crop Coefficient Gages

Snow water Equivalent Gages

Time series data is information that includes time as a variable. Precipitation is usually the only type of time series data used in spillway analyses unless snowmelt is considered, in which case temperature, solar radiation and snow water equivalent gages may also be included.

7.1.5 Paired Data

Paired data are tables of information that identify relationships or functions between two variables for use in runoff and routing models. Options for paired data include:

Storage-Discharge Functions
Elevation-Discharge Functions
Elevation-Storage Functions
Elevation-Area Functions
Cross Sections
Inflow-Diversion Functions
Diameter-Percentage Functions
Unit hydrograph Curves
Percentage Curves
ATI-Meltrate Functions
ATI-Coldrate Functions
Groundmelt Patterns
Meltrate Patterns

Elevation, storage and discharge data are normally associated with reservoirs and spillways. Cross sections are used in channel routing methods. Most of the remaining paired data could be used in spillway analyses if needed.

7.1.6 Grid Data

Grid data for runoff-routing model is based on data captured during a discrete time frame and utilizes radar-based estimates for simulation. Grid data provides actual spatial data over a basin, whereas other time series data assumes uniform areal distribution over a basin. Therefore, it can be useful for calibration of a specified storm, but data may be hard to obtain. The options for grid data include:

Precipitation Grids
Temperature Grids
Solar Radiation Grids
Crop Coefficient Grids
Storage Capacity Grids
Percolation Rate Grids
Storage Coefficient Grids
Moisture Deficit Grids
Impervious Area Grids
SCS Curve Number Grids
Elevation Grids
Cold Content Grids
Cold Content ATI Grids
Meltrate ATI Grids
Liquid Water Content Grids
Snow Water Equivalent Grids

7.1.7 Simulation Runs and Results

HEC-HMS allows the user to create and run simulations for specified subbasins and meteorological models. Features in HEC-HMS gives the user options to check data prior to computations and messages appear to give the user information about the simulation, such as warnings and errors. Once a run is successfully computed, the user can view a variety of tables and graphs that display the results of the simulation.

7.2 SUGGESTED PHASE APPROACH

Modeling flood routing for evaluating spillway capacity can be a detailed and complex effort. When the cost of conducting such a study is considered, it is a benefit to the user and potential clients to look at ways to expedite the evaluation process and to save time and money where possible. Therefore, in this section we offer suggestions on phasing the evaluation process as an approach to determine spillway adequacy.

If detailed information is available and building a reliable model is relatively easy, then it is always better to use the best available data. Sometimes introducing overly conservative data, such as assuming no infiltration of rainfall, is a way of determining if the spillway exceeds its required capacity and limiting the time to develop more a detailed model. However, this approach does not allow a reasonable estimate of the basin's reaction to rainfall nor does it provide an accurate estimate of the spillway's actual capacity.

The following are steps suggested for building a flood routing model in a phased approach:

- Develop the model with data needed to begin the evaluation process:
    - Reservoir and spillway elevation-storage-discharge paired data.
    - Rainfall/snowmelt time-series data for the required return interval. For dams with estimated large LOL downstream, if it is suspected that the reservoir will pass the PMF, it may be wise to look at the PMF first. If the reservoir passes the PMF, there is no need to estimate the LOL downstream or calculate the IDF.
    - Basic basin characteristics such as drainage area and transform (unit hydrograph) information.
- Make conservative assumptions first to check if spillway capacity is adequate.
    - Conservative assumptions include: reservoir storage that is smaller than actual; larger rainfall storm than required; smaller spillway size than actual, use of lag equation for routing subbasin flows down to reservoir; etc.
- Run the model with conservative soil/infiltration assumptions first and check spillway adequacy.
    - Assume no initial abstraction and little to no rainfall losses. Note that HEC-HMS will calculate initial abstraction when using NRCS Curve number method if an initial abstraction of zero is entered.
- If spillway does not pass the routed flow at each intermediate steps, build a more detailed model with more exact information.

8.0 MODEL VERIFICATION

Any hydrologic model is as "good", or accurate, as the information input to the model. It is crucial to modeling that some form of verification be conducted to assure the model is as accurate as possible. In dam safety, the consequences of inaccurate modeling can be long-lasting and even severe. Underestimating spillway size may have the unfortunate result of dam failure, which can be devastating for the owner, engineer, and the public downstream. Overestimating spillway size is very costly to an owner. Putting effort into verifying the model may cost more in engineering analysis, but usually is a relatively small amount if done in a logical and professional manner, especially compared to the high cost of construction or the overwhelming cost of damages from failure.

This section provides guidance for conducting verification of hydrologic models used for spillway analyses. Actual hydrologic data may be scarce or difficult to obtain, but there are publications available that can assist the user in most cases.

8.1 MODEL UNCERTAINTY

In Montana, hydrologic records have been kept, at best, approximately one hundred years. Some data may have longer records and most are shorter. Streamflow gages exist on many waterways, but are more common on larger rivers. Most small streams are not gaged. Studies have been conducted by the USGS and other agencies that produced regression relationships to help predict flow frequency and magnitude on ungaged streams. While the regression equations developed for ungaged streams are reasonably accurate, they are based on gage data from regional streams, which have limited record lengths, usually no more than about one hundred years. So when spillway hydrologic analyses are conducted for runoff events that exceed a return interval of 500 years and greater the uncertainty associated with the flow estimates can be very significant.

Parameter estimates for basin characteristics tend to be general in nature, especially in larger basins, and are based on best available data or empirical relationships. Parameter selection,

such as soil and ground cover type, infiltration rates and unit hydrograph parameters each introduce uncertainty to the model.

The same is true for meteorological data, where gage data is likely not available for watersheds being considered, and where gage records, if available, are relatively short in length compared to the return intervals required for spillway analyses. User decisions for temporal and spatial distribution are subjective, though there are references for Montana that provide guidance based on statistical analyses of actual gage data. Regardless, rainfall and snowmelt input to a hydrologic model will invariably introduce additional uncertainty.

But any uncertainty introduced into a model is balanced against what should be considered reasonable, when using best available data. The methods included in this technical note provide references to data that are considered to be the best available for Montana. The goal of "reasonable" is reached when model verification is accomplished to within standard error bounds of recorded gage data or regression equations. Variability of model results will still exist among different users and according to differing objectives for specific spillway analyses, but hopefully the procedures for verification mentioned in this section will produce somewhat consistent methodologies.

8.2 MODEL CONSERVATISM

Because of uncertainty of a hydrologic model for spillway analysis, there is sometimes a common reaction for users to intentionally introduce conservatism as an assurance that the model will exceed standards and reduce risk of failure. Being conservative in spillway analyses is a choice that professionals must make depending on the dam, the risk of failure, and input from regulatory agencies, the public and the dam owner.

As briefly mentioned in Section 7.2, introducing overly conservative data as a first step in a phased approach to modeling is an option in determining if a spillway exceeds required capacity and it tends to reduce the time of analysis if the spillway successfully passes the conservative flood flow. This may be effective for only determining if the spillway "passes or fails" the simulated flow. But further analysis is necessary if the spillway does not

successfully pass the conservative flow, or if the analysis will be used to route multiple levels of storm magnitudes as part of the spillway analysis that would require verification that the storm estimates are reasonable.

Introducing conservative assumptions at various points in a hydrologic analysis make it difficult to verify model results. In Section 8.3, where model verification techniques are discussed, the goal is to verify, to the extent possible with available data, the results of the hydrologic model using peak flows established by statistical gage analyses or regional regression equations. If model input is knowingly conservative, verification will not be possible.

By virtue of the spillway standards set for high hazard dams in Montana, at least some conservatism is inherently introduced in the spillway analysis. Section 2.0 of this technical note provides an explanation of standards whereby spillway standards are established on the basis of LOL in the event of dam failure. An IDF is assigned a return interval of 1,000 times the expected LOL up to a 5,000 year return period. Between 5 and 20 LOL, the IDF is interpolated between the 5,000 year return period and the PMF. The PMF is the standard for LOL equal to or greater than 1,000. All of the IDF standards, including the minimum 500-year flood, are very large events established because of the catastrophic consequences, but whose occurrences are very rare. Adding conservatism to already rare events may make the analysis unreasonable, in addition to being unverifiable.

8.3 VERIFICATION METHODS

Because streamflow records are limited, statistical analyses to determine storm frequency peak flows can only estimate up to approximately 100-year, or possibly 500-year, return interval peaks. While these storm peaks may be relatively small in comparison to spillway design peaks, they still represent large, infrequent storms. The response of a Montana drainage basin to a 100- or 500-year rainfall event may be similar to that of a larger event, especially if soil infiltration rates reach the point of saturation and most of the rainfall becomes direct runoff. It is reasonable, then, to use 100- or 500-year peak streamflows to

verify hydrologic models for a spillway IDF. Smaller return intervals may be used for model verification if no other data exists.

In this section, we will discuss methods to conduct verification (sometimes called "pseudo-calibration") of hydrologic models using peak flows developed from streamflow gage data or USGS regression equations for ungaged basins. Adjustment of the model to match estimated peaks usually requires modification of basin characteristics. More specifically, it is common to adjust model parameters such as the unit hydrograph and basin losses so that the modeled peak flows match or exceed peak streamflow estimates from USGS regression equations or flood-frequency analyses. This also means that appropriate return interval rainfall to match the streamflow return interval peaks will need to be input to the model. This is contrary to the concept that rainfall of a specified return period will not always produce peak runoff of the same return period, but it is the closest method available.

8.3.1 Model Parameters

The primary model parameters that may be utilized to pseudo-calibrate the runoff peaks from the model are those associated with the unit hydrograph and basin losses. Although both will affect the runoff peak, changes made to the basin losses will also affect the runoff volume. It is generally more conservative to calibrate by adjusting the unit hydrograph since this will only affect the runoff peak without affecting the total runoff volume.

Unit Hydrograph Parameters: Tc and R (Clark Unit Hydrograph) and tp and qp (Dimensionless Unit Hydrograph) should be estimated using the equations given in *WSP 2420* (Section 3.2.2.1). These two parameters may be utilized to pseudo-calibrate the model, but should remain within one standard deviation of the estimated value.

Basin Infiltration Parameters: The parameters available to pseudo-calibrate the model are the "percent impervious area", "initial abstractions", and the loss rate (typically the curve number or ultimate infiltration rate). Each of these parameters has a range of "reasonable" values that may be estimated utilizing published guidelines (Section 3.3). The model should

be run with various combinations of basin infiltration parameters during the process of verification.

8.3.2 Gage Data

If the drainage basin upstream of a reservoir considered for spillway analysis has one or more streamflow gages near the reservoir or nearby in the basin, the recorded data could be used to determine a desired return period peak flow by a direct frequency analysis or analysis by transposition.

Probably the most common distribution used to conduct a frequency analysis of streamflow gage data is Log Pearson Type III. This distribution has been found to fit well with streamflow data and has wide application in hydrologic studies. Use of Log Pearson Type III analysis was popularized with the publication of Bulletin 17B (USGS, 1981) by the Interagency Advisory Committee on Water Data. Methods developed in Bulletin 17B have become the standard for conducting streamflow frequency analyses. The user can follow Bulletin 17B methods to conduct frequency analyses on streamflow data sets of at least 10 years. It is desirable to estimate flows to the highest return period possible in order to allow reasonable model verification for extreme floods.

Techniques for transposition of flows from a gage that is not located near the location of the reservoir but within the drainage basin being considered can be found other hydrologic technical references.

8.3.3 USGS Regression Equations (USGS WRIR 03-4308)

Approximately every ten years, the USGS publishes an updated version of regression equations that estimate flood frequency for ungaged streams. The latest publication is Water-Resources Investigations Report (WRIR) 03-4308 (2004) which is based on water data through 1998. Regression equations were developed that relate frequency peak flows to various basin and climate characteristics, as well as to bankfull widths. Estimates can be calculated for return intervals of 2, 5, 10, 25, 50, 100, 200, and 500 years.

Methods in WRIR 03-4308 are easy to implement and provide reasonable estimates of frequency flows when no gage data is available.

8.4 CONFIDENCE IN VERIFICATION AND MODEL CONSERVATISM

Since analysis of gage data and the use of regression equations have associated uncertainty, and "best estimates" for parameters have been utilized throughout the development of the model, it is necessary that the model be verified to insure that it's results are reasonable and that an appropriate level of conservatism is applied at this final step. The model results are typically considered to be "reasonably conservative" if they are within a confidence band between the calculated mean value and the mean value plus one standard deviation of the streamflow estimates (whether from gauged data or from the USGS regression equations). Additionally, it is important to verify that the model will continue to yield reasonably conservative results when it is used to estimate flows beyond the 500-year flood. This may best be accomplished by plotting the model results for the 100-year and 500-year peak inflows on the flood-frequency graph that contains the historic (or regression) streamflow estimates. The slope of the line between the 100-year and 500-year model result points should be equal to or greater than the slope between the corresponding streamflow estimate points. If the slope is too flat, it is very likely that the model will underestimate peak flows for larger events.

9.0 REFERENCES

Bentley Systems, Inc. 2005. FlowMaster, The Hydraulic Toolbox software.

Clark, O.A. 1945. Storage and the unit hydrograph. Transactions of the American Society of Civil Engineers, v. 110, p. 1419-1446.

Cudworth, A.G., Jr. 1989. Flood hydrology manual. Denver, Colorado, Bureau of Reclamation, 243 p.

DHI Group, Inc. 2008. MIKE FLOOD software.

FLO-2D Software, Inc. 2007. FLO-2D, 2-Dimensional Flood Routing Model.

Sherman, L.K. 1932. Streamflow from rainfall by the unit-hydrograph method. Engineering News Record, v. 108, p. 501-505.

Snyder, F.F. 1938. Synthetic unit hydrographs. American Geophysical Union Transactions, v. 19, pt. 1, p. 447-454.

U.S. Army Corps of Engineers, Hydrologic Engineering Center. 2008. HEC-HMS, Hydrologic Modeling System, Version 3.2. April.

U.S. Army Corps of Engineers, Hydrologic Engineering Center. 2008. HEC-RAS, River Analysis System, Version 4.0. March.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2007. Title 210 – Engineering: National Engineering Handbook

U.S. Department of Commerce, National Oceanic and Atmospheric Administration. 1973. NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume I - Montana.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service. 1984. Dynamic Wave Operation Model (DWOPER). Danny Fread, author.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service. 1988. Dam Break Flood Forecasting Model (DAMBRK). Danny Fread, author.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration. 1988. Hydrometeorological Report No. 55A, Probable Maximum Precipitation Estimates – United States Between the Continental Divide and the 103rd Meridian. June.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration. 1994. Hydrometeorological Report No. 57, Probable Maximum Precipitation – Pacific Northwest States, Columbia River (including portions of Canada), Snake River and Pacific Coastal Drainages. October.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service. 1998. Flood Wave Routing Model (FLDWAV). Danny Fread, author.

U.S. Department of the Interior, U.S. Geological Survey, Interagency Advisory Committee for Water Data. 1981. Guidelines for Determining Flood Flow Frequency, Bulletin #17B of the Hydrology Subcommittee. September.

U.S. Department of the Interior, U.S. Geological Survey. 1996. Procedures for Estimating Unit Hydrographs for Large Floods at Ungaged Sites in Montana, Water-Supply Paper 2420.

U.S. Department of the Interior, U.S. Geological Survey. 1996. Full Equations (FEQ) Model for the Solution of the Full, Dynamic Equations of Motion for One Dimensional Unsteady Flow in Open Channels and Through Control Structures, Water-Resources Investigations Report 96-4240.

U.S. Department of the Interior, U.S. Geological Survey. 1997. Regional Analysis of Annual Precipitation Maxima in Montana, Water-Resources Investigations Report 97-4004.

U.S. Department of the Interior, U.S. Geological Survey. 1998. Characteristics of Extreme Storms in Montana and Methods for Constructing Synthetic Storm Hyetographs, Water-Resources Investigations Report 98-4100.

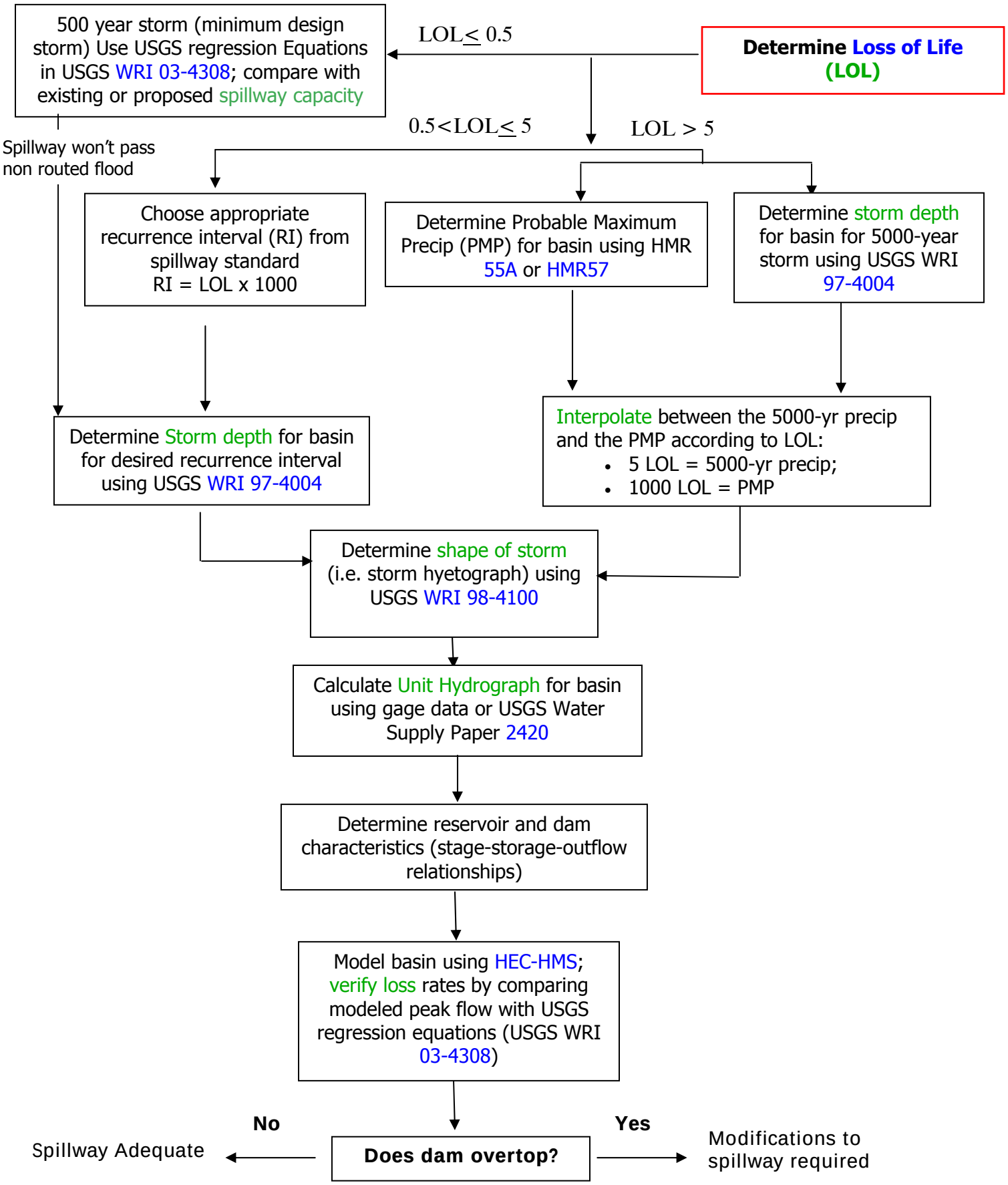
U.S. Department of the Interior, U.S. Geological Survey. 2004. Methods for Estimating Flood Frequency in Montana Based on Data through Water Year 1998, Water-Resources Investigations Report 03-4308.

Viessman, W. Jr. and Lewis, G.L. 2003. Introduction to Hydrology, 5th Edition.

APPENDIX A

FLOWCHART PROCEDURE FOR DETERMINING COMPLIANCE WITH MONTANA SPILLWAY DESIGN STANDARDS

Procedure for Determining Spillway Adequacy



APPENDIX B

MINIMUM INFLOW DESIGN FLOOD FOR HIGH HAZARD DAMS (MONTANA SPILLWAY STANDARDS COMMITTEE TECHNICAL DECISIONS, MAY 1999)

MINIMUM INFLOW DESIGN FLOOD FOR HIGH HAZARD DAMS

MONTANA SPILLWAY STANDARDS COMMITTEE

TECHNICAL DECISIONS

May 1999

Introduction

Under current Montana Rule 36.14.502, the Probable Maximum Flood (PMF) or a fraction thereof is often used to calculate the inflow design flood for high hazard dams. It is required that the reservoir and spillway safely store and pass the design flood. Inflow design criteria are based on both reservoir volume and dam height. Some form of the PMF criteria are applied unless a reservoir is less than 100 acre-feet and the dam is less than 20 feet high.

Under the current rule, the required spillway size for existing dams is not related to potential loss of life downstream from the dam. For example, the criteria remains the same regardless if one loss of life or one hundred loss of life would result from spillway failure below a given dam.

A goal of the Montana Department of Natural Resources and Conservation (DNRC), Dam Safety Section, is to implement a hydrologic standard for spillways that is risk based, with dams having a large population below being held to a more stringent criteria than dams having a low population below. Therefore, during the spring of 1997, the Montana Spillway Standards Committee was formed to advise the Dam Safety Section in development of new rules for spillway conveyance requirements. The committee is made up of dam owners, downstream residents of dams, consulting engineers, and government employees. The purpose of this report is to document the recommendations made by this committee.

In support of this effort, the U.S. Geological Survey (USGS), with some financial assistance from DNRC, conducted a study to characterize extreme storms that have a very low probability of occurrence. As a result, we are now able to estimate precipitation depths, throughout Montana, with recurrence intervals as high as 5,000-years. After determination of rainfall depth, the resulting flood is routed through the reservoir to estimate required spillway size.

Discussed in this report are recommendations by the Montana Spillway Standards Committee regarding risk vs. recurrence interval for the design flood and loss of life assessment. This report only addresses spillway requirements and not hydrologic techniques or other structural aspects of dams. Hydrologic techniques used by DNRC to help assess the proposed spillway standards are presented in "Montana Spillway Standards - Hydrologic Analysis", DNRC, May 1999.

Risk vs. Recurrence Interval - Inflow Design Flood

B.C. Hydro has pioneered the development of quantified risk analysis for dam safety evaluations. B.C. Hydro owns and operates 61 dams and is responsible for the production and distribution of electrical energy for the province of British Columbia, Canada. B.C. Hydro has adopted a mathematical annual expected value of loss of life for each dam of 0.001.

The committee recommends that a probability value of .001 (0.1% annually) of loss of one life due to spillway failure is acceptable. The associated recurrence interval for annual probability of .001 is 1,000-year. Therefore, the estimated loss of life due to spillway failure is multiplied by 1,000 to determine the inflow design storm recurrence interval that must be routed in the reservoir and passed by the spillway. For example, if a spillway failure is estimated to result in the loss of 2.4 lives, the spillway and reservoir will need to route the 2,400-year recurrence interval rainfall to be considered safe. If the spillway just meets this criteria, there will be a .042% ({1/2400}x100) chance each year that the 2.4 lives will be lost, and during a 50 year period there will be a 2% ($1-\{1-.00042\}^{50}$) chance that these lives will be lost.

The committee found that once a loss of life can be estimated from spillway failure, an appropriate inflow design storm with an assigned recurrence interval or probability of occurrence must safely be stored in the reservoir and passed by the spillway.

Committee Suggested Criteria

If the estimated loss of life is greater than zero and less than or equal to 0.5, the committee determined that the spillway and reservoir must be able to store and pass the 500-year runoff event. In other words, the minimum standard inflow design flood for high hazard dams is the 500-year flood. A graphical display of spillway standards for five loss of life or less is shown in Figure 1.

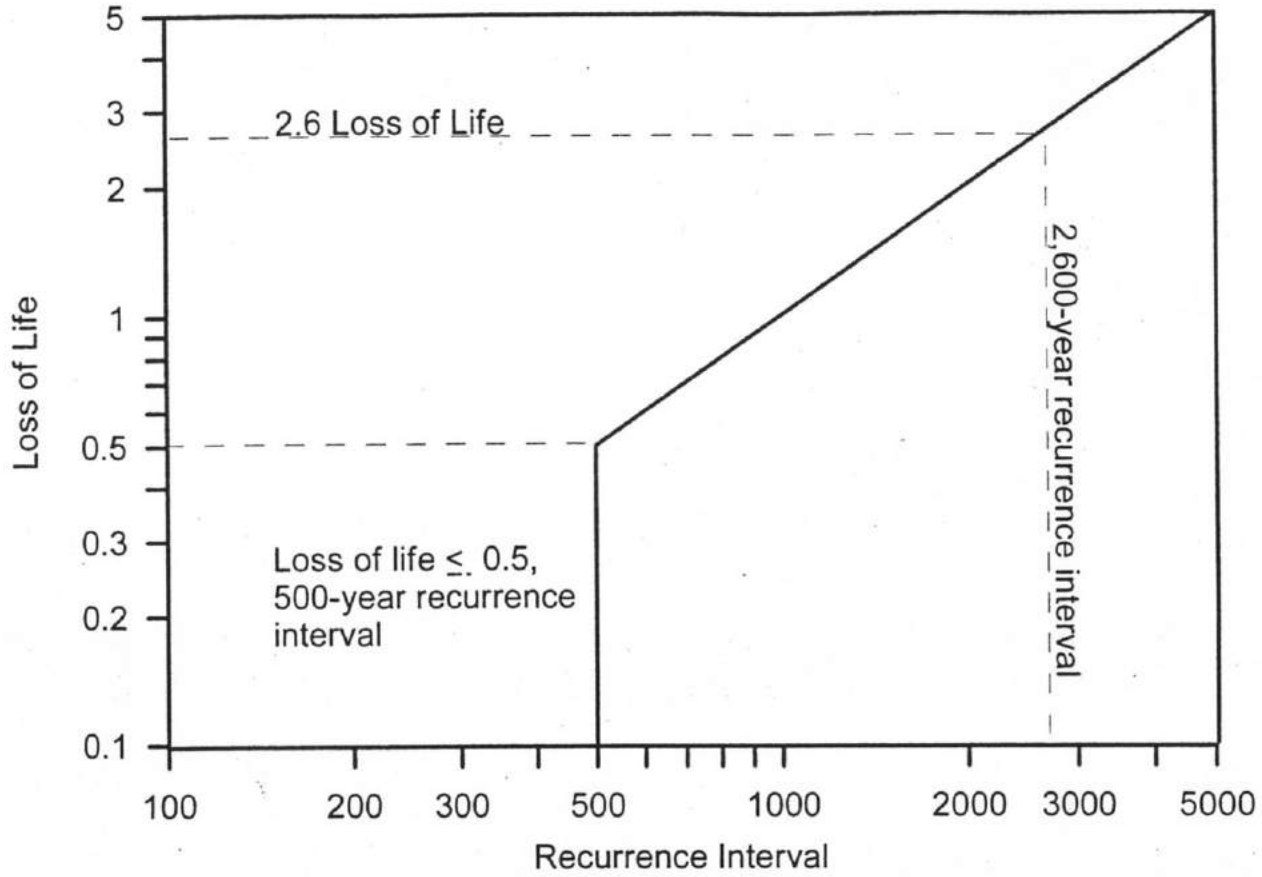


Figure 1. Minimum Standard Inflow Design Flood with an Estimated Loss of Life of Five or Less

If the loss of life is greater than 5, the probability-based approach will no longer be used and the inflow design flood is derived from the precipitation computed using equations 1 through 3. It needs to be emphasized that although no probability is associated with the standard above five loss of life, the standard does become more severe as expected loss of life increases below the dam. The results of the committee's decision on this portion of the standard are shown in Figure 2.

Eq. 1 $P_s = P_{5,000}\,(10^d)$

Eq. 2 $r = -0.304 + .435\,\log_{10}(lol)$

Eq. 3 $d = \log_{10}(PMP) - \log_{10}(P_{5,000})$

lol = *loss of life* ($5 < lol < 1{,}000$)

PMP = *Probable Maximum Precipitation*

$P_{5,000}$ = *5,000-year recurrence interval precipitation*

P_s = *Design precipitation to meet spillway standard*

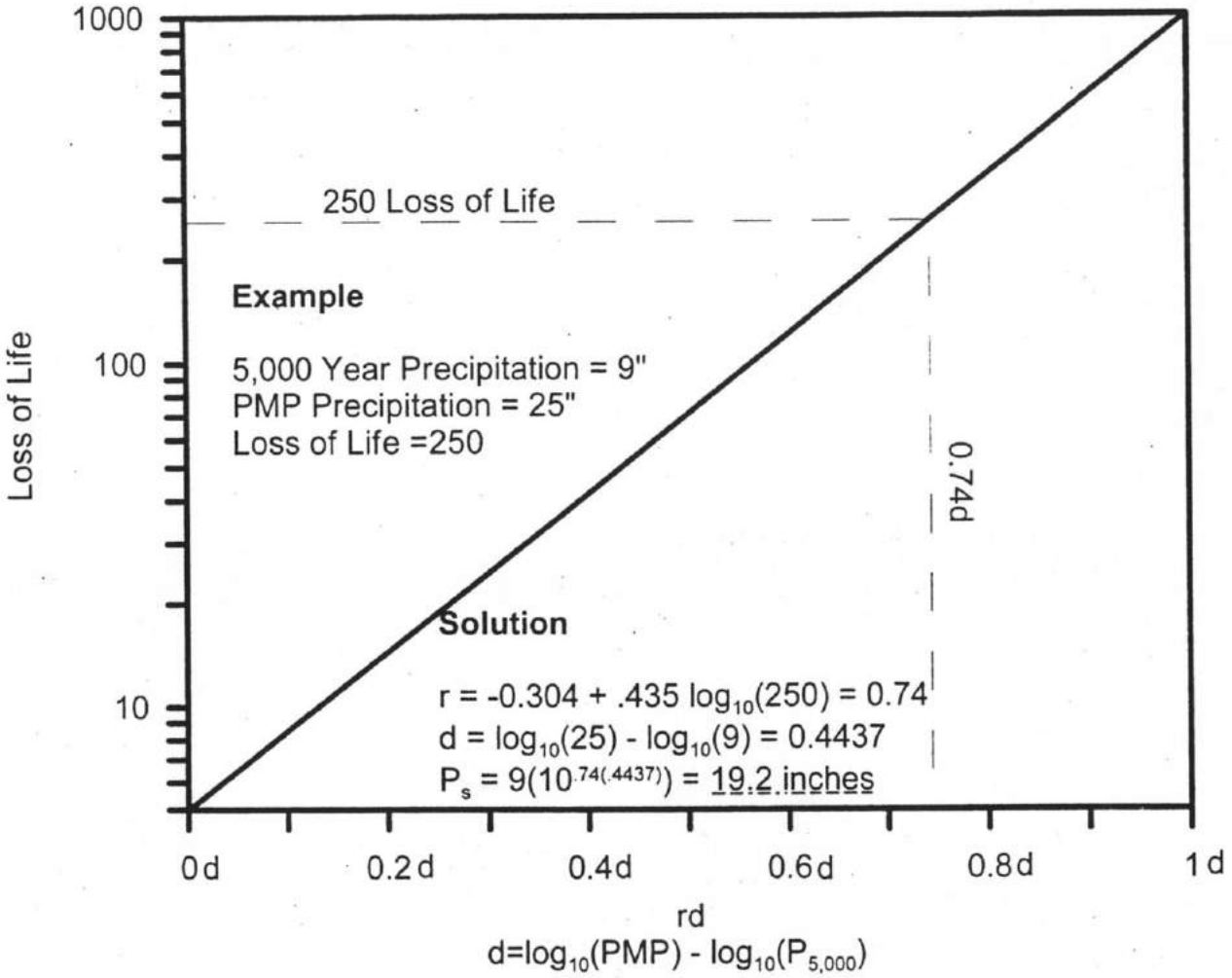


Figure 2. Minimum Standard Inflow Design Flood with an Estimated Loss of Life Between 5 and 1,000

The spillway standard changes for a loss of life greater than 5 not because the overall risk-based approach is no longer acceptable, but there is currently no acceptable way to estimate rainfalls with recurrence intervals greater than 5,000-year events.

For only the purposes of computing the risk factor, which will be discussed shortly, the PMP event is assumed a 1:1,000,000 event for interpolation.

If the loss of life is greater than or equal to 1,000, the reservoir and spillway must safely store and pass the runoff resulting from the PMP storm, often called the probable maximum flood or PMF.

Current design criteria provide for the minimum design storm to be reduced if it can be shown no further loss of life results from spillway failure. This criteria will be kept under the new standard.

Compliance of Existing Dams

For existing dams, the Montana Spillway Standards Committee has decided that it would be unreasonable to expect all existing spillways to come under compliance in a short period of time.

To assist the DNRC Dam Safety Section in prioritizing spillway construction or rehabilitation, the committee suggested using a risk factor developed using both the expected loss of life below the dam and the recurrence interval storm that the existing dam and spillway can safely store and pass. The risk factor is determined using Equation 4.

Eq. 4 $RF = RI_{SW}/LOL$

RF = *Risk Factor*

RI_{SW} = *Flood recurrence interval that the spillway can currently pass*

LOL = *Estimated loss of life associated with spillway failure*

If the RF value is 1,000 or above, the existing spillway meets or exceeds the standard and a larger spillway is not required. The committee has recommended for spillways significantly undersized (RF value below 100) that immediate action be taken. These actions may include reservoir level restrictions or breaching. These dams have a more than 1% probability each year of loss of life due to spillway failure.

For RF values between 100 and 500, proof of diligent effort towards correcting the problem will be required for issuance of operation permits.

For RF values between 500 and 1,000, dams will be evaluated on a case-by-case basis. The committee felt that these dams are sufficiently close to meeting the new standard, and the need for repair is not urgent if the spillway is in good condition.

Loss of Life Assessment

The committee examined several methods to estimate loss of life, caused by spillway

failure, downstream from a dam. Many methods base the loss of life (LOL) from the population at risk (PAR). They found the best current method to come from "Predicting Loss of Life in Case of Dam Failure and Flash Flood," Michael L. DeKay and Gary H. McClelland, Risk Analysis, Vol. 13, No. 2, 1993. In the future, new and better methods may become available. These methods should then be used.

The DeKay and McClelland method is based on an empirical approach that incorporates warning time, PAR, and the force of the flood. It is suggested by DeKay and McClelland that no one who is more than 3 hours travel time below the dam be included in the PAR. It is also strongly recommended that the PAR not be lumped into smaller reaches and zones of inundations since this leads to overestimates of LOL. The following equations are given by DeKay and McClelland to determine loss of life.

Eq. 5

$$LOL_{HF} = \frac{PAR_{HF}}{1 + 13.277(PAR_{HF}^{0.440})e^{(2.982(WT_{HF}) - 3.790)}}$$

Eq. 6

$$LOL_{LF} = \frac{PAR_{LF}}{1 + 13.277(PAR_{LF}^{0.440})e^{(0.759(WT_{LF})}}$$

LOL_{HF} = *Loss of Life in High Force Area*

LOL_{LF} = *Loss of Life in Low Force Area*

PAR_{HF} = *Population at Risk in High Force Area*

PAR_{LF} = *Population at Risk in Low Force Area*

WT_{HF} = *Warning time for High Force Area*

WT_{LF} = *Warning time for Low Force Area*

In most cases the committee recommends that 0 warning time be used. This assumption can be modified if sufficient evidence can be shown that a warning time exists.

The force of flood will often be estimated at site. In general, if the flood will occur in a narrow canyon area, the flood will likely be high force. If the area downstream of the dam is flat and wide, it is likely that much of the areas within the inundation zone will be classified low force.

If more specific information is needed regarding the flood force, the document "Downstream Hazard Classification Guidelines," ACER Technical Memorandum No. 11, U.S. Bureau of Reclamation, 1988 may be useful. Shown in Figures 3-5 are plots of velocity vs. depth for houses, mobile homes, and passenger vehicles. The various zones are high danger, low danger, and judgment.

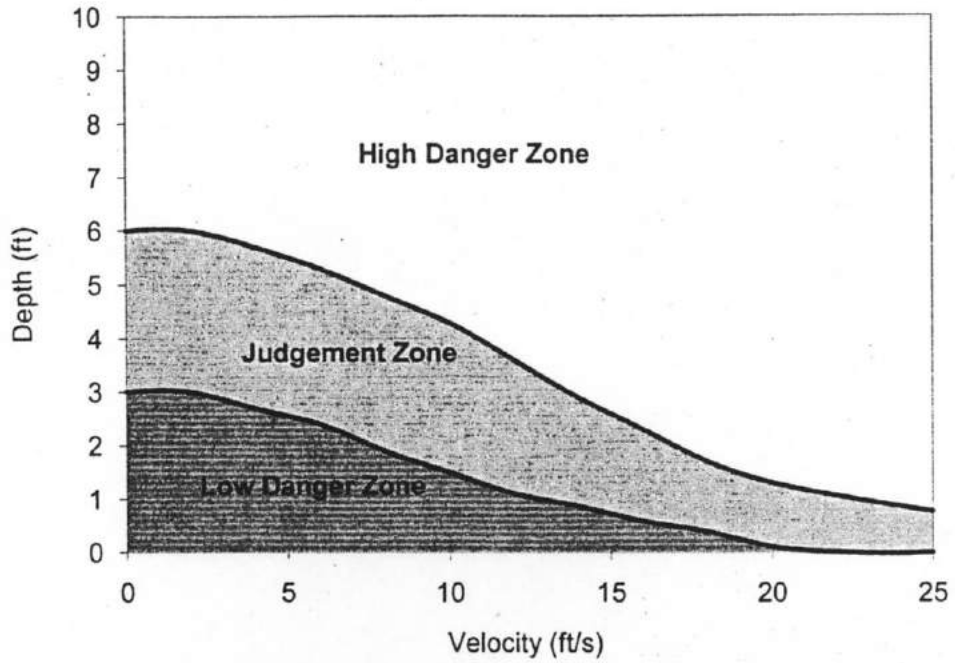


Figure 3. - Depth-Velocity Flood Danger Level Relationships for Houses Built on Foundations

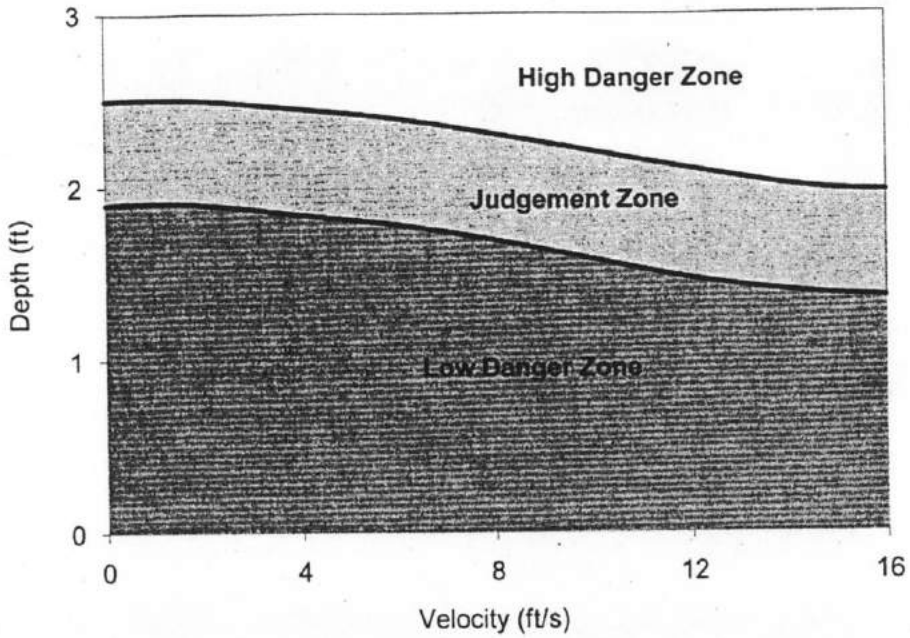


Figure 4. - Depth-Velocity Flood Danger Level Relationship for Mobile Homes

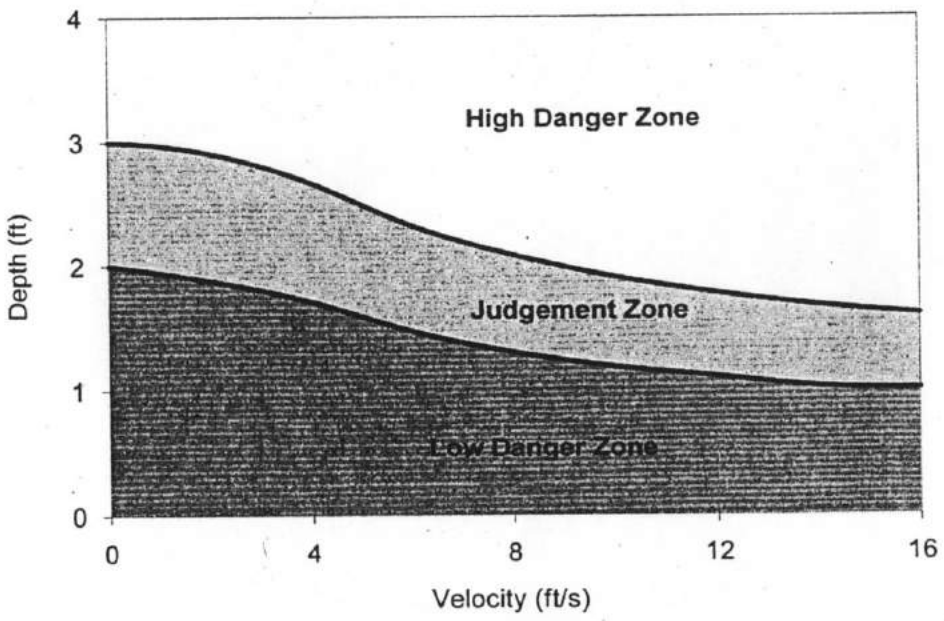


Figure 5. - Depth-Velocity Flood Danger Relationships for Passenger Vehicles

The estimation of PAR in the high force area and the subsequent use of the high force equation has the most significant effect on the LOL. Special attention will be focused on defining the area influenced by the high force wave and the PAR in the area.

Conclusion

The design precipitation used to determine spillway size under the proposed rule is very different from the design precipitation used under the current rule. The proposed rule requires the design precipitation to be based on population level downstream of the dam whereas the current rule requires the design precipitation to be based on the height and volume of water associated with the dam.

Since the population at risk is closely related to whether the force of water is high or low after dam failure, the proposed rule does still indirectly incorporate height of dam within the criteria. The current rule only considers that some population is at risk below the dam. The level of population at risk plays a small to nonexistent role in the spillway conveyance criteria.

For these reasons, dams with large populations at risk downstream, will often have more stringent spillway requirements under the proposed rules. On the other hand, dams with small populations at risk will often have less stringent spillway requirements under the proposed rules. The Montana Spillway Standards Committee has decided that the risk of life downstream should be the overriding factor in determining spillway capacity.

APPENDIX C

NRCS CURVE NUMBER TABLES FROM CHAPTER 9 HYDROLOGIC – SOIL COVER COMPLEXES OF THE NRCS NATIONAL ENGINEERING HANDBOOK, TITLE 210

Table 9.1.--Runoff curve numbers for hydrologic soil-cover complexes

(Antecedent moisture condition II, and $I_a = 0.2\ S$)

Land use	Cover: Treatment or practice	Cover: Hydrologic condition	Hydrologic soil group: A	B	C	D
Fallow	Straight row	----	77	86	91	94
Row crops	"	Poor	72	81	88	91
	"	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	"	Good	65	75	82	86
	"and terraced	Poor	66	74	80	82
	" " "	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	"and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes 1/ or rotation meadow	Straight row	Poor	66	77	85	89
	" "	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	"	Good	55	69	78	83
	"and terraced	Poor	63	73	80	83
	"and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	"	Fair	25	59	75	83
	"	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) 2/		----	72	82	87	89
(hard surface) 2/		---	74	84	90	92

1/ Close-drilled or broadcast.
2/ Including right-of-way.

E.26. Nebraska





Nebraska Safety of Dams and Reservoirs Act

Overview

The Department's Dam Safety Program was peer reviewed by the Association of State Dam Safety Officials (ASDSO) in 2002. The peer review found that overall the department had a good program, but one of the deficiencies identified was a lack of clear statutory authority to implement the program. The peer review specifically recommended that the Department consolidate program authorization and legal requirements, provide for civil enforcement authority, update and simplify fee schedules, provide authority to establish dam safety rules and regulations, and incorporate other aspects of FEMA's Model Dam Safety Law.

LB619, the Safety of Dams & Reservoirs Act, was introduced by Senator Schrock on January 19, 2005 and signed by Governor Heineman on April 7, 2005 as part of LB335. LB335 will go into effect on September 3, 2005.

Some of the highlights of LB335:

- Makes it clear that dams that are regulated under a federal dam safety program may continue to be regulated primarily by the federal program provided that the federal program has objectives, standards, and requirements that meet or exceed the purposes of the Act, and the owner has entered into a cooperative agreement with the Department.
- Adds requirement that plans, specifications, and construction supervision be the responsibility of a licensed professional engineer.
- Provides that a city, village, or county may institute overlay zoning precluding construction of structures downstream of a state permitted dam that is classified as having other than a high hazard potential, if a breach inundation study performed by an engineer, in accordance with generally accepted engineering practice, determines that construction of such structures would require that such dam be reclassified as having a high hazard potential. The owners of such dam shall provide such engineering study as a condition to requesting overlay zoning.
- Allows department employees to enter onto private property, as necessary, to perform their official duties.
- Modifies the criteria for a jurisdictional size dam: any dam 25 feet or more in height or having 50 acre-ft or more maximum storage capacity; or any dam in a high hazard location regardless of size. The following exemptions exist; any dam that is less than six feet tall or any dam with less than 15 acre-ft total storage is exempt; also canal control structures and highway and railroad embankments are exempt unless they are intended to be dams.

- Removes requirements for repair, operation, and maintenance from the law because these types of work are not, and have not been regulated by the Department in the past.
- Changes the fee structure from the current one dollar per foot in height of dam to a flat fee to be established by rule and regulation of not to exceed two hundred dollars for dams less than twenty-five feet in height, three hundred dollars for dams twenty-five feet in height to not more than fifty feet in height, and four hundred dollars for dams in excess of fifty feet in height.
- Adds a civil penalty provision that provides that any person who violates the Act or an application approval, an approval to operate, a rule, a regulation, an order, or a requirement of the department under the Act may be assessed a civil penalty in an amount not to exceed five hundred dollars per day. The Department would have to bring an action in the court in the jurisdiction in which the violation occurred.
- Adds "no fault" language with respect to the state, department, its employees and agents.
- Adds provision for the appointment of a consulting board to report on safety matters when requested by the owner.
- Expands on the authority of the department to investigate or require the owner to investigate, gather data, study, etc. as necessary for safety.
- Restates and expands on department authority to adopt rules and regulations.
- Expands on and strengthens the construction completion certification requirement for new or reconstructed dams.
- Adds requirement for the department to issue an approval to operate prior to the dam going into service.
- Expands on the department's action and authority upon receipt of a complaint relative to a dam.
- Expands on the owner's responsibilities and actions during emergencies. Also, provides the department authority to take control of a dam during an emergency.
- States requirements for dams completed prior to the enactment of LB 335.
- Expands on requirements for emergency action plans.

Please contact our office for questions regarding the Safety of Dams and Reservoirs Act at 402-471-1222, or pdiederich@dnr.state.ne.us.

Patrick J. Diederich, P.E.
Dam Safety Chief
Floodplain/Dam Safety/ Survey Division
Nebraska Department of Natural Resources

Section 46-1601

Act, how cited.

Sections 46-1601 to 46-1670 shall be known and may be cited as the Safety of Dams and Reservoirs Act.

Source:
Laws 2005, LB 335, § 1
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1602

Definitions, where found.

For purposes of the Safety of Dams and Reservoirs Act, the definitions found in sections 46-1603 to 46-1634 apply.

Source:
Laws 2005, LB 335, § 2
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1603

Abandonment, defined.

Abandonment means the process of rendering a dam incapable of impounding by (1) dewatering and filling the reservoir created by such dam with solid materials and (2) creating a stable watercourse around the site.

Source:
Laws 2005, LB 335, § 3
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1604

Adverse consequences, defined.

Adverse consequences means negative impacts that may occur upstream, downstream, or at locations remote from the dam, including, but not limited to, loss of human life, economic loss including property damage, and lifeline disruption.

Source:
Laws 2005, LB 335, § 4
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1605

Alterations, defined.

Alterations means alterations to an existing dam that directly affect the safety of the dam or reservoir, as determined by the department, but does not include maintenance and repair of the dam to retain its initial structural integrity.

Source:
Laws 2005, LB 335, § 5
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1606

Application approval, defined.

Application approval means authorization in writing issued by the department to an owner who has applied to the department for permission to construct, reconstruct, enlarge, alter, breach, remove, or abandon a dam and which specifies the conditions or limitations under which work is to be performed by the owner or under which approval is granted.

Source:
Laws 2005, LB 335, § 6
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1607

Approval to operate, defined.

Approval to operate means authorization in writing issued by the department to an owner who has completed construction, reconstruction, enlargement, or alteration of a dam.

Source:
Laws 2005, LB 335, § 7
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1608

Appurtenant works, defined.

Appurtenant works include, but are not limited to: Structures such as spillways, either in or separate from the dam; the reservoir and its rim; low-level outlet works; and water conduits including, but not limited to, tunnels, pipelines, or penstocks, either through the dam or its abutments.

Source:
Laws 2005, LB 335, § 8
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1609

Breach, defined.

Breach means partial removal of a dam creating a channel through the dam to the natural bed elevation of the stream.

Source:
Laws 2005, LB 335, § 9
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1610

Completion certification, defined.

Completion certification means a statement signed by the design engineer, certifying the completion of work on a dam in conformance with the approved plans and specifications.

Source:
Laws 2005, LB 335, § 10
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1611

Dam, defined.

(1) Dam means any artificial barrier, including appurtenant works, with the ability to impound water, wastewater, or liquid-borne materials and which (a) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum storage elevation or (b) has an impounding capacity at maximum storage elevation of fifty acre-feet or more, except that any barrier described in this subsection which is not in excess of six feet in height or which has an impounding capacity at maximum storage elevation of not greater than fifteen acre-feet shall be exempt, unless such barrier, due to its location or other physical characteristics, is classified as a high hazard potential dam.

(2) Dam does not include:

(a) An obstruction in a canal used to raise or lower water;

(b) A fill or structure for highway or railroad use, but if such structure serves, either primarily or secondarily, additional purposes commonly associated with dams it shall be subject to review by the department;

(c) Canals, including the diversion structure, and levees; or

(d) Water storage or evaporation ponds regulated by the United States Nuclear Regulatory Commission.

Source:
Laws 2005, LB 335, § 11
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1612

Days, defined.

Days, for purposes of establishing deadlines, means calendar days, including Sundays and holidays.

Source:
Laws 2005, LB 335, § 12
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1613

Department, defined.

Department means the Department of Natural Resources.

Source:
Laws 2005, LB 335, § 13
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1614

Director, defined.

Director means the Director of Natural Resources.

Source:
Laws 2005, LB 335, § 14
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1615

Emergency, defined.

Emergency includes, but is not limited to, breaches and all conditions leading to or causing a breach, overtopping, or any other condition in a dam that may be construed as unsafe or threatening to life.

Source:
Laws 2005, LB 335, § 15
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1616

Engineer, defined.

Engineer means a professional engineer licensed under the Engineers and Architects Regulation Act who (1) is competent in areas related to dam investigation, design, construction, and operation for the type of dam being investigated, designed, constructed, or operated, (2) has at least four years of relevant experience in investigation, design, construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of dams, and (3) understands adverse consequences and dam failures.

Source:
Laws 2005, LB 335, § 16
Effective date September 4, 2005.

Cross References:
Engineers and Architects Regulation Act,see section 81-3401.

~ Revised Statutes Supplement 2005

Section 46-1617

Enlargement, defined.

Enlargement means any change in or addition to an existing dam which raises or may raise the normal storage elevation of the water impounded by the dam.

Source:
Laws 2005, LB 335, § 17
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1618

Hazard potential classification, defined.

Hazard potential classification means classification of dams according to the degree of incremental adverse consequences of a failure or misoperation of a dam but does not reflect on the current condition of a dam, including, but not limited to, safety, structural integrity, or flood routing capacity.

Source:
Laws 2005, LB 335, § 18
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1619

High hazard potential, defined.

High hazard potential means a hazard potential classification such that failure or misoperation of the dam resulting in loss of human life is probable.

Source:
Laws 2005, LB 335, § 19
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1620

Incremental, defined.

Incremental means the difference in impacts that would occur due to failure or misoperation of the dam over the impacts that would occur without failure or misoperation of the dam.

Source:
Laws 2005, LB 335, § 20
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1621

Law hazard potential, defined.

Low hazard potential means a hazard potential classification such that failure or misoperation of the dam would result in no probable loss of human life and in low economic loss.

Source:
Laws 2005, LB 335, § 21
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1622

Maximum storage, defined.

Maximum storage means the reservoir storage capacity between the top of dam elevation, or the maximum routed elevation of the probable maximum flood if lower than the top of dam elevation, and the lowest downstream toe or outside limit elevation of the dam.

Source:
Laws 2005, LB 335, § 22
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1623

Minimal hazard potential, defined.

Minimal hazard potential means a hazard potential classification such that failure or misoperation of the dam would likely result in no economic loss beyond the cost of the structure itself and losses principally limited to the owner's property.

Source:
Laws 2005, LB 335, § 23
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1624

Normal storage, defined.

Normal storage means the reservoir storage capacity, excluding flood storage and freeboard allowances.

Source:
Laws 2005, LB 335, § 24
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1625

Owner, defined.

Owner includes any of the following who or which owns, controls, manages, or proposes to construct, reconstruct, enlarge, alter, breach, remove, or abandon a dam:

(1) The United States Government and its departments, agencies, and bureaus;

(2) The state and its departments, institutions, agencies, and political subdivisions;

(3) A municipal or quasi-municipal corporation;

(4) A public utility;

(5) A district;

(6) A person;

(7) A duly authorized agent, lessee, or trustee of any person or entity listed in this section; and

(8) A receiver or trustee appointed by a court for any person or entity listed in this section.

Source:
Laws 2005, LB 335, § 25
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1626

Person, defined.

Person means any individual, partnership, limited liability company, association, public or private corporation, trustee, receiver, assignee, agent, municipality, other political subdivision, public agency, or other legal entity or any officer or governing or managing body of any public or private corporation, municipality, other political subdivision, public agency, or other legal entity.

Source:
Laws 2005, LB 335, § 26
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1627

Probable, defined.

Probable means likely to occur and reasonably expected.

Source:
Laws 2005, LB 335, § 27
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1628

Probable maximum flood, defined.

Probable maximum flood means the most severe flood that is considered

probable at a site.

Source:
Laws 2005, LB 335, § 28
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1629

Reconstruction, defined.

Reconstruction means partial or complete removal and replacement of an existing dam.

Source:
Laws 2005, LB 335, § 29
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1630

Removal, defined.

Removal means complete elimination of the dam embankment or structure to restore the approximate original topographic contours of the site.

Source:
Laws 2005, LB 335, § 30
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1631

Reservoir, defined.

Reservoir means any basin which contains or will contain impounded water, wastewater, or liquid-borne materials by virtue of such water, wastewater, or liquid-borne materials having been impounded by a dam.

Source:
Laws 2005, LB 335, § 31
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1632

Significant hazard potential, defined.

Significant hazard potential means a hazard potential classification such that failure or misoperation of the dam would result in no probable loss of human life but could result in major economic loss, environmental damage, or disruption of lifeline facilities.

Source:
Laws 2005, LB 335, § 32
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1633

Storage elevation, defined.

Storage elevation means the elevation of the reservoir surface associated with a level of impoundment, such as maximum storage or normal storage.

Source:
Laws 2005, LB 335, § 33
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1634

Top of dam elevation, defined.

Top of dam elevation means the maximum design elevation for the top of the dam, including design freeboard allowances but excluding any allowance for settlement due to consolidation of foundation and embankment.

Source:
Laws 2005, LB 335, § 34
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1635

Purposes of act.

The purposes of the Safety of Dams and Reservoirs Act are to regulate all dams and associated reservoirs for the protection of public health, safety, and welfare and to minimize the adverse consequences associated with the potential failure of such dams and reservoirs.

Source:
Laws 2005, LB 335, § 35
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1636

Applicability of other law.

The Safety of Dams and Reservoirs Act does not relieve the owner or operator of a dam or reservoir from obtaining any necessary approvals from the department under sections 46-233 to 46-241 or from any other local, state, or federal regulatory authority.

Source:
Laws 2005, LB 335, § 36
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1637

Regulation by political subdivisions; restrictions; conditions.

(1) Except as provided in subsections (2) and (4) of this section, no city, village, or county may, by ordinance or resolution enacted by the legislative body thereof or adopted by the people, (a) regulate, supervise, or provide for the regulation or supervision of any dams and associated reservoirs or the construction, reconstruction, enlargement, repair, alteration, operation, breach, removal, or abandonment thereof or (b) limit the size or the impounding capacity of a dam if such action would conflict with the power and authority vested in the department pursuant to the Safety of Dams and Reservoirs Act.

(2) A city, village, or county may adopt ordinances or resolutions (a) regulating, supervising, or providing for the regulation or supervision of dams and reservoirs that are not within the state's jurisdiction and are not subject to regulation, owned, or operated by another public agency or body or (b) which apply only to adjacent structures not germane to the safety of the dam, such as, but not limited to, roads and fences.

(3) A city, village, or county may institute overlay zoning precluding construction of structures downstream of a state-permitted dam that is classified as having other than a high hazard potential if a breach-inundation study performed by an engineer, in accordance with generally accepted engineering practice, determines that construction of such structures would require that such dam be reclassified as having a high hazard potential. The owners of such dam shall provide such engineering study as a condition to requesting such overlay zoning.

(4) The Safety of Dams and Reservoirs Act does not preempt or supersede any local zoning ordinances, resolutions, rules, or regulations regarding special use permits enacted by a political subdivision with respect to permit applications for livestock waste control facilities.

Source:
Laws 2005, LB 335, § 37
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1638

Plans and specifications; responsibility of engineer.

All plans and specifications for construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of dams and supervision of construction shall be the responsibility of an engineer assisted by qualified engineering geologists and other specialists as necessary.

Source:
Laws 2005, LB 335, § 38
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1639

Immunity from liability; when.

(1) No action shall be brought against the state, the department, or its agents or employees for the recovery of damages caused by the partial or total failure of any dam by reason of control and regulation thereof pursuant to the Safety of Dams and Reservoirs Act, including, but not limited to, any of the following:

(a) Design and construction application approval of the dam or approval of interim flood routing plans during construction, reconstruction, enlargement, alteration, breach, removal, or abandonment;

(b) The issuance or enforcement of orders relative to maintenance or operation of the dam;

(c) Control and regulation of the dam;

(d) Measures taken to protect against failure of the dam during an emergency, except for negligent acts of the department in assuming control of a dam during an emergency; or

(e) Failure to act.

(2) The Safety of Dams and Reservoirs Act does not relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

Source:
Laws 2005, LB 335, § 39
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1640

Orders and approval; effect.

The findings and orders of the department, an application approval, and an approval to operate any dam issued by the department are final, conclusive, and binding upon all owners and state agencies, regulatory or otherwise, as to the safety of design, construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of any dam.

The department may report all dam incidents as defined by the National Performance of Dams Program to the National Performance of Dams Program archive.

Source:
Laws 2005, LB 335, § 40
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1641

Change of ownership; notification.

The owner of any dam subject to the Safety of Dams and Reservoirs Act shall notify the department of any change in the ownership of the dam. Notification shall be in such form and include such evidence of ownership as the director may by rule and regulation require.

Source:
Laws 2005, LB 335, § 41
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1642

Livestock waste control facility; approvals required.

An applicant for a permit for a livestock waste control facility which includes a dam, holding pond, or lagoon for which approval by the Department of Natural Resources is not otherwise required but for which approval by the Department of Environmental Quality under section 54-2429 is required shall submit an application for approval along with plans, drawings, and specifications to the Department of Natural Resources and obtain approval from the Department of Natural Resources before beginning construction. The Department of Natural Resources shall approve or deny the dam, holding pond, or lagoon pursuant to this section within sixty days after such application is submitted.

Source:
Laws 2005, LB 335, § 42
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1643

Administrative or judicial recourse; not affected.

The Safety of Dams and Reservoirs Act does not deprive the owner of any administrative or judicial recourse to the courts to which such owner is entitled under the laws of this state.

Source:
Laws 2005, LB 335, § 43
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1644

Department; employ personnel.

The department shall employ an engineer and such individuals otherwise qualified by training and experience in the design, inspection, construction, reconstruction, enlargement, repair, alteration, maintenance, operation, breach, removal, or abandonment of dams as necessary to carry out the Safety of Dams and Reservoirs Act.

Source:

Laws 2005, LB 335, § 44
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1645

Consulting board required; when; liability for costs.

When the safety and technical considerations pertaining to an application approval, an approval to operate, or the plans and specifications of a dam require it, or when requested in writing by the owner, the department shall appoint a consulting board of three or more consultants to report to the department on the safety features involved. The cost and expense of a consulting board, if appointed at the request of an owner, shall be paid by the owner.

Source:
Laws 2005, LB 335, § 45
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1646

Dams; review and approval required; when.

(1) The department shall review and approve the design, construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of all dams in the state for the protection of life and property as provided in the Safety of Dams and Reservoirs Act.

(2) No person shall construct, reconstruct, enlarge, alter, breach, remove, or abandon any dam without approval by the department.

(3) An owner of a dam who has entered into a cooperative agreement with the department pursuant to subdivision (2)(d) of section 46-1633 shall be deemed to be in compliance with the act.

Source:
Laws 2005, LB 335, § 46
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1647

Potentially hazardous dams; emergency action plans.

(1) In order to protect life and property, the owner of every high hazard potential dam shall develop and periodically test and update an emergency action plan to be implemented in the event of an emergency involving such dam. In order to protect life and property, the department may require the owners of any significant hazard potential dam to develop and periodically test and update an emergency action plan to be implemented in the event of an emergency involving such dams.

(2) Such emergency action plan shall include, but not be limited to, the following elements:

(a) Emergency notification plan with flowchart;

(b) A statement of purpose;

(c) A project description;

(d) Emergency detection, evaluation, and classification;

(e) General responsibilities;

(f) Preparedness;

(g) Inundation maps or other acceptable description of the inundated area; and

(h) Appendices.

(3) For purposes of evaluating the adequacy of an emergency action plan, the department shall review, evaluate for adequacy, and approve or disapprove each emergency action plan submitted under this section. The department shall accept emergency action plans developed for dams under a federal dam safety program.

(4) If the department determines that a dam constitutes an immediate risk to life or property, the department shall order the owner to take such action as is necessary to remove such risk.

Source:
Laws 2005, LB 335, § 47
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1648

Right of entry upon private property; when; immunity.

In making any investigation or inspection necessary to enforce or implement the Safety of Dams and Reservoirs Act, the department or its

representatives, upon reasonable notice, may enter upon private property of the dam and reservoir owner as necessary. Such right of entry shall extend to all employees, surveyors, or other agents of the department in the official performance of their duties, and such persons shall not be liable for prosecution for trespass when performing their official duties.

Source:
Laws 2005, LB 335, § 48
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1649

Department; investigations and studies.

(1) The department may investigate and gather or cause the owner to gather such data, including advances made in safety practices elsewhere, as may be needed for a proper review and study of the various features of the design, construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of dams.

(2) The department may make or cause the owner to make such watershed investigations and studies as are necessary to keep abreast of developments affecting runoff and peak storm discharges in the vicinity of a dam.

(3) The department may make or cause the owner to make such seismic investigations and studies as may be necessary to keep abreast of developments affecting seismic stability of a dam.

Source:
Laws 2005, LB 335, § 49
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1650

Department; enforcement; powers.

(1) The department may take any administrative or legal action necessary for the enforcement of the Safety of Dams and Reservoirs Act.

(2) An action or proceeding under this section may be initiated whenever any owner or any person acting as an agent of any owner:

(a) Fails to comply with the requirements imposed by the act or by any application approval, approval to operate, order, rule, regulation, or requirement of the department under the act; or

(b) Commits or allows the commission of violations of the act or of any application approval, approval to operate, order, rule, regulation, or requirement of the department under the act.

(3) Any action or proceeding under this section shall be initiated either administratively or in a court in a jurisdiction in which:

(a) The dam, area of hazard potential, or some part thereof exists;

(b) The person named in the complaint has its principal place of business; or

(c) The person named in the complaint resides.

Source:
Laws 2005, LB 335, § 50
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1651

Rules and regulations.

(1) The department may adopt and promulgate rules and regulations containing standards for the design, inspection, construction, reconstruction, enlargement, alteration, breach, removal, abandonment, and periodic testing of emergency action plans of dams to carry out the purposes of the Safety of Dams and Reservoirs Act. Such rules and regulations may also include, but are not limited to, establishing:

(a) Standards and criteria for the siting and design of dams, considering both existing and projected conditions which may affect the safety of a project during its construction and operational life;

(b) Requirements for operation of dams, including operational plans to be prepared and implemented by owners;

(c) Requirements for monitoring, inspection, and reporting of conditions affecting the safety of dams; and

(d) Requirements for emergency action plans to be prepared and implemented by owners in cooperation with emergency management authorities.

(2) In adopting rules and regulations applicable to dams which may have

a high hazard potential or a significant hazard potential, the department may consider:

(a) The state of scientific and technological knowledge and good engineering practices relating to various types of dams;

(b) The economic impact of a failure of a structure upon the state and its citizens; and

(c) The relationship of dams in hydrologic management in the watershed as a whole.

Source:
Laws 2005, LB 335, § 51
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1652

Construction or enlargement of dam; application for approval; contents.

(1) Construction of any new dam or the enlargement of any dam shall not commence until the owner has applied for and obtained from the department written application approval of plans and specifications.

(2) A separate application for each dam shall be filed with the department upon forms provided by the department. Plans and specifications signed and sealed by the design engineer shall accompany the application.

(3) The application shall provide the following information:

(a) The name and address of the owner;

(b) The name and address of the applicant, if different from the owner;

(c) The name and address of the operator or other person to be contacted regarding arrangements for inspections or other matters associated with the dam;

(d) The location, type, size, purpose, and height of the proposed dam;

(e) The reservoir surface areas and associated storage capacity at elevation intervals not exceeding two feet;

(f) Plans for proposed permanent instrument installations in the dam;

(g) The area of the drainage basin, rainfall records, streamflow records, and flood flow records and estimates, if available;

(h) Maps and design drawings showing plans, elevations, and sections of all principal structures and appurtenant works with other features of the project in sufficient detail, including design analyses, to determine safety, adequacy, and suitability of design;

(i) The estimated construction cost of the dam; and

(j) Such other pertinent information as the department requires.

(4) The department may, when in its judgment it is necessary, also require the following:

(a) Data concerning subsoil and rock foundation conditions and the materials involved in the construction of the dam;

(b) Investigations of, and reports on, subsurface conditions, exploratory pits, trenches and adits, drilling, coring, and geophysical tests to measure in place and in the laboratory the properties and behavior of foundation materials at the dam site;

(c) Investigations and reports on the geology of the dam site, possible geologic hazards, seismic activity, faults, weak seams and joints, availability and quality of construction materials, and other pertinent features; and

(d) Other appropriate information.

(5) If an application is incomplete or defective, it shall be returned to the applicant to complete or to correct the defects. The application shall be corrected and returned to the department within ninety days after it is returned to the applicant or within such additional time as may be allowed by the department. If the application is returned to the department after expiration of such time period, it shall be dismissed.

Source:
Laws 2005, LB 335, § 52
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1653

Modifications to existing dam; application for approval; contents; exemption.

(1) Before commencing the reconstruction or alteration of a dam or the abandonment, breach, or removal of a dam so that it no longer constitutes a dam, the owner shall file an application and secure the written application approval of the department.

(2) The application shall give such pertinent information or data concerning the dam as may be required by the department.

(3) The application shall give the name and address of the applicant and shall adequately detail, with appropriate references to the existing dam, the proposed reconstruction, alteration, abandonment, breach, or removal of the dam. The application shall be accompanied by plans and specifications signed and sealed by the design engineer. The department may waive any of the requirements of this section if the requirements are unnecessary for the application approval.

(4) If an application is incomplete or defective, it shall be returned to the applicant to complete or to correct the defects. The application shall be corrected and returned to the department within ninety days after it is returned to the applicant or within such additional time as may be allowed by the department. If the application is returned to the department after expiration of such time period, it shall be dismissed.

(5) In case of an emergency in which the department declares that repairs or breaching of the dam are necessary to safeguard life and property, repairs or breaching shall be started immediately by the owner or by the department at the owner's expense. The department shall be notified within twenty-four hours of emergency repairs or breaching when instituted by the owner.

(6) The proposed repairs or breaching shall conform to any orders issued by the department.

Source:
Laws 2005, LB 335, § 53
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1654

Application approval; issuance; public hearing.

(1) Approval of applications for which approval under sections 46-233 to 46-242 is not required shall be issued within ninety days after receipt of the completed application plus any extensions of time required to resolve matters diligently pursued by the applicant. At the discretion of the department, one or more public hearings may be held on an application.

(2) Approval of applications under the Safety of Dams and Reservoirs Act, for which approval under sections 46-233 to 46-242 is required, shall not be issued until all pending matters before the department under the Safety of Dams and Reservoirs Act or such sections have been resolved and approved. Approval under the act and approval under such sections shall be issued simultaneously.

(3) Application approval shall be granted with terms, conditions, and limitations necessary to safeguard life and property.

(4) If actual construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of the dam is not commenced within the time established by the department, the application approval becomes void, except that the department may, upon written application and for good cause shown, extend the time for commencing construction, reconstruction, enlargement, alteration, breach, removal, or abandonment.

(5) Written notice shall be provided to the department at least ten days before construction, reconstruction, enlargement, alteration, breach, removal, or abandonment is to begin and such other notices shall be given to the department as it may require.

Source:
Laws 2005, LB 335, § 54
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1655

Fees.

(1) The application for approval of construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of a dam shall be accompanied by a filing fee as established by rule and regulation of the department but not to exceed (a) two hundred dollars for a dam less than twenty-five feet in height, (b) three hundred dollars for a dam twenty-five feet in height to not more than fifty feet in height, and (c) four hundred dollars for a dam in excess of fifty feet in height.

(2) Only one filing fee shall be collected for an enlargement by flashboards, sandbags, earthen levees, gates, or other works, devices, or obstructions which are from time to time to be removed and replaced or opened and shut and thereby operated so as to vary the surface elevation of the reservoir.

(3) A dam subject to the Safety of Dams and Reservoirs Act and for which plans and specifications have been approved prior to September 4, 2005, shall not be required to pay any additional fee or submit an additional application for approval unless such dam requires reconstruction, enlargement, alteration, breach, removal, or abandonment.

(4) An application shall not be considered by the department until the filing fee is received.

(5) Fees collected by the department under this section shall be remitted to the State Treasurer for credit to the Dam Safety Cash Fund.

Source:
Laws 2005, LB 335, § 55
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1656

Dam Safety Cash Fund; created; use; investment.

The Dam Safety Cash Fund is created. The fund shall consist of fees credited pursuant to section 46-1655 and any money specifically appropriated to the fund by the Legislature. Money in the fund shall not be subject to any fiscal-year limitation or provision for lapse of unexpended balance at the end of any fiscal year or biennium. The fund shall be administered by the department. Money in the fund may be expended by the department for costs incurred by the department in the administration of the Safety of Dams and Reservoirs Act. Any money in the fund available for investment shall be invested by the state investment officer pursuant to the Nebraska Capital Expansion Act and the Nebraska State Funds Investment Act.

Source:
Laws 2005, LB 335, § 56
Effective date September 4, 2005.

Cross References:
Nebraska Capital Expansion Act,see section 72-1269.
Nebraska State Funds Investment Act,see section 72-1260.

~ Revised Statutes Supplement 2005

Section 46-1657

New or modified dam; owner; filing requirements; approval to operate; issuance.

(1) Upon completion of a new or reconstructed dam and reservoir or of the enlargement of a dam and reservoir, the owner shall file with the department a completion certification accompanied by supplementary drawings or descriptive matter signed and sealed by the design engineer, showing or describing the work as actually completed. Such supplementary materials may include, but need not be limited to, the following as determined by the department:

(a) A record of all geological boreholes and grout holes and grouting;

(b) A record of permanent location points, benchmarks, and instruments embedded in the structure;

(c) A record of tests of concrete or other material used in the construction, reconstruction, or enlargement of the dam; and

(d) A record of initial seepage flows and embedded instrument readings.

(2) In connection with the enlargement of a dam, the supplementary drawings and descriptive matter need apply only to the new work.

(3) An approval to operate shall be issued by the department upon a finding by the department that the dam is safe to impound within the limitations prescribed in the application approval. No impoundment by the structure shall occur prior to issuance of the approval to operate.

Source:
Laws 2005, LB 335, § 57
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1658

Alteration of dam; owner; filing requirements; approval to operate; issuance.

(1) Upon completion of the alteration of any dam, the owner shall file with the department a completion certification accompanied by supplementary drawings or descriptive matter, as determined by the department, signed and sealed by the design engineer, showing or describing the work as actually completed.

(2) An approval to operate shall be issued upon a finding by the department that the dam is safe to impound within the limitations prescribed in the application approval. Pending issuance of a new or revised approval to operate, the owner of the dam shall not cause the dam to impound beyond the limitations prescribed in the existing application approval.

Source:
Laws 2005, LB 335, § 58
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1659

Removal, breach, or abandonment of dam; design engineer; duties; department; powers.

(1) Upon completion of the removal, breach, or abandonment of a dam, the design engineer shall file with the department a completion certification.

(2) Before final approval of the removal of a dam is issued, the department may inspect the site of the work and determine that all work was accomplished in substantial conformance with the application approval.

(3) Following the removal of a dam, the department may report such removal to the National Performance of Dams Program and to the National Inventory of Dams.

Source:
Laws 2005, LB 335, § 59
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1660

Approval to operate; department; powers; hearing; notice.

(1) Each approval to operate issued by the department under the Safety of Dams and Reservoirs Act shall contain such terms and conditions as the department may prescribe.

(2) The department shall revoke, suspend, or amend any approval to operate whenever it determines that the dam constitutes a danger to life and property.

(3) Before any approval to operate is revoked by the department, the department shall hold a public hearing. Written notice of the time and place of the hearing shall be mailed to the owner at least thirty days before the date set for the hearing. Any interested persons may appear at the hearing and present their views and objections to the proposed action.

Source:
Laws 2005, LB 335, § 60
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1661

Complaint; department; duties; unsafe condition; modification.

(1) Upon receipt of a written complaint alleging that the person or property of the complainant is endangered by the construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of any dam, the department shall cause an inspection and investigation to be made unless the data, records, and inspection reports on file are found adequate to make a determination whether the complaint is valid. The complainant shall be provided with a copy of the official report of the inspection and investigation.

(2) If it is found that an unsafe condition exists, the department shall notify the owner of the dam to take such action as is necessary to correct the condition, including breaching or removal of any dam found to be beyond repair.

Source:
Laws 2005, LB 335, § 61
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1662

Periodic inspections; when; department; powers and duties.

(1) During the construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of any dam, the department may make periodic inspections for the purpose of ascertaining compliance with the approved plans and specifications. The department shall require the owner to direct the design engineer to provide adequate supervision during construction, reconstruction, enlargement, alteration, breach, removal, or abandonment and to provide sufficient information to enable the department to determine that conformity with the approved plans and specifications is being attained.

(2) If, after any inspection or investigation, during the construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of a dam or at any time prior to issuance of an approval to operate, it is found by the department that modifications or changes are necessary to ensure the safety of the dam, the department shall order the owner to revise his or her plans and specifications. The owner may, pursuant to section 46-1645, request an independent consulting board to review the order of the department.

(3) If at any time during construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of any dam, the department finds that the work is not being done in accordance with the approved plans and specifications, the department shall deliver a written notice

of noncompliance to the owner. The notice shall be delivered by registered mail or by personal service to the owner, shall state the particulars in which the approved plans and specifications are not being or have not been complied with, and shall order immediate compliance with the approved plans and specifications. The department may order that no further work be done until such compliance has been effected and approved by the department.

(4) Failure to comply with the notice delivered under subsection (3) of this section may cause revocation of application approval by the department. If compliance with the notice has not occurred within sixty days after the date of the notice, the department shall order the incomplete structure removed sufficiently to eliminate any safety hazard to life.

Source:
Laws 2005, LB 335, § 62
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1663

Record-keeping requirements; maintenance, operation, and inspection; department; powers.

(1) The department shall require owners to keep original records and any modifications to construction available and in good order.

(2) The department may:

(a) Adopt such rules and regulations and issue such orders as necessary to secure adequate maintenance, operation, and inspection by owners;

(b) Require engineering and geologic investigations to safeguard life and property;

(c) Accept approvals and reports of equivalent inspections prepared for dams under a federal dam safety program; and

(d) Enter into cooperative agreements with the owners of dams which are required to comply with a federal dam safety program that has objectives, standards, and requirements that meet or exceed the purposes of the Safety of Dams and Reservoirs Act.

Source:
Laws 2005, LB 335, § 63
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1664

Safety inspections; when; department; powers and duties.

(1) The department shall inspect dams for the purpose of determining their safety. The normal inspection frequency shall be annually for high hazard potential dams, biennially for significant hazard potential dams, and every five years for low hazard potential dams and every five years or more for minimal hazard potential dams. The department may vary the inspection frequency of some sites based on an evaluation of the site performance history. The department may conduct additional inspections at any time. If serious safety concerns are found by the department during the inspections, the department shall require the owner to conduct tests and investigations sufficient for the department to determine the condition of the dam. After review of the tests or investigations, the department may require modification, removal, or breach of the dam or alteration of operating procedures to restore or improve the safety of the dam and may require installation of instrumentation to monitor the performance of the dam.

(2) The department may report the results of dam inspections that determine unsafe conditions or noncompliance to the National Performance of Dams Program.

Source:
Laws 2005, LB 335, § 64
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1665

Emergency actions involving a dam; owner; duties; department; duties.

(1) The owner of a dam has the primary responsibility for determining when an emergency exists. When the owner of a dam determines that an emergency exists involving a dam, the owner shall immediately implement the emergency action plan as required pursuant to section 46-1647. The owner shall immediately notify any persons who may be endangered if the dam should fail, notify emergency management organizations in the area, take necessary remedial action to prevent or mitigate the consequences of failure, and notify the department. The department shall take any remedial action necessary to protect life and property if, in its judgment, either:

(a) The condition of any dam is so dangerous to the safety of life or property as not to permit time for the issuance and enforcement of an order relative to maintenance or operation; or

(b) Passing or imminent floods or any other condition threatens the safety of any dam.

(2) In applying the remedial means provided for in this section, the department may in an emergency, with its own forces or by other means at its disposal, do any or all of the following:

(a) Take full charge and control of any dam;

(b) Lower the water level by releasing water from the reservoir;

(c) Completely drain the reservoir;

(d) Perform any necessary remedial or protective work at the site; or

(e) Take such other steps as may be essential to safeguard life and property.

(3) The department shall continue in full charge and control of such dam and its appurtenant works until they are rendered safe or the emergency occasioning the action has ceased and the owner is able to take back full charge and control. The department's taking full charge and control under this section does not relieve the owner of such dam of liability for any negligent acts of such owner.

(4) The department may report emergency actions involving the safety of a dam to the National Performance of Dams Program in a timely manner.

Source:
Laws 2005, LB 335, § 65
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1666

Violations; penalties.

(1) Violation of the Safety of Dams and Reservoirs Act or of any application approval, approval to operate, order, rule, regulation, or requirement of the department under the act is a Class V misdemeanor. Each day that the violation continues constitutes a separate and distinct offense.

(2) Any person who willfully obstructs, hinders, or prevents the department from performing the duties imposed by the act commits a Class IV misdemeanor.

(3) Any owner or any person who engages in the construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of any dam or who knowingly does work on or permits work to be done on the dam without the approval of the department or in violation of the act and who fails to immediately notify the department thereof commits a Class V misdemeanor.

Source:
Laws 2005, LB 335, § 66
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1667

Notice of violation; orders; procedure.

(1) If the department has reason to believe that an owner or other person is violating or has violated the Safety of Dams and Reservoirs Act, an application approval, an approval to operate, a rule, a regulation, an order, or a requirement of the department issued or adopted pursuant to the act, the department shall give the owner or person written notice by certified mail that the owner or person appears to be in violation of the act. The owner or other person shall have thirty days from the mailing of such notice to respond or to request a hearing before the department as to why the owner or other person should not be ordered to cease and desist from the violation. The notice shall inform the owner or other person how to request the hearing and the consequences of failure to request a hearing.

(2) If the department finds that an owner or person is constructing, reconstructing, enlarging, altering, breaching, removing, or abandoning a dam without having first obtained the required application approval, the department shall issue a temporary order for the owner or person to cease and desist the construction, reconstruction, enlargement, alteration,

breach, removal, or abandonment pending final action by the department pursuant to subsection (3) of this section. The temporary order shall include written notice by certified mail to the owner or person of the time and date set by the department for a hearing to show cause why the temporary order should be vacated.

(3) After a response to a notice or a hearing pursuant to subsection (1) or (2) of this section or after the expiration of time to request a hearing, the department shall issue a decision and final order. The decision and final order may take such form as the department determines to be reasonable and appropriate and may include a determination of violation, a cease and desist order, the recommendation of a civil penalty, and an order directing that positive steps be taken to abate or ameliorate any harm or damage arising from the violation. The owner or person affected may appeal the hearing decision as provided in section 61-207.

(4) If the owner or person continues the violation after the department has issued a final decision and order pursuant to subsection (3) of this section or a temporary order pursuant to subsection (2) of this section, the department may apply for a temporary restraining order or preliminary or permanent injunction from a court of competent jurisdiction. A decision to seek injunctive relief does not preclude other forms of relief or enforcement against the violator.

Source:
Laws 2005, LB 335, § 67
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1668

Violations; civil penalty.

(1) Any person who violates the Safety of Dams and Reservoirs Act or an application approval, an approval to operate, a rule, a regulation, an order, or a requirement of the department under the act may be assessed a civil penalty in an amount not to exceed five hundred dollars per day for each day the violation continues.

(2) The department shall bring an action to recover a penalty imposed under this section in a court in the jurisdiction in which the violation occurred.

(3) In determining the amount of the penalty, the court shall consider the degree of harm to the public, whether the violation was knowing or willful, the past conduct of the defendant, whether the defendant has taken steps to cease, remove, or mitigate the violation, and any other relevant information.

Source:
Laws 2005, LB 335, § 68
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1669

Appeal.

Any affected person aggrieved by any final order or decision made by the director pursuant to the Safety of Dams and Reservoirs Act may appeal the order as provided in section 61-207. For purposes of this section, affected person means the applicant or holder of any approvals under the act and any owner of an estate or interest in or concerning land or water whose interest is or may be impacted in a direct and significant manner by such final order or decision.

Source:
Laws 2005, LB 335, § 69
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

Section 46-1670

Existing unapproved dams; requirements.

(1) Every owner of a dam subject to the Safety of Dams and Reservoirs Act that was completed prior to September 4, 2005, and not previously approved by the department when departmental approval was otherwise required shall file an application with the department for approval of such dam.

(2) A separate application for each dam shall be filed with the department upon forms supplied by the department and shall include such appropriate information concerning the dam as the department requires.

(3) The department may give notice, by certified mail to the owner's last address of record in the office of the county assessor of the county in which the dam is located, to the owner of dams required under this section to file an application who or which have failed to do so, and a failure to file within sixty days after receipt of such notice shall be punishable as provided in the act.

(4) The department may make inspections of such dams and may require owners of such dams and reservoirs to perform, at the owner's expense, such work or tests as may reasonably be required to disclose information sufficient to enable the department to determine whether to issue an approval to operate or to issue orders directing further work at the owner's expense necessary to safeguard life and property. For this purpose, the department may require an owner to lower the water level of or to drain the reservoir.

(5) If, upon inspection or upon completion to the satisfaction of the department of all work ordered, the department finds that the dam is safe to impound, an approval to operate shall be issued.

(6) If at any time the department finds that the dam is not safe to impound, the department shall notify the owner in writing and shall set a time and place for hearing on the matter. The owner of such dam shall ensure that such dam does not impound following receipt of such notice. Written notice of the time and place of the hearing shall be mailed, at least thirty days prior to the date set for the hearing, to the owner. Any interested person may appear at the hearing and present his or her views and objections to the proposed action.

Source:
Laws 2005, LB 335, § 70
Effective date September 4, 2005.

~ Revised Statutes Supplement 2005

NEBRASKA ADMINISTRATIVE CODE

TITLE 458, NEBRASKA ADMINISTRATIVE CODE, CHAPTERS 1-13

NEBRASKA DEPARTMENT OF NATURAL RESOURCES

RULES FOR THE SAFETY OF DAMS AND RESERVOIRS

Adopted June 27, 2008

NEBRASKA DEPARTMENT OF NATURAL RESOURCES
TITLE 458 - DEPARTMENT OF NATURAL RESOURCES RULES FOR SAFETY OF DAMS AND RESERVOIRS

ALPHABETICAL TABLE OF CONTENTS

SUBJECT OF TITLE	STATUTORY AUTHORITY	CODE SECTION
Change of Address	§ 46-1641 § 61-206	008
Change of Ownership	§ 46-1641 § 46-206 §76-2,124	007
Completion Certification	§ 46-1651 § 46-1657 § 46-1658 § 46-1659 § 61-206	010
Consulting Board	§ 46-1645 § 46-1651 § 61-206	011
Definitions Applicable to Title 458	§ 46-1601 to 46-1670 § 61-206	001
Documentation of Signatures	§§ 46-1601 to 46-1670	002
Fees	§ 46-1655 § 33-105(8) § 61-206	003

ALPHABETICAL TABLE OF CONTENTS

SUBJECT OF TITLE	STATUTORY AUTHORITY	CODE SECTION
Hazard Potential Classifications	§ 46-1651 § 61-206	012
Notice of Construction, Reconstruction, Enlargement, Alteration, Breach, Removal or Abandonment	§ 46-1654(5) § 46-1651 § 61-206 § 33-105(8)	009
Operation and Maintenance of a Dam and Reservoir	§ 46-1651 § 61-206	013
Outlet Works	§ 46-241 § 61-206 § 33-105(8)	006
Requirements for Dams Constructed Prior to September 4, 2005, Subject to the Safety of Dams and Reservoirs Act and not Previously Approved by the Department	§ 46-241 § 46-1611 § 46-1651 § 46-1652 § 46-1653 § 46-1670 § 61-206	005
Requirements for Application Approval	§ 46-1651 § 46-1652 § 46-1653 § 61-206	004

NEBRASKA DEPARTMENT OF NATURAL RESOURCES
TITLE 458 - DEPARTMENT OF NATURAL RESOURCES RULES FOR SAFETY OF DAMS AND RESERVOIRS

NUMERICAL TABLE OF CONTENTS

SUBJECT OF TITLE	STATUTORY AUTHORITY	CODE SECTION
Definitions Applicable to Title 458	§§ 46-1601 to 46-1670 § 61-206	001
Documentation of Signatures	§§ 46-1601 to 46-1670	002
Fees	§ 46-1655 § 33-105(8) § 61-206	003
Requirements for Application Approval	§ 46-1651 § 46-1652 § 46-1653 § 61-206	004
Requirements for Dams Constructed Prior to September 4, 2005, Subject to the Safety of Dams and Reservoirs Act and not Previously Approved by the Department	§ 46-241 § 46-1611 § 46-1651 § 46-1652 § 46-1653 § 46-1670 § 61-206	005
Outlet Works	§ 46-241 § 61-206 § 33-105(8)	006

NUMERICAL TABLE OF CONTENTS

SUBJECT OF TITLE	STATUTORY AUTHORITY	CODE SECTION
Change of Ownership	§ 46-1641 § 46-206 § 76-2,124	007
Change of Address	§ 46-1641 § 46-1651 § 61-206	008
Notice of Construction, Reconstruction, Enlargement, Alteration, Breach, Removal or Abandonment	§ 46-1654(5) § 46-1651 § 61-206 § 33-105(8)	009
Completion Certification	§ 46-1651 § 46-1657 § 46-1658 § 46-1659 § 61-206	010
Consulting Board	§ 46-1645 § 46-1651 § 61-206	011
Hazard Classifications	§ 46-1651 § 61-206	012
Operation and Maintenance of a Dam and Reservoir	§ 46-1651 § 61-206	013

NEBRASKA ADMINISTRATIVE CODE

Title 458 - NEBRASKA DEPARTMENT OF NATURAL RESOURCES
RULES FOR SAFETY OF DAMS AND RESERVOIRS

Chapter 1 – DEFINITIONS APPLICABLE TO TITLE 458

001 For purposes of Title 458 rules, the following definitions shall apply:

001.01 Abandonment means the process of rendering a dam incapable of impounding by (1) dewatering and filling the reservoir created by such dam with solid materials and (2) creating a stable watercourse around the site.

001.02 Adverse consequences means the negative impacts that may occur upstream, downstream, or at locations remote from the dam, including but not limited to, loss of human life, economic loss including property damage and lifeline disruption.

001.03 Alterations means alterations to an existing dam that directly affect the safety of the dam or reservoir, as determined by the Department, but do not include maintenance and repair of the dam to retain its initial structural integrity.

001.04 Application includes an application form, plans and specifications.

001.05 Application approval means authorization in writing issued by the Department to an owner who has applied to the Department for permission to construct, reconstruct, enlarge, alter, breach, remove, or abandon a dam and which specifies the conditions or limitations under which work is to be performed by the owner or under which approval is granted.

001.06 Appurtenant works include, but are not limited to: structures such as spillways, either in or separate from the dam; the reservoir and its rim; low-level outlet works; and water conduits including, but not limited to, tunnels, pipelines, or penstocks, either through the dam or its abutments.

001.07 Breach means partial removal of a dam creating a channel through the dam to the natural bed elevation of the stream.

001.08 Consulting Board means board appointed by the Department under the provisions of Neb. Rev. Stat. § 46-1645.

001.09 Dam means any artificial barrier, including appurtenant works, with the ability to impound water, wastewater, or liquid-borne materials and which (a) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum storage elevation or (b) has an impounding capacity at maximum storage elevation of fifty acre-feet or more, except that any barrier described in this subsection which is not in excess of six feet in height or which has an impounding capacity at maximum storage elevation of not greater than fifteen acre-feet shall be exempt, unless such barrier, due to its location or other physical characteristics, is classified as a high hazard potential dam. Dam does not include: (1) an obstruction in a canal used to raise or lower water; (2) a fill or structure for highway or railroad use, but if such structure serves, either primarily or secondarily, additional purposes commonly associated with dams it shall be subject to review by the department; (3) canals, including the diversion structure, and levees; or (4) water storage or evaporation ponds regulated by the United States Nuclear Regulatory Commission.

001.10 Days, for purposes of establishing deadlines, means calendar days, including Sundays and holidays.

001.11 Department means the Department of Natural Resources.

001.12 Diversion dam means dam constructed solely for the purpose of raising water to divert it into a canal. The height of the dam must be limited such that it provides only this function and does not create unnecessary storage.

001.13 Engineer means a professional engineer licensed under the Engineers and Architects Regulation Act who (1) is competent in areas related to dam investigation, design, construction, and operation for the type of dam being investigated, designed, constructed, or operated, (2) has at least four years of relevant experience in investigation, design, construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of dams, and (3) understands adverse consequences and dam failures.

001.14 Enlargement means any change in or addition to an existing dam which raises or may raise the normal storage elevation of the water impounded by the dam.

001.15 Hazard potential classification means classification of dams according to the degree of incremental adverse consequences of a failure or misoperation of a dam but does not reflect on the current condition of a dam, including but not limited to, safety, structural integrity, or flood routing capacity.

001.16 High hazard potential means a hazard potential classification such that failure or misoperation of the dam resulting in loss of human life is probable.

001.17 Incremental means the difference in impacts that would occur due to failure or misoperation of the dam over the impacts that would occur without failure or misoperation of the dam.

001.18 Landowner means person or persons with recorded title to land where dam and reservoir are or will be located.

001.19 Low hazard potential means a hazard potential classification such that failure or misoperation of the dam would result in no probable loss of human life and in low economic loss.

001.20 Maximum storage means the reservoir storage capacity between the top of dam elevation, or the maximum routed elevation of the probable maximum flood if lower than the top of dam elevation, and the lowest downstream toe or outside limit elevation of the dam.

001.21 Minimal hazard potential means a hazard potential classification such that failure or misoperation of the dam would likely result in no economic loss beyond the cost of the structure itself and losses principally limited to the owner’s property.

001.22 Normal storage means the reservoir storage capacity, excluding flood storage and freeboard allowances.

001.23 Owner includes any of the following who or which owns, controls, manages, or proposes to construct, reconstruct, enlarge, alter, breach, remove, or abandon a dam: (1) The United States Government and its departments, agencies, and bureaus; (2) the state and its departments, institutions, agencies, and political subdivisions; (3) a municipal or quasi-municipal corporation; (4) a public utility; (5) a district; (6) a person; (7) a duly authorized agent, lessee, or trustee of any person or entity listed in this section; and (8) a receiver or trustee appointed by a court for any person or entity listed in this section.

001.24 Person means any individual, partnership, limited liability company, association, public or private corporation, trustee, receiver, assignee, agent, municipality, other political subdivision, public agency, or other legal entity or any officer or governing or managing body of any public or private corporation, municipality, other political subdivision, public agency, or other legal entity.

001.25 Plan or plans mean engineering drawings, design reports, hazard classification studies, geotechnical reports, and other studies as required.

001.26 Probable means likely to occur and reasonably expected.

001.27 Probable maximum flood means the most severe flood that is considered probable at a site.

001.28 Reconstruction means partial or complete removal and replacement of an existing dam.

001.29 Removal means complete elimination of the dam embankment or structure to restore the approximate original topographic contours of the site.

001.30 Reservoir means any basin which contains or will contain impounded water, wastewater, or liquid-borne materials by virtue of such water, wastewater, or liquid-borne materials having been impounded by a dam.

001.31 Safety of Dams and Reservoirs Act means Neb. Rev. Stat. Sections 46-1601 to 46-1670.

001.32 Significant hazard potential means hazard potential classification such that failure or misoperation of the dam would result in no probable loss of human life but could result in major economic loss, environmental damage, or disruption of lifeline facilities.

001.33 Storage elevation means the elevation of the reservoir surface associated with a level of impoundment, such as maximum storage or normal storage.

001.34 Top of dam elevation means the maximum design elevation for the top of the dam, including design freeboard allowances but excluding any allowance for settlement due to consolidation of the foundation and embankment.

STATUTORY AUTHORITY: Neb. Rev. Stat. §§ 46-1601 to 46-1670
Neb. Rev. Stat. § 61-206

EFFECTIVE DATE: July 2, 2008

NEBRASKA ADMINISTRATIVE CODE

Title 458 - NEBRASKA DEPARTMENT OF NATURAL RESOURCES
RULES FOR SAFETY OF DAMS AND RESERVOIRS

Chapter 2 – DOCUMENTATION OF SIGNATURES

001 The following documentation must be submitted when applicable with any document required to be filed and signed under the provisions of these rules.

001.01 Persons signing as landowner shall submit a copy of the deed or other document conveying ownership of all lands under the project.

001.02 Persons signing as owners shall submit the trust agreement, lease, memorandum of agreement, deed, or other document showing sufficient interest to operate and maintain the dam or reservoir.

001.03 If an owner or landowner is a trust, they shall submit a copy of the trust agreement and the name of the trust and the names of all the trustees.

001.04 Persons signing as attorney-in-fact (power of attorney) shall submit a copy of the document granting power of attorney.

001.05 Persons signing as the personal representative shall submit a copy of the document appointing the person personal representative.

001.06 Persons signing as an agent of the owner shall submit a copy of the document granting him or her authority to act as the owner's agent.

STATUTORY AUTHORITY: Neb. Rev. Stat. §§ 46-1601 to 46-1670
Neb. Rev. Stat. § 61-206

EFFECTIVE DATE: July 2, 2008

NEBRASKA ADMINISTRATIVE CODE

Title 458 - NEBRASKA DEPARTMENT OF NATURAL RESOURCES
RULES FOR SAFETY OF DAMS AND RESERVOIRS

Chapter 3 – FEES

001 The filing fee for an application for approval of the construction, enlargement, reconstruction, alteration, abandonment, breach, or removal of a dam shall be determined by measuring the height of the dam from the natural bed of the stream or watercourse at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum storage elevation.

001.01 The fee shall be one-hundred and fifty dollars ($150.00) for dams less than twenty-five feet in height.

001.02 The fee shall be two-hundred and fifty dollars ($250.00) for dams twenty-five feet in height to not more than fifty feet in height.

001.03 The fee shall be three-hundred and fifty dollars ($350.00) for dams in excess of fifty feet in height.

002 The amount of the filing fee for the approval of plans of a previously constructed dam is the same as the amount for construction of a new dam of the same size.

003 The filing fee for a request for consulting board review is $10.

004 The filing fee for a request for a waiver to install outlet works is $10.

STATUTORY AUTHORITY: Neb. Rev. Stat. § 46-1655
Neb. Rev. Stat. § 33-105(8)
Neb. Rev. Stat. § 61-206

EFFECTIVE DATE: July 2, 2008

NEBRASKA ADMINISTRATIVE CODE

Title 458 - NEBRASKA DEPARTMENT OF NATURAL RESOURCES
RULES FOR SAFETY OF DAMS AND RESERVOIRS

Chapter 4 – REQUIREMENTS FOR APPLICATION APPROVAL

001 Applications. Any person intending to construct, enlarge, reconstruct, alter, abandon, breach, or remove a dam must file an application and obtain application approval prior to construction, enlargement, reconstruction, alteration, abandonment, breach or removal of the dam. The application must be accompanied by the filing fee.

001.01 The applicant's engineer is required to meet with the Department in a pre-design conference prior to submission of an application for a significant or high hazard class dam.

001.02 Applications must be made on a form provided by the Department. Plans and specifications must be submitted with the application form.

001.03 If the proposed project will also require a surface water storage appropriation under Neb. Rev. Stat. § 46-241, the application may be submitted with the application for a surface water storage appropriation or anytime within six months of the filing of the application for the surface water appropriation. If the application is not filed within the six month period the application for a surface water storage appropriation shall be dismissed.

001.04 If the owner of the dam is not the landowner of the land where the dam and reservoir will be located, the application shall be accompanied by documentary evidence describing the relationship and responsibilities of the owner of the dam and the owner of the land as it relates to the dam and reservoir. Acceptable documentary evidence includes but is not limited to leases, contracts, memoranda of agreements, easements, options to buy or authority to condemn under existing laws for purposes of construction of a dam and reservoir. The application will not be approved if the owner of the dam does not have sufficient legal authority to construct, operate, and maintain the dam and reservoir for its anticipated design life or sufficient authority to comply with any order the Department issues regarding the safety of the dam or operation of the dam and reservoir.

001.05 The application must be signed by all the owners of the dam and reservoir.

001.06 The application shall include the name, mailing address, electronic address and telephone number of the person or persons responsible for maintaining and operating the dam and reservoir. Each person's responsibilities shall be described in sufficient detail to provide the Department with an understanding of who is responsible for each aspect of the dam's maintenance and operation along with accurate information about how each person can be contacted. The application must include copies of all contracts or other agreements between the applicant and the person responsible for operation and/or maintenance of the dam and reservoir.

001.07 Dams are required to have an outlet for releasing water in compliance with Neb. Rev. Stat. § 46-241(5). If the dam is designed without an outlet, a request for a waiver as described in Department rule Title 458, Chapter 6 must accompany the application for approval.

001.08 The Department will return applications that are incomplete or incorrectly filled out to the applicant. The corrected or completed application must be returned to the Department within ninety days or the application will be dismissed. Any associated application for a surface water appropriation will also be dismissed. Fees will not be refunded.

002 Plans and Specifications.

002.01 An engineer shall prepare all plans and specifications assisted by qualified engineering geologist, geotechnical engineers, geologists, and other specialists as necessary. Plans and specifications submitted to the Department shall be as detailed as they would be for submission to contractors bidding on the work.

002.02 Detailed specifications or references to standard specifications for both materials and construction aspects shall accompany the plans. The specifications shall be those currently acceptable and normally used by design and construction professionals. Material specifications are those specifications which will cover the materials proposed to be used. Construction specifications are those specifications describing how the work (construction, enlargement, reconstruction, alteration, abandonment, breach, or removal)

is to be accomplished, the sequence of procedures to be followed, the limitations, and the desired results.

002.03 Plans for construction, enlargement, reconstruction, alteration, abandonment, breach, or removal of a dam shall conform to the following:

002.03A Be made on sheets with minimum dimensions of 11 inches by 17 inches and maximum dimensions of 22 inches by 34 inches and shall have adequate margins on all sides.

002.03B Be of such clarity and with distinct characters of such size as to retain clarity and resolution when reduced to 11 inches by 17 inches. Characters shall not be smaller than one-tenth inch on the 11 inches by 17 inches drawings and two-tenths inch on the 22 inches by 34 inches drawings.

002.04 Plans shall include the following information:

002.04A A map showing the outside limits of the reservoir water line at maximum storage elevation and at normal storage elevation, the dam location, the government subdivisions in which the dam and reservoir are located including the quarter section, section, township, range, and county; the location and name of any and all streams which are the source of water or on which the dam is located and, if applicable, the location of any pump or diversion facility used to provide water to the reservoir.

002.04B The latitude and longitude of the intersection of the dam centerline with the natural stream channel. Latitude and longitude must be referenced to the North American Datum of 1983.

002.04C The course of the stream or watercourse and the drainage area boundary upstream from the proposed or existing dam.

002.04D The area, time of concentration and runoff curve number of the drainage basin.

002.04E The elevations, dimensions, materials, and maximum capacities of all spillways. Elevations shall be referenced to the North American Vertical Datum of 1988.

002.04F All pertinent hydrologic and hydraulic data. For each design storm analyzed, indicate the following:

002.04F1 The design rainfall and runoff amount,

002.04F2 The recurrence interval,

002.04F3 The peak inflow into the reservoir,

002.04F4 The maximum discharge from each spillway,

002.04F5 The peak reservoir elevation and flow velocity in the auxiliary spillway, and

002.04F6 The results of the auxiliary spillway stability analysis.

002.04G A topographic map of the dam site and the return area to the natural channel from all conduits and spillway(s). The map must be derived from on site or photogrammetric survey and show 2-foot contour intervals or less.

002.04H A topographic map of the reservoir within the reservoir area. The map must be derived from on site or photogrammetric survey and show 2-foot contour intervals or less.

002.04I A table showing the reservoir surface area and incremental and cumulative reservoir storage at 2-foot elevation intervals and at the crest elevation of the drawdown, principal and auxiliary spillways, other outlets and the top of dam elevation.

002.04J The cross sections listed below, with all elevations referred to in the cross sections referenced to the North American Vertical Datum of 1988 or an assumed benchmark.

002.04J1 The valley along the centerline of the dam showing the profile of the top of the dam and the original ground line;

002.04J2 A maximum cross section perpendicular to the dam centerline and other cross-sections or views to clarify construction details;

00204J3 Other cross-sections, profiles or plan views showing the location and elevations of the drawdown works, spillways and other components.

002.04K If there are multiple owners or there are easements appurtenant to the land where the dam and reservoir are located, a plan of survey showing the boundary line of each ownership and easement. The plan of survey shall include labels to indicate separate ownerships or easements. This drawing must agree with the information provided in the application described in Chapter 4.001.04 of these rules.

002.04L The certificate of the engineer responsible for design of the facility. Examples of engineer's certificates are available on the Department's web site. The engineer's certificate shall include a designation of the hazard classification for the dam. The certificate shall be on the first sheet of the drawings.

003 Emergency Action Plans.

003.01 An emergency action plan that meets the requirements of Neb. Rev. Stat. § 46-1647 must be submitted with an application if the dam is classified as a high hazard dam. If the dam is classified as a significant hazard dam, the Department will notify the applicant if an emergency action plan is required and when the plan must be filed.

003.02 An emergency action plan shall include:

003.02A an emergency notification plan with flowchart;

003.02B a statement of purpose;

003.02C a project description;

003.02D the plan for emergency detection, evaluation, and classification;

003.02E a chart identifying the general responsibilities of emergency personnel and their names and telephone numbers;

003.02F a preparedness plan;

003.02G inundation maps or other acceptable description of the inundated area;

003.02H appendices.

STATUTORY AUTHORITY: Neb. Rev. Stat. § 46-1651
Neb. Rev. Stat. § 46-1652
Neb. Rev. Stat. § 46-1653
Neb. Rev. Stat. § 61-206

EFFECTIVE DATE: July 2, 2008

NEBRASKA ADMINISTRATIVE CODE

Title 458 - NEBRASKA DEPARTMENT OF NATURAL RESOURCES
RULES FOR SAFETY OF DAMS AND RESERVOIRS

Chapter 5 - REQUIREMENTS FOR DAMS CONSTRUCTED PRIOR TO SEPTEMBER 4, 2005, AND NOT PREVIOUSLY APPROVED BY THE DEPARTMENT.

001 This Chapter applies to all dams that were completed prior to September 4, 2005, but have not been approved by the Department.

002 Applications. Application must be made on a form provided by the Department. Plans and specifications for the dam must be submitted to the Department with the application form. The filing fee shall accompany the application.

002.01 If a surface water appropriation is required for the storage reservoir in accordance with Neb. Rev. Stat. § 46-241, the plans, specifications and application for approval shall be submitted at the same time as the application for a surface water appropriation.

002.02 If the owner of the dam is not the landowner of the land where the dam and reservoir are, the application shall be accompanied by documentary evidence describing the relationship and responsibilities of the owner of the dam and the landowner. Acceptable documentary evidence includes but is not limited to leases, contracts, memoranda of agreement, or easements. The application will not be approved if the owner of the dam does not have sufficient legal authority to operate and maintain the dam and reservoir for its anticipated design life or sufficient authority to comply with any order the Department issues regarding the safety of the dam or operation of the dam and reservoir.

002.03 The application form must be signed by all the owners of the dam and reservoir.

002.04 The application shall include the name, mailing address, electronic address and telephone number of the person or persons responsible for maintaining and operating the dam and reservoir. Each person's responsibility shall be described in sufficient detail to provide the Department a complete description of each person's duties and responsibilities and accurate information about how each person can be contacted. The application must include copies of all contracts or other agreements between the

applicant and the person responsible for operation and/or maintenance of the dam and reservoir.

002.05 If the dam does not have an outlet for releasing water in compliance with Neb. Rev. Stat. § 46-241(5), a request for a waiver as described in Department rule Title 458, Chapter 6 must accompany the application for approval.

002.06 The Department will return applications that are incomplete or incorrectly filled out to the applicant. The corrected or completed application must be returned to the Department within ninety days. Failure to refile within 90 days will result in the forfeiture of the fees, and dismissal of the application. If applicable, the application for an associated surface water storage appropriation will also be dismissed.

003 Plans. All plans and specifications shall be prepared by an engineer, assisted by qualified engineering geologists, geotechnical engineers, geologists and other specialists as necessary. Plans and specifications shall be as detailed as they would be for submission to contractors bidding on work. Plans shall include:

003.01 A topographic map of the reservoir area as determined by on-site or photogrammetric surveys with 2 foot contour intervals or less.

003.02 A table showing the incremental and cumulative reservoir surface area and reservoir storage at 2-foot elevation intervals and at the crest elevation of the drawdown, the principal and auxiliary spillways, other outlets and the top of dam elevation.

003.03 A map showing the outside limits of the reservoir water line at maximum storage elevation and at normal storage elevation, the dam location, the government subdivisions in which the dam and reservoir are located including the quarter section, section, township, range, and county; the location and name of any and all streams which are the source of water or on which the dam is located and, if applicable, the location of any pump or diversion facility used to provide water to the reservoir.

003.04 The height of the dam from the downstream toe of the dam to the maximum storage elevation.

003.05 The cross sections listed below. All elevations referred to in the cross sections must refer to the North American Vertical Datum of 1988 or an assumed benchmark.

003.05A The valley along the centerline of the dam showing the profile of the top of the dam and the original ground line;

003.05B A maximum cross section perpendicular to the dam centerline and other cross-sections or views to clarify construction details;

003.05C Other cross-sections, profiles or plan views showing the location and elevations of the drawdown works, spillways, and other components.

003.06 Elevations, dimensions, materials, and maximum capacities of all spillways.

003.07 If there are multiple owners or there are easements appurtenant to the land where the dam and reservoir are located, a plan of survey showing the boundary line of each ownership and easement. The plan of survey shall include labels to indicate separate ownerships or easements. This drawing must agree with the information provided in the application described in Chapter 5.002.02 of these rules.

003.08 A statement, certified by an engineer, as to the hazard classification of the dam and whether it is subject to the Safety of Dams and Reservoirs Act.

004 Emergency Action Plans.

004.01 An emergency action plan that meets the requirements of Neb. Rev. Stat. § 46-1647 must be submitted with an application if the dam is classified as a high hazard dam. If the dam is classified as a significant hazard dam, the Department will notify the applicant if an emergency action plan is required and when the plan must be filed.

004.02 An emergency action plan shall include:

004.02A an emergency notification plan with flowchart;

004.02B a statement of purpose;

004.02C a project description;

004.02D the plan for emergency detection, evaluation, and classification;

004.02E a chart identifying the general responsibilities of emergency personnel and their names and telephone numbers;

004.02F a preparedness plan;

004.02G inundation maps or other acceptable description of the inundated area;

004.02H appendices.

STATUTORY AUTHORITY: Neb. Rev. Stat. § 46-241
Neb. Rev. Stat. § 46-1611
Neb. Rev. Stat. § 46-1651
Neb. Rev. Stat. § 46-1652
Neb. Rev. Stat. § 46-1653
Neb. Rev. Stat. § 46-1670
Neb. Rev. Stat. § 61-206

EFFECTIVE DATE: July 2, 2008

NEBRASKA ADMINISTRATIVE CODE

Title 458 - NEBRASKA DEPARTMENT OF NATURAL RESOURCES
RULES FOR SAFETY OF DAMS AND RESERVOIRS

Chapter 6 - OUTLET WORKS

001 REQUIREMENT. In order to protect the rights of persons downstream and to facilitate compliance with interstate compacts, decrees and agreements, all dams, including all structures subject to Chapter 4 and 5 of these rules, are required to have an outlet works. The Department may waive the requirement for an outlet works if the owner of the dam has an acceptable alternative method for passing water when ordered to do so. A request for a waiver must be filed on a form provided by the Department and must describe why an outlet works is not necessary, and how the owner of the dam will meet the requirements of Neb. Rev. Stat. § 46-241(5) and be accompanied by the filing fee. The Department will not allow waivers for dams associated with public roadways, or for dams required to have emergency action plans.

STATUTORY AUTHORITY: Neb. Rev. Stat. § 46-241
Neb. Rev. Stat. § 61-206
Neb. Rev. Stat. § 33-105(8)

EFFECTIVE DATE: July 2, 2008

NEBRASKA ADMINISTRATIVE CODE

Title 458 - NEBRASKA DEPARTMENT OF NATURAL RESOURCES
RULES FOR SAFETY OF DAMS AND RESERVOIRS

Chapter 7 - CHANGE OF OWNERSHIP

001 The owner of any dam shall notify the Department of any change in the ownership of the dam or reservoir or of the land where the dam and reservoir are located. The notification shall be made on a form provided by the Department. All forms shall include the following:

001.01 For those instances where the ownership of the land has changed, a copy of the deed or other document transferring ownership of the land occupied by the dam and reservoir shall be submitted with the form.

001.02 For those instances where the ownership of the dam has changed, and the owner of the dam is not the owner of the land where the dam and reservoir are located, a copy of the trust agreement, lease, memorandum of agreement, deed, or other document transferring ownership of the dam and describing the responsibilities and authorities of the new owner shall be submitted with the form.

001.03 If the dam and reservoir are located on a tract not under one contiguous ownership, or there are holders of easements on the land where the dam and reservoir are located, the owner of the dam shall submit with the change of ownership form, a copy of an agreement, signed by all owners and applicable holders of easements, describing: (1) who is responsible for the operation of the dam and reservoir, including any releases from the reservoir; (2) who is responsible for maintenance of the structure; and (3) for reservoirs that are permitted under the provisions of Neb. Rev. Stat. § 46-241, what amount of the appropriation to impound is to be appurtenant to each owner's property and what is the basis for the distribution. Such agreements are not required when the deed or document transferring ownership or an easement describes such information and such document is submitted with the form.

STATUTORY AUTHORITY: Neb. Rev. Stat. § 46-1641
Neb. Rev. Stat. § 61-206
Neb. Rev. Stat. § 76-2,124

EFFECTIVE DATE: July 2, 2008

NEBRASKA ADMINISTRATIVE CODE

Title 458 - NEBRASKA DEPARTMENT OF NATURAL RESOURCES
RULES FOR SAFETY OF DAMS AND RESERVOIRS

Chapter 8 - CHANGE OF ADDRESS

001 The owner of any dam shall promptly notify the Department in writing of any change of address of the owner or person responsible for maintenance or operation of the dam or reservoir.

STATUTORY AUTHORITY: Neb. Rev. Stat. § 46-1641
Neb. Rev. Stat. § 46-1651
Neb. Rev. Stat. § 61-206

EFFECTIVE DATE: July 2, 2008

NEBRASKA ADMINISTRATIVE CODE

Title 458 - NEBRASKA DEPARTMENT OF NATURAL RESOURCES
RULES FOR SAFETY OF DAMS AND RESERVOIRS

Chapter 9 - NOTICE OF CONSTRUCTION, RECONSTRUCTION, ENLARGEMENT, ALTERATION, BREACH, REMOVAL, OR ABANDONMENT

001 The owner of a dam shall provide written notice to the Department at least ten days before construction, reconstruction, enlargement, alteration, breach, removal, or abandonment of the dam is to begin. Notice shall be given immediately after foundation preparation and principal spillway construction and at least two days prior to backfilling the spillway. Notices must be in writing and addressed to the Chief Engineer or the Construction Inspector of the Department's Dam Safety Section. Notices may be delivered to the Department by mail, facsimile or electronic mail.

002. This rule does not apply to dams associated with livestock waste control facilities.

STATUTORY AUTHORITY: Neb. Rev. Stat. § 46-1654(5)
Neb. Rev. Stat. § 46-1651
Neb. Rev. Stat. § 61-206
Neb. Rev. Stat. § 33-105(8)

EFFECTIVE DATE: July 2, 2008

NEBRASKA ADMINISTRATIVE CODE

Title 458 - NEBRASKA DEPARTMENT OF NATURAL RESOURCES
RULES FOR SAFETY OF DAMS AND RESERVOIRS

Chapter 10 - COMPLETION CERTIFICATION

001 The owner of a dam shall file with the Department a completion certification after completion of a new or reconstructed dam and reservoir or enlargement of a dam and reservoir, or the alteration of any dam. The completion certification shall be on a form provided by the Department accompanied by supplementary drawings or descriptive matter signed and sealed by the engineer, showing or describing the work as actually completed. The drawings and descriptive matter shall substantially conform to the requirements for plans and specifications in Chapter 4 of these regulations. If the construction, reconstruction, enlargement or alteration of the dam and reservoir meet the requirements of the Safety of Dams and Reservoirs Act and these regulations, the Department will issue an approval to operate to the owner.

002 The owner of a dam shall file with the Department a completion certification after completion of the removal, breach, or abandonment of the dam. The completion certification shall be made on a form provided by the Department accompanied by supplementary drawing or descriptive matter, signed and sealed by the engineer responsible for the work, showing or describing the work as actually completed. The drawings or descriptive matter shall substantially conform to the requirements for plans and specifications in Chapter 4 of these regulations.

003 For dams classified as high hazard, and for those significant hazard dams that are required to have an emergency action plan, the owner of the dam shall file a report of initial fill signed and sealed by the engineer. The report shall be filed by the first May 30 after the approval to operate was issued. The report shall include information on the initial seepage flows, information regarding the integrity of the dam, and the elevations and quantity of water impounded. The owner shall continue to file a report of initial fill by May 30 of each year until the reservoir has filled to the normal permitted storage capacity. After the reservoir has filled to

its normal permitted storage capacity, the owner shall submit the report of final fill. No further reports shall be required unless the Department orders the owner to submit a report to address a safety concern.

STATUTORY AUTHORITY: Neb. Rev. Stat. § 46-1651
Neb. Rev. Stat. § 46-1657
Neb. Rev. Stat. § 46-1658
Neb. Rev. Stat. § 46-1659
Neb. Rev. Stat. § 61-206

EFFECTIVE DATE: July 2, 2008

NEBRASKA ADMINISTRATIVE CODE

Title 458 - NEBRASKA DEPARTMENT OF NATURAL RESOURCES
RULES FOR SAFETY OF DAMS AND RESERVOIRS

Chapter 11 - CONSULTING BOARD

001 When the safety and technical considerations pertaining to an application approval, an approval to operate, or the plans and specifications of a dam require it, or when requested by the owner, the Department shall appoint a Consulting Board of three or more engineers to report to the Department on the safety features involved. The cost and expense of a Consulting Board, if appointed at the request of an owner, shall be paid by the owner.

002 Dam owners interested in having an independent third-party review performed shall submit their request to the Department in writing. The Department will not accept a request for review from anyone other than the owner of a dam. The request must be accompanied by the filing fee and include the following information:

002.01 The purpose of requesting a Consulting Board review.

002.02 The application number or plan number assigned to the project by the Department.

002.03 A statement acknowledging that the dam owner understands that the fees associated with the Consulting Board review are the responsibility of the dam owner and that the dam owner agrees to pay such fees.

002.04 A statement acknowledging that the conclusions and recommendations of the Consulting Board are not binding upon the Department and that the Department maintains the final authority for the approval of all designs, reports, studies, and other engineering documents.

003 Any engineer willing to serve on a Consulting Board may submit their qualifications to the Department.

004 The Department shall maintain a list of all engineers willing to serve on a Consulting Board on its website whom the Department has found to be qualified.

005 Upon receipt of a request for a Consulting Board review, the Department shall randomly appoint engineers on the list that are able to serve for the project described. Those appointed cannot have any conflict of interest concerning the project subject to review and shall not have been employed by the dam owner within the last five years.

006 Once the board is formed, the Department will schedule a meeting with the dam owner, Department and the Consulting Board. The purpose of the meeting is to discuss the purpose and extent of the review and the time frame for completing the review. The dam owner shall pay to the Board members one-half the probable costs of review prior to the start of the review.

007 The Consulting Board's role is to provide an independent review. Therefore, when reviewing plans and specifications of another engineer, the Consulting Board shall send to the Department in writing any questions it has for the design engineer, or shall request the Department to schedule a meeting with the design engineer.

008 The dam owner, the engineer or any agent of the owner are prohibited from contacting or lobbying the Consulting Board except for contact made during meetings scheduled and attended by the Department. Any contact by the dam owner, the engineer or any agent of the owner with a member of the Consulting Board shall be documented in writing by the board member and provided to the Department.

009 The Consulting Board shall compile a final report of its review and submit a copy to the Department and to the dam owner.

STATUTORY AUTHORITY: Neb. Rev. Stat. § 46-1645
Neb. Rev. Stat. § 46-1651
Neb. Rev. Stat. § 61-206

EFFECTIVE DATE: July 2, 2008

NEBRASKA ADMINISTRATIVE CODE

Title 458 - NEBRASKA DEPARTMENT OF NATURAL RESOURCES
RULES FOR SAFETY OF DAMS AND RESERVOIRS

Chapter 12 - HAZARD POTENTIAL CLASSIFICATION

001 All dams shall be classified as high hazard potential, significant hazard potential, low hazard potential, or minimal hazard potential as defined in these rules. The Department will accept only those hazard potential classifications made by an engineer with experience in classifying dam hazard potential.

002 Any dam located within three miles of the jurisdictional limits of a city of the metropolitan class or primary class, or any dam within two miles of the jurisdictional limits of a city of the first class, or any dam within one mile of the jurisdictional limits of a city of the second class or a village, shall be classified as high hazard potential unless such dam and hazard classification were previously approved by the Department.

Classification can be mitigated or adjusted if development in the breach route area is sufficiently curtailed due to zoning restrictions, easements, deed restrictions, or other methods of restriction acceptable.

STATUTORY AUTHORITY: Neb. Rev. Stat. § 46-1651
Neb. Rev. Stat. § 61-206

EFFECTIVE DATE: July 2, 2008

NEBRASKA ADMINISTRATIVE CODE

Title 458 - NEBRASKA DEPARTMENT OF NATURAL RESOURCES
RULES FOR SAFETY OF DAMS AND RESERVOIRS

Chapter 13 - OPERATION AND MAINTENANCE OF A DAM AND RESERVOIR

001 Requirement**.** It is the responsibility of the owner(s) of the dam and reservoir to notify the Department of any changes in responsibility for the maintenance or operation of the dam or reservoir, including who is responsible for any releases from the reservoir. Notification shall be made on a form provided by the Department and include the name, mailing address, electronic address and telephone number of the person or persons responsible for maintaining and operating the dam and reservoir. The owner(s) shall provide a complete description of each person's duties and responsibilities and accurate information about how each person can be contacted. Copies of all contracts or other agreements between the dam owner and the person(s) responsible for operation and/or maintenance of the dam and reservoir shall be submitted with the notification form.

STATUTORY AUTHORITY: Neb. Rev. Stat. § 46-1651
Neb. Rev. Stat. § 61-206

EFFECTIVE DATE: July 2, 2008

E.27. Nevada



State of Nevada
Department of Conservation & Natural Resources
Division of Water Resources
Jason King, P.E., State Engineer

DAM SAFETY GUIDELINES

SPILLWAY DESIGN

The single most common cause of earthen dam failures is overtopping of the embankment. **An undersized spillway will lead to overtopping**, therefore spillway design is critical to reservoirs. Very often, the cost of a spillway of ample capacity will only be moderately higher than that of one that is woefully inadequate. The spillway must be located such that discharge will not erode or undermine the toe of the dam. If the banks of the spillway are made of erosive material, provision must be made for their protection. An emergency spillway must have sufficient capacity to allow for the conveyance of peak flows during floods. Consideration must be given to the hazard to human life and potential property damage that may result from the failure of the dam or excessive flow rates through the spillway. Further consideration must be given to the likelihood of downstream development that may result in an elevation of the hazard classification.

The following flood criteria should be used when designing a spillway given the different dam hazard designations (NAC 535.240):

High Hazard: Probable Maximum Flood (PMF) on all dams.

Significant Hazard: PMF if no provision for a spillway is incorporated into the design or it is classified as a "large" dam.

The greater of 1/2PMF or a "500-year" flood (0.2 percent chance of exceedence in any year) for "medium" and "small" dams. Low Hazard: "100-year" flood (1 percent chance of exceedence in any year) on all dams.	Most effluent, process fluid and tailing impoundments are exempt from having a spillway, however, there must be diversion channels to route flood flows around the structure and/or sufficient freeboard designed into the structure to accommodate the required precipitation event. A dam may also be designed to either impound the design flood or accommodate overtopping in which case no separate emergency spillway is necessary.

[Rev. 2/18/2010 11:16:04 AM]

CHAPTER 535 - DAMS AND OTHER OBSTRUCTIONS

NRS 535.005 Chapter does not authorize use of state land without authorization from State Land Registrar.
NRS 535.010 Construction, reconstruction or alteration of dam: Permit to appropriate water required; notice; approval of plans and specifications; inspection; exemptions; penalty.
NRS 535.020 State Engineer to file copy of application to construct dam with Board of Wildlife Commissioners; installation of fishways; protection and preservation of fish.
NRS 535.030 Inspection of dams by State Engineer; powers of State Engineer to protect life or property.
NRS 535.040 Statutes and performance of State Engineer's duties do not constitute warranty.
NRS 535.050 State Engineer may order removal of dam, diversion works or obstruction; limitation; procedure; payment of costs.
NRS 535.060 Obstruction of water by beaver's dam: Procedure for removal of beaver and dams.
NRS 535.070 Construction of weir in dam situated within 2 miles of incorporated city or town.
NRS 535.080 Attorney General and County Commissioners of Washoe County authorized to institute actions to maintain flow of Truckee River.
NRS 535.090 Unlawful obstruction of appropriator's water; penalty.
NRS 535.100 Injury or obstruction of flow of water by sawmill, slaughterhouse, brewery or tannery; civil action.
NRS 535.110 Unlawful removal, damage or destruction of piling, dike, dock or lock; unlawful structures.
NRS 535.200 Additional penalties.
NRS 535.210 Injunctive and other relief.

NRS 535.005 Chapter does not authorize use of state land without authorization from State Land Registrar. Nothing in this chapter authorizes a person to use any state land administered by the Division of State Lands of the State Department of Conservation and Natural Resources without the appropriate authorization for such a use from the State Land Registrar.

(Added to NRS by 1993, 1460)

NRS 535.010 Construction, reconstruction or alteration of dam: Permit to appropriate water required; notice; approval of plans and specifications; inspection; exemptions; penalty.

1. Any person proposing to construct a dam in this state shall, before beginning construction, obtain from the State Engineer a permit to appropriate, store and use the water to be impounded by or diverted by the dam.

2. Any such person obtaining or possessing such a permit shall:

(a) Before constructing, reconstructing or altering in any way any dam, notify the State Engineer thereof; and

(b) Where the dam is or will be 20 feet or more in height, measured from the downstream toe to the crest of the dam, or is less than 20 feet in height and will impound more than 20 acre-feet of water, submit to the State Engineer in triplicate plans and specifications thereof for approval 30 days before construction is to begin.

3. The State Engineer shall examine such plans and specifications and if the State Engineer approves them the State Engineer shall return one copy with such approval to the applicant. If the State Engineer disapproves any part of the plans and specifications the State Engineer shall return them to the applicant for correction or revision.

4. The construction and use of any dam is prohibited before approval of the plans and specifications by the State Engineer.

5. The State Engineer may at any time inspect or cause to be inspected the construction work while it is in progress to determine that it is being done in accordance with the approved plans and specifications.

6. This section applies to new construction, reconstruction and alteration of old structures.

7. The provisions of this section relating to approval of plans and specifications and inspection of dams do not apply to works constructed by the United States Bureau of Reclamation or the United States Army Corps of Engineers; but such federal agencies shall file duplicate plans and specifications with the State Engineer.

8. Any person beginning the construction of any dam before approval of the plans and specifications by the State Engineer, or without having given the State Engineer 30 days' advance notice of any proposed change, reconstruction or alteration thereof, is guilty of a misdemeanor. Each day of violation of this section constitutes a separate offense and is separately punishable.

[Part 77 1/2:140:1913; added 1951, 132]—(NRS A 1981, 1844; 1993, 206)

NRS 535.020 State Engineer to file copy of application to construct dam with Board of Wildlife Commissioners; installation of fishways; protection and preservation of fish.

1. Whenever an application for approval of plans and specifications for a new dam or for the alteration and enlargement of any dam in any stream in this state is filed with the State Engineer, the State Engineer shall file a copy of the application with the Board of Wildlife Commissioners.

2. In the construction of a dam, or the alteration or enlargement of a dam, the owner shall conform with the provisions of law for the installation of fishways over or around dams and for the protection and preservation of fish in streams obstructed by dams.

[Part 77 1/2:140:1913; added 1951, 132]—(NRS A 1979, 913)

NRS 535.030 Inspection of dams by State Engineer; powers of State Engineer to protect life or property.

1. The State Engineer from time to time shall:

(a) Make inspections of dams at state expense for the purpose of determining their safety; and

(b) Require owners to perform at their expense such work as may be necessary to supply the State Engineer with information as to the safety of such dams.

2. The owners shall perform at their expense any other work necessary to maintenance and operation which will safeguard life and property.

3. If at any time the condition of any dam becomes so dangerous to the safety of life or property as not to permit sufficient time for the issuance and enforcement of an order relative to the maintenance or operation thereof, the State Engineer may, if he or she deems it necessary, immediately employ the following remedial measures to protect either life or property:

(a) Lower the water level by releasing water from the reservoir.

(b) Completely empty the reservoir.

(c) Take such other steps as may be essential to safeguard life and property.

4. The provisions of this section shall not apply to works constructed by the United States Bureau of Reclamation or the United States Army Corps of Engineers.

[Part 77 1/2:140:1913; added 1951, 132]

NRS 535.040 Statutes and performance of State Engineer's duties do not constitute warranty. The provisions of NRS 535.010, 535.020 and 535.030 and the performance by the State Engineer of the duties of the State Engineer under them do not constitute a warranty in favor of anyone concerning the water to be impounded or diverted.

[Part 77 1/2:140:1913; added 1951, 132]—(NRS A 1973, 1170; 1981, 1844)

NRS 535.050 State Engineer may order removal of dam, diversion works or obstruction; limitation; procedure; payment of costs.

1. The State Engineer has the right, power and authority to order the removal of any dam, diversion works or obstruction that has been placed in any stream channel or watercourse when the dam, diversion works or obstruction has not been legally established and recognized through a valid claim of vested right, by decree of court or by a permit issued by the State of Nevada.

2. Nothing in this section is to be construed as giving the State Engineer any right or authority to remove any dam or diversion works that has been so legally recognized and established.

3. If the dam, diversion works or obstruction has not been removed after 30 days' notice in writing given by the State Engineer and served upon the owner or person controlling the dam, diversion works or obstruction, or if no appeal has been taken from the order of the State Engineer as is provided for in NRS 533.450, then the State Engineer may remove the dam, diversion works or obstruction.

4. The State Engineer shall charge the actual cost of that removal to the water distribution account and thereafter present an itemized statement of the charge to the board of county commissioners of the county wherein those expenses were incurred. The board of county commissioners shall thereupon present a bill for the expenses to the person liable therefor under this section, and if that person neglects for 30 days thereafter to pay it, the bill and costs become a lien upon the lands and property of the person so liable for the payment of the bill, and must be collected as delinquent taxes against the lands and property are collected.

[56 1/2:140:1913; added 1951, 132]—(NRS A 1979, 670)

NRS 535.060 Obstruction of water by beaver's dam: Procedure for removal of beaver and dams.

1. On any stream system and its tributaries in this state the distribution of the waters of which are vested in the State Engineer by law or the final decree of court, where beaver, by the construction of dams or otherwise, are found to be interfering with the lawful and necessary distribution of water to the proper users thereof, the State Engineer, upon complaint of any interested water user, shall investigate or cause the investigation of the matter.

2. The State Engineer and his or her assistants and water commissioners and the Department of Wildlife and its agents may enter upon privately owned lands for the purposes of investigating the conditions complained of and the removal and trapping of beaver.

3. If satisfied that such beaver are interfering with the flow of water to the detriment of water users, the State Engineer shall serve a written notice on the owner of the land, if it is privately owned, stating:

(a) That the beaver thereon are interfering with or stopping the flow of water necessary for the proper serving of water rights; and

(b) That unless, within 10 days from receipt of the notice, written objection to the removal of such beaver is filed with the State Engineer by the landowner, the Department of Wildlife will remove such beaver or as many thereof as will rectify the existing conditions.

4. Failure of the landowner to file such written objections shall be deemed a waiver thereof. Upon receipt of written objections, the State Engineer may make further investigation and may sustain or overrule the objections as the facts warrant. Upon the overruling of the objections, the landowner may have them reviewed by the district court having jurisdiction of the land by filing therein a petition for review within 10 days from the receipt of the order of the State Engineer overruling the objections. The proceedings on the petition must be informal and heard by the court at the earliest possible moment.

5. Upon the landowner's waiver of objections to the removal of beaver from his or her land, or upon final determination by the court that the beaver should be removed, the State Engineer shall immediately notify the Department of Wildlife of the waiver or determination and the Department or its agents shall enter upon the land from which the beaver are to be removed and remove them or as many as may be necessary to prevent the improper flow of water as directed by the State Engineer.

6. The State Engineer may remove or cause the removal of any beaver dam found to be obstructing the proper and necessary flow of water to the detriment of water users.

[Part 1:61:1949; 1943 NCL § 3148.01] + [2:61:1949; 1943 NCL § 3148.02]—(NRS A 1969, 1561; 1979, 914; 1993,

1702; 2003, 1581)

NRS 535.070 Construction of weir in dam situated within 2 miles of incorporated city or town.

1. The term "water of such river," as used in this section, means the normal and natural flow of water in the river unaffected by flood, storm or other abnormal natural causes.

2. Any person owning, leasing or constructing any dam in any river of this State within 2 miles of an incorporated city governed by a board of county commissioners shall make or construct a weir in the dam of such size as to admit of the free passage of the water of such river during such portions of the year as such water is not being used for irrigating purposes.

3. If any person fails, neglects or refuses to comply with the provisions of subsection 2, the district attorney of the county wherein the dam is situated or being constructed shall commence mandamus proceedings to compel the person to comply with the provisions of subsection 2, or the board of county commissioners of the county may order the weir to be constructed at the expense of the county, and the county has a right of action against the owner or lessee of the dam for all expenses incurred by the county in constructing the weir and may recover judgment on the right of action and satisfy the judgment in the manner provided by law.

4. The provisions of this section do not apply to dams constructed or being constructed or hereafter to be constructed for the purpose of permanently storing the waters of such river for beneficial purposes.

[1:182:1913; 1919 RL p. 2668; NCL § 8002] + [2:182:1913; 1919 RL p. 2669; NCL § 8003] + [3:182:1913; 1919 RL p. 2669; NCL § 8004] + [4:182:1913; 1919 RL p. 2669; NCL § 8005]—(NRS A 1987, 1725)

NRS 535.080 Attorney General and County Commissioners of Washoe County authorized to institute actions to maintain flow of Truckee River. The Attorney General and the Board of County Commissioners of Washoe County are authorized and empowered to commence suits or take such other action as may be necessary to maintain a regular or natural flow of water in the Truckee River, and in all suits so instituted, if necessary, to use the name of "The State of Nevada."

[1:120:1879; cited BH § 5013; RL § 4140; NCL § 7326]

NRS 535.090 Unlawful obstruction of appropriator's water; penalty.

1. Whenever any appropriator of water has the lawful right-of-way for the storage, diversion or carriage of water, it shall be unlawful to place or maintain any obstruction that shall interfere with the use of his or her works or prevent convenient access thereto.

2. Any person who violates any of the provisions of this section is guilty of a misdemeanor.

[82:140:1913; 1919 RL p. 3247; NCL § 7968] + [83:140:1913; 1919 RL p. 3247; NCL § 7969]—(NRS A 1967, 610)

NRS 535.100 Injury or obstruction of flow of water by sawmill, slaughterhouse, brewery or tannery; civil action.

1. Any person who is the owner of or in possession of any sawmill used for the making of lumber, or any slaughterhouse, brewery or tannery shall not injure or obstruct the natural flow of water in any river, creek or other stream.

2. Any city or county government, or any person, who is the owner of or in possession of any agricultural lands and who is injured by reason of the violation on the part of any person of the provisions contained in subsection 1 may commence and maintain an action against the person for any damage sustained, in such manner as may be provided by law.

[Part 1:98:1862; B § 3847; BH § 353; C § 432; RL § 4718; NCL § 8248] + [2:98:1862; B § 3848; BH § 354; C § 433; RL § 4719; NCL § 8249] + [3:98:1862; B § 3849; BH § 355; C § 434; RL § 4720; NCL § 8250]—(NRS A 1967, 610; 2007, 2022)

NRS 535.110 Unlawful removal, damage or destruction of piling, dike, dock or lock; unlawful structures.

1. Every person who willfully and maliciously removes, damages or destroys a pile or other material fixed in the ground and used for securing any bank or dam of any river or other water, or any dike, dock, quay, jetty or lock is guilty of a misdemeanor.

2. Every person who:

(a) Moors any vessel, scow, barge, raft or boom to any bridge; or

(b) Erects or maintains any unlawful structure in any stream or river,

➥ is guilty of a misdemeanor.

[Part 1911; C&P § 487; RL § 6752; NCL § 10434]—(NRS A 1993, 864)

NRS 535.200 Additional penalties.

1. In addition to any other penalty provided by law, the State Engineer may, after notice and opportunity for a hearing, require a person who violates any provision of this chapter, any permit, order or decision issued by the State Engineer pursuant to this chapter or any regulation adopted by the State Engineer pursuant to NRS 532.120 to pay an administrative fine not to exceed $10,000 per day for each violation as determined by the State Engineer.

2. If an administrative fine is imposed against a person pursuant to subsection 1, the State Engineer may require the person to pay the costs of the proceeding, including investigative costs and attorney's fees.

3. An order imposing an administrative fine or requiring the payment of costs or fees pursuant to this section may be reviewed by a district court pursuant to NRS 533.450.

(Added to NRS by 2007, 2021)

NRS 535.210 Injunctive and other relief.

1. The State Engineer may seek injunctive relief in the appropriate court to prevent the continuance or occurrence of any act or practice which violates any provision of this chapter, any permit, order or decision issued by the State Engineer pursuant to this chapter or any regulation adopted by the State Engineer pursuant to NRS 532.120.

2. On a showing by the State Engineer that a person is engaged, or is about to engage, in any act or practice which violates or will violate any provision of this chapter, any permit, order or decision issued by the State Engineer pursuant to this chapter or any regulation adopted by the State Engineer pursuant to NRS 532.120, the court may issue, without a bond,

any prohibitory or mandatory injunction that the facts may warrant, including a temporary restraining order issued ex parte or, after notice and hearing, a preliminary or permanent injunction.

3. Failure to establish lack of an adequate remedy at law or irreparable harm is not a ground for denying a request for a temporary restraining order or injunction.

4. The court may require the posting of a sufficient performance bond or other security to ensure compliance with the court order within the period prescribed.

5. Any proceeding conducted or injunction or order issued pursuant to this section is in addition to, and not in lieu of, any other penalty or remedy available for a violation of this chapter.

(Added to NRS by 2007, 2021)

E.28. New Hampshire



TABLE OF CONTENTS

CHAPTER Env-Wr 100 ORGANIZATIONAL RULES
PART Env-Wr 101 DEFINITIONS
Section Env-Wr 101.01 100 – Year Flood
Section Env-Wr 101.02 50-Year Flood
Section Env-Wr 101.03 Acre-Foot
Section Env-Wr 101.04 Applicant
Section Env-Wr 101.05 Breached Dam
Section Env-Wr 101.06 Class AA Structure
Section Env-Wr 101.07 Class A Structure
Section Env-Wr 101.08 Class B Structure
Section Env-Wr 101.09 Class C Structure
Section Env-Wr 101.10 Construction Engineer
Section Env-Wr 101.11 Controlled Breach
Section Env-Wr 101.12 Dam
Section Env-Wr 101.13 Dam in Disrepair
Section Env-Wr 101.14 Days
Section Env-Wr 101.15 Department
Section Env-Wr 101.16 Discharge Capacity
Section Env-Wr 101.17 Emergency Condition
Section Env-Wr 101.18 Environmentally-Sensitive Site
Section Env-Wr 101.19 Flashboards
Section Env-Wr 101.20 Freeboard
Section Env-Wr 101.21 Great Pond
Section Env-Wr 101.22 Height
Section Env-Wr 101.23 Inflow Design Flood
Section Env-Wr 101.24 Inland Public Water
Section Env-Wr 101.25 Menace to Public Safety
Section Env-Wr 101.26 Mills
Section Env-Wr 101.27 Low Economic Loss
Section Env-Wr 101.28 Non-Permitted
Section Env-Wr 101.29 Normal Storage Capacity
Section Env-Wr 101.30 Owner
Section Env-Wr 101.31 Person
Section Env-Wr 101.32 Plans
Section Env-Wr 101.33 Reconstruction
Section Env-Wr 101.34 Removal
Section Env-Wr 101.35 Repair
Section Env-Wr 101.36 Reversible Environmental Losses
Section Env-Wr 101.37 Ruins
Section Env-Wr 101.38 Specifications
Section Env-Wr 101.39 Stage
Section Env-Wr 101.40 Storage Capacity
Section Env-Wr 101.41 Stream
Section Env-Wr 101.42 Sunny Day Flow
Section Env-Wr 101.43 Wave Run-Up

PART Env-Wr 102 DUTIES OF THE DEPARTMENT

Section Env-Wr 102.01 Summary of Duties

PART Env-Wr 103 ACCESS TO FILES
Section Env-Wr 103.01 Public Records; Access to Files

CHAPTER Env-Wr 200 PROCEDURES
PART Env-Wr 20l PURPOSE AND APPLICABILITY
Section Env-Wr 201.01 Purpose
Section Env-Wr 201.02 Applicability
Section Env-Wr 201.03 Waiver
Section Env-Wr 201.04 Definitions

PART Env-Wr 202 WAIVERS
Section Env-Wr 202.01 Applicability
Section Env-Wr 202.02 Waiver Request
Section Env-Wr 202.03 Action on Waiver Request

PART Env-Wr 203 PROCEEDINGS
Section Env-Wr 203.01 Public Hearings
Section Env-Wr 203.02 Permit Proceedings

PART Env-Wr 204 DECISION AND APPEALS
Section Env-Wr 204.01 Department Decisions
Section Env-Wr 204.02 Appeals
Section Env-Wr 204.03 Form and Appearance of Documents
Section Env-Wr 204.04 Subscription and Veracity of Documents
Section Env-Wr 204.05 Filing of Documents with the Department
Section Env-Wr 204.06 Service of Documents

PART Env-Wr 205 CONSOLIDATION AND SEVERANCE
Section Env-Wr 205.01 Consolidation
Section Env-Wr 205.02 Severance

PART Env-Wr 206 FORMAT FOR ADJUDICATORY HEARINGS
Section Env-Wr 206.01 Applicability
Section Env-Wr 206.02 Commencement, Notice of Hearing
Section Env-Wr 206.03 Time Periods and Publication of Notice
Section Env-Wr 206.04 Intervention
Section Env-Wr 206.05 Subpoena
Section Env-Wr 206.06 Evidence
Section Env-Wr 206.07 Burden of Proof
Section Env-Wr 206.08 Methods of Proceeding, Conduct of Oral Hearings

PART Env-Wr 207 DECISION AND APPEALS
Section Env-Wr 207.01 Department Order
Section Env-Wr 207.02 Appeals

PART Env-Wr 208 NON-ADJUDICATORY PUBLIC HEARINGS
Section Env-Wr 208.01 Applicability
Section Env-Wr 208.02 Non-Adjudicatory Public Hearings
Section Env-Wr 208.03 Record
Section Env-Wr 208.04 Presiding Officer

Section Env-Wr 208.05 Opening the Hearing
Section Env-Wr 208.06 Testimony
Section Env-Wr 208.07 Closing the Hearing
Section Env-Wr 208.08 Continuances

CHAPTER Env-Wr 300 EXISTING DAMS
PART Env-Wr 301 PURPOSE AND APPLICABILITY
Section Env-Wr 301.01 Purpose
Section Env-Wr 301.02 Applicability
Section Env-Wr 301.03 Roadway Culverts

PART Env-Wr 302 DAM INSPECTIONS; REPAIRS; ALTERNATIVES TO REPAIR
Section Env-Wr 302.01 Dam Inventory
Section Env-Wr 302.02 Dam Inspections
Section Env-Wr 302.03 Repairs Required
Section Env-Wr 302.04 Alternatives to Repairing or Reconstruction a Dam
Section Env-Wr 302.05 Controlled Breach; Modifications to Lower Impoundment
Section Env-Wr 302.06 Notification to Public

PART Env-Wr 303 REQUIREMENTS FOR EXISTING DAMS
Section Env-Wr 303.01 Annual Registration Fee
Section Env-Wr 303.02 Review of Hazard Classification
Section Env-Wr 303.03 Appeal of Classification
Section Env-Wr 303.04 Dam Monitoring
Section Env-Wr 303.05 Operation and Maintenance Plan
Section Env-Wr 303.06 Emergency Action Plan Required
Section Env-Wr 303.07 Dam Repair and Reconstruction
Section Env-Wr 303.08 Transfer of Ownership
Section Env-Wr 303.09 Emergency Breach
Section Env-Wr 303.10 Other Emergency Measures
Section Env-Wr 303.11 Discharge Capacity
Section Env-Wr 303.12 Meeting Discharge Capacity Requirements
Section Env-Wr 303.13 Request for Time Extension

PART Env-Wr 304 NON-PERMITTED EXISTING DAMS
Section Env-Wr 304.01 Application to Permit Existing Dam
Section Env-Wr 304.02 Inspection
Section Env-Wr 304.03 Notice to Municipality
Section Env-Wr 304.04 Procedure if Approved
Section Env-Wr 304.05 Issuance of Permit
Section Env-Wr 304.06 Limitations on Permit Issuance

CHAPTER Env-Wr 400 CONSTRUCTING OR RECONSTRUCTING A DAM
PART Env-Wr 401 PURPOSE AND APPLICABILITY
Section Env-Wr 401.01 Purpose
Section Env-Wr 401.02 Applicability

PART Env-Wr 402 APPLICATION PROCEDURES
Section Env-Wr 402.01 Application Filing

Section Env-Wr 402.02 Content of Application
Section Env-Wr 402.03 Statutory Requirements for Certain Dams
Section Env-Wr 402.04 Notice to Owner
Section Env-Wr 402.05 Classification Procedure
Section Env-Wr 402.06 Additional Information Required
Section Env-Wr 402.07 Notice to Municipality

PART Env-Wr 403 SPECIFIC DESIGN REQUIREMENTS
Section Env-Wr 403.01 Purpose
Section Env-Wr 403.02 Minimum Design Requirements of All Dams
Section Env-Wr 403.03 Additional Requirements Based on Hazard Classifications
Section Env-Wr 403.04 Design Floods for New Dams
Section Env-Wr 403.05 Hydrologic Investigations
Section Env-Wr 403.06 References for Hydraulic Determinations
Section Env-Wr 403.07 Concrete Design Criteria
Section Env-Wr 403.08 Steel Design Criteria
Section Env-Wr 403.09 Timber Design Criteria
Section Env-Wr 403.10 Earth Embankment Design Criteria

PART Env-Wr 404 ISSUANCE AND CONDITIONS OF PERMITS
Section Env-Wr 404.01 Approval
Section Env-Wr 404.02 Issuance and Recordation of Permit/Registration
Section Env-Wr 404.03 Conditions of Permit
Section Env-Wr 404.04 Time Expansion
Section Env-Wr 404.05 Design Changes

PART Env-Wr 405 DAM CONSTRUCTION INSPECTIONS
Section Env-Wr 405.01 Purpose
Section Env-Wr 405.02 Applicability
Section Env-Wr 405.03 Construction Engineer
Section Env-Wr 405.04 Inspection During Construction or Reconstruction
Section Env-Wr 405.05 Work Items to be Inspected
Section Env-Wr 405.06 Inspection Frequency
Section Env-Wr 405.07 No Design Changes Without Prior Approval
Section Env-Wr 405.08 Final Inspection Report
Section Env-Wr 405.09 Affidavit of Compliance
Section Env-Wr 405.10 As-built Drawings
Section Env-Wr 405.11 Requirements Prior to Impounding

CHAPTER Env-Wr 500 EMERGENCY ACTION PLANS
PART Env-Wr 501 PURPOSE AND APPLICABILITY
Section Env-Wr 501.01 Purpose and Applicability

PART Env-Wr 502 BREACH ANALYSIS
Section Env-Wr 502.01 When Required
Section Env-Wr 502.02 Exemption from Breach Analysis
Section Env-Wr 502.03 Repeal of Breach Analysis Exemption
Section Env-Wr 502.04 Expansion of Study Area
Section Env-Wr 502.05 Breach Analysis Required Due to Reconstruction
Section Env-Wr 502.06 Specific Requirements and Breach Parameters
Section Env-Wr 502.07 Breach Routing Methods

Section Env-Wr 502.08 Downstream Dams
Section Env-Wr 502.09 Review of Breach Analysis by Department

PART Env-Wr 503 INUNDATION MAPPING
Section Env-Wr 503.01 Inundation Map Requirements
Section Env-Wr 503.02 Simplified Inundation Map
Section Env-Wr 503.03 Department Review

PART Env-Wr 504 COORDINATION WITH LOCAL COMMUNITIES
Section Env-Wr 504.01 Communication with Community(ies)
Section Env-Wr 504.02 Acknowledgment of EAP by Local Community(ies)

PART Env-Wr 505 PREPARATION AND FORMAT OF EAP DOCUMENT
Section Env-Wr 505.01 Submittal of Draft EAP
Section Env-Wr 505.02 Format of the EAP
Section Env-Wr 505.03 Notification Flow-chart
Section Env-Wr 505.04 Responsibilities
Section Env-Wr 505.05 Notification Checklists
Section Env-Wr 505.06 Preventive Action
Section Env-Wr 505.07 Dam and Watershed Description
Section Env-Wr 505.08 Impact of Breach
Section Env-Wr 505.09 Dam Monitor and Testing
Section Env-Wr 505.10 Local Evacuation Procedure and Recovery
Section Env-Wr 505.11 List of Official EAP Holders
Section Env-Wr 505.12 Documentation

PART Env-Wr 506 FINAL DISTRUBUTION; PUBLIC NOTICE
Section Env-Wr 506.01 EAP Distribution
Section Env-Wr 506.02 Public Notice

PART Env-Wr 507 TESTING AND UPDATING PROCEDURES
Section Env-Wr 507.01 Notification Test
Section Env-Wr 507.02 EAP Review and Changes
Section Env-Wr 507.03 Reprinting of EAP

CHAPTER Env-Wr 600 REMOVAL OF DAMS
PART Env-Wr 601 PURPOSE AND APPLICABILILTY
Section Env-Wr 601.01 Purpose
Section Env-Wr 601.02 Applicability

PART Env-Wr 602 DAM REMOVAL PROPOSALS
Section Env-Wr 602.01 Qualifying Removals
Section Env-Wr 602.02 Dam Removal Proposal
Section Env-Wr 602.03 Attachment for Dam Removal Projects

PART Env-Wr 603 REVIEW PROCEDURES
Section Env-Wr 603.01 Notification
Section Env-Wr 603.02 Review

PART Env-Wr 604 APPROVAL; REPORT
Section Env-Wr 604.01 Dam Removal Approval
Section Env-Wr 604.02 Post-Removal Report

CHAPTER Env-Wr 700 LAKE LEVEL DETERMINATIONS
PART Env-Wr 701 PURPOSE AND APPLICABILITY
Section Env-Wr 701.01 Purpose
Section Env-Wr 701.02 Applicability

PART Env-Wr 702 REQUEST; PRELIMINARY INVESTIGATION
Section Env-Wr 702.01 Formal Request
Section Env-Wr 702.02 Preliminary Investigation

PART Env-Wr 703 FURTHER INVESTIGATIONS; PUBLIC HEARING
Section Env-Wr 703.01 Further Investigation and Public Hearing
Section Env-Wr 703.02 Determinations

PART Env-Wr 704 FINDINGS; DECISION
Section Env-Wr 704.01 Findings
Section Env-Wr 704.02 Report of Findings; Decision

CHAPTER Env-Wr 800 ADMINISTRATIVE FINES - **EXPIRED**

Department of Environmental Services
Water Division
29 Hazen Drive
Concord, New Hampshire 03301
Tel. No. (603) 271-3406

CHAPTER Env-Wr 100 ORGANIZATIONAL RULES

PART Env-Wr 101 DEFINITIONS

Env-Wr 101.01 "100-year flood" means the flood that has a one chance in 100 of being equaled or exceeded in a period of one year.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.02 "50-year flood" means the flood that has a one chance in 50 of being equaled or exceeded in a period of one year.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.03 "Acre-foot" means the volume of water that would cover one acre to a depth of one foot.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *8412, eff 8-20-05*

Env-Wr 101.04 "Applicant" means the person or persons filing an application to construct or reconstruct a dam.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; rpld by #4491, eff 9-20-88

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.05 "Breached dam" means a dam which no longer impounds water at the level of the primary spillway or outlet structure because of a partial or full dam failure, or because a portion of the dam has been removed.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4491, eff 9-20-88; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.06 "Class AA structure" means a dam that is not a menace because it is in a location and of a size that failure or misoperation of the dam would not result in probable loss of life or loss to property, provided the dam is:

(a) Less than 6 feet in height if it has a storage capacity greater than 50 acre-feet; or

(b) Less than 25 feet in height if it has a storage capacity of 15 to 50 acre-feet.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.07 "Class A structure" means a dam that has a low hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in any of the following:

(a) No probable loss of life;

(b) Low economic loss to structures or property;

(c) Structural damage to a town or city road or private road accessing property other than the dam owner's which could render the road impassable or otherwise interrupt public safety services;

(d) The release of liquid industrial, agricultural, or commercial wastes, septage, or contaminated sediment if the storage capacity is less than 2 acre-feet and is located more than 250 feet from a water body or water course; or

(e) Reversible environmental losses to environmentally-sensitive sites.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.08 "Class B structure" means a dam that has a significant hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in any of the following:

(a) No probable loss of life;

(b) Major economic loss to structures or property;

(c) Structural damage to a Class I or II road which could render the road impassable or otherwise interrupt public safety services;

(d) Major environmental or public health losses, including:

(1) Damage to a public water system, as defined by RSA 485:1-a, XV, which will take longer than 48 hours to repair; or

(2) The release of liquid industrial, agricultural, or commercial wastes, septage, sewage, or contaminated sediments if the storage capacity is 2 acre-feet or more; or

(3) Damage to an environmentally-sensitive site that does not meet the definition of reversible environmental losses.

Source. #1702, eff 1-1-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.09 "Class C Structure" means a dam that has a high hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in probable loss of human life as a result of:

(a) Water levels and velocities causing the structural failure of a foundation of a habitable residential structure or a commercial or industrial structure which is occupied under normal conditions;

(b) Water levels rising above the first floor elevation of a habitable residential structure or a commercial or industrial structure which is occupied under normal conditions when the rise due to dam failure is greater than one foot;

(c) Structural damage to an interstate highway which could render the roadway impassable or otherwise interrupt public safety services;

(d) The release of a quantity and concentration of materials which qualify as "hazardous waste" as defined by RSA 471-A:2 VI; or

(e) Any other circumstance which would more likely than not cause one or more deaths.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.10 "Construction engineer" means a professional engineer, licensed in New Hampshire, who has been hired by the owner to oversee construction or reconstruction of a dam.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.11 "Controlled breach" means an opening in a dam which extends from the top of the dam to the streambed made specifically for the purpose of lowering the level of impounded water to a safe level for the dam.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.12 "Dam" means "dam" as defined by RSA 482:2, II, namely "any artificial barrier, including appurtenant works, which impounds or diverts water, and which has a height of 4 feet or more, or a storage capacity of 2 acre-feet or more, or is located at the outlet of a great pond. A roadway culvert shall not be considered a dam if its invert is at the natural bed of the water course, it has adequate discharge capacity, and it does not impound water under normal circumstances. Artificial barriers which create surface impoundments for industrial, or commercial wastes or municipal sewage, regardless of height or storage capacity, shall be considered dams".

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.13 "Dam in disrepair" means "dam in disrepair" as defined by RSA 482:2, V, namely "a dam which is a menace to public safety and is incapable of safely impounding flood waters to its crest, or incapable of maintaining a reasonably constant level of waters impounded, or is one which does not contain adequate gates and sluiceways to provide for the holding or controlled discharge of waters impounded."

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.14 "Days" means calendar days unless otherwise specified.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.15 "Department" means the department of environmental services.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4491, eff 9-20-88; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.16 "Discharge capacity" means the amount of water which can safely pass the structure through its normal discharge channels.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *8412, eff 8-20-05*

Env-Wr 101.17 "Emergency condition" means:

(1) A situation has arisen at a dam which could jeopardize the integrity of the dam; or

(2) Failure of the dam is imminent or has occurred.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.18 "Environmentally-sensitive site" means:

(a) A site listed and tracked by the natural heritage inventory, as maintained by the department of resource and economic development;

(b) A prime wetland designated per RSA 482-A:15;

(c) A river segment designated pursuant to RSA 483;

(d) A prime habitat for resident or migratory fishes, as determined by the fish and game department; or

(e) Surface waters immediately downstream of a dam that support coldwater fish communities, as determined by the fish and game department.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.19 "Flashboards" means boards which temporarily raise the pond elevation above the permanent spillway crest and are designed to automatically fall over when the water level rises to a particular level.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.20 "Freeboard" means the vertical distance from the water surface to the lowest elevation at which water would flow over the dam at a section not designed to be overflowed.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4278, eff 6-30-87; ss by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.21 "Great Pond" means a water body of 10 acres or more in its natural condition.

Source. #4278, eff 6-30-87; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.22 "Height" means the vertical distance from the lowest point of natural ground on the downstream side of the dam to the highest part of the dam which would impound water.

Source. #4278, eff 6-30-87; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.23 "Inflow design flood" is the flood flow above which dam failure would not contribute to endangering public safety or property downstream of the dam.

Source. #4278, eff 6-30-87; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.24 "Inland public water" as used in RSA 482:79 means any public water of 10 acres or more whose level is controlled by a dam.

Source. #4278, eff 6-30-87; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.25 "Menace to public safety" as used in RSA 482:2, V and "menace to the public safety" as used in RSA 482:9, III, means that the failure or misoperation of the dam would threaten human life or public health or interrupt safety services. The term includes any class A, class B, or class C dam but does not include any class AA dam.

Source. #4278, eff 6-30-87; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.26 "Mills" means "mills" as defined by RSA 482:2, VII, namely "manufacturing plants and plants at which electric power is generated for public distribution or for the operation of mills, railroads or public utilities."

Source. #4278, eff 6-30-87; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.27 "Low economic loss" means economic loss to undeveloped agriculture, uninhabited structures such as storage sheds, or minor impact to sites listed or tracked by the natural heritage inventory, as maintained by the department of resource and economic development.

Source. #4278, eff 6-30-87; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.28 "Non-permitted" means:

(a) For a dam constructed subsequent to 1917, that a permit, order, or authorization for construction or registration by the department or a predecessor state agency responsible for such at the time has never been issued; or

(b) For a dam constructed prior to 1917, that the location of the dam is not on file with the department.

Source. #4278, eff 6-30-87; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.29 "Normal storage capacity" means the volume of water and material which could be impounded above the natural ground elevation, when the water level is at the elevation of the lowest free-flowing discharge structure.

Source. #4278, eff 6-30-87; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.30 "Owner" means the person or persons who own a dam.

Source. #4278, eff 6-30-87; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.31 "Person" means "person" as defined by RSA 482:2,VIII, namely "any individual, partnership, association, corporation, company, organization or legal entity of any kind."

Source. #4399, eff 4-19-88, EXPIRED 4-19-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.32 "Plans" means engineering drawings including plan views, elevations, sections, and details.

Source. #4491, eff 9-20-88; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.33 "Reconstruction" means "reconstruction" as defined by RSA 482:2, X, namely:

"(a) A change in the height, length or discharge capacity the structure;

(b) Restoring a breached dam or one in ruins;

(c) Modification of flashboards which either increases their height or increases the headwater elevation at which the flashboards will fail; or

(d) A change in the structural configuration of a dam."

Source. #4491, eff 9-20-88; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.34 "Removal" means the physical elimination of a dam as governed by Env-Wr 600.

Source. #4491, eff 9-20-88; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.35 "Repair" means work on a dam that does not change the height, length or discharge capacity of the structure and that does not constitute reconstruction.

Source. #4491, eff 9-20-88; ss by #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

Env-Wr 101.36 "Reversible environmental losses" means damage to an ecosystem which is expected to self-remediate within 5 years.

Source. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.37 "Ruins" means the remains of a dam which no longer impounds water and whose deterioration is to the extent that the original configuration can no longer be determined.

Source. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.38 "Specifications" means the descriptions of materials and methods of work sufficient in quantity and detail to convey the intent of the designer.

Source. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.39 "Stage" means the depth of water or elevation of water surface.

Source. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.40 "Storage capacity" means the maximum volume of water and material which could be impounded by a dam above the natural ground elevation when the water level is at:

(a) The top of dam; or

(b) The highest elevation which could be hydrologically attained, if this elevation is below the top of dam.

Source. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.41 "Stream" means any watercourse delineated on a USGS topographic map as a dashed or solid line, or any watercourse not delineated on a USGS topographic map that flows continuously in a well-defined channel for at least 30% of the year.

Source. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.42 "Sunny day flow" means the flow occurring in a river or stream channel during normal hydrologic conditions.

Source. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

Env-Wr 101.43 "Wave run-up" means the height of water above the still water level which would be expected to occur at a dam as a result of high winds.

Source. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by *#8412, eff 8-20-05*

PART Env-Wr 102 DUTIES OF THE DEPARTMENT

Env-Wr 102.01 Summary of Duties. Pursuant to its statutory authority under RSA 482, the department performs the following duties:

(a) Enters interstate compacts for conserving and regulating flow, lessening flood damages and removing or preventing sources of pollution, pursuant to RSA 482:91;

(b) Monitors flow by establishing and maintaining a network of stream flow gauging stations with cooperation from the United States Geological Survey, pursuant to RSA 482:85;

(c) Constructs, maintains and operates small watershed projects with cooperation from the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), pursuant to RSA 482:77;

(d) When duly-authorized by the legislature, accepts, repairs, maintains, and operates certain dams, pursuant to RSA 482:48;

(e) Makes determinations whether it will be in the public interest to grant the right to erect a dam, pursuant to RSA 482:9, V(a) and RSA 482:31;

(f) Maintains a current list of existing dams, including their size, location, classification and owner, pursuant to RSA 482:8;

(g) Regulates the construction and reconstruction of dams, pursuant to RSA 482:7-11;

(h) Makes determinations of whether dams are in disrepair and conduct follow-up proceedings, pursuant to RSA 482:11-a and RSA 482:61;

(i) Periodically inspects dams, pursuant to RSA 482:12;

(j) Makes determinations of public use and benefit, pursuant to RSA 482:17 and RSA 482:31;

(k) Grants owners of mill dams certain rights when in the public interest, pursuant to RSA 482:31;

(l) Makes channel improvements in the public interest, pursuant to RSA 482:1;

(m) Makes orders, conduct hearings, subpoena and examine under oath persons and their books, records, documents, correspondence, and accounts, as necessary to carry out its obligations, pursuant to RSA 482:87;

(n) Adopts and enforces rules, pursuant to RSA 482:87;

(o) Investigates the levels of inland public waters, pursuant to RSA 482:79;

(p) Contracts with village districts for the purpose of impounding water, pursuant to RSA 52:25;

(q) Monitors the ground water resources with the cooperation of the United States Geological Survey, pursuant to RSA 482:3, II;

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-A, eff 2-21-97; ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

PART Env-Wr 103 ACCESS TO FILES

Env-Wr 103.01 Public Records; Access to Files.

(a) The files of the department relating to activities under RSA 482 shall be open to public inspection.

(b) Information which is available for public distribution may be copied. A fee of $0.15 per page shall be assessed for photocopies made at the department's public information center by the person requesting the copies, and a fee of $0.25 per page shall be assessed for photocopies prepared by department personnel.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; #4278, eff 6-30-87; ss by #4580, eff 2-27-89; rpld by #5080, eff 2-22-91

New. #6462-A, eff 2-21-97 (formerly Env-Wr 105.01); ss by #8288, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #*8412, eff 8-20-05*

CHAPTER Env-Wr 200 RULES OF PRACTICE AND PROCEDURE

PART Env-Wr 201 APPLICABILITY, PURPOSE AND DEFINITIONS

Env-Wr 201.01 Applicability. The rules within this chapter shall govern proceedings before the department. These rules shall be construed to secure a just and speedy determination of every proceeding.

(a) The rules in this chapter are intended to supplement Env-C 200 and RSA 541-A in governing proceedings before the department under RSA 482. These rules shall be construed to secure a just and speedy determination of every proceeding.

(b) The purpose of any proceeding governed by this chapter shall be to allow the department to acquire sufficient information to make a reasonable decision, and to afford persons who may be affected by decisions of the department the opportunity to present evidence and argument to the department prior to the making of that decision.

Source. #1644, eff 10-7-80; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8413, eff 8-20-05

Env-Wr 201.02 Applicability. These rules shall apply to all proceedings initiated under RSA 482 relative to dams and lake level determinations.

Source. #1644, eff 10-7-80; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8413, eff 8-20-05

PART Env-Wr 202 WAIVERS

Env-Wr 202.01 Applicability. The rules contained in subtitle Env-Wr are intended to apply to a variety of conditions and circumstances. It is recognized that strict compliance with all rules prescribed herein might not fit every conceivable situation. Thus, any person who is or would be directly and adversely affected by the strict application of these rules may request a waiver of the rule(s) or portion(s) thereof which so affect that person.

Source. #1644, eff 10-7-80; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8413, eff 8-20-05

Env-Wr 202.02 Waiver Request.

(a) The person requesting a waiver shall submit the request in writing unless the need for a waiver does not become apparent until a hearing is underway, in which case the request shall be presented orally and made part of the record.

(b) The request for a waiver shall contain the following information:

(1) A description of the dam to which the waiver request relates, including name, address, and dam number;

(2) A citation to the specific section(s) of the rules from which a waiver is sought;

(3) A full explanation of why a waiver is being requested, including an explanation of the hardship that would be caused by compliance with the rule;

(4) A full explanation of the alternative(s) to the rule(s) for which a waiver is sought, with backup data for support; and

(5) A full explanation of how the alternative(s) are consistent with the intent of RSA 482:11-a and RSA 482:12 and would adequately protect human life, public safety, and the environment.

Source. #1644, eff 10-7-80; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8413, eff 8-20-05

Env-Wr 202.03 Action on Waiver Request.

(a) The department shall approve a request for a waiver upon determining that:

(1) The alternatives proposed are adequate to ensure that the intent of RSA 482 is met;

(2) The requirement is not one that is prescribed by statute; and

(3) Human life, public safety, and the environment will be protected.

(b) The department shall issue a written decision on a request for a waiver. If the request is denied, the decision shall specify the reason(s) for the denial.

Source. #8413, eff 8-20-05

PART Env-Wr 203 PROCEEDINGS

Env-Wr 203.01 Public Hearings. Any hearing held to receive public comment under the following statutory provisions shall be conducted in accordance with the provisions of Env-C 200 applicable to non-adjudicative hearings:

(a) RSA 482:6 relative to the management and control of the outlet of a great pond;

(b) RSA 482:9, V(a) relative to public benefit of a proposed class B or class C dam;

(c) RSA 482:30 relative to public benefit of a dam proposed under RSA 482:29; and

(d) RSA 482:79 relative to lake level determinations.

Source. #1644, eff 10-7-80; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8413, eff 8-20-05

Env-Wr 203.02 Permit Proceedings. An application for approval to construct or reconstruct a dam shall be considered a non-adjudicative proceeding in accordance with RSA 541-A:29, II(a).

Source. #8413, eff 8-20-05

PART Env-Wr 204 DECISION AND APPEALS

Env-Wr 204.01 Department Decisions.

(a) All final department decisions under RSA 482 shall be issued in writing.

(b) A final decision to grant a permit application shall be distributed as follows:

(1) Subject to Env-Wr 404.02(b), the original shall be sent to the applicant; and

(2) Copies shall be sent to all municipalities which were notified of the application pursuant to Env-Wr 304.03 or Env-Wr 402.07.

(c) A final decision to deny a permit application shall be distributed as follows:

(1) The original shall be sent to the applicant; and

(2) Copies shall be sent to all municipalities which were notified of the application pursuant to Env-Wr 304.03 or Env-Wr 402.07.

(d) Copies of a final decision in a lake level investigation shall be sent to:

(1) The owner of the dam that is the subject of the order;

(2) The person(s) who requested the investigation, if any;

(3) Each municipality in which the impounded water is located; and

(4) Each person who participated in the investigation who specifically requested to be notified of the decision.

(e) Copies of an order issued pursuant to RSA 482:11 or RSA 482:12 shall be sent to:

(1) The owner of the dam that is the subject of the order; and

(2) Each municipality in which the impounded water is located.

Source. #1644, eff 10-7-80; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4336, eff 11-5-87; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (from Env-Wr 205.01); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8413, eff 8-20-05

Env-Wr 204.02 Appeals. Appeals of department decisions under RSA 482 shall be directed to the water council in accordance with Env-WC 200.

Source. #1644, eff 10-7-80; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (from Env-Wr 205.02); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8413, eff 8-20-05

CHAPTER Env-Wr 300 EXISTING DAMS

PART Env-Wr 301 PURPOSE AND APPLICABILITY

Env-Wr 301.01 Purpose. The purpose of this chapter is to ensure that existing dams are maintained in a manner so that public health, safety, and the environment are protected.

Source. #4399, eff 4-19-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 301.02 Applicability.

(a) Subject to (b), below, the requirements in this chapter shall apply to:

(1) Any structure which qualifies as a dam in accordance with RSA 482:2, II; and

(2) Any roadway culvert meeting the requirements of Env-Wr 301.03.

(b) The requirements in this chapter shall apply to a dam regulated by the Federal Energy Regulatory Commission (FERC) pursuant to the Federal Power Act, 16 U.S.C. Chapter 12, Subchapter I, only when they do not conflict with rules, standards, protocols, licenses, certificates, or orders promulgated by the FERC pursuant to that authority.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4399, eff 4-19-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 301.03 Roadway Culverts.

(a) A roadway embankment whose culvert is set at the natural streambed shall be considered a dam if during the 25 year storm:

(1) The water surface elevation at the culvert inlet is 6 feet or more above the water surface elevation at the culvert outlet; and

(2) It impounds 2 acre-feet or more of water over the crown, or top, of the culvert.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4399, eff 4-19-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

PART Env-Wr 302 DAM INSPECTIONS; REPAIRS; ALTERNATIVES TO REPAIR

Env-Wr 302.01 Dam Inventory. The department shall maintain an inventory of all dams in the state as to ownership, height, location, and hazard classification.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 302.02 Dam Inspections.

(a) The department shall inspect dams in accordance with the following frequency:

(1) Class A structures shall be inspected at least once every 6 years;

(2) Class B structures shall be inspected at least once every 4 years;

(3) Class C structures shall be inspected at least once every 2 years; and

(4) Class AA structures having a height of 25' or more or having a storage capacity of 50 acre-feet or more shall be inspected at least once every 6 years.

(b) An individual may request the department to inspect any dam by putting such request in writing to the department.

(c) The written request for inspection shall include:

(1) The location of the dam or water body on which the dam is located;

(2) The name, mailing address, and daytime telephone number of the owner, if known; and

(3) A statement explaining why the requestor believes the dam should be inspected.

(d) The department shall review the request and any other available information on the dam. If the department determines that public safety requires the dam to be inspected, the department shall schedule an inspection of the dam.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 302.03 Repairs Required.

(a) Subject to (c), below, if the department determines as a result of an inspection that repairs or reconstruction to a dam are needed to maintain the dam in a safe condition, it shall notify the owner in writing of such repairs or reconstruction as are necessary and request the owner to undertake such repairs within the time period specified in the notice.

(b) If the owner does not undertake the needed repairs or reconstruction within the time period indicated in a notice sent pursuant to (a), above, the department shall proceed under RSA 482:12 to order the owner to undertake the repairs or reconstruction.

(c) The department shall not issue a request but instead shall directly issue an order requiring repairs or reconstruction if:

(1) The condition of the dam poses an imminent threat to public safety; or

(2) The owner of the dam has been non-responsive to department requests relating to other compliance issues.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 302.04 Alternatives to Repairing or Reconstructing a Dam.

(a) In lieu of repairing or reconstructing a dam as required pursuant to Env-Wr 302.03, the owner may:

(1) Remove the dam in accordance with Env-Wr 600; or

(2) Breach or modify the dam in accordance with Env-Wr 302.05.

(b) Such removal, breach, or modification shall be equivalent to complying with the repair or reconstruction order.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 302.05 Controlled Breach; Modifications to Lower Impoundment.

(a) The owner may request approval from the department to perform a controlled breach or to modify the dam so that the impoundment is lowered to a level that is safe for the dam.

(b) To request approval for a controlled breach or modification, the owner shall submit the following information in writing to the department:

(1) The name, mailing address, and daytime telephone number of the owner;

(2) The date of the department's order to repair or reconstruct the dam, if any, and if none, the:

a. Tax map and lot number of the property on which the dam is located;

b. Location of the dam on the applicable USGS Quadrangle map;

c. Name of the stream, river, or other water body on which the dam is located, if applicable;

d. Reason(s) for the proposed breach or modification; and

e. Hazard classification of the dam;

(3) The amount of water currently impounded by the dam, in acre-feet;

(4) Whether the request is for a controlled breach or other modification;

(5) A detailed explanation of the specific work that will be performed, including anticipated flows during the work and the effect of such flows on upstream and downstream property and public safety;

(6) The name(s), mailing address(es), and daytime telephone number(s) of the person(s) proposed to perform the work; and

(7) A proposed schedule for the work, which shall include time for the notice and hearing required by RSA 482:13.

(c) The department shall approve the proposed breach or modification if the department determines that:

(1) The proposed breach or modification will cause the structure to no longer meet the definition of a dam; and

(2) The work will be performed in a manner that will not cause flows that would result in property damage or threaten public safety upstream or downstream of the dam.

(d) If the department determines that after the proposed breach or modification the structure will still meet the definition of a dam, the department shall approve the breach or modification of the dam provided that:

(1) The work will be performed in a manner that will not cause property damage or threaten public safety upstream or downstream of the dam;

(2) The threat posed to life or property after completion of the work is no more than it would have been if the work required by the department pursuant to Env-Wr 302.03 had been completed, if applicable; and

(3) The requirements of Env-Wr 303.11 relative to discharge capacity will be met as a result of the proposed work.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 302.06 Notification to Public. After receiving approval pursuant to Env-Wr 302.05, the owner shall refrain from undertaking the work until the requirements of RSA 482:13 relative to notice to municipalities and hearing have been met.

Source. #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

PART Env-Wr 303 REQUIREMENTS FOR EXISTING DAMS

Env-Wr 303.01 Annual Registration Fee.

(a) Pursuant to RSA 482:8-a, annual registration fees for dams in the amount specified in RSA 482:8-a shall be payable to the department on January 1 of each calendar year.

(b) The department shall send a written notice, by October 31 of each year, to each owner specifying the amount of the registration fee that shall be due.

(c) The department shall send a second notice to each owner who fails to submit the annual registration fee by January 1. Such notice shall inform the owner that the payment is overdue and that if the owner fails to submit the registration fee within 10 days, the owner shall be subject to the penalties authorized by RSA 482:15 and RSA 482:89.

(d) Notices sent pursuant to (b) and (c), above, shall include whatever information the department has relative to the tax map and lot number of the dam and the volume and page number of the deed to the dam and to the property on which the dam is located, if different. At the time of paying the annual registration fee, the owner shall confirm or, if necessary, provide or correct the information.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4534, eff 11-10-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 303.02 Review of Hazard Classification.

(a) The department shall review the classification of a dam in conjunction with any inspection conducted pursuant to Env-Wr 302.02.

(b) If the department determines that a dam no longer meets the criteria of the class to which it had been assigned, the department shall reassign the dam to the proper classification.

(c) Upon reassigning a dam to a different classification, the department shall notify the owner in writing of:

(1) The new classification; and

(2) Any new requirements that may apply as a result of the reclassification.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 303.03 Appeal of Classification.

(a) If the owner disagrees with the department's decision to reclassify a dam's hazard classification, the owner may request that the department reconsider the decision.

(b) To request reconsideration, the owner shall submit a written request to the department that includes the following:

(1) The name, mailing address, and daytime telephone number of the owner;

(2) The dam number assigned by the department, if known, and if not known, the location of the dam by:

a. Tax map and lot number of the property on which the dam is located;

b. Location of the dam on the applicable USGS Quadrangle map; and

c. Name of the stream, river, or other water body on which the dam is located, if applicable;

(2) The results of a dam breach analysis, including routing of the flow downstream of the dam, completed in accordance with Env-Wr 502; and

(3) An assessment of all structures potentially impacted by a dam failure, including the depth of flooding at critical structures or groups of structures.

(c) If the department determines that the information requested in (b) is insufficient to grant the requested reconsideration, the department shall:

(1) Deny the request; or

(2) If the department believes that a favorable decision might be made if inundation mapping is provided, request the owner to provide inundation mapping completed in accordance with Env-Wr 503.01.

(d) The department shall notify the owner of its decision in writing within 60 days of receiving complete information.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 303.04 Dam Monitoring.

(a) The owner of a class A, class B, or class C dam, or the owner's designee, shall monitor the dam in accordance with this section.

(b) The dam monitor shall:

(1) Be trained in the operation of the dam;

(2) Be trained to detect and assess conditions that could affect the safety of the dam;

(3) Have authority from the owner to operate the structure during emergency situations;

(4) For a class B or class C dam, be available at the dam within 2 hours at all times; and

(5) For a class A dam, be available at the dam within 2 hours during periods of heavy precipitation, high water levels, or receipt of notification of other events that could threaten the structural integrity of the dam.

(c) The owner of a class A, class B, or class C dam shall provide:

(1) A communication system between the monitor and the local communities; and

(2) The means, materials, and equipment needed to make emergency repairs to the structure.

(d) The owner of a class B or class C dam also shall provide the training and equipment, including alternative power sources, necessary to operate the structure.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 303.05 Operation and Maintenance Plan.

(a) The owner of a class A, class B, or class C dam shall submit a written operation and maintenance plan for approval by the department.

(b) The operation and maintenance plan shall:

(1) Describe the seasonal control of impoundment levels;

(2) Describe regular maintenance activities; and

(3) Identify the name(s) and address(es) of the dam monitor(s) required by Env-Wr 303.04 and any other emergency contacts for operation of the dam that the owner wishes to designate.

(c) The department shall approve the plan if:

(1) The information submitted addresses the items specified in (b), above; and

(2) Compliance with the submitted plan will result in a dam that will be operated safely during all flow conditions and not become a dam in disrepair.

(d) The owner shall update the operation and maintenance plan as necessary and shall submit a written update to the department within 15 days of any changes.

(e) An owner that is required to complete an emergency action plan ("EAP") pursuant to Env-Wr 303.06 may incorporate the operation and maintenance plan as an appendix to the EAP.

(f) The owner shall operate and maintain the dam in accordance with the approved operation and maintenance plan.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4354, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 303.06 Emergency Action Plan Required.

(a) As required by RSA 482:11-a, the owner shall develop an emergency action plan (EAP) for any dam, the failure of which may threaten life or property.

(b) The owner of a class B or class C dam shall develop an EAP in accordance with Env-Wr 500.

(c) The operation and maintenance plan prepared by the owner of a class A dam shall constitute the EAP for that dam.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 303.07 Dam Repair and Reconstruction.

(a) Pursuant to RSA 482:9, the owner shall not initiate, or authorize anyone else to initiate, work on a dam which qualifies as reconstruction without first obtaining a permit from the department pursuant to Env-Wr 400.

(b) The owner may undertake repairs other than those qualifying as reconstruction without prior department approval.

(c) An owner wishing to perform a controlled breach or otherwise modify the dam to lower the impoundment to a safe level shall proceed in accordance with Env-Wr 302.05.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4534, eff 11-30-88; rpld by #5080, eff 2-22-91

New. #8414, eff 8-20-05

Env-Wr 303.08 Transfer of Ownership.

(a) The owner shall provide the information specified in (b), below, to any prospective owner prior to transferring:

(1) Title to the dam; or

(2) If ownership of the dam is tied to ownership of the property, the property on which the dam is located.

(b) The owner shall provide the following information:

(1) The existence of the dam;

(2) The dam number assigned by the department; and

(3) Any letters or orders issued by the department relative to the condition of the dam.

(c) Within 30 days of the transfer of ownership of a dam or the property on which a dam is located, the new owner shall inform the department in writing of the transfer of ownership by providing the following information:

(1) The name of the former owner;

(2) The dam number assigned by the department;

(3) The name, mailing address, and daytime telephone number of the new owner;

(4) The tax map and lot number of the dam; and

(5) The volume and page number of the deed which transferred ownership of the dam or the property on which the dam is located.

Source. #8414, eff 8-20-05

Env-Wr 303.09 Emergency Breach.

(a) An owner may purposefully breach a dam without prior approval from the department only when a threat to public safety or public health exists or significant damage to public or private property is imminent.

(b) The owner shall notify the department and the local police and fire departments prior to performing an emergency breach, if possible.

(c) If it is not possible to notify the department and local police and fire departments prior to performing an emergency breach, the owner shall make such notification as soon as reasonably possible, but never more than one hour after the initiation of the emergency breach.

(d) Within 30 days of performing an emergency breach, the owner shall submit an application to the department:

(1) To reconstruct the dam in accordance with Env-Wr 400, indicating whether the owner plans to further modify or rebuild the dam; or

(2) To remove the dam in accordance with Env-Wr 600.

Source. #8414, eff 8-20-05

Env-Wr 303.10 Other Emergency Measures.

(a) An owner may take measures which otherwise would require a permit to reconstruct a dam, other than emergency breaches, when it is necessary to do so in order to eliminate or reduce the risk of full or partial dam failure. Emergency repairs shall be limited to temporary stabilization of the site or mitigation of the immediate threat.

(b) The owner shall notify the department prior to taking such measures if possible but never more than 24 hours after the initiation of necessary repairs.

(c) Within 48 hours of completing the emergency repairs, the owner shall submit a written statement to the department that explains the nature of the emergency and what corrective measures were taken.

(d) Within 30 days of performing the emergency repairs, the owner shall submit an application to the department to reconstruct a dam in accordance with Env-Wr 400.

Source. #8414, eff 8-20-05

Env-Wr 303.11 Discharge Capacity.

(a) All class A, class B, or class C dams constructed prior to February 19, 1981 shall pass the flows indicated below with one foot of freeboard and without manual operations:

(1) Class A dams shall pass a 50-year flood, or at the owner's option, the site specific inflow design flood;

(2) Class B dams shall pass the 100-year flood, or at the owner's option, the site specific inflow design flood; and

(3) Class C dam shall pass 250% of the 100-year flood, or at the owner's option, the site specific inflow design flood.

(b) Dams constructed after February 19, 1981 shall pass the flow required by the administrative rules in place at the time of the dam's construction, in accordance with the classification of the dam at the time of construction.

Source. #8414, eff 8-20-05

Env-Wr 303.12 Meeting Discharge Capacity Requirements.

(a) If a dam does not have adequate discharge capacity to pass the flood specified in Env-Wr 303.11 with one foot of freeboard, the owner shall submit a plan to the department to address the deficiency.

(b) The plan submitted pursuant to (a), above, shall:

(1) Specify the action to be taken, per (c), below;

(2) Specify the proposed timeframe for taking the action; and

(3) Include the results of hydrologic analyses completed pursuant to Env-Wr 403.05, assessing the floods and discharge capacity of the structure.

(c) The plan shall specify which of the following actions the owner intends to pursue:

(1) Increase the capacity of the dam to pass the flood with one foot of freeboard and without manual operations;

(2) Submit a stability analysis to the department showing that the dam is safe against sliding, overturning, or erosion by overtopping, as applicable, during the specified flood, using the methods outlined in "Engineering Guidelines for Evaluation of Hydropower Projects" published by the Federal Energy Regulatory Commission, October 2002;

(3) Stabilize the dam so that it is safe under the specified flood conditions; or

(4) Modify the dam so that the hazard classification is lowered and the dam passes the appropriate flow for the new classification.

(d) The department shall approve the plan if the department determines that:

(1) The proposed action will bring the dam into compliance with Env-Wr 303.11;

(2) The work can be done in a way that will not:

a. Endanger life or property downstream of the dam; or

b. Cause environmental losses that are not reversible environmental losses; and

(3) The time frame for the work is reasonable under the circumstances, including the risk posed by the deficiency, the owner's financial resources, and the timing of the work in relation to other uses of the impounded water.

(e) The department shall notify the owner in writing of its decision. If the plan is not approved, the notice shall specify the reason(s) for the non-approval.

(f) If work under the plan as approved constitutes reconstruction of the dam, the owner shall submit an application in accordance with Env-Wr 400.

Source. #8414, eff 8-20-05

Env-Wr 303.13 Request for Time Extension.

(a) An owner may request a time extension to comply with any directive of the department issued pursuant to RSA 482:12.

(b) The request shall be submitted in writing to the department with the following information:

(1) The reason(s) why an extension is needed;

(2) The current status of the repairs or investigations; and

(3) The length of time of extension requested.

(c) The department shall grant the request for time extension if it determines that:

(1) The owner has in good faith pursued the work required by the directive;

(2) The owner is unable to complete the work during the time period specified;

(3) The current condition of the dam is such that it is not expected to fail under flow conditions anticipated during the extension; and

(4) The condition of the dam will not deteriorate so as to pose a threat to public safety under flow conditions anticipated during the extension.

(d) The department shall notify the owner of the decision on the request in writing. If the department denies the request, the department shall state the reason(s) for the denial.

Source. #8414, eff 8-20-05

PART Env-Wr 304 NON-PERMITTED EXISTING DAMS

Env-Wr 304.01 Application to Permit Existing Dam.

(a) When the department gains knowledge of the existence of a non-permitted dam, either by its own reconnaissance or by reports of others, it shall send a letter by certified mail to the owner of the property on which the dam is located stating the non-permitted status of the dam and the requirements with which the owner shall comply.

(b) The department shall include with the letter an "application to permit an existing dam" and a copy of RSA 482:5.

(c) Upon written notice from the department that an existing dam is non-permitted, the owner shall file the following information on or with, as applicable, the permit application form:

(1) The height and length of the dam, in feet;

(2) The volume and page number at the county registry of deeds of the deed to the dam and of the property on which the dam is located, if different;

(3) The tax map and lot number of the property on which the dam is located;

(4) The location of the dam on the applicable USGS Quadrangle map;

(5) The name of the stream, river, or water body on which the dam is located, if applicable;

(6) The type and purpose of the dam;

(7) A description of the dam foundation material;

(8) The size of the drainage area, normal pond area, maximum pond area, normal storage capacity, and maximum storage capacity of the dam;

(9) An operation and maintenance plan prepared as specified in Env-Wr 303.05;

(10) Plans and specifications which shall, at a minimum, include the following:

a. A scaled plan view;

b. A scaled cross-section view of the dam through the outlet, showing elevations of pipe inlet and outlet, if applicable, watertight connections, and embankment material; and

c. Design and cover of embankment slopes; and

(11) The name, address, and daytime telephone number of the owner.

(d) The owner shall include the following with the application:

(1) The fee required by RSA 482:5, II; and

(2) A statement that the owner has legal flowage rights on all lands which will be permanently or temporarily flooded by the dam and an indication of whether those rights are fee simple ownership, a flowage easement, prescriptive rights, or mill privileges.

(e) The owner shall sign the application and the statement required by (d)(2), above, if such statement is separate from the application.

(f) The owner's signature shall constitute certification that the information provided is true and complete to the knowledge and belief of the owner.

(g) The owner shall return the completed permit application within 30 days of receiving the letter sent pursuant to (a), above.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 304.02 Inspection. Within 30 days of receipt of the permit application, the department shall inspect the dam and area affected by the dam for conditions and factors affecting the hazard potential classification, and determine whether repair or reconstruction of the dam is required for the public safety.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 304.03 Notice to Municipality.

(a) Pursuant to RSA 541-A:39, when the department receives an application to permit a non-permitted dam, the department shall issue a notice to the municipality in which the dam is located to invite the municipality to submit data or information pertaining to the department's assessment of the dam's potential hazard. If the department receives such correspondence within 20 days of the town's receipt of the notice, it shall consider the information in issuing a permit.

(b) For structures that are likely to be classified as class B or class C, the department shall notify the municipality in which the structure is located and any municipalities which could be affected by a failure of the structure of a public hearing to be held by the department in the municipality in which the dam is located or in a municipality which could be affected by a failure of the structure. At the public hearing, the owner shall present information about the dam and a draft emergency action plan, and the department shall receive comment from the public.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4534, eff 11-30-88, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 304.04 Issuance of Permit. Subject to Env-Wr 304.05, the department shall issue a permit for the dam pursuant to RSA 482:5 if:

(a) The application is complete, including all information required by Env-Wr 304.01;

(b) The department has determined that the dam's condition is such that it does not pose an imminent threat to public safety; and

(c) Issuance of the permit is consistent with RSA 482:1.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4534, eff 11-30-88, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 304.05 Limitations on Permit Issuance.

(a) A permit for a class B or class C non-permitted dam built on or after July 25, 2000 shall be issued only if the dam meets the criteria established in RSA 482:9, V.

(b) A permit for a dam on a great pond shall be issued only in accordance with RSA 482:6.

Source. #8414, eff 8-20-05

CHAPTER Env-Wr 400 CONSTRUCTION OR RECONSTRUCTING A DAM

PART Env-Wr 401 PURPOSE AND APPLICABILITY

Env-Wr 401.01 Purpose. The purpose of this chapter is to implement RSA 482:9 by specifying the procedures for applying for a permit to construct or reconstruct a dam.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 401.02 Applicability.

(a) Subject to (b), below, the requirements in this chapter shall apply to any person who:

(1) Plans to construct or reconstruct a structure that qualifies as a dam pursuant to Env-Wr 301.02; or

(2) Has taken emergency measures as specified in Env-Wr 303.09 or Env-Wr 303.10.

(b) The requirements in this chapter shall apply to a dam regulated by the Federal Energy Regulatory Commission (FERC) pursuant to the Federal Power Act, 16 U.S.C. Chapter 12, Subchapter I, only when they do not conflict with rules, standards, protocols, licenses, certificates, or orders promulgated by the FERC pursuant to that authority.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

PART Env-Wr 402 APPLICATION PROCEDURES

Env-Wr 402.01 Application Filing.

(a) An application to construct a dam shall be filed by the owner(s) of the property on which the dam is proposed to be located.

(b) An application to reconstruct a dam, including an application relative to emergency measures pursuant to Env-Wr 401.02(a)(2), shall be filed by the owner(s) of the dam.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 402.02 Content of Application.

(a) The applicant shall submit a completed "application to construct or reconstruct a dam" form to the department.

(b) The applicant shall provide the following information on or with the form:

(1) The name, mailing address, and daytime telephone number of each applicant;

(2) The volume and page number of the deed for the property on which the dam is or is proposed to be located and, for an existing dam that was conveyed separately from the property, the volume and page number of the deed for the dam;

(3) The location of the existing or proposed dam on the applicable USGS Quadrangle map;

(4) The city/town tax map number and lot number for the property on which the dam is or is proposed to be located;

(5) The name of the stream, river, or other water body on which the dam is or will be located, if applicable;

(6) The height and length of the existing or proposed dam;

(7) The type and purpose of the existing or proposed dam;

(8) A description of the type of existing or proposed foundation material;

(9) The size of the drainage area, normal pond area, maximum pond area, normal storage capacity, and maximum storage capacity of the existing or proposed dam; and

(10) A plan and cross-section sketch of proposed dam.

(c) The owner shall include the following with the application:

(1) The fee required by RSA 482:9, II; and

(2) A statement that the owner has legal flowage rights on all lands which will be permanently or temporarily flooded by the dam and an indication of whether those rights are fee simple ownership, a flowage easement, prescriptive rights, or mill privileges.

(d) All forms shall be printed in ink, or typed.

(e) The owner shall sign the application and the statement required by (c)(2), above, if such statement is separate from the application.

(f) The owner's signature shall constitute certification that the information provided is true and complete to the knowledge and belief of the owner.

(g) Incomplete or improperly completed forms shall be returned by the department to the applicant or applicants with a statement for the reason(s) for the return and the additional information required.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 402.03 Statutory Requirements for Certain Dams.

(a) Pursuant to RSA 482:7, a new dam on a great pond shall not be constructed without specific authorization from the legislature.

(b) The department shall hold a public hearing pursuant to RSA 482:30 and RSA 482:31 upon receipt of an application for construction or reconstruction of dams falling within the scope of RSA 482:17.

(c) The public hearing shall be conducted in accordance with the provisions of Env-C 200 relative to non-adjudicative proceedings.

(d) Pursuant to RSA 482:9, V, no permit to construct a class B or class C dam shall be issued unless the requirements of that section are met.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 402.04 Notice to Owner.

(a) Within 10 days of receipt of an application, the department shall provide the owner with the following:

(1) The dam number;

(2) The date of receipt of the application; and

(3) A statement that construction shall not commence until the department and all other appropriate state or federal agencies have granted final approval.

(b) Within 30 days of classification by the department, the department shall provide the owner with the following:

(1) Design and construction requirements for the particular structure depending upon classification;

(2) Specific information needed for design review per Env-Wr 403 if the submitted design is lacking in particular areas; and

(3) For class B and C structures, notification that a permit will not be issued until a draft EAP has been submitted to the department for review and a public hearing held by the department in the community in which the dam is located.

Source. #8414, eff 8-20-05

Env-Wr 402.05 Classification Procedure.

(a) The department shall review all new dam applications to classify the structure in accordance with Env-Wr 101.06 through Env-Wr 101.09.

(b) If the owner disagrees with the department's hazard classification, the owner shall submit, for review by the department, the following:

(1) The results of a dam breach analysis performed in accordance with Env-Wr 502.06;

(2) Breach routing in accordance with Env-Wr 502.07; and

(3) Inundation mapping in accordance with Env-Wr 503.01.

(c) The owner of a proposed dam shall meet specific requirements relative to design, construction, inspection and maintenance of the structure in accordance with the applicable provisions of Env-Wr 403.

Source. #8414, eff 8-20-05

Env-Wr 402.06 Additional Information Required. If the dam will be a class A, class B, or class C structure, the owner shall submit:

(a) Plans and specifications which shall, at a minimum, include the following:

(1) Scaled plan view;

(2) Scaled cross-sectional view of dam through the outlet, showing elevations of inlet and outlet, watertight connections, embankment material;

(3) Design of and cover treatment for embankment slopes;

(4) Gradation analysis for all soils to be used during construction;

(5) Compaction specifications in accordance with Env-Wr 403.02(d) and (e);

(6) Construction sequence; and

(7) For reconstruction, the plans shall be of sufficient detail to show the location of the proposed work in relation to the entire dam; and

(b) A written operation and maintenance plan, which:

(1) Describes the seasonal control of impoundment levels;

(2) Describes regular maintenance activities; and

(3) Includes the name(s) and address(es) of the dam monitor(s).

Source. #8414, eff 8-20-05

Env-Wr 402.07 Notice to Municipality.

(a) Subject to (b) and (c), below, when the department receives an application to construct or reconstruct a dam, it shall issue a notice to the municipality in which the proposed dam will be located pursuant to RSA 541-A:39, to inform the municipality of the location, height and size of the impoundment of the proposed dam. The municipality may submit data or information pertinent to the department's consideration of the application. If the department receives such correspondence within 20 days of the town's receipt of the notice, it shall consider the information in issuing a permit to construct or reconstruct the dam.

(b) When the department receives an application to construct a Class B or class C structure, the department shall send the notice to the municipality and any municipalities which could be affected by a failure of the dam, and shall include notice of a public hearing to be held by the department in the municipality in which the dam is located or in a municipality that may be affected by a failure of the dam. At the public hearing, the owner shall present information about the dam and a draft emergency action plan, and the department shall receive comment from the public.

(c) If the application is to construct a dam on a great pond, the department shall send the notice to all municipalities in which the great pond is located.

Source. #8414, eff 8-20-05

PART Env-Wr 403 SPECIFIC DESIGN REQUIREMENTS

Env-Wr 403.01 Purpose. The purpose of this part is to set forth the minimum design requirements for all new dams and the minimum design requirements for the specific work proposed for reconstruction of existing dams.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 403.02 Minimum Design Requirements of All Dams. An application for construction of a new dam or reconstruction of an existing dam shall incorporate the following design requirements:

(a) The embankment slopes shall be no steeper than 2.5 horizontal to 1 vertical unless a specific design for a steeper slope shows that the embankment is stable and capable of being safely maintained;

(b) The embankment top width shall be 6 feet or greater;

(c) Any earthen spillway shall be constructed in natural ground;

(d) Soil compaction specifications shall be shown on the plans; and

(e) Pre-compacted lift thickness shall be compatible with the material and equipment to be used, but no greater than 12 inches in depth.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 403.03 Additional Requirements Based on Hazard Classification.

(a) For the construction or reconstruction of a class A, class B, or class C dam:

(1) All final plans and design documents shall be stamped by a professional engineer, licensed in the State of New Hampshire, with a minimum of 5 years of engineering experience related to the design and construction of similar dam projects, as determined by the department after a review of the engineer's resume;

(2) The project shall be inspected in accordance with Env-Wr 405; and

(3) A construction inspection plan, prepared in accordance with Env-Wr 405.04, shall accompany the application for construction or reconstruction.

(b) A design for construction of a new class A, class B, or class C dam, with the exception of dams impounding liquid industrial, agricultural, or commercial wastes, or municipal sewage, shall be equipped with a pond drain.

(c) A design for construction of a class B or class C dam shall also include the following:

(1) The results of a stability analysis of the structure for overturning, sliding, and slope failure, as applicable, including factors of safety, using the methods outlined in the Federal Energy Regulatory Commission's publication, Engineering Guidelines for Evaluation of Hydropower Projects, October, 2002;

(2) The results of a seepage analysis;

(3) The results of subsurface explorations, including, but not limited to borings and test pits; and

(4) A draft emergency action plan (EAP), or if an EAP has already been approved, an updated EAP, in accordance with Env-Wr 500.

(d) A design for reconstruction of a class B or class C dam shall include the items identified in (c), above, if the department determines that the items are applicable based on the type of work to be done.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 403.04 Design Floods for New Dams.

(a) A new dam shall be designed to safely pass the flows indicated below without manual operation and with the freeboard requirements indicated:

(1) A class AA structure shall pass the 50-year flood or, at the owner's option, the site-specific inflow design flood, with one foot of freeboard or, at the owner's option, freeboard equal to the effects of maximum wave run-up;

(2) A class A structure shall pass the 100-year flood or, at the owner's option, the site-specific inflow design flood, with one foot of freeboard or, at the owner's option, freeboard equal to the effects of maximum wave run-up;

(3) A class B structure shall pass ½ of the probable maximum flood (PMF) as determined using Hydrometeorological Report No. 52 (HMR 52) from the National Oceanic and Atmospheric Administration (NOAA) or the site-specific inflow design flood, with freeboard equal to the effects of maximum wave run-up; and

(4) A class C structure shall pass the PMF as determined using HMR 52, or the site-specific inflow design flood, with freeboard equal to the effects of maximum wave run-up;

(b) Wave run-up calculations shall identify maximum wind speeds and fetch limitations.

(c) For a class B or class C dam, and when the option is applied for a class AA or class A dam, the owner shall submit wave run-up calculations with the application.

(d) The owner shall submit the results of calculations performed for hydrologic and hydraulic analyses pursuant to (a), above, and Env-Wr 403.05 with the application.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 403.05 Hydrologic Investigations.

(a) Hydrologic investigations shall be performed on the entire contributing drainage area.

(b) Precipitation estimates for the design flood shall be obtained from:

(1) NRCC Research Publication RR 93-5, Atlas of Precipitation Extremes for Northeastern United States and Southeastern Canada, 1995; or

(2) U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Hydrometeorological Report No. 51, Probable Maximum Precipitation Estimates, United States East of the 105th Meridian, June 1978.

(c) Hydrologic modeling for 50-year or 100-year storms shall incorporate the following:

(1) The size of the drainage area;

(2) The shape of the drainage area;

(3) Antecedent moisture condition 2, as defined in the USDA NRCS National Engineering Handbook, 210-VI-NEH-630.10, August 1, 1969;

(4) Ground slopes;

(5) Soil types;

(6) Vegetation;

(7) Land use;

(8) Distribution of varying precipitation amounts throughout the watershed; and

(9) Ponds, swamps, and other factors affecting the amount and rate of runoff.

(d) The storm duration used in the modeling shall exceed the time for water to flow from the outermost point in the system to the subject location so as to ensure that the total runoff volume will be included in the routing of the storm through the dam structure.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 403.06 References for Hydraulic Determinations.

(a) Because the engineering science of hydraulics is documented in many competent texts, most of which rely on the same basic concepts, relationships and formulas, the designer may use any text, combination of texts, or related computer software applications for their design analysis.

(b) One or more of the following texts shall be used in evaluating the competence of the submitted design:

(1) "National Engineering Handbook, Section 5, Hydraulics" by USDA NRCS 1956; or

(2) "Handbook of Hydraulics", Sixth Edition, by Horace W. King and Earnest F. Brater, Mcgraw Hill Book Co., 1982.

Source. #8414, eff 8-20-05

Env-Wr 403.07 Concrete Design Criteria.

(a) Because the design of concrete structures is documented in many competent texts, the designer may use any text, combination of texts or related computer software application.

(b) One or more of the following texts shall be used in evaluating the competence of the submitted design:

(1) "Building Code Requirements for Structural Concrete & Commentary," ACI 318-05, American Concrete Institute, dated 2005;

(2) "Design of Small Dams" by US Department of Interior, Bureau of Reclamation, third Edition, 1987; or

(3) "National Engineering Handbook, Section 6, Structural Design", USDA NRCS, 1980.

Source. #8414, eff 8-20-05

Env-Wr 403.08 Steel Design Criteria.

(a) Because the design of steel structures is documented in many competent texts, the designer may use any text, combination of texts or related computer software applications.

(b) One or more of the following texts shall be used in evaluating the competence of the submitted design:

(1) "Manual of Steel Construction" by the American Institute of Steel Construction, Ninth Edition, First Revision, 1991; or

(2) "National Engineering Handbook, Section 6, Structural Design" USDA NRCS, 1980.

Source. #8414, eff 8-20-05

Env-Wr 403.09 Timber Design Criteria.

(a) Because the design of timber structures is documented in many competent texts, the designer may use any text, combination of texts or related computer software applications.

(b) One or more of the following texts shall be used in evaluating the competence of the submitted design:

(1) "Timber Construction Manual" by the American Institute of Timber Construction, Fourth Edition, dated 1994; or

(2) "National Engineering Handbook, Section 6, Structural Design" USDA NRCS, 1980.

Source. #8414, eff 8-20-05

Env-Wr 403.10 Earth Embankment Design Criteria.

(a) Because the design of earth embankments is documented in many competent texts, the designer may use any text, combination of texts or related computer software applications.

(b) One or more of the following texts shall be used in evaluating the competence of the submitted design:

(1) USDA NRCS Technical Release 60 (TR 60) revised October 1985;

(2) "Design of Small Dams" U.S. Department of the Interior, Bureau of Reclamation, third edition, 1987;

(3) ACER Technical Memorandum No. 9, "Guidelines for Controlling Seepage Along Conduits Through Embankments" by the U.S. Department of the Interior, Bureau of Reclamation, 1987; or

(4) For class AA and class A dams only:

a. "Detention and Retention Basins" BMP in the Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire publication dated August 1992; or

b. U.S. Department of Agriculture, NRCS Agricultural Handbook No. 590, September 2000.

Source. #8414, eff 8-20-05

PART Env-Wr 404 ISSUANCE AND CONDITIONS OF PERMITS

Env-Wr 404.01 Approval.

(a) Subject to (b) through (d), below, the department shall approve an application to construct or reconstruct a dam if:

(1) The requirements of Env-Wr 402 and Env-Wr 403 have been met; and

(2) Issuance of the permit is consistent with RSA 482:1 and any other applicable provisions of RSA 482.

(b) If the proposed dam is a class B or class C dam, the application shall not be approved until:

(1) A final emergency action plan has been completed and approved in accordance with Env-Wr 505; and

(2) The department has determined that the dam will serve a public benefit as required by RSA 482:9, V.

(c) If the proposed dam is a new dam on a great pond, the application shall not be approved until the owner has been granted authority by the legislature to construct or reconstruct the dam.

(d) If the dam is proposed under RSA 482:17, the application shall not be approved until the department has determined after holding a non-adjudicative hearing in accordance with the applicable provisions of Env-C 200 that it is in the public benefit to grant the permit pursuant to RSA 482:31.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 404.02 Issuance and Recordation of Permit/Registration.

(a) Upon review and approval of the application, the department shall issue a permit authorizing the construction or reconstruction. The permit shall include any restrictions, requirements or disclaimers as specified in Env-Wr 404.03.

(b) The department shall send the original permit to the registry of deeds for the county in which the dam is located to be recorded.

(c) The department shall send a copy of the permit to the owner at the time of approval. The department shall send the original permit to the owner upon receiving it back from the registry of deeds.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 404.03 Conditions of Permit. The following conditions shall apply to all permits to construct or reconstruct a dam:

(a) The permit shall be valid for 2 years from the date of issuance;

(b) Work under the permit shall be completed within 2 years unless the owner has requested and received a time extension in accordance with Env-Wr 404.04;

(c) All work on the dam shall comply with the approved plans and specifications, subject to design changes approved and documented in accordance with Env-Wr 404.05;

(d) The construction engineer shall provide a final inspection report in accordance with Env-Wr 405.08;

(e) The construction engineer shall certify to the department that the work was completed in accordance with the approved plans and specification and design intent as required by Env-Wr 405.09;

(f) Inspections shall be performed in accordance with the plan submitted pursuant to Env-Wr 405.04;

(g) At least 10 days prior to commencing work, the owner shall notify the department by certified mail of the date that the work is expected to commence;

(h) The owner shall notify the department upon completion of the work in accordance with Env-Wr 405.10(a);

(i) If an emergency action plan is required, no liquid shall be impounded until the EAP is approved by the department.

(j) The owner shall maintain a current mailing address with the department;

(k) The owner shall operate and maintain the structure in accordance with the written operation and maintenance procedures submitted in accordance with Env-Wr 402.06(b); and

(l) The department shall include in the permit any other conditions necessary to ensure protection of public safety that are based on the specific design, site, and watershed.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 404.04 Time Extension. The department shall grant a 2-year time extension to construct a dam if:

(a) The owner requests the extension in writing prior to the permit's expiration date;

(b) The hazard classification or the design requirements outlined in Env-Wr 403 have not changed since the issuance of the original permit; and

(c) The site is stabilized and the condition of the project is such that granting a time extension to complete the construction will not threaten human life, public safety, or the environment.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 404.05 Design Changes.

(a) No changes shall be made to the plans and specifications approved by the department, either before or during construction, unless:

(1) The changes are approved by the design engineer; and

(2) The changes are approved by the department in writing.

(b) To request a change, the owner or the owner's designee shall submit a request for the change in writing to the department, which shall include:

(1) The specific information regarding the requested change; and

(2) The reason the change is being requested.

(c) The department shall approve the change if the overall design as revised would have been approved if it had been submitted originally.

(d) The department shall notify the owner and the owner's designee, if applicable, of the decision on the request in writing. If the request is denied, the decision shall state the reason(s) for the denial.

(e) If time is of the essence, the department shall convey verbal approval prior to issuing written approval.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

PART Env-Wr 405 DAM CONSTRUCTION INSPECTIONS

Env-Wr 405.01 Purpose. The purpose of this part is to set forth the requirements for dam construction inspections.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 405.02 Applicability. These rules shall apply to construction inspections which are required during construction and reconstruction of a class A, class B, or class C dam pursuant to RSA 482:11.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 405.03 Construction Engineer.

(a) Prior to any work on the dam starting, the owner shall engage a construction engineer to ensure compliance with approved plans and specifications.

(b) The construction engineer shall have a minimum of 5 years of engineering experience related to construction inspection or design of similar dam construction projects.

(c) The owner shall submit the construction inspector's resume of related construction inspection or design experience to the department for review and approval. Department approval shall be based upon satisfaction of the criterion of (b), above.

(d) The construction engineer shall have ultimate responsibility for:

(1) The accurate completion of all inspection tasks; and

(2) Compliance with approved plans and specifications.

(e) The construction engineer may assign some inspection tasks to a duly-authorized agent provided that the agent's inspection tasks are explicitly identified in the construction inspection plan described in submitted pursuant to Env-Wr 405.04.

(f) Prior to any work on the dam starting, the construction engineer shall sign, date, and submit to the department a completed acknowledgement form provided by the department, as specified in (g), below.

(g) The construction engineer shall provide the following on the acknowledgement form:

(1) The name and address of the owner of the dam;

(2) The name of the dam and the dam's location, by town;

(3) The dam number assigned by the department;

(4) The construction engineer's name and professional engineer's license number;

(5) The name and professional engineer's license number of the design engineer;

(6) The date of the plans, specifications, supporting assumptions, and calculations reviewed by the construction engineer; and

(7) A certification that he or she has reviewed the plans, specifications, supporting assumptions, and calculations, and understands the design and the intent of the design.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 405.04 Inspections During Construction or Reconstruction.

(a) Prior to any work on the dam starting, the owner shall submit a written inspection plan to the department.

(b) The plan required by (a) above shall contain detailed information relative, but not limited, to the following:

(1) Which activities shall be monitored and by whom;

(2) Field tests to be performed and the frequency of testing;

(3) Material testing requirements; and

(4) Documentation and reporting requirements, including inspection reports and construction progress photographs.

(c) The department shall approve the plan if it determines that the plan is adequate to ensure that the dam will be constructed or reconstructed in accordance with the approved plans and specifications.

(d) The department shall inform the owner of its decision on the plan in writing. If the plan is not approved, the decision shall state the reason(s) for the non-approval.

(e) Inspections during construction or reconstruction shall be performed in accordance with the approved plan.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 405.05 Work Items to be Inspected. The construction engineer shall inspect, document, and photograph the following work items:

(a) Excavation and sub-grade preparation;

(b) Pipe placement;

(c) Placement of graded aggregate drain materials;

(d) Earthfill;

(e) Cut-off construction;

(f) Steel placement;

(g) Final grading; and

(h) Pouring of concrete.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 405.06 Inspection Frequency. The frequency of inspections for construction and reconstruction projects shall be as follows:

(a) Class A dam inspections shall be as frequent as needed to ensure compliance with approved plans and specifications; and

(b) Class B and Class C dam inspections shall be conducted continuously by on-site inspectors unless specifically exempted by the approved inspection plan for particular items of work.

Source. #8414, eff 8-20-05

Env-Wr 405.07 No Design Changes Without Prior Approval. No changes from the approved plans and specifications shall be implemented unless the change is approved in accordance with Env-Wr 404.05.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 405.08 Final Inspection Report.

(a) The construction engineer shall submit an inspection report to the department within 30 days of the completion of the project.

(b) The report shall include:

(1) A copy of all test results;

(2) The construction engineer's observations of the work items specified in Env-Wr 405.05;

(3) Representative construction progress photographs;

(4) Documentation of department-approved changes in design;

(5) Documentation and results of all construction inspections, including photographs;

(6) Foundation conditions observed during excavation; and

(7) Any other data pertinent to determining the integrity of the structure.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; rpld by #6462-B, eff 2-21-97

New. #8414, eff 8-20-05

Env-Wr 405.09 Affidavit of Compliance. Within 10 days of completing the project, the construction engineer shall provide the department with an affidavit of compliance indicating that the construction or reconstruction was completed in accordance with approved plans, specifications, and the intent of the design, including any design changes approved in accordance with Env-Wr 404.05.

Source. #8414, eff 8-20-05

Env-Wr 405.10 As-built Drawings. The construction engineer shall submit as-built drawings of the project to the department within 180 days of submitting the affidavit of compliance.

Source. #8414, eff 8-20-05

Env-Wr 405.11 Requirements Prior to Impounding.

(a) The owner shall notify the department in writing upon the completion of construction or reconstruction of any class A, class B, or class C dam and prior to filling the reservoir. The notice shall include the dam number and the location of the dam.

(b) Within 10 working days of receipt of notice from the owner, the department shall perform a final visual inspection with the reservoir drained.

(c) The department shall either authorize filling of the reservoir by issuance of a certificate of approval or order remedial action for noncompliance with the approved plans and specifications.

(d) No person shall close gates or take other actions that cause the dam to impound water until the owner is authorized by the department in writing to fill the reservoir.

(e) The department shall authorize the owner to fill the reservoir only after the department:

(1) Determines that the construction was completed in accordance with the approved plans and specifications;

(2) Performs a final visual inspection of the dam;

(3) Approves the emergency action plan; and

(4) Receives the construction engineer's final inspection report and affidavit of compliance.

Source. #8414, eff 8-20-05

CHAPTER Env-Wr 500 EMERGENCY ACTION PLANS

PART Env-Wr 501 PURPOSE AND APPLICABILITY

Env-Wr 501.01 Purpose and Applicability.

(a) The purpose of the rules in this chapter is to establish the requirements for an emergency action plan (EAP), whose purpose is to assist emergency responders in the event of a specific dam failure by:

(1) Delineating the area which could be affected;

(2) Providing notification procedures; and

(3) Identifying the responsibilities of individuals or agencies in a response.

(b) The owner shall prepare an EAP in accordance with these rules for:

(1) Any class C dam; and

(2) Any class B dam, unless:

a. The dam is classified as a class B structure only because it impounds a public water supply and the owner has submitted to the department an emergency plan for a community water system pursuant to Env-Ws 360.14; or

b. The dam is classified as a class B structure only because it impounds liquid industrial, agricultural, or commercial waste, septage, sewage, or contaminated sediments and the owner maintains a list of emergency contact numbers as a condition of the dam's permit under RSA 485-A or RSA 485-C.

(c) EAPs for dams subject to the jurisdiction of the Federal Energy Regulatory Commission (FERC) shall be prepared in accordance with Chapter 6 of FERC's Engineering Guidelines for the Evaluation of Hydropower Projects (November 1998) and filed with the department.

(d) EAPs for the following U.S. Army Corps of Engineers (USACE) dams shall be prepared in accordance with Chapter 6 of USACE "Dam Safety Preparedness", EP 1110-2-13 (June 1996) and filed with the department:

(1) Franklin Falls Dam;

(2) Blackwater Dam;

(3) Hopkinton-Everett Dams;

(4) Edward MacDowell Dam;

(5) Otter Brook Dam; and

(6) Surrey Mountain Dam.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

PART Env-Wr 502 BREACH ANALYSIS

Env-Wr 502.01 When Required. Unless exempted pursuant to Env-Wr 502.02, prior to preparing an EAP the owner shall have a dam breach analysis performed in accordance with this part.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 502.02 Exemption from Breach Analysis.

(a) Subject to Env-Wr 502.03, an owner shall be exempted from the development of a breach analysis if the department determines that the hazard classification is based solely on the potential damage to one or more isolated and easily identified bridges, roadways, or other structures located below the dam, and no other damages will result from a dam breach.

(b) If this exemption applies to a dam, department shall:

(1) Notify the owner in writing of the exemption; and

(2) Inform the owner of the exact structures to be delineated on a simplified inundation map, as required by Env-Wr 503.02.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 502.03 Repeal of Breach Analysis Exemption.

(a) If downstream developments change such that additional bridges, roadways, or other structures would be affected by a dam failure and these structures are not isolated and easily identifiable, the department shall notify the owner in writing that a dam breach analysis, as described in Env-Wr 502.06, shall be required due to the new developments downstream of the dam.

(b) Within 90 days of notification pursuant to (a), above, the owner shall:

(1) Complete a breach analysis in accordance with this part; and

(2) Produce and distribute an inundation map in accordance with Env-Wr 503.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 502.04 Expansion of Study Area.

(a) If after approving a breach analysis the department determines that downstream development has changed such that new structures would be affected by a dam failure and the threat to these structures is not

easily identifiable, the department shall notify the owner in writing that the scope of the dam breach analysis previously performed must be expanded

(b) Within 90 days of notification pursuant to (a), above, the owner shall:

(1) Expand the scope of the previously-approved breach analysis to include the newly developed area(s); and

(2) Produce an amended inundation map and distribute it to all EAP holders

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4580, eff 2-27-89; ss by #5080, eff 2-22-91; ss by #6462-B, eff 2-21-97; ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 502.05 Breach Analysis Required Due to Reconstruction. The owner shall complete a new or revised breach analysis, as applicable, to ascertain the impacts of a dam failure if:

(a) The dam is reconstructed, resulting in a larger or higher impoundment; or

(b) A change in the discharge capacity would result in reducing or increasing the effects of a dam failure.

Source. #8414, eff 8-20-05

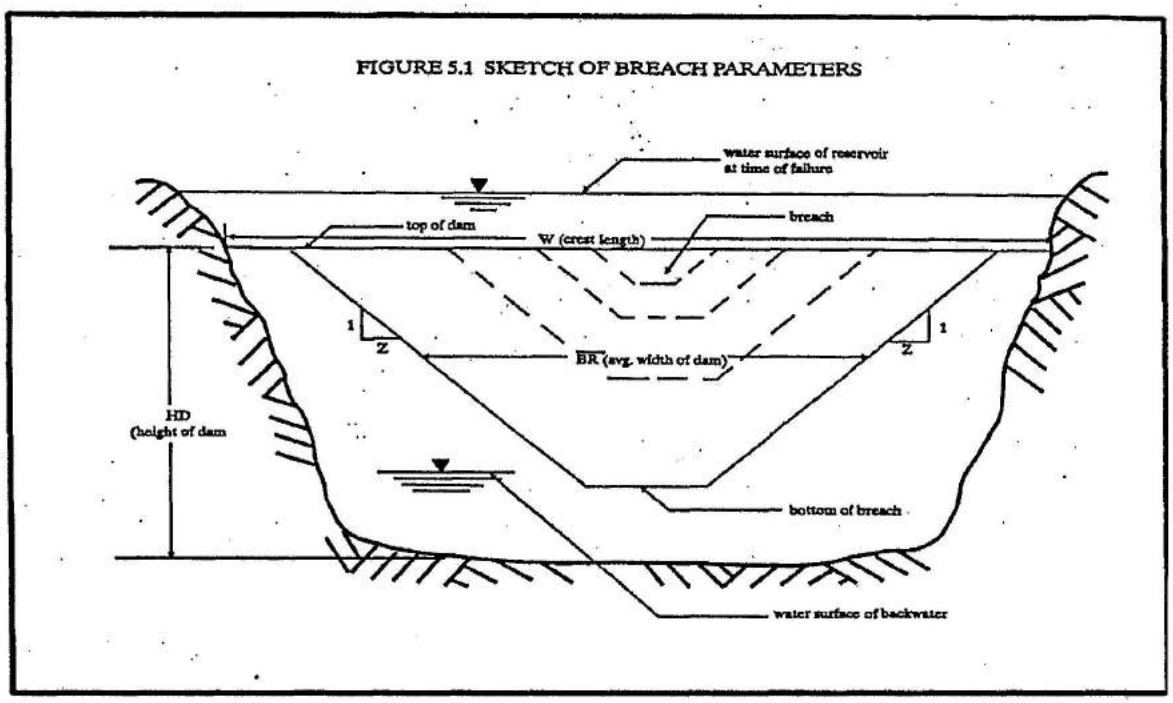
Env-Wr 502.06 Specific Requirements and Breach Parameters.

(a) The dam breach analysis shall be performed under the direction of and stamped by a professional engineer licensed in New Hampshire and experienced in hydrology and hydraulics.

(b) The breach parameters shall be in accordance with Table 5.1 and Figure 5.1 below, unless the department approves the use of other parameters pursuant to (c), below:

Table 5.1 Dam Breach Parameters

PARAMETER	TYPE OF DAM	VALUE
Average Width of Breach (BR)	Arch	BR = Crest Length
	Masonry, Gravity	BR = Width of one or more monoliths, usually BR $\leq$0.5 W
	Earth, Rockfill, Timber Crib	HD $\leq$ BR $\leq$ 5HD (usually between 2HD and 4HD)
Horizontal Component of Side Slope of Breach (Z)	Arch	0 $\leq$ Z $\leq$ slope of valley walls
	Masonry, Gravity	Z = 0
	Earth, Rockfill, Timber Crib	1/4 $\leq$ Z $\leq$ 1
Time to Failure (TFH) in hours	Arch	TFH $\leq$ 0.1
	Masonry, Gravity	0.1 $\leq$ TFH $\leq$ 0.3
	Earthen (Engineered, Compacted) Timber Crib	0.1 $\leq$ TFH $\leq$ 1.0
	Earthen (Non-Engineered, Poor Construction)	0.1 $\leq$ TFH $\leq$ 0.5



(c) The department shall allow use of different parameters due to specific dam or site conditions, if the applicant requests to use different parameters and demonstrates by clear and convincing evidence that the use of the alternative parameters would result in an accurate model and would not underestimate the effects of a dam failure.

(d) A dam breach flow shall be routed together with each of the following base flows:

(1) The sunny day flow as defined in Env-Wr 101.42; and

(2) The 100-year flood flow.

(e) The breach flow together with the base flows in (d), above, shall:

(1) Be routed downstream of the dam; and

(2) Include provisions to identify the number of hours or minutes from the start of a failure to the time when the river initially starts to rise and the time to reach peak stage.

(f) Peak flow velocities also shall be determined and shown on the inundation map for critical stations such as road crossings and populated areas below the dam.

(g) The routing shall continue downstream until:

(1) The point at which the water surface elevation due to dam failure is no more than 2 feet above the non-failure conditions in areas of potential threat to life and major property damage; or

(2) A point upstream of the point determined pursuant to (1), above, if the owner shows that there is no longer a threat to public safety beyond that point.

Source. #8414, eff 8-20-05

Env-Wr 502.07 Breach Routing Methods.

(a) The owner shall use one of the following routing methods for dam breach analysis:

(1) Methods and procedures used by the United States Department of Agriculture, Natural Resources Conservation Service in:

a. Technical Release T.R. 66 "Simplified Dam Breach Routing Procedures", March 1979;

b. Computer Program for Project Formulation Hydrology, T.R. 20, March 1986; and

c. WSP 2 Computer Program, T.R. 61, May 1976, which shall be used in conjunction with each other; or

(2) Methods and procedures using the National Weather Service Dam-Break Flood Forecasting Model authored by Dr. Danny L. Fread, from the National Weather Service in Silver Springs, Maryland, dated July 18, 1984, reprinted February 1987; or

(3) Methods and procedures for dam breach simulation and routing developed by the U.S. Army Corps of Engineers' Hydrologic Engineering Center, and incorporated in HEC-RAS, version 3.1.

(b) An owner wishing to use other techniques for breach routing shall submit a written request for approval of the technique to the department for each particular site prior to using the technique. The request shall contain a description of the technique, including how the technique addresses the parameters addressed by the techniques identified in (a), above.

(c) If the department determines that the technique can be correctly applied to the hydrologic and topographic conditions of the dam and downstream area, within the limitations and capabilities of the modeling technique, and that it will provide the detailed information required by these rules, the department shall approve the technique for use on that site and shall so notify the owner in writing.

(d) The department shall not require previously-approved dam breach analyses that were completed using methods other than those specified in (a), above, to be reassessed using those methods, provided, however, that if an expansion of the breach analysis is required pursuant to Env-Wr 502.04, the owner shall use a technique specified in (a) or approved pursuant to (b) and (c), above.

Source. #8414, eff 8-20-05

Env-Wr 502.08 Downstream Dams.

(a) When there are dams downstream located within the study area as determined by Env-Wr 502.06(g), the owner shall evaluate the effect of the breach flow on these dams.

(b) If a downstream dam would not be overtopped, no stability analysis of this structure shall be required.

(c) If a downstream dam would be overtopped by failure of the subject dam, the owner shall:

(1) Include the downstream dam's failure in the breach model; or

(2) Submit to the department the results of a stability analysis for overturning and sliding or slope failure, as applicable, including factors of safety, on the downstream dam.

(d) If the stability analysis performed pursuant to (c)(2), above, indicates that a downstream dam is unstable during overtopping, the owner shall include the failure of the downstream dam in the breach model.

(e) If the stability analysis performed pursuant to (c)(2), above, indicates that a downstream dam is stable, its failure shall not be required to be modeled in the dam breach analysis.

Source. #8414, eff 8-20-05

Env-Wr 502.09 Review of Breach Analysis by Department.

(a) The owner shall submit the following to the department for review:

(1) Structural and hydraulic breach assumptions and base flow criteria;

(2) Methods for determining base flows;

(3) Structural stability analyses of downstream dams, if applicable; and

(4) Summary of the results of the breach analysis.

(b) The owner shall submit inundation maps prepared in accordance with Env-Wr 503 for review, by submitting draft inundation maps with the information listed in (a), above, or after receiving approval of the breach analysis.

(c) If the information submitted pursuant to (a), above, is incomplete or the dam failure is incorrectly modeled, the department shall, within 60 days of receipt of the information, notify the owner in writing of the items which need to be addressed and the deadline for submittal of the amended analysis, which shall be 60 days from the date of the notice.

(d) If the information submitted pursuant to (a), above, is complete and failure is correctly modeled, the department shall, within 60 days of receipt of the submitted information:

(1) Determine whether the sunny day failure or the 100-year flood failure represents the most critical threat to the downstream community; and

(2) Notify the owner in writing of which failure scenario to use in the mapping.

Source. #8414, eff 8-20-05

PART Env-Wr 503 INUNDATION MAPPING

Env-Wr 503.01 Inundation Map Requirements.

(a) The owner shall produce an inundation map to provide the local emergency responders with a tool for planning evacuation procedures.

(b) The inundation map shall delineate the area impacted by a potential dam failure, as determined by the breach analysis required by Env-Wr 502.

(c) The inundation map shall meet the following criteria:

(1) The map shall be at a scale of 1:2,000 or of greater detail;

(2) Residences, commercial, and industrial structures or clusters of structures, when located in close proximity to each other, within the inundation area shall be shown on the most recent USGS

topographic mapping, supplemented by locations derived from aerial photography available on the DES website, www.des.nh.gov;

(3) Roads within the inundation area and within at least 0.5 mile from the exterior boundary of the inundation area shall be shown;

(4) The time for the floodwave to reach critical areas, including those outlined in (2) and (3), above, including time to rise and time to peak shall be shown;

(5) Peak flood wave velocities at critical areas shall be shown;

(6) Peak flood wave depths shall be shown;

(7) Political boundaries shall be shown;

(8) The map shall indicate whether the inundation area represents a sunny day failure or a storm day failure scenario; and

(9) The date on which the map was prepared shall be included on the map.

(d) If the inundation map consists of 3 or more pages, the owner shall provide an index map which clearly directs the user to the appropriate map for a given area.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; rpld by #4534, eff 11-30-88

New. #6462-B, eff 2-21-97 (from Env-Wr 504.01); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-04

Env-Wr 503.02 Simplified Inundation Map.

(a) An owner who has been exempted from the requirement of a breach analysis pursuant to Env-Wr 502.02 shall submit a simplified inundation map.

(b) The simplified inundation map shall include the elements specified in Env-Wr 503.01(a), (c)(1) - (3), and (8).

Source. #8414, eff 8-20-05

Env-Wr 503.03 Department Review.

(a) The owner shall submit the inundation map to the department for review and approval prior to incorporating it into the emergency action plan.

(b) The department shall inform the owner in writing within 60 days of receipt whether the inundation map is approved or what changes are necessary.

Source. #8414, eff 8-20-05

PART Env-Wr 504 COORDINATION WITH LOCAL COMMUNITIES

Env-Wr 504.01 Communications with Community(ies).

(a) Prior to finalizing the EAP, the owner shall supply all local community(ies) located within the inundation area with an inundation map to assist them in determining their response to a potential dam failure.

(b) The owner shall discuss with the local emergency management director, or at the emergency management director's discretion, the local fire department or police department, to determine which individuals or agencies shall be notified during an actual or impending emergency condition at the dam. These discussions shall be held with the appropriate personnel in each of the towns which could be impacted, as shown on the inundation map. If a municipality has not designated an emergency management director, the owner shall meet with the local governing body.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (from Env-Wr 505.01); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 504.02 Acknowledgment of EAP by Local Community(ies).

(a) The owner shall request that each affected community in the inundation area sign a form acknowledging its role in the EAP.

(b) If a community refuses to provide such statement, the owner shall notify the department certifying that a copy of the draft EAP has been delivered to the community.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (from Env-Wr 505.02); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Part Env-Wr 505 PREPARATION AND FORMAT OF EAP DOCUMENT

Env-Wr 505.01 Submittal of Draft EAP.

(a) The owner shall submit a copy of the draft EAP prepared pursuant to Env-Wr 505.02 to the department for review. The draft may be submitted as unbound pages.

(b) The department shall review the document for compliance with this chapter. Within 60 days of submittal, the department shall notify the owner in writing of its approval of the EAP or of any inadequacies.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4580, eff 2-27-89; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (formerly Env-Wr 506.01); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 505.02 Format of the EAP.

(a) The format of the EAP shall be 8½ x 11 loose-leaf paper in a 3-ring binder to allow for ease of supplementation and revision as required.

(b) The content of the EAP shall be standardized as follows:

(1) Table of Contents;

(2) Section 1, Notification flow-chart;

(3) Section 2, Responsibilities under the EAP;

(4) Section 3, Notification checklists;

(5) Section 4, Preventive action; and

(6) Appendices, including:

a. Appendix A, Dam and watershed description;

b. Appendix B, Summary of breach analysis;

c. Appendix C, Inundation map;

d. Appendix D, Monitor training and testing procedures;

e. Appendix E, Local evacuation procedure;

f. Appendix F, List of EAP holders; and

g. Appendix G, Documentation.

(c) The required contents of each section or appendix shall include the information identified in Env-Wr 505.03 through Env-Wr 505.12, as applicable.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4452, eff 8-1-88; amd by #4580, eff 2-27-89; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (formerly Env-Wr 506.02); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 505.03 Notification Flow-chart.

(a) Section 1 of the EAP shall be a chart identifying the individuals and local and state government agencies to be notified during a potential or actual emergency condition at the dam.

(b) The notification flow-chart shall be developed in accordance with local and state emergency responders and shall conform with the community's current notification protocol.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (formerly Env-Wr 506.03); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 505.04 Responsibilities. Section 2 of the EAP shall describe the roles and responsibilities of each individual and local or state government agency in an emergency response.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (formerly Env-Wr 506.04); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 505.05 Notification Checklists.

(a) Section 3 of the EAP shall include a notification checklist for each individual and local or state government agency responsible for making calls during an emergency situation or during a test of the EAP.

(b) The notification checklist shall include a table to be filled in by the participating individual or agency making notifications, including the name(s) of the agency(ies) or individual(s) to be contacted and the time at which the contact was made.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (formerly Env-Wr 506.05); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 505.06 Preventive Action. Section 4 of the EAP shall:

(a) Indicate actions which the monitor shall take to correct a malfunction of the dam;

(b) Identify the means, materials, and equipment needed to make emergency repairs to the structure;

(c) Identify the necessary training and equipment including alternative power sources to operate the structure;

(d) Include a list of preventive and mitigative action measures to be undertaken during emergency situations.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (formerly Env-Wr 506.06); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 505.07 Dam and Watershed Description. Appendix A of the EAP shall include the following information:

(a) The height and length of the dam, in feet;

(b) The normal and maximum surface area of the impoundment, in acres;

(c) The normal and maximum volume of the impoundment, in acre-feet;

(d) The size of the drainage area, in square miles; and

(e) A description of all outlet works, including the length of the spillway and a description of any gates.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (formerly Env-Wr 506.07); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 505.08 Impact of Breach. Appendix B of the EAP shall be a summary of the breach analysis, written so as to be easily understood during an actual emergency, in order to provide local emergency responders with a brief description of the areas downstream of the dam which would be affected by a dam failure.

Source. #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (formerly Env-Wr 506.08); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 505.09 Dam Monitor and Testing. Appendix D of the EAP shall include:

(a) The following information regarding the monitor(s) required by Env-Wr 303.04:

(1) Name, address and home and business telephone numbers;

(2) Type of training provided by owner; and

(3) Type of communication system between dam and local community; and

(b) The following information regarding EAP testing:

(1) A narrative describing the testing procedures, as outlined in Env-Wr 507.04;

(2) A summary of the responsibilities of the owner and the roles of any individuals or state or local agencies involved in the testing; and

(3) The name and mailing address of the person responsible for collecting the notification checklists after testing or after an actual emergency condition.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; ss by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (formerly Env-Wr 506.09); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 505.10 Local Evacuation Procedure and Recovery. Appendix E shall include any evacuation and recovery plans developed by the communities. If the communities have not developed such plans, the owner shall so indicate in this appendix.

Source. #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (from Env-Wr 506.10); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 505.11 List of Official EAP Holders. Appendix F shall be a listing of all individuals and local and state agencies holding official copies of the EAP, as follows:

(a) The mailing addresses and telephone numbers of the local emergency responders, including police and fire departments in accordance with the town's procedures;

(b) The mailing addresses and telephone numbers of dispatchers for local emergency responders;

(c) The mailing addresses and telephone numbers of the local emergency management director(s);

(d) The telephone number of the contact person at the New Hampshire department of safety, bureau of emergency management;

(e) The telephone number of the contact person at the department's division of water;

(f) The telephone number of the contact person at the New Hampshire department of safety, state police;

(g) The names, mailing addresses, and telephone numbers of the owners of downstream dams that would be affected by a dam breach;

(h) The telephone number of the contact person at the New Hampshire department of transportation, highway district 5, dispatch section;

(i) If state roads would be impacted by a dam failure, the name and telephone number of the contact person at the appropriate New Hampshire department of transportation highway district office; and

(j) The telephone number of the contact person at the New Hampshire department of safety, emergency communications section (911).

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (formerly Env-Wr 506.11); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

Env-Wr 505.12 Documentation. Appendix G shall include copies of signed acknowledgement forms, as described in Env-Wr 504.02, and any correspondence relative to the EAP's development.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84; amd by #4534, eff 11-30-88; ss by #5080, eff 2-22-91; ss and moved by #6462-B, eff 2-21-97 (formerly Env-Wr 506.12); ss by #8285, INTERIM, eff 2-21-05, EXPIRES: 8-20-05; ss by #8414, eff 8-20-05

PART Env-Wr 506 FINAL DISTRIBUTION; PUBLIC NOTICE

Env-Wr 506.01 EAP Distribution. Upon receiving department approval of the draft EAP pursuant to Env-Wr 505.01, the owner shall distribute the EAP to local and state emergency response personnel who have responsibilities for implementing the EAP, as listed in Env-Wr 505.11.

Source. #8414, eff 8-20-05

Env-Wr 506.02 Public Notice. If the local community(ies) request information relative to the EAP to be given to the general public, the owner shall provide such information either by mail to all residential, industrial, and commercial buildings within the inundation area or by holding an informal meeting at a location near the dam or the inundation area.

Source. #8414, eff 8-20-05

PART Env-Wr 507 TESTING AND UPDATING PROCEDURES

Env-Wr 507.01 Notification Test.

(a) The owner shall conduct a test of the emergency communication network within one month of approval of the EAP and every 2 years thereafter for a class C dam and every 4 years thereafter for a class B dam.

(b) The test shall consist of the owner making the primary contact as shown on the flow-chart and indicating that a required test of the EAP is being conducted.

(c) The owner shall request each individual or agency contacted during the test to execute its duties relative to the notification flow-chart, complete the checklists, and return the checklists to the owner.

(d) Within 30 days of conducting the test, the owner shall inform the department of the results of the test, indicating the time it took each individual and agency to make their notifications and whether miscommunications occurred.

(e) The owner shall provide records of communication for each individual and agency, including time of contact and person contacted, if the notifications were not made within a 15-minute time period.

Source. #8414, eff 8-20-05

Env-Wr 507.02 EAP Review and Changes.

(a) If the owner becomes aware of any changes necessary to the notification flow-chart, either as a result of the notification test or by other means, the owner shall:

(1) Make the changes to the notification flow-chart and in other portions of the EAP as necessary; and

(2) Distribute update pages to all holders of the EAP.

(b) The owner shall review the entire EAP annually to ensure the accuracy of the communication flow-chart and inundation areas.

(c) If development has occurred within the inundation area, the owner shall:

(1) Revise the inundation map to show the new development; and

(2) Distribute the updated map to all holders of the EAP.

(d) The owner shall submit written documentation to the department that the annual review of the EAP was performed, by providing one of the following:

(1) A statement that the EAP was reviewed and that no changes to the EAP were necessary; or

(2) Any applicable sections of the EAP which required revision.

Source. #8414, eff 8-20-05

Env-Wr 507.03 Reprinting of EAP.

(a) The owner shall reprint the entire EAP document and distribute the pages to all holders of the EAP every 8 years, to ensure that all holders have complete and orderly copies, unless:

(1) No changes have been required; or

(2) Changes have been made only to the notification flow-chart, and copies of the updated flow-chart have been distributed to all EAP holders.

(b) When a reprint of the EAP is required, the owner shall:

(1) Send the reprint return receipt requested; or

(2) Include forms with the mailing to be signed by the EAP holders and returned to the owner, indicating that a copy of the reprinted EAP was received.

(c) If there have been no changes to the inundation map since the last reprint of the EAP and the owner does not include an inundation map in the mailing, the owner shall:

(1) Specify the date of the current inundation map; and

(2) Include a check-off item on the form required by (b), above, indicating the EAP holder has a copy of the current inundation map.

(d) If an EAP holder does not have the current inundation map, the owner shall provide a copy of the map to the EAP holder upon being so notified by the EAP holder.

Source. #8414, eff 8-20-05

CHAPTER Env-Wr 600 REMOVAL OF DAMS

PART Env-Wr 601 PURPOSE AND APPLICABILITY

Env-Wr 601.01 Purpose. The purpose of the rules in this chapter is to specify the procedures to be followed when proposing to remove a dam under the auspices of the department's river restoration program and the criteria that will be applied in reviewing such proposals.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #8414, eff 8-20-05

Env-Wr 601.02 Applicability. The requirements of this part shall apply to any person who seeks to remove a dam under the auspices of the department's river restoration program.

Source. #8414, eff 8-20-05

PART Env-Wr 602 DAM REMOVAL PROPOSALS

Env-Wr 602.01 Qualifying Removals.

(a) In order to qualify as a dam removal under this chapter, the structure shall be removed:

(1) To at least the depth of the natural streambed elevation; and

(2) Subject to (b) and (c), below, to the width of the free-flowing ordinary high water mark of the river or stream in the area of the footprint of the dam from bank to bank.

(b) The person seeking to remove a dam pursuant to this chapter may request the department to approve a narrower opening by submitting the request in writing with the following:

(1) The width of the free-flowing ordinary high water mark of the river or stream in the area of the footprint of the dam from bank to bank, in feet;

(2) The width of the proposed opening, in feet, at:

a. The natural streambed elevation;

b. The ordinary high water mark; and

c. The widest point of the opening, if other than the natural streambed elevation or ordinary high water mark;

(3) The shape of the proposed opening; and

(4) An explanation of how the narrower opening will meet the criteria specified in (c), below.

(c) The department shall approve the request for a narrower opening if the department determines that:

(1) The structure will no longer be considered a dam as defined in RSA 482:2, II;

(2) The remains of the dam between the ordinary high water marks on both sides of the river will not create a safety hazard to the public when using the river;

(3) The natural flow of sediment and nutrients will not be impeded; and

(4) The passage of fish and other aquatic species will not be impeded.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #8414, eff 8-20-05

Env-Wr 602.02 Dam Removal Proposal. The person seeking to remove a dam shall submit:

(a) A "standard dredge and fill application" as required under RSA 482-A and Wt 500, including the plans and specifications required for that application; and

(b) An "attachment to the standard dredge and fill application for dam removal projects" as specified in Env-Wr 602.03.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #8414, eff 8-20-05

Env-Wr 602.03 Attachment for Dam Removal Projects. The information provided on the "attachment to the standard dredge and fill application for dam removal projects" shall include the following:

(a) The name, mailing address, and daytime telephone number of the applicant and, if the applicant is not the owner, the name and mailing address of the owner;

(b) The state dam identification number;

(c) The hazard classification of the dam;

(d) The current use of the dam;

(e) The height and length of the dam, in feet;

(f) The type of construction of the dam;

(g) The approximate surface area of the impoundment, in acres;

(h) The name(s), mailing address(es), and daytime telephone number(s) of the person(s) proposed to remove the dam;

(i) A description of the proposed methods to remove the dam, including construction sequence, so as to meet the criteria of Env-Wr 602.01 and Env-Wr 604.01(a)

(j) An explanation of the purpose for removing the dam.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #8414, eff 8-20-05

PART Env-Wr 603 REVIEW PROCEDURES

Env-Wr 603.01 Notification.

(a) The person proposing to remove a dam shall notify the local governing body of the municipality or municipalities in which the dam or the water body formed by the dam is located in accordance with RSA 482:13, I.

(b) The person proposing to remove the dam shall provide a copy of the notice sent pursuant to (a), above, to the department.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #8414, eff 8-20-05

Env-Wr 603.02 Review.

(a) Upon receiving an application to remove a dam, the department shall review the application to determine whether it is complete.

(b) If the department determines that all of the information required by Env-Wr 602.02 or the notice required by Env-Wr 603.01(b) has not been submitted, the department shall notify the person proposing to remove the dam of what is needed to complete the application.

(c) After receiving a complete application and after the meeting required by RSA 482:13, II has been held, the department shall review the application.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #8414, eff 8-20-05

PART Env-Wr 604 APPROVAL; REPORT

Env-Wr 604.01 Dam Removal Approval.

(a) The department shall approve the removal of the dam if the applicant:

(1) Proposes a dam removal project that meets the criteria of Env-Wr 602.01; and

(2) Demonstrates that the dam removal will be performed in a manner that:

a. Will not cause damage to structures downstream of the dam; and

b. Will not cause environmental damage that cannot self-restore within one year.

(b) The department shall notify the applicant and the owner, if the applicant is not the owner, in writing of its decision.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #8414, eff 8-20-05

Env-Wr 604.02 Post-Removal Report. Upon completion of the removal, the person removing the dam shall file with the department a written statement certifying that the removal was completed in accordance with the approved plans and specifications.

Source. #1716, eff 2-20-81; ss by #2207, eff 12-13-82; ss by #2900, eff 11-7-84, EXPIRED 11-7-90

New. #8414, eff 8-20-05

CHAPTER Env-Wr 700 LAKE LEVEL DETERMINATIONS

PART Env-Wr 701 PURPOSE AND APPLICABILITY

Env-Wr 701.01 Purpose. The purpose of the rules in this chapter is to specify the procedures to be followed when a lake level investigation is conducted pursuant to RSA 482:79.

Source. #4278, eff 6-30-87; ss by #5662, eff 7-1-93, EXPIRED: 7-1-99

New. #8414, eff 8-20-05

Env-Wr 701.02 Applicability. The requirements of this chapter shall apply to any lake level investigation initiated pursuant to RSA 482:79.

Source. #4278, eff 6-30-87; ss by #5662, eff 7-1-93, EXPIRED: 7-1-99

New. #8414, eff 8-20-05

PART Env-Wr 702 REQUEST; PRELIMINARY INVESTIGATION

Env-Wr 702.01 Formal Request.

(a) A request for a lake level investigation pursuant to RSA 482:79 shall be:

(1) In writing; and

(2) Mailed or delivered to the department at the following address:

Department of Environmental Services
Water Division
29 Hazen Drive
P.O. Box 95
Concord, NH 03302-0095

(b) The request shall state clearly the reason(s) for the request.

(c) The request shall be signed by at least 10 property owners whose land abuts the water body whose water level is the subject of the request.

Source. #4278, eff 6-30-87; ss by #5662, eff 7-1-93, EXPIRED: 7-1-99

New. #8414, eff 8-20-05 (formerly Env-Wr 401.01)

Env-Wr 702.02 Preliminary Investigation.

(a) As required by RSA 482:79, the department shall commence a preliminary investigation of conditions affecting the use and enjoyment of a water body under any of the following circumstances:

(1) Upon receipt of a request per Env-Wr 702.01;

(2) Upon request of the New Hampshire attorney general; or

(3) On its own motion, when information received by the department warrants further investigation.

(b) The department shall investigate:

(1) The current and past management and control of the outlet; and

(2) The effects, if any, of such management and control on:

a. The use and enjoyment of shore property above the outlet;

b. Any riparian rights below the outlet; and

c. The use and enjoyment of the waters above and below the outlet by the public and by owners of littoral or riparian property.

(c) Based upon the preliminary investigation, the department shall determine whether the management and control of the outlet is having a serious and adverse effect on any of the factors identified in (b)(2), above.

(d) For purposes of the determination in (c), above, a "serious and adverse effect" means an impact that has a reasonable likelihood of interfering with the use and enjoyment of littoral or riparian property or public waters by:

(1) Eroding shorelines above or below the outlet;

(2) Flowing property that is not covered by a flowage easement;

(3) Interfering with access to the waters above or below the outlet;

(4) Causing the waters above or below the outlet to be unsuitable for navigation or recreation;

(5) Causing harm to aquatic or land-based habitat; or

(6) Any combination of (1) through (5), above.

Source. #4278, eff 6-30-87; ss by #5662, eff 7-1-93, EXPIRED: 7-1-99

New. #8414, eff 8-20-05 (formerly Env-Wr 401.02)

PART Env-Wr 703 FURTHER INVESTIGATIONS; PUBLIC HEARING

Env-Wr 703.01 Further Investigation and Public Hearing.

(a) If the department finds a serious and adverse effect under Env-Wr 702.02(c), the department shall conduct a further investigation.

(b) If the department determines that a public hearing to receive information would be helpful to its further investigation, the department shall schedule and conduct the public hearing in accordance with Env-C 200 relative to non-adjudicative procedures.

Source. #4278, eff 6-30-87; ss by #5662, eff 7-1-93, EXPIRED: 7-1-99

New. #8414, eff 8-20-05 (formerly Env-Wr 401.03)

Env-Ws 703.02 Determinations. Based on the further investigation, the department shall:

(a) Ascertain the rights of the owner of the outlet by considering whether:

(1) The dam is registered with the department;

(2) Flowage is within any clear deeded flowage limits;

(3) Base flows are sufficient to accommodate downstream riparian rights;

(4) The operation is in accordance with any deeded rights associated with the former mill dam act, RSA 482:17 through RSA 482:41, if applicable; and

(5) Any other factors identified by the owner within the jurisdiction of the department under RSA 482.

(b) Ascertain the rights of the public and owners of property above and below the outlet, by considering the following:

(1) Whether there is public access to the impoundment or the stream below the outlet via a government-owned access point;

(2) The extent to which the impoundment or the stream below the outlet is used for fishing, including whether the impoundment is stocked by the New Hampshire fish and game department;

(3) What range of water levels is optimum for the ecological health of the impoundment and the stream below the outlet;

(4) The extent to which the impoundment or the stream below the outlet is used for navigation and what range of water levels is optimum for such navigation;

(5) The extent to which the impoundment or the stream below the outlet is used for swimming and what range of water levels is optimum for swimming; and

(6) The extent to which the impoundment or the stream below the outlet is used for other recreation and range of what water levels is optimum for such other recreation.

(c) In making its determination, the department shall consider all information and testimony presented as part of the proceeding.

Source. #4278, eff 6-30-87; ss by #5662, eff 7-1-93, EXPIRED: 7-1-99

New. #8414, eff 8-20-05 (formerly Env-Wr 401.03)

PART Env-Wr 704 FINDINGS; DECISION

Env-Wr 704.01 Findings. After completing its further investigation in accordance with Env-Wr 703, the department shall prepare written findings regarding whether:

(a) The management and control of the outlet is adversely affecting the rights of owners of property above the outlet by eroding shorelines, flowing property not covered by a flowage easement, preventing access to property that is accessible only by boat, or interfering with the use and enjoyment of the water for recreational purposes, including boating, swimming, and fishing;

(b) The management and control of the outlet is adversely affecting the rights of owners of property below the outlet by eroding shorelines, releasing insufficient water for reasonable riparian uses, or interfering with the use and enjoyment of the water for recreational purposes, including boating, swimming, and fishing;

(c) The management and control of the outlet is adversely affecting the rights of the public to use public waters for navigation or recreational purposes, including boating, swimming and fishing;

(d) The management and control of the outlet is lawful;

(e) The benefits of the current management and control of the outlet outweigh any adverse effects that may be occurring;

(f) Changes to the management and control of the outlet would be of benefit to the public and private interests concerned; and

(g) Changes in the management and control of the outlet to benefit the use and enjoyment of the waters above or below the outlet by the public or by owners of property above or below the outlet would deprive the owner of the outlet or others of rights to which they are lawfully entitled.

Source. #4278, eff 6-30-87; ss by #5662, eff 7-1-93, EXPIRED: 7-1-99

New. #8414, eff 8-20-05 (formerly Env-Wr 401.04)

Env-Wr 704.02 Report of Findings; Decision. Based upon its findings, the department shall:

(a) Order no change in the management and control of the outlet if it finds that:

(1) The benefits of the present management and control of the outlet outweigh any adverse effects on the public and on owners of property above or below the outlet; and

(2) Changes in the management and control of the outlet would not be expected to produce benefits that:

a. Are greater than those resulting from the present management; and

b. Would outweigh any adverse effects of the changes;

(b) Order changes in the management and control of the outlet if the benefits expected from the change are:

(1) Greater than the benefits from the present management and control of the outlet; and

(2) Expected to outweigh any adverse effects of the changed management and control of the outlet;

(c) Report to the governor and council its findings, including an estimate of damages, if it finds that changes in the management and control would be of benefit to the public and private interests concerned but would deprive the owner of the outlet or others of rights to which they are lawfully entitled; or

(d) Report to the attorney general if the management and control of the outlet is unlawful.

Source. #4278, eff 6-30-87; ss by #5662, eff 7-1-93, EXPIRED: 7-1-99

New. #8414, eff 8-20-05 (formerly Env-Wr 401.05)

CHAPTER Env-Wr 800 ADMINISTRATIVE FINES - EXPIRED

Source. #5082, eff 2-22-91, EXPIRED: 2-22-97; Env-Wr 802.01(e) was amd by #5495, eff 10-27-92, EXPIRED: 10-27-98

Appendix

Rule	Specific State or Federal Statutes or Regulations the Rule Implements
Env-Wr 301	RSA 482:1; RSA 482:2; RSA 482:87
Env-Wr 302	RSA 482:5; RSA 482:11-a; RSA 482:12; RSA 482:87
Env-Wr 303	RSA 482:5; RSA 482:8-a; RSA 482:11-a; RSA 482:12; RSA 482:87
Env-Wr 304	RSA 482:5; RSA 482:87
Env-Wr 401	RSA 482:1; RSA 482:7; RSA 482:9 – 11-a; RSA 482:29 – 31; RSA 482:87
Env-Wr 402	RSA 482:1; RSA 482:7; RSA 482:9 – 11-a; RSA 482:29 – 31; RSA 482:87
Env-Wr 403	RSA 482:1; RSA 482:7; RSA 482:9 – 11-a; RSA 482:29 – 31; RSA 482:87
Env-Wr 404	RSA 482:1; RSA 482:7; RSA 482:9 – 11-a; RSA 482:29 – 31; RSA 482:87
Env-Wr 405	RSA 482:1; RSA 482:7; RSA 482:9 – 11-a; RSA 482:29 – 31; RSA 482:87
Env-Wr 501	RSA 482:1; RSA 482:11-a; RSA 482:12; RSA 482:87
Env-Wr 502	RSA 482:1; RSA 482:11-a; RSA 482:12; RSA 482:87
Env-Wr 503	RSA 482:1; RSA 482:11-a; RSA 482:12; RSA 482:87
Env-Wr 504	RSA 482:1; RSA 482:11-a; RSA 482:12; RSA 482:87
Env-Wr 505	RSA 482:1; RSA 482:11-a; RSA 482:12; RSA 482:87
Env-Wr 506	RSA 482:1; RSA 482:11-a; RSA 482:12; RSA 482:87
Env-Wr 507	RSA 482:1; RSA 482:11-a; RSA 482:12; RSA 482:87
Env-Wr 601	RSA 482:1; RSA 482:2; RSA 482:87
Env-Wr 602	RSA 482:1; RSA 482:2; RSA 482:87
Env-Wr 603	RSA 482:1; RSA 482:2; RSA 482:87
Env-Wr 604	RSA 482:1; RSA 482:2; RSA 482:87
Env-Wr 701	RSA 482:1; RSA 482:4; RSA 482:79-83; RSA 482:87
Env-Wr 702	RSA 482:1; RSA 482:4; RSA 482:79-83; RSA 482:87
Env-Wr 703	RSA 482:1; RSA 482:4; RSA 482:79-83; RSA 482:87
Env-Wr 704	RSA 482:1; RSA 482:4; RSA 482:79-83; RSA 482:87

E.29. New Jersey



FEMA

Hydrologic Research Needs for Dam Safety Analyses

by
Joseph J. Skupien, PE, PP[1]

Somerset County Dam Safety Program

The following describes both the current scope and research needs of the dam safety program of Somerset County, New Jersey. The County encompasses 305 square miles in the central portion of the state and has a population of approximately 300,000, yielding a population density of approximately 1000 people per square mile. The County has experienced significant land development pressure since the 1970's with no significant abatement expected in the foreseeable future.

Somerset County's dam safety program includes the analysis, operation, inspection, and maintenance of nine Significant Hazard dams ranging in height from 13 to 40 feet with drainage areas ranging from approximately 50 acres to 10 square miles. Eight of these dams serve as regional stormwater detention facilities that help offset the adverse hydrologic impacts of land developments within their watersheds. The remaining dam is a former water intake dam located on property acquired from a private water purveyor and converted into a County park. Since their original design, engineering activities at the dams include the determination and periodic reassessment of their hazard classifications and Spillway Design Floods (SDFs) as well as any subsequent revisions to their Emergency Action Plans (EAPs). These activities are performed in accordance with the Dam Safety Standards (N.J.A.C. 7:20) of the Dam Safety Section of the N.J. Department of Environmental Protection (NJDEP).

In addition to the dam safety activities described above, the County Planning Board also regulates that stormwater management aspects of all new land developments in the County that front on a County road and/or drain to a County bridge or culvert. These regulations typically result in the design and construction of one or more onsite stormwater detention basins that can range up to approximately 15 feet in height and up to 100 acres in drainage area. While the design of such basins do not normally require a dam break and downstream inundation analysis, the design does include the determination of emergency spillway size and top of dam elevation. This is done using County-based emergency spillway criteria at all dams not subject to the NJDEP Dam Safety Standards noted above. An unofficial survey indicates that there are presently more than 500 such basins in County, most close to residential, commercial, and/or industrial structures.

[1] Principal Hydraulic Engineer, Division of Engineering, Somerset County, New Jersey

Current State and County Practices

As noted above, all County-owned dams are regulated by the Dam Safety Standards of the NJDEP's Dam Safety Section. Similar to the FERC's Engineering Guidelines for the Evaluation of Hydropower Projects, these state standards classify dams by Hazard Class based upon the threat posed by a dam failure to downstream structures and roadways. A summary of the various NJDEP Hazard Classes is presented in Table 1 below.

Table 1

Summary of Dam Hazard Classes and Spillway Requirements
NJDEP Dam Safety Standards

Hazard Class	Downstream Failure Threat	Spillway Design Storm
I – High	Loss of Life or Extensive Property Damage	PMP
II- Significant	Significant Property Damage	One-Half PMP
III – Low	Minor Property Damage	100-Year NRCS Type III
IV – Small Dams	Height < 15 Feet, Storage < 15 Acre-Feet, Drainage Area < 150 Acres*	100-Year + 50 Percent NRCS Type III

* Class IV Dam criteria only applicable if Class I or II threats do not exist.

According to discussions with NJDEP Dam Safety personnel, PMP rainfall amounts are typically obtained from HMR No. 51. For the majority of projects, spatial distribution of the rainfall is not necessary and the rainfalls are temporally distributed in accordance with a variety of storm distributions, including the NRCS Type III distribution and the U.S. Army Corps of Engineers PMP distribution as contained in HEC-1 Flood Hydrograph Package. One foot of freeboard is required above the routed SDS water surface. The NRCS Runoff Equation and Dimensionless Unit Hydrograph are typically used to compute losses and convert the rainfall to runoff. Antecedent Moisture Conditions are typically assumed to be either average (AMC II) or high (AMC III). Sources of dam failure parameters vary, with those published in the FERC Engineering Guidelines or derived from the Froelich equations utilized most frequently.

Downstream discharges and water surface profiles are typically computed using steady flow assumptions with HEC-1 used for discharge and failure computations and either HEC-2 Water Surface Profiles or HEC-RAS River Analysis System used for profile computations. Unsteady flow computations using either DAMBRK or FLDWAV are used on approximately 10 percent of the projects, which typically involve large dams and drainage areas. Downstream failure impacts are typically assessed based upon the difference in water surface with and without a dam failure, with a difference greater than two feet considered excessive. A minority of projects utilizes the Downstream Hazard Classification Guidelines published by the Bureau of Reclamation.

As noted above, the Somerset County dam safety criteria, which were originally established in 1975, apply to all structures subject to County Planning Board approval unless superceded by the NJDEP regulations described above. Hazard classification for

all dams is assumed to be Class B as defined by the NRCS unless a reconnaissance of downstream conditions warrants a higher classification. Safe spillway capacity and freeboard requirements are based upon routing Emergency Spillway (ESH) and Freeboard (FBH) Hydrographs through the facility based upon 24-hour rainfalls of 10 and 17 inches, respectively. These rainfalls were derived from the same equations used by the NRCS to develop the Service's 6-hour ESH and FBH rainfalls. It should also be noted that the County's 17 inch FBH rainfall is equivalent to one-half of the 24-hour PMP for the County.

Problems and Research Needs

A summary of technical and operational problems and related hydrologic research needs of both the NJDEP and Somerset County dam safety programs is presented below. The NJDEP problems and needs were identified during interviews with representatives of the NJDEP's Dam Safety Section. Resolution of these problems and needs, either through research and/or policy decisions, will help improve the effectiveness and efficiency of both programs.

1. Perhaps the most significant operational problem facing the State and County dam safety programs is the lack of hydrologic and hydraulic expertise in many of the engineers performing dam failure, inundation, and hazard classification studies and/or preparing emergency spillway designs. In the last 20 years, both the sophistication and availability of computer-based models to perform such studies and designs has increased significantly, along with the data to base them on. Unfortunately, these models and databases have exceeded, in many instances, the knowledge and expertise of the modelers and designers of small dams. This "ability gap" leads to inaccurate studies and designs and prevents many dam safety programs from realizing their full potential, thereby negating the efforts of researchers and regulators to create advanced, effective dam safety programs. Under such conditions, further technical advances can be expected to only widen this gap.

Research Request: Investigate the feasibility of establishing minimum education and/or experience requirements for engineers performing dam safety studies and designs for small dams. Alternately, develop a basic set of small dam hydrology and hydraulic courses that can be presented by state and/or local dam safety officials to engineers within their jurisdictions.

2. A technical problem that has grown more acute in recent years involves the presence of concrete corewalls within older earthen dams that have come under closer scrutiny by dam safety personnel. Similar problems also arise with older dams that have been constructed with masonry or concrete walls along their upstream face. These walls were commonly utilized to prevent seepage from the upstream impoundment and, while they theoretically have little structural strength, experience has shown that some have been able to remain intact even after the loss of large portions of the downstream fill material. Such dams, due to their age, typically have principal spillways that are inadequate under

present standards and, as such, are prone to failure due to overtopping. However, modeling this failure can be difficult, particularly in the selection of failure width and time due to the presence of the concrete wall within or upstream of the earthen fill. While conservatively large width and short time parameters can be selected, their use may result in overestimates of hazard class and Spillway Design Storm. This, in turn, may require the construction of excessive remedial measures that the owners, who are predominantly private individuals or organizations, may find cost-prohibitive.

Research Request: Develop typical failure parameters and/or policies for dams with corewalls and upstream face walls that can be utilized or adopted by local and state dam safety programs.

3. Standard computation methods for drainage area Time of Concentration (TC) are typically intended for use in estimating flood peaks and hydrographs for frequencies up to the 100-Year storm. However, both theory and experience suggest that shorter TCs should be used when computing peaks and hydrographs from larger, less frequent events such as the PMF, due primarily to the greater flow depths and velocities. As such, the standard computation methods may be yielding lower peak flow estimates for such events, which can lead to inaccurate hazard classification and underdesigned remedial measures.

Research Request: Investigate accuracy of standard TC computation methods under extreme storm conditions. If necessary, develop alternative methods or policies for estimating drainage area TCs for such extreme events.

4. Since the majority of dams subject to local or state dam safety regulations have drainage areas less than 10 square miles, questions arise over the most appropriate temporal rainfall distribution to utilize in a hazard classification and/or Spillway Design Storm analysis. These questions include concerns whether the NRCS design storm distributions are appropriate for extreme rainfall amounts and whether other popular storm distributions such as the Corps of Engineers' Standard Project Storm is appropriate for small drainage areas.

Research Request: Investigate suitability of popular design storm distributions for extreme rainfall amounts falling over small drainage areas. Develop appropriate distribution for such rainfalls and areas through research and/or policy.

5. As noted above, the majority of water surface profile computations downstream of a dam failure are based upon steady rather than unsteady flow assumptions. In most instances, however, the selection of steady over unsteady flow is not based upon theoretical grounds but rather on the difficulty in performing the unsteady flow computations with the DAMBRK and FLDWAV computer programs (see 1 above). The recent inclusion of unsteady flow in HEC-RAS offers an opportunity to address this problem. However, limited training has been available to date to small dam designers and analysts and local and state dam safety personnel.

Research Request: Develop guidelines and limitations for use of steady flow models in dam safety studies. Also develop effective HEC-RAS unsteady flow and FLDWAV training courses for small dam analysts and designers and local and state dam safety personnel.

6. The most significant and, at times, prohibitive cost of an accurate hazard classification or Spillway Design Storm study for a small dam is incurred during the development of the hydraulic model of the downstream waterway. Costs associated with field surveys, topographic mapping, and model data development often exceed the remaining study costs.

Research Request: Develop inexpensive techniques to develop waterway and floodplain topography and cross sections in a digital format that can readily be input into available hydraulic computer models.

7. According to the FERC's Engineering Guidelines, dam failures should not be assumed to begin on the rising limb of the inflow hydrograph. Instead, the presumably more conservative assumption of failure starting at the maximum water surface should be made. However, instances have arisen where greater discharges are computed when the failure is assumed to occur somewhat before the maximum water surface is achieved. This is particularly true at certain small dams with very short (10 to 15 minute) failure times. In these instances, the rapid enlargement of the dam breach begins while the water surface is still rising, leading to ultimately greater heads and resultant peak outflows due to the failure. While these greater peak outflows can be identified through sensitivity analyses of failure starting times, such analyses can increase costs for small dam projects.

Research Request: Determine the sensitivity of starting water surface elevation to peak outflows from small dam failures and establish parameters to identify the most conservative starting water surface assumptions.

Acknowledgements

The author gratefully acknowledges the assistance of Mr. John Ritchey and Mr. Joseph Ruggeri of the NJDEP's Dam Safety Section in preparing the discussions of current State of New Jersey practices, problems, and research needs.

Page left intentionally blank

SAFE DAM ACT

58:4-1 Reservoir, dam restrictions.

58:4-1. a. No municipality, corporation or person shall, without the consent of the Commissioner of Environmental Protection, hereafter in this chapter designated as the commissioner, build any reservoir or construct any dam, or repair, alter or improve existing dams on any river or stream in this State or between this State and any other state which will raise the waters of the river or stream more than five feet above its usual mean low-water height.

No municipality, corporation or person shall, without the consent of the commissioner, build any reservoir or construct any dam, or repair, alter or improve existing dams in the pinelands area, as designated by subsection a. of section 10 of P.L.1979, c.111 (C.13:18A-11), which will raise the waters of any river or stream more than eight feet above the surface of the ground where the drainage area above the dam or reservoir is more than one square mile in extent and where the water surface created by the dam or reservoir is more than 100 acres in extent.

The commissioner may investigate and take appropriate action regarding any dam or reservoir about which the commissioner has a security or safety concern.

With respect to dams and reservoirs located on lands utilized for agricultural or horticultural purposes within the pinelands area, the commissioner's actions shall be undertaken after consultation with the Secretary of Agriculture.

b. The commissioner shall not require a permit for the repair of any dam used for agricultural purposes within a special agricultural production area designated pursuant to N.J.A.C.7:50-5.14 in the pinelands area.

Amended 1981, c.249, s.3; 1985, c.33; 1995, c.402, s.1; 2001, c.82, s.1.

58:4-2. Approval of plans of reservoirs and dams

Every municipality, corporation or person, before constructing any reservoir or dam subject to the provisions of this chapter shall apply to the commissioner for the approval of the plans of such reservoir or dam, which approval the commissioner may grant with such modifications, limitations or changes as in his judgment may be necessary for the protection of life and property.

Amended by L.1981, c. 249, s. 4, eff. Aug. 6, 1981.

58:4-3. Descriptions, surveys and plans of existing reservoirs and dams

Every municipality, corporation or person owning and maintaining or having control of any reservoir or dam shall, upon written request therefor, furnish to the commissioner as full, true and particular description of the reservoir or dam as may be practicable, and shall, when so requested by the commissioner cause to be made such surveys, plans and drawings of the reservoir or dam as may be necessary to give sufficient information for the determination of its safety as may be required by the commissioner.

Amended by L.1981, c. 249, s. 5, eff. Aug. 6, 1981.

58:4-4. Inspection of reservoirs and dams

Upon written application by any person owning or representing property liable to be injured or destroyed by the breaking of any reservoir or dam, or upon application by the mayor or governing body of any municipality on account of possible danger of loss of life or of injury to any property within the municipality from the breaking of any reservoir or dam, or without such complaint whenever the commissioner shall choose, he shall forthwith thoroughly inspect such reservoir or dam.

Amended by L.1981, c. 249, s. 6, eff. Aug. 6, 1981.

58:4-5 Alterations, additions and repairs of unsafe reservoirs or dams; duties of owner.

58:4-5. a. An owner or person having control of a reservoir or dam shall:

(1)Implement all measures required pursuant to this chapter or the provisions of P.L.1981, c.249 (C.58:4-8.1 et seq.), or any rule, regulation, code, permit or order issued pursuant thereto, including but not limited to, performance of periodic inspections required pursuant to section 2 of P.L.1981, c.249 (C.58:4-8.2) or development, updating and implementation of emergency action plans;

(2)Provide to the Department of Environmental Protection, upon request, any reports or information required pursuant to this chapter or the provisions of P.L.1981, c.249, or any rule or regulation adopted, or permit or order issued pursuant thereto; and

(3)Implement any action ordered by the Commissioner of Environmental Protection to correct conditions that render the reservoir or dam to be considered, as determined by the commissioner, unsafe or improperly maintained or to bring the reservoir or dam into compliance with standards established pursuant to this chapter, or any rule or regulation adopted, or permit or order issued pursuant thereto.

b. If, in the judgment of the commissioner, any reservoir or dam is not sufficiently strong to resist the pressure of water that is or may be upon it or there is reasonable cause to believe that danger to life or property may be anticipated from the reservoir or dam, or if for any other cause the commissioner shall determine the reservoir or dam to be unsafe or improperly maintained, the commissioner shall take any action authorized pursuant to this section to compel compliance with the provisions of this chapter, or any rule or regulation adopted, or permit or order issued pursuant thereto, and shall determine whether the water in the reservoir or above the dam shall be drawn off in whole or in part, and what alterations, additions and repairs are necessary to be made to the reservoir or dam to make it safe and properly maintained or whether the dam or appurtenant structures located therein should be removed. The commissioner also may take action as authorized pursuant to R.S.58:4-6 against the owner or person having control of the reservoir or dam for such relief as the commissioner may determine. The commissioner shall forthwith in writing order the owner or person having control of the reservoir or dam to cause the alterations, additions and repairs to be made within the time to be limited in the order. A copy of any order issued by the commissioner pursuant to this section shall be sent to the clerk of the municipality and the clerk of the county in which the reservoir or dam is located. The commissioner also may order the water in the reservoir or above the dam to be drawn off in whole or in part as the commissioner may determine. The commissioner shall not approve the decommissioning of a reservoir or dam until the commissioner has provided 30 days' prior notice

and the commissioner has complied with the provisions of R.S.58:4-10 as applicable. The notice of the proposed decommissioning shall be published at least 30 days prior to the decommissioning of the reservoir or dam in at least one newspaper of general circulation in the municipality in which the reservoir or dam is located. The commissioner shall have the right to enter upon any and all properties for the purpose of obtaining information about the safety and proper maintenance of any reservoir, dam or appurtenant structures located therein.

c. Any owner or person having control of a reservoir or dam who fails to comply with an order issued pursuant to this section or R.S.58:4-6 may be liable to the department in an amount equal to the cost of removal of the dam or appurtenant structures located therein undertaken by the department, including attorney's fees and court costs, pursuant to subsection d. of this section.

Whenever two or more owners or persons having control of a reservoir or dam are liable for the cost of removal, including attorney's fees and court costs, the department may allocate the cost of removal among the liable parties using such factors as the department determines are appropriate. Nothing in this subsection shall affect the right of any party to seek contribution from any other person responsible for the cost of removal of the dam pursuant to any other statute or under common law.

d. (1) Whenever the commissioner determines that a dam is in imminent danger of failure and has reasonable cause to believe that danger to life or property may be anticipated from the reservoir, dam or appurtenant structures located therein, and the owner of the dam or person having control of the reservoir or dam has failed to comply with an order to repair the dam issued pursuant to subsection a. of this section or R.S.58:4-6, or to take such interim measures as the department determines are appropriate, including reducing the amount of water impounded by the dam or breaching the dam, the department may, in addition to actions authorized pursuant to R.S.58:4-6, enter upon any and all properties wherein the reservoir, dam or appurtenant structures are located and, using resources and personnel available to the department, remove or cause to be removed the dam or appurtenant structures located therein, allowing the water to flow freely.

Prior to any action by the department pursuant to this subsection, the owner or person having control of the reservoir or dam, shall, no later than 60 days after receipt of a notice from the department of a pending removal action, submit to the department, in writing, an acceptable implementation plan addressing the proposed actions to be taken regarding the failed or failing reservoir or dam.

(2)Any expenditures made by the department pursuant to this section shall constitute, in each instance, a debt to the State. The debt shall constitute a lien on all property owned by the owner or person having control of the reservoir or dam when a certificate of debt, incorporating a description of the property of the owner or person having control of the reservoir or dam subject to the repair, and related costs, is duly filed with the clerk of the Superior Court. The clerk shall promptly enter upon the civil judgment and order docket the name and address of the owner or person having control of the reservoir or dam and the amount of the lien as set forth in the certificate of debt. Upon entry by the clerk, the lien, to the amount committed by the department for dam repair, shall attach to the revenues and all real and personal property of the owner or person having control of the reservoir or dam, whether or not the owner or person having control of the reservoir or dam is insolvent.

The certificate of debt filed pursuant to this paragraph which affects the property of an owner or person having control of a reservoir or dam subject to the dam repairs shall create a lien with priority over all other claims or liens which are or have been filed against the property, except if the property comprises six dwelling units or less and is used exclusively for residential purposes, this certificate of debt shall not affect any valid lien, right or interest in the property filed in accordance with established procedure prior to the filing of this certificate of debt.

The certificate of debt filed pursuant to this subsection which affects any property of an owner or person having control of a reservoir or dam, other than the property subject to the repairs, shall have priority from the day of the filing of the certificate of debt over all other claims and liens filed against the property, but shall not affect any valid lien, right, or interest in the property filed in accordance with established procedure prior to the filing of a certificate of debt pursuant to this subsection.

Whenever the owner or person having control of the reservoir or dam is a private lake association or other body representing owners of property adjacent to the reservoir or lake created by the dam or impoundment, liens may be imposed upon the individual owners of the property represented by the association. An owner whose property has such a lien imposed may release the property from a lien claimed under this subsection by filing with the clerk of the Superior Court a cash or surety bond, payable to the department in the amount of the sums expended by the department pursuant to this section, including attorney's fees and court costs, or the value of the property after the abatement action is complete, whichever is less.

e. The provisions of this section shall not limit the use of other remedies available to the department pursuant to law.

f. The commissioner may adopt, pursuant to the "Administrative Procedure Act," P.L.1968, c.410 (C.52:14B-1 et seq.), any rules or regulations necessary to implement the provisions of this section.

Amended 1981, c.249, s.7; 1994, c.84, s.1; 2005, c.228, s.1.

58:4-6 Enforcement powers of department, civil, criminal; violations; penalties.

58:4-6. a. Whenever the Commissioner of Environmental Protection finds that a person has violated any provision of the "Safe Dam Act," P.L.1981, c.249 (C.58:4-8.1 et seq.), or any rule, regulation or order issued pursuant thereto, the commissioner may:

(1)Issue an order requiring any such person to comply in accordance with subsection b. of this section; or

(2)Bring a civil action in accordance with subsection c. of this section; or

(3)Levy a civil administrative penalty in accordance with subsection d. of this section; or

(4)Bring an action for a civil penalty in accordance with subsection e. of this section; or

(5)Petition the Attorney General to bring a criminal action in accordance with subsection f. of this section.

Recourse to any of the remedies available under this section shall not preclude recourse to any of the other remedies prescribed in this section or by any other applicable law.

b. Whenever, on the basis of available information, the commissioner finds a person in violation of any provision of P.L.1981, c.249, or any rule, regulation or order issued pursuant thereto, the commissioner may issue an administrative order: (1) specifying the provision or provisions of the law, rule, regulation, or order, of which the person is in violation; (2) citing the action which constituted the violation; (3) requiring compliance with the provision or provisions violated; (4) requiring the restoration of the area which is the site of the violation; and (5) providing notice to the person of the right to a hearing on the matters contained in the order.

c. The commissioner is authorized to institute a civil action in Superior Court for appropriate relief from any violation of P.L.1981, c.249, or any rule, regulation or order issued pursuant thereto. Such relief may include, singly or in combination:

(1)A temporary or permanent injunction, including an order or judgment as will effectually secure the persons interested from danger of loss from the breaking of a dam. The court may proceed in the action in a summary manner or otherwise;

(2)Assessment of the violator for the costs of any investigation, inspection, or monitoring survey which led to the establishment of the violation, and for the reasonable costs of preparing and bringing legal action under this subsection;

(3)Assessment of the violator for any costs incurred by the State in removing, correcting, or terminating the adverse effects resulting from any violation for which legal action under this subsection may have been brought;

(4)Assessment against the violator for compensatory damages for any loss or destruction of wildlife, fish or aquatic life, and for any other actual damages caused by a violation;

(5)A requirement that the violator restore the site of the violation to the maximum extent practicable and feasible.

d. The commissioner is authorized to assess a civil administrative penalty of up to $25,000 for each violation of any provision of P.L.1981, c.249, or any rule, regulation or order issued pursuant thereto, and each day during which each violation continues shall constitute an additional, separate, and distinct offense. Any amount assessed under this subsection shall fall within a range established by regulation by the commissioner for violations of similar type, seriousness, and duration. In adopting rules and regulations establishing the amount of any penalty to be assessed, the commissioner may take into account the economic benefits from the violation gained by the violator. No assessment shall be levied pursuant to this section until after the party has been notified by certified mail or personal service. The notice shall: (1) identify the section of the law, rule, regulation or order violated; (2) recite the facts alleged to constitute a violation; (3) state the amount of the civil penalties to be imposed; and (4) affirm the rights of the alleged violator to a hearing. The ordered party shall have 20 days from receipt of the notice within which to deliver to the commissioner a written request for a hearing. After the hearing and upon finding that a violation has occurred, the commissioner may issue a final order specifying the amount of the fine imposed. If no hearing is requested, the notice shall become final after the expiration of the 20-day period. Payment of the assessment is due when a final order is issued or

the notice becomes a final order. The authority to levy an administrative penalty is in addition to all other enforcement provisions in this act and in any other applicable law, rule, or regulation, and the payment of any assessment shall not be deemed to affect the availability of any other enforcement provisions in connection with the violation for which the assessment is levied. Any civil administrative penalty assessed under this section may be compromised by the commissioner upon the posting of a performance bond by the violator, or upon such terms and conditions as the commissioner may establish by regulation.

e. A person who violates any provision of P.L.1981, c.249 or any rule, regulation or order issued pursuant thereto, an administrative order issued pursuant to subsection b. of this section, or a court order issued pursuant to subsection c. of this section, or who fails to pay a civil administrative penalty in full pursuant to subsection d. of this section, shall be subject, upon order of a court, to a civil penalty not to exceed $10,000 per day of such violation, and each day during which the violation continues shall constitute an additional, separate, and distinct offense. Any civil penalty imposed pursuant to this subsection may be collected with costs in a summary proceeding pursuant to the "Penalty Enforcement Law of 1999," P.L.1999, c.274 (C.2A:58-10 et seq.). In addition to any penalties, costs or interest charges, the court may assess against the violator the amount of actual economic benefit accruing to the violator from the violation. The Superior Court and the municipal court shall have jurisdiction to enforce the provisions of the "Penalty Enforcement Law of 1999" in connection with this section.

f. A person who purposely, knowingly or recklessly violates any provision of P.L.1981, c.249, or any rule, regulation or order issued pursuant thereto, shall be guilty, upon conviction, of a crime of the fourth degree and, notwithstanding any provision of N.J.S.2C:43-3 to the contrary, shall be subject to a fine of not less than $2,500 nor more than $25,000 per day of violation, in addition to any other applicable penalties and provisions under Title 2C of the New Jersey Statutes. A second or subsequent offense under this subsection shall subject the violator to a fine, notwithstanding any provision of N.J.S.2C:43-3 to the contrary, of not less than $5,000 nor more than $50,000 per day of violation, in addition to any other applicable penalties and provisions under Title 2C of the New Jersey Statutes. A person who knowingly makes a false statement, representation, or certification in any application, record, or other document filed or required to be maintained under the provisions of P.L.1981, c.249 shall be guilty, upon conviction, of a crime of the fourth degree and, notwithstanding any provision of N.J.S.2C:43-3 to the contrary, shall be subject to a fine of not more than $10,000, in addition to any other applicable penalties and provisions under Title 2C of the New Jersey Statutes.

g. In addition to the penalties prescribed in this section, a notice of violation of any provision of P.L.1981, c.249, or any rule, regulation or order issued pursuant thereto, shall be recorded on the deed of the property wherein the violation occurred, on order of the commissioner, by the clerk or register of deeds and mortgages of the county wherein the affected property is located and with the clerk of the Superior Court and shall remain attached thereto until such time as the violation has been remedied and the commissioner orders the notice of violation removed.

h. The department may require an owner or person having control of a reservoir or dam to provide any information the department requires to determine compliance with any provision of P.L.1981, c.249, or any rule, regulation or order issued pursuant thereto.

i. Any person who knowingly, recklessly, or negligently makes a false statement, representation or certification in any application, record, or other document filed or required to be maintained

under the provisions of P.L.1981, c.249, shall be in violation of the act and shall be subject to the penalties assessed pursuant to subsections d. and e. of this section.

j. All penalties collected pursuant to this section or sums collected pursuant to R.S.58:4-5 shall be deposited in the "Environmental Services Fund," established pursuant to section 5 of P.L.1975, c.232 (C.13:1D-33), and kept separate from other receipts deposited therein, and appropriated to the department for the removal of dams in the State.

k. The department shall have the authority to enter any property, facility, premises, or site for the purpose of conducting inspections to determine the condition of any dam, or to conduct inspections of ordered repairs or to otherwise determine compliance with the provisions of P.L.1981, c.249.

Amended 1953, c.54, s.5; 1981, c.249, s.8; 2005, c.228, s.2.

58:4-8. Personnel to conduct inspections

The commissioner may, when provided with sufficient funds, employ personnel for the inspection of existing reservoirs and dams and the supervision of the erection of new reservoirs and dams in this State or between this and any other state so that said structures may be built with due regard for the safety of property and life which might be endangered by improper construction thereof.

Amended by L.1981, c. 249, s. 9, eff. Aug. 6, 1981.

58:4-8.1. Short title

This act shall be known and may be cited as the "Safe Dam Act."

L.1981, c. 249, s. 1, eff. Aug. 6, 1981.

58:4-8.2. Periodic dam safety inspection and reporting procedure

The Commissioner of Environmental Protection shall, by rule, establish a periodic dam safety inspection and reporting procedure, on an annual or longer term basis, for the owner of any dam meeting the criteria contained in R.S. 58:4-1. The owner shall have a professional engineer inspect the dam and prepare and submit a report containing such information as the commissioner may require, concerning the safety of said dam and appurtenant structures. Every dam which raises the waters of any stream more than 70 feet above its usual mean low-water height or which impounds more than 10,000 acre-feet of water shall be inspected on an annual basis by a professional engineer retained by the owner, in the company of a professional engineer assigned from the Department of Environmental Protection.

L.1981, c. 249, s. 2, eff. Aug. 6, 1981.

58:4-9. Maintenance of existing reservoirs and dams; petition against abandonment

58:4-9. Where a reservoir or dam has been in existence 20 years and the owners of land along the shores above the dam or on the reservoir have made or shall have made permanent improvements on the land or where the shores have become a populated community, depending upon the permanency of the condition created, or where the reservoir or dam has become a valuable resource for the quality of life in the municipality in which the reservoir or dam is located, and a petition signed by a majority of the landowners along the shore of any pond formed by the reservoir or dam, or by any number of residents of the municipality in which the

reservoir or dam is located, or by the governing body of the municipality, protesting against the removal of the reservoir, water or dam or the decommissioning of the reservoir or dam has been filed with the commissioner, the owner or owners of the reservoir or dam shall not, without the consent of the commissioner, tear down, destroy or abandon the reservoir or dam, or, except for the purpose of making necessary repairs, withdraw the water below the usual low-water mark, or maintain the water at the reduced level.

Amended 1981,c.249,s.10; 1994,c.84,s.2.

58:4-10. Hearing on petition; fixing low-water mark; maintenance expenses

58:4-10. When a petition has been filed protesting against the removal of any reservoir, water or dam or against the decommissioning of any reservoir or dam as provided in R.S.58:4-9, the commissioner shall hold a public hearing, upon 30 days' notice to all parties interested, and following prior notice published 30 days before the hearing in at least one newspaper of general circulation in the municipality in which the reservoir or dam is located. Following this public hearing, the commissioner may make a determination concerning the removal of the reservoir, water or dam or decommissioning of the reservoir or dam and may then establish and fix a permanent low-water mark. Should it appear that the maintenance of the reservoir or dam would be an undue burden upon the owner thereof, the commissioner shall enter into negotiations with the landowners interested around the reservoir or above the dam, the governing body of the municipality in which the reservoir or dam is located, and any other parties to the petition filed with the commissioner protesting against the removal of the reservoir, water or dam or the decommissioning of the reservoir or dam, for the purpose of determining how and by whom the expenses of maintenance shall be paid.

Amended 1981,c.249,s.11; 1994,c.84,s.3.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

N.J.A.C. 7:20

Dam Safety Standards

Statutory authority: Safe Dam Act, N.J.S.A. 58:4-1

Date last amended: June 16, 2008

For regulatory history and effective dates see the New Jersey Administrative Code Table of Contents

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

DAM SAFETY STANDARDS
N.J.A.C. 7:20
EFFECTIVE DATE: SEPTEMBER 8, 2005,
AMENDMENT JUNE 16, 2008
EXPIRATION DATE: SEPTEMBER 8, 2010

SUBCHAPTER 1. APPLICATION PROCEDURE; DESIGN CRITERIA FOR DAM CONSTRUCTION; DAM INSPECTION PROCEDURE

N.J.A.C. 7:20-1.1 Scope and applicability

The rules in this subchapter were adopted pursuant to the authority of N.J.S.A. 58:4-1 et seq., as amended by the Safe Dam Act of 1981, and N.J.S.A. 13:1D-l et seq.

1. These rules set forth procedures for application to construct, repair or modify a dam, as defined in N.J.A.C. 7:20-1.2 and set standards for design and maintenance of dams. These rules also establish a dam inspection procedure.

2. Any dam which raises the waters of a stream five feet or less above its usual, mean, low water height falls under the jurisdiction of the Flood Hazard Area Control Act, N.J.S.A. 58:16A-50 et seq.

3. The requirements in this subchapter shall not affect or relate to a dam or reservoir in the pinelands area, as designated by subsection a. of section 10 of P.L. 1979, c.111 (C. 13:18A-ll), which will raise the waters of any river or stream less than eight feet above the surface of the ground where the drainage area above the same is less than one square mile in extent and where the water surface created by the dam or reservoir is less than 100 acres in extent except that the commissioner may investigate and take appropriate action regarding any dam or reservoir about which he has a security or safety concern. With respect to dams and reservoirs located on lands utilized for agricultural or horticultural purposes within the pinelands area, the commissioner's actions shall be undertaken after consultation with the Secretary of Agriculture. See N.J.S.A. 58:4-1, P.L. 1985, c.33, Sl and 2.

N.J.A.C. 7:20-1.2 Definitions

The following words and terms, as used in this chapter, shall have the following meanings, unless the context clearly indicates otherwise.

"Applicant" means any person making application for a dam permit.

"Auxiliary spillway" means the second used spillway during flood flows which is not the emergency spillway.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

"Dam" means any artificial dike, levee or other barrier, together with appurtenant works, which is constructed for the purpose of impounding water on a permanent or temporary basis, that raises the water level five feet or more above the usual, mean, low water height when measured from the downstream toe-of-dam to the emergency spillway crest or, in the absence of an emergency spillway, the top-of dam.

"Department" means the New Jersey Department of Environmental Protection.

"Design freeboard" means the minimum freeboard which would exist during passage of the design flood.

"Division" means the Division of Engineering and Construction in the Department of Environmental Protection.

"Emergency spillway" means the spillway capable of passing the spillway design storm with the principal and/or auxiliary spillway blocked.

"Environmental impact statement" means a report which describes the real and potential impacts which will or may result from the construction and operation of a proposed dam project, the adverse environmental impacts which cannot be avoided, the steps to be taken to minimize adverse impacts and the alternatives to the project with reasons for the acceptability or unacceptability; and

1. The report shall address real or potential impacts upon ecology, natural resources, historical and archeological resource, recreational resources, aesthetic resources, endangered and non-game species, fisheries and any other identifiable impacts;

2. The report shall include a listing of qualifications of those preparing the report and a reference list of pertinent published information relating to the project, the project site and the surrounding region.

"Formal inspection" means the inspection by a New Jersey licensed professional engineer to reevaluate the safety and integrity of the dam and appurtenant structures to determine if the structure meets current design criteria, including a field inspection and a review of the records on project design, construction and performance.

"Freeboard" means the vertical dimension between the crest of the embankment of a dam (without camber) and the reservoir water surface at the spillway design flood stage.

"Height-of-dam" means the vertical dimension from the lowest point in the stream bed or ground surface at the downstream toe of the dam to the elevation of the top of dam (without camber).

"Independent Review Board" means one or more independent professional engineers who are qualified in the design, construction and rehabilitation of dams to perform a review of

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

the project design and construction.

"Informal inspection" means the visual inspection of the dam by the dam owner or operator to detect apparent signs of deterioration or other deficiencies of the dam structure or function.

"Levee" or "dike" means any artificial barrier together with appurtenant works that will divert or restrain the flow of a stream or river.

"One-hundred-year storm" means the storm which is estimated to have a one percent chance, or one chance in 100, of being equaled or exceeded in one year.

"Outlet" means an opening through which water can be freely discharged from a reservoir for a particular purpose.

"Owner and/or operator" means any person who owns, controls, operates, maintains, manages or proposes to construct a dam.

"Permit" or "dam permit" means all approvals required under N.J.S.A. 58:4-1 et seq. for the construction and operation of a dam.

"Person" means any individual, proprietorship, partnership, association, corporation, municipality, county or public agency.

"Pipe conduit" means any hollow tube which conveys water through a dam from a reservoir, either as a spillway or as a drain.

"Principal spillway" means the primary or first used spillway during normal inflow and flood flows.

"Probable maximum precipitation" or "(PMP)" means the theoretically greatest depth of precipitation for a given duration that is physically possible, over a given size storm area, at a particular geographic location, at a certain time of year.

"Regular inspection" means the visual inspection of a dam by a New Jersey licensed professional engineer to detect any signs of deterioration in material, developing weaknesses or unsafe hydraulic or structural behavior.

"Reservoir" means any impoundment or any potential impoundment that will be created by a dam, dike or levee.

"Spillway" means a structure other than low flow outlets, over or through which flood flows are discharged.

"Spillway design storm" means the storm upon which the hydraulic capacity of the spillway structure is designed.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

"Toe-of-dam" means the junction of the downstream face of a dam with the ground surface or the invert of the outlet pipe whichever is the lowest point.

N.J.A.C. 7:20-1.3 Permit-by-rule

(a) All dams must be designed, constructed, operated, maintained or removed in compliance with the rules in this subchapter except as set forth below:

1. Owners and operators of Class IV dams (see N.J.A.C. 7:20-1.8, Dam classification) are not required to file documents with nor obtain a permit from the Department, but must meet the following requirements, in addition to those set forth elsewhere in this subchapter:

i. Design must be based upon a spillway design storm that results in rainfall of 50 percent greater than a 24- hour, 100-year, Type III storm (Later technology adopted by the United States Department of Agriculture, Natural Resources Conservation Service may be substituted for the use of the Type III storm.); and

ii. All necessary local approvals must be obtained;

iii. A New Jersey licensed professional engineer must design the Class IV Dam to meet all technical requirements of this subchapter; and

iv. If the Class IV dam is designed or constructed for stormwater management purposes, the dam shall comply with the Stormwater Management Rules at N.J.A.C. 7:8.

2. Owners and operators of Class III agricultural impoundments, meaning any impoundment used for fish and wildlife, fire control or livestock or crop production and maintenance, where the drainage area is less than one-half square mile in extent, must meet only the following requirements.

i. All necessary local approvals must be obtained;

ii. Design and construction must be supervised by the United States Department of Agriculture, Natural Resources Conservation Service.

(b) The Department may, in its discretion, require the owner or operator of any dam subject to (a) above to obtain a permit and/or to submit any information relating to dam design, construction, operation or maintenance.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

(c) The Department may, in its discretion, require the owner or operator of any dam to make modification of the design, construction or operation of the dam in order to comply with the intent of this chapter and the Safe Dam Act, N.J.S.A. 58:4-1 et seq.

N.J.A.C. 7:20-1.4 General requirements and prohibitions

(a) No person may construct or operate a new dam or modify or repair an existing dam without first having obtained a permit from the Department, unless subject to the permit-by-rule provision in N.J.A.C. 7:20-1.3. Where emergency circumstances justify, repairs of a dam may be undertaken prior to obtaining a permit, in accordance with (i) below.

(b) No dam may be approved by the Department where, in the opinion of the Department, there is an unacceptable potential for harm to human health or to human safety.

(c) Backwater created by a dam during a 100-year storm shall be the minimum which is contained within the applicant's property unless written consent is obtained from all potentially affected property owners. Effects on both surface and ground water shall be considered, during normal pool conditions.

(d) No person may construct a dam in any waterway of this state which is a runway for migratory fish, without installing a fish ladder or other approved structure to permit the fish to pass the dam in either direction (see N.J.S.A. 23:5-29.1).

1. This provision is applicable to dams of any size.

2. The Department will determine whether a stream is currently a runway for migratory fish, during the review of the dam permit application. Applicants should consult the Division of Fish and Wildlife in this matter prior to finalizing the application.

(e) Unless otherwise approved by the Department, dam construction shall commence within one year from the date of the permit and be completed within two years from the said date or the permit will become null and void. For good cause shown, the Department may extend the two year construction deadline for a total of no more than five years, one year at a time. Applicants must make written request for an extension, prior to the expiration date of the permit or prior extension.

(f) No action shall be brought against the State or the Department or its agents or employees for the recovery of damages caused by the partial or total failure of any dam or reservoir or through the operation of any dam or reservoir upon the ground that the Department is liable by virtue of any of the following:

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

1. The approval of the dam or reservoir, or approval of flood handling plans during construction.

2. The issuance or enforcement of orders relative to maintenance or operation of the dam or reservoir.

3. Control, regulation and inspection of the dam or reservoir.

4. Measures taken to protect against failure during an emergency.

(g) The Department may deny any application for a dam permit, based upon its conclusion that the construction or operation of dam will cause an unacceptable threat to or impact on natural or cultural resources or the environment.

(h) The Department shall be notified immediately by the owner or operator upon the detection of any condition which may jeopardize the safety of the structure.

(i) Situations which threaten the public health, safety, and welfare and require emergency dam repair will be considered by the Department under the following procedure:

1. The owner or operator shall inform the Department by telephone as to the extent of work to be performed, the reason for the emergency and the location of the project.

2. The owner or operator shall perform the emergency work upon verbal approval of the Department, which approval shall be verified by the Department in writing within three working days. The Department shall offer guidance and instructions in performing the work.

3. After the work has been completed in accordance with the Department's instructions, the owner or operator shall submit a dam Permit Application and "as built" drawings to the Department for review. A letter shall be issued by Department in lieu of a dam permit.

(j) The Department shall be notified in writing on or before the transfer of dam ownership.

(k) Unless otherwise approved by the Department in writing, no person shall dredge within 200 feet of a dam.

(l) Utilities crossing within dam embankments are prohibited unless demonstrated to the satisfaction of the Department that such utilities will not jeopardize the safety of the dam.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

(m) No person shall remove or breach an existing dam without first having obtained a permit from the Department unless subject to the permit-by-rule provisions in N.J.A.C. 7:20-1.3.

(n) Unless otherwise approved by the Department, no trees shall be permitted to grow on the dam embankment.

N.J.A.C. 7:20-1.5 General application procedures

(a) The procedures for applying for a dam construction, modification or repair permit and for submitting the supporting engineering documents include the preapplication stage and the application stage, as described below. For Class III dams (see N.J.A.C. 7:20-1.8) all required information may be submitted at one time, with such detail as is appropriate to the safe design of the type of structure proposed.

(b) The applicant for a dam permit must use a New Jersey licensed professional engineer to prepare the plans and specifications and to supervise the inspection of the construction.

(c) The Department may require any owner or operator of an existing dam to obtain a permit for repair or modification of the dam and appurtenances where:

1. Repair or modification is necessary to insure protection of human health or safety; or

2. Modification is required to comply with the provisions of this chapter, unless the following circumstances exist:

i. Compliance is impracticable; and,

ii. Noncompliance poses no unacceptable threat to human health or safety.

(d) Appeal procedures; permit denials

1. 1. An applicant for a dam permit may request in writing an administrative hearing from the Department within 15 days of receipt of the decision by the Department to deny the application. The request for a hearing shall be sent to the Office of Legal Affairs, ATTENTION: Adjudicatory Hearing Requests, Department of Environmental Protection, CN 402, Trenton, New Jersey 08625-0402.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

2. The request for a hearing shall specify in detail the basis for the request, including all issues of fact or law. The Department may attempt to settle the dispute by conducting such proceedings, meetings and conferences as deemed appropriate. Should the efforts to settle the dispute fail and if the Department determines that the matter is a contested case, the Department shall forward the request for a hearing to the Office of Administrative Law, pursuant to the provisions of the Administrative Procedure Act (N.J.S.A. 52:14B-l et seq.)

(e) Applicants for a dam permit for a Class III dam, as defined pursuant to N.J.A.C. 7:20-1.8, may submit a preliminary application, which should include that information needed to establish a Class III hazard classification. Thereafter, in its discretion, the Department may waive certain documentation and inspection requirements set forth in these rules.

N.J.A.C. 7:20-1.6 Preapplication Stage

(a) The applicant must submit a written Preliminary Report which must include the following:

1. A general description of the dam and all appurtenances thereto, and the proposed dam classification, pursuant to N.J.A.C. 7:20-1.8. The description shall include the following:

i. A statement of the purpose for which the dam and appurtenances are to be used; and

ii. A description of the potential effects of project construction and operation upon the environment.

2. Maps of the area within one-half mile of the dam and impoundment boundary, showing the following:

i. The location of the proposed dam and all appurtenances, thereto;

ii. The location of all structures;

iii. The county and township;

iv. The boundary of the reservoir;

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

v. The location of all streets and roads;

vi. The location of all major utilities, i.e. pipe lines and transmission, telegraph, and telephone lines; all minor utilities shall be identified in the immediate vicinity of the dam and impoundment area.

vii. The topography and scale; and

viii. All other structures or facilities affected by the proposed dam, including the area downstream from the dam (State, county, and U.S.G.S. maps and aerial photographs may be used for this purpose).

3. A written report of the surficial conditions (i.e. geology, topography, and culture), based upon a field reconnaissance by the applicant's engineer;

4. Typical cross-sections of the dam, and any dike(s) and levee(s), showing proposed elevations, pool levels and top and bottom widths;

5. Preliminary design data, tentative conclusions and references. The design data shall address hydrologic features such as drainage area and rainfall data, the basis for proposed dam location, the basis for the type of structure and spillway proposed, the soils and geologic engineering criteria and the basis for design and construction;

6. The hydrologic design procedure and the storm durations which are used in the design;

7. All documentation and information related to determining hazard classification; and

8. Other information required by the Department.

(b) Upon review of the pre-application, the Department will notify the applicant of what design criteria will apply.

(c) Applicants for a permit to repair an existing dam are not required to submit a preliminary report unless the Department determines it to be necessary.

N.J.A.C. 7:20-1.7 Application Stage

(a) The application shall be on forms specified and supplied by the Department and

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

must be accompanied by two copies of the final design report, construction specifications and all plans, drawings, and designs. Upon the written request of the applicant, the Department may waive certain requirements for documentation in the application stage set forth at (b) to (g) below for a permit to modify, repair or remove an existing dam.

(b) The application shall include a Final Design Report, which must contain the following:

1. A report of the field and laboratory investigation(s) of the foundation soils and/or bedrock, a location map to identify borings and the materials that will comprise the dam and any dikes or levees. Stability and settlement analyses and seepage and underseepage studies are required, unless the applicant can demonstrate to the satisfaction of the Department that these analyses are not necessary.

2. The bases, references, calculations and conclusions relative to hydrologic studies and design of spillway.

3. Structural and hydraulic design studies and calculations. Structural, hydraulic and hydrologic design procedures should be used, as established by one of the following: the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, the U.S. Natural Resources Conservation Service and other procedures universally accepted as sound engineering practice.

(c) The application must include all drawings necessary to fully describe the proposal. Drawings must be prepared in accordance with the following:

1. All drawings must be prepared by a New Jersey licensed professional engineer or land surveyor, as appropriate. Each drawing shall have a title block which meets the requirements of the State Board of Professional Engineers and Land Surveyors.

2. Drawings must clearly show the datum to which elevations shown are referred. The National Geodetic Vertical Datum of 1929 (N.G.V.D.), formerly known as the U.S. Coast & Geodetic Survey datum, should be used wherever possible. If the N.G.V.D. datum is not used, an appropriate conversion equation must be indicated on the drawings.

3. The applicant must submit drawings showing the following information:

i. A general plan of the dam, drawn to an appropriate scale, which must show accurately the position of all essential details, such as the spillway and its point of discharge into the stream, pipes through the dam, inlets, outlets, screen chambers, gate or valve houses, head-races, the canal mill or power plant, tailraces and downstream

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

bridges which might cause backwater on the dam;

ii. A longitudinal section of the dam and cross-section of the valley at the site of the dam, showing the elevation of the crest of the dam, the elevation of the normal and design storm flow line of the lake or reservoir, the original surface of the ground, the nature and depth of the underlying strata, the probable depth of the excavation for the foundation of the dam and for the cutoff, foundation treatment, elevation of the restored surface of the ground, the location and elevation of all pipes or conduits passing through the dam, the core wall, if any, and the spillway structure;

iii. Typical cross sections, including a maximum section of the dam and of a spillway section which shall meet the following requirements;

(1) Cross sections must show the original surface of the ground, subsurface conditions as disclosed by test pits or borings, the probable depth of excavations for the foundation and for cutoff, the elevations of the top of the dam, the crest of the spillway and the normal flow line or water surface in the reservoir;

(2) For earth dams, the depth of stripping must be shown, as well as the position, material and dimensions of the cutoff or core wall, the width of the crest, the slopes and the nature and dimensions of the slope protection, the position and dimensions of the outlet pipes or conduits and the cutoff to prevent seepage along such structures, the disposition of different classes of embankment material if of varying composition, toe drains and clay blankets;

(3) For concrete or other composite dams, the cross sections shall show all dimensions and shall indicate the position and kinds of material to be included in the structure.

iv. If not clearly indicated on one or more of the drawings listed above, the following details shall be shown on additional detail sheets:

(1) Detail of spillway or overflow, showing the length and depth of opening, together with the width and shape of the crest, grade and shape of the approach and discharge channels, if any, methods of protecting the toe of the dam or end of the discharge channel from erosion and the dimensions of all

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

walls, floors and paving;

(2) Details of the intake and outlet works, showing the location and dimensions of all valves or sluice gates, intakes, screen chambers, racks, outlet towers and gate houses and appurtenances;

(3) For reinforced concrete dams, detailed drawings must also be submitted, showing the size, spacing and arrangement of all reinforcing steel and expansion joints; and

(4) Special drawings shall be submitted showing any special construction features not otherwise shown, such as piling, fishways, aprons, materials used in the core wall, movable dams, tainter gates and mechanical devices, drains and instrumentation.

(d) The application must include specifications, containing the following:

1. General provisions, specifying the rights, duties and responsibilities of the owner, applicant, applicant's engineer and the builder;

2. The estimated project schedule and sequence of work; and

3. Technical provisions, describing carefully and in detail the approved work methods and procedures, standards for equipment and testing, materials to be used and the results to be obtained.

(e) The applicant shall complete all investigations, including the following, prior to submission of the final design report which shall meet the following requirements:

1. The scope and the degree of precision of investigations required for a specific project shall be based on the complexities of the site, the importance of the proposed structure and the hazard created by the proposed structure.

2. The foundation investigation shall consist of borings, test pits, seismic investigations or other subsurface explorations and must be performed so as to accurately define the soil and rock stratigraphy and the ground water conditions to the satisfaction of the Department.

3. Laboratory testing of undisturbed and remolded soil specimens and rock samples may be required by the Department.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

4. The applicant must determine the nature and extent of materials which are proposed for use in the structure, (e.g., borrow material, concrete aggregate, riprap stone, filter materials) and their structural properties when incorporated into the proposed structure.

5. Stability analysis and calculations for the proposed structure to ensure safety against failure due to overturning, sliding or overstressing must be submitted and approved by the Department.

6. Topographic surveys must be performed with sufficient accuracy to locate the proposed construction and to define the volume of the storage in the reservoir and the flowage limits. The upstream and downstream area must be investigated in order to delineate the area of potential damage in case of failure or flooding. Locations of baselines, centerlines and other horizontal and vertical control points must be shown on the topographic map of the site.

7. The drainage area must be accurately determined. Both present and projected future land use must be considered in determining the runoff characteristics of the drainage area. The most severe of these two conditions must be used in the design. The hydrologic assumptions and design calculations used in spillway designs shall be specified and shall include:

   i. Drainage area size;

   ii. Rainfall and runoff data;

   iii. Reservoir inflow hydrographs;

   iv. Reservoir area-capacity-elevation data;

   v. Spillway elevation-discharge data; and

   vi. Reservoir flood routings, except as otherwise provided in this subchapter.

(f) All applicants must submit an Operation and Maintenance Manual in accordance with N.J.A.C. 7:20-1.1 and applicants for Class I and II dams (see N.J.A.C. 7:20-1.8) shall prepare and submit an Emergency Action Plan which shall at least include a Dam Breach Analysis, Inundation Maps and Emergency Notification and Evacuation Plans.

(g) The Department may require the submission of an Environmental Impact

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

Statement, as defined in N.J.A.C. 7:20- 1.2, by any applicant for a dam permit.

(h) The application to remove or breach a dam shall include the following:

1. Design report, and plans and computations to effect the breach including size of breach, shape of breach, disposal of spoil material;

2. Plans and computations for stabilization of the lake bed including the channel upstream of the breach, and for the control of sediment within the lake and downstream of the breach during and after the breach has been effected;

3. Computations for design of the method and timing for dewatering the lake;

4. Computations detailing the effects of the breach on the downstream channel and demonstrating that the project will not adversely affect flooding conditions downstream during the 10, 50 and 100 year storms;

5. Specifications containing the technical provision which describe in detail the proposed work methods and equipment and, in addition, a work schedule for the entire project;

6. A plan of the existing dam and lake along with surrounding property lines;

7. Evidence that all adjoining property owners of the impoundment and the municipality where the reservoir or dam is located have received notification that an application has been submitted to the Department to remove or breach a dam and proof of publication of notice of the proposed removal application in at least one newspaper of general circulation in the municipality where the reservoir or dam is located;

8. A description of the potential effects of the dam removal or breach upon the environment; and

9. A description of the potential effects of the dam removal or breach upon life and property downstream of the dam.

(i) When a petition has been filed in accordance with the Safe Dam Act, N.J.S.A. 58:4-9, protesting against the removal of any reservoir, water or dam or against the decommissioning of any reservoir or dam, the Commissioner shall, pursuant to the requirements of N.J.S.A. 58:4-10, hold a public hearing, upon 30 days notice to all parties interested, and following prior notice published 30 days before the hearing in at least one newspaper of general circulation in the municipality in which the reservoir or dam is located.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

N.J.A.C. 7:20-1.8 Dam Classification

(a) The Department will use the following guidelines to classify dams according to hazard. Probable future development of the area downstream from the dam which might be affected by its failure will be considered in determining the hazard classification. The Department may, in its discretion, change the hazard class of any proposed or existing dam.

1. Class I - High Hazard Potential: This classification includes those dams, the failure of which may cause the probable loss of life or extensive property damage.

   i. The existence of normally occupied homes in the area that are susceptible to significant damage in the event of a dam failure will be assumed to mean "probable loss of life".

   ii. Extensive property damage means the destructive loss of industrial or commercial facilities, essential public utilities, main highways, railroads or bridges. A dam may be classified as having a high hazard potential based solely on high projected economic loss.

   iii. Recreational facilities below a dam, such as a campground or recreation area, may be sufficient reason to classify a dam as having a high hazard potential.

2. Class II - Significant Hazard Potential: This classification includes those dams, the failure of which may cause significant damage to property and project operation, but loss of human life is not envisioned. This classification applies to predominantly rural, agricultural areas, where dam failure may damage isolated homes, major highways or railroads or cause interruption of service of relatively important public utilities.

3. Class III - Low Hazard Potential: This classification includes those dams, the failure of which would cause loss of the dam itself but little or no additional damage to other property. This classification applies to rural or agricultural areas where failure may damage farm buildings other than residences, agricultural lands or non-major roads.

4. Class IV - Small Dams: This classification includes any project which impounds less than 15 acre-feet of water to the top of dam, has less than 15 feet height-of-dam and which has a drainage area above the dam of 150 acres or less in extent. No dam may be included in Class IV if it meets the criteria for Class I or II. Any applicant may request consideration as a Class III dam upon submission of a positive report and demonstration proving low hazard.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

N.J.A.C. 7:20-1.9 Design criteria

(a) The minimum design storm used to calculate required spillway capacity must be determined according to the following table:

Hazard	Spillway Design Storm (SDS)
Class I	PMP
Class II	One-half PMP
Class III	24 hour 100 year frequency, Type III storm*
Class IV	24 hour 100 year frequency, Type III storm plus 50%*

*Any later technology adopted by the U.S. Department of Agriculture, Natural Resources Conservation Service may be substituted for the use of the Type III storm.

(b) For existing dams, it is recognized that the relationships between valley slope and width, total reservoir storage, drainage area, and other hydrologic factors have a critical bearing on determining the safe spillway design flood. When appropriate, based on the design of a dam, rational selection of a reduced spillway design for specific site conditions based on quantitative and relative impact analysis is acceptable. The spillway should be sized so that the increased downstream damage resulting from overtopping failure of the dam would not be significant as compared with the damage caused by the flood in the absence of a dam overtopping failure. The minimum design storm for the dam shall be the 100 year storm.

(c) All Class II and III dams shall, where practicable incorporate in the proposed design, the ability to make modifications necessary to increase the spillway capacity of the facility or other alternative measures if the downstream hazard potential increases.

(d) All dams shall have an adequate storage for the design storm or have a spillway system which will safely pass the design storm without endangering the safety of the dam.

(e) Each spillway shall include a satisfactory means of dissipating the energy of flow at its outlet without endangering the safety of the dam.

(f) The capacity of the spillway system shall be equal to the peak inflow of the design flood unless the applicant demonstrates by flood routing procedures that the spillway system has the capacity to safely pass the resulting water flow.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

(g) Pipe conduits may be used for the primary (principal) spillway. When so used, the following requirements shall be met:

1. Pipe conduits shall be of such design as to safely support the total external loads in addition to the total internal hydraulic pressure without leakage. The type of construction material used shall be consistent with the anticipated life of the structure. Corrugated metal pipe shall not be used in the construction of new dams.

   i. For Class I and II dams, the minimum allowable inside dimension of the pipe conduit is 30 inches.

   ii. For Class III dams, the minimum allowable inside diameter of the pipe conduit is 18 inches.

   iii. For Class IV dams, the minimum allowable inside diameter of the pipe conduit is 12 inches.

2. All pipe conduits shall convey water at the maximum design velocity without damage to the interior surface;

3. The pipe conduit must be designed so that negative pressures will not occur at any point along the primary (principal) spillway system;

4. Drainage filters or other methods approved by the Department must be installed to control seepage along the conduit;

5. Adequate allowances shall be incorporated in the design to compensate for differential settlement and possible elongation of the pipe conduit;

6. An anti-vortex device must be included in the design, unless the applicant can demonstrate that one is not necessary.

7. A trash rack, approved by the Department, shall be installed at the intake to prevent clogging of the pipe conduit; and

8. An emergency spillway shall be provided; and

9. Cathodic protection is required for all metal pipes .

(h) Should a vegetated or unlined auxiliary spillway, approved by the Department, be installed, it must be able to pass the design storm without jeopardizing the safety of

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

the structure and that has a predicted average frequency of use less than:

1. Once in 100 years for Class I dams:

2. Once in 50 years for Class II dams; or

3. Once in 25 years for Class III and IV dams.

(i) Drawdown requirements are as follows:

1. Except for excavated impoundments, all dams shall include a device to permit draining the reservoir, as approved in writing by the Department. Computations for the minimum time required to drain the reservoir shall be required for new and existing dams.

2. Unless the applicant demonstrates to the satisfaction of the Department that there is a need to locate a valve downstream from the dam and that the areas downstream of the dam will remain protected, all valves or sluice gates in pipe conduit drains must be installed upstream of the dam.

3. All pipe conduits used as drawdown drains for all dam classifications shall meet requirements of (g) above, except that the minimum allowable inside dimension may be less than 30 inches.

4. Dams which impound water on a permanent basis shall include a means to allow the reduction of the reservoir water surface elevation five feet in 10 days at a rate not to exceed one foot per day. This requirement shall not apply to dams whose intended purpose requires and whose design allows faster drawdown times. For existing dams which satisfactorily meet Department safety and operating criteria, the applicant may, with prior approval of the Department, present alternative reservoir drawdown plans.

(j) Design references used shall be cited in the information submitted to the Department.

(k) Monitoring devices to permit inspection and assessment of the dam's condition may be required by the Department for use in the inspections during and after completion of construction.

(1) The applicant shall demonstrate to the Department that the riparian rights of downstream property owners will be protected during construction, during the period when the reservoir is being filled and during the life of the dam and reservoir.

(m) Unless the applicant can demonstrate that an alternative slope is acceptable, upstream slopes of an earth dam may be no steeper than three horizontal to one

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

vertical ratio, and downstream slopes may be no steeper than two horizontal to one vertical ratio. Measures are required for protection of upstream slopes against wave action or rapid draw-down and for protection of the downstream slope against scour or erosion due to high tailwater.

(n) Freeboard requirements are as follows:

1. Sufficient freeboard shall be provided to prevent overtopping of the dam or any dike or levee due to passage of the design flood or due to frost damage, ice damage or wave action.

2. For all dams the minimum elevation of the top of the dam must be that necessary to pass the design storm with at least one foot of freeboard to the top of dam.

3. Where special conditions of severe frost damage, ice damage or wave action may occur, higher elevations than required in (n)2 above may be required and should be considered by the applicant.

(o) The Department may require the design and installation of any additional or modified measures by any applicant for a dam permit where appropriate to insure the protection of human health or safety.

N.J.A.C. 7:20-1.10 Construction

(a) Requirements relating to supervision of dam construction are as follows:

1. All applicants shall submit a written description and schedule of the proposed construction, including:

i. The estimated time to complete the construction activities, see N.J.A.C. 7:20-1.4(e);

ii. Where applicable, a description of the means by which stream flow will be diverted around or through the dam site, or otherwise kept from interfering with the work;

iii. The number of inspectors designated for inspection for construction quality control; and

iv. Steps to be taken to minimize erosion and sediment production during construction.

2. The extent and method of inspection for construction quality control must be described and approved by the Department, including an inspection schedule.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

3. The diversion facility, as outlined in l.i above, must remain open and no water may be permanently stored in the reservoir until the permittee demonstrates to the Department that storage of water will neither interfere with construction activities nor create a hazard to life, health or property.

4. The professional engineer responsible for inspecting the construction must submit progress reports to the Department at least once each month, during the construction period.

5. The permittee shall promptly advise the Department of all proposed changes in the approved design, plans or specifications. There may be no change in the approved design, plans or specifications without prior approval of the Department. All approved changes must be recorded on the complete set of as-built plans, required in (a) 6, below. The Department may require the submission of revised designs at any time. Written prior approval from the Department is required for major modifications, which shall include significant changes in scale, use, design, impact, etc. of the project, as initially approved. The Department may require written, prior approval of any proposed modification.

6. A complete set of as-built designs, plans and specifications must be submitted to the Department upon completion of the project.

7. The professional engineer who has inspected the construction shall submit written certification that the structure has been built in conformance with the designs, plans and specifications, and with any changes approved by the Department.

(b) The Department may, in its discretion, require the owner to obtain the services of an Independent Review Board to oversee the design and construction of any proposed or existing dam.

(c) Construction inspection program requirements are as follows:

1. The Department may inspect the dam during construction to insure that it is being built in compliance with the designs, plans and specifications submitted to the Department. Departmental inspections in no way relieve either the permittee or the professional engineer in charge from the responsibility of providing adequate inspection of the work.

2. If, at any time during the progress of the work, the Department finds that the work is not being performed in accordance with the approved designs, plans and specifications and any approved changes, the Department will serve a written notice to that effect on the permittee or his representative. Such notice will state the particulars with which the work has not complied.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

Additionally, the Department may order the immediate compliance with such designs, plans, specifications, and changes and suspension of all other work until compliance has been effected. If the owner or his representative fails to comply with this order, the permit under which construction is authorized may be revoked or suspended by the Department.

3. Upon receipt of the as-built plans required in subsection (a) 6 above and the engineer's certification required in subsection (a) 7 above the Department will inspect the completed construction within 45 days. If the Department finds that construction was completed in accordance with the approved designs, plans, specifications and approved changes, the construction will be approved in writing within 30 days. The approval date shall be the date such approval is sent by the Department.

4. In the 12th month following approval of construction by the Department pursuant to (b) 3 above, the Department will make a final inspection of the construction. If the Department makes a final inspection of the construction, a final approval may be given by the Department, if the final inspection shows that the terms of the permit, designs, plans, specifications and approved changes thereof have been met.

N.J.A.C. 7:20-1.11 Dam operating requirements and inspections: new and existing dams

(a) The owners and operators of all dams shall develop and use an Operation and Maintenance Manual which provides guidance and instruction to project personnel for the proper operation and maintenance of the reservoir and dam, and meets the following requirements:

1. The manual shall be composed of two parts:

i. Part One shall include an introduction, project description, project authorizations, project history and list of project contracts.

ii. Part Two shall contain the operation and maintenance instructions for major project facilities and equipment and a schedule for maintenance.

(b) The owners or operators of all dams which raise the waters of any stream more than 70 feet above its usual mean low-water height or which impound more than 10,000 acre-feet of water shall have a regular inspection performed annually and formal inspections performed every three years by a New Jersey licensed professional engineer. These inspections must be attended by a professional engineer assigned from the Department. In the year of the formal inspection, regular or informal

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

inspections need not be performed.

(c) Owners or operators of Class I dams not meeting the size characteristics described in (b) above shall have a regular inspection performed once every two years and a formal inspection performed every six years.

(d) Owners or operators of Class II dams shall have a regular inspection performed once every two years and a formal inspection performed every 10 years.

(e) Owners or operators of Class III and IV dams shall have a regular inspection performed every four years. The Department may at its discretion require the owner or operators to perform a formal inspection of a Class III or IV dam.

(f) All dam inspections shall be performed from March through December.

(g) All inspections shall be performed in compliance with the following requirements:

1. A written guide provided by the Department for the preparation of a Report on Condition of the dam shall be used for all inspections.

2. Formal and regular dam inspections shall be performed by a licensed New Jersey professional engineer. Except for Class IV dams, the required report shall be submitted to the Department by the engineer within 30 days of completion of the inspection. The report shall indicate the results of the inspection, documenting the conclusions and recommendations. Reports for Class IV dams shall be submitted to the county and/or municipal engineer having jurisdiction over the dam structure.

3. Informal inspections may be performed by the dam owner or operator and the Report on Condition shall be part of the owner's or operator's permanent file and, unless requested by the Department, Reports shall not be submitted to the Department.

4. The Department may extend the time for submission of the required material for up to 30 days, if the owner or operator justifies the need for such extension.

5. Failure by the permittee to inspect within the required time periods or failure to submit the Report on Condition may result in an order to drain the impoundment under the provisions of the Safe Dam Act (N.J.S.A. 58:4-1 et seq.), and/or any other remedy allowed by law.

(h) For good cause, the Department may require the owner or operator of any dam to perform an inspection of any type at any time.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

(i) The owner or operator of all Class I and II dams shall prepare and use an Emergency Action Plan, as described in N.J.A.C. 7:20-1.7(f).

N.J.A.C. 7:20-1.12 Duty to Provide Information

The Department may require an owner or person having control of a reservoir or dam to provide any information the Department requires to determine compliance with any provision of the Safe Dam Act, or any rule, regulation or order issued pursuant to the Safe Dam Act.

N.J.A.C. 7:20-1.13 Inspection Authority

The Department shall have the authority to enter any property, facility, premises, or site for the purpose of conducting inspections to determine the condition of any dam, or to conduct inspections of ordered repairs or to otherwise determine compliance with the provisions of the Safe Dam Act.

Subchapter 2. CIVIL ADMINISTRATIVE PENALTIES; REQUESTS FOR ADJUDICATORY HEARINGS; ACTIONS BY THE DEPARTMENT TO REPAIR OR MITIGATE

N.J.A.C. 7:20-2.1 Authority and purpose

(a) This subchapter governs the assessment of uniform civil administrative penalties pursuant to the Safe Dam Act, N.J.S.A. 58:4-1 et seq. and the issuance of orders for the violation of any provision of the Safe Dam Act or any regulation, rule, permit or order adopted or issued by the Department pursuant thereto. This subchapter also establishes the procedure for requesting an adjudicatory hearing or appeal from a notice of civil administrative penalty assessment or administrative order.

(b) Neither the issuance of an administrative order nor the assessment of a civil administrative penalty shall affect the availability to the Department of any other enforcement provision in N.J.S.A. 58:4-5 and 4-6 or any other action or remedy available by law.

N.J.A.C. 7:20-2.2 Procedures for Issuing an Administrative Order Pursuant to the Safe Dam Act

(a) Whenever the Department finds that a person has violated any provision of the Safe Dam Act, or any regulation, rule or order adopted or issued by the Department pursuant thereto, the Department may issue an administrative order specifying the provision or provisions of the law, rule, regulation, or order, of which the person is in

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

violation citing the action which constituted the violation requiring compliance with the provision or provisions violated; requiring specific actions by the violator to achieve compliance with provisions violated; and providing notice to the person of the right to an adjudicatory hearing on the matters contained in the order. The ordered party shall have 20 days from receipt of the order within which to deliver to the Department a written request for a hearing in accordance with N.J.A.C. 7:20-2.4.

N.J.A.C. 7:20-2.3 Procedures for assessment, settlement and payment of civil administrative penalties for violations

(a) To assess a civil administrative penalty, the Department shall notify the violator by certified mail (return receipt requested) or personal service. This notice of civil administrative penalty assessment shall:

1. Identify the section of the Safe Dam Act, or the rule, regulation and/or administrative order violated;

2. State the facts which constitute the violation;

3. State the amount of the civil administrative penalty to be imposed and the amount of any other costs and economic benefit to be imposed; and

4. Advise the violator of the right to request an adjudicatory hearing under N.J.A.C. 7:20-2.4.

(b) The violator shall pay a civil administrative penalty immediately upon receipt of the Department's final order in a contested case, or as soon as a notice of civil administrative penalty assessment becomes a final order as follows:

1. If no hearing is requested pursuant to N.J.A.C. 7:20-2.4, a notice of civil administrative penalty assessment becomes a final order on the 21st day after the violator receives the notice;

2. If the Department denies a hearing request under N.J.A.C. 7:20-2.4, a notice of civil administrative penalty assessment becomes a final order upon the violator's receipt of the denial; or

3. If the Department grants the hearing request, a notice of civil administrative penalty assessment becomes a final order upon issuance of a final order by the Department.

N.J.A.C. 7:20-2.4 Procedures to Request an Adjudicatory Hearing to Contest an Administrative Order and/or a Notice of Civil Administrative Penalty Assessment; Procedures for Conducting Adjudicatory Hearings

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

(a) To request an adjudicatory hearing to contest an administrative order and/or a notice of civil administrative penalty assessment issued pursuant to the Safe Dam Act, the person to whom the administrative order and/or notice of civil administrative penalty assessment was issued, shall within 20 days of receipt of the order and/or notice submit an original written request for an adjudicatory hearing to:

New Jersey Department of Environmental Protection
Office of Legal Affairs
Attention: Adjudicatory Hearing Requests
401 East State Street
P.O. Box 402
Trenton, New Jersey 08625-0402

(b) A complete copy of the request shall be submitted to the Bureau of Dam Safety and Flood Control at :

New Jersey Department of Environmental Protection
Bureau of Dam Safety and Flood Control
501 E. State Street
P.O. Box 419
Trenton, New Jersey 08625-0419

(c) The written request shall include all information required by the "Adjudicatory Hearing Request Checklist and Tracking Form" available from the Bureau of Dam Safety and Flood Control, 501 E. State Street, P.O. Box 419, Trenton, NJ 08625-0419 and on the Department's website at www.state.nj.us/dep/damsafety, including the following:

1. The name, address, and telephone number of the violator and its authorized representative;

2. The date the violator received the enforcement document being contested;

3. A copy of the administrative order and/or notice of civil administrative penalty assessment and a list of all issues being appealed;

4. The violator's defenses to each of the findings of fact stated in short and plain terms;

5. An admission or denial of each of the findings of fact. If the violator is without knowledge or information sufficient to form a belief as to the truth of a finding, the violator shall so state and this shall have the effect of a denial. A denial shall fairly meet the substance of the findings denied. When the violator intends in good faith to deny only a part or a qualification of a finding, the violator shall specify so much as is true

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

and material and deny only the remainder. The violator may not generally deny all of the findings but shall make all denials as specific denials of designated findings. For each finding the violator denies, the violator shall allege the fact or facts as the violator believes it or them to be;

6. Information supporting the request and specific reference to or copies of other written documents relied upon to support the request;

7. An estimate of the time required for the hearing (in days/and or hours); and

8. A request, if necessary, for a barrier-free hearing location for physically disabled persons.

(d) If the Department does not receive the written request for a hearing within 20 days after receipt by the person of the administrative order and/or notice of civil administrative penalty assessment being contested, the Department shall deny the hearing request.

(e) The Department shall notify the requester if the request for a hearing is granted and, if denied, the reason why. If a hearing request is granted, the Department shall refer the matter to the Office of Administrative Law for an adjudicatory hearing in accordance with the Administrative Procedure Act, N.J.S.A. 52:14B-1 et seq., and the Uniform Administrative Procedure Rules, N.J.A.C. 1:1.

(f) If the person fails to include all the information required by (a) above, the Department may deny the hearing request.

N.J.A.C.7:20-2.5 Civil Administrative Penalty Assessment for Violation of the Safe Dam Act

(a) The Department may assess a civil administrative penalty of up to $25,000 for each violation of any provision of the Safe Dam Act, N.J.S.A. 58:4-1 et seq., or for any failure to comply with any rule or regulation adopted pursuant to the Act, or for any failure to comply with any permit, order or directive issued pursuant to the Act, or for failure to comply with a request for information or request to enter upon the property.

(b) Each violation of any provision of the Safe Dam Act, or any rule or regulation adopted pursuant to the Act, or for any failure to comply with any permit, order or directive issued pursuant to the Act, or for failure to comply with a request for information or request to enter upon the property shall constitute a separate and distinct offense.

(c) and Each day during which a violation continues shall constitute an additional, separate distinct offense.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

(d) When the Department determines that the violator has gained economic benefit from a violation, the Department may, in addition to any other civil administrative penalty assessed, include as a part of a civil administrative penalty the economic benefit that the violator has realized as a result of not complying or delaying compliance. Economic benefit shall include the amount of savings realized from avoided costs; the return earned or that may be earned on the amount of the avoided costs; and any other benefits resulting from the violation.

N.J.A.C.7:20-2.6 Civil Administrative Penalty Amount for Violation of the Safe Dam Act

(a) The Department may assess the following civil administrative penalty for each day that the respective identified violations continue:

1. Failure to draw off (drain or lower) an impoundment:

   i. Class I Dams $10,000-$25,000;

   ii. Class II Dams $5,000-$10,000;

   iii. Class III and IV Dams $1,000-$5,000;

2. Failure to submit a permit application, compliance schedule, inspection report, Emergency Action Plan or Operation and Maintenance plan or other document required by the Safe Dam Act or these rules, or failure to respond to a request for information:

   i. Class I Dams $5,000;

   ii. Class II Dams $2,500;

   iii. Class III and IV Dams $1,000;

3. Failure to conduct or complete dam repairs, maintenance, modification or removal:

   i. Class I Dams $10,000-$25,000;

   ii. Class II Dams $5,000-$10,000;

   iii. Class III and IV Dams $1,000-$5,000;

4. Failure to obtain Department approval prior to the construction or modification of a dam or appurtenant structure:

   i. Class I Dams $10,000-$25,000;

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

ii. Class II Dams $5,000-$10,000;

iii. Class III and IV Dams $1,000-$5,000;

5. Failure to allow access to a dam site, including appurtenant structures, to representatives of the Department presenting proper credentials:

i. All dams $1,000-$5,000;

6. Failure to implement a security plan:

i. Class I Dams $10,000-$25,000;

ii. Class II Dams $5,000-$10,000;

iii. Class III and IV Dams $1,000-$5,000;

7. Failure to comply with any permit requirement:

i. Class I Dams $10,000-25,000;

ii. Class II Dams $5,000-$10,000;

iii. Class III and IV Dams $1,000-$5,000;

8. Knowingly, recklessly, or negligently making a false statement, representation, or certification in any application, record or other document filed or required to be maintained by the Safe Dam Act:

i. All Dams $1,000-$5,000.

(b) The civil administrative penalty shall be established at the mid-point of the ranges set forth at (a) above unless adjusted by the Department in its discretion within the range on the basis of the following factors:

1. The compliance history of the violator;

2. The number, frequency and severity of the violations;

3. The measures taken by the violator to mitigate the effect of the current violation or to prevent future violations;

4. The cooperation of the violator in correcting the violation, remedying the damage caused by the violation and ensuring the violation does not reoccur;

5. The deterrent effect of the penalty;

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

6. Any costs or impacts directly or indirectly imposed on the public or the environment as a result of the violation; and

7. Other specific circumstances of the violator or violation.

(c) In settling a civil administrative penalty, the Department may in its discretion consider the following:

1. Mitigating and extenuating circumstances;

2. Measures taken to mitigate impact of the violation; and

3. Other terms and conditions acceptable to the Department.

N.J.A.C. 7:20-2.7 Notice of Violation Recorded on Property Deed

In addition to penalties prescribed in this subchapter, a notice of violation issued pursuant to the Safe Dam Act, or any rule, regulation or order issued pursuant thereto, shall, on order of the Commissioner, be recorded on the deed of the property wherein the violation occurred, by the clerk or register of deeds and mortgages of the county wherein the affected property is located and with the clerk of the Superior Court and shall remain attached thereto until such time as the violation is remedied and the Commissioner orders the notice of violation removed.

N.J.A.C. 7:20-2.8 Penalty Collection

All penalties collected pursuant to this subchapter or sums collected pursuant to N.J.S.A. 58:4-5 shall be deposited in the "Environmental Services Fund," established pursuant to N.J.S.A. 13:1D-33, and kept separate from other receipts deposited therein, and appropriated to the Department for the removal of dams in the State.

N.J.A.C. 7:20-2.9 Action by the Department to Repair and Mitigate

(a) Whenever the Commissioner determines that a dam is in imminent danger of failure and has reasonable cause to believe that danger to life or property may be anticipated from the reservoir, dam or appurtenant structures located therein, and the owner of the dam or person having control of the reservoir or dam has failed to comply with an order to repair the dam or to take such interim measures as the Department determines are appropriate, including reducing the amount of water impounded by the dam or breaching the dam, the Department may, in addition to other actions authorized by the Safe Dam Act, these regulations and other law, enter upon any and all properties wherein the reservoir, dam or appurtenant structures are located, and using resources and personnel available to the Department, remove or cause to be removed the dam and/or appurtenant structures located therein, allowing the water to flow freely.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

(b) The Department shall provide notice to the owner or person having control of the reservoir or dam prior to the removal action provided for in (a) above. The owner shall, no later than 60 days after receipt of notice, submit to the Department in writing, an implementation plan addressing the proposed actions the owner or person having control of the reservoir or dam intends to take to repair or remove the failed or failing reservoir or dam, along with a schedule for implementation of the proposed actions. Any permits required for the proposed actions shall be applied for within the 60-day time period.

(c) If the proposed actions, schedule and permit applications are timely submitted and the Department in its discretion determines that the proposed actions and schedule will satisfactorily address the danger specified in (a) above, and that the permits applied for can properly be issued, the Department shall allow the owner or person having control of the reservoir or dam to take the actions identified. If the owner or person having control of the reservoir or dam fails to comply with the proposed schedule, the Department may take removal action in (a) above.

(d) Any expenditures made by the Department pursuant to (a) shall constitute a debt to the State and a lien on all property owned by the owner or person having control of the reservoir or dam. When a certificate of debt incorporating a description of the property subject to the removal action and the costs is filed with the clerk of the Superior Court, the lien shall attach to all revenues and all real and personal property of the owner or person having control of the reservoir or dam.

(e) The lien described in (d) above shall have priority over all other liens, interests or claims on the dam or reservoir property subject to the Department's removal action. However, if that property is six dwelling units or less and used exclusively for residential purposes, the certificate of debt shall not affect any valid lien, claim or interest which was filed prior to the certificate of debt. When the lien described in (d) above affects property other than the property subject to the removal action, it shall have priority from the date of filing but shall not affect any valid lien, interest or claim filed prior to filing of the certificate of debt.

(f) Whenever the owner or person having control of the reservoir or dam is a private lake association or other body representing owners or property adjacent to the reservoir or lake created by the dam or impoundment, liens may be imposed upon the individual owners of the property represented by the association. An owner whose property has such a lien imposed may release the property from a lien claimed under this subsection by filing with the clerk of the Superior Court a cash or surety bond, payable to the Department in the amount of the sums expended by the Department pursuant to this section, including attorney's fees and court costs, or the value of the property after the abatement action is complete, whichever is less.

(g) The provisions of this section shall not limit the use of other remedies available to the Department pursuant to law.

THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

E.30. New Mexico



RULES AND REGULATIONS

GOVERNING DAM DESIGN, CONSTRUCTION

AND DAM SAFETY



JOHN R. D'ANTONIO, JR., P.E.

STATE ENGINEER

March 31, 2005

The New Mexico Office of the State Engineer Dam Safety Bureau is located in Santa Fe. Copies of forms referred to herein and a copy of these rules and regulations can be obtained from the Dam Safety Bureau or from the Office of the State Engineer website. All documents filed for dams shall be delivered to the Dam Safety Bureau.

Phone Number: 505-827-6122
Fax Number: 505-827-6068
Web-Site: www.ose.state.nm.us

Mailing Address:
Office of the State Engineer
Dam Safety Bureau
P.O. Box 25102
Santa Fe, New Mexico 87504

Street Address:
Office of the State Engineer
Dam Safety Bureau
Lew Wallace Building, Room 210
495 Old Santa Fe Trail
Santa Fe, New Mexico 87501

TITLE 19 NATURAL RESOURCES AND WILDLIFE
CHAPTER 25 ADMINISTRATION AND USE OF WATER – GENERAL PROVISIONS
PART 12 DAM DESIGN, CONSTRUCTION AND DAM SAFETY

19.25.12.1 ISSUING AGENCY: New Mexico Office of the State Engineer
[19.25.12.1 NMAC - N, 3/31/2005]

19.25.12.2 SCOPE: These regulations apply to the design and construction of all jurisdictional dams in New Mexico and are intended to facilitate the continued safe operation and maintenance of all non-federal jurisdictional dams. These regulations govern the review and acceptance of plans for construction, alteration, modification, repair, enlargement and removal of a jurisdictional dam. These regulations ensure the continued safe operation, maintenance, site security and emergency preparedness for existing non-federal jurisdictional dams. These regulations do not authorize the appropriation or use of water pursuant to 19.26 NMAC and 19.27 NMAC.
[19.25.12.2 NMAC - N, 3/31/2005]

19.25.12.3 STATUTORY AUTHORITY: Section 72-5-32 NMSA requires any person, association or corporation, public or private, the state or the United States that is intending to construct a jurisdictional dam to submit detailed plans to the state engineer. Sections 72-5-9 and 72-5-10 NMSA establish the state engineer's authority over the construction of works and issuing certificates of construction. Sections 72-5-8 and 72-5-14 NMSA require construction to be completed in a time limit set by the state engineer and procedures for requesting an extension of time. Sections 72-5-11, 72-5-12 and 72-5-13 NMSA gives the state engineer jurisdiction over unsafe works, penalties for failure to comply with state engineer orders and priority of liens. Section 72-2-6 NMSA gives the state engineer the authority to assess fees. Section 72-2-8 NMSA gives the state engineer authority to adopt regulations and codes to implement and enforce any provision of any law administered by him. Section 72-8-1 NMSA gives the state engineer the authority to enter upon private property for the performance of his duties. Nothing in these rules shall be construed so as to limit the state engineer's authority to take lawful alternative or additional actions relating to the design, construction and safety of dams.
[19.25.12.3 NMAC - N, 3/31/2005]

19.25.12.4 DURATION: Permanent.
[19.25.12.4 NMAC - N, 3/31/2005]

19.25.12.5 EFFECTIVE DATE: March 31, 2005 unless a later date is cited at the end of a section.
[19.25.12.5 NMAC - N, 3/31/2005]

19.25.12.6 OBJECTIVE: To establish minimum design requirements, minimum submittal requirements and dam site owner responsibilities that shall be addressed to the state engineer's satisfaction in order to ensure a dam is designed, constructed, operated, maintained and secured in a safe manner.
[19.25.12.6 NMAC - N, 3/31/2005]

19.25.12.7 DEFINITIONS: Unless defined below or in a specific section of these regulations, all other words used herein shall be given their customary and accepted meaning.

A. Abutment: That part of the valley side against which the dam is constructed. The left and right abutments of dams are defined with the observer viewing the dam looking in the downstream direction.

B. Alteration, modification, repair, rehabilitation or enlargement of an existing dam: To change from the state engineer accepted construction drawings and specifications or current condition.

C. Appurtenant structure: Auxiliary features of a dam such as outlets, spillways, access structures, tunnels and related housing at a dam.

D. American society for testing and materials (ASTM): An accepted standard for testing the properties of materials. Methods cited in these regulations include laboratory compaction characteristics of soils.

E. Breach: An opening through a dam or spillway that is capable of draining a portion of the reservoir or the entire reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional discharge from the reservoir.

F. Consequences of failure: Potential loss of life or property damage downstream of a dam caused by waters released at the dam or by waters released by partial or complete failure of dam; includes effects of landslides upstream of the dam on property located around the reservoir.

G. Crest width: The thickness or width of a dam at the crest level (excluding corbels or parapets). In general, the term thickness is used for gravity and arch dams and width is used for other dams.

H. Dam: A man-made barrier constructed across a watercourse or off-channel for the purpose of storage, control or diversion of water.

(1) Jurisdictional dam: A dam that is more than 10 feet in height measured from the lowest point on the downstream toe to the dam crest or impounds more than 10 acre-feet of water as measured from the lowest point on the downstream toe to the spillway crest. Dams constructed under the supervision of the U.S. army corps of engineers before May 19, 2004, become jurisdictional when such supervision by the U.S. army corps of engineers is terminated. For purposes of these regulations, reference to a dam means a jurisdictional dam unless otherwise noted.

(2) Non-jurisdictional dam: Any dam less than or equal to 10 feet in height and having storage less than or equal to 10 acre-feet of water. The state engineer does not regulate the design, construction and operation of a non-jurisdictional dam unless the dam is unsafe and there is a threat to life or property, as determined by the state engineer. Waters impounded by a non-jurisdictional dam may not be exempt from water right permit requirements; therefore a separate state engineer water right permit for the water impounded in the reservoir created by a non-jurisdictional dam may be required. Non-jurisdictional dams shall meet the requirements of 19.26.2.15 NMAC unless otherwise exempt. The structures listed below are considered non-jurisdictional dams:

(a) Stock dam: A stock dam constructed prior to May 19, 2004 with a storage capacity of 10 acre-feet or less regardless of the height of the dam.

(b) Erosion control dam: A dam for the sole purpose of erosion control constructed on a naturally dry watercourse as determined by the state engineer, with a storage capacity of 10 acre-feet or less as measured from the lowest point on the downstream toe to the spillway crest and the reservoir drains in 96 hours unless a quicker drain time is required by court decree.

(c) Levee or diversion dike: A structure where water flows parallel to the length of the levee or diversion dike as determined by the state engineer.

(d) Roadway embankment: A structure across a watercourse designed for the sole purpose of supporting a roadbed or other means of conveyance for transportation as determined by the state engineer; where the area upstream has not been enlarged to increase flood storage; and where the embankment is provided with an uncontrolled conduit of sufficient capacity to satisfy requirements of the appropriate state or local transportation authority. If no transportation authority has jurisdiction over the structure, the current drainage design criteria of the New Mexico department of transportation shall apply.

I. Dam crest: The lowest elevation of the uppermost surface of a dam, usually a road or walkway excluding any parapet wall, railing, etc.

J. Dam failure: The breakdown of a dam, characterized by the uncontrolled release of impounded water. There are varying degrees of failure.

K. Dam height: The vertical distance from the lowest point on the downstream toe to the dam crest.

L. Dam incident: An event at a dam that interrupts normal procedures and performance, affects the safety of the dam or results in a potential loss of life or damage to property.

M. Fetch: The straight-line distance across a body of water subject to wind forces. The fetch is one of the factors used to calculate wave heights in a reservoir.

N. Freeboard: The vertical distance between the spillway crest and the lowest point of the dam crest not including camber.

O. Functional exercise: A meeting in a conference room environment involving the dam owner and state and local emergency personnel with responsibilities in the emergency action plan. The exercise takes place in a stress-induced environment with time constraints and involves simulation of a dam failure and other specific events. The exercise is designed to evaluate both the internal capabilities and responses of the dam owner and the workability of the information in the emergency action plan used by emergency management officials.

P. High water line: The highest water level elevation in the reservoir as determined from routing the spillway design flood or inflow design flood.

Q. Inflow design flood: The flood flow above which the incremental increase in downstream water surface elevation due to failure of a dam is no longer considered to present an unacceptable additional downstream threat. The upper limit of the inflow design flood is the flood resulting from the probable maximum precipitation and the lower limit is the flood resulting from the 100-year precipitation.

R. Inundation map: A map delineating the area that would be flooded by a particular flood event.

S. Length of dam: The length measured along the dam axis at the dam crest. This also includes the spillway, powerplant, navigation lock, fish pass, etc., where these form part of the length of the dam. If detached from the dam these structures should not be included.

T. Loss of life: The likely number of human fatalities that would result from a dam failure flood event. No allowances for evacuation or other emergency actions by the population should be considered.

U. Naturally dry watercourse: A watercourse or portion thereof, which under normal conditions is dry, which flows only in direct response to precipitation and whose channel is at all times above the groundwater table.

V. Normal operating level: The water level elevation corresponding to the maximum storage level that excludes any flood control or surcharge storage.

W. North American vertical datum 1988 (NAVD88): The current vertical control datum in use in North America established from nine space geodetic stations. This basis of establishing elevation provides a precise surface, whereas the North American vertical datum 1927 (NAVD27) is elevation established from mean sea level.

X. One-hundred year flood: A flood that has 1 chance in 100 of being equaled or exceeded during any year.

Y. Owner: The individual, association or corporation, public or private, the state or the United States, owning the land upon which a dam is constructed; having a contractual right to construct, operate or maintain a dam; or the beneficiary of an easement to construct, operate or maintain a dam.

Z. Probable maximum precipitation: Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular location during a certain time of year.

AA. Spillway: A structure over or through which excess flow is discharged from a reservoir. If the rate of flow is controlled by mechanical means such as gates, it is considered a controlled spillway. If the geometry of the spillway is the only control, it is considered an uncontrolled spillway. For purposes of these regulations, an uncontrolled outlet conduit that is used to drain the reservoir is not considered a spillway.

BB. Spillway crest: The lowest level at which water can flow over or through the spillway.

CC. Spillway design flood: The required flood that a spillway must pass without failure of the dam.

DD. Storage: For purposes of determining whether a dam is jurisdictional, the storage is the volume of water impounded by the dam above the lowest elevation of the downstream toe to the elevation of the spillway crest. For dams with no spillway, storage is measured to the dam crest. Definitions of specific types of storage in reservoirs are:

(1) Dead storage is the storage volume of a reservoir that lies below the invert of the lowest outlet and therefore, cannot readily be withdrawn from the reservoir.

(2) Flood surcharge storage is the storage volume between the maximum operating level and the maximum water level during the spillway design flood.

(3) Live storage is the storage volume of a reservoir that is available for use and lies above the invert of the lowest outlet.

(4) Reservoir storage capacity is the sum of the dead and live storage of the reservoir.

(5) Maximum storage is the sum of the reservoir storage capacity and flood surcharge storage.

EE. Tabletop exercise: A meeting in a conference room environment involving the dam owner and state and local emergency personnel with responsibilities in the emergency action plan. The format is a discussion of an emergency event, response procedures to resolve concerns regarding coordination and responsibilities.

FF. Toe: The contact line between the outer shell of the dam and the natural ground surface.

GG. Wave runup: Vertical height above the water level to which water from a specific wave will run up the face of a structure or embankment.

[19.25.12.7 NMAC - N, 3/31/2005]

19.25.12.8 FEE SCHEDULE: The state engineer assesses fees for filing forms, reviewing plans and specifications for dams and appurtenant structures and construction inspections.

A. For filing an application for permit to construct and operate a dam the fees shall be $25.

B. For each review of design plans, construction drawings and specifications for a dam the fee shall be $2 per $1000 or fraction thereof of the estimated construction cost. For determination of fees, inclusion of contingencies, taxes and other permit fees is not required. Assessment of multiple review fees for the same application is at the sole discretion of the state engineer.

C. For issuing an extension of time for construction of a dam the fee shall be $50.

D. For inspecting construction of a dam the fee shall be $100/8-hour day and actual and necessary traveling expenses.

E. For filing a proof of completion of works for a dam the fee shall be $25.

F. For filing a change of ownership for a dam the fee shall be $5.

G. For copies of dam safety records up to 11 inches by 17 inches the fee shall be $0.20 per copy.

H. For copies of dam safety records greater than 11 inches by 17 inches the fee shall be $3.00 per copy.

[19.25.12.8 NMAC - N, 3/31/2005]

19.25.12.9 SIZE CLASSIFICATION: A dam shall be less than or equal to the maximum height and storage to qualify for the size classification.

A. Small: A small dam is greater than 10 feet but less than or equal to 40 feet in height, or greater than 10 acre-feet but less than or equal to 1000 acre-feet of storage.

B. Intermediate: An intermediate dam is greater than 40 feet but less than or equal to 100 feet in height, or greater than 1000 acre-feet but less than or equal to 50,000 acre-feet of storage.

C. Large: A large dam is greater than 100 feet in height, or greater than 50,000 acre-feet of storage.

[19.25.12.9 NMAC - N, 3/31/2005]

19.25.12.10 HAZARD POTENTIAL CLASSIFICATION: The hazard potential classification is a rating for a dam based on the potential consequences of failure. The rating is based on loss of life, damage to property and environmental damage that is likely to occur in the event of dam failure. No allowances for evacuation or other emergency actions by the population should be considered. The hazard potential classification is not a reflection of the condition of the dam.

A. Low hazard potential: Dams assigned the low hazard potential classification are those dams where failure or misoperation results in no probable loss of life and low economic and/or environmental losses. Losses are principally limited to the dam owner's property.

B. Significant hazard potential: Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in populated areas with significant infrastructure.

C. High hazard potential: Dams assigned the high hazard potential classification are those dams where failure or misoperation will probably cause loss of human life.

[19.25.12.10 NMAC - N, 3/31/2005]

19.25.12.11 DESIGN OF A DAM: Any person, association or corporation, public or private, the state, or the United States that is intending to construct a dam shall submit an application to construct and operate a dam and supporting documentation acceptable to the state engineer. This section primarily addresses the design and construction of embankment dams. Other types of dams shall conform to sound engineering principles and current state of the practice. Because each site, design and operating practice is unique, waivers of specific requirements in this section will be considered on a case-by-case basis. Request for waiver shall be in writing accompanied with documentation justifying the request. If the request is not justified to the satisfaction of the state engineer the request will be denied. Construction shall not begin until the state engineer has accepted the supporting documentation and approved the application with construction and operation conditions. The application and supporting documentation shall include:

A. Application: An application form shall be completed with original signature of the dam owner and accompanied with a filing fee in accordance with Subsection A of 19.25.12.8 NMAC. The form will be the only information available to the public before the project is approved for construction. All other supporting documentation is considered draft until accepted by the state engineer. A plan review fee in accordance with Subsection B of 19.25.12.8 NMAC shall accompany the submittal of the design report, construction drawings and specifications. A detailed estimate of the construction cost for the proposed dam and appurtenant structures shall be submitted in support of the plan review fee.

B. Water right: A water right is required for water impounded by the dam. If the dam owner has a permit for the diversion of water, documentation addressing the necessity for storage, diversion periods and release conditions for the reservoir may be required. This requirement is waived for flood control dams that do not detain

water longer than 96 hours in accordance with Subparagraph (b) of Paragraph (7) of Subsection C of 19.25.12.11 NMAC or provide documentation that a waiver by the state engineer has been granted. Flood control dams that do not drain within 96 hours require a water right for water permanently stored beyond the 96-hour drain time requirement and for associated losses due to evaporation and other potential depletions to the system unless a waiver in accordance with 19.25.12.11 NMAC is obtained.

C. Design report: A design report, which includes information to evaluate the safe design of the dam and appurtenant structures, shall be submitted in a form acceptable to the state engineer. The design report shall contain the information described below and any other additional information determined necessary by the state engineer. A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare or supervise the preparation of the design report. The front cover shall show the name of the dam (identical to the application), the county in which the dam is located and type of report. The first page behind the front cover shall show the name of the dam (identical to the dam name on the application), the county in which the dam is located and the signed certifications for the engineer and state engineer in accordance with Subsections B and E of 19.25.12.12 NMAC. The design report shall include:

(1) Hazard potential classification. A hazard potential classification shall be based on the dam failure condition that results in the greatest potential for loss of life and property damage. If the state engineer concurs, the classification may be based on the judgment and recommendation of the professional engineer. For all other cases, a low or significant hazard potential classification shall be supported by a dam breach analysis, which includes calculations and data that supports the predicted dam failure flood. This analysis shall also address the potential for foreseeable future development. Evaluation of the effects of flooding from dam failure shall extend at least to the location downstream where the classification can be properly identified. The dam breach analysis shall include, but not be limited to:

(a) dam failure inundation maps;

(b) map of the water surface profiles;

(c) cross-sections drawn to scale showing water surface elevation at critical sections where structures are impacted and showing discharge in cubic feet per second, average velocity in feet per second, flood wave travel times, rate of rise and structures located in the flooded sections;

(d) a tabulation and justification of assumed parameters used in the analysis;

(e) a sensitivity analysis of the assumed parameters used in the analysis;

(f) references to all computer models, data and supporting justification used in the analysis; and

(g) appropriate data sheets and computer program output computations from computerized analysis shall be provided.

(2) Hydrologic analysis. The hydrologic analysis shall include a discussion of methodology used to calculate the spillway design flood for determining the available flood storage and spillway capacity. Consideration of how the dam will perform under these hypothetical flood conditions shall be evaluated. The hydrologic analysis shall include, but not be limited to:

(a) a topographic map of the drainage area above the dam with the drainage area and sub-basins delineated and presented on a map of appropriate scale and size;

(b) a description of the topography, soils and vegetative cover of the drainage area;

(c) a discussion of the depth, duration and distribution of the spillway design storm;

(d) a tabulation, discussion and justification of all hydrologic parameters and methodology used to calculate runoff from rainfall;

(e) a discussion of the peak inflow, volume of runoff and maximum reservoir water level elevation for the inflow hydrograph;

(f) a plot of the reservoir inflow and outflow hydrographs extended until flow is negligible and plotted on the same figure of appropriate size and scale;

(g) a table showing the reservoir area (in acres) and storage capacity (in acre-feet) for each foot of elevation above the bottom of the reservoir to the dam crest; the table shall be determined from the reservoir topography map; indicate the amount of dead storage, elevation of the invert of the outlet and elevation of the crest of each spillway; all elevations shall be based on North American vertical datum 1988 or more recent adjustment; and

(h) appropriate data sheets and computer program output computations from computerized analysis shall be provided.

(3) Spillway design flood. The spillway design flood is the flood that a spillway must be capable of conveying without dam failure. For perimeter embankment dams with no spillway and no external drainage area, the dam must be capable of impounding the spillway design flood without dam failure. A spillway design flood less than these requirements is acceptable to the state engineer if an incremental damage analysis is presented to justify the inflow design flood in accordance with Paragraph (4) of Subsection C of 19.25.12.11 NMAC. The spillway design flood is based on size classification and hazard potential classification of the dam as follows:

(a) Dams classified as low hazard potential, regardless of size, shall have spillways designed to pass a flood resulting from a 100-year precipitation event expressed as a percentage of the probable maximum precipitation.

(b) Dams classified as small and intermediate, with a significant hazard potential rating shall have spillways designed to pass a flood resulting from 50 percent of the probable maximum precipitation.

(c) Dams classified as large, with a significant hazard potential rating shall have spillways designed to pass a flood resulting from 75 percent of the probable maximum precipitation.

(d) Dams classified as high hazard potential, regardless of size, shall have spillways designed to pass a flood resulting from the probable maximum precipitation.

(4) Incremental damage assessment. Where spillways are not in compliance with Paragraph (3) of Subsection C of 19.25.12.11 NMAC an incremental damage assessment shall justify the inflow design flood used to size the spillway. The assessment shall evaluate the consequences of dam failure. The assessment shall compare the impact of with-failure and without-failure conditions on downstream water levels and existing and known future development. The assessment shall include a dam breach analysis in accordance with Subparagraphs (a) through (g) of Paragraph (1) of Subsection C of 19.25.12.11 NMAC for the failure and non-failure conditions. Methods for assessing the damage between failure and non-failure conditions shall be fully documented.

(5) Spillway capacity. The spillway capacity shall be adequate to pass the spillway design flood in accordance with Paragraph (3) of Subsection C of 19.25.12.11 NMAC or accepted inflow design flood in accordance with Paragraph (4) of Subsection C of 19.25.12.11 NMAC without failure of the dam. If design calculations show that overtopping will occur, an erosion study of the embankment documenting that the dam will not breach is required. If the outlet works are gated, the design discharge of the outlet works shall not be considered when routing the spillway design flood through the reservoir and spillway. The water level shall be at the normal operating level at the beginning of the spillway design storm. A spillway rating curve and table showing elevation in one-foot increments versus maximum discharge capacity shall be prepared. The rating curve and table shall include data from the crest of the spillway to the dam crest. The parameters used to calculate the spillway capacity shall be justified and appropriate data sheets and computer program output computations from computerized analysis shall be provided. Elevations shall be based on North American vertical datum 1988 or more recent adjustment.

(6) Spillway design. Spillways shall be evaluated for erosion potential during normal operation and the design flood event. Damage to a spillway during the design flood event is acceptable; however, a breach of the spillway is unacceptable. The spillway design shall address the following minimum requirements:

(a) The material required for spillway lining depends on the spillway location, frequency of discharge and velocity of discharge to adequately address erosion and breach potential. The design shall provide adequate justification for the material selected.

(b) The design shall provide aeration of the nappe for cavitation control where control weirs are used at the spillway crest.

(c) The spillway must discharge away from the toe of the dam and abutment slopes.

(d) The potential for the accumulation of debris that may block the spillway shall be addressed.

(e) Energy dissipation to control erosion of the natural channel due to spillway discharge shall be addressed.

(f) Channel lining shall be placed on a suitably prepared, stable subgrade. All edges and joints in channel lining material must be designed to prevent undermining and erosion. Concrete channel lining must be provided with adequate jointing to permit thermal expansion and contraction and adequate reinforcing to control thermal cracking. Adequate water stops are required at joints in the spillway lining. Concrete lining shall be adequately anchored against displacement and uplift and shall be provided with adequate subdrainage to relieve hydrostatic pressure and prevent frost heave.

(g) Where training dikes are used to divert the water away from the dam, the dike shall be designed with a compaction to at least 95% of the maximum standard Proctor density, ASTM D 698, or at least 90% of the maximum modified Proctor density, ASTM D 1557, or at least 70% relative density if Proctor testing is not

appropriate. Erosion protection for the dike shall be addressed in accordance with Paragraph (16) of Subsection C of 19.25.12.11 NMAC.

(7) Outlet works capacity. Dams shall be designed with a low level outlet to drain the entire contents above the elevation of the downstream toe of the dam. If environmental consequences prevent draining of the reservoir, the state engineer will grant a waiver if written justification is provided to the satisfaction of the state engineer. The outlet shall be sized to provide adequate capacity to satisfy water rights of downstream priority users. A stage discharge curve and table showing elevation in one-foot increments versus discharge capacity shall be prepared. The rating curve and table shall be from the invert of the outlet to the dam crest. The parameters used to calculate the outlet works capacity shall be justified and appropriate data sheets and computer program output computations from computerized analysis shall be provided. Elevations shall be based on North American vertical datum 1988 or more recent adjustment. The outlet works capacity shall meet the following minimum requirements:

(a) Outlets for water storage reservoirs shall drain in 45 days with supporting calculations provided.

(b) Outlets for flood control dams shall drain the reservoir in 96 hours unless a waiver is granted by the state engineer. The 96-hour time frame begins once the reservoir storage drops to the emergency spillway crest or reaches its peak during the 100-year, 24-hour event. Documentation supporting the waiver shall include the time to drain more frequent events.

(8) Outlet works design. The outlet works design includes the intake structure, conduit and terminal structure. The outlet works design shall meet the following minimum requirements:

(a) Minimum conduit diameter is 18 inches unless a waiver is granted by the state engineer. Documentation supporting a waiver shall include identification of methods to inspect the interior of the conduit.

(b) Metal conduits used in dams that are classified as significant hazard potential where the sole purpose of the dam is flood control, or in dams classified as low hazard potential, shall have adequate strength after corrosion for a minimum of 200 years, based on corrosivity testing of onsite soils. Cathodic or other protection of metal conduits is permissible and may be considered in this analysis. Metal conduits are not acceptable for dams classified as high hazard potential or dams classified as significant hazard potential with permanent water storage except as interior forms for cast-in-place concrete conduits.

(c) Outlet conduits for storage reservoirs shall be gated at the upstream end unless a waiver is granted by the state engineer. Where gates are located other than at the upstream end of the conduit, a guard gate or bulkhead shall be provided at the upstream end to allow draining of the conduit for inspection, maintenance and repair.

(d) Outlet conduits shall be adequately vented. Where the outlet conduit ties directly to a downstream pipe, a by-pass valve shall be provided.

(e) Outlet controls and equipment shall be properly designed to be secure from damage due to vandalism, weather, ice, floating debris, wave action, embankment settlement and other reasonably foreseeable causes. The outlet control operators shall remain accessible during outlet works and spillway releases.

(f) Outlets for flood control structures shall be ungated. Where a gate is required to satisfy downstream release restrictions, a waiver from the state engineer is required. The written request for waiver shall include a plan for timely release of the floodwater.

(g) Outlet works intake structures shall be provided with trash racks or grates to prevent clogging with debris. Grate opening size or bar spacing shall be adequate to satisfy applicable public safety requirements, if appropriate. Total size of grate openings must be at least three times the cross-sectional area of the outlet conduit.

(h) The design of the outlet works terminal structure shall address energy dissipation to prevent erosion and shall include supporting calculations.

(i) Outlet conduits shall be designed for full embankment loading and for hydrostatic pressure equal to the maximum reservoir head, acting separately and in combination, with an adequate factor of safety for the conduit material. If future increases in embankment height and/or reservoir head are foreseeable, allowance shall be made in the design.

(j) The conduit together with all joints and fittings shall be watertight at the design pressure and shall be pressure tested prior to backfilling. Conduits shall be designed for all reasonably foreseeable adverse conditions including corrosion, abrasion, cavitation, embankment settlement and spreading, thermal effects and seismic loading. The ability of the conduit to withstand deflection and separation at the joints shall be addressed in the design of the outlet conduit.

(k) Outlet works shall be supported by stable, well-consolidated foundation materials. Where the conduit is placed in embankment fill or native overburden materials, settlement analysis shall be performed.

(l) Minimizing seepage along conduits shall be addressed including the methods for ensuring compaction of backfill around and beneath the conduit.

(m) All supporting documentation and calculations for the outlet works design shall be provided. The outlet works design shall include all foreseeable loading conditions, including but not limited to ice loading, debris buildup, wave action and embankment settlement. Structural design calculations for the intake structure, conduit and outlet structure shall be submitted.

(9) Geological assessment. A geological assessment of the dam and reservoir site is required for all dams classified as high or significant hazard potential. The geological assessment may be included in the geotechnical investigation or seismic study, or may be submitted as a separate document. The geological assessment shall address regional geologic setting; local and site geology; geologic suitability of the dam foundation; slide potential of the reservoir rim and abutment areas; and seismic history and potential.

(10) Geotechnical investigation. A geotechnical investigation shall assess site conditions and support the design. A professional engineer licensed in the state of New Mexico qualified to provide geotechnical expertise in the design and construction of dams shall prepare, stamp and sign the geotechnical investigation, which may be submitted as a separate report. The scope of the geotechnical investigation is dependent on the size classification, hazard potential classification, anticipated materials and construction methods, site geology and seismicity, anticipated soil strata and other site-specific conditions. The geotechnical investigation shall include a field investigation and laboratory testing. Results of field and laboratory testing shall be presented in a report, including recommended parameters to be used in design and construction of the dam and appurtenant structures. The field investigation and laboratory testing shall include but not be limited to the following:

(a) test borings in the footprint of the embankment, spillway excavations and appurtenant structures extending to bedrock or to a depth equal to at least the height of the dam; where appropriate, borings may include coring of bedrock materials to determine the quality and character of the rock;

(b) standard penetration tests or other field-testing to assess soil character and consistency;

(c) "undisturbed" sampling for further tests such as insitu density, shear strength and compressibility;

(d) supplemental test pits, if deemed necessary, to obtain bulk and undisturbed samples, assess soil layering and measure bedrock orientation;

(e) measurement of water level in drill holes;

(f) field permeability testing, if feasible;

(g) logs of test borings and test pits, location map and profile along dam axis with soil information shown;

(h) testing to determine the relevant properties of the material to be used in construction, including but not limited to shear strength, permeability, compressibility and filter characteristics; the testing method shall conform to accepted industry standards and be appropriate for the material being tested;

(i) evaluation of liquefaction potential and dynamic shear strength testing if deformation analysis is required; and

(j) identification of the location of the borrow material to be used during construction.

(11) Seepage and internal drainage. The effects of seepage and potential for internal erosion shall be evaluated. A seepage analysis shall be performed to address the performance of the embankment under steady-state conditions for dams classified as high or significant hazard potential. All parameters and assumptions used in the analysis shall be summarized in a table and justified in the seepage analysis. A waiver may be requested in writing for flood control dams or reservoirs with synthetic liners. The seepage analysis and internal drainage design shall include but not be limited to the following:

(a) Flow nets of appropriate size and scale shall be prepared. The effects of anisotropy with respect to permeability shall be addressed. Ratios of horizontal to vertical permeability of less than 4 for constructed embankments and less than 9 for native deposits shall be supported by field and laboratory permeability tests. Appropriate data sheets and computer program output computations from computerized analysis shall be provided.

(b) The design shall address the effects of anticipated seepage beneath, around and through the dam. Seepage shall not exit on the dam face and excessive exit seepage gradients are unacceptable. All filter, transition and drainage zones within earth dams shall have a thickness adequate to address constructability and enhance seismic stability with a minimum thickness of 3 feet for each zone.

(c) Collector pipes and conduits for internal drains shall be made of non-corrodible material capable of withstanding the anticipated loads. If possible, pipes shall be located where they can be exposed for repair or replacement without threatening the stability of the dam. Collector pipes for drains shall be enveloped in a free-draining medium meeting filter criteria for adjacent embankment or foundation zones. Where surging or hydraulic gradient reversal is likely, perforation size must be less than the diameter at which 15 percent of the surrounding medium is finer. Where surging or hydraulic gradient reversal are unlikely, the perforation size must be less than the diameter at which 85 percent of the surrounding medium is finer.

(d) Drain pipes shall be sized to provide a flow depth no more than ¼ of the pipe diameter when carrying the anticipated discharge. Drain pipes shall be at least 6 inches in diameter unless the availability of technology for inspection and maintenance can be demonstrated. Individual pipes shall discharge to a gallery, well, manhole, or to daylight such that the flow of each pipe can be monitored and measured. Manifold connections, tees and wyes are not permitted. If the anticipated flow from a drain line exceeds 10 gpm, a measuring flume or weir shall be provided for that line. If the anticipated flow from a drain line is less than 10 gpm, the outfall shall be designed to allow a 5 gallon bucket to be used to collect and measure discharge. Where pipes from internal drains are discharged to daylight, a rodent screen shall be provided.

(12) Stability analysis. Cross-sectional design for dams shall be supported by slope stability analysis. Dams classified as low hazard potential with upstream slopes no steeper than 3 horizontal to 1 vertical, downstream slopes no steeper than 2 horizontal to 1 vertical and which are 25 feet or less in height will not require slope stability analysis. The analysis model shall adequately represent the geometry and zoning, shear strength parameters, material unit weights, pore pressure and seepage conditions, external loading and other relevant factors of the critical cross section or sections. Manual computations in the analysis will be accepted if judged to be sufficiently rigorous. Where appropriate, the analysis shall consider noncircular or block and wedge type failure surfaces as well as circular failures. All parameters and assumptions used in the analysis shall be summarized in a table and justified in the geotechnical investigation. A scale drawing, utilizing the same scale for vertical and horizontal dimensions, shall be provided for each cross-sectional model used in the analysis, with the critical failure surface(s) identified. Appropriate data sheets and computer program output computations from computerized analysis shall be provided. Dams shall be designed to provide the following minimum factors of safety from the stability analysis:

(a) 1.5 for steady state long-term stability;

(b) 1.5 for operational drawdown conditions;

(c) 1.2 for rapid drawdown conditions; and

(d) 1.2 for end of construction.

(13) Seismic design and analysis. Dams classified as high or significant hazard potential shall be analyzed for seismic stability. Seismic analysis for water storage dams shall be based on full reservoir under steady state seepage conditions. Flood control dams with ungated outlets that satisfy Subparagraph (b) of Paragraph (7) of Subsection C of 19.25.12.11 NMAC without waiver shall be designed for earthquake loads under empty reservoir conditions and need not consider steady-state seepage. Dams sited on active faults shall obtain a waiver from the state engineer. To obtain a waiver the analysis shall show that the location of the dam is unavoidable and the dam must be designed to withstand anticipated fault movement without compromising its integrity. Appropriate data sheets and computer program output computations from computerized analysis shall be provided. The seismic analysis shall meet the following minimum requirements:

(a) A seismological investigation for the dam area and reservoir area. This study may be part of the geological or geotechnical report for the structure, or may be a separate effort. The study shall determine and justify the appropriate seismic parameters to be used for design. The seismic parameters shall be based on the following design earthquake:

(i) Dams classified as high hazard potential other than flood control structures shall be designed for the maximum credible earthquake or for an earthquake with a 5000-year return frequency.

(ii) Dams classified as significant hazard potential or high hazard potential dams whose sole purpose is for flood control shall be designed for a 2% chance of occurrence in 50 years (approximately 2500-year return frequency).

(b) An analysis of materials in the foundation, reservoir area and proposed embankment shall be completed to determine the potential for liquefaction, earthquake-induced sliding, or other seismic sensitivity, which may be accomplished as part of the geotechnical investigation.

(c) Pseudostatic analysis will be acceptable for the following cases:

(i) the embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D 698, or at least 90% of the maximum modified Proctor density, ASTM D 1557 or

at least 70% relative density if Proctor testing is not appropriate; no materials prone to liquefaction are present in the foundation and peak bedrock acceleration is 0.20g or less; or

(ii) the embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D 698, or at least 90% of the maximum modified Proctor density, ASTM D 1557; potentially submerged portions of the embankment except for internal drain elements are constructed of clayey material; the dam is constructed on clayey soil or bedrock foundation and peak bedrock acceleration is 0.35g or less; and

(iii) all safety factor requirements in accordance with Subparagraphs (a) through (d) of Paragraph (12) of Subsection C of 19.25.12.11 NMAC are met;

(iv) minimum freeboard requirements in accordance with Subparagraphs (a) through (e) of Paragraph (15) of Subsection C of 19.25.12.11 NMAC are met; and

(v) the pseudostatic coefficient selected for analysis must be at least 50% of the predicted peak bedrock acceleration, but not less than 0.05g and the factor of safety under pseudostatic analysis shall be 1.1 or greater. In determining the factor of safety for pseudostatic analysis, a search for the critical failure surface shall be made.

(d) For dams not satisfying the requirements for pseudostatic analysis, a deformation analysis is required. The resulting embankment must be capable of withstanding the design earthquake without breaching and with at least 3 feet of freeboard remaining after deformation. The analysis shall also assess the potential for internal erosion as a result of cracking during deformation.

(e) The seismic assessment shall also address the stability of appurtenant structures to the dam during the design earthquake as appropriate, unless failure of an appurtenance due to earthquake does not represent an immediate threat to the dam, in which case the operating basis earthquake may be used.

(14) Dam geometry. The dam geometry shall be supported by the stability and seismic analysis and meeting the following minimum requirements:

(a) The crest width shall be at least equal to the dam height in feet divided by 5 plus 8 feet, with the minimum permissible crest width being 10 feet and the maximum required crest width being 24 feet.

(b) Roads located on the crest shall have appropriate surfacing to provide a stable base that resists rutting and provides adequate friction for safety in wet conditions.

(c) The crest design shall provide a minimum of 2 feet of cover or the depth of frost penetration; whichever is greater, above clay cores to prevent cracking of the core due to desiccation or frost penetration.

(d) Turnarounds should be provided on dead-end service roads on dam crests, located in such a manner that backing maneuvers longer than 300 feet are eliminated.

(e) The crest shall be provided with adequate cross slope to prevent ponding.

(f) The slope or slopes to which crest drainage is directed must be provided with adequate erosion protection to accept the crest drainage.

(g) The crest longitudinal profile shall be provided with adequate camber to maintain the profile after embankment settlement. Camber should be based on settlement analysis and shall be at least 2 percent of the total embankment height, with a minimum of 1 foot at the highest point of the dam. The tops of internal core zones shall also be provided with camber in a similar manner to the crest of the dam.

(h) In the event that safety berms, street curbs, or other longitudinal features which block, control, or concentrate drainage are required on the dam crest, the design shall provide for collection and conveyance of accumulated water to discharge away from the embankment without erosion.

(15) Freeboard. Dams shall be provided with adequate freeboard. Wave runup shall be determined taking into consideration wind speed, reservoir fetch, embankment slope and roughness of the slope surface. Freeboard shall satisfy the following conditions:

(a) Anticipated wave runup resulting from a 100 mph wind with reservoir level at the spillway crest will not overtop the dam.

(b) Anticipated wave runup resulting from a 50 mph wind with maximum reservoir level from routed spillway design flood will not overtop the dam.

(c) Clay core cover and capillary rise requirements in accordance with Subparagraph (c) of Paragraph (14) of Subsection C of 19.25.12.11 NMAC are satisfied.

(d) A minimum of 3 feet of freeboard remains after seismic deformation.

(e) In any case, at least 4 feet of freeboard shall be provided. The minimum of 4 feet of freeboard may be waived for perimeter embankments with no spillway, provided a written request is made to the state engineer accompanied with supporting justification.

(16) Erosion protection. Erosion protection shall be addressed to protect the dam and appurtenant structures from erosion that can threaten the safety of the structure. At a minimum, the following areas of erosion shall be addressed:

(a) Wave erosion. The upstream slope shall be protected from wave erosion. The material selected and area of coverage shall be appropriate for the protection required with justification provided. Flood control dams in compliance with Subparagraph (b) of Paragraph (7) of Subsection C of 19.25.12.11 NMAC without waiver are exempt from wave protection.

(b) Surface erosion. The slope, crest, abutment and groins, toe areas and any other constructed areas associated with the dam and appurtenant structures shall be protected from surface erosion and concentrated flows. The material selected and area of coverage shall be appropriate for the protection required with justification provided.

(17) Geotextile design. Geotextiles are an acceptable material for use in dam design if the geotextile is placed so that it does not jeopardize the dam or appurtenant structures during repair or failure of the geotextile. The geotextile material shall be used in accordance with the manufacturer's recommendations and intended use for the product. Installation shall be by certified personnel and the completed installation certified by installer or manufacturer, if required by the manufacturer.

(18) Structural design. The structural design information for all appurtenant structures, addressing water, earth, ice and any other applicable load shall be provided. Reinforced concrete design including assumptions for loads and limiting stresses and sample calculations shall be provided. Appropriate data sheets and computer program output computations from computerized analysis shall be provided.

(19) Utilities design. Utility placement or relocation shall be addressed as applicable. Utilities located in the vicinity of the proposed embankment footprint should be relocated and trenches backfilled and compacted with suitable material to the satisfaction of the state engineer. If utilities are allowed to remain, they will be required to satisfy applicable provisions for outlet conduits in accordance with Paragraph (8) of Subsection C of 19.25.12.11 NMAC.

(20) Miscellaneous design. Because each design is unique, all design elements not specifically addressed in these regulations shall be documented and justified with sample calculations and appropriate data sheets and computer program output computations from computerized analysis shall be included in the design report.

D. Construction drawings: A professional engineer licensed in the state of New Mexico qualified in dam design and construction shall prepare the construction drawings. Illegible, mutilated, careless or otherwise poorly prepared drawings are not acceptable for filing with the state engineer. Plan drawings and maps prepared with the aid of a computer require the submittal of the digital data files in tagged image file format or other format acceptable to the state engineer. The preparation of construction drawings is described below and shall include the following items:

(1) Quality. Construction drawings and maps shall be made from actual field or photogrammetric surveys of an accuracy acceptable to the state engineer. Construction drawings and maps shall be prepared with permanent black ink on mylar. All original signatures, dates and acknowledgments appearing on the sheet(s) shall be in permanent ink. Plan drawings and maps shall always be rolled, never folded, for transmittal.

(2) Scale and size. Sheets shall be twenty-four (24) inches by thirty-six (36) inches with one (1) inch margins on all sides. The scale(s) used on the drawings may vary according to requirements and space available to show all necessary data in detail clearly in feet and decimals and to be clearly legible when the drawings are reduced to eleven (11) inches by seventeen (17) inches. Detailed dimensions of appurtenant structures shall be given in feet and inches. All sheets shall have bar scales in order to allow scaling of reduced drawings.

(3) Sheet numbers. Each sheet shall be numbered sequentially with the first sheet being sheet number one in conjunction with the total numbered sheets (example Sheet 1 of 5). The sheet number on the last sheet shall equal the total number of sheets.

(4) Engineer's seal and signature. Each sheet shall have the responsible engineer's seal and signature.

(5) Orientation and date. The direction of north and the basis of bearings shall be shown on all maps. The date that field surveys are made or the date of the aerial photography used shall be shown on the maps.

(6) Title sheet. The first sheet of a set of plans is the title sheet. The title sheet shall only contain sufficient information to summarize the scope of the project, the title of the project and signed certifications for the

dam owner, engineer and state engineer in accordance with Subsections A, B and E of 19.25.12.12 NMAC. The title sheet shall summarize the properties of the dam and shall include the following information, as appropriate:

(a) name of the dam (same as shown on the application);
(b) type of dam (material);
(c) hazard potential classification;
(d) maximum height above the downstream toe in feet;
(e) maximum length in feet;
(f) crest width in feet;
(g) slope of the upstream face (horizontal to 1 vertical);
(h) slope of the downstream face (horizontal to 1 vertical);
(i) elevation of the dam crest;
(j) elevation of spillway crest;
(k) elevation of outlet conduit flow line;
(l) freeboard in feet;
(m) maximum spillway discharge capacity in cubic feet per second;
(n) type of outlet conduit (give size and material);
(o) maximum outlet conduit discharge capacity in cubic feet per second; and
(p) location of the outlet works intake structure (using latitude and longitude or to the New Mexico state plane coordinate system).

(7) Vicinity map. A vicinity map of sufficient scale and size to locate the pertinent area shall be shown on the title sheet or second sheet of the drawings.

(8) Site topography. A detailed topography of the dam site including sufficient area upstream and downstream and at the abutments shall be provided. Elevations shall be based on North American vertical datum 1988 or more recent adjustment.

(9) Design details. Detailed information of the various construction features including plan view, elevations, cross-sections at the maximum section and along the outlet works, profile along and section through the centerline of the dam showing construction features and cross-sections and a profile of the emergency spillway with dimensions and construction details shall be provided. Any other information necessary for the state engineer to determine the feasibility and safety of the dam shall be required.

(10) Reservoir area, capacity and high water line traverse. The topography of any proposed reservoir site shall be determined to industry standards and a contour map with a contour interval of 1 foot shall be prepared. Elevations of the contours shall be tied to the North American vertical datum of 1988 or more recent adjustment. The high water line at the elevation of the dam crest will be highlighted on the contour map. A curve or table of elevation versus area and storage capacity for the reservoir shall be prepared from the contour map. The curve or table shall be from the bottom of the reservoir to the dam crest. Area shall be provided in acres and storage capacity in acre-feet.

(11) Point of outlet. A location of the outlet works shall be referenced using latitude and longitude or to the New Mexico state plane coordinate system.

(12) Permanent bench mark. A permanent bench mark shall be established above the high water line at a location unlikely to settle or be disturbed. The North American vertical datum of 1988 or more recent adjustment and latitude and longitude or the New Mexico state plane coordinate system for the bench mark elevation and location shall be provided. A detail of construction of the permanent bench mark shall be provided.

E. Specifications: Specifications shall be prepared for each project describing work to be done and materials to be used to supplement construction drawings. Specifications must be clear and concise and include detailed methods of construction, qualities and sizes of materials, unit amounts to be used and methods of testing and quality control, construction supervision and inspection. Specifications shall be prepared by a professional engineer licensed in the state of New Mexico qualified in the design and construction of dams. The specifications shall meet the following requirements:

(1) The front cover of the specifications shall show the name of the dam (identical to the application) and the county in which the dam is located. The first page behind the front cover shall show the name of the dam (identical to the dam name on the application), the county in which the dam is located, signed certifications for the engineer and state engineer in accordance with Subsections B and E of 19.25.12.12 NMAC and a statement recognizing the authority of the state engineer. An approved model statement recognizing the authority of the state engineer is provided below. Changes to the model statement require prior approval of the state engineer.

"All construction shall be performed in strict accordance with the accepted plans and specifications. Representatives of the state engineer shall have full authority to perform inspections during construction and shall have full power to act pursuant to the law and in accordance with Title 19, Chapter 25, Part 12, Dam Design, Construction and Dam Safety of the New Mexico Administrative Code if plans and specifications are not followed."

(2) The specifications shall be indexed.

(3) The specifications shall be bound and submitted on a good grade of white 8 1/2-inch by 11-inch paper.

(4) The general conditions shall include statements that the construction drawings and specifications cannot be significantly changed without the prior written approval of the state engineer.

F. Boundary, easement or right of way plat of survey: A professional surveyor licensed in the state of New Mexico shall prepare a plat of survey showing the dam owner's property boundaries or easement and/or right of way granted by the land owner. The plat of survey shall be prepared in conformance with the requirements as set forth in the Minimum Standards for Surveying in New Mexico, 12.8.2 NMAC. The plat of survey shall clearly state to whom an easement is granted and what rights are conveyed with the easement. The plat of survey shall show the footprint of the dam and appurtenant structures and the high water line in the reservoir. The plat of survey shall be submitted with the construction drawings and recorded with the county clerk of the county or counties in which the survey is located. A certificate signed by the surveyor in accordance with Subsection C of 19.25.12.12 NMAC shall appear on the plat of survey. A certified copy of the recorded plat of survey bearing the recorded page and endorsement of the county clerk shall be submitted to the state engineer for filing upon completion of construction. Adequate property ownership, easement or right of way shall be required for the following conditions:

(1) to access the dam and outlet controls during normal and flood events;

(2) to prevent development encroachment into the reservoir area defined by normal operation and the spillway design flood;

(3) to prevent development in the approach, control and discharge section of the spillway that may restrict flow through the spillway;

(4) to return outlet works and spillway discharge to the natural drainage and allow the outlet works to discharge freely; and

(5) to perform maintenance on the dam, appurtenant structures and surrounding areas to ensure the safe performance of the dam.

G. Dam site security: Dams classified as high or significant hazard potential shall address security at dams to prevent unauthorized operation or access. If in the opinion of the state engineer, the failure of the dam will result in catastrophic consequences, a security and risk management program for the dam will be required. Elements of a security and risk management program are:

(1) threat, vulnerability and risk assessments;

(2) physical security plans; and

(3) integration of security operational procedures.

H. Instrumentation plan: An instrumentation plan providing the ability to monitor and evaluate the performance of a dam is required for dams classified as high or significant hazard potential. The instrumentation plan may be submitted as a separate report or part of the operation and maintenance manual. Minimum requirements of the instrumentation plan shall include:

(1) general description of instrumentation;

(2) reading schedule;

(3) identification of critical readings;

(4) specifics for each installation including:

(a) detailed description of installations;

(b) purpose of the instrumentation;

(c) reading and maintenance schedule instructions; and

(5) special instrumentation or monitoring requirements.

I. Operation and maintenance manual: An operation and maintenance manual is required for dams classified as high or significant hazard potential. The operation and maintenance manual identifies activity necessary to address the continued safe operation, maintenance and overall performance of the dam. Any restrictions imposed by the design shall be addressed in the operation and maintenance manual. The operation and maintenance manual shall conform to the requirements set forth in 19.25.12.17 NMAC.

J. Emergency action plan: An emergency action plan is required for dams classified as high or significant hazard potential. The emergency action plan identifies potential emergency conditions at a dam and specifies preplanned actions to be followed to minimize property damage and loss of life. The emergency action plan shall conform to the requirements set forth in 19.25.12.18 NMAC.
[19.25.12.11 NMAC - N, 3/31/2005]

19.25.12.12 CERTIFICATIONS: Signed certifications by the dam owner, engineer, surveyor, state office of emergency management and the state engineer are required by these regulations on specific documents. Approved model certifications for the dam owner, engineer, surveyor, state office of emergency management and state engineer are provided below. Changes to the model certifications require prior approval of the state engineer.

A. DAM OWNER'S CERTIFICATE: A certificate followed by the dated signature of the dam owner and notary public acknowledgment is required on the title sheet of the construction drawings and first page behind the front cover of the operation and maintenance manual and emergency action plan. The following model certification is considered to be an example of the minimum that the dam owner shall certify. If the dam owner is a corporation, political subdivision or other governmental entity a model certificate is also provided.

state of _____)
) ss.
county of _____)

I, (dam owner's name) , being first duly sworn, upon my oath, state that I have read and examined the accompanying _____ (construction drawings consisting of ____ sheets, operation and maintenance manual, or emergency action plan) and know the contents and representations therein for _____ dam and all that is shown herein is done with my free consent and in accordance with my wishes and state that the same are true and correct to the best of my knowledge and belief.

_____
Dam owner signature Date

Subscribed and sworn to before me this _____ day of _____ , 20__.

_____
Notary public

My commission expires _____ (SEAL)

If a claimant is a corporation, political subdivision or other governmental entity the following shall be used:

state of _____)
) ss.
county of _____)

I, (representative's name), being first duly sworn, upon my oath, state than I am the _____ (officer) of the _____, a corporation duly organized under the laws of the state of _____, that the accompanying _____ (construction drawings consisting of ____ sheets, operation and maintenance manual, or emergency action plan) for _____ dam were made under authority of the board of directors of said corporation and that, in their behalf, I have read and examined the statements and representations and all that is shown herein is done with their free consent and in accordance with their wishes and state that the same are true and correct to the best of my knowledge and belief.

_____
Representative signature, title Date

Subscribed and sworn to before me this _____ day of _____ , 20__.

_____
Notary public

My commission expires _____ (SEAL)

B. ENGINEER'S CERTIFICATE: A certificate followed by the dated signature, license number and seal of the engineer responsible for preparing the design report, construction drawings, specifications, operation and maintenance manual and engineering elements of the emergency action plan is required. The certificate shall be placed on the title sheet of the construction drawings and first page behind the front cover of the design report, specifications, operation and maintenance manual and emergency action plan. The following model certification is considered to be an example of the minimum that the engineer should certify to:

state of _____)
) ss.
county of _____)

I, (engineer's name) , hereby certify that I am a professional engineer licensed in the state of New Mexico, qualified in _____ (civil, geotechnical, etc.) engineering; that the accompanying _____ (design report, construction drawings consisting of ____ sheets, specifications, operation and maintenance manual, or _____ elements of the emergency action plan) was prepared by me or under my supervision; that the accompanying _____ (design report, construction drawings consisting of ____ sheets, specifications, operation and maintenance manual, or _____ elements of the emergency action plan) is in compliance with the Dam Design, Construction and Dam Safety Regulations (19.25.12 NMAC) and that the same are true and correct to the best of my knowledge and belief.

(Engineer's signature), License number _____, (SEAL)
Engineer's name

Date submitted _____

C. SURVEYOR'S CERTIFICATE: The professional surveyor licensed in the state of New Mexico preparing the plat of survey showing property boundaries, acquired easements or rights-of-way shall include a certificate on the plat of survey as modeled in Paragraph (2) of Subsection J of 12.8.2.9 NMAC, the Minimum Standards for Surveying in New Mexico. The following model certificate is considered to be an example of the minimum that the surveyor should certify to:

I, (surveyor's name) , New Mexico professional surveyor no. (surveyor's license number), do hereby certify that this (boundary, easement, or right of way) plat of survey and the actual survey on the ground upon which it is based were performed by me or under my direct supervision; that I am responsible for this survey; that this survey meets the Minimum Standards for Surveying in New Mexico; and that it is true and correct to the best of my knowledge and belief. I further certify that this survey is not a land division or subdivision as defined in the New Mexico Subdivision Act and that this instrument is a (boundary, easement, or right of way) plat of survey of _____ dam.

(Surveyor's signature), License number _____, (SEAL)
Surveyor's name

Date submitted _____

D. STATE OFFICE OF EMERGENCY MANAGEMENT: A certificate form for the state office of emergency management acceptance shall be placed on the first page behind the front cover of the emergency action plan. This certificate is to be signed by state office of emergency management after all necessary corrections or additions, if any, have been made.

state of _____)
) ss.
county of _____)

I hereby certify that the accompanying emergency action plan for _____ dam has been duly examined by me and accepted for filing on the _____ day of _____, 20__.

_____
State office of emergency management

E. STATE ENGINEER'S CERTIFICATE: A certificate form for the state engineer acceptance shall be placed on the title sheet of the construction drawings and first page behind the front cover of the design report, specifications, operation and maintenance manual and emergency action plan. This certificate is to be signed by the state engineer or his representative after all necessary corrections or additions, if any, have been made.

state of _____)
) ss.
county of _____)

I hereby certify that the accompanying _____ (design report, construction drawings, specifications, operation and maintenance manual or emergency action plan) for _____ dam and appurtenant structures has been duly examined by me and accepted for filing on the _____ day of _____, 20__.

_____
State engineer

[19.25.12.12 NMAC - N, 3/31/2005]

19.25.12.13 CONSTRUCTION AND OPERATION CONDITIONS: After reviewing the required documentation, the state engineer will notify the dam owner if any deficiencies are found with the submittal to construct and operate a dam. The dam owner will be given an opportunity to correct any deficiencies noted in the review process. Once all deficiencies have been addressed the state engineer will approve the application for permit to construct and operate a dam with conditions under which construction and operation shall occur. Failure to comply with conditions of the approved permit may result in the state engineer issuing an order to redesign, reconstruct or restrict operation of the dam and reservoir until conditions are met. Construction must be completed within two years of approving the application unless an extension of time for the construction is requested and approved by the state engineer. The conditions of construction and operation shall include, but not be limited to the following:

A. Engineer supervising construction: Prior to initiation of construction, the dam owner shall designate a professional engineer licensed in the state of New Mexico qualified in the design and construction of dams to supervise construction. If the state engineer finds the engineer acceptable, an order is issued approving the engineer and setting forth conditions under which the engineer will supervise construction. Conditions shall include, but shall not be limited to:

(1) The engineer supervising construction shall submit monthly progress reports including summary of test results, problems encountered and their solutions.

(2) Construction shall be in accordance with accepted drawings and specifications. State engineer approval of any modifications to the accepted drawings or specifications is required prior to undertaking the modifications. Requests for changes or modifications by the engineer supervising construction shall be submitted in writing, supported with appropriate documentation.

(3) The engineer supervising construction shall provide the state engineer a minimum of 72 hours notice to perform inspections as specified in the conditions of construction.

(4) Upon completion of construction, the engineer supervising construction shall submit to the state engineer the following items:

(a) a completion report, which shall include descriptions of problems and their solutions;

(b) a summary of materials test data and labeled and dated construction photographs;

(c) record mylar construction drawings including signed certifications on the title sheet; and

(d) a certificate that the dam was constructed in accordance with the accepted drawings and specifications and is in satisfactory condition. An approved model certificate for the engineer supervising construction is shown below. Changes to the language in the certification require prior approval by the state engineer.

state of _____)
) ss.
county of _____)

I, _____, (engineer's name) state that I am a qualified professional engineer licensed in the state of New Mexico, that I have inspected the _____ dam and appurtenant structures and find them to be completed in accordance with the record construction drawings and specifications and are now in a satisfactory condition for acceptance.

(Engineer's signature)____ License number _____, (SEAL)
Engineer's name

Date submitted _____

B. State engineer's authority during construction: The state engineer may perform inspections at any time during construction of the dam and appurtenant structures. Inspections will vary with each project, based on the complexity of the design. Inspection of specific construction items are standard construction conditions in the permit and require the engineer supervising construction to provide the state engineer with a minimum of 72 hours advanced notice. If the state engineer receives a minimum of 72 hours advanced notice, a delay of construction to schedule a state engineer inspection is not required. State engineer inspection fees are charged in accordance with Subsection D of 19.25.12.8 NMAC. Fees for inspection of construction by the state engineer not paid on demand shall become a lien on any land or other property of the dam owner and may be recovered by the state engineer.

C. Completion of construction: Upon completion of construction, a proof of completion of works form for the dam shall be submitted in accordance with 19.25.12.14 NMAC. Owners of dams classified as high or significant hazard potential shall submit to the state engineer an updated operation and maintenance manual in accordance with 19.25.12.17 NMAC and an updated emergency action plan in accordance with 19.25.12.18 NMAC incorporating any modifications made during construction. Upon the satisfactory completion of all conditions in the permit, pending the issuance of a certificate of construction and license to operate a dam, use of the reservoir shall require written permission from the state engineer. Use of the dam and reservoir are restricted until the state engineer accepts the updated operation and maintenance manual and emergency action plan, if required.

D. Extension of time for construction: The state engineer will grant an extension of time for completing construction upon proper showing by the dam owner of due diligence or reasonable cause for delay and accompanied with a fee in accordance with Subsection C of 19.25.12.8 NMAC. An affidavit by a professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall be filed with the state engineer providing evidence that the design of the dam meets or exceeds the design requirements in accordance with 19.25.12.11 NMAC. An extension of time may be granted for a period not to exceed five (5) years. No extension of time shall be granted which in combination extend the time allowed by the permit beyond ten (10) years from the initial date of approval of the application, unless the state engineer in his discretion expressly waives this limitation pursuant to NMSA 1978, Section 72-5-14. Failure to request an extension of time shall result in cancellation of the permit by the state engineer.
[19.25.12.13 NMAC - N, 3/31/2005]

19.25.12.14 PROOF OF COMPLETION OF WORKS: Upon completion of all construction conditions a proof of completion of works for the dam shall be filed on a form provided by the state engineer with appropriate fees in accordance with Subsection E of 19.25.12.8 NMAC. The proof of completion of works for the dam shall be filed with original signature of the dam owner and engineer supervising construction.
[19.25.12.14 NMAC - N, 3/31/2005]

19.25.12.15 CERTIFICATE OF CONSTRUCTION OF A DAM: Upon receipt of the proof of completion of works form, the state engineer will determine if all construction conditions of the permit were met. Upon a

determination by the state engineer that all construction conditions have been complied with, the state engineer shall issue a certificate of construction. The certificate of construction shall address the general properties of the dam and appurtenant structures. The dam owner shall record the certificate of construction with the county clerk of the county within which the works are located.
[19.25.12.15 NMAC - N, 3/31/2005]

19.25.12.16 LICENSE TO OPERATE A DAM: Upon issuance of a certificate of construction the state engineer shall issue a license to operate a dam. The license to operate a dam shall address operation conditions and dams shall be operated in accordance with the operation conditions. In addition, dams classified as high and significant hazard potential shall operate in accordance with the operation and maintenance manual and emergency action plan prepared in accordance with Sections 17 and 18 of 19.25.12 NMAC. Failure to comply with the conditions of the license to operate a dam may result in a state engineer order that limits operation, requires specific action by the owner and if necessary the license to operate a dam may be revoked by the state engineer. If a license to operate a dam is revoked the state engineer may order the dam breached in accordance with Subsections B or C of 19.25.12.19 NMAC.
[19.25.12.16 NMAC - N, 3/31/2005]

19.25.12.17 OPERATION AND MAINTENANCE MANUAL: Owners of dams classified as high or significant hazard potential shall prepare, maintain and adhere to an operation and maintenance manual that addresses the continued safe operation, maintenance and performance of the dam. Because each site, design and operating practice is unique, waivers of specific requirements in this section will be considered on a case-by-case basis. Request for waiver shall be in writing accompanied with documentation justifying the request. If the request is not justified to the satisfaction of the state engineer the request will be denied. A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare the operation and maintenance manual. The front cover shall show the name of the dam (identical to the application), the county in which the dam is located and type of report. The first page behind the front cover shall show the name of the dam (identical to the dam name on the application), the county in which the dam is located and signed certifications for the dam owner, engineer and state engineer in accordance with Subsections A, B and E of 19.25.12.12 NMAC. Operation or maintenance of the dam in violation of the procedures presented in the accepted operation and maintenance manual that affect the safety of the dam will result in an order being issued requiring the dam owner to address the problem. Failure to comply with orders issued by the state engineer may result in the license to operate the dam being revoked and the dam being ordered breached in accordance with Subsection B or C of 19.25.12.19 NMAC. Generally, the operation and maintenance manual shall address the following, with modification depending on the specific dam application:

A. Project information: General information on the project including the purpose, location, history, responsibilities and description and properties of the dam and appurtenant structures shall be required.

B. Operation: Operation instructions for the project shall include but not be limited to the following:

(1) Reservoir:

(a) storage allocations;

(b) spillway design flood water level;

(c) emergency reservoir evacuation procedures and maximum discharge rate; and

(d) first filling criteria and monitoring requirements.

(2) Outlet works:

(a) first operation;

(b) seasonal startup;

(c) seasonal shutdown;

(d) installation and removal of bulkhead;

(e) operation procedures for specific equipment; and

(f) electrical systems and controls.

C. Instrumentation: The following elements for monitoring instrumentation shall be addressed

(1) general description;

(2) purpose;

(3) critical readings;

(4) reading and maintenance procedures; and

(5) reading schedule.

D. Maintenance: Maintenance requirements and schedule shall be included.

E. Inspection: Inspection requirements, schedule and recommended checklist shall be included.

F. Updates and revisions: An update and revision procedure shall be included.

G. Appendices: Appendices to include any design consideration and the instrumentation plan to ensure any restrictions imposed by the design are incorporated into the operation and maintenance manual shall be included. Copies of inspections forms and any other information that supports and supplements the material used in the development and maintenance of the operation and maintenance manual.

[19.25.12.17 NMAC - N, 3/31/2005]

19.25.12.18 EMERGENCY ACTION PLAN: Owners of dams classified as high or significant hazard potential shall prepare, maintain and exercise an emergency action plan for immediate action in the event of a potential dam failure. The emergency action plan shall follow the format provided by the state engineer or a format that has prior approval of the state engineer. Because each site and operating practice is unique, waivers of specific requirements in this section will be considered on a case-by-case basis. Request for waiver shall be in writing accompanied with documentation justifying the request. If the request is not justified to the satisfaction of the state engineer the request will be denied. The front cover shall show the name of the dam (identical to the application), the county in which the dam is located and type of report. The pages immediately behind the front cover shall show the name of the dam (identical to the dam name on the application), the county in which the dam is located and signed certifications for the dam owner, engineer, state office of emergency management and state engineer in accordance with Subsections A, B, D and E of 19.25.12.12 NMAC. The dam owner shall coordinate with the local emergency management office in preparing the emergency action plan. The coordination is required to ensure that there is an agreement on responsibilities. The dam owner shall submit a copy to the state office of emergency management for acceptance prior to submittal to the state engineer. The dam owner shall review the emergency action plan annually, update as necessary and furnish a copy of updates to the state engineer, state office of emergency management and all copyholders. The dam owner shall exercise the emergency action plan to verify those involved in its implementation know their roles and responsibilities. It is recommended the dam owner conduct a functional exercise of the emergency action plan every 5 years with a table top exercise conducted 2 to 3 years before the functional exercise. The exercise may result in updates to ensure the emergency action plan maintains operational readiness, timeliness and responsiveness. Failure to act in accordance with the accepted emergency action plan that affects the safety of the dam will result in an order being issued requiring the dam owner to address the problem. Failure to comply with orders issued by the state engineer may result in the license to operate the dam being revoked and the dam being ordered breached in accordance with Subsection B or C of 19.25.12.19 NMAC. A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare engineering elements of the emergency action plan as specified below. An emergency action plan shall contain the following minimum elements:

A. Notification flowchart: A notification flowchart showing who is to be notified, by whom and in what priority.

B. Emergency detection, evaluation and classification: Procedures for reliably and timely identifying an emergency situation to ensure that an appropriate course of action is implemented. A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare this element.

C. Responsibilities: A list designating responsibilities for the emergency action plan related tasks including, but not limited to developing, maintaining, exercising, implementing, warning, evacuation and termination of the emergency.

D. Preparedness: A list of materials, equipment and manpower available to moderate or alleviate the effects of a dam failure or spillway release. A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare this element.

E. Inundation map: An inundation map delineating the areas that will be flooded as a result of dam failure. The dam breach analysis shall be prepared in accordance with Subparagraphs (a) through (g) of Paragraph (1) of Subsection C of 19.25.12.11 NMAC for the failure with the water level at the reservoir storage capacity and at the maximum water level during the spillway design flood event. If a dam is located upstream, failure scenarios with the upstream dam shall also be evaluated. Flood control dams that have not experienced a fill to the spillway crest shall prepare a failure scenario with the water level at the spillway crest. Flood inundation maps shall also be prepared for the maximum release without failure of the dam. Evaluation of the effects of flooding from dam failure shall extend at least to the location downstream where the flood no longer poses a threat to life or property. A

professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare this element.

F. Appendices: All information that supports and supplements the material used in the development and maintenance of the emergency action plan.

[19.25.12.18 NMAC - N, 3/31/2005]

19.25.12.19 CHANGES TO AN EXISTING DAM: A dam owner proposing to reconstruct, enlarge, modify, restore reservoir capacity, repair, remove or breach an existing dam must make application to and receive approval from the state engineer prior to undertaking any such action. The current condition of the dam, the type of repair or modification and the proposed means to achieve the repair or modification shall dictate the detail of the information provided to the state engineer in order to obtain approval. Because each site, design change and operating practice is unique, waivers of specific requirements in this section will be considered on a case-by-case basis. Request for waiver shall be in writing accompanied with documentation justifying the request. If the request is not justified to the satisfaction of the state engineer the request will be denied. Existing dams present the same hazards to life and property downstream as new dams. Therefore, owners of dams classified as high or significant hazard potential shall evaluate the current condition of the dam and address in the submittal to the state engineer whether the dam is in compliance with the design requirements in Subsection C of 19.25.12.11 NMAC. If the state engineer determines compliance with requirements in Subsection C of 19.25.12.11 NMAC are critical to the safety of the dam, the state engineer shall issue an order requiring the deficiency be addressed as part of the proposed change. Owners of dams classified as low hazard potential shall comply with the design requirements in Subsection C of 19.25.12.11 NMAC for the proposed change only. Maintenance activity performed in accordance with 19.25.12.17 NMAC does not require prior state engineer approval. Dam owners shall not abandon a dam without breaching or removing the dam to ensure the dam no longer poses a risk to life, property, the environment surrounding the dam or downstream of the dam. In the event of any changes of ownership affecting the title to a dam, the new owner shall file a change of ownership form for a dam with the state engineer. Recognition of the responsibility and liability associated with dam ownership is required along with fees for filing the change in ownership form for a dam in accordance with Subsection F of 19.25.12.8 NMAC. This section exempts federal dams if no change to the water storage permit is required. In general, the following minimum submittal is required to make changes to an existing dam:

A. Proposed changes to an existing dam: For dam owners proposing to reconstruct, enlarge, modify, restore reservoir capacity, or repair an existing dam, the following supporting documentation is required prior to undertaking any such action:

(1) An amended application if properties of the dam and appurtenant structures change. Fees for filing the amended application and for reviewing drawings and specifications shall be in accordance with Subsections A and B of 19.25.12.8 NMAC. Fees are waived if the state engineer requires the change to address a dam safety deficiency.

(2) Documentation of sufficient water rights if changes in storage or release requirements are proposed in accordance with the requirements of Subsection B of 19.25.12.11 NMAC.

(3) A design report addressing the proposed change in accordance with the requirements of Subsection C of 19.25.12.11 NMAC. Owners of dams classified as high or significant hazard potential shall submit a design report addressing whether the existing condition of the dam is in compliance with the design requirements listed in Subsection C of 19.25.12.11 NMAC. Where the existing condition of the dam is not in compliance with the design requirements of Subsection C of 19.25.12.11 NMAC, the design report shall propose changes to address compliance with the design requirements of Subsection C of 19.25.12.11 NMAC or request a waiver that the deficiency is not critical to the safety of the dam and provide adequate justification for the waiver.

(4) Construction drawings and specifications addressing the proposed change in accordance with the requirements of Subsections D and E of 19.25.12.11 NMAC.

(5) A plat of survey showing the dam owner's property boundaries, easement, or right of way. The plat of survey shall be in accordance with the requirements of Subsection F of 19.25.12.11 NMAC.

(6) For dams classified as high or significant hazard potential, a dam site security assessment in accordance with the requirements of Subsection G of 19.25.12.11 NMAC.

(7) For dams classified as high or significant hazard potential, an instrumentation plan in accordance with the requirements of Subsection H of 19.25.12.11 NMAC.

(8) For dams classified as high or significant hazard potential, an updated operation and maintenance manual and emergency action plan in accordance with the requirements of Sections 17 and 18 of 19.25.12 NMAC.

B. Removal or breach of dams classified as high or significant hazard potential: Dam owners intending to breach or remove a dam classified as high or significant hazard potential shall submit a plan to the state engineer for approval prior to breaching or removing the dam. The plan shall evaluate the potential effects of the dam removal or breach on life, property and the environment downstream. A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare the plan. The state engineer will revoke the license to operate a dam upon completion of all construction conditions. The plan shall meet the following conditions:

(1) The reservoir shall be emptied in a controlled manner, which will not endanger lives or damage property downstream.

(2) The dam or breach area shall be excavated down to the level of natural ground and the breach shall be of sufficient width to safely pass the 100-year, 24-hour flood.

(3) The side slopes of the breach shall be excavated to a stable angle.

(4) The breach shall be armored as necessary to prevent erosion of the breach area.

(5) The plan shall control sediment previously deposited in the reservoir.

(6) Drawings and specifications shall be prepared in accordance with the appropriate requirements listed in Subsections D and E of 19.25.12.11 NMAC and shall include a title sheet with required certifications and signatures, the location, dimensions and lowest elevation of the breach and any other detail to sufficiently describe the proposal.

(7) Designation of the professional engineer licensed in the state of New Mexico qualified in the design and construction of dams that will supervise construction of the breach or dam removal. Submittal of the professional engineer's qualifications for state engineer approval is required.

C. Removal or breach of dams classified as low hazard potential: Owners of dams classified as low hazard potential shall submit a written notice to the state engineer of intent to breach the dam. The state engineer will revoke the license to operate a dam upon completion of all construction conditions. The breach notice shall meet the following minimum requirements:

(1) The bottom width elevation of the breach shall be to original ground.

(2) The bottom width of the breach shall be a minimum of one-half the height of the dam but not less than 10 feet.

(3) The side slopes not steeper than one horizontal to one vertical.

(4) The excavated material shall not be placed in the streambed.

D. Closure of a tailings facility. A closure plan is prepared to address the closure of a tailings facility. State engineer approval is required before any modification occurs to a jurisdictional tailings dam. A professional engineer licensed in the state of New Mexico qualified in the design and construction of tailings dams shall prepare the closure plan, which shall include a design report, drawings and specifications prepared in accordance with the appropriate requirements listed in Subsections C, D and E of 19.25.12.11 NMAC. The state engineer will revoke the license to operate a dam upon completion of all construction conditions. The plan shall address the following issues:

(1) long-term stability under static and dynamic conditions;

(2) control of surface runoff to avoid erosion;

(3) plan for long term monitoring, if appropriate; and

(4) identification of an engineer licensed in the state of New Mexico qualified in tailings dam design and construction to supervise implementation of the closure plan. Submittal of the engineer's qualifications for state engineer approval is required.

E. Construction and operating conditions: After reviewing the required documentation, the state engineer will notify the dam owner if any deficiencies are found with the submittal. The dam owner will be given an opportunity to correct any deficiencies noted in the review process. Once all deficiencies have been addressed the state engineer will approve the amended application or proposed change with conditions under which construction and operation shall occur. Action by the state engineer will be in accordance with 19.25.12.13 NMAC, appropriately modified to address the proposed changes.

F. Proof of completion of works, certificate of construction and license to operate: Requirement for a proof of completion of works form for the dam, certificate of construction and license to operate a dam for changes to a dam shall be in accordance with the Sections 14, 15 and 16 of 19.25.12 NMAC, appropriately modified to address the proposed changes. If the dam is breached, the state engineer will cancel the permit and revoke the license to operate a dam.

[19.25.12.19 NMAC - N, 3/31/2005]

19.25.12.20 CHANGES TO AN EXISTING NON-JURISDICTIONAL DAM: A dam owner proposing to reconstruct, enlarge, or modify a non-jurisdictional dam, resulting in a jurisdictional dam after construction is completed, shall comply with 19.25.12.11 NMAC before construction begins. If the purpose of a non-jurisdictional dam changes, resulting in a jurisdictional dam, or if ownership changes, resulting in a jurisdictional dam, the owner shall comply with 19.25.12.11 NMAC. The state engineer will give the owner a reasonable amount of time to comply with 19.25.12.11 NMAC. If the owner fails to comply with 19.25.12.11 NMAC, the dam will be ordered breached in accordance with Subsection B or C of 19.25.12.19 NMAC.
[19.25.12.20 NMAC - N, 3/31/2005]

19.25.12.21 EXISTING DAMS: The state engineer inspects existing dams to verify dams are operated and maintained in a safe manner. Access to the dam site shall be made available to the state engineer upon request. If a critical dam safety problem is observed by the state engineer or reported to the state engineer, an order will be issued requiring the dam owner to address the problem. If a dam incident occurs at a dam, the dam owners shall report the incident to the state engineer within 72 hours. If a major repair is required at an existing dam, the plan to repair the dam shall be in accordance with 19.25.12.19 NMAC. Minor repairs not identified as maintenance activity in accordance with 19.25.12.17 NMAC require state engineer approval. Failure to comply with orders issued by the state engineer may result in the license to operate a dam being revoked and the dam ordered breached in accordance with Subsection B or C of 19.25.12.19 NMAC. Owners of existing dams shall comply with the following:

A. Owners acquiring property with a dam shall promptly notify the state engineer on a form provided by the state engineer of the change in ownership. Recognition of the responsibility and liability associated with dam ownership is required along with fees for filing the change in ownership form for a dam in accordance with Subsection F of 19.25.12.8 NMAC.

B. Owners of dams classified as low or significant hazard potential shall evaluate the hazard classification if downstream development occurs. The dam owner shall submit the results of the hazard potential evaluation prepared in accordance with Paragraph (1) of Subsection C of 19.25.12.11 NMAC to the state engineer for approval and a plan for addressing design deficiencies. If the hazard potential classification changes due to downstream development, the state engineer shall give the dam owner a time limit to address deficiencies. Deficiencies shall be addressed in accordance with Paragraphs (3), (12) and (13) of Subsection C of 19.25.12.11 NMAC and Sections 17 and 18 of 19.25.12 NMAC. If the dam owner fails to address a deficiency, the state engineer may revoke the license to operate the dam and order the dam breached in accordance with Subsection B or C of 19.25.12.19 NMAC.

C. Dams classified as high or significant hazard potential shall be inspected on an interval no greater than 5 years by a professional engineer licensed in the state of New Mexico qualified in the design and construction of dams. The owner is responsible for securing the services of the professional engineer. The professional engineer shall provide a signed and sealed report to the state engineer describing the findings of the inspection and recommendations for corrective action or changes to the operating procedures. Routine inspection by the state engineer as described in 19.25.12.21 NMAC satisfies this requirement.

D. Owners of dams classified as high or significant hazard potential in an unsafe condition may receive an order from the state engineer to address the deficiency pursuant to NMSA 1978, Section 72-5-11 (1979). The state engineer may also issue an order to an owner of a non-jurisdictional dam if the dam is unsafe and a threat to life or property, as determined by the state engineer. Owners shall comply with orders issued by the state engineer pursuant to NMSA 1978, Section 72-5-12 (1979).

E. Owners of dams classified as high or significant hazard potential shall comply with 19.25.12.17 NMAC requiring an operation and maintenance manual. Upon compliance with 19.25.12.17 NMAC the state engineer will issue a license to operate the dam. Dams classified as high hazard potential shall comply by December 31, 2008. Dams classified as significant hazard potential shall comply by December 31, 2010.

F. Owners of dams classified as high or significant hazard potential shall comply with 19.25.12.18 NMAC requiring an emergency action plan. Dams classified as high hazard potential shall comply by December 31, 2008 unless the dam is for flood control purposes with no permanent storage, then compliance by December 31, 2010 is required. Dams classified as significant hazard potential shall comply by December 31, 2010 unless the dam is for flood control purposes with no permanent storage, then compliance by December 31, 2012 is required. Owners of 5 or more dams classified as high or significant hazard potential may propose a schedule for compliance with the emergency action plan requirement. The schedule must be submitted by the owner to the state engineer by December 31, 2005 and is subject to review and approval or modification by the state engineer. The schedule must

propose compliance dates for each dam. The first dam must be in compliance by December 31, 2008 and at least an additional dam must be in compliance each year thereafter. All dams must be in compliance by December 31, 2015. Upon failure to meet an approved compliance schedule all dams will revert to compliance dates shown above.

G. Dam owners that transfer the entire water right out of the reservoir shall have their license to operate a dam revoked and may receive from the state engineer an order to breach the dam in accordance with Subsection B or C of 19.25.12.19 NMAC.

H. Dam owners that fail to obtain state engineer approval prior to construction of a dam shall comply with all conditions imposed by the state engineer within a time limit established by the state engineer or the state engineer may order the dam breached in accordance with Subsection B or C of 19.25.12.19 NMAC.

[19.25.12.21 NMAC - N, 3/31/2005]

19.25.12.22 SEVERABILITY: If any portion of this part is found to be invalid, the remaining portion of this part shall remain in force and not be affected.

[19.25.12.22 NMAC - N, 3/31/2005]

History of 19.25.12 NMAC: [RESERVED]

DRAFT COPY

Comments requested by December 13, 2002

DAM SAFETY
DESIGN AND OPERATION
CRITERIA



Eagle Nest Dam

NEW MEXICO
OFFICE OF THE STATE ENGINEER
2002

TABLE OF CONTENTS

1. INTRODUCTION 1
2. STATE ENGINEER'S JURISDICTION OVER DAMS 2
3. PERMITTING / ACCEPTANCE OF PLANS 3
   3.1. Application for Permit 4
   3.2. Design Report 5
      3.2.1. Hazard Potential Classification 6
      3.2.2. Hydrologic Analysis 7
         3.2.2.1. Spillway Design Flood 8
         3.2.2.2. 100-Year Frequency Storm 9
         3.2.2.3. Probable Maximum Flood and Probable Maximum Precipitation 9
         3.2.2.4. Inflow Design Flood (IDF) 10
         3.2.2.5. Incremental Increase in Damage 11
      3.2.3. Outlet Works Design 11
      3.2.3. Spillway Design 14
      3.2.4. Miscellaneous Design Issues 16
      3.2.5. Geotechnical Design 17
         3.2.5.1. Geological Assessment 17
         3.2.5.2. Geotechnical Investigation 17
         3.2.5.3. Seepage Analysis and Internal Drainage 19
         3.2.5.4. Stability Analysis 21
         3.2.5.5. Seismic Analysis and Design 22
         3.2.5.6. Dam Geometry and Freeboard 24
         3.2.5.7. Erosion Protection 26
         3.2.5.8. Geotextiles 27
   3.3. Construction Drawings and Specifications 28
   3.4. Easement and Access 28
   3.5. Designer's Operating Criteria and Instrumentation Plan 29
   3.6. Emergency Action Plan 29
4. CONSTRUCTION AND OPERATION APPROVAL 29

5. CERTIFICATE OF CONSTRUCTION 31
6. CHANGES TO THE APPROVED PERMIT 31
6.1. Removal or Breach of an Existing Dam 31
6.2. Permanent Closure of a Tailings Facility 33
7. OPERATION AND MAINTENANCE MANUAL 33
8. EMERGENCY ACTION PLAN 35
9. REFERENCES 37
APPENDIX A 39
GLOSSARY OF TERMS 41
APPENDIX B 53
DAM SAFETY STATUTUES 55
MANUAL OF RULES AND REGULATIONS GOVERNING THE APPROPRIATION AND USE OF THE SURFACE WATERS OF THE STATE OF NEW MEXICO 59
APPLICATION FOR PERMIT TO CONSTRUCT AND OPERATE A DAM, CHANGE OF OWNERSHIP OF A DAM, AND PROOF OF COMPLETION OF WORKS 81
APPENDIX C 93
SUBMITTAL REQUIREMENTS FOR AN APPLICATION TO CONSTRUCT AND OPERATE A DAM 93
APPENDIX D 99
OPERATION AND MAINTENANCE MANUAL 101
APPENDIX E 115
STANDARDIZED FORMAT AND TEXT FOR AN EMERGENCY ACTION PLAN 115

1. INTRODUCTION

The Dam Safety Design and Operation Criteria (Criteria) describes the State Engineer's authority over dams in the State of New Mexico. It addresses design criteria and filing requirements in order to obtain a permit for the construction of a dam. The Criteria also addresses the State Engineer's authority over the continued safe operation and maintenance of the dam, modification to the dam, abandonment of a dam or removal of a dam.

Dam owners and potential dam owners must recognize that impoundment of water entails risk, and the responsibility of constructing, operating and maintaining a safe dam rests with the owner. Because dam failures present the same consequence to life and property downstream, the standards for existing dams should be the same for new dams. Therefore, the Criteria are applicable to both new and existing dams.

The Criteria are intended to provide a minimum standard for dam design, operation and maintenance, with consideration given to current engineering practice and accumulated experience. The Criteria are not intended to be a textbook of dam design and construction, and are not a substitute for experience and sound judgment on the part of the design engineer. Compliance with the Criteria will not guarantee a safe structure or prevent failure. However, competent design by engineers experienced in dams and in compliance with the Criteria and current engineering practices, followed by careful construction, safe operation and diligent maintenance, can substantially reduce the risk of failure.

The State Engineer recognizes that certain requirements contained in the Criteria may be mitigated by site conditions, operating practices, design details, and other factors specific to the dam in question. In these cases, requirements can often be modified or waived. However, modification or waiver of requirements will only be considered when requested in writing by the responsible engineer and supported with adequate

documentation justifying the waiver. The request and justification will be evaluated by the State Engineer and accepted or rejected on its merits. Deviations from the Criteria that are not accompanied by a written request and justification will not be accepted. The State Engineer will be the ultimate authority for acceptance or rejection of the design, requests for waiver or modification of requirements.

The Criteria primarily address design and construction of earth embankment dams, as this is the predominant type of dam currently submitted for State Engineer review. Other types of jurisdictional dams, such as concrete arch, gravity, and buttress dams, roller compacted concrete dams, soil-cement dams, rockfill dams, etc. are occasionally constructed. While many elements of the Criteria will apply to these structures, dams constructed using these methods would also be expected to conform to sound engineering principles and current state of the practice for the proposed type of dam. It is recommended that owners and engineers considering dam types other than earth embankment dams confer with State Engineer dam safety personnel regarding appropriate design standards before executing the design.

Appendices in this publication provide additional information related to the Criteria. A Glossary of Terms used in the Criteria is listed in Appendix A and was derived from the Federal Emergency Management Agency's (FEMA) Glossary of Terms for Dam Safety[1].

2. STATE ENGINEER'S JURISDICTION OVER DAMS

The State Engineer is charged with approving permits for all dams in the state with a few exceptions. Dams that store less than or equal to 10 acre-feet of water and are less than or equal to 10 feet in height from the lowest point on the downstream toe to the top of the dam do not require a permit for the dam; however, a permit to store water is required regardless of storage or height if the dam was constructed after June 20, 1997. Flood control and sediment control dams supervised by the U.S. Army Corps of Engineers (COE) do not require a permit before construction; however, if the dam is transferred to an owner other than the COE, the new owner must obtain a permit. Stock dams and erosion control dams storing less than or equal to 10 acre-feet are also

exempt from obtaining a permit for the dam, however, a Water Right permit may still be required. If the purposes of the stock or erosion control dam changes, then a dam permit shall be required. If the owner is unable to comply with the conditions to obtain a permit, an order to breach the dam will be issued by the State Engineer. The State Engineer's permitting authority over dams is contained in Section 72-5-32, NMSA 1978 and the Manual of Rules and Regulations Governing the Appropriation and Use of the Surface Waters of the State of New Mexico (Rules and Regulations). The State Engineer's authority over construction is contained in Section 72-5-9, NMSA 1978. The dam safety statutes, rules and regulations related to dams and application for permit is contained in Appendix B.

A dam is a potential hazard to life and property downstream if the dam were to fail or operate while storing water. Because of this hazard, dam safety is regulated by almost all states in the country. The Office of the State Engineer Dam Safety Bureau administers the New Mexico Dam Safety Program. The State Engineer's authority over unsafe non-federal dams is defined in Section 72-5-11 through and 72-5-12, NMSA 1978. Bureau staff inspects existing non-federal dams to verify the dams are operated and maintained in a safe manner. Operation and Maintenance (O&M) Manuals are required for High and Significant Hazard potential dams to ensure the continued safe performance of the dam. Emergency Action Plans (EAP) are required for High and Significant Hazard potential dams to ensure a plan of action is available in the event of an emergency. Dam owners are responsible for the preparation of the O&M Manual and EAP.

3. PERMITTING / ACCEPTANCE OF PLANS

Any activity related to the safety of dams that are within the jurisdiction of the State Engineer require a permit or approval from the State Engineer before any construction begins. Activities that commonly fall within this category include the following:

- Construction of a new dam;
- Reconstruction of an existing dam;
- Enlargement of an existing dam;

- Modification or alteration of an existing dam;
- Repair of an existing dam;
- Removal of an existing dam;
- Abandonment of an existing dam;
- Operation and maintenance of an existing non-federal dam;
- Impoundment of water; and
- Change of ownership.

3.1. Application for Permit

Prior to initiation of construction for a new dam, reconstruction of an existing dam, enlargement of an existing dam or modification of an existing dam a permit or amended permit from the State Engineer is required. In order for the State Engineer to act on an application for permit, the following minimum items are required.

1. Application for Permit to Construct and Operate a Dam shall be submitted to the State Engineer in triplicate with original signatures by the Dam Owner on each copy. Fees for filing the application and reviewing the plans and specifications are $10 application fee and $2 per $1000 or fraction thereof of the estimated construction cost. Fees for reviewing plans are waived when the State Engineer requires plans to address a dam safety deficiency.

2. Water Right Permit shall be submitted for water impounded by the dam. The permit shall address the recommended fill rate that will satisfy downstream release requirements. A pending Application for a Water Right Permit does not meet this requirement. If the applicant has a permit for the diversion of water, a letter from the Water Rights Division is needed addressing storage and release conditions for the reservoir. This requirement is waived for flood control dams that adhere to the Flood Control Dam Detention Time policy or provide documentation that an exception by the State Engineer has been granted.

3. The Design Report shall be prepared by a Professional Engineer registered in New Mexico and experienced in the design and construction of dams. The Design Report shall address:

    a) Hazard Potential Classification;
    b) Hydrologic Analysis;
    c) Outlet Works Design;
    d) Spillway Design; and
    e) Geotechnical Design;

4. Construction drawings and specifications shall be prepared in accordance with the filing requirements in the Rules and Regulations. A professional engineer registered in New Mexico and experienced in the design and construction of dams shall prepare the construction drawings and specifications.

5. Flood and Maintenance Right-of-Way certification from the owner is required. Supporting documentation that a permanent easement has been obtained for the reservoir inundation zone, reservoir and spillway releases and adequate easement for operation and maintenance of the dam and appurtenances shall accompany the certification. A map with certification showing the Right-of-Way boundaries shall be provided with the construction drawings.

6. Designer's Operating Criteria (DOC), if required, for inclusion in the Operation and Maintenance (O&M) Manual shall accompany the application. The O&M Manual shall be required on or before completion of construction.

7. Instrumentation Plan, if required, for inclusion in the O&M Manual shall accompany the application.

8. Draft copy of Emergency Action Plan and Final Dambreak Analysis and Flood Inundation Maps, if required, shall accompany the application. The Final EAP shall be required on or before completion of construction. The State Office of Emergency Management shall approve the EAP before being submitted to the State Engineer for approval.

Checklist addressing submittal requirements is provided in Appendix C.

3.2. Design Report

A Design Report shall be submitted with construction drawings and specifications. The Design Report shall include a description of the project, purpose of the dam, ownership of the dam and address the hazard potential classification, hydrologic design, spillway and outlet conduit design, structural design, geotechnical design and any other information needed to support the design of the dam. A professional engineer registered in New Mexico with experience in dam design and construction shall prepare and stamp the Design Report. The Design Report shall address compliance with all applicable State and Federal rules and regulations.

3.2.1. Hazard Potential Classification

The Hazard Potential Classification shall be indicated on the application form and on the first sheet of the construction drawings. The State Engineer has adopted the Hazard Potential Classification[2] published by FEMA. These classifications take environmental consequences into account and restrict dams having a low hazard potential classification to primarily harming the dam owner's property. The hazard potential is not a reflection of the condition of the dam itself, but rather an indication of the damage if a dam failure should occur. The Hazard Potential Classifications are shown in Table 1.

The hazard potential classification assigned to a dam shall be based on the worst-case failure conditions. In other words, the classification is based on failure consequences resulting from the failure condition that will result in the greatest potential for loss of life and property damage. In most cases, the worst-case condition occurs if the dam were to fail during an extreme flood event.

Table 1

Hazard Potential Classifications

Low	Dams assigned the low hazard potential classification are those dams where failure or misoperation results in no probable loss of life and low economic and/or environmental losses. Losses are principally limited to the owner's property.
Significant	Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifelines facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
High	Dams assigned the high hazard potential classification are those dams where failure or misoperation will probably cause loss of human life.

In situations where the hazard potential is obvious, the classification may be based on engineering judgment provided the State Engineer concurs with the selected classification. For the remaining situations the hazard potential classification shall be based on dambreak/inundation studies. Dambreak studies shall assume a “sunny day” as the initial failure scenario. If other than a high hazard potential is valid for the “sunny day” assumption then the loading condition is increased to a probable maximum flood (PMF) with failure. If the dam break plus the PMF results in a higher hazard potential classification, determining the incremental effects of a dambreak flood and inflow flood becomes necessary. The Bureau of Reclamation (USBR)[3] provides guidelines and criteria for identifying downstream hazards and evaluating the incremental effects of dam failure.

When evaluating the potential for loss of life from a dam failure, the presence of facilities that would attract people on a temporary basis (e.g., public facilities, improved campgrounds, recreation areas, State or National Parks) requires special consideration. The type of flow conditions from the flood wave such as flow velocity, flow depth, debris flow and terrain conditions may increase the potential for loss of life and need to be considered in temporary occupied areas.

The hazard potential classification determines the level of engineering analysis, the criteria that are applicable and the inspection frequency by the State Engineer. The hazard potential of a dam can change due to downstream development. Therefore, the likelihood of future downstream development must be considered when determining the hazard potential classification of a dam, and the hazard potential for low and significant hazard potential dams must periodically be reevaluated to ensure public safety if downstream conditions change.

3.2.2. Hydrologic Analysis

When designing a dam, consideration of how the dam will perform under flood conditions must be evaluated. The hydrologic analysis will produce a design storm volume and peak runoff that the dam must safely pass or impound without failure of the

structure. The hydrologic analysis shall include a detailed study of the watershed draining into the dam and design storm characteristics. All parameters and assumptions used in the analysis shall be summarized in a table and justified in the hydrologic report. Appropriate data sheets and computer program output computations from the computerized analysis shall be provided. A plot of the inflow and outflow hydrographs shall be shown on the same figure in the hydrologic report. The outflow hydrograph shall be extended until discharge is negligible. The time of peak reservoir storage shall be shown on the outflow hydrograph for flood control dams in order to determine the time to drain the reservoir.

3.2.2.1. Spillway Design Flood

The State Engineer has adopted spillway design standards that focus on ensuring public safety; therefore, the capacity of a spillway shall be based on the hazard potential and size of a dam, or based on an incremental damage assessment. A summary of the Size Classifications and Spillway Design Flood (SDF) criteria are shown in Table 2 and 3, respectively. A dam must be less than or equal to both the height and storage criteria to qualify for the size classification. A spillway stage/discharge curve or table to the top of dam shall be provided. The SDF shall also be used for determining the maximum height of the dam, freeboard and flood storage requirements.

Table 2

Size Classifications

Size	Height (Feet)	Storage (Acre-feet)
Small	> 10 and ≤ 40	> 10 and ≤ 1000
Intermediate	> 40 and ≤ 100	> 1000 and ≤ 50,000
Large	> 100	> 50,000

Table 3

Spillway Design Flood

Hazard	Size	Spillway Design Flood
High	All Sizes	PMF
Significant	Small	0.5 PMF
	Intermediate	0.5 PMF
	Large	0.75 PMF
Low	All Sizes	100-Year (Expressed as a percentage of the PMF)

At the discretion of the State Engineer, a SDF less than the standard shown in Table 3 may be acceptable if the SDF is based on an incremental damage assessment. FEMA has published guidelines for selecting an Inflow Design Flood (IDF)[4], which provides procedures to determine the appropriate design flood based on incremental damage assessment. Additional discussion is also contained in Subsections 3.2.2.4 and 3.2.2.5

3.2.2.2. 100-Year Frequency Storm

Low hazard potential dams by definition have minimal impact on property or no probable loss of life downstream; therefore the spillway shall have the minimum capacity to safely pass the 100-year flood event. The 100-year flood event shall be estimated from the 100-year precipitation[5] and the peak discharge from the 100-year event shall be expressed as a percentage of the peak discharge from the PMF hydrograph. Where adequate flood records are available for the drainage area above the dam, a flood flow frequency analysis should be performed to evaluate the model results.

3.2.2.3. Probable Maximum Flood and Probable Maximum Precipitation

The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are

reasonably possible in the drainage basin under study. The Probable Maximum Precipitation (PMP) shall be used to determine the PMF and average conditions for the watershed may be assumed for the PMF analysis. Hydrometeorological Reports (HMR)[6, 7] provide regionalized estimates for the PMP. The HMRs provide step-by-step procedures for computing the local and general storm PMP. These procedures should be addressed in the design report. The PMP derived from both local and general storm will have to be individually evaluated in the PMF analysis and the more critical flood used in the design. The spatial and temporal distribution for the design storm shall be documented. When the volume of the runoff hydrograph is an important consideration (i.e. retention and detention ponds), the duration of the rainfall must extend for a period long enough to include all rainfall excess. The State Engineer may accept a detailed site-specific hydrometeorologic analysis if adequate justification is provided.

3.2.2.4. Inflow Design Flood (IDF)

The IDF is the flood flow above which the incremental increase in water surface elevation downstream due to failure of a dam is no longer considered to present an "unacceptable additional downstream threat". The upper limit of the IDF is the PMF. The lower limit of the IDF is the 100-year frequency event. The peak discharge from the IDF shall be expressed as a percentage of the peak discharge from the PMF hydrograph.

The degree of study required to sufficiently define the impacts of dam failure for selecting an appropriate IDF will vary with the extent of existing and potential downstream development, the size of the reservoir (depth and storage volume), and type of dam. Evaluation of the river reach and areas impacted by a dam failure should proceed until sufficient information is generated to reach a sound decision or until there is a good understanding of the consequences of failure. Evaluation of the consequences of dam failure must be based on the dam being in place, and must compare the impacts of with-failure and without-failure conditions on existing development and known and prospective future development. The consequences of dam failure must be defined in order to evaluate whether a dam failure causes an

"unacceptable additional downstream threat". In most cases, detailed studies, including dambreak analyses, will be required to fully evaluate the consequences of dam failure.

When preparing dambreak studies, the water surface profiles with and without dam failure, the flood wave travel times, and rates of rise should be determined for each flood flow condition. Dambreak studies require selection of the size, shape and time of formation of the breach as input parameters for the computations; therefore, sensitivity analyses are considered necessary as well as documentation of the methodology for selecting breach parameters.

3.2.2.5. Incremental Increase in Damage

Methods of assessing the incremental increase in damage vary from examining individual structures to applying general criteria. The Federal Energy and Regulatory Commission (FERC)[8] have criteria where an incremental increase in flood level of 2 feet or less is not judged to pose a significant increase in the hazard. The USBR[3] has guidelines for assessing the hazards posed by floods. The application of general criteria for evaluating incremental damage will be reviewed on a case-by-case basis.

3.2.3. Outlet Works Design

Outlet conduits shall be sized to provide the capacity to satisfy water rights of downstream priority users and meet owner's release requirements and shall be a minimum of 18-inches in diameter. The 18-inch minimum diameter may be waived if documentation is provided supporting that the inspection of the interior of the conduit can be performed in accordance with Section 7. The conduit design shall address the required operation and maintenance items in Section 7.

Metal conduits may be used in low hazard dams and in significant hazard flood control dams with no permanent storage, provided they are designed to possess adequate strength after corrosion for a minimum period of 200 years, based on corrosivity testing (e.g. resistivity and pH) of onsite soils. Cathodic or other protection of metal conduits is permissible to obtain this value. Metal conduits will not be accepted for other dams

except as an interior form for cast-in-place reinforced concrete conduits, in which case no structural contribution for the metal conduit shall be considered in the design.

All dams shall be provided with a low–level outlet positioned in such a manner that the entire contents of the reservoir above the lowest point of the embankment can be efficiently drained. If environmental consequences prevent draining, a waiver shall be submitted fully justifying the waiver. Outlets for water storage reservoirs shall be capable of evacuating the reservoir contents in less than 45 days, unless a waiver supported by justification acceptable to the State Engineer is granted. The design report shall justify the size selected and shall provide an inspection, maintenance and emergency evacuation plan including documentation of technology to be used.

Outlet conduits for storage reservoirs shall be gated at the upstream end unless exception is granted by the State Engineer. At a minimum, outlet gate valves in earth dams should be located upstream of low permeability core materials and within the upstream third of the dam. Where gates are located other than at the upstream end of the conduit, a guard gate or bulkhead shall be provided at the upstream end to allow draining of the conduit for inspection, maintenance and repair. Pressurized conduits through the dam are discouraged. The conduit downstream of the gate or valve shall be adequately vented. Where the outlet conduit discharges directly to a downstream pipe, a bypass valve shall be provided.

Outlet gate operators and equipment shall be properly designed to be secure from damage due to vandalism, weather, ice, floating debris, wave action, embankment settlement, and other reasonably foreseeable causes. Outlets shall be secure from unauthorized operation. Direction of operation for outlet controls must be clearly marked to minimize the possibility of overstressing and damage to the mechanism by operating in other than the intended direction. Outlet controls must remain accessible during outlet works and spillway releases.

Outlets for flood control structures shall be ungated. Where a gate is required to satisfy downstream release restrictions, a waiver from the Water Rights Division is required. The waiver shall include justification for the request and an operating plan for eventual release of floodwater and exercise and maintenance of the gate. Gated flood control dams must meet design requirements for water storage dams. No dead storage shall be allowed unless a separate permit to store water is provided. The outlet conduit for Flood Control Dams shall be sized to adhere to the Detention Time Policy. The 96-hour time frame begins once the reservoir storage reaches its peak during any inflow event including the Spillway Design Flood (SDF). If the design does not meet the 96-hour requirement, an exception from the Water Rights Division is required. If an exception to the Flood Control Dam Detention Time regulation is requested, documentation estimating the time to drain less frequent events, such as the 2-year, 5-year, 10-year and 100-year, should be submitted to the Water Rights Division in support of the request.

Outlet works intake must be provided with trash racks or grates to prevent clogging with debris. Openings in trash racks or grates shall be sized to pass small debris without clogging the grate, but collect large debris that would potentially clog the outlet conduit. Grate opening size or bar spacing shall be adequate to satisfy applicable public safety requirements, if appropriate. Total size of grate openings must be at least three times the cross-sectional area of the outlet conduit. Where the intake requires discharge over a weir, the need for aeration of the nappe shall be evaluated. The design of the outlet structure shall address energy dissipation to prevent erosion with supporting calculations provided.

Outlet conduits shall be designed for full embankment loading and for hydrostatic pressure equal to the maximum reservoir head, acting separately and in combination, with an adequate factor of safety. If future increases in embankment height and/or reservoir head are foreseeable, allowance shall be made in the design. The conduit together with all joints and fittings shall be watertight at the design pressure, and shall be pressure tested prior to backfilling. Conduits shall be designed for all reasonably

foreseeable adverse conditions including corrosion, abrasion, cavitation, embankment settlement and spreading, thermal effects, and seismic loading. The required joint extensibility shall be addressed in the design of outlet conduits.

Outlet works must be supported by stable, well-consolidated foundation materials. Where the conduit is placed in embankment fill or native overburden materials, settlement analysis should be performed and consideration given to articulated design. The outlet works design shall address prevention of seepage along conduits. Typical methods for seepage control include concrete or grout encasement and filter diaphragms with drains. Past practices have allowed cutoff collars; however, cutoff collars are seldom effective in controlling seepage and may apply unwanted stresses to the conduit. For these reasons, use of cutoff collars is discouraged. Regardless of the method used for seepage control, methods for compaction of backfill around and beneath the conduit must be addressed.

The design report shall include all supporting documentation and calculations for the outlet works design. The outlet works design shall include all foreseeable loading conditions, including but not limited to ice loading, debris buildup, wave action and embankment settlement. Structural design calculations for the intake structure, conduit and outlet structure shall be submitted in the design report. A stage/discharge curve or table to the top of dam for the outlet works shall be provided in the Design Report.

3.2.3. Spillway Design

Spillways should be located in natural ground and not on the embankment if possible. Unprotected earth or vegetated earth spillways will be accepted for low hazard structures only. Spillways excavated in rock or weathered rock will be evaluated on an individual basis. Unprotected spillways should be provided with a check structure at the crest to minimize the possibility for headcutting. Where control weirs are used at the spillway crest, aeration of the nappe for cavitation control must be addressed. Where a potential exists for accumulation of large floating debris that could block the spillway, the use of log booms or other debris control features should be a design element.

The spillway must discharge away from the toe of the dam and abutment slopes. Where training dikes are used to divert the water away from the dam, the dike shall be designed with adequate compaction and erosion protection. Energy dissipation shall be addressed to allow spillway discharge to be released to the natural channel without destructive erosion.

The material required for spillway lining will depend on the spillway location and frequency of discharge. Design analysis shall address these factors and provide adequate justification for the material selected. Table 4 may be used as a general guideline for selecting spillway lining materials.

Table 4

Guidelines for Spillway Lining

Spillway Lining	**Allowable Frequency of Discharge, Open Channel Spillways**	
	Spillway in Native Ground	**Spillway on Embankment**
Concrete	Continuous	2 years
Soil Cement	1 year	5 years
Grouted Riprap	2 years	10 years
Wire-enclosed Riprap	2 years	10 years
Riprap	5 years	25 years
Unweathered Bedrock	5 years	N/A
Weathered Bedrock	10 years[1]	N/A
Vegetated Earth	25 years[1, 2]	Not Permitted
Bare Earth	50 years[1, 2]	Not Permitted

1. Concrete check structure required at spillway crest.
2. For low-hazard structures only.

Channel lining must be placed on a suitably prepared, stable subgrade. All edges and joints in channel lining material must be designed to prevent undermining and erosion. Concrete channel lining must be provided with adequate jointing to permit thermal expansion and contraction, and adequate reinforcing to control thermal cracking. Adequate water stops are required at joints in the spillway lining. Concrete lining shall be adequately anchored against displacement and uplift, and shall be provided with adequate subdrainage to relieve hydrostatic pressures and prevent frost heave.

3.2.4. Miscellaneous Design Issues

Retaining walls associated with dams and appurtenances shall be designed for full at-rest earth pressure rather than active earth pressure. Where earth fill will be placed against vertical concrete surfaces, the surfaces shall be battered from vertical at least 1 horizontal to 10 vertical to facilitate compaction of fill. Hydrostatic pressure at retaining walls shall be addressed in the design. To the extent practical, the design should be such that self-propelled mechanical compaction equipment can be used effectively, and areas requiring hand-operated compacting equipment should be minimized or if possible eliminated.

The structural design information for all appurtenances, addressing water, earth, ice and any other applicable load shall be included in the Design Report. Reinforced concrete design including assumptions for loads and limiting stresses and sample calculations shall be provided.

Underground utilities located in the vicinity of the proposed embankment footprint shall be relocated and trenches backfilled and compacted with suitable material to the satisfaction of the State Engineer. If utilities are allowed to remain, they will be required to satisfy standards for outlet conduits. Since typical utility bedding, backfill, etc., does not meet these standards, these utilities will require reconstruction in most cases.

3.2.5. Geotechnical Design

When locating and designing a dam, a detailed geotechnical design must be submitted with the design report. The geotechnical design shall include a geological assessment, geotechnical investigation including a field investigation and laboratory testing of soil samples, seepage analysis, seismic analysis and design addressing potential for liquefaction, and recommended geometry of the dam.

3.2.5.1. Geological Assessment

A geological assessment of the dam and reservoir site is required for all high and significant hazard dams. The geological assessment may be included in the geotechnical investigation report or seismic study, or may be submitted as a separate document. The geological assessment shall be based on available literature and mapping, aerial photography interpretation, unpublished reports and data, site reconnaissance, and other sources as available and appropriate. At a minimum, the geological assessment shall address regional geologic setting, local and site geology, geologic suitability of the dam foundation, slide potential of reservoir rim and abutment areas, and seismic history and potential unless covered in a separate seismicity study.

3.2.5.2. Geotechnical Investigation

A geotechnical investigation is required for all dams meeting jurisdictional requirements regardless of hazard classification. Scope of the study will depend on a variety of factors including size, hazard classification, anticipated materials and construction methods of the dam, site geology and seismicity, anticipated soil strata, etc., and may be modified during the course of the investigation due to materials and conditions encountered. The investigation must adequately assess site conditions and support the design. The exact scope of the investigation should be determined by the geotechnical engineer. If in the judgment of the State Engineer the geotechnical investigation is not adequate for the structure in question, additional work will be required.

Typically, the geotechnical investigation shall include, but not be limited to, the following elements:

Field Investigation:

1. Test borings in the footprint of the proposed embankment, spillway excavations and appurtenances to the dam, extending to bedrock or to a depth equal to at least the height of the dam. Where appropriate, borings may include coring of bedrock materials to determine the quality and character of the rock.
2. Supplemental test borings to determine soil characteristics in borrow and cut areas, spillway excavations and beneath appurtenances to the dam, etc.
3. Standard penetration tests or other field testing to assess soil character and consistency.
4. “Undisturbed” sampling for further tests such as insitu density, shear strength, and compressibility.
5. Supplemental test pits to obtain bulk and undisturbed samples, assess soil layering, measure bedrock orientation, etc. as required.
6. Measurement of water level in drill holes.
7. Field permeability testing, if feasible.
8. Logs of test borings and test pits, location map, and profile along dam axis with soil information shown.

Laboratory Testing:

1. Classification testing (gradation and plasticity characteristics) and classification according to the Unified Soil Classification System.
2. Laboratory determination of insitu density and moisture content.
3. Shear strength testing of embankment and foundation materials.
4. Laboratory permeability testing.
5. Volume change testing (consolidation, expansion, collapse, etc.).
6. Proctor tests for potential embankment materials.
7. Test for dispersive clays.
8. Gradations for potential filter and drain materials if appropriate.
9. Evaluation of liquefaction potential, and dynamic shear strength testing if deformation analysis is required.

The investigation should identify the location of sufficient borrow material to construct the dam as designed. Sufficient testing should be done to determine or estimate relevant properties of each zone or layer of the embankment and foundation, including but not limited to shear strength, permeability, compressibility, and filter characteristics.

Shear strength testing shall be selected to be appropriate for the material being tested and to provide appropriate parameters for the intended analysis. Most commonly, triaxial testing is performed on clays, and direct shear testing is performed on nonplastic materials. Effective stress parameters for clayey soils, when required, can be

determined from consolidated-undrained triaxial testing with pore pressure measurements to permit calculation of drained parameters. In the event that the direct shear test is used to determine effective stress parameters of clayey soils, supporting documentation must be provided to assure that specimens are saturated during testing, that strain rates are adequate to allow drainage to occur, and that excessive consolidation is not induced during shearing.

Results of field investigations and laboratory testing shall be presented in a formal report, including recommended parameters to be used in design and other pertinent information or recommendations for design and construction of the dam and appurtenances. The geotechnical investigation report may be included as part of the design report or as a separate document.

3.2.5.3. Seepage Analysis and Internal Drainage

The effects of seepage and internal drainage and the potential for internal erosion shall be evaluated for all structures. For significant and high hazard structures, a seepage analysis shall be performed to address the performance of the embankment under steady-state conditions.

The seepage analysis requirement may be waived for flood control dams with ungated outlets that satisfy the 96-hour drainage requirement, provided a written request for the waiver is made, accompanied by supporting justification. However, the geotechnical investigation, engineering analysis, design details, and construction techniques must be adequate to ensure that these dams will not have high-permeability layers that serve as a conduit for seepage water. In some cases, low-permeability cutoff trenches or upstream blankets may be required. The seepage analysis requirement may also be waived for reservoirs having synthetic impermeable liners constructed on well-drained sites, provided a written request is made with supporting justification.

Seepage analysis may be performed with hand-drawn flow nets or with computer techniques. Permeabilities for this analysis should be determined by field and

laboratory tests where feasible; values derived from published sources or obtained from similar soils in the region may be accepted with adequate justification. The effects of anisotropy with respect to permeability must be addressed, particularly the ratio of vertical to horizontal permeability of a given soil material. Ratios of horizontal to vertical permeability of less than four for constructed embankments and less than nine for native deposits will not be accepted unless supported by permeability test data acceptable to the State Engineer.

The design shall address the effects of anticipated seepage beneath and around the dam. Where practical, a cutoff trench integral with the core zone extending through permeable deposits and into low permeability bedrock should be provided. Where permeable foundation deposits are too deep for a cutoff trench to be practical, other cutoff options such as slurry walls and grout curtains may be considered. Partial cutoffs are often ineffective and generally should be avoided. Where complete cutoff is not practical or economically feasible, possible solutions include upstream impermeable blankets, extended downstream embankment zones, downstream horizontal drainage blankets, toe drains, drainage curtains, and re-siting the dam.

The dam shall be designed so that seepage does not exit on the face of the dam and excessive exit gradients are avoided. Embankment zoning and/or internal drainage may be necessary in order to control seepage. All adjacent material zones in the dam and foundation shall satisfy filter criteria acceptable to the State Engineer. The State Engineer has previously accepted filter criteria used by the Natural Resource Conservation Service (NRCS)[9], the U.S. Army Corps of Engineers (COE)[10, 11], and the USBR[12]. Other criteria will be reviewed for acceptability on a case-by-case basis. Where materials do not meet filter criteria with respect to one another, transition zones meeting the filter criteria will be necessary. All filter, transition, and drainage zones within earth dams shall have a thickness adequate to address constructability and enhance seismic stability, with a minimum thickness of 3 feet for each zone. Clay core zones shall extend above the anticipated phreatic surface a sufficient distance that water will not be lifted above the core by capillary rise in the adjacent material zones.

Collector pipes and conduits for internal drains shall be made of non-corrodible material capable of withstanding the anticipated loads. Insofar as possible, pipes should be located where they can be exposed for repair or replacement without threatening the stability of the dam. Collector pipes for drains shall be enveloped in a free-draining medium meeting filter criteria for adjacent embankment or foundation zones. Pipe perforation size (e.g. hole diameter or slot width) depends on the surrounding medium and condition of use. Where surging or gradient reversal is likely, perforation size must be less than the D_{15} of the surrounding medium. Where surging and gradient reversal are unlikely, the perforation size must be less than D_{85} of the surrounding medium.

Drain pipes should be sized to provide a flow depth no more than ¼ of the pipe diameter when carrying the anticipated discharge. Drain pipes must be at least 6 inches in diameter unless the availability of technology for inspection and maintenance can be demonstrated. Individual pipes must discharge to a gallery, well, manhole, or to daylight such that the flow of each pipe can be monitored. Manifold connections, tees, and wyes will not be permitted. If the anticipated flow from a drain line exceeds 10 gpm, a measuring flume or weir shall be provided for that line. If the anticipated flow from a drain line is less than 10 gpm, the outfall shall be designed to allow a 5-gallon bucket to be used to collect and measure discharge. Where pipes from internal drains are discharged to daylight, a rodent screen shall be provided.

3.2.5.4. Stability Analysis

Cross-sectional design for dams shall be supported by adequate slope stability analysis. The analysis model shall adequately represent the geometry and zoning, shear strength parameters, material unit weights, pore pressure and seepage conditions, external loading, and other relevant factors of the critical cross section or sections. Computer-assisted limit-equilibrium analyses with automated search routines are typical and preferred. Manual computations will be accepted if judged to be sufficiently rigorous. Chart solutions and infinite slope analysis may be accepted in certain cases, with justification and supporting documentation that the solution is applicable to the problem

and the results are conservative. Where appropriate, the analysis shall consider noncircular or block and wedge type failure surfaces as well as circular failures.

All parameters and assumptions used in the analysis shall be summarized in a table and justified in the geotechnical investigation. A scale drawing, utilizing the same scale for vertical and horizontal dimensions, shall be provided for each cross-sectional model used in the analysis, with the critical failure surface(s) identified. Appropriate data sheets and computer program output computations from computerized analysis shall be provided.

Dams shall be designed to provide the following minimum factors of safety from the stability analysis:

- Steady state long-term stability 1.5
- Operational drawdown conditions 1.5
- Rapid Drawdown conditions 1.2
- End-of-construction 1.2

Low hazard dams with upstream slopes no steeper than 3 horizontal to 1 vertical and downstream slopes no steeper than 2 horizontal to 1 vertical and which are 25 feet or less in height will not require slope stability analysis.

3.2.5.5. Seismic Analysis and Design

All High and Significant hazard dams shall be analyzed for seismic stability. Seismic analysis may also be warranted for low hazard structures if a future change in hazard classification can be reasonably foreseen or if otherwise deemed necessary by the State Engineer. The level of effort required for seismic analysis will be unique for each dam depending on the type of dam, site geology and seismicity, embankment and foundation materials, dam and foundation geometry, construction methods used, consequences of failure, and other factors.

Seismic analysis for water storage dams should be based on full reservoir under steady state seepage conditions. Flood control dams with ungated outlets that satisfy the 96-hour release requirement should be designed for earthquake loads under full reservoir conditions, but need not consider steady-state seepage since it is unlikely to develop.

At a minimum, seismic analysis shall include the following steps:

1. A seismological investigation shall be made for the dam area and reservoir area, considering local and regional earthquake history, available technical literature, unpublished reports or data if available, geologic mapping, and field mapping and measuring of faults if appropriate, and other information deemed relevant by the investigator. This study may be part of the geological or geotechnical report for the structure, or may be a separate effort. The study shall determine and justify the appropriate seismic parameters to be used for design. High hazard dams other than flood control structures shall be designed for the Maximum Credible Earthquake (MCE) or for an earthquake with a 5000-year return frequency. For significant hazard dams and high hazard flood control dams, a 2% chance of occurrence in 50 years (approx. 2500 year return frequency) used in determining the design earthquake will be accepted.

2. An analysis of materials in the foundation, reservoir area, and proposed embankment shall be completed, to determine the potential for liquefaction, earthquake-induced sliding, or other seismic sensitivity. This is generally accomplished as part of the geotechnical investigation for the structure. However, if potentially liquefiable materials are encountered or anticipated, additional field and laboratory testing and engineering analysis may be warranted.

3. Pseudostatic analysis will be acceptable for the following cases:

    a. The embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D 698, or at least 90% of the maximum modified Proctor density, ASTM D 1557 (or at least 70% relative density if Proctor testing is not appropriate), no materials prone to liquefaction are present in the foundation, and peak bedrock acceleration is 0.20g or less; or

    b. The embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D 698, or at least 90% of the maximum modified Proctor density, ASTM D 1557, potentially submerged portions of the embankment except for internal drain elements are constructed of clayey material (classified as CL, CH, CL-ML, SC, or GC under

the Unified Soil Classification System), the dam is constructed on clayey soil or bedrock foundation, and peak bedrock acceleration is 0.35g or less; and

c. All safety factor requirements for static stability given in the Criteria are met; and

d. Minimum freeboard requirements of the Criteria are met.

The pseudostatic coefficient selected for analysis must be at least 50% of the predicted peak bedrock acceleration, but not less than 0.05g. Factor of safety under pseudostatic analysis shall be 1.1 or greater. In determining the factor of safety for pseudostatic analysis, a search for the critical failure surface shall be made, rather than simply applying pseudostatic coefficients to the failure surface from static analysis.

4. For dams not satisfying the requirements for pseudostatic analysis, a deformation analysis acceptable to the State Engineer will be required. The resulting embankment must be capable of withstanding the design earthquake without breaching and with at least 3 feet of freeboard remaining after deformation. The analysis shall also assess the potential for internal erosion as a result of cracking during deformation. Defensive design measures, such as treating or removing sensitive materials, flaring or widening cores and drainage zones, adjusting location of internal zones to minimize embankment saturation, providing additional freeboard, or adding outlet capacity to shorten reservoir drainage times should be considered for embankments in this category.

5. The seismic assessment shall also address the stability of appurtenances to the dam during the design earthquake as appropriate. However, if failure of an appurtenance due to earthquake does not represent an immediate threat to the dam, the Operating Basis Earthquake (OBE) may be used for this assessment.

Where possible, dams must not be sited on active faults. If this is unavoidable, the dam must be designed to withstand anticipated fault movement without compromise to its integrity.

3.2.5.6. Dam Geometry and Freeboard

Dam Crest - Crest width shall be at least h/5 + 8 feet, with the minimum permissible crest width being 10 feet and the maximum required crest width being 24 feet. Where access and maintenance roads are located on the crest, appropriate surfacing shall be placed to provide a stable base that resists rutting and provides adequate friction for safety in wet conditions. Crest design shall include adequate cover above clay cores to prevent cracking of the core due to desiccation or frost penetration. A minimum of 2 feet of cover is required above the core, with additional cover being required if

warranted by local conditions. Turnarounds should be provided on dead-end service roads on dam crests, located in such a manner that backing maneuvers longer than 300 feet are eliminated. The crest shall be provided with adequate cross slope to prevent ponding. The slope or slopes to which crest drainage is directed must be provided with adequate erosion protection to accept the crest drainage. The crest longitudinal profile shall be provided with adequate camber to maintain the profile after embankment settlement. Camber should be based on settlement analysis and shall be at least 2 percent of the total embankment height, with a minimum of 1 foot at the highest point of the dam. The tops of internal core zones shall also be provided with camber in a similar manner to the crest of the dam.

In the event that safety berms, street curbs, or other longitudinal features which block, control, or concentrate drainage are required on the dam crest, the design shall provide for collection and conveyance of accumulated water to discharge away from the embankment without erosion.

Freeboard Requirements - Dams shall be provided with adequate freeboard. Freeboard is defined as the vertical distance between the spillway crest and the lowest point of the top of the dam, without camber. Freeboard shall satisfy the following conditions:

- Anticipated wave runup resulting from a 100 mph wind with reservoir level at the spillway crest will not overtop the dam.
- Anticipated wave runup resulting from a 50 mph wind with maximum reservoir level from routed SDF will not overtop the dam.
- Clay core cover and capillary rise requirements are satisfied.
- A minimum of 3 feet of freeboard remains after seismic deformation.
- In any case, at least 4 feet of freeboard shall be provided.

Wave runup shall be determined taking into consideration wind speed, reservoir fetch, embankment slope, and roughness of the slope surface. Crest camber shall not be considered as part of available freeboard. The minimum of 4 feet of freeboard may be

waived for parameter embankments with no spillway, provided a written request is made with supporting justification.

3.2.5.7. Erosion Protection

The dam shall be protected against erosion. Erosion protection shall be extended onto abutments and toes of slopes a sufficient distance that erosion in these areas does not threaten the dam. Additionally, the dam owner is responsible for compliance with any applicable environmental laws and regulations concerning erosion and sediment control.

Wave Erosion Protection – The upstream slope of the dam shall be provided with armoring sufficient to protect against anticipated wave erosion. At a minimum, the armoring shall extend from the lowest operational water surface elevation to the highest anticipated wave runup elevation. Wave erosion protection materials typically include dumped riprap, soil-cement, hand-placed riprap, and concrete slope paving, in general order of preference. Selection of wave protection material is primarily based on economics. If riprap is used for armoring, it shall be placed on a properly designed filter bedding layer. Flood control structures that have ungated outlets and are designed to release their contents within 96 hours are exempted from the wave erosion protection requirement.

Surface Erosion Protection – Slopes and crest of earth dams, abutment and toe areas adjacent to dams, and any other constructed or graded slopes associated with the dam or appurtenances shall be protected from surface erosion. This may be accomplished with vegetative cover, gravel surfacing, slope paving, or other approved means. Where vegetative cover is used, a site-specific seed mixture shall be provided, with supporting documentation that the proposed vegetative cover will become established and survive under anticipated climate conditions. The seed mixture shall be free of woody vegetation types and potentially large brushy vegetation types. The dam design shall address methods of establishing and maintaining vegetation, including seeding season,

supplemental watering during establishment if necessary, future removal of undesirable vegetation, and management of burrowing rodents attracted to vegetation.

Dam safety inspections seem to indicate that a surface gravel or stone layer is much more effective than seed and mulch in preventing surface erosion in the arid portions of New Mexico. Angular crushed or quarried products, if available, stay in position and are more effective than rounded gravel, particularly where the material will be subject to foot or vehicle traffic. A heavy gravel layer also appears to be effective in discouraging small burrowing rodents, and may be adequate for relatively low volume concentrated flows, such as at abutment groins.

Erosion From Concentrated Flows – The design shall address erosion at locations where flows become concentrated, such as abutment groins, intersecting dikes, points of inflection of the embankment, areas behind spillway retaining walls, low points of crest roads, low ends of diversion berms, and bare slopes beneath paved areas. Possible solutions at these locations may include riprap, paved swales, heavy angular gravel, half-pipe sections, small check dams or grade stabilization structures, slope drains, etc.

3.2.5.8. Geotextiles

The acceptance of geotextiles by the State Engineer for dam design will be application-specific and will be determined for each design on a case-by-case basis. Geotextiles must be used in a manner consistent with the manufacturer's recommendations and intended use for the product. Geotextiles generally should only be used where failure of the geotextile would not cause a catastrophic release of the contents of the reservoir. Geotextiles should not be used at a location where their exposure for repair or replacement may jeopardize the stability of the dam or appurtenances.

Geotextiles and geosynthetic membranes used for impermeable liners of reservoirs, lagoons, and retention ponds shall be placed in accordance with the manufacturer's requirements, including certification of installation personnel if required. Liners either

must be certified by the manufacturer for long-term exposure to sunlight or must be covered with a suitable protective layer. Where the reservoir will be periodically or normally empty, the liner shall be adequately ballasted or anchored for stability in the wind. Ballast and anchoring material must be capable of withstanding sunlight and weather conditions; for example, where sandbags are used for ballast, the bag material must be resistant to degradation from sunlight exposure. Joints or seams between liner panels and anchorage details at edges must be in compliance with manufacturer recommendations. Penetrations in the liner such as at inlets and outlets must be designed and constructed to minimize leakage. Drainage zones or filter diaphragms may be an appropriate defense against damage caused by leakage at penetrations.

3.3. Construction Drawings and Specifications

Construction drawings and specifications shall be prepared in accordance with the requirements of the Rules and Regulations. Drawings shall be submitted with all appropriate review and application fees. A Professional Engineer licensed in New Mexico, with experience in the design and construction of dams, shall prepare the construction drawings and specifications. An as-built mylar drawing submittal is required at completion of construction. The State Engineer may waive mylar drawings during the review process and require mylar as-built drawings if a request is submitted in writing. In the event the requirement for mylar drawings is waived until submittal of as-built drawings, a mylar filing sheet will still be required as part of the permit application submittal.

3.4. Easement and Access

The owner shall obtain permanent right of way or easements to access the dam during normal operation and flood events; to impound water and safely discharge water; and to maintain the dam and appurtenances in a safe manner. Easements for returning spillway flows to the natural drainage are required. Urban dams have unique flood easement issues that will be evaluated on a case-by-case basis. A detailed map, with certifications, showing all right of way easements shall be provided with the construction drawings.

3.5. Designer's Operating Criteria and Instrumentation Plan

The Designer's Operating Criteria (DOC) is prepared by the design engineer to ensure the dam and appurtenances are operated within any restrictions imposed by the design. The Instrumentation Plan provides a means to monitor and evaluate the performance of a dam. The DOC and Instrumentation Plan are critical elements of the Operation and Maintenance (O&M) Manual, which shall be addressed in the design phase of the project for significant and high hazard potential dams. An O&M Manual is also required for all significant and high hazard potential dams. The O&M Manual shall conform to the requirements set forth in Section 7 and is required at completion of construction. The DOC and Instrumentation Plan shall be submitted during the review process for new dams or modification to an existing dam.

3.6. Emergency Action Plan

An Emergency Action Plan (EAP) is required for all significant and high hazard potential dams. The EAP shall conform to the requirements set forth in Section 8. The EAP shall be prepared under the direction of a Professional Engineer licensed in New Mexico, with experience in the design and operation of dams. A draft copy of the EAP shall be submitted during the review process for new dams or modification to an existing dam. The draft copy shall include final submittal of the dambreak analysis and flood inundation maps, including all supporting documentation and calculations. A final EAP is required at completion of construction.

4. CONSTRUCTION AND OPERATION APPROVAL

Final action by the State Engineer on the application to Construct and Operate a Dam will address construction and operation conditions. Following the State Engineer's approval of the application and prior to commencement of construction, the owner nominates an engineer, registered in New Mexico, with experience in dam construction to supervise construction of the dam. If the State Engineer finds the engineer acceptable an order is issued approving the engineer and setting forth conditions under which the engineer will supervise construction. Construction shall be in accordance

with approved plans and specifications. The State Engineer must approve any modifications to the approved plans and specifications or design changes in writing prior to undertaking the modifications.

The engineer supervising construction shall submit monthly progress reports to the State Engineer, which shall include a summary of test results. The State Engineer has full authority to perform inspections at any time during construction of the dam and appurtenances. Inspections will vary with each project, based on the complexity of the design. Generally, representatives of the State Engineer inspect construction when

- The foundation is exposed;
- The embankment is one-half complete;
- Construction of any major structural feature is in progress; and
- Final completion of the dam or modification.

Inspection fees are charged at the rate of $100/day. Inspection fees may be waived when construction is required by the State Engineer to address dam safety deficiencies.

Upon completion of construction, the engineer supervising construction shall submit to the State Engineer:

- A completion report, which shall include descriptions of problems and their solutions.
- A summary of materials test data and construction photographs.
- As-built mylar drawings including all signatures on the title sheet.
- A certificate that the dam as constructed is safe for the intended use.

Once all construction conditions in the approved permit are met, pending the issuance of a Certificate of Construction, use of the reservoir shall require written permission from the State Engineer. Use of the reservoir is restricted until the State Engineer approves the final O&M Manual and EAP.

5. CERTIFICATE OF CONSTRUCTION

Upon completion of construction, the owner shall submit an O&M Manual and EAP for approval by the State Engineer and Proof of Completion of Works form, with appropriate fees. Upon receiving this form, the State Engineer will determine if all conditions of the approved application were met. If there are no outstanding conditions, the State Engineer will issue a Certificate of Construction. The dam owner shall record the Certificate of Construction with the county clerk of the county where the dam is located.

6. CHANGES TO THE APPROVED PERMIT

State Engineer approval of reconstruction, enlargement, modification, reservoir capacity restoration, repair, removal, abandonment or ownership change of an existing dam is required prior to any construction taking place. The current condition of the dam, the type of repair or modification, and the proposed means to achieve the repair or modification all dictate the detail of the information that shall be provided to the State Engineer in order to obtain approval. Construction drawings shall adhere to the requirements in the Rules and Regulations and shall include a design report to support the proposed plan. Changes to the permit will require that all deficiencies with the Criteria be addressed. Routine maintenance work defined in the O&M Manual does not require prior approval. All other repair or modification activities not covered by the O&M Manual require State Engineer approval. Preliminary submittal of the drawings, specifications and design report is recommended to determine what criteria are appropriate.

6.1. Removal or Breach of an Existing Dam

The removal, breach or abandonment of an existing dam under the jurisdiction of the State Engineer requires the State Engineer's advanced approval. An existing dam may not be abandoned without breaching, removing or reclaiming the dam to ensure the dam no longer poses a risk to life, property, the environment surrounding the dam or

downstream of the dam. The dam owner shall notify the State Engineer that the owner wishes to remove, breach or reclaim the dam and cancel the permit.

Owners of significant and high hazard potential dams shall submit to the State Engineer a plan evaluating the potential effects of the dam removal or breach on the environment and life and property downstream. A Professional Engineer licensed in New Mexico, with experience in the operation of dams, shall prepare the plan. The plan shall meet the following conditions:

- The dam shall be excavated down to the level of natural ground and the breach shall be of sufficient width to safely pass the 100-year, 24-hour flood;
- The side slopes of the breach shall be excavated to a stable angle;
- The breach shall be armored as necessary to prevent erosion of the breach area;
- The breach shall be designed to control sediment previously deposited on the reservoir bottom;
- The reservoir shall be emptied in a controlled manner, which will not endanger lives or damage property downstream; and
- Drawings shall include a filing sheet, the location, dimensions and lowest elevation of the breach, and any other detail to sufficiently describe the proposal.
- Identification of an engineer registered in New Mexico, with experience in dam construction, to supervise construction of the breach or dam removal. Submittal of engineer's qualifications is required.

If the State Engineer finds the plan and construction engineer acceptable, an order is issued approving the engineer and setting forth conditions under which the engineer will supervise construction of the breach or dam removal. Upon completion of the breach or dam removal, the supervising engineer shall certify that the dam no longer posses a hazard to life and property.

Owners of low hazard potential dams shall submit a written notice to the State Engineer of intent to breach the dam. The breach shall meet the following minimum requirements:

- The bottom width of the breach shall be to original ground;
- The bottom width of the breach shall be a minimum of one-half the height of the dam but not less than 10 feet;
- The side slopes not steeper than one horizontal to one vertical; and
- The excavated material shall not be placed in the streambed.

6.2. Permanent Closure of a Tailings Facility

The permanent closure of a Tailings Facility typically involves numerous regulatory agencies including the State Engineer. Typically a Closure Plan is prepared to address the permanent closure. State Engineer approval is required before any modification occurs to a jurisdictional tailings dam. A Professional Engineer licensed in New Mexico, with experience in the design and construction of tailings dams, shall prepare the closure plan. The plan shall address the following issues:

- Long-term stability under static and dynamic conditions;
- Control of surface runoff to avoid erosion;
- Plan for long term monitoring, if appropriate; and
- Identification of an engineer, registered in New Mexico, with experience in tailings dam construction to supervise construction of the closure plan. Submittal of engineer's qualifications is required.

If the State Engineer finds the plan and construction engineer acceptable, an order is issued approving the engineer and setting forth conditions under which the engineer will supervise construction of the closure plan. Upon completion of construction, the supervising engineer shall certify that the tailings dam no longer posses a hazard to life, property and the environment.

7. OPERATION AND MAINTENANCE MANUAL

An Operation and Maintenance (O&M) Manual shall be prepared for the purpose of documenting accurate, current and comprehensive information for operation, maintenance and monitoring a dam. Because failure of a dam has a potential catastrophic impact on dam owners, water users and downstream public and private

property, an O&M Manual is required for all new and existing high and significant hazard potential dams. The O&M Manual shall contain, at a minimum, all information and instructions necessary for dam owners and operating personnel to operate and maintain a safe dam. A Professional Engineer licensed in New Mexico, with experience in the design and operation of dams, shall prepare the O&M Manual.

An O&M Manual shall be reviewed and updated at least annually or (1) whenever modifications or replacement of the facilities or equipment are completed, or (2) if a need is recognized by the dam owner or operator. Updates shall be submitted to the State Engineer with documentation to support the results of the review.

The O&M Manual shall be bound with a fastening system to facilitate revisions, and each page shall bear the date of the original page or revision. Additional information and discussion is provided in Appendix D. The O&M Manual shall contain the following elements:

- Certification statements by the owner and engineer with approval by the State Engineer.
- General information on the project including the purpose, location, history, responsibilities and description of project and properties.
- Operation instructions for the reservoir, control mechanisms and any other feature of the project.
- Instrumentation details and monitoring requirements.
- Maintenance requirements and schedule.
- Inspection requirements and schedule.
- An update and revision procedure.
- Appendices to include the Designer's Operating Criteria and Instrumentation Plan to ensure any restrictions imposed by the design are included in the O&M Manual.

8. EMERGENCY ACTION PLAN

The Emergency Action Plan (EAP) identifies potential emergency conditions at a dam and specifies preplanned actions to be followed to minimize property damage and loss of life. The EAP assists in pre-planning with the responsible local, state and federal emergency organizations to provide timely notification of a warning of a dam emergency and evacuation in the event of potential dam failure.

An EAP is required for all new and existing significant and high hazard potential dams. The EAP shall conform to the standardized format included in Appendix E and be bound with a fastening system to facilitate revisions. The EAP shall also be submitted to the State Office of Emergency Management (SOEM) for review and approval, prior to submittal to the State Engineer. Annual review and updates (as necessary) to the EAP shall be provided to the State Engineer and SOEM for review and approval. The EAP shall be prepared by a Professional Engineer licensed in New Mexico, with experience in the design and operation of dams.

The EAP should be user friendly and reflect the capabilities and responsibilities of the dam owner and each organization. The EAP must be tailored to each dam's specific conditions, to the capabilities of the owner and operator, and to the emergency response organizations that will implement the EAP. Preparation of an EAP requires coordinated planning with all the principal parties responsible for emergency response and public safety.

The State Engineer requires that owners of high and significant hazard potential classified dams address the following:

- Prepare, maintain and exercise an EAP for immediate action in the event of an emergency at a dam.
- Have the Local Emergency Manager or government official responsible for public safety review their plan, and make appropriate modifications.

- Provide the primary persons and agencies responsible for executing the plan with copies of the EAP and distribute the EAP to all affected entities.
- Review, update and exercise the plan on an annual basis.

The State Engineer has adopted EAP guidelines and standardized format developed by FEMA[13]. A summary of FEMA's guidelines is discussed below.

The following six basic elements shall be included in an EAP:

1. **Notification Flowchart**. The notification flow chart shows who is to be notified, by whom and in what priority. The information on the notification flowchart is necessary for the timely notification of persons responsible for taking emergency action.
2. **Emergency Detection, Evaluation and Classification**. This element includes early detection and evaluation of the situation or event that would trigger the initiation of the EAP or require an emergency action. This element also includes the procedures for reliably and timely identifying an emergency situation to ensure that an appropriate course of action is implemented. Defining various types of emergency situations would be included in this element in order to determine the level of action required for each type of emergency.
3. **Responsibilities.** A determination of responsibility for EAP related tasks must be made during the development of the plan. Since the dam owner is responsible for the development, maintenance and implementation of the EAP, the dam owner will need to work with the emergency preparedness agency in the county in order to define the responsibilities. State and local emergency management officials have statutory obligations and are responsible for warning and evacuation within the affected areas. The dam owner's responsibilities must also be clearly specified to ensure effective and timely action is taken in the event of an emergency at the dam. The EAP must be site-specific since the conditions at a dam and downstream of a dam are different for each dam.
4. **Preparedness.** This section of the EAP will include preparedness actions that can be taken before an emergency. A list of materials, equipment and

manpower available to moderate or alleviate the effects of a dam failure or spillway release should be included in this section.

5. **Inundation Map.** An inundation map delineating the areas that will be flooded as a result of dam failure is a key component of the EAP. The inundation map is used by both the dam owner and emergency management officials to assist in identifying the area that would need to be notified and evacuated as the result of a dam failure or flooding condition. These maps are a useful tool to graphically display the flooded areas, travel times for a wave front and flood peaks at critical locations.
6. **Appendices.** The appendices contain information that supports and supplements the material used in the development and maintenance of the EAP.

Because emergency management agencies rely on the inundation map to develop evacuation procedures, both a “sunny day” failure and a failure during the worst case flood flow conditions should be analyzed and shown on the inundation maps. If a dam is located upstream, failure scenarios with the upstream dam shall also be evaluated. Flood control dams, which have experienced a first fill to the spillway crest, may request a waiver from the “sunny day” failure scenario if adequate justification is provided. The inundation maps should be prepared to show the time and distance from the dam when the flood wave will arrive at critical areas in relation to the beginning of the dam failure hydrograph, the maximum discharge (Q_p) and the depth of flow. Critical public facilities (e.g. water supplies, hospitals, electric utilities, etc.) that would be affected by the flooding should be identified. The dam breach analysis and flood inundation maps shall be submitted to the State Engineer for approval before the EAP is finalized.

9. REFERENCES

1. Federal Emergency Management Agency. *Glossary of Terms for Dam Safety,* FEMA 148, 1988.
2. Federal Emergency Management Agency. *Federal Guidelines for Dam Safety: Hazard Potential Classification Systems for Dams,* FEMA 333, 1998.

3. Bureau of Reclamation (USBR). *Downstream Hazard Classification Guidelines,* ACER Technical Memorandum No. 11, 1988.
4. Federal Emergency Management Agency. *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams,* FEMA 94, 1998
5. National Oceanic and Atmospheric Administration (NOAA) *Atlas 2 -Precipitation-Frequency Atlas of the Western United States, Volume IV- New Mexico,* 1973.
6. National Oceanic and Atmospheric Administration (NOAA). *Hydrometeorological Report 49 (HMR 49) - Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainage,* U.S Department of Commerce, 1977.
7. National Oceanic and Atmospheric Administration (NOAA). *Hydrometeorological Report No. 55A (HMR 55A) - Probable Maximum Precipitation Estimates - United States Between the Continental Divide and the 103rd Meridian,* U.S Department of Commerce, 1988.
8. Federal Energy and Regulatory Commission (FERC). *Engineering Guidelines for Evaluation of Hydropower Projects,* Office of Hydropower Licensing, FERC 0119-2, Chapter II and Appendix IIC, 1991.
9. Natural Resource Conservation Service (NRCS). *Gradation Design of Sand and Gravel Filters,* Chapter 26, Part 633 National Engineering Handbook, U.S. Department of Agriculture, 1994.
10. U.S. Army Corps of Engineers (COE). *Seepage Analysis and Control for Dams.* Engineer Manual No. 1110-2-1901, Appendix D- Filter Design, Department of the Army, 1993.
11. U.S. Army Corps of Engineers (COE). *Earth and Rock-Fill Dams – General Design and Construction Considerations.* Engineer Manual No. 1110-2-2300, Appendix B- Filter Design, Department of the Army, 1994.
12. Bureau of Reclamation (USBR). *Design of Small Dams, 3rd Edition.* 1987.
13. Federal Emergency Management Agency. *Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners,* FEMA 64, 1998.

APPENDIX A

GLOSSARY OF TERMS

Abutment – That part of the valley side against which the dam is constructed. The left and right abutments of dams are defined with the observer viewing the dam looking in the downstream direction, unless otherwise indicated.

Acre-foot – A unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet.

Appurtenant structure – Ancillary features of a dam such as outlets, spillways, power plants, tunnels, etc.

Axis of Dam – The vertical plane or curved surface, chosen by a designer, appearing as a line, in plan or in cross-section, to which the horizontal dimensions of the dam are referenced.

Base Thickness – Also referred to as base width. The maximum thickness or width of the dam measured horizontally between upstream and downstream faces and normal to the axis of the dam, but excluding projections for outlets, or other appurtenant structures.

Bedrock – The consolidated body of natural solid mineral matter which underlies the overburden soils.

Berm – A nearly horizontal step in the sloping profile of an embankment dam. Also a step in a rock or earth cut.

Borrow Area – The area from which material for an embankment is excavated.

Breach – An opening through a dam which drains the reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional discharge from the reservoir.

Cavitation – The formation of a partial vacuum at the interface of fast-flowing water with a surface, typically at a point of turbulence such as a valve or impeller or immediately downstream from an obstruction or offset. Usually accompanied by noise and vibration, and is potentially destructive.

Channel – A general term for any natural or artificial facility for conveying water.

Cofferdam – A temporary structure to facilitate construction dewatering or to divert water away from construction, which is removed prior to completion of construction as part of construction phasing. Common types include steel sheet piles, earthen dikes, and water-filled bladders.

Compaction – Mechanical action which increases the density by reducing the voids in a material.

Conduit – A closed channel to convey water through, around, or under a dam.

Consequences of Failure – Potential loss of life or property damage downstream of a dam caused by floodwaters released at the dam or by waters released by partial or complete failure of dam; includes effects of landslides upstream of the dam on property located around the reservoir.

Construction Joint – The interface between two successive placings or pours of concrete where bond, and not permanent separation, is intended.

Contact Grouting – Filling, with cement grout, any voids existing at the contact of two zones of different materials, e.g. between a concrete tunnel lining and the surrounding rock.

Core – A zone of low permeability material in an embankment dam. The core is sometimes referred to as central core, inclined core, puddle clay core, rolled clay core, or impervious zone.

Core Wall – A wall built of relatively impervious material, usually of concrete or asphaltic concrete, in the body of an embankment dam to prevent seepage.

Crest of Dam – The lowest elevation of the uppermost surface of a dam, usually a road or walkway excluding any parapet wall, railing, etc.

Crest Width – The thickness or width of a dam at the crest level (excluding corbels or parapets). In general, the term thickness is used for gravity and arch dams, and width is used for other dams.

Cross Section – An elevation view of a dam formed by passing a plane through the dam perpendicular to the axis.

Cutoff Trench – A foundation excavation later to be filled with impervious material so as to limit seepage beneath a dam.

Cutoff Wall – A wall of impervious material usually of concrete, asphaltic concrete, or steel sheet piling constructed in the foundation and abutments to reduce seepage beneath and adjacent to the dam.

Dam – A barrier constructed across a watercourse or off channel for the purpose of storage, control, or diversion of water. Types of dams are listed below.

a. Arch Dam – A concrete or masonry dam, which is curved upstream so as to transmit the major part of the water load to the abutments.

b. Buttress Dam – A dam consisting of a watertight part supported at intervals on the downstream side by a series of buttresses. Buttress dam can take many forms, such as flat slab or massive head buttress.

c. Concrete Dam – A dam constructed primarily of concrete, usually cast-in place but possibly including precast or roller-compacted elements. Types of concrete dams include arch, buttress, and gravity, among others.

d. Live storage. The storage volume of a reservoir that is available for use and lies above the invert of the lowest outlet.

e. Reservoir storage capacity. The sum of the dead and live storage of the reservoir.

f. Earth Dam – An embankment dam in which more than 50% of the total volume is formed of compacted earth material generally smaller than 3-inch size.

g. Gravity Dam – A dam constructed of concrete and/or masonry which relies on its weight and internal strength for stability.

h. Masonry Dam – any dam constructed mainly of stone, brick or concrete blocks jointed with mortar. A dam having only a masonry facing should not be referred to as a masonry dam.

i. Multiple Arch Dam – a buttress dam comprised of a series of arches for the upstream face.

j. Rockfill Dam – An embankment dam in which more than 50% of the total volume is comprised of compacted or dumped cobbles, boulders, rock fragments, or quarried rock generally larger than 3-inch size.

k. Roller Compacted Concrete Dam – A concrete gravity dam constructed by the use of a dry mix concrete transported by conventional construction equipment and compacted by rolling, usually with vibratory rollers.

l. Saddle dam (or dike) – a subsidiary dam of any type of constructed across a saddle or low point on the perimeter of a reservoir. When a saddle dam is above the water surface for the permanent storage pool, it may be referred to as a saddle dike.

m. Tailings Dam – An industrial waste dam in which the waste materials come from mining operations or mineral processing. The waste products are conveyed as fine material suspended in water to the reservoir impounded by the embankment.

The embankment may be built of conventional materials but sometimes incorporates suitable waste products.

Dam Failure – The catastrophic breakdown of a dam, characterized by the uncontrolled release of impounded water. There are varying degrees of failure.

Design Water Level – The maximum water elevation including the flood surcharge, that a dam is designed to withstand.

Dike – See saddle dam.

Diversion Channel, Canal, or Tunnel – A waterway used to divert water from its natural course. The term is generally applied to a temporary arrangement, e.g. to by-pass water around a dam site during construction. “Channel” is normally used instead of “canal” when the waterway is short.

Drain, Blanket – A horizontal or gently sloping layer of pervious material placed to facilitate drainage of the foundation and/or embankment.

Drain, Chimney – A vertical or inclined layer of pervious material in an embankment to facilitate and control drainage of the embankment fill.

Drain. Toe – A system of pipe and/or pervious material along the downstream toe of a dam used to collect seepage from the foundation and embankment and convey it to a free outlet.

Drainage Area – The area draining to a particular point of study on a river or stream.

Drainage Curtain (also called drainage wells or relief wells) – A line of vertical wells or boreholes to facilitate drainage of the foundation and abutments and to reduce water pressure.

Drawdown – The difference between a water level and a lower water level in a reservoir within a particular time. Used as a verb, it is the lowering of the water surface.

Earthquake – A sudden motion or trembling in the earth caused by the abrupt release of accumulated stress along a fault.

Earthquake, Maximum Credible (MCE) – The most severe earthquake that can be expected to occur at a given site on the basis of geologic and seismological evidence.

Earthquake, Operating Basis (OBE) – The earthquake(s) for which the structure is designed to resist and remain operational. It reflects the level of earthquake protection desired for operational or economic reasons and may be determined on a probabilistic basis considering the regional and local geology and seismology.

Emergency Action Plan (EAP) – A plan of action to be taken to reduce the potential for property damage and loss of life in an area affected by a dam failure or large flood.

EAP Exercise – An activity designed to promote emergency preparedness; test or evaluate EAPs, procedures, or facilities; train personnel in emergency management duties; and demonstrate operational capability. Exercises consist of the performance of duties, tasks, or operations very similar to the way they would be performed in a real emergency. However, the exercise performance is in response to a simulated event.

EAP Exercise, Comprehensive – An in-depth exercise of an EAP that involves the interaction of the dam owner with the state and local emergency management agencies in a stressful environment with time constraints. Functional and full-scale EAP exercises are considered comprehensive EAP exercises.

Emergency Management Agency – The state and local agencies responsible for emergency operations, planning, mitigation, preparedness, response, and recovery for all hazards. Names of emergency management agencies may vary such as: Division of Emergency management, Comprehensive Emergency Management, Disaster Emergency Services, Civil Defense Agency, Emergency and Disaster Services.

Emergency Operations Center (EOC) – The location or facility where responsible officials gather during an emergency to direct and coordinate emergency operations, to communicate with other jurisdictions and with field emergency forces, and to formulate protective action decisions and recommendations during an emergency.

Energy Dissipator – A device constructed in a waterway to reduce the kinetic energy of fast flowing water.

Erosion – The wearing away of a surface (bank, streambed, embankment) by floods, waves, wind, or any other natural process.

Fault – A fracture or fracture zone in the earth crust along which there has been displacement of the two sides relative to one another.

Fault, Active – A fault which, because of its present tectonic setting, can undergo movement from time to time in the immediate geologic future.

Fault, Capable – An active fault that is judged capable of producing macro-earthquakes and exhibits one or more of the following characteristics:

a. Movement at or near the ground surface at least once within the past 35,000 years.

b. Macroseismicity (3.5 magnitude Richter or greater) instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault.

c. A structural relationship to a capable fault such that movement on one fault could be reasonably expected to cause movement on the other.

d. Established patterns of microseismicity which define a fault, with historic macroseismicity that can be reasonably be associated with the fault.

Fetch – The straight line distance across a body of water subject to wind forces. The fetch is one of the factors used in calculating wave heights in a reservoir.

Filter (filter zone) – One or more layers of granular material graded (either naturally or by selection) so as to allow seepage through or within the layers while preventing the migration of material from adjacent zones.

Flood – A temporary rise in water surface elevation resulting in inundation of areas not normally covered by water. Hypothetical floods may be expressed in terms of average probability of exceedance per year such as one-percent-chance flood, or expressed as a fraction of the probable maximum flood or other reference flood.

Flood Inundation Zone – The downstream area that would be inundated or otherwise affected by the failure of a dam or by large flood flows.

Flood Routing – A process of determining progressively over time the amplitude of a flood wave as it moves past a dam and continues downstream.

Flood Storage – The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel.

Freeboard – Vertical distance between the spillway crest and the lowest point of the top of dam, without chamber.

Gallery – A passageway in the body of a dam used for inspection, foundation grouting, and/or drainage.

Gate – A movable water barrier for the control of water.

a. Bulkhead gate. A gate used either for temporary closure of a channel or conduit before dewatering it for inspection or maintenance or for closure against flowing water when the head difference is small, e.g., for diversion tunnel closure.

b. Emergency gate – A standby or auxiliary gate used when the normal means of water control is not available. Sometimes referred to as guard gate.

c. Outlet gate – A gate controlling the flow of water through a reservoir outlet.

d. Regulating gate (regulating valve) – A gate or valve that operates under full pressure flow conditions to regulate the rate of discharge.

e. Slide gate (sluice gate) – A gate that can be opened or closed by sliding in supporting guides.

Gate chamber (valve chamber) – A room from which a gate or valve can be operated, or sometimes in which the gate is located.

Geotextiles – Any fabric or textile (natural or synthetic) when used as an engineering material in conjunction with soil, foundations or rock. Geotextiles have the following uses: drainage, filtration, separation of materials, reinforcement, moisture barriers, and erosion protection.

Groin – The area along the contact (or intersection) of the face of a dam with the abutments.

Grout – A fluidized material that is injected into soil, rock, concrete, or other construction material to seal openings and to lower the permeability and/or provide additional structural strength. There are four major types of grouting materials: chemical; cement; clay; and bitumen.

Grout Curtain – One or more zones, usually thin, in the foundation into which grout is injected to reduce seepage under or around a dam.

Hazard Potential Classification – A rating for a dam based on the potential consequences of failure. The rating is based on potential for loss of life and damage to property that failure of that dam could cause. Such classification is related to the amount of development downstream of a dam.

Head, Static – The vertical distance between two points in a fluid.

Heel – The junction of the upstream face of a gravity or arch dam with the ground surface. For an embankment dam the junction is referred to as the upstream toe of the dam.

Height – The maximum height from the lowest natural ground surface, which is typically on the downstream side, to the top of the dam.

Height, Structural – The vertical distance between the lowest point of the excavated foundation to the top of the dam.

Hydrograph, Breach or Dam Failure – A flood hydrograph resulting from a dam breach.

Hydrograph, Flood – A graphical representation of the flood discharge with respect to time for a particular point on a stream or river.

Hydrology – One of the earth sciences that encompasses the natural occurrence, distribution, movement, and properties of the waters of the earth and their environmental relationships.

Inflow Design Flood (IDF) – The flood flow above which the incremental increase in downstream water surface elevation due to failure of a dam or other water impounding structure is no longer considered to present an unacceptable additional downstream threat. The upper limit of the IDF is the probable maximum flood (PMF).

Instrumentation – An arrangement of devices installed into or near dams (i.e., piezometers, inclinometer, strain gauges, measurement points, etc.), which provide for measurements that can be used to evaluate the structural behavior and performance parameters of the structure.

Intake – Any upstream structure in a reservoir, dam or river through which water can be discharged.

Inundation Map – A map delineating the area that would be flooded by a particular flood event.

Jurisdictional Dam – A dam greater than 10 feet in height or storing greater than 10 acre-feet, that is not exempt under Section 72-5-32 NMSA.

Length of Dam – The length measured along the dam axis at the top of dam. This also includes the spillway, powerplant, navigation lock, fish pass, etc., where these form part of the length of the dam. If detached from the dam these structures should not be included.

Liquefaction – A condition whereby soil undergoes continued deformation at a constant low residual stress or with low residual resistance, due to the buildup and maintenance of high pore water pressures, which reduces the effective confining pressure to a very low value. Pore pressure buildup leading to liquefaction may be due either to static or cyclic stress applications and the possibility of its occurrence will depend on the void ratio or relative density of a cohesionless soil and the confining pressure.

Loss of Life – The likely number of human fatalities that would result from a dam failure flood event. No allowances for evacuation or other emergency actions by the population should be considered.

Meterology – The science that deals with the atmosphere and atmospheric phenomena, the study of weather, particularly storms and the rainfall they produce.

Minimum Operating Level – The lowest level to which the reservoir is drawn down under normal operating conditions.

Notification – To inform appropriate individuals about an condition so they can take appropriate action.

Observation Well – A hole used to observe the groundwater surface at atmospheric pressure within soil or rock.

One-Hundred Year Flood – A flood that has 1 chance in 100 of being equaled or exceeded during any year.

Outlet – An opening through which water can be discharged.

Outlet Works – A dam appurtenance that provides release of water (generally controlled) from a reservoir.

Parapet Wall – A solid wall built along the top of a dam (upstream or downstream edge) used for ornamentation, for safety of vehicles and pedestrians, or to prevent overtopping caused by wave runup.

Phreatic Surface – The free surface of water seeping at atmospheric pressure through soil and rock.

Piezometer – An instrument used for measuring fluid pressure (air or water) within soil, rock, or concrete.

Piping – The progressive development of internal erosion by seepage.

Probability – The likelihood of an event occurring.

Probable Maximum Flood (PMF) – The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the drainage basin under study.

Probable Maximum Precipitation (PMP) – Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location during a certain time of year.

Purpose – The purpose for which the reservoir is used. Typical choices are: Irrigation, Hydroelectric, Flood Control, Water Supply, Recreation, Stock, Fish and Wildlife, and Tailings.

Reservoir – A body of water impounded by a dam and in which water can be stored.

Reservoir Inundation Zone – The area bounded by the water surface elevation associated with the routing of the IDF.

Reservoir Regulation (or operating) Procedure – Operating procedures that govern reservoir storage and releases.

Reservoir Rim – The boundary of the reservoir including all areas along the valley sides above and below the water surface elevation associated with the routing of the IDF.

Reservoir Surface Area – The area covered by a reservoir when filled to a specified elevation.

Riprap – A layer of large uncoursed stone, precast blocks, bags of cement or other suitable material, generally placed on the upstream slopes of an embankment or along a watercourse as protection against wave action, erosion or scour. Riprap is usually placed by dumping or other mechanical methods and in some cases is hand placed. It consists of pieces of relatively large size as distinguished from a gravel blanket.

Risk – The relationship between the consequences resulting from an adverse event and its probability of occurrence.

Slope – Inclination from the horizontal. Sometimes referred to as batter when measured from vertical.

Sluice – An opening for releasing water from below the static head elevation.

Spillway – A structure over or through which flow is discharged from a reservoir. If the rate of flow is controlled by mechanical means such as gates, it is considered a controlled spillway. If the geometry of the spillway is the only control, it is considered an uncontrolled spillway.

a. Auxilliary – Any secondary spillway which is designed to be operated very infrequently and possibly in anticipation of some degree of structural damage or erosion to the spillway during operation.

b. Principal (or service) – A spillway designed to provide continuous or frequent releases from a reservoir, without significant damage to either the dam or its appurtenant structures.

c. Emergency – A spillway that is designed to provide additional protection against overtopping of dams, and is intended for use under extreme flood conditions or misoperation or malfunction of the service spillway and/or the auxiliary spillway.

Spillway Channel – An open channel or closed conduit conveying water from the spillway inlet downstream.

Spillway Crest – The lowest level at which water can flow over or through the spillway.

Spillway Design Flood (SDF) – The required flood that a spillway must pass without failure of the dam.

Spillway Effective Length – The measured length of the crest of the spillway reduced by contraction of flow. Effective length is used to determine the spillway discharge.

Stilling Basin – A basin constructed to dissipate the energy of rapidly flowing water, e.g., from a spillway or outlet, and to protect the riverbed from erosion.

Storage – The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel. Definitions of specific types of storage in reservoirs are:

a. Dead storage. The storage volume of a reservoir that lies below the invert of the lowest outlet and that, therefore, cannot readily be withdrawn from the reservoir.

b. Flood surcharge storage. The storage volume between the maximum operating level and the design water level.

c. Maximum storage. The sum of the reservoir storage capacity and flood surcharge storage.

Storm – The depth, area, and duration distribution of precipitation.

Sunny Day Failure – Failure from other than a large flood such as earthquake induced, structural weakness, piping, etc. The maximum operating water level is assumed.

Toe of Dam – The junction of the downstream slope of a dam with the ground surface; also referred to as the downstream toe. The junction of the upstream slope with the ground surface is called the heel or the upstream toe. For concrete dams, see heel.

Top of Dam – See crest of dam.

Top Thickness (top width) – See crest width.

Trashrack – A device located at an intake to prevent floating or submerged debris from entering the intake.

Tunnel – A long underground excavation with two or more openings to the surface, usually having a uniform cross section used for access, conveying flows, etc.

Type of Dam – See descriptions listed for Dam.

Upstream Blanket – An impervious blanket placed on the reservoir flood and abutments upstream of a dam. For an embankment dam, the blanket may be connected to the core.

Valve – A device fitted to a pipeline or orifice in which the closure member is either rotated or moved transversely or longitudinally in the waterway so as to control or stop the flow.

Volume of Dam – The total space occupied by the materials forming the dam structure computed between abutments and from top to bottom of dam. No deduction is made for small openings such as galleries, adits, tunnels, and operating chambers within the dam structure. Portions of powerplants, locks, spillway, etc., should be included only if they are necessary for the structural stability of the dam.

Wave Runup – Vertical height above the stillwater level to which water from a specific wave will run up the face of a structure or embankment.

Watershed – The region draining into a river, river system or body or water.

Weir – An overflow structure built across an open channel to raise or control the upstream water level and/or to measure the flow of water.

a. Weir, broad-crested. An overflow structure on which the nappe is supported for an appreciable length in the direction of flow.

b. Weir, measuring. A device for measuring the rate of flow of water. It generally consists of a rectangular, trapezoidal, triangular, or other shaped notch, located in a vertical, thin plate over which water flows. The height of water above the weir crest is used to determine the rate of flow.

c. Weir, ogee. An overflow structure with its cross-section in the form of a reverse curve, shaped like an elongated letter “S”. The downstream faces of overflow spillways are often made to this shape.

APPENDIX B

DAM SAFETY STATUTUES

Statutory Chapters in New Mexico Statutes Annotated 1978

CHAPTER 72 WATER LAW

ARTICLE 5 APPROPRIATION AND USE OF SURFACE WATER

72-5-9. Supervision; inspection; completion of works; alterations.

For the supervision of the construction of works for the storage, diversion or carriage of water there shall be in charge a registered professional engineer, whose qualifications have been approved by the State Engineer. This engineer shall have full authority to carry out such inspections and instructions that are deemed necessary by the State Engineer. On the date set for the completion of the work, or prior thereto, upon notice from the owner that the work has been completed, the State Engineer shall cause the work to be inspected, after due notice to the owner of the permit. Such inspection shall be thorough and complete, in order to determine the actual capacity of the works, their safety and efficiency. If not properly and safely constructed, as plans approved, the State Engineer may require the necessary changes to be made within a reasonable time, to be fixed by him and shall not issue his certificate of completion until such changes are made. If at or before the expiration of said time, good cause is shown why said change could not be made within said time, then additional time may be allowed in which to make said change. Failure to make such changes shall cause the postponement of the priority under the permit for such time as may elapse from the date for completing such changes until made to the satisfaction of the State Engineer, and applications subsequent in time shall have the benefit of such postponement of priority: the State Engineer, if he deems it necessary to the public safety, may bring in consulting engineers, geologists or other expert consultants, compensation for which will be paid for by the owner of the permit; provided, that for works involving the diversion of not exceeding twenty cubic feet of water per second or a dam not exceeding ten feet in height from the lowest natural ground surface elevation the State Engineer may, in his discretion, waive the above provisions and accept the report of the inspection by a registered professional engineer.

History: Laws 1907, ch. 49, § 30; Code 1915, § 5688; C.S. 1929, § 151-139; Laws 1937, ch. 178, § 4; 1941, ch. 126, § 12; 1941 Comp., § 77-508; 1953 Comp., § 75-5-8.

72-5-10. [State Engineer's certificate of construction.]

When the works are found in satisfactory condition, after inspection, the State Engineer shall issue his certificate of construction, setting forth the actual capacity of the works and such limitations on the water right as shall be warranted by the condition of the works, but in no manner extending the rights described in the permit.

History: Laws 1907, ch. 49, § 31; Code 1915, § 5689; C.S. 1929, § 151-140; 1941 Comp., § 77-509; 1953 Comp., § 75-5-9.

72-5-11. Inspection and correction of unsafe works.

If the State Engineer shall in the course of his duties find that any works constructed for the storage, diversion or carriage of water are unsafe and a menace to life or property, he shall at once notify the owner or agent, specifying the changes necessary and allowing a reasonable time for putting the works in safe condition. Upon the request of any party, accompanied by the estimated cost of inspection, the State Engineer shall cause any alleged unsafe works to be inspected. If they shall be found unsafe by the State Engineer, the money deposited by such party shall be refunded, and the fees for inspection shall be paid by the owner of such works; and, if not paid by him within thirty days after the decision of the State Engineer, shall be a lien against the property of such owner, to be recovered by suit instituted by the district attorney of the county at the request of the State Engineer. The State Engineer may, when in his opinion necessary, inspect any works under construction for the storage, diversion or carriage of water and may require any changes necessary to secure their safety; and the fees for such inspection shall be a lien on any property of the owner and shall be subject to collection as provided herein; provided that nothing contained in this section shall be construed to make works being constructed or owned by the United States while under supervision of officers of the United States subject to inspection by the State Engineer.

Nothing contained in this section and no action or failure to act under this section shall be construed:

A. to create any liability in the state or its officers or employees for the recovery of damages caused by such action or failure to act; or

B. to relieve the owner or operator of water impoundment works of the legal duties, obligations or liabilities incident to the ownership or operation of water impoundment works.

History: Laws 1907, ch. 49, § 32; Code 1915, § 5690; C.S. 1929, § 151-141; 1941 Comp., § 77-510; 1953 Comp., § 75-5-10; Laws 1979, ch. 314, § 1.

72-5-12. Failure to comply with State Engineer order; penalty.

Any owner of works for the diversion, storage, carriage or impoundment of water, his agent or employees, who, following notice to place such works in a safe condition as provided in Section 72-5-11 NMSA 1978, fails to take action specified by the State Engineer within the time allowed, shall be guilty of a misdemeanor. Any violation of this section shall be punishable by a fine of not more than two hundred fifty dollars ($250) for each offense or by imprisonment for a definite term not to exceed six months, or both. It is the duty of the State Engineer to give prompt notice to the district attorney of the county in which the works are located in case of such violation. The district attorney shall at once proceed against the owner and all parties responsible therefor.

History: Laws 1907, ch. 49, § 33; Code 1915, § 5691; C.S. 1929, § 151-142; 1941 Comp., § 77-511; 1953 Comp., § 75-5-11; Laws 1979, ch. 314, § 2.

72-5-32. Construction of dams exceeding ten feet in height. (1997)

Any person, association or corporation, public or private, the state or the United States hereafter intending to construct a dam shall meet the requirements of filing applications for appropriations and use of water pursuant to Section 72-5-1, 72-5-22, 72-5-23 or 72-5-24 NMSA 1978. Any person, association or corporation, public or private, the state or the United States intending to construct a dam that exceeds ten feet in height from the lowest natural ground surface elevation to the crest of the dam or impounds more than ten acre-feet of water shall submit on a form prescribed by the State Engineer detailed plans to the State Engineer for approval before construction. If the State Engineer finds that the dam design is safe, he shall approve the plans; provided that this section shall not apply to stock dams or erosion control structures whose maximum storage capacity does not exceed ten acre-feet or any dam constructed for the sole purpose of sediment and flood control under the supervision of the United States army corps of engineers.

History: Laws 1941, ch. 126, § 25; 1941 Comp., § 77-530; 1953 Comp., § 75-5-30; Laws 1979, ch. 114, § 1; 1997, ch. 66, § 1.

MANUAL OF RULES AND REGULATIONS GOVERNING THE APPROPRIATION AND USE OF THE SURFACE WATERS OF THE STATE OF NEW MEXICO

Revised August, 1953

(Copies of pertinent Sections Only)

I. CONSTITUTIONAL PROVISIONS AND GENERAL PRINCIPLES OF APPROPRIATION

All existing rights to the use of water for beneficial purposes in New Mexico were recognized and confirmed by the State Constitution at the time of its adoption.

The State Engineer is empowered to make all rules and regulations necessary to administer the duties devolved upon his office.

All natural waters flowing in streams and water courses in New Mexico are declared to be public and subject to appropriation for beneficial use.

Beneficial use is the basis, measure and limit of the right to use water. No water right, therefore, may be granted or claimed for more than the amount that can be beneficially used.

The unauthorized use of water to which another is entitled, or the willful waste of water to the detriment of another or of the public is a misdemeanor. Excessive, wasteful and otherwise non-beneficial uses do not constitute a valid water right.

Priority in time shall give the better right.

All water appropriated for irrigation purposes, except as otherwise provided by written contract between the owner of the land and the owner of any ditch, reservoir, or other works for the storage or conveyance of water, is appurtenant to the land upon which it is used and shall so continue as long as it can be beneficially used on or until it is lawfully severed from the land. Water which is appurtenant to certain lands may not be transferred to other lands or used for other beneficial purposes excepting with the consent of the owner of the land and as provided by law.

No appropriation of water shall be exercised to the detriment of anyone having prior, valid and existing rights to the use of the waters of the stream system.

Excepting for water rights acquired prior to March 19, 1907, any right to the use of public waters must originate by application to the State Engineer as provided by statute. Unauthorized use shall be a misdemeanor.

The public is notified of proposed appropriations by publication in a newspaper of general circulation in the stream system and any water right owner who feels that the use of water under such application would be detrimental to his prior right may file a protest thereto. After due consideration of the facts, the State Engineer shall approve or reject the application.

It is unlawful to commence any construction of works until the formal application to appropriate water has been approved and signed by the State Engineer.

The diversion and distribution of water for irrigation and domestic purpose in New Mexico is a public purpose, and an appropriator may exercise the right of eminent domain to acquire rights-of-way for canals, ditches, reservoirs, etc., necessary to accomplish such purpose.

License to appropriate water is issued by the State Engineer after the works are satisfactorily completed and the water is applied to beneficial use.

Excepting stored waters, failure of an owner to beneficially use all or any part of the water in which he has a vested right for a period of 4 consecutive years constitutes forfeiture and such unused water shall revert to the public; except that forfeiture does not necessarily occur should such non-use be caused by circumstances beyond the owner's control.

To the end that the waters of the several stream systems of the state may be so utilized as to prevent waste and damage and in order that the benefits of such waters be distributed among the land owners along said streams as equitably as possible without interfering with vested rights, the natural right of the people living in the upper valleys to impound and utilize a reasonable share of such waters has been recognized and declared, subject always to the provisions of the water right statutes.

The appropriation statutes do not apply to stockmen who shall build or construct tanks or ponds for watering stock which do not exceed 10 acre feet in capacity. The owners are, however, at all times responsible for any detriment or damage to prior water rights which may result from the construction of and storage of water in such stock ponds.

The State Engineer has the right and duty of supervision of the apportionment of water according to the licenses issued by his office and to the adjudications of the courts. Although water rights acquired prior to March 19, 1907, may be adjudicated only by the courts, all such rights are subject to regulation, adjudication and forfeiture for non-use as provided in the statutes; provided, that in all cases where the rights to the use of the waters in interstate streams of owners of land not included in conservancy districts, irrigation districts, or Federal reclamation projects have been the subject of litigation in

the State or Federal courts of an adjoining state, the State Engineer shall assume control of all or any part of such interstate stream and the diversions and distribution of the waters of the same in the public interest.

II. PROCEDURE FOR APPROPRIATING PUBLIC SURFACE WATERS

A. Initiation of Water Right---Filling Fees---Priority.

The right to appropriate the public surface waters of New Mexico may be acquired by any person, firm, association, corporation, the State of New Mexico or the United States of America. Excepting projects of the Bureau of Reclamation (see page 21), all rights acquired after March 19, 1907, must be initiated in the office of the State Engineer by filing an application to make such appropriation. Acceptance of the filing by the State Engineer gives the applicant a tentative right to proceed according to statute in establishing his water right. It is unlawful, however, to commence any construction of works prior to the formal approval of the application by the State Engineer. The necessary blank forms for making water right application will be furnished by the State Engineer upon request. All other regular blank forms will be sent to applicant as required.

A water right may be initiated by filing Notice of Intention, to be followed within a designated time by Formal Application; or the right may be initiated by filing Formal Application directly. In either case there is a filing fee which is a necessary part of the application. The fee for filing Notice of Intention is $25.00. The fee for filing Formal Application is graduated in amount and depends upon the size and complexity of the project (see Article VII Fees). Excepting as it may be changed by the provisions of Sections D, E, F or K of this Article, the priority date of any water right is the date of receipt of initial filing papers accompanied by proper fee.

B. Notice of Intention.

Notice of Intention to make Formal Application for Permit shall be filed in duplicate on the proper forms, accompanied by a $25.00 filing fee. Upon receipt of the Notice properly filled out, the State Engineer shall endorse thereon the date of receipt and shall establish the date for filing Formal Application. Initiation of a right by Notice of Intention is optional and is designed as the lawful means of establishing a priority date for a reasonable length of time sufficient to make surveys and prepare necessary maps, plans, etc., as required by statute. The time granted is usually 6 months but depends somewhat upon the size and complexity of the proposed project. Additional time may be granted at the discretion of the State Engineer in special or unusual cases where the original time allowance proves insufficient, but in no case may the time between filing of Notice of Intention and filing of Formal Application exceed an aggregate of 3 years.

C. Surveys---Maps---Plans.

Field surveys of the project shall be made and maps, plans, field notes, specifications, etc., of the proposed works prepared by a qualified registered professional engineer.

Small projects for simple diversion and distribution and which involve no planning or design of dams, canal structures, etc., may be prepared for filing by a registered surveyor, if qualified to do the work. The engineer is responsible for the reasonable correctness of maps, plans, etc., which he prepares for filing with the State Engineer.

The maps, plans, etc., must be prepared from actual field surveys and must be detailed and complete enough to determine the feasibility, safety and adequacy of the proposed works. In cases involving storage or diversion of large amounts of water, the State Engineer may require any additional information he deems necessary to describe and define the proposed use.

Description and details of the data, certificates, etc., which must be shown on the maps and plans will be found under Article VI, “Filing Maps, Plans, Specifications.”

D. Formal Application

Formal Application shall be filed in duplicate on the proper forms. If Formal Application is an initial filing, it shall be accompanied by the required filing fees; if it follows a Notice of Intention it shall be filed not later than the date set by the State Engineer for such filing and shall be accompanied by the required filing fees from which amount has been deducted the $25.00 fee paid at the time of filing such Notice of Intention. Upon receipt of the proper application forms, completed in every detail, the Notice of Publication shall be issued. The information, maps, field notes, and detail required in plans and specifications to be submitted with the application will depend upon the nature and complexity of the works and will be specified by the State Engineer in each case. In general, it will not be necessary to submit plans and specifications with the application. After receipt of the affidavit of Proof of such Publication and the end of the protest period (and hearing on said protested application if necessary said application shall be approved or denied. Application shall be approved only with the provision that complete plans and specifications shall be submitted within a reasonable length of time to be designated by the State Engineer, and that no construction of the works shall commence until such plans and specifications have been approved. Additional fees required for the examination and study of detailed plans and specifications are set forth in Article VII.

The date of receipt of Formal Application by the State Engineer shall be endorsed thereon and noted in his record. If Formal Application is filed later than the limiting date fixed by Notice of Intention or by subsequent extensions of time thereto, it shall, excepting as to filing fee, be treated as a new application and the priority date shall become the date of the filing of Formal Application.

Formal Application defines and limits the maximum amount of water which may be appropriated, and no subsequent act, excepting as provided by statute, can extend or amplify such appropriation. A right can be acquired for any amount less than that asked for in the Formal Application, however, it should be emphasized here, also, that proposed irrigated areas described in the Formal Application cannot be changed or

other areas substituted in lieu thereof, nor can the proposed point of diversion be changed, excepting as provided by law.

H. Fees for Examining Plans and Specifications.
Before he shall approve an application the State Engineer shall require the deposit of the fees prescribed by statute for the examination and study of the plans and specifications of the proposed works (see Article VII, "Fees"). These fees are graduated in amount and depend upon the size and complexity of the project, excepting that no fees are charged in the case of small, simple diversion projects where the submission of plans and specifications are not required, and no fees may be charged for studying plans and specifications in the case of projects initiated by the United States or its authorized agencies.

I. Approval---Permit.
In approving an application, the State Engineer shall sign his endorsement upon the Formal Application and shall set the time within which applicant shall construct the works and apply water to beneficial use, but not to exceed five years for construction of works and four years in addition thereto for application to beneficial use. If, in his opinion, sufficient unappropriated waters are not available to satisfy the project, the State Engineer may approve the application for a smaller amount of water than that applied for. In no case may the amount be increased excepting by a new or amended filing. Applications are always approved with the provision that they must not be exercised to the detriment of any appropriators having prior, valid and existing rights to the use of the water of the stream system. For special conditions, special additional provisions may be imposed.

Upon approval the application becomes a permit to appropriate water. A permit does not in itself constitute a water right but merely allows the permittee to demonstrate to the State and others that he can and will, in good faith and with due diligence, construct the works and apply water to beneficial use as provided by the terms thereof. The permit defines and limits the water right which may be required and should be filed of record with the clerk of the county within which the works are to be situated.

K. Construction of Works---Inspection.
The works shall be constructed by the permittee under the supervision of a qualified registered professional engineer unless this provision is specifically waived by the State Engineer. If he deems it necessary to the public safety, the State Engineer may call in consulting engineers or geologists to study and pass upon the project. Cost of such supervision and consulting work shall be borne by the permittee. Construction shall be carried on according to the plans and specifications approved by the State Engineer and no changes or alterations shall be made without his knowledge and consent. As soon as possible after notification of completion of works, the State Engineer, or a proper assistant, shall make a thorough inspection of the works to determine their actual capacity, their adequacy, safety and efficiency, and shall file his report thereon as a part of the permanent record; provided that, in the case of work involving the diversion of not to exceed 20 cubic feet of water per second of time or a dam not exceeding 10 feet in

height above stream bed, the State Engineer may appoint a registered engineer or land surveyor to make the inspection. If the works have been materially changed from the original plans on file, corrections shall be made on the originals, or amended plans shall be submitted for the record. If found to be improperly constructed or unsafe, the State Engineer shall require the making, within a reasonable time limit fixed by him, of all changes or repairs indicated as necessary. If the time allowed proves insufficient, the State Engineer may, upon sufficient showing by the permittee, grant additional time for making the required changes. Failure to make such corrections shall cause the postponement of the priority date of the permit for the length of time elapsing between the date set by the State Engineer and the date when the changes have been satisfactorily completed.

Upon completion, the permittee shall file in duplicate on the proper forms Proof of Completion of Works, which shall be duly sworn to and signed by the inspecting engineer after he has made a thorough field inspection. If not done previously, the owner shall at this time make affidavit or submit proof that he holds all necessary rights-of-way for his works without controversy. A fee of $25.00 for the issuance of a Certificate of construction shall accompany this filing.

L. Certificate of Construction.
The State Engineer shall then issue a Certificate of Construction which shall include the location of the point or points of diversion, the capacities of canals and reservoirs, and shall certify to the adequacy of the works for the intended use. Owner shall record the Certificate of Construction with the clerk of the county within which the works lie.

N. Final Inspection
Upon due notice to the owner of the permit, the State Engineer, one of his assistants, or a qualified registered professional engineer or land surveyor appointed by him shall make an inspection at the owner's expense and shall prepare and file as a part of the record a final report on the project, incorporating therein his recommendations of water use. Such report shall describe in detail by legal subdivision the land irrigated, giving acreages and as closely as possible the quantity of water applied on the lands. Such report is not required to determine losses in transit as they are uncertain and vary widely according to methods of delivery and character of soils thru which the works are constructed. A license to apply a given quantity of water on the land carries with it the right to divert from the stream an additional quantity sufficient to cover actual necessary losses in transit.

In the case of small diversion or storage projects, the State Engineer may in his discretion, when requested by the owner, cause the inspection of works and final inspection of application of water to beneficial use to be made at the same time.

V. ADDITIONAL PROVISIONS AND REQUIREMENTS

The following sections describe additional provisions and requirements of the law in connection with appropriation and use of the surface waters of the State. They are included herein to delineate more clearly certain rights and duties of the water users and of the State Engineer.

Federal Reclamation Projects
Whenever the proper officers of the United States authorized to construct reclamation projects under the terms of the Federal reclamation act shall notify the State Engineer that the United States intends to make use of certain unappropriated waters of the State, the waters so reserved shall not be subject to further appropriation for a period of three years, within which time such officers shall file comprehensive maps and plans of the proposed project. The waters so reserved are not subject to adverse claim or appropriation unless no plans have been filed within the 3-year period or unless such waters are formally released in writing by the proper officer of the United States.

This section involves only works initiated and built under the terms of the Federal Reclamation Law, and does not apply to other Federal agencies.

Unsafe Works---Inspection---Repair
If, upon the request of any party, accompanied by the estimated cost of inspection, or in the course of his regular duties, the State Engineer shall find by inspection that any works used for the storage, diversion or carriage of water are unsafe and a menace to life and property, he shall at once notify the owner thereof, specifying the changes necessary and allowing a reasonable time for putting the works in safe condition. The cost of such inspection shall be a lien upon the property, unless the works are found to need no repair or change, in which case the cost shall be borne by the party requesting the inspection. The continued use of unsafe works after notification by the State Engineer and contrary to his instructions shall be a misdemeanor.

Excepting for works under construction or being owned by the United States while under supervision of officers of the United States, the State Engineer may inspect any works under construction and may require any changes necessary to secure their safety, and the costs of such inspection shall be a lien upon the property.

VI. FILING MAPS, PLANS, SPECIFICATIONS

A. General Filing Requirements
TRACINGS---All filing maps, as well as supplementary plan and detail sheets, shall be original tracings, carefully and neatly done. If more than one sheet is required, they shall be properly numbered in sequence (example---Sheet 1 of 3 Sheets). In general the filing map shall be separate from the plans and detail sheets, excepting that, in the case of small simple diversion projects, all necessary information may be contained on a single sheet. All sheets shall conform to the standards given below.

DIMENSIONS---They shall be prepared on good quality tracing cloth, 24 inches by 36 inches, outside dimensions, with a one-inch margin on all sides. Tracings which vary from this standard size will not be accepted. Writing or other data must not appear in the margins of the sheets.

WATERPROOF INDIA INK---As all tracings are a part of the permanent record, they must be prepared with a good quality permanent black waterproof India drawing ink. This requirement also applies to all signatures, dates, acknowledgments, etc., appearing on the sheets. No sheets which do not fully comply with this provision can be accepted.

CARELESS OR UNSATISFACTORY WORK---CORRECTION---Illegible, mutilated, careless or otherwise poorly prepared maps and plans are not acceptable for filing purposes and may be returned to be redone and retraced. Maps and plan sheets upon which the data are incomplete, faulty or missing will be returned for correction or addition.

TRACINGS NOT FOLDED---Tracings must never be folded but should be rolled about a strong round stick or in a heavy cardboard mailing tube for transportation and handling purposes.

SCALE OF MAPS, PLANS AND DETAIL SHEETS---The scale or scales used on the filing sheets will, of course, vary according to requirements and space available. However, a standard engineer's scale of sufficient size to show all necessary data clearly and in detail should be chosen. All distances shall be shown in feet and decimals thereof; detail dimensions of structures, headgates, drops, etc., may be given in feet and inches. If part of the works is located on State or Federal lands over which right-of-way must be obtained, the scale chosen should preferably be the scale required by such agency, so that replatting to meet their requirements for obtaining right-of-way will not be necessary.

DIRECTION OF NORTH---Maps shall be platted to the true meridian and all bearings shown shall be true bearings. The direction of North shall be placed on the map. Magnetic declination should also be shown if used in making the field survey.

ENGINEER'S AND NOTARY'S SEALS---The impressions of the seals of the engineer or land surveyor preparing the filing and of the notary public shall be placed on the tracing cloth following or near the signatures thereof.

FIELD NOTES---TRAVERSES---Field notes showing courses and distances of canals or pipelines, or of extreme high water line of a reservoir, are a necessary part of a filing, particularly when the works lie on or cross lands thru which right-of-way must be acquired. As nearly as possible a station should be located on each public survey line wherever the traverse crosses such lines. Stations should be numbered consecutively from the point of beginning to the end of the works and bearings and distances shown

by tabulation on the filing map. Where traverses approach public survey corners along their routes, ties should be made to such corners as can be found. Corners which are located in the field and used in the survey should be indicated on the map by encircling them with a diamond or other mark to distinguish from corners not located.

HYDRAULIC PROPERTIES OF MAIN CANALS, PIPELINES, ETC.---All pertinent hydraulic properties of main canals, pipelines, etc., including their dimensions, gradients, coefficients of roughness, freeboard and working capacities, shall be determined and shown on the plan and detail sheets. All elevations, plans, sections, construction details, etc., necessary to properly describe the works shall be shown.

RESERVOIR AREA AND CAPACITY---The topography of any proposed reservoir site shall be determined with reasonable accuracy and a contour map thereof prepared and placed on the filing map, the contour intervals not to exceed 5 feet each in elevation. The State Engineer may require a smaller contour interval than 5 feet if necessary for obtaining reasonable accuracy. Detailed topography of the dam site including sufficient area upstream and downstream and at the sides to properly design spillways, outlets, coffer-dams, etc., shall be taken. An area and capacity table of each reservoir shall also appear on the map, the contour intervals of which may be designated as “feet above bottom of outlet,” or they may be given in “elevations above mean sea level,” or above some assumed datum. It is important that a permanent bench mark above high water line should be established and fully described in order that the established reservoir datum may be available at all times.

DESIGN OF DAMS---The design and specifications of any dam for the storage or diversion of water shall conform in all respects with the State Engineer's code of dam construction, a copy of which code will be sent applicants upon request. This requirement is essential, as much for the protection of the investment of the appropriator as it is for the protection of the lives and property of those living below the dam and for the conservation of the public water supply.

In general, earthen storage dams shall be constructed with a slope not less than 2: horizontal to 1 vertical on the upstream or water side and 2 horizontal to 1 vertical on the downstream side. Fill shall be placed in layers not to exceed 1 foot in thickness and each layer should be thoroughly compacted. In designing uncomplicated low earthen structures a suggested formula for computing width of crest is: Crest width = 2 /height + 3 feet, which width shall never be less than a minimum of 8 feet. The freeboard above high water line shall not be less than 5 feet. The upstream face shall be protected from wind and wave erosion by an adequate facing of rock, concrete or other suitable riprap material. Masonry and concrete dams shall be structurally safe as determined by acceptable design formulas. Foundations, cut-off walls, outlet works, etc., shall be adequate and properly designed. (Inspections made by the State Engineer's office indicate that many earlier earthen storage dams of the State had inadequate spillways, were constructed on steeper slopes than the above or were not properly compacted nor were the foundations properly prepared. As evidence that such construction is inadequate or worse, it may be mentioned here that perhaps half of the dams inspected

have failed either partially or completely, or else seep water so badly that their usefulness is impaired. It is poor economy to build storage structures which are not safe and adequate).

HIGH WATER LINE TRAVERSE---The extreme high water line of each reservoir (the maximum boundaries of the land temporarily covered by water when the spillway is discharging at maximum capacity) shall be determined by a closed transit traverse and included on the topographic map. A station should be located as nearly as possible on each public survey line wherever the traverse crosses such lines and the distance from that station to the nearest survey corner shown. Stations should be numbered consecutively from the point of beginning, and the courses and distances of the traverse tabulated on the map. Error of closure shall not exceed 1 foot per 5000 feet of distance measured. Such a traverse is necessary in procuring easements or rights-of-way.
With the approval of the State Engineer a high water line contour indicated on the topographic map may be substituted for the high water line traverse on ungated flood retention projects where reservoir basins will be drained within a specified time after each filling. Said contour to be obtained from actual field survey or by stereoplotting methods. Method used in obtaining the contours shall be noted on the map.

INITIAL POINT OF RESERVOIR TRAVERSE---POINT OF OUTLET---The location of the control gates (point of outlet from reservoir) shall be determined by course and distance from some known public survey corner. If the initial point of the high water line traverse does not coincide with this point, it also should be tied to a known survey corner or else tied to the point of outlet.

RESERVOIR DRAINAGE AREA---SPILLWAY CAPACITY---The drainage area above and tributary to the reservoir shall be determined with reasonable accuracy and a spillway of size adequate to handle the runoff therefrom shall be designed. It is desirable that the filing map shall show a small scale map of the basin above the dam which will indicate the length, size and shape of the contributing area, the location with respect to towns, railroads, highways, shipping points, etc. A proper design of the approach section of the spillway is important because any overflow section, no matter how large, is useless if the water cannot flow to it at a rate sufficient to safely carry away excess waters. A spillway of ample size is essential to protect the dam itself and it insure the safety of those living below the reservoir. The size and capacity of the spillway and of the outlet gates from the reservoir shall be indicated on the plans.

DIVERSIONS BELOW RESERVOIR---The point or points of diversion below a reservoir shall be determined and shown on the map by course and distance from some public survey corner. Traverses of main canals diverting below reservoirs, their directions of flow and their names or locations, if more than one, shall also be indicated.

STOCK-WATER DAMS---In general the following will govern the design and construction of stock-water dams impounding more than 10 acre-feet:

1. Preparation of Foundation All vegetation of every description together with all boggy or unstable materials within the area upon which the dam will rest shall be

removed and deposited outside the toes of the dam. The banks of the stream channel shall be dressed to a slope of about 12 horizontal to 1" vertical. A core trench, with sloping sides and a bottom width of not less than 5 feet and depth of 4 feet, shall be excavated along the center line for the full length of the dam and shall be refilled with the most impervious materials available. The foundation shall then be scarified or plowed lengthwise of the dam to secure proper bonding between the foundation and the embankment.

2. Embankment The fill material shall be placed in the core trench and the embankment in layers not exceeding 6 inches in thickness. Each layer shall be thoroughly compacted by a sheep's-foot roller, caterpillar treads, or trucks used during construction. The embankment material shall be placed in a horizontal plane for the full width and length of the work. No side dumping of material shall be permitted. When necessary, water shall be added to the fill material to obtain proper compaction. Puddling of material with water shall not be permitted. No frozen material, large clods, boulders, or organic matter shall be incorporated in the embankment. The upstream slope shall be constructed not steeper than 3 horizontal to 1 vertical and the downstream slope not steeper than 2 horizontal to 1 vertical. The crest width of the finished embankment depends upon the maximum height. Minimum crest widths are as follows:

Maximum height of dam (feet)	less than 10	10-14	14-18	16-22	22-26
Minimum crest width (feet)	8	9	11	12	13

The upstream two-thirds of the embankment section should consist of the most impervious materials available such as clay loam, or a mixture of clay and sand, and the downstream one-third of more previous materials, such as sand or gravel. On all dams where it is necessary to protect against wave action, the upstream face shall be adequately riprapped with stone or other suitable material.

3. Outlet Should the State Engineer so require, a pipe not less than 18 inches in diameter equipped with a suitable control gate and operating mechanism shall be installed. Such outlet pipe, when required, shall be provided with anti-seep collars of approved design. The pipe shall be placed in a trench and shall be completely surrounded with well compacted impervious material.

4. Spillway For the protection of the dam, an adequate spillway shall be constructed, of sufficient capacity to carry the entire discharge from the drainage basin above the dam during periods of excessive runoff. The spillway shall be located in stable material and shall discharge at a safe distance from the dam. The vertical distance from the crest of the spillway to the crest of the dam shall not be less than 5 feet. When necessary to provide the minimum free-board required (as specified below) this vertical distance may have to be increased. Unless the spillway is located in well-grassed earth, hard clay, shale, or rock the discharge velocity shall not exceed 3.5 feet per second. In earth this requires that the slope of the control section shall not exceed 0.25 foot per 100 feet. The freeboard (vertical distance between the water surface elevation at maximum discharge and the crest of the dam) shall be not less than 2.5 feet. The following

method shall be used to determine the minimum area of the control section (below maximum high water) based upon a maximum spillway slope of 0.25 foot per 100 feet and an assumed peak runoff of between 0.6 and 0.7 cubic feet per second per acre of drainage area:

Area of spillway control section (earth) in square feet = 0.2 x drainage area in acres.

Where a drainage basin is in hilly or rough country, with steep gradients or rocky ground cover, peak runoffs may considerably exceed those assumed above and the area of the spillway control section should be increased accordingly. If the spillway is located in shale or hard rock formation throughout its length, the cross sectional area of the control section may be reduced by increasing the velocity of discharge. The width of the entrance to the spillway should be one-third wider than the control section and the bottom should slope from this section toward the reservoir at a rate of approximately 1.0 foot per 50 feet.

5. Borrow Pits Borrow pits from which materials are taken shall be cleared of all vegetation and no material shall be borrowed within a distance of 50 feet of any part of the dam. Material excavated from the spillway, outlet works and core trench, when suitable, may be used in constructing the dam.

The above are considered to be the minimum requirements necessary for the construction of satisfactory stock-water dams. However, each structure will be considered upon its own merits. Depending on the magnitude of the structure and the proximity to downstream development, such as houses, roads, bridges, railways, etc., more stringent requirements may be imposed by the State Engineer. Water right filing procedures and the requirement of having a registered professional engineer prepare the plans and supervise construction will remain unchanged.

POWER PROJECTS---A map submitted in connection with a power project shall, in addition to the usual data, contain a statement of the effective head on the turbines, the maximum, minimum and average required flow in second feet and the effective horsepower to be developed.

PLANS---The plans sheets shall cover detailed information of the various works to be constructed, including plan, elevation, cross-section and profile of any dams and spillways with dimensions and construction details shown; also cross-sections, dimension and other pertinent detail of canals, headgates, flumes, siphons, measuring devices, pipelines, etc. All data necessary for the State Engineer to determine the safety and feasibility of the works shall be included.

SPECIFICATIONS---Specifications are usually necessary to supplement the plans of construction, defining and circumscribing the work to be done and the materials to be used. Simple projects involving little or no engineering may require no specifications. Projects of appreciable size or complexity, however, especially those involving contract work, shall be controlled by an adequate set of specifications covering work to be done,

methods of construction, types, qualities and sizes of materials, unit amounts to be used, supervision, inspection, etc. Such specifications should be clear, concise, definite and impartial to both owner and contractor. Arbitrary, unfair, ambiguous or unreasonable requirements should be carefully avoided.

Two copies of the specifications must accompany the formal application, maps and plans, and must receive the approval of the State Engineer. They should be typewritten or mimeographed on one side of legal size paper and firmly bound or clipped together. The project engineer's and the State Engineer's certificates should appear at the front or on the first sheet of the specifications. They shall contain a clause giving the State Engineer authority of inspection during construction and full power to act in the event specifications are not met, unless the appropriator is otherwise specifically exempted by law.

The designing engineer shall prepare detailed estimates of the cost of the construction, which shall be submitted to the State Engineer at the time of filing formal application.

The State Engineer may, in his discretion, waive the requirements for detailed plans and specifications in the case of small direct diversion or storage projects where there is no possibility of the constructed works being a menace to life or property.

CLAIMANT'S CERTIFICATE---A claimant's certificate shall be placed on and made a part of the filing map and shall be signed by the applicant and acknowledged by a Notary Public, using a permanent black India ink for the purpose. An alternate certificate is shown which should be used in case the applicant is a corporation. If the filing map (not including plan sheets) consists of more than one sheet, such certificate should be placed on the first sheet, due reference being made to all succeeding sheets.

ENGINEER'S CERTIFICATES---The qualified registered professional engineer or land surveyor (see Article II, Sec. C, “Surveys---Maps---Plans”) making the survey or under whose direction the survey was made, shall place on the filing map (or first sheet, if more than one) the engineer's certificate, which he shall sign before a notary public. The engineer's license number together with impressions of his seal and that of the notary public shall accompany this certificate.

The registered engineer preparing the plans and specifications shall also place upon the first sheets of the plans and of the specifications, certificates to the effect that they were prepared by him and such certificates shall be signed by him and witnessed by a notary public. The engineer's license number and the impressions of his and of the notary's seals shall accompany these certificates.

STATE ENGINEER'S CERTIFICATES---A certificate form for the State Engineer's approval shall be placed on the first sheet of the filing maps and similar certificates on the first sheet of the plans and of the specifications. These certificates are to be signed by the State Engineer after all necessary corrections or additions, if any, have been

made to the Formal Application, filing maps, plans, etc., and such endorsement is to certify his approval of the adequacy of the works for the proposed use.

B. Map Title, Statements and Affidavits

The following map title and statements shall be placed on and made a part of the filing map. They may be altered somewhat, if required, to fit the individual application.

MAP
of the

_____
(name of ditch, ditch and reservoir, irrigation, power, etc., system)

_____, Applicant
Located in _____County, State of New Mexico.
All courses true Magnetic Variation_____East*

Scale of Map, 1 In. = _____feet.

The undersigned, _____, claimant, whose post office address is _____, County of _____, State of _____has caused to be located by a qualified registered
_____
(professional engineer, land surveyor, or professional engineer and land surveyor)
the _____
(name of ditch, power, irrigation, etc., system)
as hereinafter described and indicated, hereby makes these several statements relative thereto and offers this map (these maps) **and statements for acceptance and filing in compliance with the laws of the State of New Mexico.**

* Include only if magnetic needle courses have been used in making survey.

For direct diversion system or diversion to an off-channel reservoir:

The headgate, which is the point of diversion from _____, from which the works derive their water supply,
(river, creek, spring, arroyo, etc.)
is located in the _____ quarter of the _____ quarter of section _____, Township _____ Range _____, N.M.P.M., (as projected, being on unsurveyed land), **at a point whence the _____ corner of section _____, Township _____, Range _____, bears _____ feet distant.**
(direction) (distance)

For any storage reservoir, for any power or similar project where the water returns to the stream undiminished in quantity, or for the location of any other important point of the works:

The _____ is located in the _____ quarter of the
(see note)
_____ quarter of section _____, Township _____, Range _____, N.M.P.M., (as projected, being on unsurveyed land) **at a point whence the _____ corner of section _____, Township _____, Range _____, bears _____ feet distant.**
(direction) (distance)

(Note: Use the following: (a) "outlet gate from the reservoir (or lake)"; (b) "initial point of the high water line traverse"; (c) "point of return to the stream," in the case of power or similar projects; (d) any other important point to be described and located.)

The main canal, pipeline, etc., from the stream in the case of a direct diversion project or diversion to an off-channel reservoir, and the main canal or canals carrying water to the lands below a reservoir shall be described according to the follow form:

The hydraulic properties of the _____ are as follows:
(name of canal)
bottom width, _____ feet; depth of water at full operating capacity, _____ feet; total depth (maximum water depth plus freeboard), _____ feet; side slopes, _____ horizontal to 1 vertical; diameter (in case of pipeline or circular flume), _____ feet; slope, _____ feet per 1000 feet; hydraulic radius, _____ feet; coefficient of roughness in (see Article VIII "Hydraulic Data"), _____; velocity at full operating capacity (see Article VIII), _____ feet per second; capacity _____ cubic feet per second.

(Note: This form shall be repeated for all main canals or conduits to be described.)

The storage dam or dams shall be described according to the following form:

The _____ has the following properties: maximum height
(name of storage dam)
above foundation, _____ feet; maximum length, _____ feet; maximum width at base, _____ feet; crest width, _____ feet; slope of upstream face, _____ horizontal to 1 vertical; slope of downstream face, _____ horizontal to 1 vertical; elevation (mean sea level or assumed datum) of spillway crest, _____ feet; elevation of bottom of outlet conduit (flow line) at upstream face of dam, _____ feet; _____ vertical distance between top of dam and

elevation to which water will rise when spillway is discharging maximum capacity, _____ feet; width of spillway, _____ feet; discharge capacity of spillway, _____ cubic feet per second. The outlet conduit is _____ (give size and character) **and has a maximum discharge capacity of _____cubic feet per second.**

Following the above, state the type of dam (arch, gravity, hollow arch, etc.), the construction material (concrete, masonry, earth and rock, etc), and the type of impermeable core or cut-off wall preventing percolation thru the dam.

The following area and capacity table shall follow the dam description:

Elevation (sea level or assumed datum), or Depth above Bottom of Outlet	**Water Surface Area, Acres**	**Cumulative Live Storage Capacity Acre-feet.**
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Dead storage (if any) below reservoir flow-line equals _____acre-feet.

Note: The first line shall show the water surface area at reservoir flow-line; the second line shall show area and capacity at the first contour above flow-line (may be an odd interval); the third and following lines shall show area and capacity at succeeding contour intervals; the last line shall show maximum live storage capacity at spillway crest elevation, unless automatic gates are placed in the spillway section for additional storage, in which case the last line shall show the maximum live storage at the tip of spillway gates.

The estimated cost of _____ is $_____
(canal or conduit)

(Repeat for each canal, lateral, etc.,in system)

The estimated cost of _____ is $_____
(storage or diversion dam)

(Repeat for each dam in system)

Total estimated cost of the works is $_____

The area to be irrigated consists of _____acres located and described by legal sub-division as follows:

Ownership	Sub-division	Sec.	Twp.	Rge.	Acreage
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

The efficient but not excessive duty of water in this area is _____acre feet per acre delivered on the land, claim for which is hereby made for irrigation purposes.

(Note: For appropriation of water for other proper purposes than irrigation, the above statements should be altered or revised to fit individual requirements.)

Following is the Dam Owner's certificate, to appear on the first sheet of the filing maps:

State of_____)
)ss.
County of_____)

I, _____, being first duly sworn, upon my oath, state that I have read and examined the accompanying map and statements (maps and statements consisting of _____ sheets) and know the contents thereof and representations thereon, and state that the same are true to the best of my knowledge and belief.

_____
Dam Owner.

Subscribed and sworn to before me this _____ day of _____, 20___.

_____
Notary Public.

My commission expires_____(SEAL)

If the Dam Owner is a corporation use the following:

State of_____)
)ss.
County of_____)

I, _____, being first duly sworn, upon my oath, state that I am the _____ (Officer) **of the _____, a corporation duly organized under the laws of the State of _____, that the accompanying map and statements (maps and statements consisting of _____ sheets) were made under authority of the Board of Directors of said corporation, and that, in their behalf, I have read and examined the statements and representations thereon and state that the same are true to the best of my knowledge and belief.**

_____
Dam Owner.

By_____

Subscribed and sworn to before me this _____ day of _____, 20___.

_____
Notary Public.

My commission expires_____ (SEAL)

Following is the engineer's certificate to be placed on the first sheet of the plans and the first sheet of the specifications:

State of New Mexico_____)
)ss
County of_____)

I, _____, being first duly sworn, upon my oath state that I am a registered professional engineer (or professional engineer and land surveyor), qualified in _____ engineering, and that the
(civil, mining, hydraulic, etc.)
accompanying _____ consisting of _____ sheets were
(plans, specifications)
prepared by me and are true and correct to the best of my knowledge and belief.

_____
Registered Professional Engineer (and Land Surveyor)

License No. _____ (SEAL)

Subscribed and sworn to before me this _____ day of _____, 20___.

_____

Notary Public.

My commission expires_____(SEAL)

Following is the surveyor's or engineer's certificate to be placed on the first sheet of the filing maps:

State of New Mexico_____)
)ss
County of_____)

I, _____, being first duly sworn, upon my oath state that I am the registered professional engineer and land surveyor (or registered professional engineer, or registered land surveyor) who made the map(s) of the _____ that such map was (maps consisting of _____
(name of irrigation or other system)
sheets were) prepared from field notes of actual surveys made by me or under my direction and that the same are true and correct to the best of my knowledge and belief.

_____
Registered Professional Engineer and/or Land Surveyor

License No. _____ (SEAL)

Subscribed and sworn to before me this _____ day of _____, 20___.

_____
Notary Public.

My commission expires_____(SEAL)

The State Engineer's approval of the filing maps, to appear on the first page thereof, follows:

State of New Mexico_____)
)ss
County of_____)

I hereby certify that the accompanying map(s) and statements have been examined by me and approved as to form and content, and were duly accepted for filing on the _____ day of _____, 20___.

_____
State Engineer.

The State Engineer's approval to be placed on the first sheets of the plans and the first sheet of the specifications, follows:

State of New Mexico_____)
)ss
County of_____)

I hereby certify that the accompanying _____ have been (plans, specifications)
duly examined by me and approved as to form and content, and were duly accepted for filing on the _____ day of _____, 20___.

_____
State Engineer.

VII. FEES

The State Engineer shall receive the following fees, to be paid by him into the general fund:

(a) For filing notice of intention to make formal application for permit to appropriate surface water, twenty-five dollars ($25.00), which shall be paid at the time of filing notice of intention.

(b) For filing a formal application for permit to appropriate water where the project is chiefly for diversion and direct use of the water, twenty-five dollars ($25.00) if the amount claimed does not exceed five (5) cubic feet of water per second, and five dollars ($5.00) for each cubic foot per second in excess of five (5); or if the project is chiefly for storage of excess and flood waters, ten dollars ($10.00) for each one thousand (1000) acre-feet or fraction thereon of storage capacity; or, if the project is for power purposes only, in which the water is returned to the river bed in substantially undiminished quantity, twenty-five dollars ($25.00), if the amount claimed does not exceed five (5) cubic feet of water per second, and one dollar ($1.00) for each cubic foot per second of time in excess of five (5); provided, however, that if application for permit is preceded by a notice of intention, the fee accompanying the notice of intention shall be applied on the subsequent fees. Fees included under this paragraph, which shall be paid to the State Engineer at the time of filing formal application for permit, shall include the filing of maps, plans, specifications, field notes, proof of publication and all other papers relating to the application, up to the issuing of the permit to appropriate water, and shall include the examination and study of all data therein with the exception of plans and

specifications, for the examination and study of which additional fees shall be collected as prescribed in this article.

(c) For examining in connection with any water right application the plans and specifications for a dam, two dollars ($2.00) for each one thousand dollars ($1,000) or fraction thereon of the estimated cost of such dam; for examining the plans and specifications for a canal or other water conduit, twenty-five dollars ($25.00), where the capacity does not exceed fifty (50) cubic feet of water per second, and ten dollars ($10.00) for each additional fifty (50) cubic feet per second or fraction thereof, the fees shall be paid to the State Engineer before he issues the permit to appropriate water; provided that no fee shall be paid for examining plans and specifications submitted by the United States or any agency or department of the United States.

(d) For issuing any certificate of construction or license to appropriate, twenty-five dollars ($25.00).

(e) For issuing a permit for an extension of time, fifty dollars ($50.00).

(f) For issuing any miscellaneous water right instrument or copy of any water right document filed in his office, one dollar ($1.00) for the first page thereof, and fifteen cents ($.15) for each additional page thereof.

(g) For filing any other paper necessarily forming a part of the permanent record of the water right application, permit or license, one dollar ($1.00).

(h) For a contact reproduction of any map or plan sheet accompanying an application for permit to appropriate water, three dollars ($3.00) for each sheet; for a negative of any map or plan sheet suitable to reproduce copies thereof, five dollars ($5.00) for each sheet.

(i) For inspecting dam sites, dams, irrigation systems or other construction work as required by law, one hundred dollars ($100.00) per day and actual and necessary traveling expenses. Fees for any inspection deemed necessary by the State Engineer and not paid on demand shall be a lien on any land or other property of the owner of the works and may be recovered by the State Engineer in any court of competent jurisdiction.

(j) For such other work as may be required of his office, such reasonable fees as in the judgment of the State Engineer the character and extent of the work justifies.

APPLICATION FOR PERMIT TO CONSTRUCT AND OPERATE A DAM, CHANGE OF OWNERSHIP OF A DAM, AND PROOF OF COMPLETION OF WORKS

File Number: _____
National ID Number: _____

NEW MEXICO OFFICE OF THE STATE ENGINEER
APPLICATION FOR PERMIT
TO CONSTRUCT AND OPERATE A DAM

1. OWNER:

Name: _____ Work Phone: _____

Title: _____ Home Phone: _____

Address: _____

_____

City: _____ State: _____ Zip: _____

2. PURPOSE: _____

3. HAZARD POTENTIAL CLASSIFICATION: _____

4. LOCATION:

A. ____1/4 ____1/4 ____1/4 Section:____ Township:____ Range:____ N.M.P.M.
in _____ County.

or X = _____ feet, Y = _____ feet, N.M. Coordinate System
_____ Zone Datum of _____ in the _____ Grant.

B. Latitude: ____ Degrees ____ Minutes ____ Seconds
Longitude: ____ Degrees ____ Minutes ____ Seconds

C. On land owned by: _____

D. Source of Water Supply:

a. Name of Surface Watercourse: _____ Tributary of _____

b. Name of Groundwater Basin: _____

c. Name of Ditch or Spring (Off Channel Dams): _____

E. Distance to the nearest downstream City/Town (miles): _____

5. DRAINAGE AREA AND PRECIPITATION CHARACTERISTICS:

A. Drainage area: _____ acres and _____ square miles

B. 100-year, _____ hour precipitation: _____ inches

C. Volume of runoff from the 100-year, _____ hour storm: _____ acre-feet

D. Peak runoff from the 100-year, _____ hour storm: _____ cubic feet/second

E. Probable maximum precipitation (PMP), _____ hour storm: _____ inches

F. Volume of runoff from the PMP, _____ hour storm: _____ acre-feet

G. Peak runoff from the PMP, _____ hour storm: _____ cubic feet/second

H. Peak runoff of the Spillway Design Flood (SDF): _____ cubic feet/second

I. SDF is _____ % of the PMF

File Number: _____
National ID Number: _____

NEW MEXICO OFFICE OF THE STATE ENGINEER
APPLICATION FOR PERMIT
TO CONSTRUCT AND OPERATE A DAM

6. PROPERTIES OF DAM AND RESERVOIR:

A. Length of dam: _____ feet;
B. Crest width (or thickness): _____ feet;
C. Base thickness: _____ feet;
D. Height of dam: _____ feet;
E. Structural height: _____ feet;
F. Elevation of the crest of dam: _____ feet;
G. Slope of upstream face: _____ horizontal to 1 vertical;
H. Slope of downstream face: _____ horizontal to 1 vertical;
I. Volume of dam: _____ cubic yards;
J. Type of dam: _____
K. Dead storage capacity: _____ acre-feet;
L. Reservoir storage capacity: _____ acre-feet;
M. Maximum storage capacity: _____ acre-feet;
N. Design water level elevation: _____ feet;
O. Reservoir surface area at reservoir storage capacity: _____ acres
P. Stage/Area/Storage capacity (to the crest of dam):

Elevation or depth above outlet (Feet)	Area of Water Surface, (Acres)	Storage Capacity (Acre Feet)
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

7. PROPERTIES OF OUTLET CONDUIT:

A. Outlet conduit is: _____ (give size and material);
B. Length of conduit: _____ feet;
C. Slope of conduit: _____ percent
D. Manning coefficient: _____ ;
Q. Maximum discharge capacity (at crest of dam): _____ cfs;
R. Elevation of upstream end of the invert of the outlet conduit: _____ feet;
S. Size, Type and Number of Gates: _____;
T. Time to empty the reservoir: _____ hours or _____ days.

File Number: _____
National ID Number: _____

NEW MEXICO OFFICE OF THE STATE ENGINEER
APPLICATION FOR PERMIT
TO CONSTRUCT AND OPERATE A DAM

8. PROPERTIES OF SPILLWAY:

A. Spillway is: _____ (give type and material);
B. Location: _____;
C. Discharge coefficients:_____ (dependent on type);
D. Effective length: _____ feet;
E. Discharge capacity (at design water level): _____ cfs;
F. Maximum discharge capacity (at top of dam): _____ cfs;
G. Spillway crest elevation: _____ feet;
H. Freeboard _____ feet;

9. ADDITIONAL STATEMENTS OR EXPLANATIONS:

_____

_____

_____

10. ESTIMATED COST:

Dam and appurtenances...$ _____
Other Constructed works.....$ _____
Total Cost.....$ _____

11. CONSTRUCTION DATES:
ESTIMATED DATE TO BEGIN CONSTRUCTION: _____
ESTIMATED DATE TO COMPLETE CONSTRUCTION: _____

12. Dam will be constructed under the supervision of: _____
(License No.)

13. ACKNOWLEDGEMENT FOR DAM OWNER

I,_____ affirm that the foregoing statements are true to the best of my
(Please Print)

knowledge and belief. I fully understand the responsibility and liability related to dam ownership.

By: _____
(Signature) **(Date)**

Subscribed and sworn to before me this _____ day of _____, 20___.

_____.
Notary Public

My commission expires _____(SEAL)

File Number: _____
National ID Number: _____

NEW MEXICO OFFICE OF THE STATE ENGINEER
APPLICATION FOR PERMIT
TO CONSTRUCT AND OPERATE A DAM

ACTION OF STATE ENGINEER

This application to construct and operate a dam is approved provided it is not exercised to the detriment of any others having prior, valid and existing rights to the use of waters of this stream system or groundwater basin and further provided that:

_____
_____
_____
_____
_____
_____
_____
_____

Witness my hand and seal this _____ day of _____, 20___.

State Engineer

By: _____

INSTRUCTIONS

This form shall be filed in triplicate, with original signatures on each form and accompanied by plans, specifications, design report, etc. and filing fee of $10.00 for the application and plan review fee of $2.00 per $1000 of construction cost for dam and appurtenances.

File Number and National ID Number provided by Office of the State Engineer. Refer to the Dam Safety Design and Operation Criteria for definitions and choices.

Section 1 Fill in the blanks.
Section 2 Fill in the blank. See Glossary of Terms - Purpose.
Section 3 Fill in the blank. See Table 1.
Section 4 Information for Parts A through E required.
Section 5 Low Hazard Potential Dams fill in Parts A through D and I. Significant and High Hazard Potential Dams fill in Parts A and E through I.
Section 6 Fill in all blanks. See Glossary of Terms.
Section 7 Fill in all blanks. Flood Control Dams fill in hours. Storage Dams fill in days.
Section 8 Fill in all blanks. See Glossary of Terms.
Section 9 Fill in if necessary.
Section 10 Fill in the blank. A detailed estimate is required with the submittal.
Section 11 Fill in the blanks.
Section 12 Fill in the blank. Qualifications of the N.M. Professional Engineer with experience in dam construction are required.
Section 13 Dam Owner's Signature and Notary Public seal are required.

File Number: _____
National ID Number: _____

NEW MEXICO OFFICE OF THE STATE ENGINEER
CHANGE OF OWNERSHIP OF A DAM

1. OWNER OF RECORD

Name: _____ Work Phone: _____

Title: _____ Home Phone: _____

Address: _____

_____

City: _____ State: _____ Zip: _____

NEW OWNER

Name: _____ Work Phone: _____

Title: _____ Home Phone: _____

Address: _____

_____

City: _____ State: _____ Zip: _____

2. OWNER CERTIFICATION

State of _____)
) ss.
County of _____)

I, _____ being first duly sworn, upon my oath, state that I am the owner of _____ Dam and I recognize that this Dam is under the jurisdiction of the State Engineer; I recognize the responsibility and liability of dam ownership; and all that is shown hereon is done with my free consent and in accordance with my wishes and state that the same are true to the best of my knowledge and belief.

_____
Owner

Subscribed and sworn to before me this _____ day of _____, 200__.

_____.
Notary Public

My commission expires _____(SEAL)

3. ACTION OF STATE ENGINEER

This Change of Ownership form is hereby accepted for filing. The acceptance by the State Engineer Office does not constitute validations of the right conveyed.

_____

File Number: _____
National ID Number: _____

NEW MEXICO OFFICE OF THE STATE ENGINEER
CHANGE OF OWNERSHIP OF A DAM
FOR CORPORATIONS OR POLITICAL SUBDIVISIONS

1. OWNER OF RECORD

Name: _____ Work Phone: _____

Title: _____ Home Phone: _____

Address: _____

_____

City: _____ State: _____ Zip: _____

NEW OWNER

Name: _____ Work Phone: _____

Title: _____ Home Phone: _____

Address: _____

_____

City: _____ State: _____ Zip: _____

2. OWNER CERTIFICATION

State of _____)
) ss.
County of _____)

I, _____ , being first duly sworn, upon my oath, state that I am the _____(Officer) of the _____, a _____ (corporation or political subdivision) duly organized under the laws of the State of _____, that the _____ (corporation name or political subdivision name) is the owner of _____ Dam, and that, in their behalf, I recognize that this Dam is under the jurisdiction of the State Engineer; I recognize the responsibility and liability of dam ownership; and all that is shown hereon is done with their free consent and in accordance with their wishes and state that the same are true to the best of my knowledge and belief.

_____
Representative, Title

Subscribed and sworn to before me this _____ day of _____, 200__.

_____.
Notary Public

My commission expires _____(SEAL)

3. ACTION OF STATE ENGINEER

This Change of Ownership form is hereby accepted for filing. The acceptance by the State Engineer Office does not constitute validations of the right conveyed.

_____

OSE File Number: _____

NEW MEXICO OFFICE OF THE STATE ENGINEER
PROOF OF COMPLETION OF WORKS
(SURFACE WATERS)

1. PERMITTEE

Name: _____ Work Phone: _____
Contact: _____ Home Phone: _____
Address: _____
_____
City: _____ State: __ Zip: _____

2. POINT OF DIVERSION (A, B, C, or D required, E or F if known)

A. ____1/4 ____1/4 ____1/4 Section:____ Township:____ Range:____ N.M.P.M.
in _____ County.

B. X =_____ feet, Y = _____ feet, N.M. Coordinate System
_____ Zone in the _____ Grant.
U.S.G.S. Quad Map _____

C. Latitude: _____d _____m _____s Longitude: _____d _____m _____s

D. East _____ (m), North _____ (m), UTM Zone 13, NAD __ (27 or 83)

E. Tract No. _____, Map No. _____ of the _____ Hydrographic Survey

F. Lot No. _____, Block No. _____ of Unit/Tract _____ of the
_____ Subdivision recorded in _____ County.

G. Other: _____

H. Give State Engineer File Number if existing well: _____

I. On land owned by (required): _____

J. Source of surface water supply:
a. Name of ditch, acequia, or spring: _____
b. Stream or water course: _____
c. Tributary of: _____

3. CONSTRUCTED WORKS CONSIST OF:

(Enumerate Diversion dams, main canals, headgates, pipelines, flumes,
reservoirs, laterals, etc.)_____
_____
_____

File Number: _____ Trn Number: _____

OSE File Number: _____

NEW MEXICO OFFICE OF THE STATE ENGINEER
PROOF OF COMPLETION OF WORKS
(SURFACE WATERS)

4. DIVERSION DAM (if applicable)

The diversion dam is constructed of _____;
Crest length _____ feet; Crest width _____ feet;
Height above stream bed _____ feet; Depth below stream bed _____ feet;
Side slopes of _____ horizontal to 1 (one) vertical on upstream face
And _____ horizontal to 1 (one) vertical on downstream face;
And contains about _____ cubic yards of material.

5. HYDRAULIC PROPERTIES OF MAIN CANAL OR PIPELINE (if applicable)

Name of ditch _____ ;
Bottom width _____ feet;
Depth of water at full operating capacity _____ feet;
Side slopes _____ horizontal to 1 (one) vertical;
Diameter (pipe line or circular flume) _____ feet;
Type of pipe line _____;
Slope _____ feet per 1000 feet; Capacity _____ cubic feet per second;
Length of canal or pipeline _____ feet.

6. HYDRAULIC PROPERTIES - STORAGE DAM (if applicable)

Maximum storage capacity _____ acre feet;
Maximum height above downstream toe _____ feet; length of crest _____ feet;
Maximum width at base _____ feet; Crest width _____ feet;
Slope of upstream face _____ horizontal to 1 (one) vertical;
Slope of downstream face _____ horizontal to 1 (one) vertical;
Elevation of crest of dam _____ feet; Elevation of spillway crest _____ feet;
Elevation of flow line of outlet conduit _____ feet;
Freeboard (above high water line at maximum spill) _____ feet;
Width of spillway _____ feet;
Discharge capacity of spillway _____ cubic feet per second;
Location of spillway: _____;
Cross-sectional area at maximum flow: _____ square feet;

Size and character of outlet conduit _____
_____;

Type of dam, construction material, etc. _____
_____
_____

Elevation or (feet) depth above outlet	Area of Water Surface, (Acres)	Storage Capacity (Acre Feet)	Remarks
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

File Number: _____ Trn Number: _____

OSE File Number: _____

NEW MEXICO OFFICE OF THE STATE ENGINEER
PROOF OF COMPLETION OF WORKS
(SURFACE WATERS)

7. CONSTRUCTION OF WORKS WAS COMPLETED: _____
(mm/dd/year)

8. ADDITIONAL STATEMENTS OR EXPLANATIONS:

_____
_____
_____
_____
_____
_____
_____
_____
_____

ENGINEER'S CERTIFICATE

State of New Mexico

County of _____

I,_____ state that I am a qualified registered professional engineer, that I have inspected the works as above set forth and find them to be completed in accordance with the foregoing statement of facts; that they are properly and safely constructed and are now in a satisfactory condition for acceptance.

(Engineer's Seal)

Signed: _____

License No.: _____

ACKNOWLEDGEMENT FOR NATURAL PERSONS

(I, We) _____ affirm that the
(Please Print)
foregoing statements are true to the best of (my, our) knowledge and belief.

_____ _____.
Permittee Signature Permittee Signature

File Number: _____ Trn Number: _____

APPENDIX C

SUBMITTAL REQUIREMENTS FOR AN APPLICATION TO CONSTRUCT AND OPERATE A DAM

Office of the State Engineer
Engineering Review Project Check List
I. Design Report

Applicant: **File No.:**

I. Design Report	YES	NO	N/A
1. Design Report is stamped and signed by a NM Professional Engineer			
Hydrologic			
2. Hazard Classification including justification and supporting documentation			
3. Drainage Area tributary to a proposed reservoir			
4. Hydrologic Calculations, summary table, discussion of input parameters & assumptions			
5. Inflow and Outflow Hydrographs			
6. Hydraulic calculations including engineering data used to determine the capacities of the spillways and outlet conduits, stage/discharge			
7. Stage/Storage Curve or Table			
8. Flood control dam ungated and drains within 96 hours			
Geotechnical			
9. Geologic Investigation of dam site and reservoir basin			
10. Boring logs, geologic cross-sections, location and logs of test pits			
11. Laboratory testing and analysis of data			
12. Seepage Analysis			
13. Stability Analysis both static and dynamic, input and output listings, name of computer model			
14. Internal drainage design including instrumentation to monitor the drainage system, filter design to protect against piping			
15. Foundation treatment and abutment contact design			
16. Dam Geometry and Freeboard			
Other Design Elements			
17. Erosion control			
18. Instrumentation			
19. Designer's Operating Criteria			
20. Operation and Maintenance Manual			
21. Emergency Action Plan (required for high and significant hazard dams)			

Signature: _____ Date: _____

Office of the State Engineer
Engineering Project Review Checklist
II. Construction Drawings

Applicant: **File No.:**

II. Construction Drawings	YES	NO	N/A
1. Map Quality, Scale and Size (Mylar sheets 24"x36" with one inch margins on all sides)			
2. Filing sheet separate from detail sheets.			
3. Title (Filing) sheet, Map title and statements shown on the filing sheet			
4. Engineer's Certification and Engineer's stamp or seal on the filing sheet			
5. Owner's Certification including acknowledgement by a Notary Public			
6. State Engineer's Certificate			
7. Vicinity Map			
8. Direction of North			
9. Site Topography of the dam site including sufficient area up and downstream and at the abutments			
10. Flood and Maintenance Right of Way Map showing all ROW easements			
11. Reservoir Area – Capacity Curve or Table			
12. Outlet Conduit and Spillway Rating Curve or table showing elevation vs. Discharge capacity			
13. Geologic information with Profile			
14. Dam Profile along the centerline showing the existing ground, foundation profile and proposed finished grade elevations			
15. Dam Sections a sufficient number of cross-sections and the maximum section and along the outlet works			
16. Outlet Works plan, profile and details of the outlet works including intake structure, gate system conduit details, trashrack, filter diaphragm, concrete encasement details and downstream outlet structure, minimum size of 18"			
17. Spillway plan, profile, control section and cross-sections.			
18. Permanent Bench Mark above high water line			
19. Outlet works tied to public survey corner			

Signature: _____ Date: _____

Office of the State Engineer
Engineering Project Review Checklist
III. Specifications and IV. Other

Applicant: **File No.:**

III. Specifications	YES	NO	N/A
1. Engineer's Certification and Seal			
2. State Engineer's Certificate			
3. Statement Recognizing State Engineer's Authority			
4. Earthwork Specification includes all material descriptions, placement criteria, and construction requirements.			
5. Foundation Specification includes depths, acceptable material criteria, cleaning, and grouting requirements			
6. Concrete, Grout and Shotcrete Specifications			
7. Quality Assurance/Quality Control			
8. Control of Stream During Construction			
9. Blasting, Dust Control or Other Environmental Protection Requirements			
IV. Other			
10. Cost Estimate			
11. Completed Application for Permit in triplicate with original signature by owner			
12. Filing Fee and plan review Fees			

Signature: _____ Date: _____

APPENDIX D

OPERATION AND MAINTENANCE MANUAL

For

_____ Dam

State ID Number _____

National ID Number _____

Date _____

Owner/Operator: _____

Address: _____

Phone No.: _____

1st Revision: _____

2nd Revision: _____

3rd Revision: _____

CERTIFICATIONS

Owner Certification

The O&M Manual and each revision shall include the following owner certification:

State of _____)
) ss.
County of _____)

I, _____, being first duly sworn, upon my oath, state that I have read and examined the Operation and Maintenance Manual and know the contents thereof and representations thereon, and all that is shown hereon is done with my free consent and in accordance with my wishes and state that the same are true to the best of my knowledge and belief.

_____
Owner

Subscribed and sworn to before me this _____ day of _____ , 20___.

_____
Notary Public

My commission expires _____ (SEAL)

If a claimant is a corporation, political subdivision or other governmental entity the following shall be used:

State of _____)
) ss.
County of _____)

I,_____ , being first duly sworn, upon my oath, state than I am the _____ (officer) **of the_____**, **a corporation duly organized under the laws of the State of _____**, **that the accompanying Operation and Maintenance Manual was made under authority of the Board of Directors of said Corporation, and that, in their behalf, I have read and examined the statements and representations thereon and all that is shown hereon is done with their free consent and in accordance with their wishes and state that the same are true to the best of my knowledge and belief.**

_____
Representative, Title

Subscribed and sworn to before me this ____day of _____ , 20___.

_____
Notary Public

My commission expires _____ (SEAL)

Engineer Certification

The O&M Manual and each revision shall include the following engineer certification:

State of _____)
) ss.
County of _____)

I , _____, hereby certify that I am a registered professional engineer, qualified in _____ (civil, geotechnical, etc.) **engineering and that the accompanying Operation and Maintenance Manual was prepared by me or under my direction, and that the same are true and correct to the best of my knowledge and belief.**

_____
Registered Professional Engineer

License Number _____

Date Submitted _____ Certification shall be stamped.

State Engineer Certification

The O&M Manual and each revision shall include the following State Engineer certification:

State of New Mexico)
) ss.
County of Santa Fe)

I hereby certify that the accompanying Operation and Maintenance Manual has been duly examined by me and accepted for filing on the _____ day of_____, 20___.

_____
State Engineer

TABLE OF CONTENTS

Title Page

Certifications

Table of Contents

General Information

- Purpose of the Dam and Reservoir
- Location and Access to the Dam
- Project History
- Assignment of Responsibilities
- Description of the Dam and Appurtenances

Project Operation

- Reservoir Operation
- Control Mechanisms and Other Equipment

Instrumentation and Monitoring

Maintenance

Inspection

Updates and Revisions

Appendices

- Designer’s Operating Criteria
- Instrumentation Plan
- Inspection Checklists

GENERAL INFORMATION

Purpose of the Dam and Reservoir

Explain the purpose of the dam and reservoir. For projects with more than one purpose, the primary purpose is listed with secondary purposes listed in order of importance.

Location and Access to the Dam

Provide a description of the stream on which the dam is located, the name of the county the dam is located in and the distance to the nearest town. Provide traveling directions to the site during both normal and flood conditions. A location map shall be included.

Project History

Provide a brief description of the history of the dam and reservoir including design engineer, construction engineer, contractor, original construction period and dates of modifications or major repairs. Describe State Engineer Orders or directives concerning the dam and the performance of the dam during any significant event such as flooding or earthquake.

Assignment of Responsibilities

Identify all areas of responsibility for the project and the specific personnel responsible for completing each assignment. This section shall also identify a Professional Engineer licensed in New Mexico that is available to advise the owner as needed. Areas of responsibility shall at a minimum include the following:

- Overall safety of the dam
- Operation of equipment
- Maintenance
- Collecting and Recording Instrumentation Data
- Evaluation of Instrumentation Data
- Submittal to State Engineer
- Engineer (Include Firm, address and phone number)

Description of the Dam and Appurtenances

All major project features shall be identified and the data shall be provided in tabular form. The following information shall be furnished if applicable:

Dam
- Type
- Height
- Crest Elevation
- Crest Length
- Crest Width
- Upstream Slope (H:V)
- Downstream Slope (H:V)

Reservoir
- Drainage Area
- Capacity at Spillway Crest (Provide separate tabulation for each spillway)
- Surface Area at Spillway Crest
- Maximum Elevation of SDF
- Dead Storage Capacity
- Dead Storage Elevation
- Reservoir Gage
- Sediment in Storage (if known)
- Sediment Storage Rate (if known)
- Date of most recent last area-capacity survey (if none, use original date)

Spillway (Provide separate tabulation for each spillway)
- Type (Include description of gates or other controls if applicable)
- Location
- Crest elevation
- Effective Length
- Discharge Capacity
- Maximum Discharge at SDF

Outlet Works
- Location
- Type of Intake
- Conduit size and material
- Invert Elevation
- Flow Controls (Size, type and location of gates)
- Type of Terminal Structure and Energy Dissipation Device
- Reservoir gage type(s)

PROJECT OPERATION

Reservoir Operation

A Reservoir Operation Section provides instruction to dam operators for both normal and emergency operations. An operating log shall be maintained to indicate the dates and times of operations (beginning and ending), adjustments, problems encountered and other data or observations as may be needed for the particular dam.

The first step in developing a reservoir operation plan is to determine and define what constitutes both normal operations and emergency operations, then procedures are developed for both situations. Procedures for both situations shall include the following minimum elements:

- Schedule of reservoir filling including maximum and minimum rates
- Release procedures (can vary with the season) including maximum and minimum rates
- Maximum storage level and drawdown limits
- Reservoir capacity allocations

Control Mechanisms and Other Equipment

The Control Mechanisms and Other Equipment Section provides equipment-operating instructions for all mechanisms associated with the dam and appurtenances. Step-by-step instructions for seasonal start up and shut down shall be included. Details on the correct method to open and close gates, proper sequence and gate usage shall be identified. Instructions for operating all equipment associated with the dam shall be included. This section shall also contain manufacturer-furnished operating and maintenance instructions, test procedures, shop drawings, catalog cut sheets, parts lists and replacement part sources.

INSTRUMENTATION AND MONITORING

Instrumentation at a dam provides critical data to evaluate the performance of the dam and identify potential problems. Dams with an Instrumentation Plan prepared during the design phase shall incorporate the recommendations in the instrumentation plan or provide justification why recommendations are not feasible. Minimum elements of the Instrumentation and Monitoring Plan are as follows:

- General description of instrumentation and a map showing the location of each instrument.
- Specifics for each installation
  - Purpose
  - Detailed description
  - Installations, repair and replacement procedures
  - Reading instructions
  - Maintenance instructions and schedule
  - Interpretation data including action thresholds and response measures up to and including implementing the EAP.
- Data submittal requirements to the State Engineer

MAINTENANCE

Preventive maintenance is necessary to ensure the dam will perform its intended function. Generally, the Maintenance Plan shall establish tasks, frequency and record keeping requirements. Typical tasks in a Maintenance Plan are as follows:

- Dam, Spillway, Reservoir and Outlet Channel
  - Woody vegetation control
  - Animal penetrations
  - Erosion
  - Concrete and metal protection
  - Unauthorized access
- Outlet Works
  - Exercise schedule
  - Lubrication routine for valves
  - Scheduled replacement of components
- Miscellaneous Maintenance Instructions

INSPECTION

Routine inspections by the dam owner are essential for timely identification of potential problems in order to maintain a safe dam. Minimum inspection frequency by the dam owner is monthly for water storage dams and after each large storm event but not less than every 3 months for flood control dams with no permanent pool. Site specific conditions may require a more frequent inspection schedule. Inspection forms shall be included in the Appendix.

Recommended inspection frequency of the interior of the outlet conduit by a Professional Engineer registered in New Mexico with experience in the operation of dams is every 5 years. Site-specific conditions may require a more frequent inspection schedule.

UPDATES AND REVISIONS

The O&M Manual shall be reviewed at least annually for updating needs. Generally, updates are required if there are changes of personnel, equipment or equipment operation, operation instructions, upstream or downstream conditions that require reservoir operation changes, contacts or procedures, or modification of the dam or its appurtenances. Revisions shall be submitted to the State Engineer for review and approval.

APPENDICES

The Appendices shall include any addition information needed to support the . The Designer's Operating Criteria and Instrumentation Plan prepared during the design phase shall be included in the Appendices along with Inspection Checklists.

Designer's Operating Criteria

The Designer's Operating Criteria (DOC) is prepared by the design engineer to ensure the dam and appurtenances are operated within any restrictions imposed by the design. All new dams are required to submit a DOC concurrent with the submittal of an Application to Construct and Operate a Dam. The DOC is a critical element of an O&M Manual, and is required for dams having Significant and High Hazard Potential Classification.

It is recognized that some existing dams may not have a DOC. If a dam has no prior-existing DOC, this shall be clearly stated in the O&M Manual. Any modification of the dam, mechanical equipment or appurtenances requiring approval from the State Engineer shall require the development of a DOC for the modification, including effects or limits that the modification may impose on existing structures or mechanical equipment that remain in service.

The DOC for a proposed dam shall be submitted concurrently with the Application to Construct and Operate a Dam. Each DOC shall be developed specifically to address the actual facility and conditions for operation. The following outline for the DOC is provided for general guidance.

DOC Title Page

Table of Contents

I. General Description

II. Dam Properties

III. Reservoir

- A. Storage Allocations
- B. Design Flood and Flood Routings
- C. Emergency Reservoir Evacuation
- D. First Filling Criteria/Monitoring Requirements

IV. Outlet Works

- A. General
- B. Procedures for Operation of Outlet Works
  1. First Operation
  2. Seasonal Startup
  3. Seasonal Shutdown
  4. Installation and Removal of Bulkhead
  5. Operation of Specific Equipment (including purpose, manufacturer, materials of construction, special operating instructions, etc.)
  6. Electrical Systems and Controls

V. Spillway

- A. General
- B. Overall Plan of Operation
- C. Maintenance

VI. Instrumentation

- A. General
- B. Purpose
- C. Critical Readings
- D. Reading and Maintenance Procedures
- E. Reading Schedule

VII. Reference List

Appendices (as required)

Instrumentation Plan

An Instrumentation Plan provides a means to obtain data necessary to evaluate the performance of a dam. Generally, the dam design shall incorporate sufficient instrumentation to monitor horizontal and vertical movement of the dam and significant structures, seepage, and reservoir stage. Other instruments, such as piezometers, inclinometers, extensometers, strain gages, plumb lines, tape gages, crack measurement devices, flow gages and seismographs, may be required, depending upon the purpose and design of the specific dam and appurtenant structures.

Frequently, conditions at an existing dam will require installation of new instrumentation or replacement of existing instrumentation. In these cases, an amendment to the instrumentation plan shall be developed, incorporating all new instrumentation as well as any existing instrumentation that remains in service. The O&M Manual shall be updated to reflect the amended instrumentation plan.

The Instrumentation Plan shall: (1) include drawings showing the location of dam monitoring instruments; (2) provide specific information for each type of instrument; (3) establish instrumentation reading procedures and schedules for normal and emergency conditions, (4) provide descriptions of expected performance, and (5) provide instructions for dam operators in the case of a reading or readings that vary from expected performance.

Elements of the instrumentation plan shall be as follows:

- General Description of Instrumentation and Reading Schedule
- Identification of Unexpected Data
- Specifics for Each Installation
    - Detailed Description of Installations
    - Purpose
    - Reading and Maintenance Schedule Instructions
- Special Instrumentation/Monitoring Requirements

Inspection Checklists

Inspection Checklists tailored specifically to the dam are important for documenting observations. The owner for the life of the dam shall retain copies of the inspection checklists.

APPENDIX E

STANDARDIZED FORMAT AND TEXT FOR AN EMERGENCY ACTION PLAN

EMERGENCY ACTION PLAN

For

_____Dam

State ID Number _____

National ID Number _____

Owner/Operator: _____

Address: _____

Prepared By: _____ License No.: _____

Address: _____

Date: _____ (Stamp or Seal)

APPROVALS

_____ _____
State Office of Emergency Management Date

_____ _____
County Office of Emergency Management Date

_____ _____
State Engineer Date

* (The dam owner/operator is responsible for the annual review and updating of the EAP)

1st Revision: _____

2nd Revision: _____

3rd Revision: _____

Table of Contents

Title Page

Cover Page
Table of Contents

I. Notification Flowchart
Notification Information

II. Statement of Purpose
Purpose
Scope

III. Project Description
Project Site Description
Project Site Drawings

IV. Emergency Detection, Evaluation, and Classification
Advisory Condition
Warning Condition
Emergency Condition
Breach Condition

V. General Responsibilities Under the EAP
Dam Owner/Operator Responsibilities
EAP Coordinator Responsibilities
Municipal OEM Responsibilities
County OEM Responsibilities
State OEM Responsibilities
State Dam Safety Agency Responsibilities
Responsibility for Termination
Responsibility for Recovery

VI. Preparedness
Emergency Notification Directory
Emergency Operation Center (EOC)
EOC Location Map
Surveillance Checklist
Access to the Site
Response During Adverse Weather, Weekends, Darkness, or Holidays
Alternative Systems of Communication
List of Contractors
Available On-site Materials
Available On-Site Equipment

Available Off-Site Materials
Available Off-Site Equipment
Other Site Specific Actions

VII. Inundation Maps
Description of Inundated Area
Inundation Maps

VIII. Appendices
Appendix A. Investigations and Analysis of Dambreak Floods
Appendix B. Plans for Training, Exercising, Updating and Posting
Training
Exercising
Updating
Posting
Appendix C. Definitions
Definitions
Appendix D. Site Specific Concerns
Appendix E. Approval and Distribution of the EAP
Approval
Distribution
Standard Distribution Letter & Receipt

I. Notification Flowchart

(Insert Notification flowchart)

Notification Information

Dam emergency information for the emergency classifications

Name of person reporting the emergency: _____

Affiliation: _____

Phone Number: _____

Name & State ID number of dam: _____

Location of dam

County: _____

Municipality: _____

Stream: _____

Road(s): _____

Time and date of dam emergency: _____

Type of Emergency: _____

Phone and appropriate parties: *(refer to the Emergency Notifications Flow Chart)*

"This is (your name, title & affiliation).
There is a dam (Advisory, Warning, Emergency, or Breach) condition at (name of dam).
Observation was at (time).
The situation is (explain the condition).
What is your anticipated time of arrival at the dam and what are my instructions?"
(Refer to Site Description, page X, for directions to the dam)

Communication priority list:

1. Municipal Office of Emergency Management
2. County Office of Emergency Management
3. State Office of Emergency Management
4. State Dam Safety Agency
5. Owner's Engineer

II. Statement of Purpose

Purpose

This plan defines responsibilities and provides procedures designed to identify unusual and unlikely conditions, which may endanger _____ Dam in time to take mitigative action and to notify the appropriate emergency management officials of possible, impending, or actual failure of the dam. The plan may also be used to provide notification when flood releases will create major flooding.

Scope

This Emergency Action Plan:

1. Establishes a monitoring system, which can activate the Plan.
2. Identifies the officials, organizations, agencies, and their respective responsibilities for implementing the plan.
3. Identifies those areas, residences, facilities and roads, which might be affected by a dam failure.

III. Project Description

Project Site Description

Dam Name: _____ Hazard Potential Classification: _____

State ID No.: _____ National ID No.: _____

City/Town: _____ County: _____

Location & Access (provide a location map & directions to the dam from a major highway):

_____

_____

_____

Latitude: _____ Longitude: _____

River/Stream: _____

Quad sheet: _____ Nearest City/Town: _____

Height (ft): _____ Normal Surface (ac): _____

Length (ft): _____ Normal Capacity (ac-ft): _____

Dam Type: _____ Maximum Capacity (ac-ft): _____

Spillway: _____ Spillway Capacity (cfs): _____

Drainage Area: _____

Outlet other than Spillway: _____

Instrumentation (if any): _____

Significant Upstream or Downstream Dams (if any): _____

Overview of Inundation Area: _____

_____

Method of Emergency Drawdown: _____

Project Site Drawings

*Provide/Attach project Site drawings

IV. Emergency Detection, Evaluation, and Classification

This section should discuss the procedures for timely and reliable detection, evaluation and classification of an existing or potential emergency condition. Preventative action shall be addressed for each condition. Suggested emergency classifications are:

Failure is imminent or has occurred
Potential failure situation is developing
Non-failure emergency condition

V. General Responsibilities Under the EAP

Dam Owner/Operator Responsibilities:

1. Identification of the emergency condition.
2. Notification of the State Office of Emergency Management and Office of the State Engineer Dam Safety Bureau. *(Refer to the Emergency Notification Flow Chart)*

Person responsible for the notification: _____

3. Implementation and direction of emergency repairs.
4. Update the emergency status to the State Office of Emergency Management and Office of the State Engineer Dam Safety Bureau.

Person responsible for the updates: _____

5. Provisions for security measures at the dam.
6. Provision of technical assistance to State Office of Emergency Management officials, when necessary.
7. Reporting termination of emergency situation on-site at the dam.

In non-emergency conditions, owner/operator must also provide for:

8. Routine maintenance and operations of the dam.
9. Routine surveillance of the dam.
10. Routine inspection of the dam.
11. Annual review, updating, and distribution of the EAP.

Owner/Operator's EAP Coordinator Responsibility:

Once the dam owner/operator has designated an EAP Coordinator, that person shall be responsible for EAP related activities including:

1. Inclusion and distribution of document revisions.
2. Establish training seminars.
3. Coordinate EAP exercises.
4. Contact person for any EAP related inquiries.

EAP Coordinator Name: _____
Phone Number: _____

Municipal Office of Emergency Management Responsibilities:

1. Warn the public of emergency conditions at the dam.
2. Implement and direct required evacuations of threatened areas.
3. Establish reception centers for evacuated people.
4. Secure and control access to evacuated areas.
5. Conduct rescue and recovery operations as required.
6. Determination and declaration of termination of an emergency/disaster response activity off-site.

County Office of Emergency Management Responsibilities:

1. Pass warning of emergency conditions at the dam to all affected municipalities.
2. Provide assistance to municipalities to help fulfill the emergency responsibilities.

State Office of Emergency Management Responsibilities:

1. Assumption of control and coordination (when appropriate) of all emergency actions in accordance with state statutes.
2. Provision of assistance to the affected municipalities and counties (when requested and beyond their capabilities).
3. Coordination of specialized assistance.
4. Notification of appropriate state agencies.
5. Notification of appropriate counties of any declared emergency condition.
6. Periodic testing of the emergency notification procedures.

Office of the State Engineer Dam Safety Bureau Responsibilities:

1. Provide technical assistance to the dam owner/operator.
2. Evaluation and acceptance of dambreak model and flood inundation map.
3. Assist in the evaluation and resolution of potential emergency conditions.
4. Has the authority to direct the owner/operator to take necessary safety measures.

Responsibility for Termination

The owner/operator is responsible for evaluating a declared emergency condition. The State Engineer is responsible for making the decision, when appropriate, that an emergency condition no longer exists on-site at the Dam. The State Office Of Emergency Management representatives are responsible for declaring termination of an emergency condition off-site. As such, it will be the responsibility of the owner/operator to notify the OEMs of an emergency condition termination promptly.

As part of the termination phase, the County/Municipal OEM will be responsible to conduct a critique of the overall emergency response and to prepare a report documenting emergency procedures and actions. The critique process will be a

discussion of the events that occurred prior to, during, and after a dam emergency. Participants review and evaluate their particular actions. The purpose of the critique is to determine what, if any, practicable improvements could be made for potential future emergencies, and conversely to identify deficiencies in procedures, manpower, materials and equipment.

Responsibility for Recovery

The basic goal of the recovery phase is to demobilize and return to the pre-emergency situation. The owner/operator is responsible for implementing all actions necessary to achieve this goal on-site at the dam. The State Office of Emergency Management has the responsibility to effectuate recovery off-site in the affected communities.

The owner/operator is responsible for directing all on-site recovery activities. The basic recovery actions common to the dam emergency classifications are:

- Secure access to emergency site,
- Restore basic facilities and services, and
- Assess damage.

VI. Preparedness

Emergency Notification Directory

1. Dam Owner: _____

   Contact Person: _____

   Address: _____

   Phone No.: _____ 24-Hr No: _____

2. Dam Operator: _____

   Address: _____

   Phone No.: _____ 24-Hr No: _____

3. EAP Development Crew: _____

   Coordinator: _____

   Phone No.: _____

4. Maintenance and Operations Crew: _____

   Supervisor: _____

   Phone No.: _____

5. Inspectors:

   Name: _____ Phone No: _____

   Name: _____ Phone No: _____

   Name: _____ Phone No: _____

6. Owner's Engineers: _____

   Contact Person: _____

   Address: _____

   Phone No.: _____ 24-Hr No: _____

7. Municipalities:

   Municipality: _____ Phone No.: _____ Police No.: _____

   Municipality: _____ Phone No.: _____ Police No.: _____

8. Counties:

   County: _____ Phone No.: _____ Police No.: _____

   County: _____ Phone No.: _____ Police No.: _____

9. State Agencies:

   Agency: _____ Phone No.: _____ 24 Hr No.: _____

   Agency: _____ Phone No.: _____ 24 Hr No.: _____

Emergency Operation Center (Should be located upstream of the dam)

Address: _____

_____

Direction to the Emergency Operations Center from the nearest State or County Highway:

_____

_____

_____

*Include a location map of the Emergency Operations Center.

Emergency Operations Center Location Map

Surveillance Checklist

The surveillance checklist must be specific to the site conditions of the dam and shall be approved by the State Engineer.

The surveillance checklist should be utilized by the Inspectors listed on the Emergency Notification Directory during their inspections. A record of these inspections and their findings should be kept by the owner/operator for ready reference.

Routine inspection intervals should be specified and individuals responsible for the inspection identified.

Access to the Site

A narrative description of primary and secondary access routes should be included. Attach map if necessary.

Response During Adverse Weather, Weekends, Darkness and Holidays

Supply a discussion of emergency response during periods other than office hours and during periods of adverse weather. Actions should be described in detail. The effects on response time should also be included.

Alternative Systems of Communication

Alternative channels of communication to be used in case of failure of the primary system or failure of other systems immediately available should be listed.

List of Contractors

It is the responsibility of the owner to maintain a current list of contractors that may be contacted during an emergency condition for equipment, materials, and repairs.

For each contractor on the list, the following must be provided:

1. Contractor:

   Contact Person: _____ Phone No.: _____
   Address: _____

   Services contracted for: _____

2. Contractor:

   Contact Person: _____ Phone No.: _____
   Address: _____

   Services contracted for: _____

Available On-Site Materials

Material	Location	Quantity

Available On-Site Equipment

Equipment	Location	Quantity

Available Off-Site Materials

Material	Company & Location	Phone No.	Arrival Time to Dam (min.)

Available Off-Site Equipment

Equipment	Company & Location	Phone No.	Arrival Time to Dam (min.)

Other Site Specific Actions

Describe any other site-specific actions devised to moderate or alleviate the extent of potential emergencies.

VII. Inundation Maps

Description of Inundated Area

_____

_____

_____

_____

Attach map that delineates area of inundation.

The official inundation map attached to the EAP should be, whenever possible, in foldout format, no larger than 11 inches by 17 inches, and provide the most accurate, up-to-date data available. As such, it may be necessary to reduce the map scale once the inundated areas are identified.

VIII. Appendices

Appendix A. Investigations and Analysis of Dambreak Floods

Input data, printouts, and survey information from the dam failure analysis should be included in this section.

Appendix B. Plans for Training, Exercising, Updating, & Posting

The owner of the dam is responsible for the training of personnel, and the exercising and updating of the EAP. The training plan and exercise schedule should be included in this section. The revision schedule and distribution of the EAP should also be discussed. The location of each copy of the EAP and notification flowchart, if posted separately, should be stated in this section.

Appendix C. Definitions

Appendix D. Site Specific Concerns

This section of the appendix should provide a discussion of any site-specific concerns that provide valuable information affecting the EAP. The EAP should emphasize where appropriate structural drawings and flood data are maintained on-site.

Appendix E. Approval and distribution of the EAP

Once the EAP has been developed and approved by local and state emergency officers, the owner/operator shall submit the completed EAP to the State Engineer for approval. Once the State Engineer approves the EAP, the owner must distribute the EAP to all individuals who will be involved during an emergency. Any revisions to the EAP should be furnished to all individuals to whom the original EAP was distributed.

Each party receiving an EAP must sign and return a receipt to the distributor (owner/operator) of the EAP. The signed receipt is to assure that all parties are aware of and understand the EAP and agree to their assigned roles should an emergency occur. A standard distribution letter and receipt is included for reference.

The document holder and location of each copy of the up-to-date EAP should be included in this section of the EAP

Standard Distribution Letter & Receipt

(Date)

(Name of EAP document holder)
(Company or affiliation)
(Mailing address)

Re: EAP for (name of dam) Dam ID No.

Dear (Name of EAP holder):

(Name of the owner/operator) has (prepared or revised) the Emergency Action Plan for (name of the dam) Dam located within (name of township), (name of county). The EAP is a public safety regulatory required document. The (year) revisions are described in the REVISION SUMMARY.

Please insert the new material with the revision date in your controlled copy and remove the obsolete material (the effective dates generally are printed at the lower right corner of the pages). Please acknowledge your receipt of the controlled copy distribution by returning the obsolete pages to the undersigned with the attached acknowledgement, signed and dated.

We appreciate your continued cooperation in the revisions of the EAP. Should you have any recommendations or questions regarding the EAP, please do not hesitate to contact the undersigned.

Sincerely,

(Your Name)
(Affiliation)

I acknowledge receipt of the (revision date) revision to the (name of dam) EAP and have inserted the revision pages in my controlled copy. This EAP will be maintained at the designated location for use in the event of a drill or actual emergency declaration.

Controlled Document holder name: _____ Document No. _____

Signature: _____ Date: _____

NEW MEXICO OFFICE OF THE STATE ENGINEER
Dam Safety Bureau
Hydrologic Analysis for Dams
August 15, 2008

Hydrologic analysis requirements for dams are cited in the Rules and Regulations Governing Dam Design, Construction and Dam Safety, which were filed with the New Mexico State Record Center as Title 19, Chapter 25, Part 12 of the New Mexico Administrative Code (19.25.12 NMAC). Hydrologic analysis shall be performed in accordance with Subsection C of 19.25.12.11 NMAC. The design life of a dam is much longer than the record retention period of most engineering firms and memories of most design engineers. It is important that the analysis stand on its own in a manner that is comprehensible to future engineers who may be involved with the structure. Therefore, the Office of the State Engineer (OSE) requires that the hydrologic analysis be fully documented and supported independent of computer programs or other computational methodology used in the analysis.

Most dams are constructed on a watercourse or have a contributing drainage area upstream from the dam. Intense rainfall creates inflow to the reservoir of the dam, which is routed through the reservoir and allowed to pass the dam through a spillway or multiple spillways. Earlier dams typically were provided with spillways that were sized to pass the largest observed floods. These dams frequently overtopped and failed, and roughly half of all known dam failures have been the result of flood overtopping. During the 20th Century, methods were developed to better evaluate infrequent or extreme flood events, and provide adequate spillway capacity to safely pass these floods. Hydrologic analysis is one of the most important aspects in the design of a safe dam, and will be closely reviewed by the New Mexico Office of the State Engineer (OSE) Dam Safety Bureau.

Presented below is an outline of the typical steps for completing a hydrologic analysis satisfying the requirements outlined in Subsection C of 19.25.12.11 NMAC. In order to facilitate review by the OSE Dam Safety Bureau the hydrologic analysis report must be organized in an easy to follow layout and format. Submittals that are not consistent with this document and the requirements outlined in Subsection C of 19.25.12.11 NMAC will cause a delay in the review by the OSE Dam Safety Bureau and may be returned to the owner with no review provided. Inadequate hydrology submittals may also require review fees to be resubmitted prior to subsequent review by the OSE Dam Safety Bureau.

The following steps are typically required in completing hydrologic analysis for dams for submittal to New Mexico Office of the State Engineer:

1. Determine hazard potential classification for the dam location.
2. Determine appropriate design storm requirements for location.
3. Determine geographic location, limits and area of watershed contributing to dam and reservoir.
4. Divide watershed into subbasins as appropriate, and determine subbasin areas, channel locations for routing, etc.
5. Determine basin or subbasin geometry such as longest flow path for each basin or subbasin, channel slope and cross section, highest and lowest points, basin centroid(s), mean basin elevation, etc. as required for methodology to be used.

6. Determine appropriate timing and routing parameters for the elements in the watershed model.
7. Determine reservoir characteristics including stage-storage and stage-discharge relationships.
8. Develop total watershed model by arranging subbasins, routing reaches, etc. in the proper sequence with appropriate parameters.
9. Derive the precipitation to be used for design.
10. Develop incremental precipitation from depth-duration relationship and arrange increments to create an appropriate temporal distribution of precipitation.
11. Develop spatial distribution of precipitation if appropriate.
12. Determine loss parameters or functions and apply to incremental precipitation.
13. Deduct losses from precipitation increments to estimate precipitation excess.
14. Select an appropriate transform methodology for converting excess rainfall to runoff.
15. Apply the transform methodology to each subbasin using incremental precipitation excess.
16. Add stream base flow, etc., to obtain flood hydrograph for each subbasin.
17. Combine and/or route subbasin hydrographs to determine the inflow design flood.
18. Route flood through reservoir and spillway to obtain estimates of reservoir peak stage, peak outflow, peak storage, flood duration, etc.
19. Review results for reasonableness, comparing to known floods or otherwise calibrating if possible.
20. Adjust model parameters, spillway characteristics, etc. as necessary and appropriate and repeat process.
21. Prepare hydrologic analysis report for OSE review and for the permanent record.

Discussion:

The steps taken in the analysis, along with assumptions made and parameters used, must be fully documented. Documentation requirements are discussed in the final section of this paper. Discussion of each of the steps for performing hydrologic analysis is as follows:

1. Hazard Potential Classification

Hazard Potential Classification is a function of dam location and downstream conditions, and is not a measure of the integrity of the dam or the adequacy of the design. High hazard potential classification applies if loss of life is probable if the dam fails catastrophically. This is usually fairly obvious, based on downstream development conditions. In some cases, breach and flood wave analysis is needed to establish hazard potential classification. If site is not High hazard potential, in most cases it will be Significant, due to substantial risk to property or assets (highways, barns, irrigation ditches, etc.) or potential for significant environmental consequences. Low hazard potential is typically limited to remote, small structures such as ranch ponds for cattle watering and limited irrigation. Flood control dams typically are High or Significant hazard potential, because the need to control flooding suggests life and/or assets being protected downstream. Evaluations for Low or Significant hazard potential dams must consider the potential for future downstream development.

2. Design Precipitation Requirements

Generally, high hazard potential dams require consideration of Probable Maximum Precipitation (PMP). Significant hazard potential dams require consideration of 50% PMP if 100 feet or less in height and having 50,000 acre-feet or less storage, or 75% PMP if greater than 100 feet in height or having over 50,000 acre-feet of storage. For significant hazard potential dams, percentages are applied to precipitation prior to hydrologic analysis. Low hazard potential dams require consideration of 100-year storm, expressed as a percentage of PMP. Therefore, most dams will require evaluation of PMP. In some cases, waiver of evaluation of PMP will be entertained for low hazard potential dams with no realistic possibility for future hazard potential change.

In addition to precipitation requirements for spillway design, flood control dams must be able to drain from spillway crest or 100-year, 24-hour peak reservoir level within 96 hours. This implies determination of 100-year, 24-hour precipitation in most cases. For high and significant hazard potential flood control dams conforming to local flood control authority or NRCS requirements for 100-year, 24-hour flood routing, OSE will defer to these requirements for determination of compliance with the 96-hour rule.

3. Watershed Location, Limits, and Area

Watershed location, limits and area have traditionally been obtained from 7-1/2 minute USGS quad maps by tracing the divide, and then determining the area by planimeter or other measurement. For smaller drainages, a site topo map is sometimes used. Recent analyses frequently use ArcView or other GIS software in conjunction with DEM or DTM. Determination of precipitation will require geographic location (latitude and longitude) of the approximate basin centroid or a georeferenced perimeter at an appropriate scale. Methodology used must be described and supported as appropriate. Drainage area for existing dams must be independently verified rather than relying on area indicated on drawings or in design report, particularly for older dams. Precipitation depths may require adjustment based on watershed area. Average elevation of the watershed is needed for determination of Local Storm PMP.

4. Subdivision of Watershed

Logical subdivision can be made where topography or surface features and development are dissimilar. SCS methodology would suggest maximum subbasin size of about 20 square miles. USBR – Cudworth recommends 500 square miles maximum area per subbasin. Subbasin areas should be reasonably similar – for example, don't combine 20 square mile and 0.5 square mile subbasins in the same model if you can help it. Avoid dividing into unnecessary subbasins, as this complicates the model and usually does not improve results. Particularly, avoid overdividing small basins, such as dividing 5 square miles into 20 subbasins. Subbasins should generally correspond with logical junction points and routing reaches.

5. Basin and Subbasin Geometry

Specific information required will depend on methodology used for timing parameters and runoff transform. Typical requirements might include length of longest watercourse, length to a point opposite the basin centroid, watercourse slope, average basin slope, estimated length of overland flow, length, slope, and cross-section of channel reaches, etc.

6. Timing and Routing Parameters

Typical parameters may include time of concentration, lag time, time-to-peak, time of travel, kinematic wave travel time, channel geometry and roughness, etc. depending on requirements of the transform methodology and channel routing used. To add to confusion, a parameter may be defined in different ways for different methodologies, even if the name is the same. The parameter(s) used must be appropriate for and compatible with transform methodology as defined within that methodology. Also, assumptions or limitations for the timing parameters must be consistent with the watershed being studied. These may include basin size or watershed length, channel condition (natural vs. improved or hardened), degree of development, etc. Method of determining timing and routing parameters must be indicated and justified as appropriate for location and transform methodology, with sample derivation and references.

7. Reservoir Characteristics

This may be developed as elevation-area or elevation-storage, depending on modeling requirements or input parameters for the method used. However, OSE Rules and Regulations require reservoir characteristics to be reported as elevation-storage table in one-foot intervals. Water storage reservoirs generally are assumed to be full to the point of uncontrolled discharge, e.g. spillway crest. Flood control dams with uncontrolled outlets and no permanent storage generally are assumed to be empty at the start of the modeling period.

8. Watershed Model

The basin and subbasin geometry and characteristics, routing reaches and parameters, reservoir characteristics, etc. are assembled to create the watershed model for the dam. It is useful to create a schematic or flow chart for the watershed model, particularly if software being used does not provide a graphical or schematic representation. A schematic or graphical representation of the model and tables of relevant model parameters will be required in the report submitted to OSE.

9. Precipitation Derivation

PMP east of the Continental Divide is derived using methodology of HMR 55A, PMP west of the Continental Divide is derived using HMR 49. Both HMR documents provide for 1) a Local Storm (thunderstorm), with 6 hours total duration, and 2) a General Storm, with 72 hours duration. Neither HMR includes procedures or allowances for durations less than the complete storm, such as a 1-hour thunderstorm or a 24-hour general storm. If a shorter duration is used, justification must be provided.

Concerning durations less than the complete storm, FEMA as quoted in City of Albuquerque *Development Process Manual* states, “FEMA’s position regarding the duration of rainfall is that the storm must extend for a period long enough to include all rainfall excess when the volume of the runoff hydrograph is an important consideration. This includes conditions when detention storage is involved, when sediment processes are a significant factor, and when combining and routing subbasin hydrographs to obtain watershed runoff. When the peak flow is the primary concern, and it is established that the use of a longer duration storm would not increase the peak flow, shorter duration storms are acceptable.” This would suggest that using the most intense 24 hours of the General Storm would only be appropriate if it can be shown that no excess

precipitation will occur outside of this period, or if it can be shown that the peak flow is not sensitive to storm volume if peak flow is the primary concern.

Both HMR documents require obtaining index precipitation from maps, and then adjusting precipitation depths for area, elevation, and orographic effects specific to the watershed being studied. The index precipitation depths are plotted against duration to develop a smooth depth-duration passing through the origin. Area adjustments typically are based on the total contributing area above the dam or other point of interest, rather than on individual subbasin areas. Since precipitation depth for PMP is adjusted for storm area during the derivation, no additional reductions should typically be taken during the hydrologic analysis.

The 1984 reprint of HMR 49 contains an Errata sheet following the title page. The entry for page 154 on this Errata sheet changes the basis for local storm elevation adjustments from the lowest elevation in the drainage to the mean elevation. This generally will result in greater reductions in precipitation depth for cases where the elevation adjustment applies. This change is not well documented anywhere else in the literature. Electronic versions of HMR 49 not containing this correction may still be available online.

Both Local and General Storm should be evaluated, unless clear evidence and justification can be provided showing that one storm or the other obviously controls. For example, in the Eastern portion of the New Mexico HMR 55A area, the 1- and 6-hour ordinates for the General Storm frequently are greater than the 1- and 6-hour ordinates of the Local Storm. Conversely, in certain locations of HMR 49 where the orographic component of General Storm precipitation is low, total storm volume for the General Storm can be less than the Local Storm. In most other cases, it is not sufficient to simply compare precipitation depths, since routing effects may result in greater spillway discharge from the General Storm, even though the Local Storm precipitation depths are greater at 1 and 6 hours.

Alternatives to HMR 49 and HMR 55A include site-specific analysis for PMP and Incremental Damage Assessment, either of which should be discussed first with OSE. In the future, an Extreme Precipitation Analysis Tool may be available for portions of the state, to provide an updated estimate of extreme precipitation.

Precipitation for frequency-based events, such as the 100-year storm, is obtained from NOAA Atlas 14, available online. Precipitation is obtained by latitude and longitude, and is point precipitation. The precipitation values from Atlas 14 are considered appropriate for storm areas of 10 square miles or less, and the full precipitation depth should be used for watersheds less than 10 square miles. For larger areas, an approved procedure for reducing precipitation based on area may be applied. The online documentation for Atlas 14 does not provide areal reduction factors specific to Atlas 14, but instead references three possible sources:

1. NOAA Atlas 2, *Precipitation-Frequency Atlas of the Western United States*, 1973. This method was originally presented in Technical Paper No. 40, *Rainfall Frequency Atlas of the United States*, U.S. Weather Bureau, 1961, and is incorporated into the Frequency Storm methodology in HEC-1 and HEC-HMS.

2. Technical Report 24, *A Methodology for Point-to-Area Rainfall Frequency Ratios*, NOAA, 1980.
3. Technical Memorandum HYDRO-40, "Depth-Area Ratios in the Semi-Arid Southwest United States," NOAA, 1984.

These methods will allow reductions for areas less than 10 square miles; however, Atlas 14 seems to recommend using the point precipitation values for 10 square miles or less. If areal reductions are made for drainage areas less than 10 square miles, justification must be provided. Areal reductions for frequency storms should be based on the total watershed contributing to the point of interest, and not on individual subbasin areas. For watersheds with total area exceeding the limits of the reduction method (400 square miles for NOAA Atlas 2/U.S. weather Bureau Technical Paper 40) the services of a qualified meteorologist may be necessary to determine appropriate reductions of point precipitation.

10. Precipitation Increments and Distribution

Precipitation increment size should generally correspond to the computational time step used, although this is not mandatory for many computer programs including HEC-HMS. Increments are obtained from the depth-duration curve by subdividing the curve by increment length and successively subtracting curve ordinates. For small, fast basins in particular it is important to use a sufficiently small increment size and computational time step to avoid under-prediction of peak runoff.

Once the increments have been determined, they must be arranged in an appropriate distribution. One of the most common arrangements sometimes called "center-peaking" or "balanced" distribution, places the largest increment at the center of the storm duration. The second largest increment is placed directly in front of the first, the third largest placed behind the first, and the procedure is continued with successively smaller increments until the distribution is filled. A similar distribution, favored by Bureau of Reclamation for 72-hour general storm PMP, can be termed "late-peaking." This distribution places the largest increment at the 2/3 point of the storm, then places the second and third largest increment successively in front of the largest increment, then the fourth largest increment immediately behind the largest increment, then continuing the sequence with two increments in front, one behind until the distribution is filled and all increments are used. Either the center-peaking or late peaking distribution will be acceptable for 72-hour General Storm PMP.

Both HMR 49 and HMR 55A refer to two recommended distributions for the 6-hour Local Storm. One is obtained from HMR 5, and the other from the USACE EM1110-2-1411. The distributions are similar, with the USACE EM1110-2-1411 distribution peaking later in the storm. HMR 49 states, "In application, the choice of either of these distributions is left to the user since one may prove to be more critical in a specific case than the other." This suggests that both methods should be evaluated and the more critical distribution should be used. In practice, the USACE EM1110-2-1411 appears to provide the higher peak discharge in the majority of cases. While not specifically discussed in either HMR 49 or HMR 55A, a center-peaking distribution of local storm PMP has been used in the past and is acceptable to OSE. In any case,

the distribution used must be justified as being appropriate for the specific drainage area being evaluated.

The center-peaking and late-peaking distributions described above are frequently approximated in HEC-HMS or HEC-1 using the Frequency Storm definition for precipitation. Using the Frequency Storm to distribute PMP can cause unintended consequences if one is not careful, and probably should be avoided by infrequent users. The Frequency Storm requires input of precipitation depths for durations corresponding to the frequency series of 5 min, 15 min, 1 hour, 2 hours, 3 hours, 6 hours, 24 hours, 48 hours, etc. The frequency series does not include a 72-hour duration, and so will not emulate the full General Storm PMP. The General Storm index values from HMR 55A do not include values for 5 min, 15 min, 2 hour, 3 hour, or 48 hour durations, and the index values from HMR 49 do not include 5 min, 15 min, 1, 2, or 3 hour values, requiring values to be interpolated or read from curve plots, introducing a possible source of error. The Frequency Storm method can result in unintended reductions of precipitation due to inappropriate use of Storm Area and Probability inputs in HEC-HMS and HEC-1. It is probably best to discuss with OSE before using the Frequency Storm to distribute PMP.

In cases where 100-year precipitation is required (primarily for low-hazard potential dams) the preferred distribution is a center-peaking distribution based on the frequency series from NOAA Atlas 14. The Frequency Storm functions in HEC-HMS, HEC-1, and possibly other programs, are suitable and are intended for this type of storm. Since the precipitation from Atlas 14 is point precipitation, reductions for storm area may be taken as appropriate. The common SCS Type II distribution used for most of the US east of New Mexico will not be appropriate in New Mexico in most cases. The Type IIA distributions used by NRCS in New Mexico may be appropriate, but it is recommended that their use be discussed with OSE prior to using these distributions.

The following distribution methods, which have all been used in submittals to OSE, are not generally appropriate:

- Using the depth-duration curve as the distribution.
- Straight-line distribution of equal increments throughout the storm or during peak periods of the storm.
- Using SCS Type II or NRCS Type II-a distribution for PMP.
- Compressing SCS or NRCS distributions for durations less than 24 hours
- Using a Huff distribution.

11. Spatial Distribution of Precipitation

Spatial distribution of precipitation intensity within a basin through use of isohyetal storm patterns is typically done only for relatively large basins. This method is not common in submittals to OSE, and the services of a qualified meteorologist is required if this method is used. The method is illustrated in HMR 52, which contains information for applying this method east of the 105th meridian, comprising roughly the eastern third of New Mexico.

The more typical submittal applies precipitation uniformly across the basin, with reductions in precipitation depth for larger areas as appropriate. The reductions in these cases are applied during the derivation of precipitation using HMR 49 or HMR 55A. When the isohyetal method

of spatial distribution is used, the full index precipitation is used without reduction, since reduction is effected by application of the isohyetal pattern.

12. Loss Function Parameters

Not all of the precipitation that falls is available to generate runoff. The primary losses to precipitation are interception, evaporation, retention, and infiltration. The first three of these are grouped, along with part of the infiltration loss, and termed "initial losses." For large, infrequent events such as the PMP, initial losses are relatively low compared to infiltration losses, and are assumed to have occurred due to antecedent rainfall prior to the start of the PMP. Therefore, initial losses are commonly neglected in evaluating PMP. Common loss characterizations include SCS curve numbers, initial/constant loss rates, exponential losses, and Green-Ampt method. Other methods are available as well. SCS curve numbers are typically used with SCS hydrograph methodology, and are not recommended for other hydrograph methods. Initial/Constant loss rate methodology is used with USBR and other unit hydrograph methods. Green-Ampt and exponential methods have not been frequently used in submittals to OSE. Parameters must be justified, both in terms of appropriateness for basin conditions (soil and vegetative cover or land use) and appropriateness with the selected transform methodology. For PMP, loss rates frequently are lower than those used with typical return frequency storms such as the 100-year event. Constant loss rates in excess of 0.5 inches/hour will require adequate supporting justification. Typical loss rates for the four SCS soil groups are as follows:

SCS Soil Group	Descriptive Characteristic	Ultimate Infiltration Rate
A	Low Runoff Potential	0.3 to 0.5 inches/hour
B	Moderate Infiltration Rate	0.15 to 0.30 inches/hour
C	Slow Infiltration Rate	0.05 to 0.15 inches/hour
D	High Runoff Potential	0 to 0.05 inches/hour

Source: USBR *Flood Hydrology Manual*, 1989, P. 112

13. Precipitation Excess

Determination of precipitation excess typically is embedded in hydrology software program, but is a straightforward step that can be assumed to be handled correctly with reputable software. The total rainfall excess must be determined and reported, in addition to instantaneous peak discharge. As a rule of thumb for General Storm PMP, rainfall excess less than 70% of total storm volume for 72-hour precipitation depth greater than 25 inches, or less than 60% of 72-hour storm volume for total precipitation depth less than 25 inches, will require justification. Loss parameters and precipitation increment size and distribution can have significant effect on rainfall excess.

14. Transform Methodology

The most common transform methodology is some sort of synthetic unit hydrograph procedure. SCS is fairly common, but may not be the best choice for PMP of extreme storms. SCS parameters are interrelated, and any deviation from the methodology (e.g. Initial-Constant loss rates rather than Curve Numbers) must be justified. The USBR *Flood Hydrology Manual* methodology is also commonly used. USBR is developed for the West, and has three regional unit hydrograph lag relationships that apply within New Mexico: "Great Plains," "Rocky

Mountains," and "Southwest Desert, Great Basin, and Colorado Plateau." Additionally, the Manual contains information for urban basins. It is important to select the correct relationship for the watershed being evaluated. Other unit hydrograph procedures include Clark's and Snyder's unit hydrographs. If these are used, parameters must be provided and justified. User-specified unit hydrographs or other relationships derived from gaging records are possible, but submittals to OSE using these methods have been rare. SCS, Clark's and Snyder's unit hydrographs are available in HEC HMS, and parameters must be provided and justified but unit hydrographs need not be provided. IF USBR methodology or other user-specified unit hydrographs are used, unit hydrograph ordinates must be provided. Kinematic Wave methodology is sometimes used, and is probably most suitable where the watershed can be conveniently be described as rectangular plane surfaces draining into lateral channels. Other distributed-model methodologies may exist or emerge, and should probably be discussed with OSE before submittal.

15. Application of Transform Methodology for Each Subbasin

For computer-based analysis, this is primarily a matter of properly configuring subbasin models and hydrologic parameters within the program.

16. Evaluation of Base Flow

In New Mexico, stream base flow is usually minimal or non-existent except in response to storm events. A possible exception might be snowmelt in mountainous regions. The USBR *Flood Hydrology Manual* discusses modeling base flow and snowmelt. If base flow in the stream will contribute significantly to the hydrograph, it should be considered, and base flow modeling assumptions documented. It may be desirable to model a token base flow if the resulting flood hydrograph will be analyzed in a program such as HEC-2 or HEC HMS for downstream water surface profiles under unsteady-flow conditions.

17. Hydrograph Combining and Routing to Determine IDF

Combining and routing is generally done by the computer model. Model input and output must be carefully scrutinized to make sure that the model is performing as intended

18. Reservoir Routing

Stage-storage information used in routing must be provided; the Rules and Regulations require this to be in elevation intervals of 1 foot. Outlet and spillway capacity rating curve or table must be developed and provided. Relying on older, previously generated rating curves without independently verifying their appropriateness is not acceptable. Spillway capacity is most frequently based on the Weir Equation, $Q = CL(H)^{1.5}$, Where Q is discharge, L is weir length perpendicular to flow, H is head on the weir typically taken as reservoir elevation minus weir elevation, and C is a discharge coefficient for the weir. The weir equation is only appropriate if flow passes through critical depth over the weir and supercritical flow will be present a sufficient distance downstream from the weir that backwater effects will not constrain flow over the weir. If supercritical flow is not assured, then a backwater analysis such as HEC-2 or HEC-RAS is needed to validate spillway capacity. Also if a significant channel exists between the weir and the reservoir, a backwater analysis is needed to confirm that the reservoir stage remains below the dam crest at the anticipated spillway capacity. Care must be exercised in selecting the coefficient C, as it is not constant with respect to flow depth and is sensitive to geometry of the

spillway crest and entrance. Textbook values for typical broad-crested and ogee weirs may not be appropriate. The most common error is to select too high of a coefficient, for example, 3.0 or 3.1 for an open-cut spillway for which 2.6 or 2.7 may be more appropriate.

19. Review of Results for Reasonableness

It is tempting to assume that if the computer program gives an answer and doesn't crash that this is the correct answer. In reality, the computer is not especially intelligent and will do exactly what you tell it to, whether this makes any sense or not. This is not just a matter of "garbage-in, garbage-out." Sometimes, parameters that are in the ballpark when taken individually can compound to skew results in one direction or another. Also, sometimes the program will perform functions not intended by the analyst, such as inappropriate reduction of precipitation for storm area, if you do not tell it exactly what you want and understand the significance of program defaults. Therefore, a review of intermediate steps and final results for reasonableness is important. Calibration of the hydrologic model for PMP is difficult since storms approaching this magnitude are rare. Calibrating against lesser storms such as the 100-year or smaller events may not be appropriate for PMP. Reasonableness of results compared to past experience with similar input parameters may be the best tool available. It is important not only to ensure that the spillway design flood is not underestimated for reasons of public safety, but also that it is not overestimated for reasons of economics. Often, the predicted flood is significantly less probable than the precipitation, which in the case of PMP already has an essentially indefinable but extremely low probability. In some cases, particularly for rehabilitation projects, this can have a substantial impact on project costs.

20. Adjustment of Model Parameters

Based on review of results for reasonableness, it may be appropriate to adjust parameters and recalculate. This will obviously be necessary if the selected spillway turns out not to be adequate for the computed flood. Sensitivity analysis with respect to critical parameters is sometimes useful in forming an opinion with regard to the appropriateness of the result.

21. Hydrologic Analysis Report

Assuming the hydrologic analysis has included the required steps previously discussed, it is important that the methods and parameters used, the results obtained, and supporting justification be documented in a coherent report. This will allow OSE staff to verify that regulatory requirements for hydrology have been satisfied and evaluate whether the proposed design adequately addresses the required design storm. A secondary, but equally important purpose is to provide documentation of methods and assumptions to assist future engineering consultants and OSE staff in understanding the basis for design and assessing adequacy and safety of the structure. Personnel can turn over rapidly, analysis methods change over time, and the structure will almost certainly outlast both the designers and their methods. The hydrology report will serve as a guidance document to help future engineers understand the analysis. As a general principle, the information submitted must be adequate to allow an independent analyst, possibly at some point in the future, to replicate the analysis with comparable results. The information must be transparent and independent of the software program used for computation. The following are some of the items required in the report and supporting documentation:

1. Identification of the hazard potential classification, and any assumptions used in determining this classification. If the classification is anything other than High, supporting documentation, potentially including breach analysis and flood studies, may be required.
2. Determination of appropriate design precipitation based on hazard potential classification and size of structure. Provide detailed analysis report if design precipitation is based on incremental damage assessment or site-specific PMP study, either of which must be discussed with OSE in advance.
3. Location map and topographic map of drainage area contributing to the dam and reservoir, with drainage boundary and total area indicated.
4. Map indicating subbasin boundaries with areas indicated, hydrograph combination points, channels for routing, etc. This may be superimposed on the topographic map described in 3. above if of suitable scale.
5. Table of relevant basin and channel characteristics to be used in the analysis as dictated by the selected analysis methodology, including flow path lengths, centroid distances, mean basin elevations, channel slope, roughness, and cross-section, etc.
6. Discussion of timing and routing parameter derivation including methods or equations used and their applicability to this particular project, example calculations, and summary tables of input data and computed parameters.
7. Narrative discussion of watershed model accompanied by schematic showing the interrelation of various components of the model.
8. Elevation-storage and elevation-discharge tables for reservoir, outlets and spillways. These should be in 1-foot increments unless the dam is very high, in which case the appropriate interval must be discussed in advance with OSE.
9. Worksheets for Local Storm and General Storm PMP derivation from HMR 49 or 55A as appropriate. For Low hazard potential dams, copies of tables from NOAA Atlas 14 website, indicating latitude and longitude of point precipitation, must be included.
10. Table of distributed precipitation increments, distribution curve and/or hyetograph illustrating graphically how precipitation is distributed, and narrative describing and justifying the methodology for distributing precipitation.
11. If spatial distribution is used, full documentation of methodology and assumptions by qualified meteorologist is required.
12. Discussion of loss methodology and documentation of derivation of parameters, tables of soil and land use areas and percentages for each subbasin, and justification of the appropriateness of the parameters and methodology in the context of the overall analysis.
13. Table or graph of precipitation excess for each increment for which excess exists, and identification of total precipitation excess in inches and percentage of rainfall.
14. Discussion of transform methodology used. Coefficients or parameters for common synthetic unit hydrograph procedures (e.g. SCS. Snyder, Clark). If other than a common synthetic unit hydrograph procedure is used, unit hydrograph ordinates must be provided.
15. Table or computer echo of input parameters, with parameters identified or notated for each subbasin, routing reach, or other element.
16. Discussion of base flow or snowmelt methodology or considerations.
17. Table of combining and routing results, supported by computer output. Results must be concurrent with model schematic discussed in 7. above.

18. Elevation-storage and elevation-discharge tables for the reservoir in 1-foot increments, and table of routed hydrograph ordinates with peak inflow to reservoir and routed peak outflow identified. Inflow and outflow hydrographs plotted on same figure of appropriate scale.
19. Discussion of reasonableness of results, including any calibration or comparison information available.
20. Discussion of any parameter adjustments or sensitivity analysis performed in order to validate or improve reasonableness of results.

Special Case – Perimeter Dams:

An increasing number of dams regulated by OSE are perimeter embankments with no contributing watershed outside of the reservoir, interior slopes, and embankment crest. These dams may include wastewater pond dams, industrial evaporation pond dams, municipal raw water storage dams, tailings dams, etc. Water or potentially mobile contents are pumped or discharged to the reservoir as part of a controlled process.

For these perimeter dams, hydrology typically is greatly simplified. The contributing area (reservoir surface, interior slopes, and crest) is determined, and the design precipitation depth is applied to this area to determine the volume contribution of the storm to the reservoir. Where the design storm is all or a percentage of the PMP, the General Storm 72-hour index precipitation should be used. Losses are neglected, and the full precipitation depth is treated as excess contributing to the reservoir. In most cases, storage for this volume of water is provided above the normal maximum water level, with additional freeboard above flood stage to satisfy the freeboard requirements of OSE Rules and Regulations. In some cases, a spillway may be designed to allow routing and discharge of some of the flood volume, thereby reducing embankment height above normal maximum water level.

In addition to water from extreme precipitation events, perimeter embankments are susceptible to misoperation, where discharge into the reservoir continues past the design maximum reservoir level and eventually overtops the embankment, resulting in failure. For this reason, perimeter embankments must be provided with an overflow section with capacity equal to or greater than the discharge capacity into the reservoir, so that misoperation or failure of reservoir controls does not lead to embankment failure.

References:

Cudworth, Arthur G. Jr. (1989), *Flood Hydrology Manual*, USBR.

NOAA Atlas 2 (1973), *Precipitation-Frequency Atlas of the Western United States*.

NOAA Atlas 14 (2006), *Precipitation Frequency Atlas of the United States, Volume 1 Version 4.0: Semiarid Southwest*, available online at http://hdsc.nws.noaa.gov/hdsc/pfds/index.html.

NOAA, USACE Hydrometeorological Report No. 49 (1984), *Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages*.

NOAA, USACE Hydrometeorological Report No. 52 (1982), *Application of Probable Maximum Precipitation Estimates – United States East of the 105th Meridian*.

NOAA, USACE, USBR Hydrometeorological Report No. 55A (1988), *Probable Maximum Precipitation Estimates – United States Between the Continental Divide and the 103rd Meridian*.

NOAA Technical Memorandum HYDRO-40 (1984), *Depth-Area Ratios in the Semi-Arid Southwest United States.*

NOAA Technical Paper No. 40 (1961), *Rainfall Frequency Atlas of the United States*, U.S. Weather Bureau.

NOAA Technical Report 24 (1980), *A Methodology for Point-to-Area Rainfall Frequency Ratios.*

OSE (2005), *Rules and Regulations Governing Dam Design, Construction, and Dam Safety,* Title 19, Chapter 25, Part 12 New Mexico Administrative Code.

U.S. Army Corps of Engineers EM1110-2-1411 (1965) *Standard Project Flood Determinations.*

U. S. Weather Bureau Hydrometeorological Report 5 (1947), *Thunderstorm Rainfall.*

NOTICE OF PROPOSED REGULATIONS AND PUBLIC HEARING

OFFICE OF THE STATE ENGINEER
P.O. BOX 25102
SANTA FE, NEW MEXICO 87504-5102
(505) 827-6122
www.ose.state.nm.us

The State Engineer has released proposed amendments to Rules and Regulations Governing Dam Design, Construction and Dam Safety. The proposed amendments were developed to address changes to Section 72-5-32 NMSA effective on June 19, 2009 and to address improvements to the standards of dam design, construction and operation practice in New Mexico.

Amendments are proposed to the following sections of the Rules and Regulations Governing Dam Design, Construction and Dam Safety: (7) Definitions, (8) Fee Schedule, (9) Size Classification, (10) Hazard Potential Classification, (11) Design of a Dam, (12) Certifications, (13) Permit Conditions, (14) Proof of Completion of Works, (17) Operation and Maintenance Manual, (18) Emergency Action Plan, (19) Changes to an Existing Dam (20) Changes to an Existing Non-Jurisdictional Dam, and (21) Existing Dams.

The proposed regulations are available at the Office of the State Engineer in Santa Fe, Albuquerque, Las Cruces, Roswell, Deming, Aztec, and Cimarron. The proposed regulations are also posted on the Office of the State Engineer web site and may be accessed at www.ose.state.nm.us/water_info_dam_safety_rules.html. Click on the link under Proposed Rules and Regulations. To request that a copy of the rules and regulations be sent to you in the mail or by email, please contact Judy Leyba at 505-827-6111 or email judy.leyba@state.nm.us.

A public hearing will be held on the above described proposed and amended regulations at the State Capitol, Santa Fe, New Mexico, on October 29, 2010 beginning at 10:00 a.m. Any person who is or may be affected by these proposed rules and regulations may appear and testify. If you are an individual with a disability who is in need of special assistance or accommodation to attend or participate in the hearing, please contact Judy Leyba at (505) 827-6122. The Office of the State Engineer requests ten days advance notice to provide any special accommodation.

Written comments on the proposed regulations may be submitted to the Office of the State Engineer in Santa Fe or to any of the district offices. Written comments on the proposed rules and regulations may also be mailed to:

Office of the State Engineer
Dam Safety Bureau
Attention: Elaine Pacheco
P.O. Box 25102
Santa Fe, NM 87504

Please submit your written comments to the Office of the State Engineer no later than October 15, 2010. After October 15, 2010, written and oral comments must be submitted at the hearing in Santa Fe on October 29, 2010.

BEFORE THE NEW MEXICO STATE ENGINEER

IN THE MATTER OF THE PROPOSED	)
AMENDMENT OF RULES GOVERNING	)
DAM DESIGN, CONSTRUCTION AND	)
DAM SAFETY	)

FINDINGS OF FACT, ORDER
AND NOTICE OF PROPOSED RULEMAKING

COMES NOW John R. D'Antonio, Jr., P.E., State Engineer of the State of New Mexico, pursuant to NMSA 1978, Section 72-2-8(D), and makes the following **FINDINGS OF FACT**:

1. In accordance with NMSA 1978, Sections 72-2-8, 72-2-12 and 72-2-17, the State Engineer is authorized to adopt regulations, appoint hearing examiners, and conduct hearings on matters that are properly before him. A designated hearing examiner shall have such power as may be delegated by the State Engineer to regulate all proceedings before him, and to perform acts and take all necessary or proper measures for the efficient and orderly conduct of such proceedings.

2. The existing Rules and Regulations Governing Dam Design, Construction and Dam Safety do not adequately reflect and address:

a. The 2009 amendment to NMSA 1978, Section 72-5-32, which changed the definition of dams that are under the jurisdiction of the State Engineer;

b. Current state of the practice of the Office of the State Engineer concerning dam design, construction and dam safety; and

c. Industry standards relating to dam design, construction and dam safety.

3. It is necessary and appropriate to provide clear standards and regulations for the design, construction and safety of dams under the State Engineer's jurisdiction. Therefore, the existing rules should be amended so that consistent and detailed rules will be in place.

4. The proposed amendments have been reviewed by counsel for the State Engineer.

5. A detailed synopsis of the substantive proposed amendments is attached as Exhibit 1 to this Order and a list of references supporting the proposed amendments is attached as Exhibit 2.

6. A public hearing should be held on the proposed amendments to existing rules 19.27.12 NMAC (Dam Design, Construction and Dam Safety). Accordingly, the proposed amendments should be made publicly available, and a resume of the proposed amendments should be published together with notice of the public hearing pursuant to NMSA 1978, Section 72-2-8(D).

WHEREFORE, the State Engineer hereby **ORDERS:**

A. The proposed amended rules shall be filed for public inspection in the Office of the State Engineer in each District field office on or before August 23, 2010, and notice of the proposed rulemaking and public hearing shall be mailed to each person included in the file of interested persons in the Office of the State Engineer.

B. A resume of the substantive proposed amendments shall be published together with notice of public hearing in a minimum of five newspapers of general circulation once a week for two consecutive weeks, and notice shall also be published in the New Mexico Register. Publication shall be completed by October 8, 2010.

C. A public hearing on the proposed amendments shall be held in Santa Fe, New Mexico beginning at 10:00 a.m. on October 29, 2010.

Witness my hand and seal this 20th day of August, 2010.



John R. D'Antonio, Jr., P.E.
State Engineer of New Mexico

EXHIBIT 1

SYNOPSIS OF SUBSTANTIVE PROPOSED AMENDMENTS TO 19.25.12 NMAC
Dam Design, Construction and Dam Safety Rules and Regulations

Following is a synopsis of the sections of the substantive proposed amendments to rules and regulations governing dam design, construction and dam safety. Proposed procedural amendments are not included in this synopsis.

19.25.12.7 DEFINITIONS: The following definitions were added or amended.

19.25.12.7.A(2)
"**Aesthetic fill**: Cosmetic fill added to the downstream slope of a dam that is not required to address the safe design. Aesthetic fill shall not be considered when determining the properties of the dam for the purposes of evaluating the jurisdictional status and shall not be used to support the safe design."

19.25.12.7.D(1)(a)
"Jurisdictional dam" definition revised to conform to requirements of Section 72-5-32, NMSA 2009, as amended. See Exhibit 2, Reference 4.

19.25.12.7.D(1)(b)
"Non-jurisdictional dam" definition revised to conform to requirements of Section 72-5-32, NMSA 2009, as amended. Exemption for stock dams and erosion control dams as non-jurisdictional is no longer required. See Exhibit 2, Reference 4.

19.25.12.7.D(2)
"Dam crest" definition revised to recognize the crest is the entire uppermost surface and not a single location. The lowest elevation reference is moved to the dam height definition.

19.25.12.7.D(4)
"**Dam height**: The vertical distance from the lowest point on the downstream toe to the lowest point on the dam crest."

19.25.12.7.E(1)
"**Earthquake**: A sudden motion or trembling of the earth caused by the abrupt release of accumulated stress along a fault."

19.25.12.7.E(1)(a)
"**Operating basis earthquake**: The earthquake that can reasonably be expected to occur within the service life of the dam or appurtenant structures." See Exhibit 2, Reference 6.

19.25.12.7.E(1)(b)
"**Maximum credible earthquake**: The greatest earthquake that can reasonably be expected to be generated by a specific source on the basis of seismological and geological evidence." See Exhibit 2, Reference 6.

19.25.12.7.E(2)
"**Evacuation map**: A map prepared in collaboration with local emergency managers defining the area to be evacuated from a dam failure."

19.25.12.7.F(1)
"Fetch" definition amended to the more specific distance between the dam and farthest reservoir shore rather than the general distance across a body of water.

19.25.12.7.G
"**Geotextile**: Any fabric or textile (natural or synthetic) used as an engineering material in conjunction with soil, foundations or rock. Geotextiles provide the following uses: drainage, filtration, separation of materials, reinforcement, moisture barriers and erosion protection." See Exhibit 2, Reference 8.

19.25.12.7.I(1)
"**Incremental impacts**: Under a given flood, earthquake or other conditions, the difference in impacts that would occur due to failure or misoperation of the dam and appurtenant structures compared to those that would have occurred without failure or misoperation of the dam and appurtenant structures." See Exhibit 2.

19.25.12.7.N(3)
"North American vertical datum" definition corrected to reference the national geodetic vertical datum 1929 rather than the North American vertical datum 1927.

19.25.12.7.R
"**Residual freeboard**: The vertical distance between the high water line and the lowest point on the dam crest."

19.25.12.7.S(5)
"**Sunny day failure**: Dam failure with the reservoir at the normal operating level."

19.25.12.8 FEE SCHEDULE:

19.25.12.8.B
Fee for alter, repair or rehabilitation of a dam is added to the fee schedule.

19.25.12.8.H-I
Schedule of fees for all copies is replaced with a statement that fees will be charged to offset the cost of the service and consistent with state engineer policy adopted pursuant to the NM Inspection of Public Records Act.

19.25.12.9 SIZE CLASSIFICATION:

19.25.12.9.A
"Small" classification is revised to conform to requirements of Section 72-5-32, NMSA 2009, as amended.

19.25.12.11 DESIGN OF A DAM:

19.25.12.11
Introduction amendment adds an option to require a quality management plan if the supporting documentation does not meet acceptable engineering standards as determined by the state engineer.

19.25.12.11.C(1)(a)-(g)
Hazard potential classification amendments reorganize and describe in greater detail the information that must be included in the dam breach and flood routing analysis. See Exhibit 2, Reference 7.

19.25.12.11.C(2)(b)
Hydrologic analysis amendment requires a description of land treatment for the drainage area.

19.25.12.11.C(4)
Incremental damage assessment amendments clarify that the assessment is a process used when spillways cannot be designed to comply with the spillway design flood listed in 19.25.12.11.C(3). A detailed description of the process to assess incremental impacts is provided in the amendment. See Exhibit 2, Reference 2.

19.25.12.11.C(5)
Spillway capacity amendment deletes the option of performing an erosion study of the embankment to justify overtopping of a new dam due to inadequate spillway capacity.

19.25.12.11.C(6)(e)
Energy dissipation for spillway discharge amendment states: "<u>The design shall address energy dissipation to control erosion of the natural channel due to spillway discharge reasonably expected to occur during the life of the dam.</u>"

19.25.12.11.C(6)(g)
Training dikes amendment deletes the reference to compaction to "at least 70% relative density if Proctor testing is not appropriate."

19.25.12.11.C(8)(l)
Minimizing seepage along conduits amendment adds the following statement: "<u>Seepage collars are not an acceptable design standard for controlling seepage.</u>" See Exhibit 2, Reference 5.

19.25.12.11.C(11)
Seepage and internal drainage amendment requires the evaluation of seepage and internal drainage for dams with aesthetic fill on the downstream slope and removes the option of requesting a waiver for reservoirs with synthetic liners on that basis alone.

19.25.12.11.C(11)(d)
Seepage and internal drainage amendments replace the requirement for a specific device depending on flow rate to a more general requirement that the measuring device must be appropriate for the rate of flow. A requirement for an upstream catchment for the seepage collection device is also added.

19.25.12.11.C(12)
Stability analysis amendment requires the evaluation of stability for dams with aesthetic fill on the downstream slope and requires the stability of the reservoir rim to be evaluated if the slopes are steeper than 3 horizontal to 1 vertical.

19.25.12.11.C(12)(c)-(d)
Stability analysis amendment increases the factor of safety for rapid drawdown and end of construction loading conditions from 1.2 to 1.3. See Exhibit 2, Reference 9.

19.25.12.11.C(13)
Seismic design and analysis amendment adds the requirement of a seismic analysis for appurtenant structures. See Exhibit 2, Reference 6.

19.25.12.11.C(13)(a)
Seismological investigation amendment provides the criteria for the operating basis earthquake to be used in the seismological investigation study. See Exhibit 2, Reference 6.

19.25.12.11.C(13)(a)(i)
Seismological investigation amendment states: "Dams classified as high hazard potential other than flood control structures shall be designed for the maximum credible earthquake or for a 1% probability of exceedance in 50 years (approximately 5000-year return frequency)." See Exhibit 2, Reference 6.

19.25.12.11.C(13)(c)(i)
Pseudostatic analysis amendment deletes the reference to compaction of "at least 70% relative density if Proctor testing is not appropriate".

19.25.12.11.C(13)(c)(ii)
Pseudostatic analysis amendment states that a pseudostatic analysis is acceptable if the peak ground acceleration is 0.35g or less.

19.25.12.11.C(17)
Geotextile design amendment requires the geotextile design computations to be provided and clarifies the installation requirements for the geotextile.

19.25.12.11.C(19)
Utilities design amendment requires the evaluation of utilities in the spillway and seepage limits of the dam.

19.25.12.11.D(2)
Scale and size amendment allows drawings to range in size from 22 inches to 24 inches by 34 inches to 36 inches.

19.25.12.11.D(12)
Permanent bench mark amendment deletes the option of providing the location of the permanent bench mark based on the New Mexico state plane coordinate system.

19.25.12.11.E
Specifications amendments clarify that a specification package is required to be submitted for each project and that reference to standard specifications is not acceptable; however, inclusion of appropriate specifications from model specifications is appropriate. The amendment also requires the specifications to address frequency of testing and frequency of inspection.

19.25.12.11.E(4)
General conditions of the specifications amendment add the requirement that statements recognizing the authority of the state engineer to perform inspections during construction and acknowledging that the construction drawings and specifications cannot be changed without prior written approval from the state engineer be included in the specification package.

19.25.12.11.H
Instrumentation plan amendment adds the requirement that details of the instrumentation must be included in the construction drawings and that specifications must be consistent with the instrumentation plan. See Exhibit 2, Reference 1.

19.25.12.11.H(3)
Calibration amendment adds the requirement of including calibration and maintenance schedules, and instructions in the instrumentation plan. See Exhibit 2, Reference 1.

19.25.12.11.H(5)
Data reduction amendment adds the requirement of including data reduction and interpretation instructions in the instrumentation plan. See Exhibit 2, Reference 1.

19.25.12.12 CERTIFICATIONS:

19.25.12.12
Certifications introduction amendment adds the requirement for a certification from the local emergency management official.

19.25.12.12.D
Local and state emergency management official's certificate amendments revise the certification requirements to include a certification from the local emergency management official.

19.25.12.13 PERMIT CONDITIONS:

19.25.12.13.A(1)
Engineer supervising construction amendments add the requirements that the monthly construction report be signed and sealed by the engineer supervising construction and the monthly construction report includes a summary of construction activities and captioned and dated construction photographs.

19.25.12.13.A(4)(a)
Construction completion amendment requires the construction completion report to include signed certifications from the engineer and a certification for the state engineer.

19.25.12.13.A(4)(b)
Record mylar drawings amendments require the drawings to contain signed certifications from the owner and the engineer supervising construction and a certificate for the state engineer. The design engineer may also be required to sign a certification depending on the changes.

19.25.12.13.E
Operation condition amendment specifies a list of operation conditions that shall be included in the permit.

19.25.12.17 OPERATION AND MAINTENANCE MANUAL:

19.25.12.17
The amendment to the introduction first deletes the requirement that a professional engineer prepare the entire operation and maintenance manual and instead specifies that a professional engineer is only needed to prepare the complex technical aspects of the operation and maintenance manual if deemed appropriate by the state engineer. Second, the amendment clarifies that the state engineer may order storage restrictions if the operation and maintenance procedures are not followed.

19.25.12.17.A
General information amendment adds the requirement of including in the operation and maintenance manual information on access to the dam and the history of construction, repairs and performance. See Exhibit 2, Reference 1.

19.25.12.17.B(1)
Operation amendment adds the requirement of including the following information in the operation and maintenance manual: discharge information specific for the outlet conduit and spillway; an elevation, area and storage curve and table to the dam crest; and elevation of the high water line. See Exhibit 2, Reference 1.

19.25.12.17.B(3)
Operator safety amendment adds the requirement of including the following information in the operation and maintenance manual: confined space entry and permits; fall protection; lockout/tag out; and other applicable safety requirements.

19.25.12.17.C (2)-(7)
Instrumentation amendment revises this section to conform to the requirements of the instrumentation plan specified in 19.25.12.11.H. Under the amendment, the following additional information must be included in the operation and maintenance manual: detailed description of installation; calibration schedule and instructions; reading instructions; data reduction and interpretation; notification procedures; and schedule for reporting data with interpretations. See Exhibit 2, Reference 1.

19.25.12.17.H
Appendices amendment adds the requirement of including the following information in the appendices of the operation and maintenance manual: captioned and dated photographs; key sheets from the record construction drawings; instrumentation construction drawings; instrumentation rating tables and calibration details; monitoring and inspection forms; and copies of any relevant procedures.

19.25.12.18 EMERGENCY ACTION PLAN:

19.25.12.18
The introduction amendment adds the requirement of including in the emergency action plan a signed certification from the local emergency official and requires the dam owner to coordinate with emergency management officials to establish the evacuation limits.

19.25.12.18(D)
Preparedness amendment deletes the requirement for a professional engineer to prepare this element of the emergency action plan.

19.25.12.18(E)
Evacuation map amendment adds the requirement of including an evacuation map in the emergency action plan. The amendment specifies that the evacuation map is required to extend to a point where the consequences of dam failure no longer pose a threat to life and evacuation or restricting access is no longer required. See Exhibit 2, Reference 3.

19.25.12.18(E)(1)-(4)
Evacuation map amendment adds the requirement of including the following information in the evacuation map: distance downstream from the dam; arrival time of the leading edge of the flood wave; peak flow depth, incremental rise or water surface elevation in feet; and peak velocity in feet per second. See Exhibit 2, Reference 3.

19.25.12.18(F)
Inundation map amendment deletes the requirement that every dam breach and flood routing analysis report for preparing an emergency action plan be prepared to the same level as required for a design effort. The amendment specifies that the use of a simplified dam breach and flood routing analysis is acceptable if the consequences of failure justify a simplified process and the state engineer concurs. The amendment also specifies that the effects of flooding from dam failure must be routed until the flood no longer poses a threat to life and evacuation or restricting access are no longer required. See Exhibit 2, Reference 3.

19.25.12.18(F)(1)-(4)
Inundation map amendment adds the requirement of including the following information in the inundation map: distance downstream from the dam; arrival time of the leading edge of the flood wave; peak flow depth, incremental rise or water surface elevation in feet; and peak velocity in feet per second. See Exhibit 2, Reference 3.

19.25.12.19 CHANGES TO AN EXISTING DAM:

19.25.12.19.A
Proposed changes to an existing dam amendment adds the requirement that dam owners adding aesthetic fill to an existing dam obtain approval from the state engineer prior to undertaking any actions.

19.25.12.19.A(1)
Application amendment waives plan review fees for only the first review of plans to alter, repair or rehabilitate a dam.

19.25.12.19.B(2)
Removal or breach of a dam amendment adds the requirement that a breach be sized to pass the peak discharge without attenuation of the flood through the reservoir.

19.25.12.19.F
Proof of completion of works amendment clarifies that the requirement for a proof of completion of works form for changes to an existing dam will be made on a case by case basis by the state engineer.

19.25.12.20 CHANGES TO AN EXISTING NON-JURISDICTIONAL DAM:

19.25.12.20
The introduction amendment clarifies that a non-jurisdictional dam will no longer become jurisdictional if the purpose changes, but that a non-jurisdictional dam can become jurisdictional when the ownership changes from federal to non-federal.

19.25.12.21 EXISTING DAMS:

19.25.12.21.A
The introduction amendment adds the following statement: "Failure to comply with state engineer directives or these regulations may result in an order to reduce storage or to take corrective action."

19.25.12.21.B
Hazard classification change amendment deletes the following statement: "If the dam owner fails to address a deficiency, the state engineer may revoke the license to operate the dam and order the dam breached in accordance with Subsection B or C of 19.25.12.19 NMAC."

19.25.12.21.E
Operation and maintenance manual requirement amendment deletes compliance deadlines because the amendment will be promulgated on or after the deadlines and the deleted deadlines are no longer relevant. Existing owners of dams classified as high or significant hazard potential will be out of compliance if they have not complied with the requirements of 19.25.12.17 NMAC for an operation and maintenance manual.

19.25.12.21.F
Emergency action plan requirement amendment deletes compliance deadlines for all but significant hazard potential flood control dams and owners of 5 or more dams because the amendment will be promulgated on or after the deadlines and the deleted deadlines are no longer relevant.

EXHIBIT 2

REFERENCES FOR SELECT AMENDMENTS TO 19.25.12 NMAC
Dam Design, Construction and Dam Safety

1. Federal Emergency Management Agency, Federal Guidelines for Dam Safety, FEMA 93, 2004.

2. Federal Emergency Management Agency, Federal Guidelines for Dam Safety, Guidelines for Selecting and Accommodating Inflow Design Floods for Dam Safety, FEMA 94, 2004.

3. National Dam Safety Review Board, Simplified Inundation Maps for Emergency Action Plans, September 2009.

4. Section 72-5-32 NMSA, 2009

5. U.S. Army Corps of Engineers, General Design and Construction Considerations for Earth and Rock-fill Dams, EM 1110-2-2300, 2004.

6. U.S. Army Corps of Engineers, Earthquake Design and Evaluation for Civil Works Projects, ER 1110-2-1806, 1995.

7. U.S. Bureau of Reclamation, Downstream Hazard Classification Guidelines, ACER Technical Memorandum No. 11, 1988.

8. U.S. Bureau of Reclamation, Glossary, www.usbr.gov/projects/glossary.jsp.

9. United States Society on Dams, Strength of Materials for Embankment Dams, February 2007.

TITLE 19 NATURAL RESOURCES AND WILDLIFE
CHAPTER 25 ADMINISTRATION AND USE OF WATER - GENERAL PROVISIONS
PART 12 DAM DESIGN, CONSTRUCTION AND DAM SAFETY

19.25.12.1 ISSUING AGENCY: New Mexico Office of the State Engineer
[19.25.12.1 NMAC - N, 3/31/2005]

19.25.12.2 SCOPE: These regulations apply to the design and construction of all jurisdictional dams in New Mexico and are intended to facilitate the continued safe operation and maintenance of all non-federal jurisdictional dams. These regulations govern the review and acceptance of plans for construction, alteration, modification, repair, enlargement and removal of a jurisdictional dam. These regulations ensure the continued safe operation, maintenance, site security and emergency preparedness for existing non-federal jurisdictional dams. These regulations do not authorize the appropriation or use of water pursuant to 19.26 NMAC and 19.27 NMAC.
[19.25.12.2 NMAC - N, 3/31/2005]

19.25.12.3 STATUTORY AUTHORITY: Section 72-5-32 NMSA requires any person, association or corporation, public or private, the state or the United States that is intending to construct a jurisdictional dam to submit detailed plans to the state engineer. Sections 72-5-9 and 72-5-10 NMSA establish the state engineer's authority over the construction of works and issuing certificates of construction. Sections 72-5-8 and 72-5-14 NMSA require construction to be completed in a time limit set by the state engineer and procedures for requesting an extension of time. Sections 72-5-11, 72-5-12 and 72-5-13 NMSA gives the state engineer jurisdiction over unsafe works, penalties for failure to comply with state engineer orders and priority of liens. Section 72-2-6 NMSA gives the state engineer the authority to assess fees. Section 72-2-8 NMSA gives the state engineer authority to adopt regulations and codes to implement and enforce any provision of any law administered by him. Section 72-8-1 NMSA gives the state engineer the authority to enter upon private property for the performance of his duties. Nothing in these rules shall be construed so as to limit the state engineer's authority to take lawful alternative or additional actions relating to the design, construction and safety of dams.
[19.25.12.3 NMAC - N, 3/31/2005]

19.25.12.4 DURATION: Permanent.
[19.25.12.4 NMAC - N, 3/31/2005]

19.25.12.5 EFFECTIVE DATE: March 31, 2005 unless a later date is cited at the end of a section.
[19.25.12.5 NMAC - N, 3/31/2005]

19.25.12.6 OBJECTIVE: To establish minimum design requirements, minimum submittal requirements and dam site owner responsibilities that shall be addressed to the state engineer's satisfaction in order to ensure a dam is designed, constructed, operated, maintained and secured in a safe manner.
[19.25.12.6 NMAC - N, 3/31/2005]

19.25.12.7 DEFINITIONS: Unless defined below or in a specific section of these regulations, all other words used herein shall be given their customary and accepted meaning.

A. Terms starting with the letter 'A' are defined as follows:

[~~A.~~] (1) Abutment: That part of the valley side against which the dam is constructed. The left and right abutments of dams are defined with the observer viewing the dam looking in the downstream direction.

(2) Aesthetic fill: Cosmetic fill added to the downstream slope of a dam that is not required to address the safe design. Aesthetic fill shall not be considered when determining the properties of the dam for the purposes of evaluating the jurisdictional status and shall not be used to support the safe design.

[~~B.~~] (3) Alteration, modification, repair, rehabilitation or enlargement of an existing dam: To change from the state engineer accepted construction drawings and specifications or current condition.

[~~C.~~] (4) Appurtenant structure: Auxiliary features of a dam such as outlets, spillways, access structures, tunnels and related housing at a dam.

[~~D.~~] (5) [~~American society for testing and materials (ASTM): An accepted standard for testing the properties of materials.~~] ASTM: Standards promulgated by ASTM international for testing the properties of materials. Methods cited in these regulations include laboratory compaction characteristics of soils.

B. Terms starting with the letter 'B' are defined as follows:

[~~E.~~] Breach: An opening through a dam or spillway that is capable of draining a portion of the reservoir or the entire reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional discharge from the reservoir.

C. Terms starting with the letter 'C' are defined as follows:

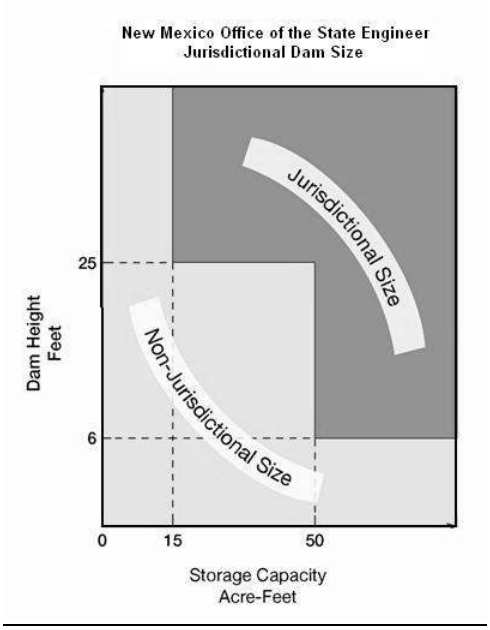
[~~F.~~] (1) Consequences of failure: Potential loss of life or property damage downstream of a dam caused by waters released at the dam or by waters released by partial or complete failure of dam; includes effects of landslides upstream of the dam on property located around the reservoir.

[~~G.~~] (2) Crest width: The thickness or width of a dam at the crest level (excluding corbels or parapets). In general, the term thickness is used for gravity and arch dams and width is used for other dams.

D. Terms starting with the letter 'D' are defined as follows:

[~~H.~~] (1) Dam: A man-made barrier constructed across a watercourse or off-channel for the purpose of storage, control or diversion of water.

[~~(1)~~] (a) Jurisdictional dam: [~~A dam that is more than 10 feet in height measured from the lowest point on the downstream toe to the dam crest or impounds more than 10 acre-feet of water as measured from the lowest point on the downstream toe to the spillway crest. Dams constructed under the supervision of the U.S. army corps of engineers before May 19, 2004, become jurisdictional when such supervision by the U.S. army corps of engineers is terminated.~~] A dam 25 feet or greater in height, which impounds more than 15 acre-feet of water or a dam that impounds 50 acre-feet or more of water and is 6 feet or greater in height. For purposes of these regulations, reference to a dam means a jurisdictional dam unless otherwise noted.
See figure of jurisdictional dam size.



[~~(2)~~] (b) Non-jurisdictional dam: [~~Any dam less than or equal to 10 feet in height and having storage less than or equal to 10 acre-feet of water.~~] Any dam not meeting the height and storage requirements of a jurisdictional dam. The state engineer does not regulate the design, construction and operation of a non-jurisdictional dam unless the dam is unsafe and there is a threat to life or property, as determined by the state engineer. Waters impounded by a non-jurisdictional dam may not be exempt from water right permit requirements; therefore a separate state engineer water right permit for the water impounded in the reservoir created by a non-jurisdictional dam may be required. Non-jurisdictional dams shall meet the requirements of 19.26.2.15 NMAC unless otherwise exempt. The structures listed below are considered non-jurisdictional dams:

~~**[(a) Stock dam:** A stock dam constructed prior to May 19, 2004 with a storage capacity of 10 acre-feet or less regardless of the height of the dam.~~

~~**(b) Erosion control dam:** A dam for the sole purpose of erosion control constructed on a naturally dry watercourse as determined by the state engineer, with a storage capacity of 10 acre-feet or less as measured from the lowest point on the downstream toe to the spillway crest and the reservoir drains in 96 hours unless a quicker drain time is required by court decree.~~]

[~~(c)~~] (i) Levee or diversion dike: A structure where water flows parallel to the length of the levee or diversion dike as determined by the state engineer.

[~~(d)~~] (ii) Roadway embankment: A structure across a watercourse designed for the sole purpose of supporting a roadbed or other means of conveyance for transportation as determined by the state engineer; where the area upstream has not been enlarged to increase flood storage; and where the embankment is provided with an uncontrolled conduit of sufficient capacity to satisfy requirements of the appropriate state or local transportation authority. If no transportation authority has jurisdiction over the structure, the current drainage design criteria of the New Mexico department of transportation shall apply.

[~~I.~~] (2) Dam crest: The [~~lowest elevation of the~~] uppermost surface of a dam, usually a road or walkway excluding any parapet wall, railing, etc.

[~~J.~~] (3) Dam failure: The breakdown of a dam, characterized by the uncontrolled release of impounded water. [~~There are varying degrees of failure.~~]

[~~K.~~] (4) Dam height: The vertical distance from the lowest point on the downstream toe to the lowest point on the dam crest.

[~~L.~~] (5) Dam incident: An event at a dam that interrupts normal procedures and performance, affects the safety of the dam or results in a potential loss of life or damage to property.

E. Terms starting with the letter 'E' are defined as follows:

(1) Earthquake: A sudden motion or trembling of the earth caused by the abrupt release of accumulated stress along a fault.

(a) Operating basis earthquake: The earthquake that can reasonably be expected to occur within the service life of the dam or appurtenant structures.

(b) Maximum credible earthquake: The greatest earthquake that can reasonably be expected to be generated by a specific source on the basis of seismological and geological evidence.

(2) Evacuation map: A map prepared in collaboration with local emergency managers defining the area to be evacuated from a dam failure.

F. Terms starting with the letter 'F' are defined as follows:

[~~M.~~] (1) Fetch: The straight-line distance [~~across a body of water~~] between the dam and farthest reservoir shore subject to wind forces. The fetch is one of the factors used to calculate wave heights in a reservoir.

[~~N.~~] (2) Freeboard: The vertical distance between the spillway crest and the lowest point of the dam crest not including camber.

[~~O.~~] (3) Functional exercise: A meeting in a conference room environment involving the dam owner and state and local emergency personnel with responsibilities in the emergency action plan. The exercise takes place in a stress-induced environment with time constraints and involves simulation of a dam failure and other specific events. The exercise is designed to evaluate both the internal capabilities and responses of the dam owner and the workability of the information in the emergency action plan used by emergency management officials.

G. Terms starting with the letter 'G' are defined as follows: Geotextile: Any fabric or textile (natural or synthetic) used as an engineering material in conjunction with soil, foundations or rock. Geotextiles provide the following uses: drainage, filtration, separation of materials, reinforcement, moisture barriers and erosion protection.

H. Terms starting with the letter 'H' are defined as follows:

[~~P.~~] High water line: The highest water level elevation in the reservoir as determined from routing the spillway design flood or inflow design flood.

I. Terms starting with the letter 'I' are defined as follows:

(1) Incremental impacts: Under a given flood, earthquake or other conditions, the difference in impacts that would occur due to failure or misoperation of the dam and appurtenant structures compared to those that would have occurred without failure or misoperation of the dam and appurtenant structures.

[~~**Q. Inflow design flood:** The flood flow above which the incremental increase in downstream water surface elevation due to failure of a dam is no longer considered to present an unacceptable additional downstream threat. The upper limit of the inflow design flood is the flood resulting from the probable maximum precipitation and the lower limit is the flood resulting from the 100-year precipitation.~~]

[~~R.~~] (2) Inundation map: A map delineating the area that would be flooded by a particular flood event.

J. Terms starting with the letter 'J' [Reserved]

K. Terms starting with the letter 'K' [Reserved]

L. Terms starting with the letter 'L' are defined as follows:

[~~S.~~] (1) Length of dam: The length measured along the dam axis at the dam crest. This also includes the spillway, powerplant, navigation lock, fish pass, etc., where these form part of the length of the dam. If detached from the dam these structures [~~should~~] shall not be included.

[~~T.~~] (2) Loss of life: The likely number of human fatalities that would result from a dam failure flood event. No allowances for evacuation or other emergency actions by the population [~~should~~] shall be considered.

M. Terms starting with the letter 'M' [Reserved]

N. Terms starting with the letter 'N' are defined as follows:

[~~U.~~] (1) Naturally dry watercourse: A watercourse or portion thereof, which under normal conditions is dry, which flows only in direct response to precipitation and whose channel is at all times above the groundwater table.

[~~V.~~] (2) Normal operating level: The water level elevation corresponding to the maximum storage level that excludes any flood control or surcharge storage.

[~~W.~~] (3) North American vertical datum 1988 (NAVD 88): The current vertical control datum in use in North America established from nine space geodetic stations. This basis of establishing elevation provides a precise surface, [~~whereas the North American vertical datum 1927 (NAVD27)~~] whereas the national geodetic vertical datum 1929 (NGVD 29) is elevation established from mean sea level.

O. Terms starting with the letter 'O' are defined as follows:

[~~X.~~] (1) One-hundred year flood: A flood that has 1 chance in 100 of being equaled or exceeded during any year.

[~~Y.~~] (2) Owner: The individual, association or corporation, public or private, the state or the United States, owning the land upon which a dam is constructed; having a contractual right to construct, operate or maintain a dam; or the beneficiary of an easement to construct, operate or maintain a dam.

P. Terms starting with the letter 'P' are defined as follows:

(1) Probable: Likely to occur, reasonably expected, realistic.

[~~Z.~~] (2) Probable maximum precipitation: Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular location during a certain time of year.

Q. Terms starting with the letter 'Q' [Reserved]

R. Terms starting with the letter 'R' are defined as follows: Residual freeboard: The vertical distance between the high water line and the lowest point on the dam crest.

S. Terms starting with the letter 'S' are defined as follows:

[~~AA.~~] (1) Spillway: A structure over or through which excess flow is discharged from a reservoir. If the rate of flow is controlled by mechanical means such as gates, it is considered a controlled spillway. If the geometry of the spillway is the only control, it is considered an uncontrolled spillway. For purposes of these regulations, an uncontrolled outlet conduit that is used to drain the reservoir is not considered a spillway.

[~~BB.~~] (2) Spillway crest: The lowest level at which water can flow over or through the spillway.

[~~CC.~~] (3) Spillway design flood: The required flood that a spillway must pass without failure of the dam.

[~~DD.~~] (4) Storage: For purposes of determining whether a dam is jurisdictional, the storage is the volume of water impounded by the dam above the lowest elevation of the downstream toe to the elevation of the spillway crest. For dams with no spillway, storage is measured to the dam crest. Definitions of specific types of storage in reservoirs are:

[~~(1)~~] (a) Dead storage is the storage volume of a reservoir that lies below the invert of the lowest outlet and therefore, cannot readily be withdrawn from the reservoir.

[~~(2)~~] (b) Flood surcharge storage is the storage volume between the maximum operating level and the maximum water level during the spillway design flood.

[~~(3)~~] (c) Live storage is the storage volume of a reservoir that is available for use and lies above the invert of the lowest outlet.

[~~(4)~~] (d) Reservoir storage capacity is the sum of the dead and live storage of the reservoir.

[~~(5)~~] (e) Maximum storage is the sum of the reservoir storage capacity and flood surcharge storage.

(5) Sunny day failure: Dam failure with the reservoir at the normal operating level.

T. Terms starting with the letter 'T' are defined as follows:

[~~EE.~~] (1) Tabletop exercise: A meeting in a conference room environment involving the dam owner and state and local emergency personnel with responsibilities in the emergency action plan. The format is a discussion of an emergency event, response procedures to resolve concerns regarding coordination and responsibilities.

[~~FF.~~] (2) Toe: The contact line between the outer shell of the dam and the natural ground surface.

U. Terms starting with the letter 'U' [Reserved]

V. Terms starting with the letter 'V' [Reserved]

W. Terms starting with the letter 'W' are defined as follows:

[~~GG.~~] Wave runup: Vertical height above the water level to which water from a specific wave will run up the face of a structure or embankment.

X. Terms starting with the letter 'X' [Reserved]

Y. Terms starting with the letter 'Y' [Reserved]

Z. Terms starting with the letter 'Z' [Reserved]

[19.25.12.7 NMAC - N, 3/31/2005; A, xx/xx/2010]

19.25.12.8 FEE SCHEDULE: The state engineer assesses fees for filing forms, reviewing plans and specifications for dams and appurtenant structures and construction inspections.

A. For filing an application for permit to construct and operate a dam the fees shall be $25.

B. For filing an application to alter, repair or rehabilitate a dam the fee shall be $25.

[~~**B.**~~] **C.** For each review of design plans, construction drawings and specifications for a dam the fee shall be $2 per $1000 or fraction thereof of the estimated construction cost. For determination of fees, inclusion of contingencies, taxes and other permit fees is not required. Assessment of multiple review fees for the same application is at the sole discretion of the state engineer.

[~~C.~~] D. For issuing an extension of time for construction of a dam the fee shall be $50.

[~~D.~~] E. For inspecting construction of a dam the fee shall be $100/8-hour day and actual and necessary traveling expenses.

[~~E.~~] F. For filing a proof of completion of works for a dam the fee shall be $25.

[~~F.~~] G. For filing a change of ownership for a dam the fee shall be $5.

[~~G.~~] H. [~~For copies of dam safety records up to 11 inches by 17 inches the fee shall be $0.20 per copy.~~] The state engineer shall charge reasonable fees for copy and reproduction to offset the cost of the service, consistent with the state engineer's current policy adopted pursuant to the New Mexico Inspection of Public Records Act, NMSA 1978 Section 14-2 et seq.

[~~**H.** For copies of dam safety records greater than 11 inches by 17 inches the fee shall be $3.00 per copy.~~]

[19.25.12.8 NMAC - N, 3/31/2005; A, xx/xx/2010]

19.25.12.9 SIZE CLASSIFICATION: A dam shall be less than or equal to the maximum height and storage to qualify for the size classification.

A. Small: [~~A small dam is greater than 10 feet but less than or equal to 40 feet in height, or greater than 10 acre-feet but less than or equal to 1000 acre-feet of storage.~~] A small dam is 25 feet or greater but less than or equal to 40 feet in height, or 50 acre-feet or greater but less than or equal to 1000 acre-feet of storage.

B. Intermediate: An intermediate dam is greater than 40 feet but less than or equal to 100 feet in height, or greater than 1000 acre-feet but less than or equal to 50,000 acre-feet of storage.

C. Large: A large dam is greater than 100 feet in height[~~,~~] or greater than 50,000 acre-feet of storage.

[19.25.12.9 NMAC - N, 3/31/2005; A, xx/xx/2010]

19.25.12.10 HAZARD POTENTIAL CLASSIFICATION: The hazard potential classification is a rating for a dam based on the potential consequences of failure. The rating is based on loss of life, damage to property and environmental damage that is likely to occur in the event of dam failure. No allowances for evacuation or other emergency actions by the population [~~should~~] shall be considered. The hazard potential classification is not a reflection of the condition of the dam.

A. Low hazard potential: Dams assigned the low hazard potential classification are those dams where failure or misoperation results in no probable loss of life and low economic [~~and/or~~] or environmental losses. Losses are principally limited to the dam owner's property.

B. Significant hazard potential: Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in populated areas with significant infrastructure.

C. High hazard potential: Dams assigned the high hazard potential classification are those dams where failure or misoperation will probably cause loss of human life.

[19.25.12.10 NMAC - N, 3/31/2005; A, xx/xx/2010]

19.25.12.11 DESIGN OF A DAM: Any person, association or corporation, public or private, the state, or the United States that is intending to construct a dam shall submit an application to construct and operate a dam and supporting documentation acceptable to the state engineer. This section primarily addresses the design and construction of embankment dams. Other types of dams shall conform to sound engineering principles and current state of the practice. Because each site, design and operating practice is unique, waivers of specific requirements in this section will be considered on a case-by-case basis. Request for waiver shall be in writing accompanied with documentation justifying the request. If the request is not justified to the satisfaction of the state engineer the request will be denied. If the supporting documentation for the design of a dam does not meet acceptable engineering standards and does not conform to these regulations, as determined by the state engineer, a quality management plan or third party review may be required by the state engineer. Construction shall not begin until the state engineer has accepted the supporting documentation and approved the application with [~~construction and operation~~] permit conditions. The application and supporting documentation shall include[~~:~~] the information described below.

A. Application: An application form shall be completed with original signature of the dam owner and accompanied with a filing fee in accordance with Subsection A of 19.25.12.8 NMAC. The form will be the only information available to the public before the project is approved for construction. All other supporting documentation is considered draft until accepted by the state engineer. A plan review fee in accordance with Subsection [~~B~~] C of 19.25.12.8 NMAC shall accompany the submittal of the design report, construction drawings and specifications. A detailed estimate of the construction cost for the proposed dam and appurtenant structures shall be submitted in support of the plan review fee.

B. Water right: A water right is required for water impounded by the dam. If the dam owner has a permit for the diversion of water, documentation addressing the necessity for storage, diversion periods and release conditions for the reservoir may be required. This requirement is waived for flood control dams that do not detain water longer than 96 hours in accordance with Subparagraph (b) of Paragraph (7) of Subsection C of 19.25.12.11 NMAC or provide documentation that a waiver by the state engineer has been granted. Flood control dams that do not drain within 96 hours require a water right for water permanently stored beyond the 96-hour drain time requirement and for associated losses due to evaporation and other potential depletions to the system unless a waiver in accordance with 19.25.12.11 NMAC is obtained.

C. Design report: A design report, which includes information to evaluate the safe design of the dam and appurtenant structures, shall be submitted in a form acceptable to the state engineer. [~~The design report shall contain the information described below and any other additional information determined necessary by the state engineer.~~] The final design report shall also be submitted in an electronic format acceptable to the state engineer. The design report may be submitted as a single report or as individual reports documenting the information described below. A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare or supervise the preparation of the design report. [~~The front cover shall show the name of the dam (identical to the application), the county in which the dam is located and type of report.~~] The front cover shall show the name of the dam, the county in which the dam is located, the dam owner and the type of report. [~~The first page behind the front cover shall show the name of the dam (identical to the dam name on the application), the county in which the dam is located and the signed certifications for the engineer and state engineer in accordance with Subsections B and E of 19.25.12.12 NMAC.~~] The first page behind the front cover shall show the name of the dam, the county in which the dam is located, a signed certification from the engineer and a certification for the state engineer in accordance with Subsections B and E of 19.25.12.12 NMAC. [~~The design report shall include:~~] The design report shall contain the information described below and any other additional information determined necessary by the state engineer to evaluate if the design is safe.

(1) Hazard potential classification. A hazard potential classification shall be based on the dam failure condition that results in the greatest potential for loss of life and property damage. If the state engineer concurs, the classification may be based on the judgment and recommendation of the professional engineer. For all other cases, a

low or significant hazard potential classification shall be supported by a dam breach and flood routing analysis, which includes calculations and data that supports the predicted dam failure flood. This analysis shall also address the potential for foreseeable future development. Evaluation of the effects of flooding from dam failure shall extend at least to the location downstream where the classification can be properly identified. The dam breach and flood routing analysis shall include, but not be limited to:

(a) [~~dam failure inundation maps;~~] description of the dam breach and flood routing methodology;

[~~(b)~~ ~~map of the water surface profiles;~~

~~(c)~~ ~~cross-sections drawn to scale showing water surface elevation at critical sections where structures are impacted and showing discharge in cubic feet per second, average velocity in feet per second, flood wave travel times, rate of rise and structures located in the flooded sections;~~]

[~~(d)~~] (b) a tabulation and justification of [~~assumed~~] parameters used in the analysis;

[~~(e)~~] (c) a sensitivity analysis of the [~~assumed~~] parameters used in the analysis;

[~~(f)~~] (d) references to all computer models, data and supporting justification used in the analysis; [~~and~~]

[~~(g)~~] (e) [~~appropriate data sheets and computer program output computations from computerized analysis shall be provided.~~] appropriate data sheets, computer program input and output computations and electronic files from computerized analysis;

(f) table of results for the flood routing for the sunny day failure and the failure and no failure scenarios for multiple flood events up to and including the spillway design flood as defined in Subparagraph (a) through (d) of Paragraph (3) of Subsection C of 19.25.12.11 NMAC; the table of results for all critical locations downstream shall include the depth of flow in feet, velocity of flow in feet per second, rate of flow in cubic feet per second and the incremental impacts; and

(g) dam failure inundation maps downstream of the dam for the sunny day failure and failure during the spillway design flood event showing the depth of flow in feet, average velocity in feet per second and rate of flow in cubic feet per second at critical locations downstream.

(2) Hydrologic analysis. The hydrologic analysis shall include a discussion of methodology used to calculate the spillway design flood for determining the available flood storage and spillway capacity. Consideration of how the dam will perform under these hypothetical flood conditions shall be evaluated. The hydrologic analysis shall include, but not be limited to:

(a) a topographic map of the drainage area above the dam with the drainage area and sub-basins delineated and presented on a map of appropriate scale and size;

(b) a description of the topography, soils and vegetative cover and land treatment of the drainage area;

(c) a discussion of the depth, duration and distribution of the spillway design storm;

(d) a tabulation, discussion and justification of all hydrologic parameters and methodology used to calculate runoff from rainfall;

(e) a discussion of the peak inflow, volume of runoff and maximum reservoir water level elevation for the inflow hydrograph;

(f) a plot of the reservoir inflow and outflow hydrographs extended until flow is negligible and plotted on the same figure of appropriate size and scale;

(g) a table showing the reservoir area (in acres) and storage capacity (in acre-feet) for each foot of elevation above the bottom of the reservoir to the dam crest; the table shall be determined from the reservoir topography map; indicate the amount of dead storage, elevation of the invert of the outlet and elevation of the crest of each spillway; all elevations shall be based on North American vertical datum 1988 or more recent adjustment; and

(h) appropriate data sheets and computer program output computations from computerized analysis [~~shall be provided~~].

(3) Spillway design flood. The spillway design flood is the flood that a spillway must be capable of conveying without dam failure. For perimeter embankment dams with no spillway and no external drainage area, the dam must be capable of impounding the spillway design flood without dam failure. A spillway design flood less than these requirements is acceptable to the state engineer if an incremental damage analysis is presented to justify the inflow design flood in accordance with Paragraph (4) of Subsection C of 19.25.12.11 NMAC. The spillway design flood is based on size classification and hazard potential classification of the dam as [~~follows~~] described below.

(a) Dams classified as low hazard potential, regardless of size, shall have spillways designed to pass a flood resulting from a 100-year precipitation event expressed as a percentage of the probable maximum precipitation.

(b) Dams classified as small and intermediate, with a significant hazard potential rating shall have spillways designed to pass a flood resulting from 50 percent of the probable maximum precipitation.

(c) Dams classified as large, with a significant hazard potential rating shall have spillways designed to pass a flood resulting from 75 percent of the probable maximum precipitation.

(d) Dams classified as high hazard potential, regardless of size, shall have spillways designed to pass a flood resulting from the probable maximum precipitation.

(4) Incremental damage assessment. [~~Where spillways are not in compliance with Paragraph (3) of Subsection C of 19.25.12.11 NMAC an incremental damage assessment shall justify the inflow design flood used to size the spillway. The assessment shall evaluate the consequences of dam failure. The assessment shall compare the impact of with failure and without failure conditions on downstream water levels and existing and known future development.~~] Where spillways cannot be designed to comply with Paragraph (3) of Subsection C of 19.25.12.11 NMAC an incremental damage assessment shall justify the spillway design flood used to size the spillway. The spillway design flood from an incremental damage assessment is the flood above which the incremental increase in downstream water surface elevation due to failure of a dam is no longer considered to present an unacceptable additional downstream threat when compared to the same flood without dam failure. The lower limit is the flood resulting from the 100-year precipitation. The assessment shall compare the incremental impacts on downstream areas including existing and foreseeable future development. The assessment shall include a dam breach and flood routing analysis in accordance with Subparagraphs (a) through (g) of Paragraph (1) of Subsection C of 19.25.12.11 NMAC for the failure and non-failure conditions. Methods for assessing the damage between failure and non-failure conditions shall be fully documented.

(5) Spillway capacity. The spillway capacity shall be adequate to pass the spillway design flood in accordance with Paragraph (3) of Subsection C of 19.25.12.11 NMAC or accepted inflow design flood in accordance with Paragraph (4) of Subsection C of 19.25.12.11 NMAC without failure of the dam. [~~If design calculations show that overtopping will occur, an erosion study of the embankment documenting that the dam will not breach is required.~~] If the outlet works are gated, the design discharge of the outlet works shall not be considered when routing the spillway design flood through the reservoir and spillway. The water level shall be at the normal operating level at the beginning of the spillway design storm. A spillway rating curve and table showing elevation in one-foot increments versus maximum discharge capacity shall be prepared. The rating curve and table shall include data from the crest of the spillway to the dam crest. The parameters used to calculate the spillway capacity shall be justified and appropriate data sheets and computer program output computations from computerized analysis shall be provided. Elevations shall be based on North American vertical datum 1988 or more recent adjustment.

(6) Spillway design. Spillways shall be evaluated for erosion potential during normal operation and the design flood event. Damage to a spillway during the design flood event is acceptable; however, a breach of the spillway is unacceptable. The spillway design shall address the [~~following~~] minimum requirements[~~:~~] described below.

(a) The material required for spillway lining depends on the spillway location, frequency of discharge and velocity of discharge to adequately address erosion and breach potential. The design shall provide adequate justification for the material selected.

(b) The design shall provide aeration of the nappe for cavitation control where control weirs are used at the spillway crest.

(c) The spillway must discharge away from the toe of the dam and abutment slopes.

(d) The design shall address the potential for the accumulation of debris that may block the spillway [~~shall be addressed~~].

(e) [~~Energy dissipation to control erosion of the natural channel due to spillway discharge shall be addressed.~~] The design shall address energy dissipation to control erosion of the natural channel due to spillway discharge reasonably expected to occur during the life of the dam.

(f) Channel lining shall be placed on a suitably prepared, stable subgrade. All edges and joints in channel lining material must be designed to prevent undermining and erosion. Concrete channel lining must be provided with adequate jointing to permit thermal expansion and contraction and adequate reinforcing to control thermal cracking. Adequate water stops are required at joints in the spillway lining. Concrete lining shall be

adequately anchored against displacement and uplift and shall be provided with adequate subdrainage to relieve hydrostatic pressure and prevent frost heave.

(g) Where training dikes are used to divert the water away from the dam, the dike shall be designed with a compaction to at least 95% of the maximum standard Proctor density, ASTM D 698, or at least 90% of the maximum modified Proctor density, ASTM D 1557[~~, or at least 70% relative density if Proctor testing is not appropriate~~]. Erosion protection for the dike shall be addressed in accordance with Paragraph (16) of Subsection C of 19.25.12.11 NMAC.

(7) Outlet works capacity. Dams shall be designed with a low level outlet to drain the entire contents above the elevation of the downstream toe of the dam. If environmental consequences prevent draining of the reservoir, the state engineer will grant a waiver if written justification is provided to the satisfaction of the state engineer. The outlet shall be sized to provide adequate capacity to satisfy water rights of downstream priority users. A stage discharge curve and table showing elevation in one-foot increments versus discharge capacity shall be prepared. The rating curve and table shall be from the invert of the outlet to the dam crest. The parameters used to calculate the outlet works capacity shall be justified and appropriate data sheets and computer program output computations from computerized analysis shall be provided. Elevations shall be based on North American vertical datum 1988 or more recent adjustment. The outlet works capacity shall meet the [~~following~~] minimum requirements [~~:~~] described below.

(a) Outlets for water storage [~~reservoirs~~] dams shall drain the reservoir in 45 days with supporting calculations provided.

(b) Outlets for flood control dams shall drain the reservoir in 96 hours unless a waiver is granted by the state engineer. The 96-hour time frame begins once the reservoir storage drops to the emergency spillway crest or reaches its peak during the 100-year, 24-hour event. Documentation supporting the waiver shall include the time to drain more frequent events.

(8) Outlet works design. The outlet works design includes the intake structure, conduit and terminal structure. The outlet works design shall meet the [~~following~~] minimum requirements [~~:~~] described below.

(a) Minimum conduit diameter is 18 inches unless a waiver is granted by the state engineer. Documentation supporting a waiver shall include identification of methods to inspect the interior of the conduit.

(b) Metal conduits used in dams that are classified as significant hazard potential where the sole purpose of the dam is flood control, or in dams classified as low hazard potential, shall have adequate strength after corrosion for a minimum of 200 years, based on corrosivity testing of onsite soils. Cathodic or other protection of metal conduits is permissible and may be considered in this analysis. Metal conduits are not acceptable for dams classified as high hazard potential or dams classified as significant hazard potential with permanent water storage except as interior forms for cast-in-place concrete conduits.

(c) Outlet conduits for storage reservoirs shall be gated at the upstream end unless a waiver is granted by the state engineer. Where gates are located other than at the upstream end of the conduit, a guard gate or bulkhead shall be provided at the upstream end to allow draining of the conduit for inspection, maintenance and repair.

(d) Outlet conduits shall be adequately vented and shall include all supporting calculations. Where the outlet conduit ties directly to a downstream pipe, a by-pass valve shall be provided.

(e) Outlet controls and equipment shall be properly designed to be secure from damage due to vandalism, weather, ice, floating debris, wave action, embankment settlement and other reasonably foreseeable causes. The outlet control operators shall remain accessible during outlet works and spillway releases.

(f) Outlets for flood control structures shall be ungated. Where a gate is required to satisfy downstream release restrictions, a waiver from the state engineer is required. The written request for waiver shall include a plan for timely release of the floodwater.

(g) Outlet works intake structures shall be provided with trash racks or grates to prevent clogging with debris. Grate opening [~~size~~] area or bar spacing shall be adequate to satisfy applicable public safety requirements, if appropriate. Total [~~size~~] area of grate openings must be at least three times the cross-sectional area of the outlet conduit.

(h) The design of the outlet works terminal structure shall address energy dissipation to prevent erosion and shall include supporting calculations.

(i) Outlet conduits shall be designed for full embankment loading and for hydrostatic pressure equal to the maximum reservoir head, acting separately and in combination, with an adequate factor of safety for the

conduit material. If future increases in embankment height [~~and/or~~] or reservoir head are foreseeable, allowance shall be made in the design.

(j) The conduit together with all joints and fittings shall be watertight at the design pressure and shall be pressure tested prior to backfilling. Conduits shall be designed for all reasonably foreseeable adverse conditions including corrosion, abrasion, cavitation, embankment settlement and spreading, thermal effects and seismic loading. The ability of the conduit to withstand deflection and separation at the joints shall be addressed in the design of the outlet conduit.

(k) Outlet works shall be supported by stable, well-consolidated foundation materials. Where the conduit is placed in embankment fill or native overburden materials, settlement analysis shall be performed.

(l) Minimizing seepage along conduits shall be addressed including the methods for ensuring compaction of backfill around and beneath the conduit. Seepage collars are not an acceptable design standard for controlling seepage.

(m) All supporting documentation and calculations for the outlet works design shall be provided. The outlet works design shall include all foreseeable loading conditions, including but not limited to ice loading, debris buildup, wave action and embankment settlement. Structural design calculations for the intake structure, conduit and outlet structure shall be submitted.

(9) Geological assessment. A geological assessment of the dam and reservoir site is required for all dams classified as high or significant hazard potential. The geological assessment may be included in the geotechnical investigation or seismic study, or may be submitted as a separate document. The geological assessment shall address regional geologic setting; local and site geology; geologic suitability of the dam foundation; slide potential of the reservoir rim and abutment areas; and seismic history and potential.

(10) Geotechnical investigation. A geotechnical investigation shall assess site conditions and support the design. A professional engineer licensed in the state of New Mexico qualified to provide geotechnical expertise in the design and construction of dams shall prepare, stamp and sign the geotechnical investigation, which may be submitted as a separate report. The scope of the geotechnical investigation is dependent on the size classification, hazard potential classification, anticipated materials and construction methods, site geology and seismicity, anticipated soil strata and other site-specific conditions. The geotechnical investigation shall include a field investigation and laboratory testing. Results of field and laboratory testing shall be presented in a report, including recommended parameters to be used in design and construction of the dam and appurtenant structures. The field investigation and laboratory testing shall include but not be limited to the following:

(a) test borings in the footprint of the embankment, spillway excavations and appurtenant structures extending to bedrock or to a depth equal to at least the height of the dam; where appropriate, borings may include coring of bedrock materials to determine the quality and character of the rock;

(b) standard penetration tests or other field-testing to assess soil character and consistency;

(c) "undisturbed" sampling for further tests such as insitu density, shear strength and compressibility;

(d) supplemental test pits, if deemed necessary, to obtain bulk and undisturbed samples, assess soil layering and measure bedrock orientation;

(e) measurement of water level in drill holes;

(f) field permeability testing, if feasible;

(g) logs of test borings and test pits, location map and profile along dam axis with soil information shown;

(h) testing to determine the relevant properties of the material to be used in construction, including but not limited to shear strength, permeability, compressibility and filter characteristics; the testing method shall conform to accepted industry standards and be appropriate for the material being tested;

(i) evaluation of liquefaction potential and dynamic shear strength testing if deformation analysis is required; and

(j) identification of the location of the borrow material to be used during construction.

(11) Seepage and internal drainage. The effects of seepage and potential for internal erosion shall be evaluated. For dams with aesthetic fill on the downstream slope, the effects of seepage shall be evaluated with and without the aesthetic fill. A seepage analysis shall be performed to address the performance of the embankment under steady-state conditions for dams classified as high or significant hazard potential. All parameters and assumptions used in the analysis shall be summarized in a table and justified in the seepage analysis. A waiver may be requested in writing for flood control dams [~~or reservoirs with synthetic liners~~] that drain in 96 hours. The

seepage analysis and internal drainage design shall include [~~but not be limited to the following:~~] the minimum requirements described below.

(a) Flow nets of appropriate size and scale shall be prepared. The effects of anisotropy with respect to permeability shall be addressed. Ratios of horizontal to vertical permeability of less than 4 for constructed embankments and less than 9 for native deposits shall be supported by field and laboratory permeability tests. Appropriate data sheets and computer program output computations from computerized analysis shall be provided.

(b) The design shall address the effects of anticipated seepage beneath, around and through the dam. Seepage shall not exit on the dam face and excessive exit seepage gradients are unacceptable. All filter, transition and drainage zones within earth dams shall have a thickness adequate to address constructability and enhance seismic stability with a minimum thickness of 3 feet for each zone.

(c) Collector pipes and conduits for internal drains shall be made of non-corrodible material capable of withstanding the anticipated loads. If possible, pipes shall be located where they can be exposed for repair or replacement without threatening the stability of the dam. Collector pipes for drains shall be enveloped in a free-draining medium meeting filter criteria for adjacent embankment or foundation zones. Where surging or hydraulic gradient reversal is likely, perforation size must be less than the diameter at which 15 percent of the surrounding medium is finer. Where surging or hydraulic gradient reversal are unlikely, the perforation size must be less than the diameter at which 85 percent of the surrounding medium is finer.

(d) Drain pipes shall be sized to provide a flow depth no more than ¼ of the pipe diameter when carrying the anticipated discharge. Drain pipes shall be at least 6 inches in diameter unless the availability of technology for inspection and maintenance can be demonstrated. Individual pipes shall discharge to a gallery, well, manhole, or to daylight such that the flow of each pipe can be monitored and measured. Manifold connections, tees and wyes are not permitted. [~~If the anticipated flow from a drain line exceeds 10 gpm, a measuring flume or weir shall be provided for that line. If the anticipated flow from a drain line is less than 10 gpm, the outfall shall be designed to allow a 5 gallon bucket to be used to collect and measure discharge.~~] A seepage measuring device must be appropriate for the rate of anticipated flow. The measuring device must include an upstream catchment to detect any sediment in the seepage. Where pipes from internal drains are discharged to daylight, a rodent screen shall be provided.

(12) Stability analysis. Cross-sectional design for dams shall be supported by slope stability analysis. For dams with aesthetic fill on the downstream slope, the stability of the downstream slope shall be evaluated with and without the aesthetic fill. Dams classified as low hazard potential with upstream slopes no steeper than 3 horizontal to 1 vertical, downstream slopes no steeper than 2 horizontal to 1 vertical and which are 25 feet or less in height will not require slope stability analysis. Stability analysis of the reservoir rim is required where slopes are steeper than 3 horizontal to 1 vertical. The analysis model shall adequately represent the geometry and zoning, shear strength parameters, material unit weights, pore pressure and seepage conditions, external loading and other relevant factors of the critical cross section or sections. Manual computations in the analysis will be accepted if judged to be sufficiently rigorous. Where appropriate, the analysis shall consider noncircular or block and wedge type failure surfaces as well as circular failures. All parameters and assumptions used in the analysis shall be summarized in a table and justified in the geotechnical investigation. A scale drawing, utilizing the same scale for vertical and horizontal dimensions, shall be provided for each cross-sectional model used in the analysis, with the critical failure surface(s) identified. Appropriate data sheets and computer program output computations from computerized analysis shall be provided. Dams shall be designed to provide the following minimum factors of safety from the stability analysis:

(a) 1.5 for steady state long-term stability;

(b) 1.5 for operational drawdown conditions;

(c) [~~1.2~~] 1.3 for rapid drawdown conditions; and

(d) [~~1.2~~] 1.3 for end of construction.

(13) Seismic design and analysis. Dams and appurtenant structures classified as high or significant hazard potential shall be analyzed for seismic stability. Seismic analysis for water storage dams shall be based on full reservoir under steady state seepage conditions. Flood control dams with ungated outlets that satisfy Subparagraph (b) of Paragraph (7) of Subsection C of 19.25.12.11 NMAC without waiver shall be designed for earthquake loads under empty reservoir conditions and need not consider steady-state seepage. Dams sited on active faults shall obtain a waiver from the state engineer. To obtain a waiver the analysis shall show that the location of the dam is unavoidable and the dam must be designed to withstand anticipated fault movement without compromising its integrity. Appropriate data sheets and computer program output computations from computerized

analysis shall be provided. The seismic analysis shall meet the [~~following~~] minimum requirements [~~:~~] described below.

(a) A seismological investigation for the dam area and reservoir area shall be performed. This study may be part of the geological or geotechnical report for the structure, or may be a separate effort. The study shall determine and justify the appropriate seismic parameters to be used for design. The dam and appurtenant structures shall be capable of withstanding the operating basis earthquake without damage. The operating basis earthquake has a 50% probability of exceedance during the service life of the dam or appurtenant structures. In no case shall the service life be less than 100 years. The dam and appurtenant structures critical to the safety of the dam shall be capable of withstanding the design earthquake without failure. The seismic parameters shall be based on the [~~following~~] design earthquake [~~:~~] requirements described below.

(i) Dams classified as high hazard potential other than flood control structures shall be designed for the maximum credible earthquake or for [~~an earthquake with a 5000-year return frequency~~] a 1% probability of exceedance in 50 years (approximately 5000-year return frequency).

(ii) Dams classified as significant hazard potential or high hazard potential dams whose sole purpose is for flood control shall be designed for a 2% [~~chance of occurrence~~] probability of exceedance in 50 years (approximately 2500-year return frequency).

(b) An analysis of materials in the foundation, reservoir area and proposed embankment shall be completed to determine the potential for liquefaction, earthquake-induced sliding, or other seismic sensitivity, which may be accomplished as part of the geotechnical investigation.

(c) Pseudostatic analysis will be acceptable for the following cases:

(i) the embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D 698, or at least 90% of the maximum modified Proctor density, ASTM D 1557 [~~or at least 70% relative density if Proctor testing is not appropriate~~]; no materials prone to liquefaction are present in the foundation and peak [~~bedrock~~] ground acceleration is 0.20g or less; or

(ii) the embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D 698, or at least 90% of the maximum modified Proctor density, ASTM D 1557; potentially submerged portions of the embankment except for internal drain elements are constructed of clayey material; the dam is constructed on clayey soil or bedrock foundation and peak [~~bedrock~~] ground acceleration is 0.35g or less; and

(iii) all safety factor requirements in accordance with Subparagraphs (a) through (d) of Paragraph (12) of Subsection C of 19.25.12.11 NMAC are met;

(iv) minimum freeboard requirements in accordance with Subparagraphs (a) through (e) of Paragraph (15) of Subsection C of 19.25.12.11 NMAC are met; and

(v) the pseudostatic coefficient selected for analysis must be at least 50% of the predicted peak [~~bedrock~~] ground acceleration, but not less than 0.05g and the factor of safety under pseudostatic analysis shall be 1.1 or greater. In determining the factor of safety for pseudostatic analysis, a search for the critical failure surface shall be made.

(d) For dams not satisfying the requirements for pseudostatic analysis, a deformation analysis is required. The resulting embankment must be capable of withstanding the design earthquake without breaching and with at least 3 feet of freeboard remaining after deformation. The analysis shall also assess the potential for internal erosion as a result of cracking during deformation.

[~~**(e)** The seismic assessment shall also address the stability of appurtenant structures to the dam during the design earthquake as appropriate, unless failure of an appurtenance due to earthquake does not represent an immediate threat to the dam, in which case the operating basis earthquake may be used.~~]

(14) Dam geometry. The dam geometry shall be supported by the stability and seismic analysis and [~~meeting the following minimum requirements:~~] shall meet the minimum requirements described below.

(a) The crest width shall be at least equal to the dam height in feet divided by 5 plus 8 feet, with the minimum permissible crest width being 10 feet and the maximum required crest width being 24 feet.

(b) Roads located on the crest shall have appropriate surfacing to provide a stable base that resists rutting and provides adequate friction for safety in wet conditions.

(c) The crest design shall provide a minimum of 2 feet of cover or the depth of frost penetration; whichever is greater, above clay cores to prevent cracking of the core due to desiccation or frost penetration.

(d) Turnarounds [~~should~~] shall be provided on dead-end service roads on dam crests, located in such a manner that backing maneuvers longer than 300 feet are eliminated.

(e) The crest shall be provided with adequate cross slope to prevent ponding.

(f) The slope or slopes to which crest drainage is directed must be provided with adequate erosion protection to accept the crest drainage.

(g) The crest longitudinal profile shall be provided with adequate camber to maintain the profile after embankment settlement. Camber [~~should~~] shall be based on a settlement analysis and shall be at least 2 percent of the total embankment height, with a minimum of 1 foot at the highest point of the dam. The tops of internal core zones shall also be provided with camber in a similar manner to the crest of the dam.

(h) In the event that safety berms, street curbs, or other longitudinal features which block, control, or concentrate drainage are required on the dam crest, the design shall provide for collection and conveyance of accumulated water to discharge away from the embankment without erosion.

(15) Freeboard. Dams shall be provided with adequate freeboard. Wave runup shall be determined taking into consideration wind speed, reservoir fetch, embankment slope and roughness of the slope surface. Freeboard shall satisfy the [~~following conditions:~~] minimum requirements described below.

(a) Anticipated wave runup resulting from a 100 mph wind with reservoir level at the spillway crest will not overtop the dam.

(b) Anticipated wave runup resulting from a 50 mph wind with maximum reservoir level from routed spillway design flood will not overtop the dam.

(c) Clay core cover and capillary rise requirements in accordance with Subparagraph (c) of Paragraph (14) of Subsection C of 19.25.12.11 NMAC are satisfied.

(d) A minimum of 3 feet of freeboard remains after seismic deformation.

(e) In any case, at least 4 feet of freeboard shall be provided. The minimum of 4 feet of freeboard may be waived for perimeter [~~embankments~~] embankment dams with no spillway and no external drainage area, provided a written request is made to the state engineer accompanied with supporting justification.

(16) Erosion protection. Erosion protection shall be addressed to protect the dam and appurtenant structures from erosion that can threaten the safety of the structure. [~~At a minimum, the following areas of erosion shall be addressed:~~] Erosion protection shall address the minimum requirements described below.

(a) Wave erosion. The upstream slope shall be protected from wave erosion. The material selected and area of coverage shall be appropriate for the protection required with justification provided. Flood control dams in compliance with Subparagraph (b) of Paragraph (7) of Subsection C of 19.25.12.11 NMAC without waiver are exempt from wave protection.

(b) Surface erosion. The slope, crest, abutment and groins, toe areas and any other constructed areas associated with the dam and appurtenant structures shall be protected from [~~surface~~] wind erosion and erosion from concentrated and sheet flows. The material selected and area of coverage shall be appropriate for the protection required with justification provided.

(17) Geotextile design. Geotextiles are an acceptable material for use in dam design only if the geotextile is placed so that it does not jeopardize the dam or appurtenant structures during repair or failure of the geotextile. The geotextile [~~material~~] shall be used in accordance with the manufacturer's recommendations and intended use for the product. [~~Installation shall be by certified personnel and the completed installation certified by installer or manufacturer, if required by the manufacturer.~~] Geotextile design computations shall be provided. Where a geotextile is used for fluid containment the installation shall be performed by certified personnel and the completed installation shall be certified by a qualified independent entity.

(18) Structural design. The structural design information for all appurtenant structures, addressing water, earth, ice and any other applicable load shall be provided. Reinforced concrete design including assumptions for loads and limiting stresses and sample calculations shall be provided. Appropriate data sheets and computer program output computations from computerized analysis shall be provided.

(19) Utilities design. Utility placement or relocation shall be addressed as applicable. Utilities located in the vicinity of the proposed embankment [~~footprint should~~] and spillway footprint and seepage limits must be relocated and trenches backfilled and compacted with suitable material to the satisfaction of the state engineer. If utilities are allowed to remain, they will be required to satisfy applicable provisions for outlet conduits in accordance with Paragraph (8) of Subsection C of 19.25.12.11 NMAC.

(20) Miscellaneous design. Because each design is unique, all design elements not specifically addressed in these regulations shall be documented and justified with sample calculations and appropriate data sheets and computer program output computations from computerized analysis shall be included in the design report.

D. Construction drawings: Construction drawings shall be submitted in a form acceptable to the state engineer. The final construction drawings shall also be submitted in an electronic format acceptable to the state engineer. A professional engineer licensed in the state of New Mexico qualified in dam design and construction shall prepare the construction drawings. Illegible, mutilated, careless or otherwise poorly prepared drawings are not acceptable for filing with the state engineer. [~~Plan drawings and maps prepared with the aid of a computer require the submittal of the digital data files in tagged image file format or other format acceptable to the state engineer. The preparation of construction drawings is described below and shall include the following items:~~] Construction drawings shall contain the information described below and any other additional information determined necessary by the state engineer to evaluate if the construction drawings are consistent with the design.

(1) Quality. Construction drawings and maps shall be made from actual field or photogrammetric surveys of an accuracy acceptable to the state engineer. Construction drawings and maps shall be prepared with permanent black ink on mylar. All original signatures, dates and acknowledgments appearing on the sheet(s) shall be in permanent ink. [~~Plan~~] Construction drawings and maps shall always be rolled, never folded, for transmittal.

(2) Scale and size. Sheets shall [~~be~~] range in size from twenty-two (22) to twenty-four (24) inches by thirty-four (34) to thirty-six (36) inches with one (1) inch margins on all sides. The scale(s) used on the drawings may vary according to requirements and space available to show all necessary data in detail clearly in feet and decimals and to be clearly legible when the drawings are reduced to eleven (11) inches by seventeen (17) inches. Detailed dimensions of appurtenant structures shall be given in feet and inches. All sheets shall have bar scales in order to allow scaling of reduced drawings.

(3) Sheet numbers. Each sheet shall be numbered sequentially with the first sheet being sheet number one in conjunction with the total numbered sheets (example Sheet 1 of 5). The sheet number on the last sheet shall equal the total number of sheets.

(4) Engineer's seal and signature. Each sheet shall have the responsible engineer's seal and signature. Seals and signatures shall be presented in accordance with 16.39.3 NMAC.

(5) Orientation and date. The direction of north and the basis of bearings shall be shown on all maps. The date that field surveys are made or the date of the aerial photography used shall be shown on the maps.

(6) Title sheet. The first sheet of a set of [~~plans~~] construction drawings is the title sheet. The title sheet shall only contain sufficient information to summarize the scope of the project, [~~the title of the project and signed certifications for the dam owner, engineer and state engineer in accordance with Subsections A, B and E of 19.25.12.12 NMAC.~~] the title of the project, signed certifications from the dam owner, engineer and a certification for the state engineer in accordance with Subsections A, B and E of 19.25.12.12 NMAC. The title sheet shall summarize the properties of the dam and shall include the following information, as appropriate:

(a) name of the dam (same as shown on the application);
(b) type of dam (material);
(c) hazard potential classification;
(d) maximum height above the downstream toe in feet;
(e) maximum length in feet;
(f) crest width in feet;
(g) slope of the upstream face (horizontal to 1 vertical);
(h) slope of the downstream face (horizontal to 1 vertical);
(i) elevation of the dam crest in feet;
(j) elevation of spillway crest in feet;
(k) [~~elevation of outlet conduit flow line;~~] length of the conduit in feet;
(l) invert elevation of the upstream end of the conduit in feet;
(m) invert elevation of the downstream end of the conduit in feet;
[~~(l)~~] (n) freeboard in feet;
(o) residual freeboard in feet;
[~~(m)~~] (p) maximum spillway discharge capacity in cubic feet per second;
[~~(n)~~] (q) type of outlet conduit (give size and material);
[~~(o)~~] (r) maximum outlet conduit discharge capacity in cubic feet per second; and

[~~**(p)**~~] **(s)** location of the outlet works intake structure (using latitude and longitude [~~or to the New Mexico state plane coordinate system~~] in decimal degrees).

(7) Vicinity map. A vicinity map of sufficient scale and size to locate the pertinent area shall be shown on the title sheet or second sheet of the drawings.

(8) Site topography. A detailed topography of the dam site including sufficient area upstream and downstream and at the abutments shall be provided. Elevations shall be based on North American vertical datum 1988 or more recent adjustment.

(9) Design details. Detailed information of the various construction features including plan view, elevations, cross-sections at the maximum section and along the outlet works, profile along and section through the centerline of the dam showing the foundation materials, construction features and cross-sections and a profile of the emergency spillway with dimensions and construction details shall be provided. Any other information necessary for the state engineer to determine the feasibility and safety of the dam shall be [~~required~~] provided.

(10) Reservoir area, capacity and high water line traverse. The topography of any proposed reservoir site shall be determined to industry standards and a contour map with a contour interval of 1 foot shall be prepared. Elevations of the contours shall be tied to the North American vertical datum of 1988 or more recent adjustment. [~~The high water line at the elevation of the dam crest will be highlighted on the contour map.~~] The elevation of the high water line will be highlighted on the contour map. A curve [~~or~~] and table of elevation versus area and storage capacity for the reservoir shall be prepared from the contour map. The curve [~~or~~] and table shall be from the bottom of the reservoir to the dam crest. Area shall be provided in acres and storage capacity in acre-feet.

[~~**(11)** Point of outlet. A location of the outlet works shall be referenced using latitude and longitude or to the New Mexico state plane coordinate system.~~]

[~~**(12)**~~] **(11)** Permanent bench mark. A permanent bench mark shall be established above the high water line at a location unlikely to settle or be disturbed. The North American vertical datum of 1988 or more recent adjustment [~~and latitude and longitude or the New Mexico state plane coordinate system~~] for the bench mark elevation and the latitude and longitude in decimal degrees for the bench mark location shall be provided. A detail of construction of the permanent bench mark shall be provided.

E. Specifications: [~~Specifications~~] A specification package shall be prepared for each project describing work to be done and materials to be used to supplement construction drawings. [~~Specifications must be clear and concise and include detailed methods of construction, qualities and sizes of materials, unit amounts to be used and methods of testing and quality control, construction supervision and inspection.~~] Specifications shall be submitted in a form acceptable to the state engineer. The specifications shall also be submitted in an electronic format acceptable to the state engineer. Reference to standard specifications is not acceptable. Inclusion of appropriate specification sections derived from model specifications is acceptable. Specifications must be clear and concise. Specifications shall include detailed methods of construction, qualities and sizes of materials, unit amounts to be used, methods and frequency of testing and quality control, construction supervision and frequency of inspection. Specifications shall be prepared by a professional engineer licensed in the state of New Mexico qualified in the design and construction of dams. The specifications shall [~~meet the following requirements:~~] contain the information described below and any other additional information determined necessary by the state engineer to evaluate if the construction methods are consistent with the design and construction drawings.

(1) The front cover of the specifications shall show the name of the dam (identical to the application) and the county in which the dam is located. The first page behind the front cover shall show the name of the dam (identical to the dam name on the application), the county in which the dam is located, [~~signed certifications for the engineer and state engineer in accordance with Subsections B and E of 19.25.12.12 NMAC and a statement recognizing the authority of the state engineer. An approved model statement recognizing the authority of the state engineer is provided below. Changes to the model statement require prior approval of the state engineer. "All construction shall be performed in strict accordance with the accepted plans and specifications. Representatives of the state engineer shall have full authority to perform inspections during construction and shall have full power to act pursuant to the law and in accordance with Title 19, Chapter 25, Part 12, Dam Design, Construction and Dam Safety of the New Mexico Administrative Code if plans and specifications are not followed."~~.] a signed certification from the engineer and a certification for the state engineer in accordance with Subsections B and E of 19.25.12.12 NMAC.

(2) The specifications shall [~~be indexed~~] include a table of contents.

(3) The specifications shall be bound and submitted on [~~a good grade of white~~] 8 1/2-inch by 11-inch white paper.

(4) [~~The general conditions shall include statements that the construction drawings and specifications cannot be significantly changed without the prior written approval of the state engineer.~~] The general conditions shall include a statement that the construction drawings and specifications cannot be changed without the prior written approval of the state engineer and must recognize the authority of the state engineer to perform inspections during construction. An approved model statement is provided below. Changes to the model statement require prior approval of the state engineer. All construction shall be performed in strict accordance with the accepted construction drawings and specifications. Changes to the accepted construction drawings or specifications require prior written approval of the state engineer. Representatives of the state engineer shall have full authority to perform inspections during construction and shall have full power to act pursuant to the law and in accordance with Title 19, Chapter 25, Part 12, Dam Design, Construction and Dam Safety of the New Mexico Administrative Code if construction drawings and specifications are not followed."

F. Boundary, easement or right of way plat of survey: A plat of survey shall be submitted in a form acceptable to the state engineer. A professional surveyor licensed in the state of New Mexico shall prepare a plat of survey showing the dam owner's property boundaries or easement [~~and/or~~] or right of way granted by the land owner. The plat of survey shall be prepared in conformance with the requirements as set forth in the Minimum Standards for Surveying in New Mexico, 12.8.2 NMAC. The plat of survey shall clearly state to whom an easement is granted and what rights are conveyed with the easement. The plat of survey shall show the footprint of the dam and appurtenant structures and the high water line in the reservoir. The plat of survey shall be [~~submitted with the construction drawings and~~] recorded with the county clerk of the county or counties in which the survey is located. A certificate signed by the surveyor in accordance with Subsection C of 19.25.12.12 NMAC shall appear on the plat of survey. A certified copy of the recorded plat of survey bearing the recorded page and endorsement of the county clerk shall be submitted to the state engineer for filing [~~upon completion of construction~~]. Adequate property ownership, easement or right of way shall be required for the following conditions:

(1) to access the dam and outlet controls during normal and flood events;

(2) to prevent development encroachment into the reservoir area defined by normal operation and the spillway design flood that adversely affects the performance of the dam;

(3) to prevent development in the approach, control and discharge section of the spillway that may restrict flow through the spillway;

(4) to return outlet works and spillway discharge to the natural drainage and allow the outlet works to discharge freely; and

(5) to perform maintenance on the dam, appurtenant structures and surrounding areas to ensure the safe performance of the dam.

G. Dam site security: Dams classified as high or significant hazard potential shall address security at dams to prevent unauthorized operation or access. If in the opinion of the state engineer, the failure of the dam will result in catastrophic consequences, a security and risk management program for the dam will be required. Elements of a security and risk management program are:

(1) threat, vulnerability and risk assessments;

(2) physical security plans; and

(3) integration of security operational procedures.

H. Instrumentation plan: An instrumentation plan shall be submitted in a form acceptable to the state engineer. An instrumentation plan providing the ability to monitor and evaluate the performance of a dam is required for dams classified as high or significant hazard potential. Instrumentation details must be included on the construction drawings and specifications must be consistent with the instrumentation plan. The instrumentation plan may be submitted as a separate report or as part of the [~~operation and maintenance manual~~] design report. Minimum requirements of the instrumentation plan shall include:

[~~**(1)** general description of instrumentation;~~

~~**(2)** reading schedule;~~

~~**(3)** identification of critical readings;~~

~~**(4)** specifics for each installation including;~~

~~**(a)** detailed description of installations;~~

~~**(b)** purpose of the instrumentation;~~

~~**(c)** reading and maintenance schedule instructions; and~~

~~**(5)** special instrumentation or monitoring requirements.~~]

(1) description and purpose;

(2) detailed description of installations;
(3) calibration and maintenance schedule and instructions;
(4) reading schedule and instructions;
(5) data reduction and interpretation instructions; and
(6) identification of critical readings.

I. Operation and maintenance manual: An operation and maintenance manual is required for dams classified as high or significant hazard potential. The operation and maintenance manual identifies activity necessary to address the continued safe operation, maintenance and overall performance of the dam. Any restrictions imposed by the design shall be addressed in the operation and maintenance manual. The operation and maintenance manual shall conform to the requirements set forth in 19.25.12.17 NMAC.

J. Emergency action plan: An emergency action plan is required for dams classified as high or significant hazard potential. The emergency action plan identifies potential emergency conditions at a dam and specifies preplanned actions to be followed to minimize property damage and loss of life. The emergency action plan shall conform to the requirements set forth in 19.25.12.18 NMAC.

[19.25.12.11 NMAC - N, 3/31/2005; A, xx/xx/2010]

19.25.12.12 CERTIFICATIONS: Signed certifications by the dam owner, engineer, surveyor, [~~state office of emergency management~~] local and state emergency management officials and the state engineer are required by these regulations on specific documents. Approved model certifications for the dam owner, engineer, surveyor, [~~state office of emergency management~~] local and state emergency management officials and state engineer are provided below. Changes to the model certifications require prior approval of the state engineer.

A. DAM OWNER'S CERTIFICATE: A certificate followed by the dated signature of the dam owner and notary public acknowledgment is required on the title sheet of the construction drawings and first page behind the front cover of the operation and maintenance manual and emergency action plan. The following model certification is considered to be an example of the minimum that the dam owner shall certify. If the dam owner is a corporation, political subdivision or other governmental entity a model certificate is also provided.

[~~state of _____)~~
~~_____) ss.~~
~~county of _____)~~]

I, (dam owner's name), being first duly sworn, upon my oath, state that I have read and examined the accompanying _____ (construction drawings consisting of ____ sheets, operation and maintenance manual, or emergency action plan) and know the contents and representations therein for _____ dam and all that is shown herein is done with my free consent and in accordance with my wishes and state that the same are true and correct to the best of my knowledge and belief.

_____
Dam owner signature Date

Subscribed and sworn to before me this _____ day of _____ , 20__.

_____
Notary public

My commission expires _____ (SEAL)

If a claimant is a corporation, political subdivision or other governmental entity the following shall be used:

[~~state of _____)~~
~~_____) ss.~~
~~county of _____)~~]

I, (representative's name), being first duly sworn, upon my oath, state [~~than~~] that I am the _____ (officer) of the _____, a _____ [~~corporation~~] (corporation or political subdivision) duly organized under the laws of the state of _____, that the accompanying

_____ (construction drawings consisting of ____ sheets, operation and maintenance manual, or emergency action plan) for _____ dam were made under authority of the board of directors of said [~~corporation~~] (corporation or political subdivision) and that, in their behalf, I have read and examined the statements and representations and all that is shown herein is done with their free consent and in accordance with their wishes and state that the same are
true and correct to the best of my knowledge and belief.

_____
Representative signature, title Date

Subscribed and sworn to before me this _____ day of _____ , 20__.

_____
Notary public

My commission expires _____ (SEAL)

B. ENGINEER'S CERTIFICATE: A certificate followed by the dated signature, license number and seal of the engineer responsible for preparing the [~~design~~] report, construction drawings, specifications, operation and maintenance manual and engineering elements of the emergency action plan is required. The certificate shall be placed on the title sheet of the construction drawings and first page behind the front cover of the [~~design~~] report, specifications, operation and maintenance manual and emergency action plan. The following model certification is considered to be an example of the minimum that the engineer [~~should~~] must certify to:

[~~state of _____)~~
~~_____) ss.~~
~~county of _____)~~]

I, (engineer's name), hereby certify that I am a professional engineer licensed in the state of New Mexico, qualified in _____ (civil, geotechnical, etc.) engineering; that the accompanying _____ ([~~design~~] report, construction drawings consisting of ____ sheets, specifications, _____ elements of the operation and maintenance manual, or _____ elements of the emergency action plan) for _____ dam was prepared by me or under my supervision; that the accompanying _____ ([~~design~~] report, construction drawings consisting of ____ sheets, specifications, _____ elements of the operation and maintenance manual, or _____ elements of the emergency action plan) is in compliance with the Dam Design, Construction and Dam Safety Regulations (19.25.12 NMAC) and that the same are true and correct to the best of my knowledge and belief.

(Engineer's signature) _____, License number _____, (SEAL)
Engineer's name

Date [~~submitted~~]: _____

C. SURVEYOR'S CERTIFICATE: The professional surveyor licensed in the state of New Mexico preparing the plat of survey showing property boundaries, acquired easements or rights-of-way shall include a certificate on the plat of survey as modeled in Paragraph (2) of Subsection J of 12.8.2.9 NMAC, the Minimum Standards for Surveying in New Mexico. The following model certificate is considered to be an example of the minimum that the surveyor [~~should~~] must certify to:

I, (surveyor's name), New Mexico professional surveyor no. (surveyor's license number), do hereby certify that this (boundary, easement, or right of way) plat of survey and the actual survey on the ground upon which it is based were performed by me or under my direct supervision; that I am responsible for this survey; that this survey meets the Minimum Standards for Surveying in New Mexico; and that it is true and correct to the best of my knowledge and belief. I further certify that this survey is not a land division or subdivision as defined in the New Mexico Subdivision Act and that this instrument is a (boundary, easement, or right of way) plat of survey of _____ dam.

(Surveyor's signature)_____, License number_____, (SEAL)
Surveyor's name

Date [~~submitted~~]: _____

D. [~~**STATE OFFICE OF EMERGENCY MANAGEMENT:** A certificate form for the state office of emergency management acceptance shall be placed on the first page behind the front cover of the emergency action plan. This certificate is to be signed by state office of emergency management after all necessary corrections or additions, if any, have been made.~~
~~state of _____)~~
~~_____) ss.~~
~~county of _____)~~] **LOCAL AND STATE EMERGENCY MANAGEMENT OFFICIAL'S CERTIFICATE:** Certificate forms for the local and state officials responsible for emergency management shall be placed at the front of the emergency action plan and immediately after the engineer's certificate. The local official's certificate shall be placed in front of the state official's certificate.

I hereby certify that the accompanying emergency action plan for _____ dam has been duly examined by me and accepted for filing on the _____ day of _____, 20__.

[~~_____~~
~~State office of emergency management~~]
(Official's signature)_____
(Print official's name)
(Print name of local or state emergency management entity)

E. STATE ENGINEER'S CERTIFICATE: A certificate form for the state engineer acceptance shall be placed on the title sheet of the construction drawings and first page behind the front cover of the [~~design~~] report, specifications, operation and maintenance manual and immediately after the state official responsible for emergency management in the emergency action plan. This certificate is to be signed by the state engineer or his representative after all necessary corrections or additions, if any, have been made.

[~~state of _____)~~
~~_____) ss.~~
~~county of _____)~~]

I hereby certify that the accompanying _____ ([~~design~~] report, construction drawings, specifications, operation and maintenance manual or emergency action plan) for _____ dam and appurtenant structures has been duly examined by me and accepted for filing on the _____ day of _____, 20__.

_____
State engineer

[19.25.12.12 NMAC - N, 3/31/2005; A, xx/xx/2010]

19.25.12.13 [~~CONSTRUCTION AND OPERATION~~] PERMIT CONDITIONS: After reviewing the required documentation, the state engineer will notify the dam owner if any deficiencies are found with the submittal to construct and operate a dam. The dam owner will be given an opportunity to correct any deficiencies noted in the review process. Once all deficiencies have been addressed the state engineer will approve the application for permit to construct and operate a dam with conditions under which construction and operation shall occur. Failure to comply with conditions of the approved permit may result in the state engineer issuing an order to redesign, reconstruct or restrict operation of the dam and reservoir until conditions are met. Construction must be completed within two years of approving the application unless an extension of time for the construction is requested and approved by the state engineer. [~~The conditions of construction and operation shall include, but not be limited to the~~

~~following:~~] The permit conditions are described below and may include additional conditions determined necessary by the state engineer to ensure the dam is constructed and operated in a safe condition.

A. Engineer supervising construction: Prior to initiation of construction, the dam owner shall designate a professional engineer licensed in the state of New Mexico qualified in the design and construction of dams to supervise construction. If the state engineer finds the engineer acceptable, an order is issued approving the engineer and setting forth conditions under which the engineer will supervise construction. [~~Conditions shall include, but shall not be limited to:~~] Construction supervision conditions are described below.

(1) The engineer supervising construction shall submit monthly progress reports [~~including summary of test results, problems encountered and their solutions.~~] that are signed and sealed. The report shall include:

(a) summary of construction activities;

(b) summary of test results;

(c) captioned and dated construction photographs; and

(d) a discussion of problems encountered and their solutions.

(2) Construction shall be in accordance with accepted drawings and specifications. State engineer approval of any modifications to the accepted drawings or specifications is required prior to undertaking the modifications. Requests for changes or modifications by the engineer supervising construction shall be submitted in writing, supported with appropriate documentation.

(3) The engineer supervising construction shall provide the state engineer a minimum of 72 hours notice to perform inspections as specified in the conditions of construction.

[~~**(4)** Upon completion of construction, the engineer supervising construction shall submit to the state engineer the following items:~~

~~**(a)** a completion report, which shall include descriptions of problems and their solutions;~~

~~**(b)** a summary of materials test data and labeled and dated construction photographs;~~

~~**(c)** record mylar construction drawings including signed certifications on the title sheet; and~~

~~**(d)** a certificate that the dam was constructed in accordance with the accepted drawings and specifications and is in satisfactory condition. An approved model certificate for the engineer supervising construction is shown below. Changes to the language in the certification require prior approval by the state engineer.~~]

(4) Upon completion of construction, the engineer supervising construction shall submit to the state engineer the items described below.

(a) A construction completion report, which shall include a signed certification from the engineer supervising construction and a certification for the state engineer in accordance with Subsections B and E of 19.25.12.12 NMAC. The construction completion report shall also include:

(i) description of construction activities including problems and their solutions;

(ii) a summary of materials test data; and

(iii) captioned and dated construction photographs.

(b) Record mylar construction drawings including a signed certification on the title sheet from the dam owner and a certification for the state engineer in accordance with Subsections A and E of 19.25.12.12 NMAC. The record mylar drawings shall also contain a signed certificate from the engineer supervising construction that the dam was constructed in accordance with the record drawings and specifications and is in satisfactory condition. If design changes are made during construction, the design engineer may also be required to sign a certification in accordance with Subsection B of 19.25.12.12 NMAC. An approved model certificate for the engineer supervising construction is shown below. Changes to the language in the certification require prior approval by the state engineer.

[~~state of _____)~~
~~_____) ss.~~
~~county of _____)~~

~~I, _____, (engineer's name) state that I am a qualified professional engineer licensed in the state of New Mexico, that I have inspected the _____ dam and appurtenant structures and find them to be completed in accordance with the record construction drawings and specifications and are now in a satisfactory condition for acceptance.~~]

I, (engineer's name) , state that I am a qualified professional engineer licensed in the state of New Mexico, that I have supervised the (construction, repair, rehabilitation) of dam and appurtenant structures and find them to be completed in accordance with the record construction drawings and specifications and are now in a satisfactory condition for acceptance.

(Engineer's signature) License number , (SEAL)
Engineer's name

Date [~~submitted~~]: _____

B. State engineer's authority during construction: The state engineer may perform inspections at any time during construction of the dam and appurtenant structures. Inspections will vary with each project, based on the complexity of the design. Inspection of specific construction items are standard construction conditions in the permit and require the engineer supervising construction to provide the state engineer with a minimum of 72 hours advanced notice. If the state engineer receives a minimum of 72 hours advanced notice, a delay of construction to schedule a state engineer inspection is not required. State engineer inspection fees are charged in accordance with Subsection [~~D~~] E of 19.25.12.8 NMAC. Fees for inspection of construction by the state engineer not paid on demand shall become a lien on any land or other property of the dam owner and may be recovered by the state engineer.

C. Completion of construction: Upon completion of construction, a proof of completion of works form for the dam shall be submitted in accordance with 19.25.12.14 NMAC. Owners of dams classified as high or significant hazard potential shall submit to the [~~state engineer an updated operation and maintenance manual in accordance with 19.25.12.17 NMAC and an updated emergency action plan~~] state engineer any required updates to the operation and maintenance manual in accordance with 19.25.12.17 NMAC and any required updates to the emergency action plan in accordance with 19.25.12.18 NMAC incorporating any modifications made during construction. Upon the satisfactory completion of all conditions in the permit, pending the issuance of a certificate of construction and license to operate a dam, use of the reservoir shall require written permission from the state engineer. Use of the dam and reservoir are restricted until the state engineer accepts the updated operation and maintenance manual and emergency action plan, if required.

D. Extension of time for construction: The state engineer will grant an extension of time for completing construction upon proper showing by the dam owner of due diligence or reasonable cause for delay and accompanied with a fee in accordance with Subsection [~~C~~] D of 19.25.12.8 NMAC. An affidavit by a professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall be filed with the state engineer providing evidence that the design of the dam meets or exceeds the design requirements in accordance with 19.25.12.11 NMAC. An extension of time may be granted for a period not to exceed five (5) years. No extension of time shall be granted which in combination extend the time allowed by the permit beyond ten (10) years from the initial date of approval of the application, unless the state engineer in his discretion expressly waives this limitation pursuant to NMSA 1978, Section 72-5-14. Failure to request an extension of time shall result in cancellation of the permit by the state engineer.

E. Operation conditions: Operation conditions will be identified in the permit to construct and operate a dam. Operation conditions are described below:

(1) The owner shall comply with the office of the state engineer rules and regulations for dams.

(2) Changes to the easements require prior approval from the state engineer.

(3) Changes, alterations, or modifications to the dam or sediment removal or dredging not outlined in the operation and maintenance manual requires state engineer approval prior to making the change.

(4) The dam owner shall provide access to the state engineer for periodic dam safety inspections.

(5) The dam owner must comply with all state engineer safety orders issued for the dam.

(6) Owners of dams classified as low and significant hazard potential shall have the hazard classification periodically evaluated by a professional engineer licensed in New Mexico if downstream development occurs to ensure the dam design is not deficient.

(7) Operation of the dam must be in compliance with the approved operation and maintenance manual and emergency action plan.

(8) The dam owner shall operate the dam in compliance with any specific condition, requirement, or limitation established by the design engineer or otherwise applicable to the dam.

(9) Failure by the dam owner to comply with operation conditions may result in revocation of the permit or license to operate and an order to breach the dam in accordance with Subsection B or C of 19.25.12.19 NMAC.
[19.25.12.13 NMAC - N, 3/31/2005; A, xx/xx/2010]

19.25.12.14 PROOF OF COMPLETION OF WORKS: Upon completion of [~~all~~] the construction conditions a proof of completion of works for the dam shall be filed on a form provided by the state engineer with appropriate fees in accordance with Subsection [~~E~~] F of 19.25.12.8 NMAC. The proof of completion of works for the dam shall be filed with original signature of the dam owner and engineer supervising construction. The proof of completion of works form shall be provided to the state engineer as a separate submittal.
[19.25.12.14 NMAC - N, 3/31/2005; A, xx/xx/2010]

19.25.12.15 CERTIFICATE OF CONSTRUCTION OF A DAM: Upon receipt of the proof of completion of works form, the state engineer will determine if all construction conditions of the permit were met. Upon a determination by the state engineer that all construction conditions have been complied with, the state engineer shall issue a certificate of construction. The certificate of construction shall address the general properties of the dam and appurtenant structures. The dam owner shall record the certificate of construction with the county clerk of the county within which the works are located.
[19.25.12.15 NMAC - N, 3/31/2005]

19.25.12.16 LICENSE TO OPERATE A DAM: Upon issuance of a certificate of construction the state engineer shall issue a license to operate a dam. The license to operate a dam shall address operation conditions and dams shall be operated in accordance with the operation conditions. In addition, dams classified as high and significant hazard potential shall operate in accordance with the operation and maintenance manual and emergency action plan prepared in accordance with Sections 17 and 18 of 19.25.12 NMAC. Failure to comply with the conditions of the license to operate a dam may result in a state engineer order that limits operation, requires specific action by the owner and if necessary the license to operate a dam may be revoked by the state engineer. If a license to operate a dam is revoked the state engineer may order the dam breached in accordance with Subsections B or C of 19.25.12.19 NMAC.
[19.25.12.16 NMAC - N, 3/31/2005]

19.25.12.17 OPERATION AND MAINTENANCE MANUAL: Owners of dams classified as high or significant hazard potential shall prepare, maintain and adhere to an operation and maintenance manual that addresses the continued safe operation, maintenance and performance of the dam. Because each site, design and operating practice is unique, waivers of specific requirements in this section will be considered on a case-by-case basis. Request for waiver shall be in writing accompanied with documentation justifying the request. If the request is not justified to the satisfaction of the state engineer the request will be denied. [~~A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare the operation and maintenance manual. The front cover shall show the name of the dam (identical to the application), the county in which the dam is located and type of report. The first page behind the front cover shall show the name of the dam (identical to the dam name on the application), the county in which the dam is located and signed certifications for the dam owner, engineer and state engineer in accordance with Subsections A, B and E of 19.25.12.12 NMAC.~~] If deemed appropriate, the state engineer may require the owner to obtain the services of a professional engineer licensed in the state of New Mexico qualified in the design and construction of dams to prepare complex technical aspects of the operation and maintenance manual. The operation and maintenance manual shall be submitted in a form acceptable to the state engineer. The operation and maintenance manual shall also be submitted in an electronic format acceptable to the state engineer. The front cover shall identify the document as an operation and maintenance manual and shall show the name of the dam, the county in which the dam is located and the dam owner. The first page behind the front cover shall show the name of the dam, the county in which the dam is located, signed certifications from the dam owner, engineer if required and a certification for the state engineer in accordance with Subsections A, B and E of 19.25.12.12 NMAC. Operation or maintenance of the dam in violation of the procedures presented in the accepted operation and maintenance manual that affect the safety of the dam will result in an order being issued requiring the dam owner to address the problem. The state engineer may also issue an order restricting storage in order to improve the unsafe condition. Failure to comply with orders issued by the state engineer may result in the license to operate the dam being revoked and the dam being ordered breached in accordance with

Subsection B or C of 19.25.12.19 NMAC. [~~Generally, the~~] The operation and maintenance manual shall [~~address the following, with modification depending on the specific dam application:~~] contain the information described below, if relevant to the project, and any other additional information determined necessary by the state engineer to evaluate if the dam will be operated and maintained in a safe condition.

[~~**A. Project Information:** General information on the project including the purpose, location, history, responsibilities and description and properties of the dam and appurtenant structures shall be required.~~]

A. General information: Information on the project shall include but not be limited to the following:

(1) location and access;

(2) purpose and description;

(3) table of properties; and

(4) history of construction, repairs and performance.

B. Operation: Operation instructions, frequency of operation and operator safety for the project shall include but not be limited to the following:

(1) Reservoir:

(a) water right storage allocations;

(b) [~~spillway design flood water level~~] elevation, area and storage curve and table to the dam crest;

(c) [~~emergency reservoir evacuation procedures and maximum discharge rate; and~~] elevation of the high water line;

(d) discharge rating table for the outlet conduit;

(e) discharge rating table for the spillway;

(f) emergency reservoir evacuation procedures; and

[~~(d)~~] (g) first filling criteria and monitoring requirements.

(2) Outlet works:

(a) first operation;

(b) seasonal startup;

(c) seasonal shutdown;

(d) installation and removal of bulkhead;

(e) operation procedures for specific equipment; and

(f) electrical systems and controls.

(3) Operator safety:

(a) confined space entry and permits;

(b) fall protection;

(c) lockout/tag out; and

(d) other applicable safety requirements;

C. Instrumentation: [~~The following elements for monitoring instrumentation shall be addressed~~

[~~**(1)** general description~~

~~**(2)** purpose~~

~~**(3)** critical readings~~

~~**(4)** reading and maintenance procedures; and~~

~~**(5)** reading schedule.~~] Instrumentation for the project shall include but not be limited to the following;

(1) description and purpose;

(2) detailed description of installation;

(3) calibration and maintenance schedule and instructions;

(4) reading schedule and instructions;

(5) data reduction and interpretation;

(6) identification of critical readings and notification procedures; and

(7) schedule for reporting data with interpretations to the state engineer.

D. Security: Projects that include security measures shall describe the security measures along with instructions for monitoring, maintaining and inspection.

[~~**D.**~~] **E.** Maintenance: Maintenance requirements and [~~schedule~~] frequency shall be included.

[~~**E.**~~] **F.** Inspection: Inspection requirements, [~~schedule~~] frequency and recommended checklist shall be included.

[~~**F.**~~] **G.** Updates and revisions: An update and revision procedure shall be included.

[~~G.~~] **H.** Appendices: [~~Appendices to include any design consideration and the instrumentation plan to ensure any restrictions imposed by the design are incorporated into the operation and maintenance manual shall be included. Copies of inspections forms and any other information that supports and supplements the material used in the development and maintenance of the operation and maintenance manual.~~] Appendices shall include documentation that supports and supplements the manual. The appendices shall include but not be limited to the following:

(1) captioned and dated photographs;

(2) key sheets from the record construction drawing set;

(3) instrumentation construction drawings;

(4) instrumentation rating tables and calibration details;

(5) monitoring and inspection forms;

(6) instrumentation plan to ensure any restrictions imposed by the design are incorporated into the operation and maintenance manual; and

(7) copies of any relevant procedures.

[19.25.12.17 NMAC - N, 3/31/2005; A, xx/xx/2010]

19.25.12.18 EMERGENCY ACTION PLAN: Owners of dams classified as high or significant hazard potential shall prepare, maintain and exercise an emergency action plan for immediate action in the event of a potential dam failure. [~~The emergency action plan shall follow the format provided by the state engineer or a format that has prior approval of the state engineer.~~] Because each site and operating practice is unique, waivers of specific requirements in this section will be considered on a case-by-case basis. Request for waiver shall be in writing accompanied with documentation justifying the request. If the request is not justified to the satisfaction of the state engineer the request will be denied. The emergency action plan shall follow the format provided by the state engineer or a format that has prior approval of the state engineer. The emergency action plan shall also be submitted in an electronic format acceptable to the state engineer. The front cover shall identify the document as an emergency action plan and shall show the name of the dam [~~(identical to the application)~~], the county in which the dam is located and [~~type of report~~] the dam owner. [~~The pages immediately behind the front cover shall show the name of the dam (identical to the dam name on the application), the county in which the dam is located and signed certifications for the dam owner, engineer, local and state office of officials responsible for emergency management and state engineer in accordance with Subsections A, B, D and E of 19.25.12.12 NMAC.~~] The pages immediately behind the front cover shall show the name of the dam, the county in which the dam is located, signed certifications from the dam owner, engineer, local and state officials responsible for emergency management and a certification for the state engineer in accordance with Subsections A, B, D and E of 19.25.12.12 NMAC. The dam owner shall coordinate with the local emergency management office in preparing the emergency action plan. The coordination is required to ensure that there is an agreement on the evacuation limits and responsibilities. The dam owner shall submit a copy to the local and state [~~office of~~] officials responsible for emergency management for acceptance prior to submittal to the state engineer. The dam owner shall review the emergency action plan annually, update as necessary and furnish a copy of updates to [~~the state engineer, state office of emergency management and~~] all official copyholders. The dam owner shall exercise the emergency action plan to verify those involved in its implementation know their roles and responsibilities. [~~It is recommended the~~] The dam owner shall conduct a functional exercise of the emergency action plan every 5 years with a table top exercise conducted 2 to 3 years before the functional exercise. The exercise may result in updates to ensure the emergency action plan maintains operational readiness, timeliness and responsiveness. Failure to act in accordance with the accepted emergency action plan that affects [~~the safety of the dam~~] public safety will result in an order being issued requiring the dam owner to address the problem. Failure to comply with orders issued by the state engineer may result in the license to operate the dam being revoked and the dam being ordered breached in accordance with Subsection B or C of 19.25.12.19 NMAC. A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare engineering [~~elements of~~] information for the emergency action plan as specified below. An emergency action plan shall [~~contain the following minimum elements:~~] contain the information described below and any other additional information determined necessary by the state engineer or emergency management official to evaluate the planned response to an emergency situation by the dam owner.

A. Notification flowchart: A notification flowchart showing who is to be notified, by whom and in what priority.

B. Emergency detection, evaluation and classification: Procedures for reliably and timely identifying an emergency situation to ensure that an appropriate course of action is implemented. A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare this element.

C. Responsibilities: A list designating responsibilities for the emergency action plan related tasks including, but not limited to developing, maintaining, exercising, implementing, warning, evacuation and termination of the emergency.

D. Preparedness: A list of materials, equipment and manpower available to moderate or alleviate the effects of a dam failure or spillway release. [~~A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare this element.~~]

E. Evacuation map: An evacuation map delineating the areas that will be evacuated as a result of dam failure. The evacuation map shall extend to a point where the consequences of dam failure does not pose a threat to life and evacuation or restricting access is not required. If available, shape files from geographic information system software of the evacuation map shall be submitted. Evacuation maps shall include the following information at critical locations downstream as required by the local official responsible for emergency management:

(1) distance downstream from the dam;

(2) arrival time of the leading edge of the flood wave;

(3) peak flow depth, incremental rise or water surface elevation in feet; and

(4) peak velocity in feet per second.

[~~E.~~] F. Inundation map: An inundation map delineating the areas that will be flooded as a result of dam failure. [~~The dam breach analysis shall be prepared in accordance with Subparagraphs (a) through (g) of Paragraph (1) of Subsection C of 19.25.12.11 NMAC for the failure with the water level at the reservoir storage capacity and at the maximum water level during the spillway design flood event. If a dam is located upstream, failure scenarios with the upstream dam shall also be evaluated. Flood control dams that have not experienced a fill to the spillway crest shall prepare a failure scenario with the water level at the spillway crest. Flood inundation maps shall also be prepared for the maximum release without failure of the dam. Evaluation of the effects of flooding from dam failure shall extend at least to the location downstream where the flood no longer poses a threat to life or property.~~] The inundation map shall be supported by a dam breach and flood routing analysis report. The dam breach and flood routing analysis shall evaluate the sunny day failure, failure at the high water line and any additional event deemed appropriate by the dam owner. If appropriate considering the consequences of dam failure, a simplified dam breach and flood routing analysis may be used with approval from the state engineer. If a dam is located downstream, failure scenarios with the downstream dam shall also be evaluated. Evaluation of the effects of flooding from dam failure shall extend at least to the location downstream where the consequences of dam failure does not pose a threat to life and evacuation or restricting access is not required. A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare this element. If available, shape files from geographic information system software of the inundation map shall be submitted. Inundation maps shall include the following information at critical locations downstream;

(1) distance downstream from the dam;

(2) arrival time of the leading edge of the flood wave;

(3) peak flow depth, incremental rise and water surface elevation in feet; and

(4) peak velocity in feet per second.

[~~F.~~] G. Appendices: All information that supports and supplements the material used in the development and maintenance of the emergency action plan. The dam breach and flood routing analysis report shall be submitted as a separate document.

[19.25.12.18 NMAC - N, 3/31/2005; A, xx/xx/2010]

19.25.12.19 CHANGES TO AN EXISTING DAM: A dam owner proposing to reconstruct, enlarge, modify, restore reservoir capacity, repair, remove or breach an existing dam must make application to and receive approval from the state engineer prior to undertaking any such action. The current condition of the dam, the type of repair or modification and the proposed means to achieve the repair or modification shall dictate the detail of the information provided to the state engineer in order to obtain approval. Because each site, design change and operating practice is unique, waivers of specific requirements in this section will be considered on a case-by-case basis. Request for waiver shall be in writing accompanied with documentation justifying the request. If the request is not justified to the satisfaction of the state engineer the request will be denied. Existing dams present the same hazards to life and

property downstream as new dams. Therefore, owners of dams classified as high or significant hazard potential shall evaluate the current condition of the dam and address in the submittal to the state engineer whether the dam is in compliance with the design requirements in Subsection C of 19.25.12.11 NMAC. If the state engineer determines compliance with requirements in Subsection C of 19.25.12.11 NMAC are critical to the safety of the dam, the state engineer shall issue an order requiring the deficiency be addressed as part of the proposed change. Owners of dams classified as low hazard potential shall comply with the design requirements in Subsection C of 19.25.12.11 NMAC for the proposed change only. Maintenance activity performed in accordance with 19.25.12.17 NMAC does not require prior state engineer approval. Dam owners shall not abandon a dam without breaching or removing the dam to ensure the dam no longer poses a risk to life, property, the environment surrounding the dam or downstream of the dam. In the event of any changes of ownership affecting the title to a dam, the new owner shall file a change of ownership form for a dam with the state engineer. Recognition of the responsibility and liability associated with dam ownership is required along with fees for filing the change in ownership form for a dam in accordance with Subsection [~~F~~] G of 19.25.12.8 NMAC. This section exempts federal dams if no change to the water storage permit is required. [~~In general, the following minimum submittal is required to make changes to an existing dam:~~] A proposed change to an existing dam shall require the submittal of the information described below and any other additional information determined necessary by the state engineer to evaluate if the change to the dam is safe.

A. Proposed changes to an existing dam: For dam owners proposing to reconstruct, enlarge, modify, restore reservoir capacity, [~~or~~] repair or add aesthetic fill to an existing dam, the [~~following supporting documentation~~] information described below is required prior to undertaking any such action[~~:~~].

(1) An [~~amended~~] application [~~if properties of~~] to alter, repair or rehabilitate the dam and appurtenant structures [~~change~~]. Fees for filing the [~~amended~~] application and for reviewing drawings and specifications shall be in accordance with Subsections [~~A~~] B and [~~B~~] C of 19.25.12.8 NMAC. [~~Fees~~] Review fees identified in Subsection C of 19.25.12.8 NMAC are waived for the first review if the state engineer requires the change to address a dam safety deficiency.

(2) Documentation of sufficient water rights if changes in storage or release requirements are proposed in accordance with the requirements of Subsection B of 19.25.12.11 NMAC.

(3) A design report addressing the proposed change in accordance with the requirements of Subsection C of 19.25.12.11 NMAC. Owners of dams classified as high or significant hazard potential shall submit a design report addressing whether the existing condition of the dam is in compliance with the design requirements listed in Subsection C of 19.25.12.11 NMAC. Where the existing condition of the dam is not in compliance with the design requirements of Subsection C of 19.25.12.11 NMAC, the design report shall propose changes to address compliance with the design requirements of Subsection C of 19.25.12.11 NMAC or request a waiver that the deficiency is not critical to the safety of the dam and provide adequate justification for the waiver.

(4) Construction drawings and specifications addressing the proposed change in accordance with the requirements of Subsections D and E of 19.25.12.11 NMAC.

(5) A plat of survey showing the dam owner's property boundaries, easement, or right of way. The plat of survey shall be in accordance with the requirements of Subsection F of 19.25.12.11 NMAC.

(6) For dams classified as high or significant hazard potential, a dam site security assessment in accordance with the requirements of Subsection G of 19.25.12.11 NMAC.

(7) For dams classified as high or significant hazard potential, an instrumentation plan in accordance with the requirements of Subsection H of 19.25.12.11 NMAC.

(8) For dams classified as high or significant hazard potential, an updated operation and maintenance manual and emergency action plan in accordance with the requirements of Sections 17 and 18 of 19.25.12 NMAC.

B. Removal or breach of dams classified as high or significant hazard potential: Dam owners intending to breach or remove a dam classified as high or significant hazard potential shall submit a plan to the state engineer for approval prior to breaching or removing the dam. The plan shall evaluate the potential effects of the dam removal or breach on life, property and the environment downstream. A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare the plan. The state engineer will revoke the license to operate a dam upon completion of all construction conditions. The plan shall meet the [~~following~~] conditions[~~:~~] described below.

(1) The reservoir shall be emptied in a controlled manner, which will not endanger lives or damage property downstream.

(2) The dam or breach area shall be excavated down to the level of natural ground and the breach shall be of sufficient width to safely pass the 100-year, 24-hour flood peak discharge without attenuation of the flood through the reservoir.

(3) The side slopes of the breach shall be excavated to a stable angle.

(4) The breach shall be armored as necessary to prevent erosion of the breach area.

(5) The plan shall address the control of sediment previously deposited in the reservoir.

(6) Drawings and specifications shall be prepared in accordance with the appropriate requirements listed in Subsections D and E of 19.25.12.11 NMAC and shall include a title sheet with required certifications and signatures, the location, dimensions and lowest elevation of the breach and any other detail to sufficiently describe the proposal.

(7) Designation of the professional engineer licensed in the state of New Mexico qualified in the design and construction of dams that will supervise construction of the breach or dam removal. Submittal of the professional engineer's qualifications for state engineer approval is required.

C. Removal or breach of dams classified as low hazard potential: Owners of dams classified as low hazard potential shall submit a written notice to the state engineer of intent to breach the dam. The state engineer will revoke the license to operate a dam upon completion of all construction conditions. The breach notice shall meet the [~~following~~] minimum requirements[~~:~~] described below.

(1) The bottom width elevation of the breach shall be to original ground.

(2) The bottom width of the breach shall be a minimum of one-half the height of the dam but not less than 10 feet.

(3) The side slopes shall not be steeper than one horizontal to one vertical.

(4) The excavated material shall not be placed in the streambed.

D. Closure of a tailings facility: A closure plan [~~is~~] must be prepared to address the closure of a tailings facility. State engineer approval is required before any modification occurs to a jurisdictional tailings dam. A professional engineer licensed in the state of New Mexico qualified in the design and construction of tailings dams shall prepare the closure plan, which shall include a design report, drawings and specifications prepared in accordance with the appropriate requirements listed in Subsections C, D and E of 19.25.12.11 NMAC. The state engineer will revoke the license to operate a dam upon completion of all construction conditions. The plan shall address the following issues:

(1) long-term stability under static and dynamic conditions;

(2) control of surface runoff to avoid erosion;

(3) plan for long term monitoring, if appropriate; and

(4) identification of an engineer licensed in the state of New Mexico qualified in tailings dam design and construction to supervise implementation of the closure plan; submittal of the engineer's qualifications for state engineer approval is required.

E. Construction and operating conditions: After reviewing the required documentation, the state engineer will notify the dam owner if any deficiencies are found with the submittal. The dam owner will be given an opportunity to correct any deficiencies noted in the review process. Once all deficiencies have been addressed the state engineer will approve the amended application or proposed change with conditions under which construction and operation shall occur. Action by the state engineer will be in accordance with 19.25.12.13 NMAC, appropriately modified to address the proposed changes.

F. Proof of completion of works, certificate of construction and license to operate: [~~Requirement~~] The requirement for a proof of completion of works form for the dam, certificate of construction and license to operate a dam for changes to a dam will be made on a case by case basis by the state engineer. The proof of completion of works form for the dam, certificate of construction and license to operate a dam, if required, shall be in accordance with the Sections 14, 15 and 16 of 19.25.12 NMAC, appropriately modified to address the proposed changes. If the dam is breached, the state engineer will cancel the permit and revoke the license to operate a dam.

[19.25.12.19 NMAC - N, 3/31/2005; A, xx/xx/2010]

19.25.12.20 CHANGES TO AN EXISTING NON-JURISDICTIONAL DAM: A dam owner proposing to reconstruct, enlarge, or modify a non-jurisdictional dam, resulting in a jurisdictional dam after construction is completed, shall comply with 19.25.12.11 NMAC before construction begins. If the [~~purpose~~] ownership of a non-jurisdictional dam changes, resulting in a jurisdictional dam, [~~or if ownership changes, resulting in a jurisdictional~~

~~dam,~~] the owner shall comply with 19.25.12.11 NMAC. The state engineer will give the owner a reasonable amount of time to comply with 19.25.12.11 NMAC. If the owner fails to comply with 19.25.12.11 NMAC, the dam will be ordered breached in accordance with Subsection B or C of 19.25.12.19 NMAC.
[19.25.12.20 NMAC - N, 3/31/2005; A, xx/xx/2010]

19.25.12.21 EXISTING DAMS: The state engineer [~~inspects~~] may inspect existing dams to verify dams are operated and maintained in a safe manner. Access to the dam site shall be made available to the state engineer upon request. If a critical dam safety problem is observed by the state engineer or reported to the state engineer, an order [~~will~~] may be issued requiring the dam owner to address the problem. If a dam incident occurs at a dam, the dam owners shall report the incident to the state engineer within 72 hours. If a major repair is required at an existing dam, the plan to repair the dam shall be in accordance with 19.25.12.19 NMAC. Minor repairs not identified as maintenance activity in accordance with 19.25.12.17 NMAC require state engineer approval. Failure to comply with state engineer directives or these regulations may result in an order to reduce storage or to take corrective action. Failure to comply with orders issued by the state engineer may result in the license to operate a dam being revoked and the dam ordered breached in accordance with Subsection B or C of 19.25.12.19 NMAC. Owners of existing dams shall comply with the [~~following:~~] requirements described below.

A. Owners acquiring property with a dam shall promptly notify the state engineer on a form provided by the state engineer of the change in ownership. Recognition of the responsibility and liability associated with dam ownership is required along with fees for filing the change in ownership form for a dam in accordance with Subsection [~~F~~] G of 19.25.12.8 NMAC.

B. Owners of dams classified as low or significant hazard potential shall evaluate the hazard classification if downstream development occurs. The dam owner shall submit the results of the hazard potential evaluation prepared in accordance with Paragraph (1) of Subsection C of 19.25.12.11 NMAC to the state engineer for approval [~~and a plan for addressing design deficiencies~~]. If the hazard potential classification changes due to downstream development, the state engineer shall give the dam owner a time limit to address deficiencies. Deficiencies shall be addressed in accordance with [~~Paragraphs (3), (12) and (13) of~~] Subsection C of 19.25.12.11 NMAC and Sections 17 and 18 of 19.25.12 NMAC. [~~If the dam owner fails to address a deficiency, the state engineer may revoke the license to operate the dam and order the dam breached in accordance with Subsection B or C of 19.25.12.19 NMAC.~~]

C. Dams classified as high or significant hazard potential shall be inspected on an interval no greater than 5 years by a professional engineer licensed in the state of New Mexico qualified in the design and construction of dams. The owner is responsible for securing the services of the professional engineer. The professional engineer shall provide a signed and sealed report to the state engineer describing the findings of the inspection and recommendations for corrective action or changes to the operating procedures. Routine inspection by the state engineer as described in 19.25.12.21 NMAC satisfies this requirement.

D. Owners of dams classified as high or significant hazard potential in an unsafe condition may receive an order from the state engineer to address the deficiency pursuant to NMSA 1978, Section 72-5-11 (1979). The state engineer may also issue an order to an owner of a non-jurisdictional dam if the dam is unsafe and a threat to life or property, as determined by the state engineer. Owners shall comply with orders issued by the state engineer pursuant to NMSA 1978, Section 72-5-12 (1979).

E. Owners of dams classified as high or significant hazard potential shall comply with 19.25.12.17 NMAC requiring an operation and maintenance manual. Upon compliance with 19.25.12.17 NMAC the state engineer will issue a license to operate the dam. [~~Dams classified as high hazard potential shall comply by December 31, 2008. Dams classified as significant hazard potential shall comply by December 31, 2010.~~]

F. Owners of dams classified as high or significant hazard potential shall comply with 19.25.12.18 NMAC requiring an emergency action plan. [~~Dams classified as high hazard potential shall comply by December 31, 2008 unless the dam is for flood control purposes with no permanent storage, then compliance by December 31, 2010 is required. Dams classified as significant hazard potential shall comply by December 31, 2010 unless the dam is for flood control purposes with no permanent storage, then compliance by December 31, 2012 is required.~~] Dams classified as significant hazard potential for flood control purposes with no permanent storage shall comply by December 31, 2012. Owners of 5 or more dams classified as high or significant hazard potential may propose a schedule for compliance with the emergency action plan requirement. [~~The schedule must be submitted by the owner to the state engineer by December 31, 2005 and is subject to review and approval or modification by the state engineer. The schedule must propose compliance dates for each dam. The first dam must be in compliance by December 31, 2008 and at least an additional dam must be in compliance each year thereafter. All dams must be in~~

~~compliance by December 31, 2015. Upon failure to meet an approved compliance schedule all dams will revert to compliance dates shown above.~~] The schedule must propose compliance dates for each dam and all dams must be in compliance by December 31, 2015. The compliance schedule is subject to review and approval or modification by the state engineer.

G. Dam owners that transfer the entire water right out of the reservoir shall have their license to operate a dam revoked and [~~may~~] will receive from the state engineer an order to breach the dam in accordance with Subsection B or C of 19.25.12.19 NMAC.

H. Dam owners that fail to obtain state engineer approval prior to construction of a dam shall comply with all conditions imposed by the state engineer within a time limit established by the state engineer or the state engineer may order the dam breached in accordance with Subsection B or C of 19.25.12.19 NMAC.

[19.25.12.21 NMAC - N, 3/31/2005; A, xx/xx/2010]

19.25.12.22 SEVERABILITY: If any portion of this part is found to be invalid, the remaining portion of this part shall remain in force and not be affected.

[19.25.12.22 NMAC - N, 3/31/2005]

History of 19.25.12 NMAC: [RESERVED]

NEW MEXICO OFFICE OF THE STATE ENGINEER
Dam Safety Bureau
Hydrologic Analysis for Dams
August 15, 2008

Hydrologic analysis requirements for dams are cited in the Rules and Regulations Governing Dam Design, Construction and Dam Safety, which were filed with the New Mexico State Record Center as Title 19, Chapter 25, Part 12 of the New Mexico Administrative Code (19.25.12 NMAC). Hydrologic analysis shall be performed in accordance with Subsection C of 19.25.12.11 NMAC. The design life of a dam is much longer than the record retention period of most engineering firms and memories of most design engineers. It is important that the analysis stand on its own in a manner that is comprehensible to future engineers who may be involved with the structure. Therefore, the Office of the State Engineer (OSE) requires that the hydrologic analysis be fully documented and supported independent of computer programs or other computational methodology used in the analysis.

Most dams are constructed on a watercourse or have a contributing drainage area upstream from the dam. Intense rainfall creates inflow to the reservoir of the dam, which is routed through the reservoir and allowed to pass the dam through a spillway or multiple spillways. Earlier dams typically were provided with spillways that were sized to pass the largest observed floods. These dams frequently overtopped and failed, and roughly half of all known dam failures have been the result of flood overtopping. During the 20th Century, methods were developed to better evaluate infrequent or extreme flood events, and provide adequate spillway capacity to safely pass these floods. Hydrologic analysis is one of the most important aspects in the design of a safe dam, and will be closely reviewed by the New Mexico Office of the State Engineer (OSE) Dam Safety Bureau.

Presented below is an outline of the typical steps for completing a hydrologic analysis satisfying the requirements outlined in Subsection C of 19.25.12.11 NMAC. In order to facilitate review by the OSE Dam Safety Bureau the hydrologic analysis report must be organized in an easy to follow layout and format. Submittals that are not consistent with this document and the requirements outlined in Subsection C of 19.25.12.11 NMAC will cause a delay in the review by the OSE Dam Safety Bureau and may be returned to the owner with no review provided. Inadequate hydrology submittals may also require review fees to be resubmitted prior to subsequent review by the OSE Dam Safety Bureau.

The following steps are typically required in completing hydrologic analysis for dams for submittal to New Mexico Office of the State Engineer:

1. Determine hazard potential classification for the dam location.
2. Determine appropriate design storm requirements for location.
3. Determine geographic location, limits and area of watershed contributing to dam and reservoir.
4. Divide watershed into subbasins as appropriate, and determine subbasin areas, channel locations for routing, etc.
5. Determine basin or subbasin geometry such as longest flow path for each basin or subbasin, channel slope and cross section, highest and lowest points, basin centroid(s), mean basin elevation, etc. as required for methodology to be used.

6. Determine appropriate timing and routing parameters for the elements in the watershed model.
7. Determine reservoir characteristics including stage-storage and stage-discharge relationships.
8. Develop total watershed model by arranging subbasins, routing reaches, etc. in the proper sequence with appropriate parameters.
9. Derive the precipitation to be used for design.
10. Develop incremental precipitation from depth-duration relationship and arrange increments to create an appropriate temporal distribution of precipitation.
11. Develop spatial distribution of precipitation if appropriate.
12. Determine loss parameters or functions and apply to incremental precipitation.
13. Deduct losses from precipitation increments to estimate precipitation excess.
14. Select an appropriate transform methodology for converting excess rainfall to runoff.
15. Apply the transform methodology to each subbasin using incremental precipitation excess.
16. Add stream base flow, etc., to obtain flood hydrograph for each subbasin.
17. Combine and/or route subbasin hydrographs to determine the inflow design flood.
18. Route flood through reservoir and spillway to obtain estimates of reservoir peak stage, peak outflow, peak storage, flood duration, etc.
19. Review results for reasonableness, comparing to known floods or otherwise calibrating if possible.
20. Adjust model parameters, spillway characteristics, etc. as necessary and appropriate and repeat process.
21. Prepare hydrologic analysis report for OSE review and for the permanent record.

Discussion:

The steps taken in the analysis, along with assumptions made and parameters used, must be fully documented. Documentation requirements are discussed in the final section of this paper. Discussion of each of the steps for performing hydrologic analysis is as follows:

1. Hazard Potential Classification

Hazard Potential Classification is a function of dam location and downstream conditions, and is not a measure of the integrity of the dam or the adequacy of the design. High hazard potential classification applies if loss of life is probable if the dam fails catastrophically. This is usually fairly obvious, based on downstream development conditions. In some cases, breach and flood wave analysis is needed to establish hazard potential classification. If site is not High hazard potential, in most cases it will be Significant, due to substantial risk to property or assets (highways, barns, irrigation ditches, etc.) or potential for significant environmental consequences. Low hazard potential is typically limited to remote, small structures such as ranch ponds for cattle watering and limited irrigation. Flood control dams typically are High or Significant hazard potential, because the need to control flooding suggests life and/or assets being protected downstream. Evaluations for Low or Significant hazard potential dams must consider the potential for future downstream development.

2. Design Precipitation Requirements

Generally, high hazard potential dams require consideration of Probable Maximum Precipitation (PMP). Significant hazard potential dams require consideration of 50% PMP if 100 feet or less in height and having 50,000 acre-feet or less storage, or 75% PMP if greater than 100 feet in height or having over 50,000 acre-feet of storage. For significant hazard potential dams, percentages are applied to precipitation prior to hydrologic analysis. Low hazard potential dams require consideration of 100-year storm, expressed as a percentage of PMP. Therefore, most dams will require evaluation of PMP. In some cases, waiver of evaluation of PMP will be entertained for low hazard potential dams with no realistic possibility for future hazard potential change.

In addition to precipitation requirements for spillway design, flood control dams must be able to drain from spillway crest or 100-year, 24-hour peak reservoir level within 96 hours. This implies determination of 100-year, 24-hour precipitation in most cases. For high and significant hazard potential flood control dams conforming to local flood control authority or NRCS requirements for 100-year, 24-hour flood routing, OSE will defer to these requirements for determination of compliance with the 96-hour rule.

3. Watershed Location, Limits, and Area

Watershed location, limits and area have traditionally been obtained from 7-1/2 minute USGS quad maps by tracing the divide, and then determining the area by planimeter or other measurement. For smaller drainages, a site topo map is sometimes used. Recent analyses frequently use ArcView or other GIS software in conjunction with DEM or DTM. Determination of precipitation will require geographic location (latitude and longitude) of the approximate basin centroid or a georeferenced perimeter at an appropriate scale. Methodology used must be described and supported as appropriate. Drainage area for existing dams must be independently verified rather than relying on area indicated on drawings or in design report, particularly for older dams. Precipitation depths may require adjustment based on watershed area. Average elevation of the watershed is needed for determination of Local Storm PMP.

4. Subdivision of Watershed

Logical subdivision can be made where topography or surface features and development are dissimilar. SCS methodology would suggest maximum subbasin size of about 20 square miles. USBR – Cudworth recommends 500 square miles maximum area per subbasin. Subbasin areas should be reasonably similar – for example, don't combine 20 square mile and 0.5 square mile subbasins in the same model if you can help it. Avoid dividing into unnecessary subbasins, as this complicates the model and usually does not improve results. Particularly, avoid overdividing small basins, such as dividing 5 square miles into 20 subbasins. Subbasins should generally correspond with logical junction points and routing reaches.

5. Basin and Subbasin Geometry

Specific information required will depend on methodology used for timing parameters and runoff transform. Typical requirements might include length of longest watercourse, length to a point opposite the basin centroid, watercourse slope, average basin slope, estimated length of overland flow, length, slope, and cross-section of channel reaches, etc.

6. Timing and Routing Parameters

Typical parameters may include time of concentration, lag time, time-to-peak, time of travel, kinematic wave travel time, channel geometry and roughness, etc. depending on requirements of the transform methodology and channel routing used. To add to confusion, a parameter may be defined in different ways for different methodologies, even if the name is the same. The parameter(s) used must be appropriate for and compatible with transform methodology as defined within that methodology. Also, assumptions or limitations for the timing parameters must be consistent with the watershed being studied. These may include basin size or watershed length, channel condition (natural vs. improved or hardened), degree of development, etc. Method of determining timing and routing parameters must be indicated and justified as appropriate for location and transform methodology, with sample derivation and references.

7. Reservoir Characteristics

This may be developed as elevation-area or elevation-storage, depending on modeling requirements or input parameters for the method used. However, OSE Rules and Regulations require reservoir characteristics to be reported as elevation-storage table in one-foot intervals. Water storage reservoirs generally are assumed to be full to the point of uncontrolled discharge, e.g. spillway crest. Flood control dams with uncontrolled outlets and no permanent storage generally are assumed to be empty at the start of the modeling period.

8. Watershed Model

The basin and subbasin geometry and characteristics, routing reaches and parameters, reservoir characteristics, etc. are assembled to create the watershed model for the dam. It is useful to create a schematic or flow chart for the watershed model, particularly if software being used does not provide a graphical or schematic representation. A schematic or graphical representation of the model and tables of relevant model parameters will be required in the report submitted to OSE.

9. Precipitation Derivation

PMP east of the Continental Divide is derived using methodology of HMR 55A, PMP west of the Continental Divide is derived using HMR 49. Both HMR documents provide for 1) a Local Storm (thunderstorm), with 6 hours total duration, and 2) a General Storm, with 72 hours duration. Neither HMR includes procedures or allowances for durations less than the complete storm, such as a 1-hour thunderstorm or a 24-hour general storm. If a shorter duration is used, justification must be provided.

Concerning durations less than the complete storm, FEMA as quoted in City of Albuquerque *Development Process Manual* states, “FEMA’s position regarding the duration of rainfall is that the storm must extend for a period long enough to include all rainfall excess when the volume of the runoff hydrograph is an important consideration. This includes conditions when detention storage is involved, when sediment processes are a significant factor, and when combining and routing subbasin hydrographs to obtain watershed runoff. When the peak flow is the primary concern, and it is established that the use of a longer duration storm would not increase the peak flow, shorter duration storms are acceptable.” This would suggest that using the most intense 24 hours of the General Storm would only be appropriate if it can be shown that no excess

precipitation will occur outside of this period, or if it can be shown that the peak flow is not sensitive to storm volume if peak flow is the primary concern.

Both HMR documents require obtaining index precipitation from maps, and then adjusting precipitation depths for area, elevation, and orographic effects specific to the watershed being studied. The index precipitation depths are plotted against duration to develop a smooth depth-duration passing through the origin. Area adjustments typically are based on the total contributing area above the dam or other point of interest, rather than on individual subbasin areas. Since precipitation depth for PMP is adjusted for storm area during the derivation, no additional reductions should typically be taken during the hydrologic analysis.

The 1984 reprint of HMR 49 contains an Errata sheet following the title page. The entry for page 154 on this Errata sheet changes the basis for local storm elevation adjustments from the lowest elevation in the drainage to the mean elevation. This generally will result in greater reductions in precipitation depth for cases where the elevation adjustment applies. This change is not well documented anywhere else in the literature. Electronic versions of HMR 49 not containing this correction may still be available online.

Both Local and General Storm should be evaluated, unless clear evidence and justification can be provided showing that one storm or the other obviously controls. For example, in the Eastern portion of the New Mexico HMR 55A area, the 1- and 6-hour ordinates for the General Storm frequently are greater than the 1- and 6-hour ordinates of the Local Storm. Conversely, in certain locations of HMR 49 where the orographic component of General Storm precipitation is low, total storm volume for the General Storm can be less than the Local Storm. In most other cases, it is not sufficient to simply compare precipitation depths, since routing effects may result in greater spillway discharge from the General Storm, even though the Local Storm precipitation depths are greater at 1 and 6 hours.

Alternatives to HMR 49 and HMR 55A include site-specific analysis for PMP and Incremental Damage Assessment, either of which should be discussed first with OSE. In the future, an Extreme Precipitation Analysis Tool may be available for portions of the state, to provide an updated estimate of extreme precipitation.

Precipitation for frequency-based events, such as the 100-year storm, is obtained from NOAA Atlas 14, available online. Precipitation is obtained by latitude and longitude, and is point precipitation. The precipitation values from Atlas 14 are considered appropriate for storm areas of 10 square miles or less, and the full precipitation depth should be used for watersheds less than 10 square miles. For larger areas, an approved procedure for reducing precipitation based on area may be applied. The online documentation for Atlas 14 does not provide areal reduction factors specific to Atlas 14, but instead references three possible sources:

1. NOAA Atlas 2, *Precipitation-Frequency Atlas of the Western United States*, 1973. This method was originally presented in Technical Paper No. 40, *Rainfall Frequency Atlas of the United States*, U.S. Weather Bureau, 1961, and is incorporated into the Frequency Storm methodology in HEC-1 and HEC-HMS.

2. Technical Report 24, *A Methodology for Point-to-Area Rainfall Frequency Ratios*, NOAA, 1980.
3. Technical Memorandum HYDRO-40, "Depth-Area Ratios in the Semi-Arid Southwest United States," NOAA, 1984.

These methods will allow reductions for areas less than 10 square miles; however, Atlas 14 seems to recommend using the point precipitation values for 10 square miles or less. If areal reductions are made for drainage areas less than 10 square miles, justification must be provided. Areal reductions for frequency storms should be based on the total watershed contributing to the point of interest, and not on individual subbasin areas. For watersheds with total area exceeding the limits of the reduction method (400 square miles for NOAA Atlas 2/U.S. weather Bureau Technical Paper 40) the services of a qualified meteorologist may be necessary to determine appropriate reductions of point precipitation.

10. Precipitation Increments and Distribution

Precipitation increment size should generally correspond to the computational time step used, although this is not mandatory for many computer programs including HEC-HMS. Increments are obtained from the depth-duration curve by subdividing the curve by increment length and successively subtracting curve ordinates. For small, fast basins in particular it is important to use a sufficiently small increment size and computational time step to avoid under-prediction of peak runoff.

Once the increments have been determined, they must be arranged in an appropriate distribution. One of the most common arrangements sometimes called "center-peaking" or "balanced" distribution, places the largest increment at the center of the storm duration. The second largest increment is placed directly in front of the first, the third largest placed behind the first, and the procedure is continued with successively smaller increments until the distribution is filled. A similar distribution, favored by Bureau of Reclamation for 72-hour general storm PMP, can be termed "late-peaking." This distribution places the largest increment at the 2/3 point of the storm, then places the second and third largest increment successively in front of the largest increment, then the fourth largest increment immediately behind the largest increment, then continuing the sequence with two increments in front, one behind until the distribution is filled and all increments are used. Either the center-peaking or late peaking distribution will be acceptable for 72-hour General Storm PMP.

Both HMR 49 and HMR 55A refer to two recommended distributions for the 6-hour Local Storm. One is obtained from HMR 5, and the other from the USACE EM1110-2-1411. The distributions are similar, with the USACE EM1110-2-1411 distribution peaking later in the storm. HMR 49 states, "In application, the choice of either of these distributions is left to the user since one may prove to be more critical in a specific case than the other." This suggests that both methods should be evaluated and the more critical distribution should be used. In practice, the USACE EM1110-2-1411 appears to provide the higher peak discharge in the majority of cases. While not specifically discussed in either HMR 49 or HMR 55A, a center-peaking distribution of local storm PMP has been used in the past and is acceptable to OSE. In any case,

the distribution used must be justified as being appropriate for the specific drainage area being evaluated.

The center-peaking and late-peaking distributions described above are frequently approximated in HEC-HMS or HEC-1 using the Frequency Storm definition for precipitation. Using the Frequency Storm to distribute PMP can cause unintended consequences if one is not careful, and probably should be avoided by infrequent users. The Frequency Storm requires input of precipitation depths for durations corresponding to the frequency series of 5 min, 15 min, 1 hour, 2 hours, 3 hours, 6 hours, 24 hours, 48 hours, etc. The frequency series does not include a 72-hour duration, and so will not emulate the full General Storm PMP. The General Storm index values from HMR 55A do not include values for 5 min, 15 min, 2 hour, 3 hour, or 48 hour durations, and the index values from HMR 49 do not include 5 min, 15 min, 1, 2, or 3 hour values, requiring values to be interpolated or read from curve plots, introducing a possible source of error. The Frequency Storm method can result in unintended reductions of precipitation due to inappropriate use of Storm Area and Probability inputs in HEC-HMS and HEC-1. It is probably best to discuss with OSE before using the Frequency Storm to distribute PMP.

In cases where 100-year precipitation is required (primarily for low-hazard potential dams) the preferred distribution is a center-peaking distribution based on the frequency series from NOAA Atlas 14. The Frequency Storm functions in HEC-HMS, HEC-1, and possibly other programs, are suitable and are intended for this type of storm. Since the precipitation from Atlas 14 is point precipitation, reductions for storm area may be taken as appropriate. The common SCS Type II distribution used for most of the US east of New Mexico will not be appropriate in New Mexico in most cases. The Type IIA distributions used by NRCS in New Mexico may be appropriate, but it is recommended that their use be discussed with OSE prior to using these distributions.

The following distribution methods, which have all been used in submittals to OSE, are not generally appropriate:

- Using the depth-duration curve as the distribution.
- Straight-line distribution of equal increments throughout the storm or during peak periods of the storm.
- Using SCS Type II or NRCS Type II-a distribution for PMP.
- Compressing SCS or NRCS distributions for durations less than 24 hours
- Using a Huff distribution.

11. Spatial Distribution of Precipitation

Spatial distribution of precipitation intensity within a basin through use of isohyetal storm patterns is typically done only for relatively large basins. This method is not common in submittals to OSE, and the services of a qualified meteorologist is required if this method is used. The method is illustrated in HMR 52, which contains information for applying this method east of the 105th meridian, comprising roughly the eastern third of New Mexico.

The more typical submittal applies precipitation uniformly across the basin, with reductions in precipitation depth for larger areas as appropriate. The reductions in these cases are applied during the derivation of precipitation using HMR 49 or HMR 55A. When the isohyetal method

of spatial distribution is used, the full index precipitation is used without reduction, since reduction is effected by application of the isohyetal pattern.

12. Loss Function Parameters

Not all of the precipitation that falls is available to generate runoff. The primary losses to precipitation are interception, evaporation, retention, and infiltration. The first three of these are grouped, along with part of the infiltration loss, and termed "initial losses." For large, infrequent events such as the PMP, initial losses are relatively low compared to infiltration losses, and are assumed to have occurred due to antecedent rainfall prior to the start of the PMP. Therefore, initial losses are commonly neglected in evaluating PMP. Common loss characterizations include SCS curve numbers, initial/constant loss rates, exponential losses, and Green-Ampt method. Other methods are available as well. SCS curve numbers are typically used with SCS hydrograph methodology, and are not recommended for other hydrograph methods. Initial/Constant loss rate methodology is used with USBR and other unit hydrograph methods. Green-Ampt and exponential methods have not been frequently used in submittals to OSE. Parameters must be justified, both in terms of appropriateness for basin conditions (soil and vegetative cover or land use) and appropriateness with the selected transform methodology. For PMP, loss rates frequently are lower than those used with typical return frequency storms such as the 100-year event. Constant loss rates in excess of 0.5 inches/hour will require adequate supporting justification. Typical loss rates for the four SCS soil groups are as follows:

SCS Soil Group	Descriptive Characteristic	Ultimate Infiltration Rate
A	Low Runoff Potential	0.3 to 0.5 inches/hour
B	Moderate Infiltration Rate	0.15 to 0.30 inches/hour
C	Slow Infiltration Rate	0.05 to 0.15 inches/hour
D	High Runoff Potential	0 to 0.05 inches/hour

Source: USBR *Flood Hydrology Manual*, 1989, P. 112

13. Precipitation Excess

Determination of precipitation excess typically is embedded in hydrology software program, but is a straightforward step that can be assumed to be handled correctly with reputable software. The total rainfall excess must be determined and reported, in addition to instantaneous peak discharge. As a rule of thumb for General Storm PMP, rainfall excess less than 70% of total storm volume for 72-hour precipitation depth greater than 25 inches, or less than 60% of 72-hour storm volume for total precipitation depth less than 25 inches, will require justification. Loss parameters and precipitation increment size and distribution can have significant effect on rainfall excess.

14. Transform Methodology

The most common transform methodology is some sort of synthetic unit hydrograph procedure. SCS is fairly common, but may not be the best choice for PMP of extreme storms. SCS parameters are interrelated, and any deviation from the methodology (e.g. Initial-Constant loss rates rather than Curve Numbers) must be justified. The USBR *Flood Hydrology Manual* methodology is also commonly used. USBR is developed for the West, and has three regional unit hydrograph lag relationships that apply within New Mexico: "Great Plains," "Rocky

Mountains," and "Southwest Desert, Great Basin, and Colorado Plateau." Additionally, the Manual contains information for urban basins. It is important to select the correct relationship for the watershed being evaluated. Other unit hydrograph procedures include Clark's and Snyder's unit hydrographs. If these are used, parameters must be provided and justified. User-specified unit hydrographs or other relationships derived from gaging records are possible, but submittals to OSE using these methods have been rare. SCS, Clark's and Snyder's unit hydrographs are available in HEC HMS, and parameters must be provided and justified but unit hydrographs need not be provided. IF USBR methodology or other user-specified unit hydrographs are used, unit hydrograph ordinates must be provided. Kinematic Wave methodology is sometimes used, and is probably most suitable where the watershed can be conveniently be described as rectangular plane surfaces draining into lateral channels. Other distributed-model methodologies may exist or emerge, and should probably be discussed with OSE before submittal.

15. Application of Transform Methodology for Each Subbasin

For computer-based analysis, this is primarily a matter of properly configuring subbasin models and hydrologic parameters within the program.

16. Evaluation of Base Flow

In New Mexico, stream base flow is usually minimal or non-existent except in response to storm events. A possible exception might be snowmelt in mountainous regions. The USBR *Flood Hydrology Manual* discusses modeling base flow and snowmelt. If base flow in the stream will contribute significantly to the hydrograph, it should be considered, and base flow modeling assumptions documented. It may be desirable to model a token base flow if the resulting flood hydrograph will be analyzed in a program such as HEC-2 or HEC HMS for downstream water surface profiles under unsteady-flow conditions.

17. Hydrograph Combining and Routing to Determine IDF

Combining and routing is generally done by the computer model. Model input and output must be carefully scrutinized to make sure that the model is performing as intended

18. Reservoir Routing

Stage-storage information used in routing must be provided; the Rules and Regulations require this to be in elevation intervals of 1 foot. Outlet and spillway capacity rating curve or table must be developed and provided. Relying on older, previously generated rating curves without independently verifying their appropriateness is not acceptable. Spillway capacity is most frequently based on the Weir Equation, $Q = CL(H)^{1.5}$, Where Q is discharge, L is weir length perpendicular to flow, H is head on the weir typically taken as reservoir elevation minus weir elevation, and C is a discharge coefficient for the weir. The weir equation is only appropriate if flow passes through critical depth over the weir and supercritical flow will be present a sufficient distance downstream from the weir that backwater effects will not constrain flow over the weir. If supercritical flow is not assured, then a backwater analysis such as HEC-2 or HEC-RAS is needed to validate spillway capacity. Also if a significant channel exists between the weir and the reservoir, a backwater analysis is needed to confirm that the reservoir stage remains below the dam crest at the anticipated spillway capacity. Care must be exercised in selecting the coefficient C, as it is not constant with respect to flow depth and is sensitive to geometry of the

spillway crest and entrance. Textbook values for typical broad-crested and ogee weirs may not be appropriate. The most common error is to select too high of a coefficient, for example, 3.0 or 3.1 for an open-cut spillway for which 2.6 or 2.7 may be more appropriate.

19. Review of Results for Reasonableness

It is tempting to assume that if the computer program gives an answer and doesn't crash that this is the correct answer. In reality, the computer is not especially intelligent and will do exactly what you tell it to, whether this makes any sense or not. This is not just a matter of "garbage-in, garbage-out." Sometimes, parameters that are in the ballpark when taken individually can compound to skew results in one direction or another. Also, sometimes the program will perform functions not intended by the analyst, such as inappropriate reduction of precipitation for storm area, if you do not tell it exactly what you want and understand the significance of program defaults. Therefore, a review of intermediate steps and final results for reasonableness is important. Calibration of the hydrologic model for PMP is difficult since storms approaching this magnitude are rare. Calibrating against lesser storms such as the 100-year or smaller events may not be appropriate for PMP. Reasonableness of results compared to past experience with similar input parameters may be the best tool available. It is important not only to ensure that the spillway design flood is not underestimated for reasons of public safety, but also that it is not overestimated for reasons of economics. Often, the predicted flood is significantly less probable than the precipitation, which in the case of PMP already has an essentially indefinable but extremely low probability. In some cases, particularly for rehabilitation projects, this can have a substantial impact on project costs.

20. Adjustment of Model Parameters

Based on review of results for reasonableness, it may be appropriate to adjust parameters and recalculate. This will obviously be necessary if the selected spillway turns out not to be adequate for the computed flood. Sensitivity analysis with respect to critical parameters is sometimes useful in forming an opinion with regard to the appropriateness of the result.

21. Hydrologic Analysis Report

Assuming the hydrologic analysis has included the required steps previously discussed, it is important that the methods and parameters used, the results obtained, and supporting justification be documented in a coherent report. This will allow OSE staff to verify that regulatory requirements for hydrology have been satisfied and evaluate whether the proposed design adequately addresses the required design storm. A secondary, but equally important purpose is to provide documentation of methods and assumptions to assist future engineering consultants and OSE staff in understanding the basis for design and assessing adequacy and safety of the structure. Personnel can turn over rapidly, analysis methods change over time, and the structure will almost certainly outlast both the designers and their methods. The hydrology report will serve as a guidance document to help future engineers understand the analysis. As a general principle, the information submitted must be adequate to allow an independent analyst, possibly at some point in the future, to replicate the analysis with comparable results. The information must be transparent and independent of the software program used for computation. The following are some of the items required in the report and supporting documentation:

1. Identification of the hazard potential classification, and any assumptions used in determining this classification. If the classification is anything other than High, supporting documentation, potentially including breach analysis and flood studies, may be required.
2. Determination of appropriate design precipitation based on hazard potential classification and size of structure. Provide detailed analysis report if design precipitation is based on incremental damage assessment or site-specific PMP study, either of which must be discussed with OSE in advance.
3. Location map and topographic map of drainage area contributing to the dam and reservoir, with drainage boundary and total area indicated.
4. Map indicating subbasin boundaries with areas indicated, hydrograph combination points, channels for routing, etc. This may be superimposed on the topographic map described in 3. above if of suitable scale.
5. Table of relevant basin and channel characteristics to be used in the analysis as dictated by the selected analysis methodology, including flow path lengths, centroid distances, mean basin elevations, channel slope, roughness, and cross-section, etc.
6. Discussion of timing and routing parameter derivation including methods or equations used and their applicability to this particular project, example calculations, and summary tables of input data and computed parameters.
7. Narrative discussion of watershed model accompanied by schematic showing the interrelation of various components of the model.
8. Elevation-storage and elevation-discharge tables for reservoir, outlets and spillways. These should be in 1-foot increments unless the dam is very high, in which case the appropriate interval must be discussed in advance with OSE.
9. Worksheets for Local Storm and General Storm PMP derivation from HMR 49 or 55A as appropriate. For Low hazard potential dams, copies of tables from NOAA Atlas 14 website, indicating latitude and longitude of point precipitation, must be included.
10. Table of distributed precipitation increments, distribution curve and/or hyetograph illustrating graphically how precipitation is distributed, and narrative describing and justifying the methodology for distributing precipitation.
11. If spatial distribution is used, full documentation of methodology and assumptions by qualified meteorologist is required.
12. Discussion of loss methodology and documentation of derivation of parameters, tables of soil and land use areas and percentages for each subbasin, and justification of the appropriateness of the parameters and methodology in the context of the overall analysis.
13. Table or graph of precipitation excess for each increment for which excess exists, and identification of total precipitation excess in inches and percentage of rainfall.
14. Discussion of transform methodology used. Coefficients or parameters for common synthetic unit hydrograph procedures (e.g. SCS. Snyder, Clark). If other than a common synthetic unit hydrograph procedure is used, unit hydrograph ordinates must be provided.
15. Table or computer echo of input parameters, with parameters identified or notated for each subbasin, routing reach, or other element.
16. Discussion of base flow or snowmelt methodology or considerations.
17. Table of combining and routing results, supported by computer output. Results must be concurrent with model schematic discussed in 7. above.

18. Elevation-storage and elevation-discharge tables for the reservoir in 1-foot increments, and table of routed hydrograph ordinates with peak inflow to reservoir and routed peak outflow identified. Inflow and outflow hydrographs plotted on same figure of appropriate scale.
19. Discussion of reasonableness of results, including any calibration or comparison information available.
20. Discussion of any parameter adjustments or sensitivity analysis performed in order to validate or improve reasonableness of results.

Special Case – Perimeter Dams:

An increasing number of dams regulated by OSE are perimeter embankments with no contributing watershed outside of the reservoir, interior slopes, and embankment crest. These dams may include wastewater pond dams, industrial evaporation pond dams, municipal raw water storage dams, tailings dams, etc. Water or potentially mobile contents are pumped or discharged to the reservoir as part of a controlled process.

For these perimeter dams, hydrology typically is greatly simplified. The contributing area (reservoir surface, interior slopes, and crest) is determined, and the design precipitation depth is applied to this area to determine the volume contribution of the storm to the reservoir. Where the design storm is all or a percentage of the PMP, the General Storm 72-hour index precipitation should be used. Losses are neglected, and the full precipitation depth is treated as excess contributing to the reservoir. In most cases, storage for this volume of water is provided above the normal maximum water level, with additional freeboard above flood stage to satisfy the freeboard requirements of OSE Rules and Regulations. In some cases, a spillway may be designed to allow routing and discharge of some of the flood volume, thereby reducing embankment height above normal maximum water level.

In addition to water from extreme precipitation events, perimeter embankments are susceptible to misoperation, where discharge into the reservoir continues past the design maximum reservoir level and eventually overtops the embankment, resulting in failure. For this reason, perimeter embankments must be provided with an overflow section with capacity equal to or greater than the discharge capacity into the reservoir, so that misoperation or failure of reservoir controls does not lead to embankment failure.

References:

Cudworth, Arthur G. Jr. (1989), *Flood Hydrology Manual*, USBR.

NOAA Atlas 2 (1973), *Precipitation-Frequency Atlas of the Western United States*.

NOAA Atlas 14 (2006), *Precipitation Frequency Atlas of the United States, Volume 1 Version 4.0: Semiarid Southwest*, available online at http://hdsc.nws.noaa.gov/hdsc/pfds/index.html.

NOAA, USACE Hydrometeorological Report No. 49 (1984), *Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages*.

NOAA, USACE Hydrometeorological Report No. 52 (1982), *Application of Probable Maximum Precipitation Estimates – United States East of the 105th Meridian*.

NOAA, USACE, USBR Hydrometeorological Report No. 55A (1988), *Probable Maximum Precipitation Estimates – United States Between the Continental Divide and the 103rd Meridian*.

NOAA Technical Memorandum HYDRO-40 (1984), *Depth-Area Ratios in the Semi-Arid Southwest United States.*

NOAA Technical Paper No. 40 (1961), *Rainfall Frequency Atlas of the United States*, U.S. Weather Bureau.

NOAA Technical Report 24 (1980), *A Methodology for Point-to-Area Rainfall Frequency Ratios.*

OSE (2005), *Rules and Regulations Governing Dam Design, Construction, and Dam Safety,* Title 19, Chapter 25, Part 12 New Mexico Administrative Code.

U.S. Army Corps of Engineers EM1110-2-1411 (1965) *Standard Project Flood Determinations.*

U. S. Weather Bureau Hydrometeorological Report 5 (1947), *Thunderstorm Rainfall.*

E.31. New York



New York State

DEC

Division of Water

Guidelines for Design of Dams

January 1985
Revised January 1989

New York State Department of Environmental Conservation

George E. Pataki, *Governor*

John P. Cahill, *Commissioner*

GUIDELINES FOR DESIGN OF DAMS

NEW YORK STATE

DEPARTMENT OF ENVIRONMENTAL CONSERVATION

DIVISION OF WATER

BUREAU OF FLOOD PROTECTION

DAM SAFETY SECTION

625 BROADWAY

ALBANY, NEW YORK 12233-3507

GUIDELINES FOR DESIGN OF DAMS

TABLE OF CONTENTS

SECTION	TITLE	PAGE
	Preface to the January 1989 Edition	1
1	Introduction	2
2	Definitions	3
3	Hazard Classification	5
4	Design and Construction Documents	5
5	Hydrologic Criteria	7
6	Hydraulics of Spillways	10
6A	Flashboard Policy	12
7	Outlet Works and Conduits	15
8	Geotechnical Investigations	16
9	Earth Dams	18
10	Structural Stability Criteria for Gravity Dams	21
11	Existing Dams: Rehabilitation and Modification	25
12	Cofferdams	26
13	Miscellaneous	27
14	Emergency Action Plan	27
15	Approval to Fill Reservoir	28
16	References	29
17	DEC - Regional Directory	31

PREFACE TO THE JANUARY 1988 EDITION

The January 1988 revision involves:

Page	Item
2	Introduction
4	Corrected definition for the Service Spillway Design Flood (SSDF)
6	Construction Inspection
11	Insertion of Section 6A, Flashboard Policy
14	Filter and drainage diaphragm replacing antiseep collars for pipe conduits
19	Vegetation Control
22	Insertion of Loading Condition 3A
25	Cofferdams
28	The addition of references 3, 4, 5 and 6

PREFACE TO THE JANUARY 1989 EDITION

The January 1989 revision involves:

Page	Item
7	Hydrology Investigations
7	Existing Dams - Service Spillway Design Flood Criteria

1.0 INTRODUCTION

1.1 General

The Department of Environmental Conservation receives many requests for detailed information about designs for dams requiring a permit under Article 15, Section 0503 of the Environmental Conservation law. This brochure has been developed by the department for the general guidance of design engineers.

These guidelines represent professional judgment of the Dam Safety Section's staff engineers. The guidelines convey sound engineering practices in an average situation. Where unusual conditions exist and the guidelines are not applicable, it is the duty of the design engineer to notify the department which will then consider deviation from the guidelines.

Since these are only general guidelines for small dam construction in an average situation, compliance will not necessarily result in approval of the application. The determination by the department of the acceptability of the design and adequacy of the plans and specifications will be made on a case-by-case basis. The primary responsibility of proper dam design shall continue to be that of the applicant.

In the administration of this law, the department is concerned with the protection of both the health, safety and welfare of the people and the conservation and protection of the natural resources of the State. (See Reference 1 and 2).

Water stored behind a dam represents potential energy which can create a hazard to life and property located downstream of the dam. At all times the risks associated with the storage of water must be minimized. This document deals with the engineering guidelines for the proper design of a dam. In order for a dam to safely fulfill its intended function, the dam must also be constructed, operated and maintained properly.

Supervision of construction or reconstruction of the dam by a licensed professional engineer is required to insure that the dam will be built according to the approved plans. See Article 15-0503, Item 5 of the New York State, Environmental Conservation Law (Reference 1).

For the proper operation and maintenance of a dam, see "An Owners Guidance Manual for the Inspection and Maintenance of Dams in New York State" (Reference 6).

1.2 Application

A permit is required if the dam:

is at least 10 feet high or

stores 1 million gallons (3.07 acre feet) or

has a drainage area of 1 square mile.

Waste surface impoundments which are large enough to meet the above mentioned criteria shall not require an Article 15 dam permit. Hazardous waste surface impoundments will continue to be regulated by the Bureau of Hazardous Waste Technology, Division of Hazardous Substances

Regulation of the Department of Environmental Conservation, under 6NYCRR-Part 373, Hazardous Waste Management Regulation. Surface impoundments which are part of an approved waste water treatment process will be regulated within a SPDES permit issued by the Division of Water.

1.3 Application Forms

Applications, including the Supplement D-1 (hydrological, hydraulic and soils information), can be obtained from and should be submitted to the Regional Permit Administrator. The addresses of the Regional Permit Administrators are shown on page 31. Detailed information on application procedures is contained in the Uniform Procedures Regulations, Part 621.

Information on all pertinent items should be given. Construction plans and specifications should be prepared in sufficient detail to enable review engineers to determine if the proposed design and construction is in compliance with department guidelines. Thorough engineering review will be given each application. The time for this review and any additional time if revisions are necessary should be a consideration in each application.

2.0 DEFINITIONS

Appurtenant works are structures or materials built and maintained in connection with dams. These can be spillways, low-level outlet works and conduits.

Auxiliary spillway is a secondary spillway designed to operate only during large floods.

Cofferdam is a temporary structure enclosing all or part of the construction area so that construction can proceed in the dry.

Conduit is an enclosed channel used to convey flows through or under a dam.

Dam is any artificial barrier and its appurtenant works constructed for the purpose of holding water or any other fluid.

Department is the Department of Environmental Conservation (DEC).

Detention/Retention Basin is any structure that functions as a dam.

Earth Dam is made by compacting excavated earth obtained from a borrow area.

Energy Dissipator is a structure constructed in a waterway which reduces the energy of fast-flowing water.

Flood Routing is the computation which is used to evaluate the interrelated effects of the inflow hydrograph, reservoir storage and spillway discharge from the reservoir.

Freeboard is the vertical distance between the design high water level and the top of the dam.

Gravity Dam is constructed of concrete and/or masonry and/or laid-up stone that relies upon its weight for stability.

Height is the vertical dimension from the downstream toe of the dam at its lowest point to the top of the dam.

Low-Level Outlet is an opening at a low level used to drain or lower the water.

Major Size Dam is at least 25 feet high and holds at least 15 acre feet of water or is at least 6 feet high and holds at least 50 acre feet of water.

Maximum Impoundment Capacity is the volume of water held when the water surface is at the top of the dam.

Probable Maximum Flood (PMF) is the flood that can be expected from the severest combination of critical meteorologic and hydrologic conditions possible for the particular region. It is the flow resulting from the PMP.

Probable Maximum Precipitation (PMP) is the maximum amount of precipitation that can be expected over a drainage basin.

Seepage Collar is built around the outside of a pipe or conduit under an embankment dam to lengthen the seepage path along the outer surface of the conduit.

Service Spillway is the principal or first-used spillway during flood flows.

Service Spillway Design Flood(SSDF) is the flow discharged through the service spillway.

Spillway is a structure which discharges flows.

Spillway Design Flood(SDF) is the largest flow that a given project is designed to pass safely.

Toe of Dam is the junction of the downstream face of a dam and the natural ground surface, also referred to as downstream toe. For an earth dam the junction of the upstream face with the ground surface is called the upstream toe.

3.0 HAZARD CLASSIFICATION

3.1 General

The height of the dam, its maximum impoundment capacity, the physical characteristics of the dam site and the location of downstream facilities should be assessed to determine the appropriate hazard classification. Applications should include the design engineer's description of downstream conditions and his judgment of potential downstream hazards presented in the form of a letter designation and a written description.

3.2 Letter Designation

Class "A": dam failure will damage nothing more than isolated farm buildings, undeveloped lands or township or country roads.

Class "B": dam failure can damage homes, main highways, minor railroads, or interrupt use or service of relatively important public utilities.

Class "C": dam failure can cause loss of life, serious damage to homes, industrial or commercial buildings, important public utilities, main highways, and railroads.

3.3 Written Description

The written description is an elaboration of the letter designation. It includes descriptions of the effect upon human life, residences, buildings, roads and highways, utilities and other facilities if the dam should fail.

4.0 DESIGN AND CONSTRUCTION DOCUMENTS

4.1 Engineer Qualifications

The design, preparation of construction plans, estimates and specifications and supervision of the construction, reconstruction or repair of all structures must be done under the direction of a professional engineer licensed to practice in New York State. (See References 1 and 7).

4.2 Design Report

A design report, submitted with the application, should include an evaluation of the foundation conditions, the hydrologic and hydraulic design and a structural stability analysis of the dam. The report should include calculations and be sufficiently detailed to accurately define the final design and proposed work as represented on the construction plans. Any deviations from the guidelines should be fully explained.

4.3 Construction Plans

Construction plans should be sufficiently detailed for department evaluation of the safety aspects of the dam. The cover sheet should include a vicinity map showing the location of the dam. The size of the plans should be not less than 18 x 24 inches and no more than 30 x 48 inches. As-built plans of the project are required upon completion of construction.

4.4 Construction Inspection

The dam's performance will largely be controlled by the care and thoroughness exercised during its construction. Undisclosed subsurface conditions way be encountered which may materially affect the design of the dam. To ensure a safe design, the designer must be able to confirm design assumptions and revise the dam design if unanticipated conditions are encountered. Construction inspection is required in order to ensure that the construction work complies with the plans mid specifications and meets standards of good workmanship. Therefore, construction inspection of a dam is required by a licensed professional engineer to monitor and evaluate conditions as they are disclosed and to observe material placement and workmanship as construction progresses.

The engineer involved in the construction of the dam work will be required to submit a periodic construction report to the Department covering the critical inspection activities for the dam's construction/reconstruction. Prior to permit issuance the applicant shall submit, for review and approval, a proposed schedule of construction inspection activities to be performed by the applicant's engineer. Upon permit issuance, the approved schedule shall be part of the required work.

4.5 Specifications

Materials specifications will be required for items incorporated in the dam project. Materials specifications including format found acceptable are those issued by the following agencies and organizations.

State: New York State Department of Transportation

Federal: COE - Corps of Engineers
SCS - Soil Conservation Service

Industry: ASTM - American Society for Testing and Materials
ACI - American Concrete Institute
AWWA - American Water Works Association
CSI - Construction Specifications Institute

5.0 HYDROLOGIC CRITERIA

5.1 Hydrologic Design Criteria

A table of hydrologic design criteria giving the spillway design flood, the service spillway design flood and minimum freeboards for various hazard classifications can be found in Table 1.

5.2 Design Flood

The National Weather Service has published data for estimating hypothetical storms ranging from the frequency-based storm to the Probable Maximum Precipitation event. For the frequency-based storms Technical Paper TP-40 (Ref 17) and TP-49 (Ref 18) will be used to determine rainfall. For the Probable Maximum Precipitation event, Hydrometeorological Report HMR-51 (Ref 16) will be used.

When using the above mentioned TP's and HMR's, the minimum storm duration will be six hours. For large drainage areas in which the time of concentration exceeds six hours, the precipitation amounts must be increased by the applicable duration adjustment.

The Soil Conservation Service (SCS) has developed Technical Release 55 (TR-55) "Urban Hydrology for Small Watersheds". TR-55 presents simplified procedures for estimating runoff and peak discharge and is an acceptable procedure for designing spillways for small watersheds. In developing TR-55 the SCS uses a storm period of 24 hours for the synthetic rainfall distribution.

Although the "rational method" (Q=CIA) is used for estimating design flows for storm drains and road culverts, it normally is not an acceptable method for determining peak discharge for the design of a dam spillway. The rational method should not be used for watershed areas larger than 200 acres because of its inaccuracy above that range. The greatest weakness of the "rational method" for predicting peak discharges lies in the difficulty of estimating the duration of storms that will produce peak flow. The greatest probability for error, both as to magnitude and understanding relates to the term "intensity" or "rate of rainfall". Although the units are inches per hour, the term does not mean the total inches of rain falling in a period of one hour. "Intensity" should be related to the time of concentration. "Intensities" would be higher for storms of short duration and would be lower for storms of longer duration.

Table I indicates that the appropriate Spillway Design Flood will be a percentage of the 100 year flood or the PMF. Therefore, in order to correctly determine the peak flow, the rainfall values used will be for the 100 year flood or the PMF and the appropriate peak discharge will be computed. After the peak discharge has been found, this value will then be multiplied by the appropriate percentages. For example a small dam in the Class "B" hazard category will have the discharge based on the

rainfall from a 100 year flood and this discharge will then be multiplied by 2.25 to obtain the peak discharge. The percentages should be applied to the discharge vllues in the final step of the calculations. It is incorrect to apply the percentages to the rainfall values.

5.3 Existing Dams - Design Flood

Existing dams that are being rehabilitated should have adequate spillway capacity to pass the following floods without overtopping:

Hazard Classification	Spillway Design Flood (SDF)
A	100 year
B	150% of 100 year
C	50% of PMF

The Service Spillway Design Flood (SSDF) for existing dams is the same as shown for the new dams on Table 1.

TABLE 1 - NEW DAMS

HYDROLOGIC DESIGN CRITERIA TABLE

HAZARD CLASSIFICATION	SIZE DAM	SPILLWAY DESIGN FLOOD (SDF)	SERVICE SPILLWAY DESIGN FLOOD (SSDF)	MINIMUM FREEBOARD (FT.)
"A"	*SMALL	100 year	5 year	1
"A"	*LARGE	150% of 100 yr.	10 year	2
"B"	SMALL	225% of 100 yr.	25 year	1
"B"	LARGE	40% of PMF	50 year	2
"C"	SMALL	50% of PMF	25 year	1
"C"	LARGE	PMF	100 year	2

*SMALL

Height of dam less than 40 feet. Storage at normal water surface less than 1000 acre feet.

*LARGE

Height at dam equal to or greater than 40 feet. Storage at normal water surface equal to or greater than 1000 acre feet.

NOTE:

Size classification will be determined by either storage or height, whichever gives the larger size category.

6.0 HYDRAULICS OF SPILLWAYS

6.1 Spillways

Spillways protect the dam from overtopping. Consideration must be given to dams and reservoirs upstream of the dam in question when designing the spillway. A dam should be provided with either a single spillway or a service spillway-auxiliary spillway combination.

6.2 Single Spillway

For a single spillway, the structure should have the capacity and the durability to handle sustained flows as well as extreme floods and be non-erodible and of a permanent-type construction. Free overall spillways, ogee spillways, drop inlet or morning glory spillways, and chute spillways are common types. An earth or grass-lined spillway is not durable under sustained flow and should not be used as a single spillway.

6.3 Criteria for a single spillway are as follows:

6.3.1 Sufficient spillway capacity should be provided to safely pass the spillway design flood with flood routing through the reservoir. (See Table 1 for spillway design flood).

6.3.2 Assuming no inflow, the spillway should have sufficient discharge capacity to evacuate 75% of the storage between the maximum design high water and the spillway crest within 48 hours.

6.3.3 The spillway will have an energy dissipater at its terminus.

6.3.4 A drop inlet or morning glory spillway, as a single spillway, is only acceptable on a Hazard Class "A" structure with a drainage area of less than 50 acres. In this case, sufficient storage capacity should be provided between the spillway crest and top of dam to contain 150% of the entire spillway design flood runoff volume.

6.4 Service Spillway - Auxiliary Spillway Combination:
In the case of the service spillway - auxiliary spillway combination, the service spillway discharges normal flows and the more frequent floods, while the auxiliary spillway functions only during extreme floods.

Service spillways must be durable under conditions of sustained flows; whereas auxiliary spillways do not. Service spillways should have sufficient capacity to pass frequent floods and thus reduce the frequency of use of the auxiliary spillway. The service spillway usually does not have sufficient capacity to pass the entire spillway design flood. Drop inlet or morning glory spillways are common types of service spillways. This type of structure will consist of a vertical inlet riser connected to a service spillway conduit with an energy

dissipator at the outlet. An auxiliary spillway is capable of handling high but short duration flows. It may be an excavated grass-lined channel if the designer is able to limit velocities to the non-erodible range for grass. It cannot carry prolonged flows because of eventual deterioration of the grass linings. For spillways which will be required to discharge flows at a high velocity, a more permanent type of material such as concrete will be required. An auxiliary spillway may be located adjacent to a dam abutment or anywhere around the rim of the reservoir. It should be located sufficiently apart from the dam to prevent erosion of any embankment materials. A spillway over the dam is not acceptable. It may either discharge back into the natural watercourse below the dam, or so long as a flood hazard is not created, into a watercourse within an adjacent drainage basin.

6.5 Criteria for an auxiliary spillway-service spillway combination are as follows:

6.5.1 Sufficient service spillway capacity should be provided to safely pass the service spillway design flood with flood routing through the reservoir. (See Table 1 for service spillway design flood).

6.5.2 The service spillway normally should be provided with an energy dissipater at its outlet end.

6.5.3 The auxiliary spillway crest must be placed at or above the service spillway design high water, and not less than 1 foot above the service spillway crest.

6.5.4 The auxiliary spillway-service spillway combination must provide sufficient discharge capacity to safely pass the spillway design flood with flood routing through the reservoir (See Table 1 for spillway design flood).

6.5.5 Assuming no inflow, the auxiliary spillway-service spillway combination should have sufficient capacity to evacuate the storage between the maximum design high water and the auxiliary spillway crest within 12 hours.

6.5.6 Assuming no inflow, the service spillway should have sufficient capacity to evacuate 75% of the storage between the auxiliary spillway crest and the service spillway crest within 7 days.

6.5.7 Auxiliary spillways shall not be placed on fill.

6.5.8 Velocities in auxiliary spillways should not exceed the maximum permissible velocities (non-erodible velocities) of the spillway materials.

6.5.9 If an auxiliary spillway is located near an embankment,it should be located so as not to endanger the stability of the embankment. The following criteria will help guard against damage to the embankment:

a. Discharge leaving the exit channel should be directed away from the embankment and should be returned to a natural watercourse far enough downstream as to have no erosive effect on the embankment toe.

b. The spillway exit channel, from the spillway crest to a section beyond the downstream toe of dam, should be uniform in cross-section, contain no bends, and be longitudinally perpendicular to the spillway crest. Curvature may be introduced below the toe of dam if it is certain that the flowing water will not impinge on the toe of dam.

6.0 A FLASHBOARD POLICY

Background

Flashboards are used to raise the water surface of an impoundment. However, the installation of flashboards along the crest of a spillway may permanently reduce the size of the spillway opening. Our records indicate that in some instances the reduction of spillway capacity with the installation of flashboards has resulted in overtopping and subsequent dam failure. Two examples are the Tillson Lake Dam (#1942420) in Ulster County and the Lake Algonquin Dam (#171-2700) in Hamilton County.

In 1939 flashboards were placed across the spillway of the 40 foot high Tillson Lake Dam in such a manner as to greatly reduce the spillway opening. Storm flow caused dam overtopping which eroded the earth slope in front of the 100 foot wide, 30 foot high concrete core wall. Failure of the core wall resulted in a tremendous amount of erosion to farm land, loss of farm machinery, chickens, several local bridges and basement flooding. The dam was rebuilt and failed in 1955 because flashboards were again in place and did not fail during storm flow.

In 1949 the Lake Algonquin Dam failed because flashboards were not removed for the winter. A January storm caused overtopping and subsequent dam failure at the right abutment. The dam failure resulted in the loss of a home, several farm buildings and a road.

When wood flashboards are installed properly they will be

supported by steel pins. These steel pins will be designed to fail when the depth of flow over the top of the flashboards reaches a certain level. Critical to the design of the flashboard system are the diameter of the steel pin, the ultimate strength of the steel and the spacing of the pins. In very few cases is the Consulting Engineer or Contractor who designed the flashboards able to provide sufficient quality control to ascertain that the as-built condition is similar to the design proposal.

Many field maintenance personnel do not understand the need for flashboards to fail when the depth of flow over the flashboards reaches a certain level. Therefore, there is a tendency to insert the flashboards in such a manner so that they will never fail, thus permanently reducing spillway capacity and increasing the possibility of dam failure by overtopping. This is what nearly happened at the Gore Mountain Dam at North Creek. During the period of 1977-1980 DEC operations personnel installed wide flange beams to support the wood flashboards. The approved design for the flashboard supports were one inch diameter steel pins. However, operations personnel decided they would have less maintenance problems if they permanently secured the wood flashboards between the six inch wide flange beams. Under this support the flashboards would never fail.

Around February 15, 1981 a sudden thaw and rain caused the water level at Gore Mountain Dam to rise within eight inches of the top of dam. This level was about two feet, four inches over the top of the flashboards. The extra sturdy wide flange beam support system precluded any chance of flashboard failure. Fortunately this abnormally high level was reported to the DEC by a local resident while he was snowmobiling. During the fall of 1981, DEC revised the flashboard support system so that the flashboards were properly supported by one inch diameter steel pins and the steel pins would fail in bending when the depth of flow over the top of the flashboards reached one foot.

For the foregoing reasons the Dam Safety Section has developed the following policy regarding the installation of flashboards on dams.

New Dams

Flashboards shall not be installed on any new dams. The dam owner or hydroelectric developer shall determine the normal pool elevation for the proposed impoundment and provide a permanently fixed spillway crest at the selected elevation. If pool elevation fluctuations are desired, they should be achieved by means of adequately sized gates, drains, siphons or other acceptable methods.

Existing Dams

A permanently fixed spillway crest is the preferred method of establishing normal pool elevation.

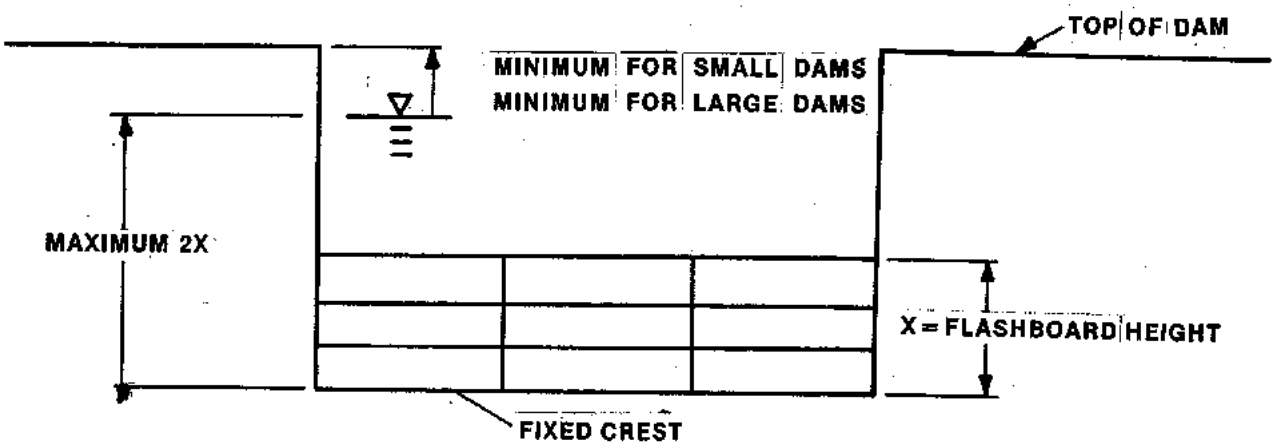
The installation or continued use of flashboards on existing dams will be considered on a case by case basis. Flashboards on existing dams will only be acceptable if the dam is able to satisfy the hydraulic and structural stability criteria contained in the Guidelines for Design of Dams. If the flashboards are designed to fail in order to satisfy either criterion, detailed failure calculations must be submitted for Department review and approval. The maximum pool elevation the flashboards are designed to fail at shall be the lower of:

1. Two times the height of the flashboards measured from the bottom of the flashboards, or

2. Two times the freeboard specified in Table 1 of these Guidelines, for a dam of the pertinent size and hazard classification, measured downward from the top of dam.

The maximum pool elevation that would be reached under Spillway Design Flood conditions, without the flashboards failing, shall also be determined.

Flashboards shall be installed, operated and maintained as intended in their design and in accordance with the terms and/or conditions of any permits or approvals. The approved flashboard configuration (pin spacing, pin size, board height, board size, etc.) shall not be modified without prior Department approval.



7.0 OUTLET WORKS AND CONDUITS

7.1 Outlet Works

A low-level outlet conduit or drain is required for emptying or lowering the water in case of emergency; for inspection and maintenance of the dam, reservoir, and appurtenances; and for releasing waters to meet downstream water requirements. The outlet conduit may be an independent pipe or it may be connected to the service spillway conduit. The low level drain is required to have sufficient capacity to discharge 90% of the storage below the lowest spillway crest within 14 days, assuming no inflow into the reservoir.

7.2 Control

Outlet conduits shall have an upstream control device (gate or valve) capable of controlling the discharge for all ranges of flow.

7.3 Conduits

Only two types of conduits are permitted on Hazard Class "B" and "C" structures; precast reinforced concrete pipe and cast-in-place reinforced concrete.

On Hazard Class "A" structures, welded steel pipe or corrugated metal pipe may be used providing the depth of fill over the pipe does not exceed 15 feet and the pipe diameter does not exceed 24 inches.

All outlet conduits shall be designed for internal pressure equal to the full reservoir head and for the superimposed embankment loads, acting separately.

The minimum size diameter conduit used as the barrel of a drop inlet service spillway shall be 12 inches.

The joints of all pipe conduits shall be made watertight.

Any pipe or conduit passing through an embankment shall have features constructed into the embankment whereby seepage occurring along the pipe or conduit is collected and safely conveyed to the downstream toe of the embankment. This can be accomplished by using a properly designed and constructed filter and drainage diaphragm. The filter and drainage diaphragm will be required unless it can be shown that antiseep collars will adequately serve the purpose.

Antiseep collars will not be permitted for dams with a height in excess of 20 feet. If antiseep, collars are used in lieu of a

drainage diaphragm, they shall have a watertight connection to the pipe. Collar material shall be compatible with pipe materials. The antiseep collars shall increase the seepage path along the pipe by at least 15%.

A means of dissipating energy shall be provided at the outlet end of all conduits 12 inches or more in diameter. If a plunge pool is used, the conduit should be cantilevered 8 feet over a concrete, steel or treated timber support located near or at the downstream toe of the embankment. The plunge pool should be riprap-lined if a conduit 18 inches or more in diameter is used. The foregoing may apply to smaller pipes if the embankment's downstream slope is steep and the soil erodible.

8.0 GEOTECHNICAL INVESTIGATION

8.1 Foundations

8.1.1 Subsurface explorations (drill holes, test pits and/or auger holes) should be located along the centerline of the dam, at the proposed service and auxiliary spillway locations, and in other critical areas. The depth of the subsurface explorations should be sufficient to locate and determine the extent and properties of all soil and rock strata that could affect the performance of the dam, the reservoir and appurtenant structures. Referring to information such as geologic bulletins, soil survey maps, groundwater resources bulletins, etc., may aid the designer in determining the scope of the exploration program needed and interpreting the results of the program. For even the smallest low hazard dams, at least three explorations should be made along the centerline of the dam, one in the deepest part of the depression across which the dam will be built and one on each side. At least one exploration should be made at the proposed auxiliary spillway location. For small low-hazard dams, to be built on a foundation known from the geology of the area to be essentially incompressible and impervious to a great depth, the minimum depth of explorations should be 5 feet unless bedrock is encountered above this depth. In other cases the minimum depth of explorations should be 10 feet, with one or more borings extending to a depth equal to the proposed height of the dam. If it is proposed to excavate in the reservoir area, the possibility of exposing pervious foundation layers should be investigated by explorations or a review of the geology of the area. If rock is encountered in explorations, acceptable procedures, such as coring, test pits, or geologic information, should be used to verify whether or not it is bedrock.

8.1.2 Sufficient subsurface explorations should be made to verify the suitability of encountered rock for use as a foundation

and/or construction material. Testing of the rock materials shall ascertain its strength, compressibility, and resistance to degradation, and its ability to safely withstand the loads expected to be imposed upon it by the proposed project.

8.1.3 Soils encountered in explorations should be described accurately and preferably classified in accordance with the Unified Soil Classification System.

8.1.4 For Hazard Class "C" dams, appropriate field and/or laboratory tests should be performed in order to aid in evaluating the strength, compressibility, permeability, and erosion resistance of the foundation soils. Also, appropriate laboratory tests should be performed on samples of the proposed embankment materials in order to ascertain their suitability for use in the dam. Field and/or laboratory tests may be required also for dams of lower hazard classification in the case of critical foundation strength or permeability conditions.

8.1.5 Stability of the foundation under all operating conditions should be evaluated.

8.1.6 Settlement of the dam and appurtenant works should be evaluated and provisions made in the design to counteract the effects of any anticipated settlements.

8.1.7 Whenever feasible, seepage under the dam should be controlled by means of a complete cutoff trench extending through all pervious foundation soils into a relatively impervious soil layer. If the dam is to be built on an impervious foundation, the cutoff or key trench should be excavated to a depth of at least 3 feet into the foundation soils and backfilled with compacted embankment material. Where the final depth of cutoff cannot be established with certainty during design, a note should appear on the plans stating that the final depth of the cutoff trench will be determined by the engineer during the time of construction. Backfilling of the cutoff or key trench should be performed in the dry, unless special construction procedures are used. The bottom width of the trench should be at least 8 feet and should be increased in the case of dams more than 20 feet high. The widths of complete cutoffs my be made considerably less if the cutoff is extended vertically a minimum distance of 4 feet into impervious material. In the case of a cutoff or key trench extending to bedrock, the trench does not have to extend into rock. However, all shattered and disintegrated rock should be removed and surface fissures filled with cement grout. The need for pressure grouting rock foundations should be evaluated and, if necessary, adequately provided for.

8.2 Borrow Sources for Embankment Materials

Sufficient subsurface explorations should be made in borrow areas to verify the suitability and availability of an adequate supply of borrow materials. Logs of explorations should be included for review with the plans and specifications. Exposure of pervious soils and fissured rock below normal water surface of the proposed pond, at borrow areas located in or connected to the reservoir area, should be avoided.

If pervious soils or fissured rock conditions are encountered during borrow operations these exposed areas should be sealed with a sufficient thickness of compacted impervious material. In no case should this seal be less than two feet thick and consideration should be given to utilizing a greater thickness where site conditions and hazard classifications dictate.

Borrow areas should be located with due consideration to the future safety of the dam and should be shown on the plans. In general, no borrow should be taken within a distance measured from the upstream toe of the dam equal to twice the height of the dam or 25 feet, whichever is greater.

9.0 EARTH DAMS

9.1 Geometry

9.1.1 The downstream slope of earth dams without seepage control measures should be no steeper than 1 vertical on 3 horizontal. If seepage control measures are provided, the downstream slope should be no steeper than 1 vertical on 2 horizontal.

9.1.2 The upstream slope of earth dams should be no steeper than 1 vertical on 3 horizontal.

9.1.3 The side slopes of homogenous earth dams may have to be made flatter based on the results of design analyses or if the embankment material consists of fine grained plastic soils such as CL, MH or CH soils as described by the Unified Soil Classification System.

9.1.4 The minimum allowable top width (W) of the embankment shall be the greater dimension of 10 feet or W, as calculated by the following formula:

$W = 0.2H + 7$; where H is the height of the embankment (in feet)

9.1.5 The top of the dam should be sloped to promote drainage and minimize surface infiltrations and should be cambered so that the design freeboard is maintained after post-construction settlement takes place.

9.2 Slope Stability

Where warranted and especially for new Hazard Class "C" dams, the department may require that slope stability analyses be provided for review. The method of analyses and appropriate factors of safety for the applicable loading conditions shall be as indicated by U. S. Army Corps of Engineers publications (latest edition) (Ref. 11).

Earth dams, in general, should have seepage control measures, such as interior drainage trenches, downstream pervious zones, or drainage blankets in order to keep the line of seepage from emerging on the downstream slope, and to control foundation seepage. Hazard Class "A" dams less than 20 feet in height and Hazard Class "B" dams less than 10 feet in height, if constructed on and of erosion-resistant materials, do not require special measures to control seepage.

In zoned embankments, consideration should be given to the relative permeability and gradation of embankment materials. No particle greater in size than six inches in maximum dimension should be allowed to be placed in the impervious zone of the dam.

9.3 Compaction Control and Specifications

Before compaction begins, the embankment material should be spread in lifts or layers having a thickness appropriate to the type of compaction equipment used. The maximum permissible layer thickness should be specified in the plans or specifications.

Specifications should require that the ground surface under the proposed dam be stripped of all vegetation, organic and otherwise objectionable materials. After stripping, the earth foundation should be moistened, if dry, and be compacted before placement of the first layer of embankment material. Inclusion of vegetation, organic material, or frozen soil in the embankment, as well as placing of embankment material on a frozen surface is prohibited and should be so stated in the specifications.

For all dams, compaction shall be accomplished by appropriate equipment designed specifically for compaction. The type of compaction equipment should be specified in the plans or specifications.

The degree of compaction should be specified either as a minimum number of complete coverages of each layer by the compaction equipment or, in the case of higher or more critical dams, based on standard ASTM test methods.

When the degree of compaction is specified as a number of complete coverages or passes, the final number of passes required shall be determined by the engineer during construction.

In order to insure that the embankment material is compacted at an appropriate moisture content, a method of moisture content control should be specified. For Hazard Class "A" dams less than 20 feet high, the moisture content may be controlled visually by a qualified inspector. Hand tamping should be permitted only in bedding pipes passing through the dam. All other compaction adjacent to structures should be accomplished by means of manually directed power tampers.

Backfill around conduits should be placed in layers not thicker than 4 inches before compaction with particle size limited to 3 inches in greatest dimension and compacted to a density equal to that of the adjacent portion of the dam embankment regardless of compaction equipment used.

Care should be exercised in placing and compacting fill adjacent to structures to allow the structures to assume the loads from the fill gradually and uniformly. Fill adjacent to structures shall be increased at approximately the same rate on all sides of the structures.

The engineer in charge of construction is required to provide thorough and continuous testing to insure that the specified density is achieved.

9.4 VEGETATION CONTROL - TREES AND BRUSH

9.4.1 Trees and Brush

Trees and brush are not permitted on earth dams because:

a. Extensive root systems can provide seepage paths for water.

b. Trees that blow down or fall over can leave large holes in the embankment surface that will weaken the embankment and can lead to increased erosion.

c. Brush obscures the surface limiting visual inspection, provides a haven for burrowing animals and retards growth for grass vegetation.

Stumps of cut trees should be removed so grass vegetation can be established and the surface mowed. Stumps should be removed either by pulling or with machines that grind them down. All woody material should be removed to about 6 inches below the ground surface. The cavity should be filled with well compacted soil and grass vegetation established.

9.4.2 Grass Vegetation

Grass vegetation is an effective and inexpensive way to prevent erosion of embankment surfaces. It also enhances the appearance of the dam and provides a surface that can be easily inspected.

10.0 STRUCTURAL STABILITY CRITERIA FOR GRAVITY DAMS

10.1 Application

These guidelines are to be used for the structural stability analysis of concrete and/or masonry sections which form the spillway or non-overflow section of gravity dams.

These guidelines are based on the "Gravity Method of Stress and Stability Analysis" as indicated in Reference 13.

If the gravity dam has keyed or grouted transverse contraction joints, then the "Trial-Load Twist Method of Analysis" (Reference 13) may be used for the stability analysis.

Elastic techniques, such as the finite element method, my be used to investigate areas of maximum stress in the gravity dam or the foundation. However, the finite element method will only be permitted as a supplement to the Gravity Method. The Gravity Method will be required for the investigation of sliding and overturning of the structure.

10.2 Non-Gravity Dams

For non-gravity structures such as arch dams, the designer is required to present calculations based on appropriate elastic techniques as approved by the Dam Safety Section.

10.3 Loads

Loads to be considered in stability analyses are those due to: external water pressure, internal water pressure (pore pressure or uplift) in the dam and foundation, silt pressure, ice pressure, earthquake, weight of the structure.

10.4 Uplift

Hydrostatic uplift pressure from reservoir water and tailwater act on the dam. The distribution of pressure through a section of the dam is assumed to vary linearly from full hydrostatic head at the upstream face of the dam to tailwater pressure at the downstream face or zero if there is no tailwater. Reduction in the uplift pressures might be allowed in the following instances:

10.4.1 When foundation drains are in place. The efficiency of the drains will have to be verified through piezometer readings.

10.4.2 When a detailed flow net analysis has been performed and indicates that a reduction in uplift pressures is appropriate. Any reduction of pressure of more than 20% must be verified by borings and piezometer readings.

10.4.3 When a sufficient number of borings have been progressed and piezometer readings support the fact that actual uplift pressures are less than the theoretical uplift pressures.

10.5 Loading Conditions

Loading Conditions to be analyzed.

Case 1 - Normal loading condition; water surface at normal reservoir level.

Case 2 - Normal loading condition; water surface at normal reservoir level plus an ice load of 5,000 pounds per linear foot, where ice load is applicable. Dams located in more northerly climates, may require a greater ice load.

Case 3 - Design loading condition; water surface at spillway design flood level.

Case 3A- Maximum hydrostatic loading condition; maximum differential head between headwater and tailwater levels as determined by storms smaller in magnitude than the spillway design flood. This loading condition will only be considered when the is submerged under Case 3 loading condition.

Case 4 - Seismic loading condition; water surface at normal reservoir level plus a seismic coefficient applicable to the location.

10.6 Stability Analysis for New Dams

10.6.1 Field Investigation

Subsurface investigations should be conducted for new dams. Borings should be made along the axis of the dam to determine the depth to bedrock as well as the character of the rock and soils under the dam. The number and depth of holes required should be determined by the design engineer based on the complexity of geological conditions. The depth of holes should be at least equal to the height of the dam. Soil samples and rock cores should be collected to permit laboratory testing. The values of cohesion and internal friction of the foundation material should be determined by laboratory testing.

On proposed sites where the foundation bedrock is exposed, the requirements for borings may be waived in some cases. An engineering geologist's professional opinion of the rock quality and the acceptability of the design assumptions will be required in those cases.

10.6.2 Overturning

The resultant force from an overturning analysis should be in the middle third of the base for all loading conditions, except for the seismic analysis (Case 4), where the resultant shall fall within the limits of the base.

10.6.3 Cracking

The resultant force falling outside the middle third of the base and its resulting tension cracks will not be accepted in the design of new dams, except for the seismic loading condition (Case 4).

10.6.4 Sliding

Sliding safety factors may be computed using the Shear-Friction method of analysis when shear values are based on either the results of laboratory testing or an engineering geologist's professional opinion. When the Shear-Friction method is used, the structure should have a minimum safety factor of 2.0 for all loading conditions except for Case 4 (seismic loading) where the minimum acceptable sliding safety factor shall be 1.5.

Designs which are not based on laboratory testing or an engineering geologist's professional opinion must be analyzed using the Friction Factor of Safety. This analysis assumes that the value of shear or cohesion is zero. The minimum safety factor using this method should be 1.5 for all loading conditions except Case 4 where the minimum safety factor shall be 1.25.

10.7 Stability Analysis for Existing Dams

10.7.1 Field Investigations

Subsurface investigations should normally be conducted as part of a detailed structural stability investigation for an existing dam and should provide information regarding the materials of the dam and its foundation. The number and depth of holes required should be determined by the engineer based on the complexity of the composition of the dam and foundation. Samples should be collected and tested to determine the material properties. The program should also measure the uplift pressures at several locations along the base of the dam.

In cases where no subsurface investigations are conducted conservative assumptions regarding material properties and uplift pressures will be required.

10.7.2 Overturning

The resultant force from an overturning analysis should be in the middle third of the base for normal loading conditions (Case 1) and within the middle half of the base for the ice loading condition (Case 2) and the spillway design flood loading condition (Case 3). For the seismic loading condition (Case 4), the resultant force should fall within the limits of the base.

10.7.3 Cracking

If the overturning analysis indicates that the resultant force is outside the middle third, then tension exists at the heel of the dam which may result in the cracking of the concrete. For existing dams cracking will be permitted for all loading conditions except the normal loading condition (Case 1). If the criteria specified above in Overturning for the location of the resultant force are not satisfied, further study and/or remedial work will be required. The Bureau of Reclamation's Cracked Section Method of analysis is acceptable for investigating the stability of the dam for the above mentioned loading conditions. When the Cracked Section Method of analysis is used, the criteria for the minimum sliding factor of safety will have to be satisfied.

10.7.4 Sliding

Sliding safety factors may be computed using the Shear-Friction method of analysis when shear values are based on the results of laboratory testing of samples from subsurface investigations. When the Shear-Friction method is used, the structure should have a minimum safety factor of 2. 0 for Case 1 and Case 2; a value of 1.5 for Case 3 and a value of 1.25 for Case 4.

If no subsurface explorations are performed, the sliding safety factors must be computed using the Friction Factor of Safety. The minimum safety factor using this method should be 1.5 for Case 1; a value of 1.25 for Case 2 and Case 3; and a value of 1.0 for Case 4.

11.0 EXISTING DAMS: REHABILITATION AND MODIFICATION

Additional data should be submitted for dam rehabilitations or dam modifications, including a report by a professional engineer describing the performance and maintenance history of the existing dam. In addition, all data regarding construction, such as existing subsurface explorations, construction materials used for the dam, and plans and specifications should be submitted. If this information is not available, the engineer should inspect and evaluate the structure as to its condition, performance, maintenance history and other information regarding foundation soils and existing conditions.

The engineer should also assess the safety and adequacy of the existing structure against those criteria for spillway capacity and structural stability, indicated in the appropriate sections of these guidelines.

Where a new embankment is to be constructed against an existing dam embankment, the existing slope shall be benched as the new fill is spread and compacted in layers as described in the plans and specifications. This benching is done to provide an interlock between the existing and new embankments. Benching shall not be done in the upstream-downstream direction.

All topsoil and sod shall be stripped from the surface of the existing embankment before placing new material within the area of reconstruction.

Remove or seal all existing drainage structures which are not to be operative in the proposed design, in order to prevent a plane of seepage from developing through the dam.

12.0 COFFERDAMS

A cofferdam in most cases is a temporary structure enclosing all or part of the construction area. The purpose of the cofferdam is to provide protection so that construction can proceed in the dry.

12.1 When using a cofferdam the following criteria must be met:

12.1.1 Flood Plain Management

A hydraulic analysis must be performed to determine the backwater effect of the cofferdam. A range of flood discharges up to and including the 100 year return frequency flood shall be evaluated to determine the potential flood damages to lands and improvements upstream of the cofferdam not owned or otherwise controlled by the applicant. The analysis shall focus on determining if the project meets the flood plain management criteria of 6NYCRR-Part 500, if applicable, or regulations adopted by the local jurisdiction for participation in the National Flood Insurance Program.

12.1.2 Dam Safety

The applicant will have to demonstrate that cofferdam failure will not adversely impact lives and property. The evaluation will focus on the potential for flooding, loss of life and damage to properties downstream of the cofferdam not owned or otherwise controlled by the applicant.

If cofferdam failure could adversely impact properties downstream of the cofferdam, not controlled by the applicant, or if the cofferdam failure could adversely impact lives, then more specific information regarding the geotechnical, structural and hydraulic aspects of the cofferdam design will be required. The determination by the department of the acceptability of the cofferdam design will be made on a case-by-case basis.

13.0 MISCELLANEOUS

The earth embankment, earth spillways, and all disturbed earth adjacent to the embankment or other appurtenances should be seeded, except where riprap or other slope protective materials are specified.

Where destructive wave action is expected, the upstream slope of the embankment should be protected with rock riprap or other suitable material for effective erosion control.

A trash rack designed to prevent debris from entering and obstructing flow in the conduit should be provided on the vertical riser for any drop inlet spillway.

An anti-vortex device is required on the vertical riser for any drop inlet spillway with riser diameter greater than 12 inches.

Instrumentation

1.Piezometers - All earth dams 40 feet high or higher shall have at least two piezometers on the downstream slope of the embankment to measure saturation levels and hydrostatic pressures. All concrete dams 40 feet or higher should have at least two piezometers along the crest of the dam.

2.Weirs - on all dams with toe drains, weirs are required at the downstream end of the drain. The weirs measure the amount of seepage water through the embankment. Measurements of the seepage should be documented and correlated with the reservoir surface elevation. See Reference 6, pages 55-56.

14.0 EMERGENCY ACTION PLAN

An emergency action plan (EAP) should be developed by the owner of a high hazard dam (Class "C").

A copy of this EAP is to be provided to the Dam Safety Section of the department during the initial permit review period for new dams and for existing dams, if a copy of the EAP has not been previously submitted. See Reference 6, pages 69-73.

15.0 APPROVAL TO FILL RESERVOIR OF A NEW DAM

Before any water can be impounded by the dam, the dam owner shall adhere to the following:

15.1 For all Hazard Class "C" and [major size] Hazard Class "B" dams.

Within two weeks after completion of dam construction the permittee shall notify the Regional Permit Administrator in writing by certified mail of its completion and shall include a notarized statement from the owner's engineer that the project has been completely constructed under his care and supervision in accordance with plans and specifications as approved by the department. Any changes in the construction of the dam from the approved plans will be reflected in the "As-Built" plans.

The department will inspect the completed dam with the owner's engineer. During the inspection, the owner's engineer will submit "As Built" drawings and other construction records for review, such as foundation data and geological features, properties of embankment and foundation materials, concrete properties and construction history. Upon review of the data and the determination of the adequacy of the structure the "Approval to Fill" letter will be issued, permitting the owner to store water.

15.2 For all Hazard Class "A" and [Below Major Size] Hazard Class "B" dams.

Within two weeks after completion of dam construction the permittee shall notify the Regional Permit Administrator in writing by certified mail of its completion and shall include a notarized statement from the owner's engineer stating that the project has been completely constructed under his care and supervision in accordance with plans and specifications as approved by the department. Any changes in the construction of the dam from the approved plans will be reflected in the "As-Built" plans that will be submitted to the Department.

No water shall be impounded for at least 15 days subsequent to the notification to the Regional Permit Administrator.

REFERENCES

1. New York State Environmental Conservation Law "Article 15-0503".

2. New York Code of Rules and Regulations (6NYCRR) "Part 621 - Uniform Procedures".

3. New York Code of Rules and Regulations (6NYCRR) "Part 673 - Dam Safety Regulations"

4. New York Code of Rules and Regulations (6NYCRR) "Part 500 - Flood Plain Development Permits"

5. New York Code of Rules and Regulations (6NYCRR) "Part 373 - Hazardous Waste Management"

6. An Owners Guidance Manual For the Inspection and Maintenance of Dams in New York State.

7. New York State Education Law "Article 55".

8. Soil Conservation Service; U. S. Department of Agriculture SCS National Engineering Handbook; August, 1972 "Section 4 -Hydrology

   Corps of Engineers; U. S. Army

9. Hydrologic Engineering Center
   "HEC-1 Flood Hydrograph Package"; 1981

10. ETL 1110-2-256; June 1981
    "Sliding Stability for Concrete Structures".

11. EM 1110-2-1902; April 1970
    "Stability of Earth and Rock-Fill Dams"

    Bureau of Reclamation; U. S. Department of the Interior

12. "Design of Small Dams", 1977 Revised Reprint

13. "Design of Gravity Dams", 1976

14. "Earth Manual"

National Oceanic and Atmospheric Administration National Weather Service; U.S. Department of Commerce

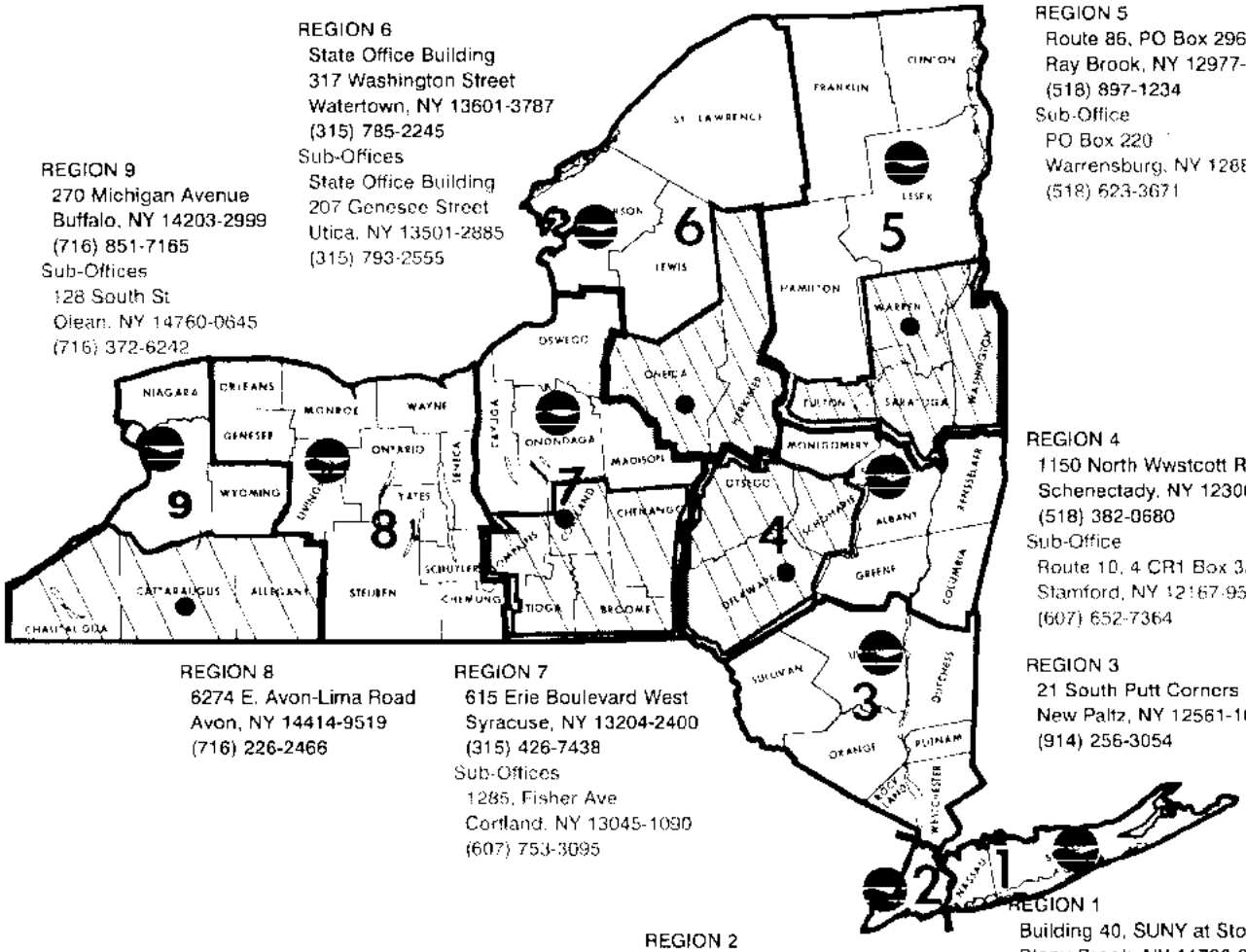
15. Hydrometeorological Report 33; April 1956 "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1000 Square Miles and Durations of 6, 12, 24 and 48 Hours"

16. Hydrometeorological Report 51; June 1978 "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian"

17. Technical Paper 40; May 1961 "Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years"

18. Technical Paper 49; 1964 "Two-to-Ten-Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States"

New York State Department of Environmental Conservation Division of Environmental Permits



REGION 6
State Office Building
317 Washington Street
Watertown, NY 13601-3787
(315) 785-2245
Sub-Offices
State Office Building
207 Genesee Street
Utica, NY 13501-2885
(315) 793-2555

REGION 5
Route 86, PO Box 296
Ray Brook, NY 12977-0296
(518) 897-1234
Sub-Office
PO Box 220
Warrensburg, NY 12885-0220
(518) 623-3671

REGION 9
270 Michigan Avenue
Buffalo, NY 14203-2999
(716) 851-7165
Sub-Offices
128 South St
Olean, NY 14760-0645
(716) 372-6242

REGION 4
1150 North Wwstcott Rd
Schenectady, NY 12306-4498
(518) 382-0680
Sub-Office
Route 10, 4 CR1 Box 3A
Stamford, NY 12167-9503
(607) 652-7364

REGION 8
6274 E. Avon-Lima Road
Avon, NY 14414-9519
(716) 226-2466

REGION 7
615 Erie Boulevard West
Syracuse, NY 13204-2400
(315) 426-7438
Sub-Offices
1285, Fisher Ave
Cortland, NY 13045-1090
(607) 753-3095

REGION 3
21 South Putt Corners Road
New Paltz, NY 12561-1696
(914) 256-3054

REGION 1
Building 40, SUNY at Stony Brook
Stony Brook, NY 11790-2356
(631) 751-0365

REGION 2
1 Hunters Point Plaza
47-40 21St Street
Long Island City, NY 11101-5407
(718) 482-4997

LEGEND

Regional Headquarters

● Regional Sub-office
(Sub-office responsible for areas printed in blue cross-hatch.)

January 2000

DOW 3.1.4 – GUIDANCE FOR
DAM ENGINEERING ASSESSMENT REPORTS

New York State Department of Environmental Conservation

DEC Program Policy

Issuing Authority: Mark Klotz	**Title:** GUIDANCE FOR DAM ENGINEERING ASSESSMENT
Date Issued:	**Latest Date Revised: New**
Originator: Alon Dominitz – Dam Safety Section	

***** N O T I C E *****

This document has been developed to provide Department staff with guidance on how to ensure compliance with statutory and regulatory requirements, including case law interpretations, and to provide consistent treatment of similar situations. This document may also be used by the public to gain technical guidance and insight regarding how the department staff may analyze an issue and factors in their consideration of particular facts and circumstances. This guidance document is not a fixed rule under the State Administrative Procedure Act section 102(2)(a)(I). Furthermore, nothing set forth herein prevents staff from varying from this guidance as the specific facts and circumstances may dictate, provided staff's actions comply with applicable statutory and regulatory requirements. This document does not create any enforceable rights for the benefit of any party.

Preliminary DRAFT

Table of Contents

I. Summary: 1
II. Policy: 1
III. Purpose and Background: 2
IV. Responsibility: 2
V. Procedure: 2
VI. Related References: 7

I. Summary:

Title 6 of New York Rules and Regulations, Part 673.13 ("Part 673.13") requires the preparation of an Engineering Assessment Report, which must be submitted to the New York State Department of Environmental Conservation ("Department").

This policy provides guidance to dam owners and engineers on the preparation of, and DEC staff on the review of, Engineering Assessment Reports pursuant to Part 673.13.

II. Policy:

The life-cycle of a dam consists of several phases, starting with construction and initial filling and transitioning to alternating periods of normal operation and maintenance, repairs, and upgrades. This cycle continues until the dam is breached or removed, or fails. For a dam to continue to serve its intended function, it must be maintained. As conditions change over time, repairs and perhaps reconstruction and/ or upgrade of the dam, for example increasing the spillway capacity, may become necessary.

A dam is a part of a dynamic system, with various forces continuously acting upon it, such as ice, flooding, earthquakes, erosion, animal burrowing, woody root penetration, and sediment accumulation. Downstream developments can affect the hazard class of a dam, upstream developments can change the way the watershed behaves during runoff events, and science and technology evolve to modify best practices and regulatory criteria over time.

The release of water stored by a dam in an uncontrolled manner represents a potential danger to downstream lives, property and the environment. As such, the dam owner must develop and implement a dam safety program. Part 673 requires that an owner's dam safety program that is appropriate to the dam's hazard classification. Those for Class C (High Hazard) or Class B (Intermediate Hazard) dams consist of periodic safety inspections and engineering assessments, along with an Inspection and Maintenance Plan ("I&M Plan") and an Emergency Action Plan ("EAP"). An I&M Plan template is available on the Department's web site. Requirements for the preparation of an EAP are described in the Department's publication "DOW 3.1.3 – Emergency Action Plans for Dams". Periodic safety inspections and engineering assessments are intended to provide an independent review of an existing structure and the owner's dam safety program, identify any deficiencies or gaps in knowledge, and determine the steps and schedule necessary to correct the deficiencies.

When deficiencies are identified, the dam owner must categorize them either as issues that can be resolved through regular or enhanced maintenance, or whether repairs and/or upgrades are required. Conditions requiring additional or continued monitoring should also be identified. Maintenance is work involved in the routine or regular upkeep of a dam, and includes, for example, debris removal, mowing grass, cleaning trash racks, and exercising valves. Repairs or upgrades generally consist of more extensive or intrusive work, which if performed improperly could endanger the structure, and therefore must be performed under the supervision of a professional engineer ("PE"), in accordance with a formal design, and require a dam safety permit issued by the Department through its Division of Environmental Permits, in pursuant to Parts 608 and 621. Although maintenance does not require a Dam Safety permit, it could require other types of permits, such as a Construction Stormwater permit, from the DEC.

Safety inspections and engineering assessments include many of the components that would be required as part of a permit application for repair or upgrading of the dam. The difference is that regular inspections and assessments are an evaluation of the *existing* structure against current dam safety criteria, whereas the Engineering Design Report, plans and specifications required for a permit must evaluate the *proposed* repairs and/or upgrades to the structure. In either case, the dam and appurtenant structures should be considered as part of an integrated system, and must function together to safely fulfill their water impounding function.

III. Purpose and Background:

It is the purpose of this guidance to inform owners, engineers, and DEC staff regarding the procedures, content, and format for dam safety engineering assessment reports as required by 6NYCRR Part 673.

Part 673 requires owners of Hazard Class B (Intermediate Hazard) and Class C (High Hazard) dams, and, at the Department's discretion, dams assigned a Condition Rating of Unsafe or Unsound, to perform an Engineering Assessment of their dam on a regular basis.

This guidance represents the professional judgment of the Department's Dam Safety Section's engineers. The guidance is applicable for the average dam in an average situation. Where unusual conditions exist, it is the duty of the dam owner's engineer to highlight any deviation from the Department's guidance and provide the specific engineering rationale for said deviation. Cost alone is not an acceptable rationale.

IV. Responsibility:

The dam safety program within the Bureau of Flood Protection and Dam Safety will interpret and maintain this policy.

V. Procedure:

The Engineering Assessment Report must, at a minimum, include the following:

1. Hazard classification evaluation
2. Complete Safety Inspection
3. Evaluation of the dam's spillway capacity
4. Evaluation of the dam's structural stability
5. Evaluate Outlet works (reservoir drain) capacity
6. Review of the dam's Emergency Action Plan, and
7. Provide a conclusion as to whether the dam is in conformance with current dam regulations and safety guidance.

The tasks normally associated with performing a dam safety Engineering Assessment can be divided as follows:

A. File review
B. On-site Engineering Inspection and Investigation

C. Engineering review, calculations, and conclusions
D. Engineering Assessment Report Generation
E. File report with Department and retain a copy with owner's records

The assessment should determine the condition of the dam relative to the appropriate safety criteria. It should identify deficiencies and recommend, as appropriate, remedial repairs, operational restrictions, monitoring, and/or modifications. The assessment should also identify any analyses and/or studies needed to assess and determine solutions to identified deficiencies.

The engineering assessment must be performed by a professional engineer registered to practice in New York State and possessing appropriate experience in evaluation of dams of type, size, and location to be assessed. The dam Engineering Assessment Report must be submitted to the Department in accordance with the schedule detailed in Part 673.13. The owner must retain a copy of the dam Engineering Assessment Report with their records of the dam.

A. Records Review

Perform a review of existing dam information. The engineer must analyze the dam's design, construction, and operational records to become fully acquainted with the present physical features as well as construction and performance history of the dam.

An owner may have a recently performed engineering assessment of the dam. At the owner's and engineer's option, the engineer may review the report for applicability to current standards and safety criteria and adopt all or parts of past reports. If an engineer does accept the analysis in any previous report, the engineer must state that the report's assumptions, analyses, or other accepted components have been reviewed and are acceptable to demonstrate compliance with selected criteria (as applicable). The engineer or owner may also choose to disregard previous assessments and perform a completely new assessment.

There may be multiple information sources, including, but not limited to, the following:

<u>Owner's Dam File:</u>

The owner should have a file for the dam that might contain dam design information and various reports generated when the dam was designed or rebuilt; hydrology, hydraulics, geology, inspections, etc. Operational records, if available, may contain vital information that should be reviewed in detail. The review should include review of the existing I&M Plan, results of past inspections, and maintenance work completed and/or planned. Finally, this part of the review should include a review of the dam's Emergency Action Plan, with particular attention to the inundation map. Part 673, effective August 19, 2010, requires the owner to retain pertinent records on a dam, and authorizes DEC to inspect those records.

<u>Department's Dam Safety File:</u>

The Department maintains a file for most dams in the state. While the DEC file may contain similar information to that contained in the owner's dam file, it can often provide supplementary information.

Note: Due to the security-sensitive nature of certain information on dams, the dam owner must submit a written request to the Department's Dam Safety Section ("DSS") asking for release of the specific file from Dam Safety to the owner's engineer. Contact information for DSS is available in Section E. of this document.

B. On-site Engineering Inspection and Investigation

The Engineer should perform at least two specific on-site activities; a hazard classification reconnaissance and a thorough dam safety inspection. Additional on-site investigations; i.e., soil borings, test pits, topographic and boundary surveys, etc., may be necessary dependent on what additional information is required to complete the engineering assessment. Interviews with maintenance personnel and other people familiar with the dam are also recommended.

Hazard Classification Reconnaissance

The dam's hazard classification influences the regulatory and design standards for the dam and is therefore a critical component to the assessment. A dam's hazard classification will typically dictate spillway capacity criteria, which in turn affects much of the remainder of the assessment, as well as the EAP requirements.

The first step in determining a dam's hazard classification is to perform a review of the downstream area of the dam. Before beginning the field reconnaissance, the engineer should become familiar with the dam's features and setting through a desktop review of the downstream area using readily accessible data such as USGS 7 ½ minute quadrangle maps, recent orthoimagery, and similar tools to determine potential downstream features that may be impacted by the dam's failure flood wave. The engineer can then perform the downstream field investigation to verify the buildings, roads, railroad, environmentally sensitive areas, etc. that will be within the flood wave's path. In most cases, field work will also be necessary to assess potential impacts and recommend a hazard classification.

The engineer should also review the local planning board's records to identify if proposed downstream development may impact the dam's future hazard classification. Draft planning documents will not impact the current hazard classification but may provide an indicator of future changes that could affect the classification and design standards.

The Engineering Assessment Report should include a written description of the hazard classification review, description of potential downstream impacts, and a recommended hazard classification in accordance with the hazard classification regulations at Part 673.5 and applicable NYS DEC guidance.

Dam Safety Inspection

The dam safety inspection is a comprehensive examination of the visible physical features of the dam and its appurtenant structures. The dam safety inspection requirements are presented in 6NYCRR Part 673.12(d). The visual inspection should comment on previously observed deficiencies, including the deficiencies' progression or advancement and identification of continuing or new corrective actions, as necessary,

with recommendations and a schedule. Corrective actions and recommendations may be deferred until after the technical analysis.
All observations and unusual features should be recorded, regardless of how insignificant they may seem. Photographs are a permanent record of the condition of the dam and provide a means to compare dam conditions at different points in time. Photographs are a required element of the Dam Safety Inspection Report.

A good source of information for conducting a dam safety inspection can be found in the Department's "An Owners Guidance Manual for the Inspection and Maintenance of Dams in New York State" which can be found at http://www.dec.ny.gov/lands/4991.html. Other references can be found on the Internet.

Underwater inspections may be required if the condition or design of underwater features is not well known. If necessary, an underwater inspection should be conducted as part of the Safety Inspection.

Other On-Site Investigations:

It may be necessary to conduct various investigations to verify assumptions that are used in the Engineering Assessment Report, i.e. subsurface investigation to obtain data for the dam's stability assessment, or determining the source of potential seepage.

C. Engineering Review, Calculations, and Conclusions

Following completion of the records review and on-site investigations, the engineering review can commence. The engineering review consists of:

1. Hazard Classification,
2. Hydrology Assessment,
3. Hydraulic Assessment,
4. Stability Assessment,
5. Conclusions and Recommendations.

Each of these tasks is described below.

1. Hazard Classification

Using information obtained during the on-site hazard classification reconnaissance and other information; i.e., topographic maps, orthoimagery, etc. (and following the Department hazard classification guidance) a hazard classification for the dam needs to be determined. If the dam is already classified as a Class C-high hazard dam, and there is no disagreement that there will be probable loss of life if the dam were to fail, it is not necessary to spend a great deal of effort on this portion of the assessment. If the assessment results in the dam's hazard classification changing, all documents supporting the hazard classification change must be included in the report. An electronic copy of all models used, not just the model's results, must be made a permanent part of the engineering assessment.

2. Hydrology Assessment

Given a dam's hazard classification, the inflow design storm can be determined, see Section 5.3 and Table 1 of the Department's *"Guidelines for the Design of Dams, Revised January 1989 ("Guidelines")"*. If existing dam documents contain a viable hydrologic study, that hydrologic study can be utilized. All assumptions and analyses used in the study need to be independently verified and all models employed need to include the latest hydrologic criteria applicable to the field of dam safety engineering, many of which are reflected in the *Guidelines*.

Note: As stated in the 1989 *Guidelines*, HMR-33 has been replaced by HMR-51 and 52, which are the applicable models for determining the Probable Maximum Flood in New York. If the dam is a high hazard dam and the hydrology model employed to determine the Probable Maximum Flood was HMR-33, the Probable Maximum Flood should now be determined using HMR- 51/52. HMR-33 is not accepted.

The Department does not have a preferred hydrology model for determining the inflow design storm, but any model used should be appropriate for the geographic and hydrologic setting of the dam being studied. The Engineering Assessment Report needs to include both the input and output pages for the model and should include an electronic copy of the model for the Department's review.

3. Hydraulic Assessment

If the dam's record contains a viable hydraulic assessment that uses the appropriate inflow design flood, that hydraulic study may be utilized. All assumptions and analyses used in previous reports must be verified by the engineer performing the new assessment, if the engineer wishes to rely on them. If the inflow design storm is different than the previous studies, a new hydraulic analysis will be necessary.

The design criteria for the hydraulics study can be found in Section 6.0 of the *"Guidelines"*. If a computer model is used to perform the hydraulic assessment, the input and output printout must be contained within the assessment and an electronic copy of the model must be provided to the department for its review.

4. Stability Assessment

If the dam's record contains a viable stability assessment, that stability study may be utilized. Even if previous loading assumptions are no longer valid, other parts of a previous stability assessment may be utilized if appropriate. Again, all assumptions and analyses used in previous reports must be verified by the engineer conducting the new assessment.

The design criteria for the stability study can be found in Section 10.0 of the *"Guidelines"*. If a computer model is used to perform the stability assessment, the model's name, model version, and the input and output printout should be placed in the assessment and an electronic copy of the model must be included within the assessment and an electronic copy of the model must be provided to the department for its review.

The stability analysis depends on the existing subsurface geology and often requires a geotechnical investigation. Previous geotechnical investigations may be available from which to gather soil or rock parameters. The need for additional or new geotechnical investigations may also be indicated. The engineer performing the Engineering

Assessment must judge whether existing information is sufficiently reliable to determine the dam's stability. If there is visual indication that the dam may be in distress because of stability reasons, additional geotechnical investigations may be needed.

5. Conclusions and Recommendations

The Assessment Report should have a summary section that briefly discusses the data reviewed and provides a conclusion as to whether the dam is in conformance with current dam safety criteria. A list of the proposed recommendations, if any, necessary to bring the dam into conformance with applicable dam safety criteria and a schedule for completing the recommendations must be provided. The report should be reviewed with the dam owner before it is submitted to the Department.

D. Engineering Assessment Report Generation

The Engineering Assessment Report should be compiled in a 3-ring binder and should contain the results of the on-site investigations, dam safety inspections, engineering assessments, and other data or reports. All previously published dam specific hydrology, geology, hydraulic, stability, etc. reports used or referenced should be made a part of the assessment report, and may be included as an appendix. The cover page must show the Dam Name, State Dam ID#, the town/city/village and county in which the dam is located, date of the Assessment, and the name and New York PE number of the engineer who performed the Assessment, and the name and signature of the dam owner.

The Assessment Report must be stamped and signed by a professional engineer registered to practice professional engineering in New York State.

E. File Report with Department and Retain a Copy with Owner's Records

One stamped and signed copy of the competed Engineering Assessment Report, as well as an electronic copy on CD, must be submitted to the following address:

New York State Department of Environmental Conservation
Division of Water - Dam Safety Section
625 Broadway, 4th Floor
Albany, NY 12233-3504

VI. Related References:

Dams shall be compared with safety criteria contained in:
"Guidelines for Design of Dams," NYS DEC, 1989.
http://www.dec.ny.gov/lands/4991.html

New York State Laws:
http://public.leginfo.state.ny.us/menugetf.cgi?COMMONQUERY=LAWS

Environmental Conservation Law 15-0507:
Structures impounding waters; structures in waters; responsibility of owner; inspection

Environmental Conservation Law 15-0503:

Protection of water bodies; permit

Executive Law Article 2-B:
State and Local Natural and Man-Made Disaster Preparedness

New York State Regulations:
http://www.dec.ny.gov/regulations/regulations.html

Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York (6 NYCRR):
Part 608 – Protection of Waters
Part 621 – Uniform Procedures (includes Emergency Authorization)
Part 673 – Dam Safety

Other Guidance Documents:

Guidance on Inspection and Maintenance of Dams is contained in the publication "Owners Guidance for the Inspection and Maintenance of Dams in New York" NYS DEC, June 1987, http://www.dec.ny.gov/lands/4991.html.

Guidance on Emergency Action Plans is contained in the publication "DOW 3.1.3 – Emergency Action Plans for Dams," NYS DEC, June 2010, http://www.dec.ny.gov/lands/4991.html.

E.32. North Carolina





North Carolina Adminsitrative Code - Title 15A Department of Environment and Natural Resources of Subchapter 2K - Dam Safety

SECTION .0100 - GENERAL PROVISIONS

.0101 DEFINITIONS
.0102 DAM SAFETY ORDERS

History Note: Statutory Authority G.S. 143-215.25; 143-215.32; 143-215.34;
Eff. January 22, 1977;
Amended Eff. November 1, 1978;
Repealed Eff. June 15, 1980.

.0103 PURPOSE
The rules and regulations contained in this Subchapter are intended to carry out the purposes of the Dam Safety Law of 1967, as expressed in G.S. 143-215.24 which authorizes the implementation of a dam inspection and certification program in the interest of public health, safety and welfare.

History Note: Statutory Authority G.S. 143-215.31; 143-215.34;
Eff. June 15, 1980.

.0104 DEFINITIONS
As used in this Subchapter, the following terms have their stated meaning:
(1) "Applicant" means any person who has notified the department that he or she desires to construct, repair, alter, or remove a dam and requests approval by the department.
(2) "Appurtenance" means an accessory or integral subordinate structure associated with a dam, such as a spillway, conduit, walkway, valve, control gate, etc.
(3) "Articulation" means provisions for safe movement at the joint or juncture of sections of conduit.
(4) "As-built plans" means drawings, photographs, test data, and descriptions that clearly and accurately define the dam and its appurtenances after all construction is completed.
(5) "Conduit" means a natural or artificial channel or pipe through which water or other fluid is conveyed.
(6) "Critical circle" means the circle with the lowest factor of safety against mass movement in a circular arc analysis of slope stability.
(7) "Critical failure wedge" means the mass or block having the lowest factor of safety against mass movement in an analysis of slope stability along planar surfaces.
(8) "Director" means the Director of the Division of Land Resources, North Carolina Department of Natural Resources and Community Development.
(9) "Equipotential lines" means lines which represent points of equal energy level or head in a flow net.
(10) "Factor of safety" means the ratio of the forces or moments resisting mass movement to the forces or moments tending to produce mass movement.
(11) "Flow lines" means lines which represent the direction of flow in a flow net.
(12) "Flow net" means a graphical representation of flow lines and equipotential lines.
(13) "Hazard potential" means the probable damage that would occur if the

structure failed, in terms of loss of human life and economic loss or environmental damage.
(14) "Maintenance plan" means written instructions prepared by the engineer that prescribe the proper servicing and repair of mechanical equipment, appurtenances, spillways, vegetative cover, and other aspects related to the safety of the dam.
(15) "Owner" means the individual or association of individuals owning the property on which the dam exists or is to be constructed, and the persons financially responsible for the construction.
(16) "Phreatic surface" means the free-water surface of a zone of seepage; it is represented by the uppermost flow line, or seepage line, in a flow net.
(17) "Qualified engineer" means a professional engineer legally qualified to practice in North Carolina pursuant to Chapter 89C of the General Statutes of North Carolina, and having appropriate specialty expertise for the particular dam engineering problem with which he is involved.
(18) "Qualified geologist" means an earth scientist experienced in applied geology with respect to the interaction of lithologies, soils, and geologic structures with dams and impoundments, who can provide professional credentials such as certification by the American Institute of Professional Geologists or registration as a geologist in the United States.
(19) "Quality control" means that combination of testing, observation, and monitoring provided during construction to confirm that requirements stated or depicted in the plans and specifications are being achieved.
(20) "Rapid drawdown" means removal of liquid from a reservoir at a rate that is significantly faster than the rate of drainage of the materials composing the portions of the reservoir exposed by the fluid removal.
(21) "Seepage" means the movement of water in a porous material and the water exiting at the visible surface of the material.
(22) "Sliding base analysis" means an analysis of the safety of a structure against lateral movement along its foundation.
(23) "Waste treatment and mine refuse dam" means a structure for impounding, restraining, storing, or disposing of liquids, slurries, or materials capable of liquification, produced from industrial, commercial, municipal, agricultural, or mining activities.
(24) "Construction" means any action, other than by natural causes, that creates a structure capable of impounding water or other liquids, or which increases the impoundment capacity of an existing structure. For the purposes of 15A NCAC 2K .0222, it shall also mean the reduction of the height or impoundment capacity of a dam when the effect of such reduction will be to exempt the dam from the North Carolina Dam Safety Law of 1967.

History Note: Filed as a Temporary Amendment Eff. November 1, 1990 For a Period of 180 Days to Expire
on April 29, 1991;
Statutory Authority G.S. 143-215.25; 143-215.31;
Eff. June 15, 1980;
Amended Eff. July 1, 1988; November 1, 1984;
ARRC Objection Lodged November 14, 1990;
ARRC Objection Removed December 20, 1990;
Amended Eff. January 1, 1991.

.0105 CLASSIFICATION OF DAMS
(a) For the purposes of this Subchapter, dams shall be divided into three classes, which shall be known as class A (low hazard), class B (intermediate hazard), and class C (high hazard):
(1) Class A includes dams located where failure may damage uninhabited low value non-residential buildings, agricultural land, or low volume roads.
(2) Class B includes dams located where failure may damage highways or secondary railroads, cause interruption of use or service of public utilities, cause minor damage to isolated homes, or cause minor damage to commercial and industrial buildings. Damage to these structures will be considered minor only when they are located in back water areas not subjected to the direct path of the breach flood wave; and they will experience no more than 1.5 feet of flood rise due to breaching above the lowest ground elevation adjacent to the outside foundation walls or no more than 1.5 feet of flood rise due to breaching above the lowest floor elevation of the structure, the lower of the two elevations governing. All other damage potential will be considered serious.
(3) Class C includes dams located where failure will likely cause loss of life or serious damage to homes, industrial and commercial buildings, important public

utilities, primary highways, or major railroads.
(b) Classifications shall be proposed by the design engineer and are subject to approval by the Director.
(c) Probable future development of the area downstream from the dam that would be affected by its failure shall be considered in determining the classification.
(d) Dams will be subject to reclassification if the Director determines that the hazard potential has changed. Non-structural provisions of adequately demonstrated effectiveness and reliability such as flood plain zoning, and early warning systems may be considered by the Director in making this determination.
(e) When dams are spaced so that the failure of an upper dam would likely fail a lower dam, the consequence of the lower dam's failure shall be a determining factor for the upper dam's hazard classification.
(f) In assigning a hazard classification where a bridge or roadway is the only damageable property below a dam, consideration shall be given to the possibility of loss of human life, indirect economic impact through loss of service, and direct cost of damage to the bridge or roadway.

History Note: Statutory Authority G.S. 143-215.31; 143-215.34;
Eff. June 15, 1980.

SECTION .0200 - OBTAINING APPROVAL FOR DAM CONSTRUCTION: REPAIR OR REMOVAL

.0201 APPLICATIONS
(a) Any person(s) who proposes to construct, repair, alter or remove a dam must file with the Director a statement concerning the location of the dam, including the name of the stream and county, height, purpose, and impoundment capacity, 10 days before start of construction. If the Director determines that the proposed dam is exempt from the law, the applicant will be notified and he may then proceed with the construction.
(b) If the Director determines that the proposed dam is not exempt from the Dam Safety Law of 1967, the applicant will be so notified within 10 days of receipt of the statement described in (a) of this Rule and construction may not commence until a full and complete application has been filed and approved. This application must be filed at least 60 days before the proposed start of construction:
(1) When an application to construct a dam has been completed pursuant to Subsection (a) of this Rule, the department shall refer copies of the completed application papers to the Department of Human Resources, the Wildlife Resources Commission, the Department of Transportation, and such other state and local agencies as it deems appropriate for review and comment.
(2) Before commencing the repair, alteration, or removal of a dam, application shall be made for written approval by the department, except as otherwise provided by this Subchapter or in accordance with G.S. 143-215.27(b). The application shall state the name and address of the applicant; shall adequately detail the changes it proposes to effect; and shall be accompanied by maps, plans, and specifications setting forth such details and dimensions as the department requires. The department may waive such requirements in accordance with G.S. 143-215.27(a). The application shall give such other information concerning the dam and reservoir required by the department concerning the safety of any change as it may require, and shall state the proposed time of commencement and completion of the work. When an application has been completed, it may be referred by the department for agency review and report as provided by G.S. 143-215.26(b) in the case of original construction.
(c) The application for any dam shall include a preliminary report. (Filing of the preliminary report prior to filing the final design report, early in the site investigation and design schedule, is encouraged to assure the state's concurrence with the hazard classification, site investigation, and design concept. This is especially encouraged for class C dams.) The preliminary report shall be filed with the application and shall include the following information:
(1) a general description of the dam and appurtenances and a proposed classification as set forth in Rule .0105 of this Subchapter; The description shall include a statement of the purpose for which the dam is to be used;
(2) a description of properties located below the dam including number of homes, buildings, roads, utilities, and other property that, as determined by the engineer, would be endangered should failure of the dam occur;
(3) maps showing the location of the proposed structure that include the county, location of state roads, access to site, and outline of the reservoir; aerial

photographs or USGS maps may be used;
(4) preliminary drawings or sketches that include cross-sections, plans and profiles of the dam, proposed pool levels, and types of all spillways;
(5) preliminary design criteria and basis for selection including a description of the size, ground cover conditions, and extent of development of the watershed, drainage area, spillway design storm, geology and geotechnical engineering, assumptions for the foundation and embankment materials, and type of materials to be used in the principal spillways(s).
(d) The Final Design Report. A "Certificate of Approval" to construct will not be issued until the final design report is received and approved. The preliminary report as described in (c) of this Rule and the final design report may be submitted as one document. The final design report shall include:
(1) a report of the investigation of the foundation soils or bedrock and the borrow materials, including the location of borrow areas, that are to be used to construct the dam;
(2) criteria to indicate that the dam will be stable during construction and filling and under all conditions of reservoir operations;
(3) computations indicating that the dam is safe against overtopping during occurrence of the inflow design flood and wave action; Wave action need not be considered when the design flood is based on the probable maximum precipitation (pmp);
(4) criteria, design data or references to indicate that seepage flow through the embankment, foundation, and abutments will be controlled so that no internal erosion will take place and so there will be no sloughing in the area where the seepage emerges;
(5) calculations and assumptions relative to design of the spillway(s);
(6) provision to protect the upstream slope, crest, and downstream slope of earth embankments and abutments from erosion due to wind and rain;
(7) other design data, assumptions, and analysis data pertinent to individual dams and site conditions;
(8) a proposed construction schedule;
(9) a proposed filling schedule for the reservoir;
(10) a maintenance and operation plan;
(11) the estimated design life of the dam and the reservoir;
(12) provision for maintaining minimum stream flow requirements.
(e) The Plans and Specifications. Five sets of plans and specifications must be submitted. The plans shall be a detailed engineering design that consists of drawings and specifications and that include the following as a minimum:
(1) Sheet one shall show the name of the project; name of owner; hazard classification of the dam; designated access to the project; and location with respect to highways, roads, streams, and any dam(s) that would affect or be affected by the proposed structure;
(2) Maps shall be included showing the drainage area and outline of the reservoir and the ownership of properties covered by the reservoir or flood pool;
(3) Geologic investigation, cross-section, profiles, logs of borings, location of borrow areas, drawings of principal and emergency spillways, and other additional sheets shall be included and drawn in sufficient detail to clearly indicate the extent and complexity of the work to be performed; The degree of detail required shall be determined by the applicable provisions of Rules .0204 through .0212 of this Section;
(4) The technical provisions, as may be required, to describe the method of construction and quality control for the project;
(5) Special provisions, as may be required, to describe technical provision needed to ensure that the dam is installed according to the approved plans and specifications;
(6) General provisions that specify the rights, duties, and responsibilities of the applicant, applicant's engineer and builder and the prescribed order of work.
(f) The Director, within 60 days following receipt of a completed application, shall notify the applicant, by mail, that the application is either approved or disapproved. An approved application shall conform to the requirements of Rule .0202 of this Section.

History Note: Statutory Authority G.S. 143-215.26,-27,-31;
Eff. June 15, 1980.

.0202 CERTIFICATE OF APPROVAL
(a) Approval of construction, repair, alteration, or removal of a dam will be contained in a certificate called a "Certificate of Approval" to be issued by the

Director. A Certificate of Approval is a letter from the Director constituting approval subject to written general stipulations and specific written stipulations deemed necessary by the Director on a case by case basis.
(b) No construction shall be performed until the certificate is issued. The Certificate of Approval period shall be valid for the construction schedule specified in the approved final design report. Construction must commence within one year after the certificate is issued.
(c) Notice by registered or certified mail shall be given to the Director at least 10 days before construction is commenced. When repairs are necessary to safeguard life and property, they may be started immediately; but the department shall be notified forthwith of the proposed repairs and of the work under way, and they shall be made to conform to its orders.
(d) If construction does not commence within one year after the certificate of approval is issued, the certificate shall expire and a new application shall be submitted. Upon written application and for good cause shown, the Director may extend the time for commencing construction.
(e) Certificates of Approval are revocable in the event that the terms of the certificate, including the written stipulations and those terms stated in G.S. 143-215.23, are violated or in the event that conditions develop during construction that are hazardous to life and property. If the certificate is revoked due to development of hazardous conditions, the Director will issue an order requiring the owner or owners of the dam to make at his or their expense maintenance, alterations, or removal as deemed necessary within a time limited by the order; provided, any dam covered by a certificate issued under this Rule is considered to be within the definition of dams in G.S. 143-215.25 and .0104 of this Subchapter.
(f) Certificates of Approval are revocable in the event that the approved construction schedule is deviated from without prior written approval of a substitute construction schedule submitted in writing. Such approval of a substitute construction schedule shall be in the form of an Addendum to the Certificate of Approval to be issued by the Director.

History Note: Statutory Authority G.S. 143-215.26,-27,-31;
Eff. June 15, 1980.

.0203 PROFESSIONAL ENGINEER REQUIREMENTS
The design, preparation of the plans and specifications, inspection of the construction of or on the dam, and certification that the dam was constructed, repaired, altered, or removed according to the plans approved by the Director and that the dam or its remains are safe shall be done by a legally qualified engineer and shall bear his professional seal unless exempted under the provisions of G.S. 89C-25.

History Note: Statutory Authority G.S. 143-215.29,-31;
Eff. June 15, 1980.

.0204 INVESTIGATIONS
(a) General. The applicant shall be required to complete all investigations prior to submission of the final plans and application. The scope and the degree of precision that will be required for a specific project will depend on the conditions of the site and the hazard created by the proposed structure.
(b) Foundations and Abutments. The foundation and abutments investigation shall consist of borings, test pits, and other subsurface exploration necessary to assess the soil, rock, and groundwater conditions. Geologic profiles and a geologic report prepared by a qualified geologist may be required for class B dams and shall be required for class C dams.
(c) Construction Materials. Specifications for construction materials shall establish minimum acceptance criteria so that design properties are achieved. If the use of on site borrow materials is specified, exploration, testing, and calculations should be performed to indicate that there are sufficient quantities of material available that meet the design criteria.
(d) Surveys. Surveys shall be made with sufficient accuracy to locate the proposed construction and to define the volume of the storage in the reservoir. The downstream area shall be investigated in order to delineate the area of potential damage in case of failure. Locations of centerlines, and other horizontal and vertical control points, shall be shown on a map of the site.
(e) Hydrologic Investigation. The drainage area shall be determined. Both present and projected future land use shall be considered in determining the runoff

characteristics of the drainage area. The most severe of these two conditions shall be used in the design. All hydrologic assumptions and design calculations shall be included in the report.

History Note: Statutory Authority G.S. 143-215.26,-27,-31;
Eff. June 15, 1980.

.0205 SPILLWAY DESIGN

(a) All dams shall have a spillway system with capacity to pass a flow resulting from a design storm indicated in (e) of this Rule for a hazard classification appropriate for the dam, unless the applicant provides calculations, designs, and plans to show that the design flow can be stored, passed through, or passed over the dam without failure occurring.

(b) A vegetated earth or unlined emergency spillway will be approved when computations indicate that it will pass the design storm without jeopardizing the safety of the structure. The risk of recurring storms, excessive erosion, and inadequate vegetative cover will be considered acceptable in such a spillway when its average frequency of use is predicted to be no more frequent than once in 25 years for existing class B and for class A dams except for small class A dams designed in accordance with all design criteria established by the U.S.D.A, Soil Conservation Service, and as contained in Engineering Standard 378 of the U.S.D.A., Soil Conservation Service; once in 50 years for new class B, small and medium new class C, and existing class C dams; and once in 100 years for large and very large new class C dams. The dam sizes referred to in this Subsection are defined in (e) of this Rule.

(c) Lined Spillways and Channels. The design report shall include design data criteria for open channel, drop, ogee, and chute spillways and other spillway types that include crest structures, walls, channel lining, and miscellaneous details. All masonry or concrete structures shall have joints that are relatively water-tight and shall be placed on foundations capable of sustaining applied loads without undue deformation. Provisions must be made for handling leakage from the channel or underseepage from the foundation which might cause saturation of underlying materials or uplift against the undersurfaces.

(d) Within 15 days following passage of the design storm peak, the spillway system shall be capable of removing from the reservoir at least 80 percent of the water temporarily detained in the reservoir above the elevation of the primary spillway.

(e) It is recognized that the relationships between valley slope and width, total reservoir storage, drainage area, other hydrologic factors, and specific cultural features have a critical bearing on determining the safe spillway design flood. Rational selection of a safe spillway design flood for specific site conditions based on quantitative analysis is acceptable. The spillway should be sized so that the increased downstream damage resulting from overtopping failure of the dam would not be significant as compared with the damage caused by the flood in the absence of dam overtopping failure. A design storm more frequent than once in 100 years will not be acceptable for any class C dam. In lieu of quantitative analysis, the following tables shall be used as criteria for spillway design storms and permissible velocities for vegetated earth spillways:

Criteria For Spillway Design Storm[1] Size Classification

Size	Total Storage (Ac-Ft)[1]	Height (Ft)[1]
Small	less than 750	less than 35
Medium	equal to or greater than 750 and less than 7,500	equal to or greater than 35 and less than 50
Large	equal to or greater than 7,500 and less than 50,000	equal to or greater than 50 and less than 100
Very Large	equal to or greater than 50,000	equal to or greater than 100

[1]The factor for determining the largest size shall govern.

Minimum Spillway Design Storms

Hazard	Size	Spillway Design Flood (SDF)
Low (Class A)	Small	50 year
	Medium	100 year
	Large	1/3 PMP
	Very Large	1/2 PMP
Intermediate (Class B)	Small	100 year
	Medium	1/3 PMP
	Large	1/2 PMP
	Very Large	3/4 PMP
High (Class C)	Small	1/3 PMP
	Medium	1/2 PMP
	Large	3/4 PMP
	Very Large	PMP

Permissible Velocities for Vegetated Earth Spillways

Permissible velocity[2] - feet per second				
	Erosion-resistant soils		Easily erodable soils	
	Percent slope of exit channel		Percent slope of exit channel	
Vegetation	0 to 5	5 through 10	0 to 5	5 through 10
Bermuda grass Bahia grass	8	7	6	5
Tall fescue Kentucky bluegrass Reed canary	7	6	5	4
Sod-forming grass mixture	5	4	4	3
Lespedeza sericea Weeping lovegrass Alfalfa Crabgrass	3.5	Do not use	2.5	Do not use

[2]Increase values 10 percent when the anticipated average use of the spillway is not more frequent than once in 50 years or 25 percent when the anticipated average use is not more frequent than once in 100 years.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31; Eff. June 15, 1980.

.0206 CONDUITS

(a) A conduit shall be provided to drain each reservoir. The conduit design shall include the computation of the minimum time required to drain the reservoir.

(b) All pipe conduits shall convey water at the design velocity without damage to the interior surface.

(c) Protection shall be provided to prohibit unsafe seepage along conduits through the dam, abutments, and foundation. The specific design for seepage protection along conduits shall be shown in the drawings and specifications.

(d) Adequate allowances shall be incorporated in the design to compensate for differential settlement and possible elongation of the pipe conduit.

(e) Trash racks shall be installed at the intake of conduits to prevent clogging the conduit.

(f) Pipe Conduit Spillway Materials

(1) Pipe conduits shall be designed to support the total external loads in addition to the total internal hydraulic pressure without leakage.

(2) Reinforced or Prestressed Concrete Pipe Conduits

(A) All conduits are to be designed and constructed to remain watertight under maximum anticipated hydraulic pressure and maximum probable joint opening, including the effects of joint rotation and extensibility.

(B) Provisions for safe movement of the barrel are to be provided at each joint in

the barrel and at the junction of the barrel and riser or inlet. Cradles are to be articulated if constructed on a yielding foundation.

(C) The engineer shall submit the final design details of the proposed pipe to be used for all class A dams where the height of the dam exceeds 35 feet and all class B and C dams.

(3) Corrugated Metal Pipe Conduits

(A) Corrugated metal pipe shall not be used in class A dams over 35 feet high or in class B and C dams, except for special cases when the design engineer can adequately demonstrate satisfactory performance.

(B) Corrugated metal pipe may be used in class A dams which are less than 35 feet high.

(C) Corrugated metal conduits shall have watertight connecting bands designed and installed to remain watertight under maximum anticipated hydrostatic head and joint rotation.

(D) Flange type couplings shall not be used for corrugated metal pipe or corrugated steel pipe where the diameter exceeds 12 inches unless the applicant produces computations to verify that the flanges and the pipe conduit are of such design to safely support the total external loads in addition to the total internal hydraulic pressure without leakage.

(g) Dissipating Devices. All gates, valves, conduits and concrete channel outlets shall be provided with a dissipator designed and constructed to control erosion and prevent damage to the embankment or the downstream outlet or channel.

(h) In the case of repair to an existing dam, the engineer may determine that the conduit should not be repaired or replaced and shall submit reasoning to support this determination in the application for the Certificate of Approval to repair. The Director shall approve, disapprove, or approve in part this determination.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31; Eff. June 15, 1980.

.0207 SEEPAGE CONTROL

(a) All dams shall be designed and constructed to prevent the development of instability due to excessive seepage forces, uplift forces, or loss of materials in the embankment, abutments, spillway areas, or foundation. Seepage analysis for design shall identify areas having high internal uplift or exit gradients.

(b) The design may include an embankment internal drainage system, a zoned embankment, a foundation cut-off, an upstream blanket, a sufficiently wide homogeneous section, or other methods to protect against instability from excessive seepage forces or high hydraulic gradients.

(c) For class C dams, a flow net analysis shall be made to determine the location of the phreatic surface, flow lines, and equipotential lines within the embankment and its foundation. This analysis may be based on graphical construction, electrical or liquid analogs, soil prototype methods, or other accepted methods. The flow net and stability analysis shall use the maximum operating pool level with not less than five feet of clear water at the surface. Possible fluctuations in tail water elevation shall be included in the analysis. The flow net and seepage analysis shall be documented in the final design report, as required by .0201(d)(4) of this Section.

(d) Piezometers for confirming the location of the phreatic surface assumed for seepage and slope stability analyses should be considered by the design engineer for class A and class B dams and shall be required for class C dams. Where piezometers are required, their design, depths, and locations shall be provided as required in .0201(d) and .0212(b) of this Section.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31; Eff. June 15, 1980.

.0208 STRUCTURAL STABILITY AND SLOPE PROTECTION

(a) Design and construction of dams to assure structural stability shall be consistent with modern engineering practice. The scope and degree of precision that will be required for a specific project will depend on the conditions of the site and the damage potential of the proposed structure. Consideration in design for structural stability shall include, but are not necessarily limited to, the following:

(1) the hazard potential of the dam under present downstream conditions and under conditions which would likely develop during the life of the reservoir;

(2) foundation bearing capacity, compressibility, and permeability; the extent and reliability of the site investigation; and the predictability of the site and foundation conditions;

(3) the reliability of construction materials, such as borrow soils, in terms of sufficient volume to complete construction without unanticipated interruption and in terms of predictability of physical properties such as strength, permeability, and compressibility;
(4) durability of construction materials;
(5) construction conditions at the site;
(6) the degree of quality control to be exercised during construction;
(7) pore pressure build-up during construction;
(8) the rate of filling the reservoir and the rate of possible reservoir drawdown;
(9) tailwater conditions and the impact of tailwater drawdown;
(10) possible effects of landslides and subsurface solution activity on the structural stability of the dam and spillway structures;
(11) the extent of piezometers and other devices which will be used to monitor the completed dam and the degree of access for inspections.
(b) Slope stability analyses should be considered by the design engineer for all embankment dams and may be required for class B and class C dams. Where slope stability analyses are required, documentation in the final design report shall include the design cross section(s) showing the soil parameters assumed for analysis, the location of the phreatic surface assumed for analysis, stability computations, and the location and computed safety factor(s) for the most critical circle(s) or failure wedge(s). A minimum factor of safety of 1.5 for slope stability for normal loading conditions, and 1.25 for quick drawdown conditions and for construction conditions, shall be required unless the design engineer provides a thoroughly documented basis for using other safety factors.
(c) Foundation bearing capacity and sliding base analyses should be considered for all dams and may be required for class B and C dams. Where bearing capacity or sliding base analyses are required, documentation of assumptions, computations, and safety factors shall be included in the final design report. A minimum factor of safety against bearing capacity and sliding wedge failure of 2.0 shall be required unless the design engineer provides a thoroughly documented basis for using other safety factors.
(d) Resistance of appurtenant structures against flotation uplift shall be provided for all dams. If the structures are anchored by dead weight alone, the buoyant weight shall be used for analysis and the minimum factor of safety shall be 1.15. If the structures are anchored to soil or rock, the minimum factor of safety for that portion of the resistance provided by soil or rock anchorage shall be 2.0 unless the design engineer provides a thoroughly documented basis for using a lower safety factor.
(e) For concrete, masonry, or other similar dams of relatively narrow cross section, resistance against overturning under maximum design loading conditions shall be considered; overturning stability computations shall be required for class B and class C dams. Where overturning analyses are required, the computations shall be included in the final design report. The minimum safety factor against overturning under maximum design loading conditions shall be 1.5 unless the design engineer provides a thoroughly documented basis for using a lower safety factor.
(f) The anticipated reservoir and tailwater drawdown conditions shall be considered in all stability computations and shall be included in the design documents provided in the final design report.
(g) The slopes must be protected against erosion by wave action, and the crest and downstream slope must be protected against erosion due to wind and rain. Riprap and other erosion protection shall be provided over the full range in stage between the lowest drawdown elevation and at least two feet above full normal pool. Exceptions for slowly rising reservoirs, such as waste storage facilities, may be approved in writing by the Director.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31; Eff. June 15, 1980.

.0209 DESIGN LIFE OF A DAM AND RESERVOIR
(a) The selection of materials and equipment to be used in a dam and all of its appurtenant features shall either be based on sufficient quality and durability to satisfactorily function throughout the design life or shall provide for safe and economical replacement within the design life span.
(b) The design life of a dam and reservoir is the period of time the dam and reservoir can be expected to perform effectively as planned. The design life of a dam shall be determined by the following:
(1) the time required to fill the reservoir with sediment from the contributing watershed,

(2) the durability of appurtenances and materials used to construct the dam,
(3) the time required to permanently fill a waste treatment or storage facility with waste,
(4) the time required to perform the specific function for which the dam was designed.

History Note: Statutory Authority G.S. 143-215.27; 143-215.31;
Eff. June 15, 1980.

.0210 SEDIMENT CONTROL
Sediment control related to earth moving activities involved in construction or repair of dams shall be provided in accordance with the North Carolina Sediment Pollution Control Act of 1973 (G.S. 113A-50 through 113A-66). Devices for sediment control during drainage of a reservoir shall be provided; exceptions for emergency drainage of a reservoir may be approved by the Director.

History Note:Statutory Authority G.S. 143-215.31, -113A-54;
Eff. June 15, 1980.

.0211 WASTE TREATMENT AND MINE REFUSE DAMS
(a) Waste treatment and mine refuse dams and reservoirs shall conform to all requirements of this Subchapter. In addition to the requirements of Rule .0105 of this Subchapter, a waste treatment or mine refuse dam may be classified A, B, or C on the basis of potential environmental damage.
(b) Mine refuse dams that are designed to be constructed in stages shall include an emergency spillway system that is capable of safely passing the required storm frequency below the top of the dam for each stage of construction. The refuse facility shall not be used until each stage of construction is completed and approved by the Director.

History Note: Statutory Authority G.S. 143-215.31;
Eff. June 15, 1980.

.0212 ADDITIONAL DESIGN REQUIREMENTS
(a) All elements of the dam and reservoir shall conform to good engineering practice. The safety factors, design standards, and design references that are used shall be included with the final design report.
(b) Monitoring or inspection devices may be required by the Director for use by inspectors or owners in the inspection during construction and filling and after completion of construction. The Director may also require that such monitoring or inspection devices, existing or installed by requirement, be read and documented at specified intervals and that copies of such be forwarded to his office.

(c) The plans, construction schedule, and construction specification shall assure that the downstream flow satisfies minimum quality and quantity standards as defined in G.S. 143-215.25(4) during the period of construction, filling, and life of the dam and reservoir.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31;
Eff. June 15, 1980.

.0213 CONSTRUCTION SCHEDULE
The applicant shall submit a construction schedule that includes:
(1) Techniques and work force to be used to insure that the dam is constructed according to the plans and specifications;
(2) A construction schedule that includes the estimated time to complete the construction activities;
(3) Techniques to be used to divert the stream flow to prevent interference with construction and hazard to life, health, or property;
(4) The extent and method of quality control shall be subject to approval of the Director.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31;
Eff. June 15, 1980.

.0214 PROPOSED CHANGES IN DESIGN
The owner shall notify the director of any proposed changes in design, plans, and specifications that will affect the stability of the dam. Approval must be obtained from the Director prior to installation. This approval shall be in the form of a written addendum to the Certificate of Approval.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31;
Eff. June 15, 1980.

.0215 AS-BUILT PLANS
Two complete sets of as-built plans shall be submitted to the Director within 30 days of completion of the project.

History Note: Statutory Authority G.S. 143-215.30; 143-215.31;
Eff. June 15, 1980.

.0216 ENGINEER'S CERTIFICATION
The engineer who has inspected the construction of or on the dam shall submit written certification bearing his professional seal, unless exempted under the provisions of G.S. 89C-25, that the dam and all appurtenances have been built, repaired, altered, or removed in conformance with the plans, specifications, and drawings approved by the Director and that the dam is safe.

History Note: Statutory Authority G.S. 143-215.30; 143-215.31;
Eff. June 15, 1980.

.0217 AUTHORITY FOR INSPECTION
Authorized personnel of the department may make inspection during construction as deemed necessary to ensure that the structure is being built in conformance with the Certificate of Approval issued. Said inspections do not relieve the engineer in charge from the responsibility of providing adequate inspection of the work.

History Note: Statutory Authority G.S. 143-215.29; 143-215.30; 143-215.31;
Eff. June 15, 1980.

.0218 EXEMPTIONS

History Note: Statutory Authority G.S. 143-215.21; 143-215.31;
Eff. June 15, 1980;
Amended Eff. November 1, 1985;
Repealed Eff. July 1, 1988.

.0219 ACCEPTABLE DESIGN: PROCEDURES AND TECHNICAL REFERENCES
The following represent acceptable design procedures and references:
(1) the design procedures, manuals, and criteria used by the United States Corps of Engineers;
(2) the procedures, manuals, and criteria used by the United States Soil Conservation Service;
(3) the procedures, manuals, and criteria used by the United States Department of Interior, Bureau of Reclamation;
(4) other procedures that are approved by the Director.

History Note: Statutory Authority G.S. 143-215.31; 143-215.34;
Eff. June 15, 1980.

.0220 GRANTING OF FINAL APPROVAL
(a) Unless the Director has reason to believe that the dam, as completed, is unsafe or not in compliance with any applicable requirement, regulation, or law, the Director, upon completion of construction and upon receipt of the engineer's certification pursuant to Rule .0215 of this Section, shall grant final approval of the work in accordance with the certificate, subject to such terms as he/she deems necessary for the protection of life and property.
(b) Pending issuance of final approval, a new dam or the addition to an existing dam shall not be used except on written consent of the Director and subject to conditions he/she may impose relating to safety of life and property and the

satisfaction of minimum stream flow requirements.

History Note: Statutory Authority G.S. 143-215.3; 143-215.30;
Eff. June 15, 1980.

.0221 DELEGATION OF AUTHORITY
The Director has the authority to:
(1) issue approval, disapproval, or approval subject to conditions for proposed construction, repair, alteration or removal of dams;
(2) require progress reports, issue notices of non-compliance and orders to comply, order a halt in construction in the event of non-compliance;
(3) receive notices of completion, specify details of description, grant final approval;
(4) assess civil penalties; and
(5) perform other related functions.

History Note: Statutory Authority G.S. 143-215.3; 143-215.3(a)(4); 143-215.28; 143-215.29; 143-215.30;
143-215.36(b);
Eff. June 15, 1980;
Amended Eff. November 1, 1982.

.0222 APPLICATION PROCESSING FEES
(a) A nonrefundable minimum application processing fee, in the amount stated in Paragraph (d)(1) of this Rule, shall be paid when an application for construction or removal of a dam is filed in accordance with 15A NCAC 2K .0201. Each application for construction or removal of a dam shall be deemed incomplete and shall not be reviewed until the minimum application processing fee is paid.
(b) A nonrefundable additional application processing fee, in the amount stated in Paragraph (d)(2) of this Rule, shall be paid when the as-built plans are submitted to the Director in accordance with 15A NCAC 2K .0215. Final approval to impound, pursuant to 15A NCAC 2K .0220, shall not be granted until the owner's certification and the accompanying documentation are filed in accordance with Paragraph (e) of this Rule, and the additional processing fee is paid.
(c) The application processing fee for the construction or removal of a dam shall be based on the actual cost of construction or removal of the applicable dam.
(1) The actual cost of construction or removal of a dam shall include all labor and materials costs associated with the construction or removal of the dam and appurtenances.
(2) The actual cost of construction or removal of a dam shall not include the costs associated with acquisition of land or right of way, design, quality control, electrical generating machinery, or constructing a roadway across the dam.
(d) Schedule of Fees:
(1) The minimum application processing fee shall be two hundred dollars ($200.00).
(2) The additional application processing fee shall be the following percentages of the cost of construction or removal:
(A) 2 percent of the actual costs between ten thousand and one dollars ($10,001) and one hundred thousand dollars ($100,000);
(B) 1.5 percent of the actual costs between one hundred thousand and one dollars ($100,001) and five hundred thousand dollars ($500,000);
(C) 1.0 percent of the actual costs between five hundred thousand and one dollars ($500,001) and one million dollars ($1,000,000);
(D) 0.5 percent of the actual costs over one million dollars ($1,000,000).
In no case, however, shall the additional application fee be more than fifty thousand dollars ($50,000).
(e) Immediately upon completion of construction or removal of a dam, the owner shall file with the Director a certification, on a form prescribed by the Department, and accompanying documentation, which shows the actual cost incurred by the owner for construction or removal of the applicable dam.
(1) The owner's certification and accompanying documentation shall be filed with the as-built plans and the engineer's certification in accordance with 15A NCAC 2K .0215 and 15A NCAC 2K .0216, respectively.
(2) If the Director finds that the owner's certification and accompanying documentation contain inaccurate cost information, the Director shall either withhold final impoundment approval, or revoke final impoundment approval, until the owner provides the accurate documentation and that documentation has been verified by the Department.
(f) Payment of the dam application processing fee shall be by check or money

order made payable to the "N.C. Department of Environment, Health, and Natural Resources". The payment should refer to the applicable dam.
(g) In order to comply with the limit on fees set forth in G.S. 143-215.28A, the Director shall, in the first half of each state fiscal year, project revenues for the fiscal year from fees collected pursuant to this Rule. If this projection shows that the statutory limit will be exceeded, the Director shall order a pro rata reduction in the fee schedule for the remainder of the fiscal year to avoid revenue collection in excess of the statutory limits.

History Note: Filed as a Temporary Rule Eff. November 1, 1990 For a Period of 180 Days to Expire on
April 29, 1991;
Statutory Authority G.S. 143-215.28A;
ARRC Objection Lodged November 14, 1990;
ARRC Objection Removed December 20, 1990;
Eff. January 1, 1991.

.0223 DAM HEIGHT AND STORAGE DETERMINATION
(a) For the purpose of determining size classification, the height of a dam shall be measured from the highest point on the crest of the dam to the lowest point on the downstream toe.
(b) The total storage capacity of a dam shall be that volume which would be impounded at the elevation of the highest point on the crest of the dam.

History Note: Filed as a Temporary Rule Eff. November 1, 1990 For a Period of 180 Days to Expire on
April 29, 1990;
Statutory Authority G.S. 143-215.31;
ARRC Objection Lodged November 14, 1990;
ARRC Objection Removed December 20, 1990;
Eff. January 1, 1991.

SECTION .0300 - INSPECTIONS: DAM SAFETY ORDERS

.0301 INSPECTION BY THE DEPARTMENT
(a) Schedule of Inspections
(1) All class A and B dams shall be inspected at least once every five years.
(2) Class C dams shall be inspected at least once every two years.
(b) At any time an inspection indicates that a dam may not perform satisfactorily or that the hazard classification has changed, the Director may require a detailed investigation at the owners expense to determine the required remedial action, if any.

History Note: Statutory Authority G.S. 143-215.31; 143-215.32;
Eff. June 15, 1980.

.0302 DAM SAFETY ORDERS
(a) The Director may issue an order directing the owner(s) of a dam to make, in not less than 90 days from issuance of the order and at the owner(s) expense, any maintenance, alteration, repairs, reconstruction, or change in construction upon a finding that the dam:
(1) is not sufficiently strong,
(2) is not maintained in good repair or operating condition,
(3) is dangerous to life or property, or
(4) does not satisfy minimum stream-flow requirements.
(b) The Director may issue an order directing the owner(s) of any dam to take such measures as may be essential, including lowering the level of the impounded water, drainage of the impoundment, and destruction of the dam or reservoir in whole or in part, immediately or within a time limited by the order if the condition of the dam is found to have become so dangerous to the safety of life or property, in the opinion of the Director, as not to safely permit sufficient time for issuance of an order in the manner provided by Subdivision (a) of this Rule.
(c) The Director may, if at any time the condition of any dam becomes so dangerous to the safety of life or property, in the opinion of the Director, as not to permit sufficient time for issuance of an order in the manner provided by Subdivision (a) or (b) of this Rule, immediately take such measures as may be essential to provide

emergency protection to life and property including the lowering of the level of a reservoir by releasing water impounded or the destruction in whole or in part of the dam or reservoir. Costs of such measures may be recovered from the owner(s) of the dam by appropriate legal action by the Commission.
(d) Orders issued by the Director may be conditioned so as to require the dam owner, if he is required or given the option to remove the dam, to undertake the removal in such a manner as to minimize the amount of sediment transported from the impoundment downstream.
(e) Dam safety orders issued by the Director in no way relieve the owner(s) of the dam from duties and obligations imposed by regulations in Section .0200 of this Subchapter, nor do they relieve the owner(s) of the dam from any liabilities or other legal obligations.

History Note: Statutory Authority G.S. 143-215.32; 143-215.34;
Eff. June 15, 1980.

SECTION .0400 - ADMINISTRATIVE HEARINGS

.0401 OPPORTUNITY FOR HEARING
An administrative hearing before the N.C. Office of Administrative Hearings shall be granted to any person:
(1) whose application for dam construction, repair, alteration, or removal has been disapproved by the Director or has been approved by the Director subject to conditions which are unacceptable to the applicant pursuant to Rule .0202 of this Subchapter;
(2) who has been denied final approval of a completed dam by the Director or who has been granted final approval by the Director subject to conditions which are unacceptable to the applicant pursuant to Rule .0219 of this Subchapter;
(3) against whom a dam safety order has been issued requiring the maintenance, alteration, repair, reconstruction, change in construction or location, or removal of a dam within 90 days, pursuant to Rule .0302(a) of this Subchapter, or the lowering of the level of the water impounded by the dam within a time period prescribed by the Director pursuant to Rule .0302(b) of this Subchapter; or
(4) who has been assessed a civil penalty pursuant to G.S. 143-215.36(b) and Subchapter 2J of this Chapter.

History Note: Statutory Authority G.S. 143-215.33; 150B-23;
Eff. June 15, 1980;
Amended Eff. July 1, 1988.

.0402 PROCEDURES
(a) Administrative hearings shall be conducted pursuant to 15A NCAC 1B .0200 et seq., and Chapter 150B of the General Statutes. Any person entitled to an opportunity for a hearing by Rule .0401 of this Section must request a hearing within ten days after receipt of the notice of the action taken under Rule .0401 of this Section.
(b) Copies of 15A NCAC 1B .0200 may be inspected in the offices of the Division of Land Resources, Land Quality Section, 512 N. Salisbury Street, Raleigh, N. C. 27611. Copies may also be inspected in the Division of Planning and Assessment, 512 N. Salisbury Street, 8th Floor, Archdale Building, Raleigh, N. C. 27611. Copies may be obtained at the previous locations or from the Rules Division of the N.C. Office of Administrative Hearings, Blount Street, Raleigh, N.C. 27611.

History Note: Statutory Authority G.S. 143-215.33; 150B-23;
Eff. June 15, 1980;
Amended Eff. August 1, 1988; November 1, 1984.

.0403 DELEGATION OF AUTHORITY: APPOINTMENT OF HEARING OFFICERS
.0404 NOTICE: WAIVER
.0405 PLACE OF THE HEARING
.0406 PROCEDURES
.0407 HEARING OFFICERS: POWERS AND DUTIES
.0408 FINAL DECISIONS: JUDICIAL REVIEW

History Note: Statutory Authority G.S. 143-215.3(a)(4); 143-215.33; 150B-23; 150B, Article 3;

150B, Article 4;
Eff. June 15, 1980;
Legislative Objection (c) Lodged Eff. October 10, 1980;
Amended Eff. November 1, 1982;
Repealed Eff. November 1, 1984.

SECTION .0500 - MINIMUM STREAM FLOWS TO MAINTAIN AQUATIC HABITAT

.0501 DEFINITIONS

(a) Aquatic habitat shall be divided into three classes - "poor," "moderate," and "good."
(1) Streams with poor aquatic habitat are those which have a "poor" fish assemblage rating, and which are rated "poor" for at least two of the following three characteristics:
(A) Substrate;
(B) Cover; and
(C) Macro-invertebrate organisms.
(2) Streams with moderate aquatic habitat are those which exhibit physical conditions and biota which are intermediate between the poor and good categories.
(3) Streams with good aquatic habitat are those which receive at least two "good" ratings when the substrate, cover, and macro-invertebrate organism characteristics are evaluated. The fish assemblage also must receive a "good" rating.
(b) Cover means objects within or overhanging the stream channel which provide shelter for aquatic organisms. "Good" cover occurs when cover is widespread and diverse. "Poor" cover occurs when the amount of cover is small or non-existent.
(c) Substrate means the predominant particle size of the material which makes up the stream bed. "Good" substrate is composed of at least 50 percent silt free substrate with gravel or cobble. "Poor" substrate is composed of at least 80 percent silt, sand, or smooth bedrock.
(d) The macro-invertebrate organisms of the affected reach are rated as "good" if the affected reach is rated good or excellent in the Division of Environmental Management's (DEM) biological monitoring database, or by a site-specific survey according to Standard Operating Procedures for Biological Monitoring, 1995, Division of Environmental Management as defined in 15A NCAC 2B .0103(b). Macro-invertebrates are rated "poor" if the reach is rated fair or poor in DEM's biological monitoring database, or by a site-specific survey according to Standard Operating Procedures for Biological Monitoring, 1995, Division of Environmental Management as defined in 15A NCAC 2B .0103(b).
(e) The fish assemblage rating shall be based on the North Carolina Index of Biotic Integrity (IBI). Existing ratings from the DEM biological monitoring database shall be used where available. If no rating exists, then a site-specific survey shall be conducted according to Standard Operating Procedures for Biological Monitoring, 1995, Division of Environmental Management as defined in 15A NCAC 2B .0103(b). The fish assemblage shall be rated as "good" if the IBI rating is good, good-excellent, or excellent. The fish assemblage shall be rated as "poor" if the IBI rating is poor or lower.
(f) The affected reach of stream means that section of a stream downstream of a dam which experiences significant changes in hydrology. The exact delineation of the affected reach shall be site-specific and depend on factors including, but not limited to:
(1) volume of storage in the impoundment;
(2) upstream and downstream hydrologic characteristics of the stream;
(3) withdrawals from the impoundment; and
(4) downstream point source discharges to the stream.
For the purpose of evaluating aquatic habitat, the affected reach of a stream does not include any portion which is in the backwater of a downstream dam when the level of that downstream impoundment is at normal pool.
(g) "Special case" streams are those which exhibit at least one of the following characteristics:
(1) supplemental classification as an Outstanding Resource Water as defined in 15A NCAC 2B .0101(e)(4) and .0216;
(2) populations of aquatic species listed as threatened or endangered by the U.S. Fish and Wildlife Service, or species which are listed as threatened or endangered by the N.C. Wildlife Resources Commission;
(3) self-sustaining populations of wild trout; or
(4) exceptional non-game or fishery resources as determined by the Wildlife Resources Commission.

(h) The use of the regression equations in Rule .0502 of this Section shall depend on the geographic region of the state in which the stream is located. The geographic region shall be determined from the North Carolina Atlas, edited by Clay, Orr, and Stuart, published by the University of North Carolina Press, 1975.
(i) A continuous stream gage record means a continuous record of daily flows from a stream gage which:
(1) has at least 15 years of continuous daily records;
(2) has no significant hydrological effects caused by upstream regulation, withdrawals, or discharges;
(3) is no less than one-half and no more than one and one-half times the drainage area of the site in question; and
(4) has low flow and average flow yields which are comparable to the site in question.
(j) A site-specific instream flow study conducted by the applicant or his consultants, which is subject to approval by the Department, means a study performed according to the following conditions:
(1) A plan of study shall be developed in consultation with the Department and submitted to the Department for review and approval prior to commencement of the study.
(2) The plan of study shall identify the aquatic habitat parameters to be evaluated by the study. The selection of these parameters shall depend on factors including, but not limited to:
(A) the aquatic species being evaluated;
(B) the habitat quality of the affected reach; and
(C) existing or potential water shortages or water use conflicts.
(3) The Department shall have the option of participating in the collection of all field data, and shall be notified prior to collection of any set of data.
(4) The results of the study shall accurately determine the parameters identified during study design.
(5) The Department may review the field data and results of these studies to determine the stream flow needed to maintain aquatic habitat.

History Note: Statutory Authority G.S. 143-215.24; 143-215.25; 143-215.31; 143-215.32; 143-215.33;
143-215.36;
Eff. December 1, 1994;
Amended Eff. April 1, 1995.

.0502 REQUIRED MINIMUM FLOW FOR DAMS (NOT SMALL HYDRO PROJECTS)
(a) A dam operated by a small power producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural stream bed, shall be exempt from this Rule.
(b) A dam proposed for a small stream with a mean annual daily flow less than or equal to 3.0 cubic feet per second (cfs) shall be subject to the following review process in determining the required minimum flow:
(1) If the mean annual daily flow is less than or equal to 3.0 cfs and the 7-day, 10-year low flow (7Q10) is less than or equal to 0.2 cfs; and if there are no existing point source discharges of wastewater to the affected stream reach; then no minimum release will be required.
(2) If the mean annual daily flow is less than or equal to 3.0 cfs and the 7Q10 is less than or equal to 0.2 cfs; and one or more existing point source discharges of wastewater enter the affected stream reach; then the minimum release shall be equal to the 7Q10.
(3) If the mean annual daily flow is less than or equal to 3.0 cfs and the 7Q10 is greater than 0.2 cfs, then the minimum release shall be equal to the 7Q10.
(c) If the mean annual daily flow is greater than 3.0 cfs, then the following procedures shall be used to determine the minimum flow requirement:
(1) The minimum flow for a dam on a stream with poor aquatic habitat shall be the 7Q10 flow determined by using U.S. Geological Survey procedures.
(2) The minimum flow for a dam on a stream with moderate aquatic habitat in the piedmont, as defined in Rule .0501(h) of this Section, shall be determined using regression equations provided in this Subparagraph.
(A) All flows used in regression equations shall be measured in cubic feet per second, all drainage areas shall be measured in square miles, and all logarithmic expressions shall refer to base 10 logarithms.
(B) The regression equation used to determine the minimum flow for a stream in the piedmont which exhibits moderate aquatic habitat, and for which no continuous

stream gage record, as defined in Rule .0501(i) of this Section, exists, shall be as follows:

LRF = (3.204 x M) - (2.618 x D)
LRF = LOG of regression flow
M = LOG of mean annual daily flow
D = LOG of drainage area

The regression flow (RF) is calculated by raising 10 to the power of the LRF. If the drainage area is greater than 95 square miles, the required minimum flow is 1.4 x RF. Otherwise the required minimum flow is equal to RF.

(C) The regression equation used to determine the minimum flow for a stream in the piedmont which exhibits moderate aquatic habitat, and for which a continuous stream gage record, as defined in Rule .0501(i) of this Section, does exist, shall be as follows:

LRF = (0.812 x M) + (8.111 x E92) - (4.806 x E85) - (3.275 x E95)
LRF = LOG of regression flow
M = LOG of mean annual daily flow
E85 = LOG of 85% annual exceedance flow
E92 = LOG of 92.5% annual exceedance flow
E95 = LOG of 95% annual exceedance flow

The regression flow (RF) is calculated by raising 10 to the power of the LRF. The required minimum flow is 1.1 x RF.

(3) The minimum flow for a dam on a stream with moderate aquatic habitat, located in a geographical region for which regression formulas are not provided, shall be determined by a site-specific instream flow study, as defined in Rule .0501(j) of this Section, conducted by the applicant or his consultants and subject to the approval of the Department.

(4) The minimum flow for a dam on a special case stream, or on a stream with good aquatic habitat, shall be determined by a site-specific instream flow study, as defined in Rule .0501(j). This study shall be conducted by the applicant or his consultants, and shall be subject to approval by the Department.

(5) If the applicant or owner disputes the minimum flow determined by the procedures described in Subparagraphs (c)(1) or (c)(2) of this Rule for streams with poor or moderate aquatic habitat, he may undertake a site-specific field study, as defined in Rule .0501(j) of this Section, subject to the review and approval of the Department. The final minimum release required will not exceed the amount determined by the procedures described in this Rule.

(6) The minimum release schedule for a water supply reservoir shall include provisions for reductions in the minimum flow which coincide with reductions in the usable water supply storage remaining in the impoundment and with reductions in the amount of water withdrawn from the reservoir.

(A) This system of tiered releases shall apply to new water supply reservoirs and any existing water supply reservoirs for which the minimum release is revised.

(B) The exact percentage of storage which triggers reductions in minimum flow will depend on several site-specific factors, including, but not limited to:

(i) size of the reservoir;

(ii) rate of the water supply demand;

(iii) hydrologic characteristics of the impounded stream; and

(iv) the impoundment levels which result in local efforts to reduce water usage through conservation measures.

(C) At least three levels of minimum releases shall be included in the release schedule for a water supply reservoir.

(D) When usable water supply storage has been reduced to a level which triggers the first reduction in minimum flow, then the average daily water withdrawal shall be reduced by at least 10 percent from the average daily withdrawal for the 60 day period immediately prior to the first reduction in the minimum flow. The water supply operator shall accomplish this reduction in withdrawal within two weeks of the reduction in the minimum release.

(E) When usable water supply storage has been reduced to a level which triggers the second reduction in minimum flow, then the average daily water withdrawal shall be reduced by at least 20 percent from the average daily withdrawal for the 60 day period immediately prior to the first reduction in the minimum flow. The water supply operator shall accomplish this further reduction in withdrawal within two

weeks of the second reduction in the minimum release.
(F) The water system operator shall document reduction in water withdrawals by submitting reports of daily water withdrawals to the Department. These shall be submitted every two weeks for as long as the minimum release is reduced below the amount normally required.
(G) An example is shown in the table below. (Note that the percentages of water supply storage which trigger the changes in minimum release are site-specific for this example and may vary according to the factors described in Part (B) of this Paragraph.)

Remaining Usable Water Level Supply Storage	Minimum Release	Water Use Reduction
between 70% and 100%	A	-------
between 40% and 70%	B	10%
below 40%	C	20%

A = Normal minimum release determined by a field study, regression equation, or use of the 7Q10
B = Intermediate reduction in minimum release
C = Low minimum release equal to no more than the 7Q10

(7) An existing dam which was built subject to review under the National or the State Environmental Policy Acts, and for which a minimum release has been established, will not have its minimum release changed under this Rule. However, the Department may review and adjust the minimum flow released by any other existing dam if there is evidence of any of the following conditions downstream of that dam:
(A) water quality standards not being maintained;
(B) water quality classifications which are being only partially supported or not being supported; or
(C) aquatic habitat not being maintained.
(8) If the minimum release required from an existing water supply reservoir is reviewed by the Department, any increase in minimum flow will be determined on a case-by-case basis in consideration of the following factors, including, but not limited to:
(A) availability of water to meet existing demands;
(B) rate of growth in water demand;
(C) planned development of alternative sources of water supply;
(D) structural difficulties;
(E) capital costs; and
(F) anticipated improvements in water quality and aquatic habitat in the affected reach resulting from the proposed change in minimum flow.

The change in minimum release shall be set no higher than an amount which would reduce the water supply safe yield, as determined by standard accepted engineering practices, by more than 10 percent.
(9) If a new minimum release requirement from an existing water supply reservoir is being delayed until a new source of water supply is developed, then this delay shall not exceed a period of five years from the written notification that a new minimum release will be required. This period may be extended by approval of the Environmental Management Commission in consideration of the following factors:
(A) delays in developing a new water supply source;
(B) changes in water quality and aquatic habitat in the affected reach; or
(C) availability of water to meet existing demands.

History Note: Statutory Authority G.S. 143-215.24; 143-215.25; 143-215.31; 143-215.32; 143-215.33;
143-215.36;
Eff. December 1, 1994;
Amended Eff. April 1, 1995.

.0503 REQUIRED MINIMUM FLOW FOR SMALL HYDROELECTRIC PROJECTS
(a) This Rule shall apply only to a dam operated by a small power producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural stream bed. The length of the bypassed reach shall be measured from the toe of the dam to the point where the diverted water re-enters the natural channel,

following the centerline of the natural channel.
(b) The minimum release for a hydroelectric project subject to this Rule shall be determined according to the procedures described in Subparagraphs (1)-(5) of this Paragraph. If at any time the inflow just upstream of the dam is less than the minimum flow required in the bypassed reach, then the minimum flow may be reduced to a level equal to this inflow.
(1) If the aquatic habitat in the bypassed reach is rated poor, then the minimum release to the bypassed reach shall be determined as follows:
(A) If the 7Q10 is less than or equal to 10 percent of the mean annual daily flow, then the minimum release to the bypassed reach shall be the 7Q10 flow.
(B) If the 7Q10 is greater than 10 percent of the mean annual daily flow, and there are no existing point source discharges of wastewater to the bypassed reach, then the minimum release to the bypassed reach shall be 0.8 times the 7Q10.
(C) If the 7Q10 is greater than 10 percent of the mean annual daily flow, and one or more existing point source discharges of wastewater enter the bypassed reach, then the minimum release to the bypassed reach shall be the 7Q10 flow.
(2) If the bypassed reach does not have an aquatic habitat rating of "poor," is not on a special case stream, and is located in the piedmont region, as defined in Rule .0501(h) of this Section, then the minimum release to the bypassed reach shall be determined as follows:
(A) If the 7Q10 is less than or equal to six percent of the mean annual daily flow, then the minimum release to the bypassed reach shall be 3.0 times the 7Q10 flow.
(B) If the 7Q10 is greater than six percent of the mean annual daily flow, and less than or equal to 10 percent of the mean annual daily flow, then the minimum release to the bypassed reach shall be 2.2 times the 7Q10 flow.
(C) If the 7Q10 is greater than 10 percent of the mean annual daily flow, then the minimum release to the bypassed reach shall be 1.2 times the 7Q10 flow.
(3) The minimum flow determined by the procedures described in Subparagraphs (1) and (2) of this Paragraph may be adjusted downward by the Department if that adjustment would not result in significant loss of aquatic habitat. This adjustment may be based on factors including:
(A) the type of aquatic habitat present in the bypassed reach;
(B) the length of the bypassed reach.
(4) If the applicant or owner disputes the minimum flow determined by the procedures described in Subparagraphs (1) and (2) of this Paragraph, he may undertake a site-specific field study, as defined in Rule .0501(j) of this Section, subject to the review and approval of the Department. The final minimum release required will not exceed the amount determined by the procedures described in this Section.
(5) The minimum flow for a dam on a special case stream, or on a stream located in the mountain region, as defined in Rule .0501(h) of this Section, which does not exhibit poor aquatic habitat; shall be determined by a site-specific instream flow study, as defined in Rule .0501(j) of this Section. This study shall be conducted by the applicant or his consultants, and shall be subject to approval by the Department.
(c) A dam operated by a small power producer, as defined in G.S. 62-3(27a), which was operating to produce power as of October 13, 1994, and which is not under the jurisdiction of the Federal Energy Regulatory Commission, shall not be required by this Rule to increase its minimum flow above the amount required on October 13, 1994.

History Note: Statutory Authority G.S. 143-215.24; 143-215.25; 143-215.31; 143-215.32; 143-215.33;
143-215.36;
Eff. December 1, 1994;
Amended Eff. April 1, 1995.

.0504 MONITORING OF MINIMUM FLOW REQUIREMENTS
(a) An owner of a dam with a minimum flow requirement greater than 1.0 cfs shall install, calibrate, and maintain one or more stream staff gages following procedures described in U.S. Geological Survey Water Supply Paper 2175, "Measurement and Computation of Streamflow." Plans for such gages shall be submitted to the Department for approval prior to installation. Staff gages shall be calibrated to indicate the water surface elevations which correspond to the required flows. Calibration shall be verified at least every two years. All initial calibration and re-calibration measurements, including field data, shall be provided to the Department within 30 days of completion.
(b) If the minimum release from a dam is less than or equal to 1.0 cfs, then an

accurately calibrated release mechanism such as a gate or pipe opening shall be acceptable in lieu of a staff gage. Plans for making the required release shall be submitted to the Department for review and approval prior to construction, repair, or modification of the dam.

(c) An owner of a dam who does not comply with a minimum flow requirement may be required to install automated gaging which continuously monitors flow. Records from this type of gage shall be provided to the Department upon request, for the time period being investigated.

(d) Minimum release requirements may be modified or suspended for a term determined by the Department for reasons including pre-scheduled maintenance or construction involving the dam. The Department must approve a written request for such a change in the minimum flow requirement prior to any change in the minimum release.

(e) Reduction or cessation of the minimum flow as a result of emergency conditions or equipment failure shall not constitute a violation of the minimum flow requirement, so long as the event is reported to the Department within 48 hours. The Department may set forth a schedule for correcting the problem and restoring the required minimum flow. If the schedule is not met, and the problem continues to cause violation of the minimum flow requirement, then this violation may be subject to enforcement action.

History Note: Statutory Authority G.S. 143-215.24; 143-215.25; 143-215.31; 143-215.32; 143-215.33;
143-215.36;
Eff. December 1, 1994.

North Carolina
Department of Environment and Natural Resources

The Division of Land Resources



Dam Hazards Classification

Site Map

Hazard Classification	Description	Quantitative Guidelines
Low	Interruption of road service, low volume roads	Less than 25 vehicles per day
	Economic damage	Less than $30,000
Intermediate	Damage to highways, Interruption of service	25 to less than 250 vehicles per day
	Economic damage	$30,000 to less than $200,000
High	Loss of human life*	Probable loss of 1 or more human lives
	Economic damage	More than $200,000
	*Probable loss of human life due to breached roadway or bridge on or below the dam.	250 or more vehicles per day

NOTE: Cost of dam repair and loss of services should be included in economic loss estimate if the dam is a publicly owned utility, such as a municipal water supply dam.



Dam Safety Law of 1967

(As amended through 1995)

§ 143-215.23. Short title.

This Part shall be known and may be cited as the Dam Safety Law of 1967. (1967, c. 1068, s. 1.)

§ 143-215.24. Declaration of purpose.

It is the purpose of this Part to provide for the certification and inspection of dams in the interest of public health, safety, and welfare, in order to reduce the risk of failure of dams; to prevent injuries to persons, damage to downstream property and loss of reservoir storage; and to ensure maintenance of minimum stream flows of adequate quantity and quality below dams. (1967, c. 1068, s. 2; 1977, c. 878, s. 1; 1993, c. 394, s. 1.)

§ 143-215.25. Definitions.

As used in this Part, unless the context otherwise requires:

(1) "Dam" means a structure and appurtenant works erected to impound or divert water.

(2) "Minimum stream flow" or "minimum flow" means a stream flow of a quantity and quality sufficient in the judgment of the Department to meet and maintain stream classifications and water quality standards established by the Department under G.S. 143-214.1 and applicable to the waters affected by the project under consideration, and to maintain aquatic habitat in the length of the stream that is affected. (1967, c. 1068, s. 3; 1973, c. 1262, ss. 23, 38; 1977, c. 771, s. 4; c. 878, ss. 2, 4; 1983, c. 306; 1987, c. 827, ss. 154, 175; 1993, c. 394, s. 2.)

§ 143-215.25A. Exempt dams.

(a) Except as otherwise provided in this Part, this Part does not apply to any dam:

(1) Constructed by the United States Army Corps of Engineers, the Tennessee Valley Authority, or another agency of the United States government, when the agency designed or approved plans for the dam and supervised its construction.

(2) Constructed with financial assistance from the United States Soil Conservation Service, when that agency designed or approved plans for the dam and supervised its construction.

(3) Licensed by the Federal Energy Regulatory Commission, or for which a license application is pending with the Federal Energy Regulatory Commission.

(4) For use in connection with electric generating facilities under the jurisdiction of the North Carolina Utilities Commission.

(5) Under a single private ownership that provides protection only to land or other property under the same ownership and that does not pose a threat to human life or property below the dam.

(6) That is less than 15 feet in height or that has an impoundment capacity of less than 10 acre-feet, unless the Department determines that failure of the dam could result in loss of human life or significant damage to property below the dam.

(b) The exemption from this Part for a dam described in subdivisions (1) and (2) of subsection (a) of this section does not apply after the supervising federal agency relinquishes authority for the operation and maintenance of

the dam to a local entity. (1993, c. 394, s. 3.)

§ 143-215.26. Construction of dams.

(a) No person shall begin the construction of any dam until at least 10 days after filing with the Department a statement concerning its height, impoundment capacity, purpose, location and other information required by the Department. A person who constructs a dam, including a dam that is otherwise exempt from this Part under subdivisions (4) or (5) of G.S. 143-215.25A(a), shall comply with the malaria control requirements of the Department. If on the basis of this information the Department is of the opinion that the proposed dam is not exempt from the provisions of this Part, it shall so notify the applicant, and construction shall not be commenced until a full application is filed by the applicant and approved as provided by G.S. 143-215.29. The Department may also require of applicants so notified the filing of any additional information it deems necessary, including, but not limited to, streamflow and rainfall data, maps, plans and specifications. Every applicant for approval of a dam subject to the provisions of this Part shall also file with the Department the certificate of an engineer legally qualified in this State. The certificate shall state that the person who files the certificate is responsible for the design of the dam and that the design is safe and adequate.

(b) The Department shall send a copy of each completed application to the State Health Director, the Wildlife Resources Commission, the Department of Transportation, and other State and local agencies it considers appropriate for review and comment. (1967, c. 1068, s. 4; 1973, c. 476, s. 128; c. 507, s. 5; c. 1262, s. 23; 1987, c. 827, s. 176; 1989, c. 727, s. 163; 1993, c. 394, s. 4; 1995, c. 509, s. 80.)

§ 143-215.27. Repair, alteration, or removal of dam.

(a) Before commencing the repair, alteration or removal of a dam, application shall be made for written approval by the Department, except as otherwise provided by this Part. The application shall state the name and address of the applicant, shall adequately detail the changes it proposes to effect and shall be accompanied by maps, plans and specifications setting forth such details and dimensions as the Department requires. The Department may waive any such requirements. The application shall give such other information concerning the dam and reservoir required by the Department, such information concerning the safety of any change as it may require, and shall state the proposed time of commencement and completion of the work. When an application has been completed it may be referred by the Department for agency review and report, as provided by subsection (b) of G.S. 143-215.26 in the case of original construction.

(b) When repairs are necessary to safeguard life and property they may be started immediately but the Department shall be notified forthwith of the proposed repairs and of the work under way, and they shall be made to conform to its orders. (1967, c. 1068, s. 5; 1979, c. 55, s. 1.)

§ 143-215.28. Action by Commission upon applications.

(a) Following receipt of agency comments the Commission shall approve, disapprove, or approve subject to conditions necessary to ensure safety and to satisfy minimum stream flow requirements, all applications made pursuant to this Part.

(b) A defective application shall not be rejected but notice of the defects shall be sent to the applicant by registered mail. If the applicant fails to file a perfected application within 30 days the original shall be canceled unless further time is allowed.

(c) If the Commission disapproves an application, one copy shall be returned with a statement of its objections. If an application is approved, the approval shall be attached thereto, and a copy returned by registered mail. Approval shall be granted under terms, conditions and limitations which the Commission deems necessary to safeguard life and property.

(d) Construction shall be commenced within one year after the date of approval of the application or such approval is void. The Commission upon written application and good cause shown may extend the time for commencing construction. Notice by registered mail shall be given the Commission at least 10 days before construction is commenced. (1967, c. 1068, s. 6; 1973, c. 1262, s. 23; 1987, c. 827, s. 154.)

§ 143-215.28A. Application fees.

(a) In accordance with G.S. 143-215.3(a)(1a), the Commission may establish a fee schedule for processing applications for approvals of construction or removal of dams issued under this Part. In establishing the fee schedule, the Commission shall consider the administrative and personnel costs incurred by the Department for processing the applications and for related compliance activities. The total amount of fees collected in any fiscal year may not exceed one-third of the total personnel and administrative costs incurred by the Department for processing the applications and for related compliance activities in the prior fiscal year. An approval fee may not exceed the larger of two hundred dollars ($200.00) or two percent (2%) of the actual cost of construction or

removal of the applicable dam. The provisions of G.S. 143-215.3(a)(1b) do not apply to these fees.

(b) The Dam Safety Account is established as a nonreverting account within the Department. Fees collected under this section shall be credited to the Account and shall be applied to the costs of administering this Part. (1989 (Reg. Sess., 1990), c. 976, s. 1; 1991 (Reg. Sess., 1992), c. 1039, s. 15; 1993, c. 394, s. 5.)

§ 143-215.29. Supervision by qualified engineers; reports and modification during work.

(a) Any project for which the Commission's approval is required under G.S. 143-215.26, 143-215.27, and 143-215.28, and any project undertaken pursuant to an order of the Commission issued pursuant to this section or G.S. 143-215.32 shall be designed and supervised by an engineer legally qualified in the State of North Carolina.

(b) During the construction, enlargement, repair, alteration or removal of a dam, the Commission may require such progress reports from the supervising engineer as it deems necessary.

(c) If during construction, reconstruction, repair, alteration or enlargement of any dam, the Commission finds the work is not being done in accordance with the provisions of the approval and the approved plans and specifications, it shall give written notice by registered mail or personal service to the person who received the approval and to the person in charge of construction at the dam. The notice shall state the particulars in which compliance has not been made, and shall order immediate compliance with the terms of the approval, and the approved plans and specifications. The Commission may order that no further construction work be undertaken until such compliance has been effected and approved by the Commission. A failure to comply with the approval and the approved plans and specifications shall render the approval revocable unless compliance is made after notice as provided in this section. (1967, c. 1068, s. 7; 1973, c. 1262, s. 23; 1977, c. 878, s. 5; 1987, c. 827, s. 154.)

§ 143-215.30. Notice of completion; certification of final approval.

(a) Immediately upon completion, enlargement, repair, alteration or removal of a dam, notice of completion shall be given the Commission. As soon as possible thereafter supplementary drawings or descriptive matter showing or describing the dam as actually constructed shall be filed with the Department in such detail as the Commission may require.

(b) When an existing dam is enlarged, the supplementary drawings and descriptive matter need apply only to the new work.

(c) The completed work shall be inspected by the supervising engineers, and upon finding that the work has been done as required and that the dam is safe and satisfies minimum streamflow requirements, they shall file with the Department a certificate that the work has been completed in accordance with approved design, plans, specifications and other requirements. Unless the Commission has reason to believe that the dam is unsafe or is not in compliance with any applicable rule or law, the Commission shall grant final approval of the work in accordance with the certificate, subject to such terms as it deems necessary for the protection of life and property.

(d) Pending issuance of the Commission's final approval, the dam shall not be used except on written consent of the Commission, subject to conditions it may impose. (1967, c. 1068, s. 8; 1973, c. 1262, s. 23; 1987, c. 827, ss. 154, 177.)

§ 143-215.31. Supervision over maintenance and operation of dams.

(a) The Commission shall have jurisdiction and supervision over the maintenance and operation of dams to safeguard life and property and to satisfy minimum streamflow requirements. The Commission may adopt standards for the maintenance and operation of dams as may be necessary for the purposes of this Part. The Commission may vary the standards applicable to various dams, giving due consideration to the minimum flow requirements of the stream, the type and location of the structure, the hazards to which it may be exposed, and the peril of life and property in the event of failure of a dam to perform its function.

(b) The Department, consistent with rules adopted by the Commission, may impose any condition or requirement in orders and written approvals issued under this Part that is necessary to ensure that stream classifications, water quality standards, and aquatic habitat requirements are met and maintained, including conditions and requirements relating to the release or discharge of designated flows from dams, the location and design of water intakes and outlets, the amount and timing of the withdrawal of water from a reservoir, and the construction of submerged weirs or other devices intended to maintain minimum streamflows. The Commission shall adopt rules that specify the minimum streamflow in the length of the stream affected.

(c) The minimum streamflow in the length of the stream affected by a dam that is operated by a small power

producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural streambed and where the water is returned to the same stream shall be:

(1) The minimum average flow for a period of seven consecutive days that would have an average occurrence of once in 10 years in the absence of the dam, or ten percent (10%) of the average annual flow of the stream in the absence of the dam, whichever is less, if prior to 1 January 1995 the small power producer was either licensed by the Federal Energy Regulatory Commission or held a certificate of public convenience and necessity issued by the North Carolina Utilities Commission.

(2) The minimum average flow for a period of seven consecutive days that would have an average occurrence of once in 10 years in the absence of the dam, or ten percent (10%) of the average annual flow of the stream in the absence of the dam, whichever is greater, if subdivision (1) of this subsection does not apply.

(3) To protect the habitat of the Cape Fear Shiner and other aquatic species, 28 cubic feet per second for any dam that diverts water from 2,500 feet or more of the natural streambed of any stream on which six or more dams operated by small power producers were located on 1 January 1995, notwithstanding subdivisions (1) and (2) of this subsection.

(d) Subsection (c) of this section establishes the policy of this State with respect to minimum streamflows in the length of the stream affected by a dam that is operated by a small power producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural streambed and where the water is returned to the same stream, whether the dam is subject to or exempt from this Part. In its comments and recommendations to the Federal Energy Regulatory Commission regarding the minimum streamflow in the length of the stream affected by a dam that is operated by a small power producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural streambed and where the water is returned to the same stream, the Commission and the Department shall not advocate or recommend a minimum streamflow that exceeds the minimum streamflow that would be required under subsection (c) of this section.

(e) The minimum streamflow in the length of the stream affected by a dam to which subsections (c) and (d) of this section do not apply shall be established as provided in subsection (b) of this section. Subsections (c) and (d) of this section do not apply if the length of the stream affected:

(1) Receives a discharge of waste from a treatment works for which a permit is required under Part 1 of this Article; or

(2) Includes any part of a river or stream segment that:

a. Is designated as a component of the State Natural and Scenic Rivers System by G.S. 113A-35.1 or G.S. 113A-35.2.

b. Is designated as a component of the national Wild and Scenic Rivers System by 16 U.S.C. § 1273 and 1274. (1967, c. 1068, s. 9; 1973, c. 1262, s. 23; 1987, c. 827, s. 154; 1993, c. 394, s. 6; c. 553, s. 80; 1995, c. 184, s. 1; c. 439, s. 1.)

§ 143-215.32. Inspection of dams.

(a) The Department may at any time inspect any dam, including a dam that is otherwise exempt from this Part, upon receipt of a written request of any affected person or agency, or upon a motion of the Environmental Management Commission. Within the limits of available funds the Department shall endeavor to provide for inspection of all dams at intervals of approximately five years.

(b) If the Department upon inspection finds that any dam is not sufficiently strong, is not maintained in good repair or operating condition, is dangerous to life or property, or does not satisfy minimum streamflow requirements, the Department shall present its findings to the Commission and the Commission may issue an order directing the owner or owners of the dam to make at his or her expense maintenance, alterations, repairs, reconstruction, change in construction or location, or removal as may be deemed necessary by the Commission within a time limited by the order, not less than 90 days from the date of issuance of each order, except in the case of extreme danger to the safety of life or property, as provided by subsection (c) of this section.

(c) If at any time the condition of any dam becomes so dangerous to the safety of life or property, in the opinion of the Environmental Management Commission, as not to permit sufficient time for issuance of an order in the manner provided by subsection (b) of this section, the Environmental Management Commission may immediately take such measures as may be essential to provide emergency protection to life and property, including the lowering of the level of a reservoir by releasing water impounded or the destruction in whole or in part of the dam or reservoir. The Environmental Management Commission may recover the costs of such measures from the owner or owners by appropriate legal action.

(d) An order issued under this Part shall be served on the owner of the dam as provided in G.S. 1A-1, Rule 4. (1967, c. 1068, s. 10; 1973, c. 1262, s. 23; 1977, c. 878, s. 3; 1987, c. 827, s. 154; 1993, c. 394, s. 7.)

§ 143-215.33. Administrative hearing.

A person to whom a decision or a dam safety order is issued under this Part may contest the decision or order by filing a contested case petition in accordance with G.S. 150B-23. A person to whom a decision is issued must file a contested case petition within 30 days after the decision is mailed to that person. A person to whom a dam safety order is issued must file a contested case petition within 10 days after the order is served. (1967, c. 1068, s. 11; 1973, c. 1262, s. 23; 1975, c. 842, s. 4; 1977, c. 878, s. 6; 1979, c. 55, s. 2; 1987, c. 827, s. 178; 1993, c. 394, s. 8.)

§ 143-215.34. Investigations by Department; employment of consultants.

The Department shall make such investigations and assemble such data as it deems necessary for a proper review and study of the design and construction of dams, reservoirs and appurtenances, and for such purposes may enter upon private property. The Department may employ or make such agreements with geologists, engineers, or other expert consultants and such assistants as it deems necessary to carry out the provisions of this Part. (1967, c. 1068, s. 12; 1973, c. 1262, s. 23; 1987, c. 827, s. 179.)

§ 143-215.35. Liability for damages.

No action shall be brought against the State of North Carolina, the Department, or the Commission or any agent of the Commission or any employee of the State or the Department for damages sustained through the partial or total failure of any dam or its maintenance by reason of any supervision or other action taken pursuant to or under this Part. Nothing in this Part shall relieve an owner or operator of a dam from the legal duties, obligations and liabilities arising from such ownership or operation. (1967, c. 1068, s. 13; 1973, c. 1262, s. 23; 1987, c. 827, s. 154.)

§ 143-215.36. Enforcement procedures.

(a) Criminal Penalties.

Any person who shall be adjudged to have violated this Article shall be guilty of a Class 3 misdemeanor and shall only be liable to a penalty of not less than one hundred dollars ($100.00) nor more than one thousand dollars ($1,000) for each violation. In addition, if any person is adjudged to have committed such violation willfully, the court may determine that each day during which such violation continued constitutes a separate violation subject to the foregoing penalty.

(b) Civil Penalties.

(1) The Secretary may assess a civil penalty of not less than one hundred dollars ($100.00) nor more than five hundred dollars ($500.00) against any person who violates any provisions of this Part, a rule implementing this Part, or an order issued under this Part.

(2) If any action or failure to act for which a penalty may be assessed under this Part is willful, the Secretary may assess a penalty not to exceed five hundred dollars ($500.00) per day for each day of violation.

(3) In determining the amount of the penalty, the Secretary shall consider the factors set out in G.S. 143B-282.1 (b). The procedures set out in G.S. 143B-282.1 shall apply to civil penalty assessments that are presented to the Commission for final agency decision.

(4) The Secretary shall notify any person assessed a civil penalty of the assessment and the specific reasons therefor by registered or certified mail, or by any means authorized by G.S. 1A-1, Rule 4. Contested case petitions shall be filed in accordance with G.S. 150B-23 within 30 days of receipt of the notice of assessment.

(5) Requests for remission of civil penalties shall be filed with the Secretary. Remission requests shall not be considered unless made within 30 days of receipt of the notice of assessment. Remission requests must be accompanied by a waiver of the right to a contested case hearing pursuant to Chapter 150B and a stipulation of the facts on which the assessment was based. Consistent with the limitations in G.S. 143B-282.1(c) and G.S. 143-282.1(d), remission requests may be resolved by the Secretary and the violator. If the Secretary and the violator are unable to resolve the request, the Secretary shall deliver remission requests and his recommended action to the Committee on Civil Penalty Remissions of the Environmental Management Commission appointed pursuant to G.S. 143B-282.1(c).

(6) If any civil penalty has not been paid within 30 days after notice of assessment has been served on the

violator, the Secretary shall request the Attorney General to institute a civil action in the Superior Court of any county in which the violator resides or has his or its principal place of business to recover the amount of the assessment, unless the violator contests the assessment as provided in subdivision (4) of this subsection. If any civil penalty has not been paid within 30 days after the final agency decision or court order has been served on the violator, the Secretary shall request the Attorney General to institute a civil action in the Superior Court of any county in which the violator resides or has his or its principal place of business to recover the amount of the assessment. A civil action shall be filed within three years of the date the final agency decision was served on the violator.

(7) The Secretary may delegate his powers and duties under this section to the Director of the Division of Land Resources of the Department.

(c) Injunctive Relief. - Upon violation of any of the provisions of this Part, a rule implementing this Part, or an order issued under this Part, the Secretary may, either before or after the institution of proceedings for the collection of the penalty imposed by this Part for such violations, request the Attorney General to institute a civil action in the superior court of the county or counties where the violation occurred in the name of the State upon the relation of the Department for injunctive relief to restrain the violation or require corrective action, and for such other or further relief in the premises as said court shall deem proper. Neither the institution of the action nor any of the proceedings thereon shall relieve any party to such proceedings from the penalty prescribed by this Part for any violation of the same. (1967, c. 1068, s. 14; 1973, c. 1262, s. 23; 1975, c. 842, s. 3; 1977, c. 771, s. 4; 1987, c. 827, ss. 154, 180; 1989 (Reg. Sess., 1990), c. 1036, s. 5; 1991, c. 342, ss. 10, 11; 1993, c. 394, s. 9; c. 539, s. 1021; 1994, Ex. Sess., c. 24, s. 14(c).)

§ 143-215.37. Rights of investigation, entry, access, and inspection.

The Commission shall have the right to direct the conduct of such investigations as it may reasonably deem necessary to carry out its duties prescribed in this Part, and the Department shall have the right to conduct such investigations, and for this purpose the employees of the Department and agents of the Commission have the right to enter at reasonable times on any property, public or private, for the purpose of investigating the condition, construction, or operation of any dam or associated equipment facility or property, and to require written statements or the filing of reports under oath, with respect to pertinent questions relating to the construction or operation of any dam: Provided, that no person shall be required to disclose any secret formula, processes or methods used in any manufacturing operation or any confidential information concerning business activities carried on by him or under his supervision. No person shall refuse entry or access to any authorized representative of the Commission or Department who requests entry for purposes of inspection, and who presents appropriate credentials, nor shall any person obstruct, hamper or interfere with any such representative while in the process of carrying out his official duties. (1967, c. 1068, s. 15; 1973, c. 1262, s. 23.)

E.33. North Dakota



NORTH DAKOTA CENTURY CODE

CHAPTER 61-03
STATE ENGINEER

61-03-21. State engineer may require plan of operation - Adequate structure. Every operator of a water storage reservoir in North Dakota having a capacity of more than one thousand acre-feet [1233481.84 cubic meters] shall annually, between the first and fifteenth day of February, file with the state engineer an operating plan for such reservoir for the calendar year in which the same is filed. The operator of any such reservoir shall be required to cooperate with the state engineer to the end that all water releases shall be compatible with the best interest of the greatest number of downstream water users and affected landowners. In the event that the state engineer declares an emergency to exist in connection with the operation of any such reservoir, the operator thereof shall promptly submit to the state engineer a separate interim operating plan therefor in addition to the annual reservoir operating plan herein required. Such interim operating plan shall then be coordinated and integrated with the suggestions and plans of the state engineer to best serve the affected interests during such emergency. The state engineer may also require such operators to maintain adequate structures and to operate them in a manner that will prevent waste, promote the beneficial use of water and not endanger the general health and welfare of persons affected thereby. In the event such operator fails to maintain and operate adequate structures in the manner provided in this section, the state engineer shall set a place and time for hearing and shall serve notice upon such operator to show cause at such time and place why his water permit should not be declared terminated and canceled. A copy of any order terminating or canceling such water right shall be filed in the office of the recorder in the county or counties where the land to which the right is appurtenant is located. An appeal may be taken from the decision of the state engineer in accordance with the provisions of chapter 28-32.

History: Enacted 1957; amended 1963, 2001.

61-03-21.1. Inspection by state engineer. Whenever the state engineer is authorized or mandated by law to inspect or investigate an alleged violation of a statute under this title, the state engineer shall have the authority to enter upon land for the purposes of conducting such an inspection or investigation. Except in emergency situations as determined by the state engineer, the state engineer shall request written permission from the landowner to enter the property. If the landowner refuses to give written permission, or fails to respond within five days of the request, the state engineer may request the district court of the district containing the property for an order authorizing the state engineer to enter the property to inspect or investigate the alleged violation.

History: Enacted 1985; amended 1991.

61-03-21.2. Removal or modification of unsafe or unauthorized works. If the state engineer pursuant to the state engineer's authority under this title determines that works are unsafe or unauthorized, the state engineer shall notify the landowners by registered mail at the landowner's last known post-office address of record. A copy of the notice must also be sent to any tenant, if the state engineer has actual knowledge of the fact that a tenant exists. The notice must specify the nature and extent of the noncompliance, the modifications necessary for compliance, and must state that if the works are not modified or removed within the period stated in the notice, but not less than thirty days, the state engineer shall cause the removal or modification of the works and assess the cost thereof, or such portion as the state engineer shall determine, against the property of the landowner responsible. The notice must also state that the affected landowner may, within fifteen days of the date the notice is mailed, demand, in writing, a hearing upon the matter. The request for a hearing must state with particularity the issues, facts, and points of law to be presented at the hearing. If the state engineer determines the issues, facts, and law to be presented are well founded and are not frivolous and the request for a hearing was not made merely to interpose delay, the state engineer shall set a hearing date without undue delay. In the event of an emergency, the state engineer may immediately apply to the appropriate district court for an injunction prohibiting the landowner or tenant from constructing or maintaining the works, or ordering the landowner to remove or modify the works. Any assessments levied under the provisions of this section must be collected in the same manner as other assessments authorized by this title. If, in the opinion of the state engineer, more than one landowner or tenant has been responsible, the costs may be assessed on a pro rata basis in proportion to the responsibility of the landowners. Any person aggrieved by action of the state engineer under the provisions of this section may appeal the decision of the state engineer to the district court of the county in which the land is located in accordance with the procedures provided under chapter 28-32. A hearing as provided for in this section is a prerequisite to an appeal, unless the hearing was denied by the state engineer.

For purposes of this section, the term "works" includes dams, dikes, wells, or other devices for water conservation, flood control, regulation, storage, diversion, or carriage of water.

History: Enacted 1985; amended 1989, 1991.

CHAPTER 61-04
APPROPRIATION OF WATER

61-04-11. Inspections of works. If the state engineer, in the course of the state engineer's duties, shall find that any works used for the storage, diversion, or carriage of water are unsafe and a menace to life or property, the state engineer at once shall notify the owner or the owner's agent, specifying the changes necessary and allowing a reasonable time for putting the works in safe condition. Upon the request of any party, accompanied by the estimated cost of inspection, the state engineer shall cause any alleged unsafe works to be inspected. If they shall be found unsafe by the state engineer, the money deposited by such party shall be refunded, and the fees for inspection shall be paid by the owner of such works. If such fees are not paid by the owner of such works within thirty days after the decision of the state engineer, they shall be a lien against any property of such owner, and shall be recovered by a suit instituted by the state's attorney of the county at the request of the state engineer. The state engineer, when in the state engineer's opinion it is necessary, may inspect any works under construction for the storage, diversion, or carriage of water, and may require any changes necessary to secure their safety. The fees for such inspection shall be a lien on any property of the owner and shall be subject to collection as provided in this chapter but neither the United States nor the state of North Dakota nor any agency thereof shall be required to pay such fees.

History: Enacted 1905; amended 1961.

CHAPTER 61-16.1
OPERATION OF WATER RESOURCE DISTRICTS

61-16.1-38. Permit to construct or modify dam, dike, or other device required - Penalty - Emergency. No dikes, dams, or other devices for water conservation, flood control regulation, watershed improvement, or storage of water which are capable of retaining, obstructing, or diverting more than fifty acre-feet [61674.08 cubic meters] of water or twenty-five acre-feet [30837.04 cubic meters] of water for a medium-hazard or high-hazard dam, may be constructed within any district except in accordance with the provisions of this chapter. An application for the construction of any dike, dam, or other device, along with complete plans and specifications, must be presented first to the state engineer. Except for low-hazard dams less than ten feet [3.05 meters] in height, the plans and specifications must be completed by a professional engineer registered in this state. After receipt, the state engineer shall consider the application in such detail as the state engineer deems necessary and proper. The state engineer shall refuse to allow the construction of any unsafe or improper dike, dam, or other device which would interfere with the orderly control of the water resources of the district, or may order such changes, conditions, or modifications as in the judgment of the state engineer may be necessary for safety or the protection of property. Within forty-five days after receipt of the application, except in unique or complex situations, the state engineer shall complete the state engineer's initial review of the application and forward the application, along with any changes, conditions, or modifications, to the water resource board of the district within which the

contemplated project is located. The board thereupon shall consider, within forty-five days, the application, and suggest any changes, conditions, or modifications to the state engineer. If the application meets with the board's approval, the board shall forward the approved application to the state engineer. The state engineer shall make the final decision on the application and forward that decision to the applicant and the local water resource board. The state engineer may issue temporary permits for dikes, dams, or other devices in cases of an emergency. Any person constructing a dam, dike, or other device, which is capable of retaining, obstructing, or diverting more than fifty acre-feet [61674.08 cubic meters] of water or twenty-five acre-feet [30837.04 cubic meters] of water for a medium-hazard or high-hazard dam, without first securing a permit to do so, as required by this section, is liable for all damages proximately caused by the dam, dike, or other device, and is guilty of a class B misdemeanor.

History: Enacted 1981; amended 1985, 1997, 2003.

NORTH DAKOTA ADMINISTRATIVE CODE

ARTICLE 89-08
DAMS, DIKES, AND OTHER DEVICES

CHAPTER 89-08-01
DEFINITIONS

89-08-01-01. Definitions. The following definitions apply in this article:

1. "Appurtenant works" means all works incident or attached to a dam, dike or other device, including but not limited to:

   a. A spillway, either in the dam or separate from it;

   b. The reservoir and its rim;

   c. A low-level outlet; and

   d. A water conduit such as a tunnel, pipeline, or penstock, either through the dam, dike or other device or their abutments.

2. "Construction" or "construct" means any activity for which a permit is required by North Dakota Century Code section 61-16.1-38, including construction, alteration, enlargement, or modification of a dam, dike, or other device.

3. "Dam" means any artificial barrier or obstruction, including any appurtenant works, across a stream channel, watercourse, or an area that drains naturally or may impound water.

4. "Dike" means an embankment, including appurtenant works, constructed to protect real or personal property.

5. "District" means a water resource district.

6. "Engineer" means a person who has been duly registered and licensed as an engineer by the North Dakota state board of registration for professional engineers and land surveyors.

7. "Height" means the vertical distance in feet from the stream channel bottom at the centerline of the dam to the top of the settled embankment.

8. "High-hazard dam" means any dam located upstream of developed or urban areas where failure may cause serious damage to homes, industrial and commercial buildings, and major public utilities. There is potential for the loss of more than a few lives if the dam fails.

9. "Inspection" means a visual or mechanical check, a measurement, a boring, or any other method necessary for determination of the adequacy of construction techniques, conformity of work with approved plans and specifications, or the safety and operating performance of a dam, dike, or other device.

10. "Low-hazard dam" means a dam located in rural or agricultural areas where there is little possibility of future development. Failure of low-hazard dams may result in damage to agricultural land, township and county roads, and farm buildings other than residences. No loss of life is expected if the dam fails.

11. "Medium-hazard dam" means a dam located in predominately rural or agricultural area where failure may damage isolated homes, main highways, or railroads, or cause interruption of minor public utilities. The potential for the loss of a few lives may be expected if the dam fails.

12. "Other device" means a water control structure, other than a dam or dike, which may include, but is not limited to, diversion ditches, dugouts, lagoons, and holding ponds.

13. "Owner" means any person who owns, controls, operates, maintains, manages, or proposes to construct a dam, dike, or other device, except that for the purpose of signing the application for construction permit, "owner" means the person who owns the property or interest in property upon which the dam, dike, or other device will be built.

14. "State engineer" means the state officer provided for in North Dakota Century Code section 61-03-01 or any of the state engineer's employees or authorized agents.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-16.1-38

89-08-01-02. Definition of unsafe dam, dike, or other device. A dam, dike, or other device is unsafe if it threatens harm to life or property, or is improperly maintained.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-03-21.2

CHAPTER 89-08-02
CONSTRUCTION PERMITS

89-08-02-01. Determining the capacity of dams, dikes, or other devices. The impounding capacity of a dam is calculated based upon the top of the settled embankment of the dam. The diverting capacity of a dike is calculated based upon the area protected as measured from the top of the dike. If the absence of the dike could result in more than fifty acre-feet of water inundating the protected area, a permit is required. The diverting capacity of a diversion ditch is calculated based upon the runoff from a twenty-five year, twenty-four hour, precipitation event. No construction on the dam, dike, or other device can begin until a construction permit is obtained.

History: Effective November 1, 1989; amended effective April 1, 2004.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-16.1-38

89-08-02-02. Contents of application. A completed application for a construction permit must be submitted to the state engineer along with plans and specifications; evidence recognized in a court of law sufficient to establish a prima facie case of a property right in the property that will be affected by the construction of the dam, dike, or other device; and any additional data or information required by the state engineer.

History: Effective November 1, 1989; amended effective June 1, 1998; April 1, 2004.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-16.1-38

89-08-02-03. Permit does not absolve liability for damages. The receipt of a permit, including a permit for emergency construction, does not relieve an applicant from liability for damages resulting from any activity conducted pursuant to the permit.

History: Effective June 1, 1998.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-16.1-38

89-08-02-04. Temporary construction permits. If the state engineer determines an emergency exists, the state engineer may issue a temporary permit to construct a dam, dike, or other device capable of impounding, obstructing, or diverting more than fifty acre-feet. A temporary permit shall have a duration of not more than six months unless extended by the state engineer.

History: Effective April 1, 2004.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-16.1-38

CHAPTER 89-08-03
INSPECTIONS

89-08-03-01. Inspections and reports during construction of high-hazard dams, medium-hazard dams, and low-hazard dams over ten feet [3.05 meters] in height. In order to protect property and assure safety, the following are conditions to all permits for high-hazard dams, medium-hazard dams, or low-hazard dams over ten feet [3.05 meters] in height:

1. An engineer must be in charge of and responsible for inspections during construction.

2. Inspections during construction must be performed at intervals necessary to ensure conformity with the construction permit and the plans and specifications.

3. Within seven days after each inspection, the engineer in charge shall submit a written report to the state engineer specifying the information obtained pursuant to the inspection. The report will specify any changes necessary under this section.

History: Effective November 1, 1989; amended effective April 1, 2004.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-16.1-38

89-08-03-02. Monitoring during construction by the state engineer. The state engineer may monitor any dam, dike, or other device during construction to ensure conformity with the construction permit and the plans and specifications.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-04-11

89-08-03-03. Changes in construction. If, pursuant to an inspection under section 89-08-03-01 or section 89-08-03-02, the state engineer or engineer in charge determines changes in construction are necessary to insure safety, whether the changes are necessary because the dam, dike, or other device does not comply with the construction permit or plans and specifications, or an unforeseen condition is discovered, or for any other reason, the state engineer may order the appropriate changes and may order construction be stopped until the changes are made.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-04-11

89-08-03-04. Requested inspections.

1. Upon receipt of an affidavit complaining a dam, dike or other device is unsafe because of its construction, maintenance, or operation, the state engineer shall examine the available information and determine if the complaint is justified.

2. If the state engineer determines the complaint is unjustified, the state engineer shall notify the complainant in writing of that fact. If the complainant continues to request an inspection even though the state engineer determines the complaint is unjustified, the state engineer shall make the inspection upon receiving from the complainant a certified check or cashier's check in an amount sufficient to cover the total cost of inspection.

3. If the state engineer determines the complaint is justified, the state engineer shall make the inspection upon receiving from the complainant a certified check or cashier's check in an amount sufficient to cover the total cost of inspection.

4. If the dam, dike, or other device is defective, the state engineer shall require the owner of the dam, dike, or other device to pay the cost of inspection, and upon payment shall return the amount deposited by the complainant. If the cost of inspection is not paid within thirty days by the owner of the defective dam, dike, or other device, the cost of inspection shall become a lien against any of the owner's property.

5. If the dam, dike, or other device is not found defective, any money deposited by the complainant for the inspection may not be returned.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-04-11, 61-03-21.1, 61-03-21.2

89-08-03-05. Periodic inspections after construction. As a condition on all construction permits, the state engineer may require inspection of a dam, dike, or other device as often as necessary after construction to protect property and assure safety.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-04-11, 61-16.1-38

89-08-03-06. As built plans. As a condition on all construction permits, the owner of the dam, dike, or other device will provide the state engineer with "as built" plans after the dam, dike, or other device has been constructed.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-16.1-38

CHAPTER 89-08-04
OPERATING PLAN

89-08-04-01. Operating plan. By the fifteenth of February of each year, the operator of a reservoir with a capacity of more than one thousand acre-feet shall submit an operation plan for that year to the state engineer. The state engineer shall review the operating plan and if deficiencies or discrepancies exist, the state engineer shall notify the owner of the dam of the deficiencies or discrepancies within thirty days of discovering the deficiencies or discrepancies. The owner of the dam shall correct the deficiencies or discrepancies and return the corrected operating plan to the state engineer within fourteen days of receiving notice of the deficiencies or discrepancies. The operation plan must be approved by the state engineer prior to the operation of the dam. If the operator receives no response from the state engineer, the operation plan is approved. The operation plan must contain at a minimum:

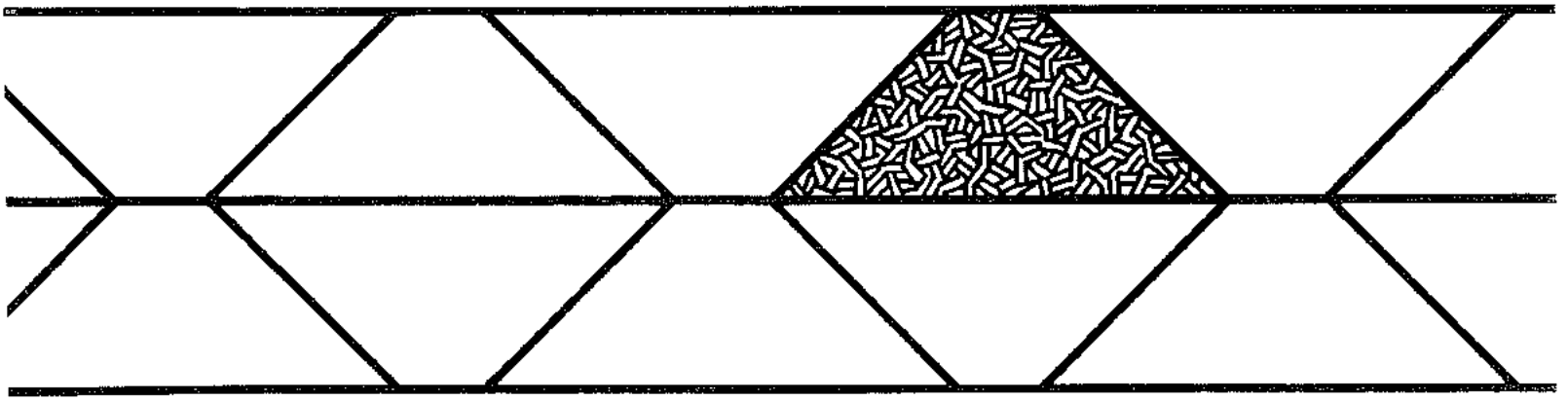
1. A reservoir operation procedure;

2. A maintenance procedure for the dam and appurtenant works; and

3. Emergency procedures and warning plans.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-03-21

North Dakota Dam Design Handbook



North Dakota State Engineer
June 1985
Project No. 1579-1

North Dakota
Dam Design Handbook

Prepared by
A. Richard Moum, P.E.
Dale L. Frink, P.E.
Eugene J. Pope, P.E.

with Assistance from
Jerome H. Spaeth

Under the Direction of
Vernon Fahy, P.E., State Engineer
Bismarck, North Dakota

Advisory Committee
Soil Conservation Service USDA
U.S. Bureau of Reclamation
U.S. Corps of Engineers
North Dakota Division of Emergency Management

SECOND PRINTING

"The work that provided the basis for this publication was supported by funding from FEMA. The publisher is responsible for the information contained herein. This information does not necessarily reflect the views of the Federal Government."

SPECIAL ACKNOWLEDGEMENT

This handbook represents a multi-agency effort at incorporating specific standards for dam design in North Dakota. The following individuals and agencies participated in writing and/or review of the handbook. Their contributions are greatly appreciated.

Agency/Affiliation	Name	City, State
Consulting Engineers	A. Richard Moum	Bismarck, ND
	Eugene J. Pope	Wahpeton, ND
	Jerome H. Spaeth	Bismarck, ND
U.S. Soil Conservation Service	Ronald Sando	Bismarck, ND
	Jon Nestoss	Bismarck, ND
	Carl A. Carlson	Bismarck, ND
U.S. Army Corps of Engineers	John W. Monzingo	Omaha, NE
	Helmer Johnson	St. Paul, MN
	James Murphy	St. Paul, MN
U.S. Bureau of Reclamation	Howard Hoovestol	Bismarck, ND
	Bernie Meskimen	Bismarck, ND
Federal Emergency Management Agency	John Liou	Denver, CO
ND Division of Emergency Management	Douglas Friez	Bismarck, ND
ND State Water Commission	Vernon Fahy	Bismarck, ND
	David Sprynczynatyk	Bismarck, ND
	Dale L. Frink	Bismarck, ND
	Edgar Schmidt	Bismarck, ND
	Arland Grunseth	Bismarck, ND
	Ronald Swanson	Bismarck, ND
	Tim Fay	Bismarck, ND
	Cary Backstrand	Bismarck, ND
	Jeff Klein	Bismarck, ND
	Brenda Bosworth	Bismarck, ND
	Kurt Kunz	Bismarck, ND
	Joseph Cichy	Bismarck, ND
	Darlene Mund	Bismarck, ND

TABLE OF CONTENTS

		Page
CHAPTER I	PURPOSE AND AUTHORITY OF MANUAL	1
CHAPTER II	LIABILITY	1
CHAPTER III	PERMIT REQUIREMENTS	2
	A. Authority	2
	B. Permits	2
	1. Construction Permit	2
	2. Water Permit	2
	3. Other Permits	2
CHAPTER IV	CLASSIFICATION OF DAMS	3
CHAPTER V	STANDARDS FOR NEW EARTHFILL DAMS	4
	A. Land Rights and Utilities	4
	1. Land Rights	4
	2. Utilities	4
	B. Hydrology	5
	1. Drainage Area Determination	5
	2. Rainfall and Snowmelt Design Data	5
	3. Hydrograph Development and Infiltration Techniques	6
	4. Routing Procedures	7
	5. Computer Models	7
	6. Dam Breach Analysis	7
	7. Runoff Yield and Reliability	7
	C. Sediment Storage	7
	1. Sediment Delivery Ratio Method	7
	2. Reservoir Sedimentation Survey Method	8
	D. Geotechnical Exploration	9
	1. Reconnaissance Surveys	9
	2. Detailed Surveys	9
	3. Soil Classification	10
	4. Sampling	10
	5. Special Consideration	10
	E. Embankment and Foundation Design	12
	1. Selection of Embankment Type	12
	2. Foundation Cutoffs	13
	3. Height	13
	4. Top Width	13
	5. Berming	14
	6. Foundation and Embankment Drainage	14
	7. Structural Stability	17
	8. Protection of Embankment Surface	18
	9. Instrumentation	18
	F. Principal Spillway Design	21
	1. General	21
	2. Types of Principal Spillways	21
	G. Emergency (Secondary) Spillway Design	25
	1. Location	25
	2. Design Considerations	25
	H. Design Documentation	25

Page

CHAPTER VI MODIFICATION OF EXISTING STRUCTURES 27
A. Land Rights 27
B. Hydrology 27
C. Sediment Storage 27
D. Geological Explorations 27
E. Embankment Design 28
F. Principal Spillway Design 28
G. Emergency Spillway Design 28
H. Design Documentation 28
CHAPTER VII CONSTRUCTION DRAWINGS AND SPECIFICATIONS 29
A. Construction Drawings 29
1. Cover Sheet 29
2. Watershed Boundary Map 29
3. Site Maps 29
4. Plan View Sheets 29
5. Profile Sheets 29
6. Cross-Section Sheets 29
7. Structural Detail Sheets 29
8. Standard Detail Sheets 29
9. Topography for Erosion Control During Construction 29
10. Details for Erosion Control During Construction 29
B. Specifications 30
CHAPTER VIII CONSTRUCTION INSPECTIONS, RECORDS AND COMPLETION DOCUMENTS 31
A. Inspections 31
1. Construction Work Inspections 31
2. Material Inspections 31
3. State Engineer Monitoring 32
B. Records 32
1. Job Diary 32
2. Change Orders 32
C. Completion Documents 32
1. As-Built Plans 32
2. Completion Report 33
CHAPTER IX OPERATIONS, INSPECTIONS AND MAINTENANCE 34
CHAPTER X EMERGENCY ACTION PLANS 35
A. Emergency Action Plan (Class I and II Dams) 35
B. Emergency Action Plan (Class III and IV Dams) 35
C. Emergency Action Plan (Class V Dams) 35
CHAPTER XI GLOSSARY 37
CHAPTER XII BIBLIOGRAPHY 41

APPENDICES

			Page
APPENDIX A	1.	Application For Permit to Construct or Enlarge a Dam or Reservoir	45
	2.	Application for Conditional Water Permit	47
APPENDIX B		Hydraulic Data Sheet (USDA-SCS Form) (ND-ENG-16)	51
APPENDIX C	1.	USDA - Soil Conservation Service "Job Diary"	57
	2.	North Dakota State Water Commission "Change Order"	61
APPENDIX D		Dam Inspection Checklist	65
APPENDIX E	1.	Example Categories of Action	75
	2.	Emergency Action Plan Directory	77

TABLES

No.	Title	Page
4-1	Dam Design Classification	3
5-1	Suggested Precipitation Criteria for Spillway Design	5
5-2	Permissible Velocities for Vegetated Emergency Spillways	6
5-3	Reservoir Sedimentation Surveys	9
5-4	Recommended Sizes of Samples	12
5-5	Suggested Minimum Top Width of Embankment	13
5-6	Nomenclature of Shear Strength Tests	18
5-7	Slope Stability Criteria for Dams	19
5-8	Monitoring Instruments	20

FIGURES

No.	Title	Page
5-1	Relationship Between Drainage Area and Sediment Delivery Ratio	8
5-2	Trap Efficiency of Reservoirs	8
5-3	Unified Soil Classification Chart	11
5-4	Earthfill Embankment Types	12
5-5	Reservoir Wave Height	13
5-6	Chimney and Foundation Drain System	15
5-7	Filter Blanket and Toe Drain System	15
5-8	Foundation Drain System	16
5-9	Pressure Relief Wells and Foundation Drain	17
5-10	Drop Inlet - Conduit Spillway	22
5-11	Overflow Weir - Chute Spillway	22
5-12	Conduit Spillway With Anti-Seep Collars and a Concrete Cradle	23

CHAPTER I:

Purpose and Authority of Manual

The North Dakota State Engineer, under Section 61-02-14 of the North Dakota Century Code (NDCC), is charged with reviewing and approving construction drawings and specifications for dams constructed in North Dakota.

This handbook is primarily for use by engineers in the design and construction of earth dams in the state of North Dakota. Water resource districts may also find the handbook of assistance in their work. The handbook is a guide for the gathering of data, the design of the structure, the preparation of construction drawings and specifications, and the inspection of construction.

The handbook is not to be considered and does not represent a comprehensive step-by-step set of requirements for dam design. Its purpose is to outline the suggested standards for dam design in North Dakota, along with recommended methods and references. The engineering for each dam will be reviewed by the State Engineer on a case-by-case basis. Latitude will be provided to engineers allowing use of other methods producing a product of satisfactory quality.

CHAPTER II:

Liability

As a general rule, engineers have a duty to "exercise that degree of skill and knowledge normally exercised by members of the profession."

A design professional who plans and supervises a construction project will be liable to all persons who may foreseeably be injured if he does not fulfill his duty of properly exercising the skill he is assumed to possess. Design engineers have been found liable to the contractor, and to workmen for damages caused by defects in a design, if an exercise of the proper degree of skill would have prevented the defect.

Section 9-08-02.1 of the NDCC voids construction contracts with provisions making the contractor liable for "errors or omissions of the owner or his agents in the plans and specifications." Under this statute, the design professional will likely be either an owner or an owner's agent. Attempts to pass the liability for design defects to the contractor generally have been ineffective.

Owners of dams have a continuing duty to maintain their dams in a safe and hazard-free condition. Their duty also applies to the area adjacent to the dam. Liability may result if it is determined that injury or damages occurred as a result of an owner's negligence in maintaining a dam.

Section 43-19.1-28 of the NDCC requires the state or any political subdivision (including water resource boards, commissions, etc.) to hire a registered professional engineer to make all engineering drawings, specifications, estimates, and to supervise construction if the cost of the project exceeds $50,000.

CHAPTER III:

Permit Requirements

A. Authority

The North Dakota State Engineer, pursuant to Chapter 61-04 and Sections 61-16.1-38 and 61-16.1-53, North Dakota Century Code, and the North Dakota State Water Commission, pursuant to Section 61-02-14 of the North Dakota Century Code, have the power, authority and general jurisdiction to regulate, control and supervise the construction and operation of all dams within the state of North Dakota, both public and private, which they deem necessary or advisable. Also, the State Water Commission has the power and authority to work with the United States and any of its departments, agencies or officers with regard to dams, and to do what is necessary to carry out the expressed and implied purposes of Chapter 61-02, North Dakota Century Code.

B. Permits

1. Construction Permit

No dams which are capable of retaining or storing more than 12½ acre-feet of water may be constructed in North Dakota without a permit. An application for the construction of a dam must be submitted first to the State Engineer. The application must be on State Water Commission Form 110 (see Appendix A) and must include complete plans and specifications for the dam or reference to standard specifications. Upon receipt, the State Engineer will review the application. Except in unique circumstances, the State Engineer will complete his initial review within 45 days. He will forward the application, plans and specifications, along with any changes or conditions, to the water resource board of the district within which the contemplated dam is located. Within 45 days, the board shall consider the application and information forwarded by the State Engineer and return it to the State Engineer with its decision and comments regarding suggested changes, conditions and modifications. The State Engineer makes the final decision and forwards that decision to the applicant and the board (61-16.1-38, N.D.C.C.).

2. Water Permit

If water is to be appropriated and put to beneficial use as a result of the construction of a dam, a conditional water permit must be obtained prior to the initiation of construction. An application form 108 (see Appendix A) and instruction booklet, for the purpose of acquiring a conditional water permit, may be obtained from the State Engineer's office in Bismarck. Chapter 61-04, NDCC, establishes the procedures that must be followed prior to acquiring a conditional water permit.

3. Other Permits

The construction of a dam may require several other permits. The Corps of Engineers may require permits under the authority of Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. The North Dakota Health Department requires a permit to discharge water into a stream. The State Engineer also requires a temporary water permit for water used during construction. Additional information on these permits can be obtained by contacting the respective agencies.

CHAPTER IV:

Classification of Dams

Dams shall be categorized according to the potential hazard to property or loss of life if the dam should suddenly fail. Existing development, as well as future downstream development, must be considered when categorizing a dam. The hazard category will be based solely on potential hazard from failure and not on the selected design criteria.

Although it is recognized that loss of life is possible with any dam failure, the following hazard categories of dams have been established for North Dakota:

Low — dams located in rural or agricultural areas where there is little possibility of future development. Failure of low hazard dams may result in damage to agricultural land, township and county roads, and farm buildings other than residences. No loss of life is expected if the dam fails;

Medium — dams located in predominantly rural or agricultural areas where failure may damage isolated homes, main highways, railroads or cause interruption of minor public utilities. The potential for the loss of a few lives may be expected if the dam fails;

High — dams located upstream of developed and urban areas where failure may cause serious damage to homes, industrial and commercial buildings and major public utilities. There is a potential for the loss of more than a few lives if the dam fails.

After a dam has been categorized according to failure hazard, it will also be classified for dam design criteria. Design criteria shall be based on the hazard classification and the height of the dam. ("Height of the dam" is defined as the distance in feet from the stream channel bottom at the centerline of the dam to the top of the settled embankment.)

Table 4-1 is based on dam height and hazard categories and outlines five classifications for dam design. Each classification will require varying degrees of intensity of investigation for hydrology, foundation and borrow explorations, soil testing, structural design, etc.

Table 4-1. Dam Design Classifications

Dam Height (Feet)	Hazard Categories		
	Low	Medium	High
Less than 10	I	II	IV
10 to 24	II	III	IV
25 to 39	III	III	IV
40 to 55	III	IV	V
Over 55	III	IV	V

CHAPTER V:

Standards for New Earthfill Dams

In general, earth dams should be designed in accordance with the following principles:

- the embankment shall not be overtopped by the design flood;
- the embankment phreatic line will not intercept the downstream face;
- the embankment slopes are stable under varying conditions;
- the embankment slopes are flat enough to limit shear stress in the foundation to the shear strength of the foundation materials with an adequate factor of safety;
- seepage water will not pass freely from the upstream embankment face to the downstream embankment face;
- seepage water passing through the embankment or the foundation shall have velocities lower than that required to move embankment or foundation materials; and
- the upstream face is protected against wave action and erosion and the downstream face is protected against erosion.

The criteria standards listed in this chapter are commensurate with the design classifications listed in Chapter IV. Thus, a low hazard dam will not require as extensive an investigation as a high hazard dam. It is recommended that the designer prepare a preliminary outline for review by the State Engineer prior to submitting the permit application. The outline shall set forth the dam classification, the general criteria to be used, and the degree of investigation and testing determined appropriate in the design of the proposed dam. The outline shall give the location, purpose, drainage area, owner, etc., of the proposed structure. The furnishing of this outline may eliminate unnecessary investigation expense.

This chapter is divided into eight sections, each covering a major component in the design of a dam. Each section includes a discussion of the general considerations along with suggested criteria standards. The majority of the suggestions are USDA-Soil Conservation Service criteria and guidelines with modifications. Deviations from these recommendations may be allowed, subject to the approval of the State Engineer, if there is a sound engineering basis for the change. The eight main sections in this chapter include:

A. Land Rights and Utilities
B. Hydrology
C. Sediment Storage
D. Geotechnical Exploration
E. Embankment and Foundation Design
F. Principal Spillway Design
G. Emergency Spillway Design
H. Design Documentation

A. Land Rights and Utilities

1. Land Rights

The need for fee title, easements and construction permits largely depends on the present and future ownership of the land involved in the dam and reservoir area. In general, stock and small irrigation dams are on the dam owner's land. In this case, land rights are usually unnecessary unless prior easements exist for other purposes. Larger dams, reservoirs and borrow areas may be located on land of several owners.

While it is the responsibility of the structure owner to obtain the necessary fee title, easements or construction permits, it is recommended that the designer prepare a land rights map for the owner and the State Engineer showing:

(a) the location of the structure (section, township, and range) on a county map which also shows prominent landmarks;

(b) a detailed site layout map showing both the land ownership, and the location of the dam, reservoir, borrow area(s) and ingress and egress routes (section, subdivisions, township and range);

(c) farmsteads and buildings;

(d) public roads;

(e) surface and buried utilities; and

(f) mines, oil wells, gravel pits, etc.

2. Utilities

Existing pipelines, cables, conduits, and materials are frequently encountered in proposed reservoir areas. Buried conduits are usually located at shallow depths in the floodplain. Utilities that represent a safety hazard should be relocated away from the site or modified to provide adequate safety assurances. Overhead cables or power lines should be relocated or raised as necessary to prevent damage or hazard to the public. All land rights, including subordination easements, should be obtained prior to bid letting or construction.

Every reasonable effort should be made to remove all conduits, cables and pipelines from the site. Most utility owners will want their facility removed from the site for easy maintenance. Only as a last resort, and

with concurrence of the affected utility owner and State Engineer, are conduits to be permitted to remain under an earth embankment.

Conduits permitted to remain under any part of the embankment are to be: (1) encased in concrete or otherwise treated to ensure durability and strength equal to that of the principal spillway; (2) properly articulated on all yielding foundations; (3) made watertight against leaking either into or out of the conduit; and (4) provided with anti-seep collars.

Enclosure of a conduit in another conduit is acceptable if the larger conduit meets the requirements of this section. The outside conduit must be positively sealed at the upstream end to prevent seepage and must extend the full distance under the embankment.

All plans for leaving utilities under the embankment or reservoir areas of a dam must have the approval of the utility owner and appropriate regulatory agencies.

B. Hydrology

One aspect in the investigation of a dam is the determination of the hydrologic performance of the project during flood events. These hydrologic investigations can usually be placed in two classes: (1) the investigations based on specific frequencies to determine the size of the principal spillway, and (2) the investigations based on Probable Maximum Precipitation (PMP) to determine the size of the emergency spillway. This section describes the procedures recommended for determining the required sizes of these two spillways.

1. Drainage Area Determination

(a) Principal Spillway Design

The contributing drainage area for principal spillway design can be adjusted for significant storage areas within the watershed. The available depressional storage may be estimated by a number of methods including field reviews, USGS topographic maps and aerial photography. It is recommended that 5-10 percent of the storage areas be randomly sampled to determine their approximate surface areas and depths. These samples should indicate both normal water levels and levels to the point of overflow. Normal water levels should be verified by landowner interviews or by examination of photographic records. Using this surface area and depth information, the volume of available storage may be estimated. If the volume of storage is large in relation to the design runoff volume, the storage areas may be considered non-contributing and may be deducted from the drainage area used to develop the design flood hydrograph for the principal spillway. Although the determination of significant storage is a judgment decision, storage should be at least 70 percent of the design runoff volume before areas are classified as non-contributing. Times of concentration and other watershed parameters should be based only on the contributing area.

(b) Emergency Spillway Design

The design storms for emergency spillway and freeboard design are critical to the safety of the dam. Also, runoff volumes are typically large, approaching the probable maximum values for high hazard structures. Because depressional storage areas may be periodically full, or partially full, reduction of the drainage area and associated runoff amounts are not recommended for the emergency spillway and freeboard design storms. Therefore, the total drainage area should be used for these design storms.

2. Rainfall and Snowmelt Design Data

Generally, principal spillway capacity and associated floodwater retarding storage is designed to meet the objectives of the dam; emergency spillway capacity is designed to provide the necessary safety requirements of the dam. The precipitation design amounts used to size these spillways is related to the dam design classifications. Table 5-1 shows the suggested hydrologic spillway criteria for both the principal and emergency spillways.

As indicated by footnote 3, Table 5-1, the State Engineer may allow adjustments to the PMP events on a case-by-case basis. One method that could be used to evaluate downstream impacts is risk analysis. Risk analysis can involve an assessment of several factors including incremental damage, depth of inundation in the downstream area and the opportunity to warn downstream areas. Incremental damage is the difference in damages, including loss of life, between two or more conditions. For example, incremental damage would be the difference in damages caused by a PMP event with a dam failure and the damages caused by a PMP event without a dam failure. The depth of inundation in the downstream area, including velocities, also merits consideration. In North Dakota, most natural floods do not produce high velocities in the inundation areas. These lower velocities reduce the risk of loss of life and, to some extent, loss of property. However, water depths and velocities resulting from a dam failure will likely be very high and, therefore, need careful review. The opportunity to warn downstream areas of a

Table 5-1. Suggested Precipitation Criteria For Spillway Design [1] [2] [3]

Dam Design Classification[4]	Principal Spillway[5]	Emergency Spillway Criteria	
		Velocity[6]	Freeboard[7]
I	—	P_{10}	P_{25}
II	—	P_{25}	P_{50}
III	P_{25}	P_{100}	.3 PMP
IV	P_{50}	.3 PMP	.5 PMP
V	P_{100}	.4 PMP	PMP

[1] Precipitation amounts by return period in years.

[2] PMP = Probable Maximum Precipitation.

[3] Each dam will have to be carefully evaluated to determine potential impact of dam failure. If the design engineer can show that damages and loss of life would not be significant as a result of failure, the State Engineer may allow a smaller event as the acceptable criteria.

[4] See Table 4-1, page 3.

[5] The requirement of the principal spillway event is to pass the flows without use of a non-structural emergency spillway.

[6] The requirement of the velocity hydrograph is to pass the flows within acceptable velocity limits (See Table 5-2, page 6).

[7] The requirement of the freeboard hydrograph is to pass the flows without overtopping the dam.

dam failure is also important. If the main impact area is only a few miles downstream, the amount of time available to warn people is short. On the other hand, the time available to warn areas 10 or 20 miles downstream is longer; therefore, the loss-of-life factor will be reduced. The development of a good warning system can significantly reduce loss-of-life impacts.

It is possible that an embankment can withstand overtopping without failing. This may be due to design features, construction methods and materials, and limited depth and duration of overtopping. If it can be shown that overtopping is not likely to result in the failure of the dam, then a smaller design event may be allowed.

(a) Principal Spillway Precipitation

The principal spillway precipitation events are used to determine the capacity of the principal spillway and the minimum elevation of the emergency spillway. Rainfall and snowmelt frequencies for design events of 100-year or less can be found in the USDA-SCS "North Dakota Hydrology Manual." The SCS soil cover complex number (curve number) procedure found in the manual is recommended for determining runoff volumes from rainfall precipitation.

Estimates of direct runoff volumes for design can be found in Soil Conservation Service's Technical Release Number 60, "Earth Dams and Reservoirs," and in the "North Dakota Hydrology Manual." Referenced volumes are for a 10-day duration and are used in the development of a principal spillway hydrograph.

The event that provides the maximum reservoir level should be used as the design event (i.e., 24-hour rainfall, 10-day rainfall or snowmelt). The critical event is dependent on the storage capacity and design of the dam. The 10-day events are the most common critical events, therefore, they should always be included in the analysis.

The time distribution of the precipitation events is also an important factor. The distribution tables found in the "North Dakota Hydrology Manual" are acceptable.

(b) Emergency Spillway Design Precipitation

The velocity precipitation amounts shown in Table 5-1 are the storm events that must be passed through the emergency spillway at a safe velocity. Allowable velocities depend on soils within the spillway. Table 5-2 lists the permissible velocities for vegetated emergency spillways. The values in Table 5-2 may be increased 10 percent when the anticipated use of the spillway is not more frequent than once in 50 years. They may be increased 25 percent when the anticipated use is not more frequent than once in 100 years. The freeboard precipitation amounts, shown in Table 5-1, are the minimum design storms that the structure must pass without overtopping the embankment. The velocity criteria does not apply to freeboard precipitation.

Hydrologic designs of emergency spillways for dam classifications III, IV and V require a determination of the PMP. These PMP amounts can be found in the U.S. Department of Commerce - National Oceanic and Atmospheric Administration (NOAA) "Hydrometeorological Report," Number 51.

For class V dams, it is suggested that the procedures outlined in NOAA "Hydrometeorological Report," Number 52 be followed in determining the Probable Maximum Flood (PMF). For lower class dams, it is adequate to determine the PMP rainfall amounts from the "North Dakota Hydrology Manual," adjust the amounts according to Table 5-1, and input this information directly into the hydrologic model.

Table 5-2. Permissible Velocities for Vegetated Emergency Spillways [1]

Cover[2]	Slope range (percent)	Permissible Velocity: Erosion resistant soils (ft/sec)	Permissible Velocity: Easily eroded soils (ft/sec)
Group 1	0-5	7	5
	5-10	6	4
	Over 10	5	3
Group 2	0-5	5	4
	5-10	4	3
Group 3	0-5	3.5	2.5
Group 4	0-5	3.5	2.5

[1] Use velocities exceeding five feet per second only where good covers and proper maintenance can be obtained. The values apply to average, uniform stands.

[2] Group 1: Sod formers used as mixture or as single species.

Creeping foxtail	Intermediate wheatgrass
Pubescent wheatgrass	Smooth bromegrass
Reed canarygrass	Streambank wheatgrass
Thickspike wheatgrass	Western wheatgrass
Big bluestem	Indiangrass
Prairie sandreed	Sand bluestem
Switchgrass	

Group 2: Mixtures composed of sod formers from Group 1 and bunch grasses from Group 3.

Group 3: Bunch grasses

Hard fescue	Tall wheatgrass
Green needlegrass	Slender wheatgrass
Blue grama	Little bluestem
Sideoats grama	

Group 4: Cover crops

Sudangrass	Oats
Spring wheat	Spring barley
Flax	Winter wheat
Rye	

3. Hydrograph Development and Infiltration Techniques

Acceptable procedures for hydrograph development are contained in the USDA-SCS "National Engineering Handbook," Section 4 - Hydrology. The Snyder and Clark unit hydrographs are also acceptable techniques.

Acceptable procedures for estimating the time of concentrations and the runoff curve numbers are outlined in the "North Dakota Hydrology Manual." The curve numbers for the 10-day rainfall event may be adjusted as shown in the SCS's Technical Release Number 60, "Earth Dams and Reservoirs." These adjustments do not apply to 24-hour and PMP rainfall events. It is recommended that an antecedent moisture condition of II or III be used in the SCS TR-20 computer model.

Base flow should also be included in hydrograph development at all sites where applicable. Base flow

amounts will be determined from available stream gage data or from regional data when site specific data are not available.

If a portion of the watershed is developed, or there is potential for development, it is recommended that the SCS's Technical Release Number 55, "Urban Hydrology for Small Watersheds," be used to make appropriate adjustments. This publication outlines procedures for increasing the runoff rates and flow velocities resulting from developed areas.

4. Routing Procedures

The purpose of flood routing is to determine what rate of flow will occur at specific times and locations in a stream or at a structure. There are two general types of flood routing as applied to dam design and evaluation: (1) stream flow routing; and (2) reservoir routing.

Stream flow or channel routing may be accomplished by several methods. The most common routing techniques are Muskingum, the modified puls, and techniques that use actual channel cross-section data.

Reservoirs can be routed by any number of level pool techniques. The basic requirements include reservoir elevation-storage information and a spillway rating curve. The principal spillway, the emergency spillway and the freeboard hydrographs should be routed through the reservoir with the starting water elevation at the normal water level. The principal spillway should also be adequate to draw down the reservoir pool level to 85 percent of the flood pool storage within a 10-day period. If the pool is not drawn down, the water level at the end of 10 days should be used as the starting water level for the design storm events. This may require an increase in either the spillway capacity or the volume of flood storage.

5. Computer Models

There are several computer models available for the hydrologic analyses in dam design. The Corps of Engineers' HEC-1 model and the SCS's TR-20 and Dams II computer models are recommended. If other models are used, the State Engineer may require model documentation. A hydrologic computer model is required for all design class IV and V dams.

When using a computer model, it is advisable to divide a watershed into subareas on the basis of size, drainage pattern, existing and proposed facilities, vegetation, soil and cover types, channel gradients and precipitation amounts. The subarea flows are connected and combined by channel routing.

It is advisable to calibrate the model results to historical flood events where adequate stream gage data is available. In this manner, the model timing, volume and peak flows can be checked. In areas where stream gage data is not available, it is recommended that alternate techniques be used to calibrate the model.

6. Dam Breach Analysis

Dam breach analysis requires a specific analytical approach rather than the use of procedures described for spillway design. A dam breach model analysis is required of all medium and high hazard dams. The suggested starting water elevation for a dam breach analysis is the elevation of the top of the dam. Although a specific modeling procedure is not required, the National Weather Service Dam Break Flood Forecasting Computer Model is suggested. There are several versions of this model. The SCS's TR-66 model, "Simplified Dam - Breach Routing Procedure," is also available for use.

7. Runoff Yield and Reliability

Where adequate stream gage data are available at a site, estimates will be based on that data. Where stream gage data are not available, it is recommended that estimates be based on procedures outlined in the SCS "North Dakota Hydrology Manual," Chapter VII.

C. Sediment Storage

To assure the full effectiveness of a reservoir, capacity must be provided for sediment accumulation. There are several ways to determine sediment yields or rates of sediment accumulation in reservoirs. Two methods are discussed in this section: (1) the Sediment Delivery Ratio Method, and (2) the Reservoir Sedimentation Surveys Method. In general, the sediment delivery ratio method provides a higher level of sediment accumulation than the survey method. Reservoir sedimentation surveys may provide more accurate data for historical sediment accumulations in North Dakota reservoirs. However, it is advised that for design purposes, the engineer be conservative when using the survey method and apply a suitable factor of safety.

The criteria in this section do not apply to dams constructed as sediment ponds for coal mining operations. Those sediment ponds must be sized in accordance with North Dakota Public Service Commission criteria.

1. Sediment Delivery Ratio Method

The sediment delivery ratio method is well-adapted for estimating current sediment yields and predicting the influence of land treatment measures on future sediment yields. The following equation is employed.

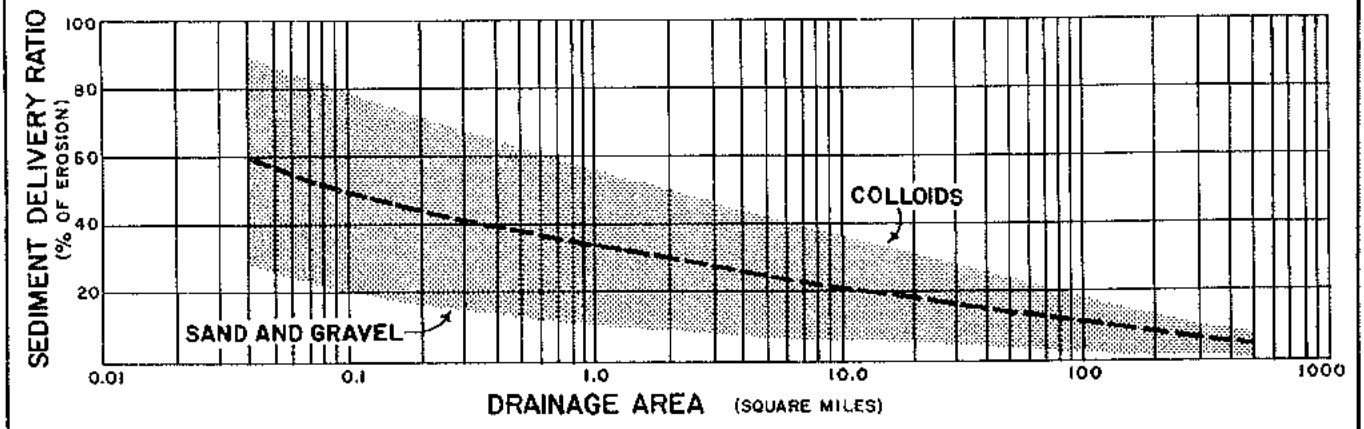
$Y = E(DR)$

Where: Y = sediment yield (tons/acre/year)
E = gross erosion (tons/acre/year)
D.R. = sediment delivery ratio (percent)

The gross or total erosion in the drainage area of a reservoir is the summation of all water erosion occurring in the drainage area. It includes sheet and rill erosion, and channel-type erosion (gullies, valley trenches, streambank erosion, etc.). Procedures for the determination of quantitative values for each type of erosion are outlined in existing guides, handbooks, and technical releases. The SCS can provide valuable assistance in computing gross erosion.

The sediment delivery ratio is dependent on the topography, geology, and size of the drainage area. Any structures above the dam site (other dams, bridges, or culverts) that slow the runoff substantially will also affect sediment delivery. The most important variable is the size of the contributing drainage area. Figure 5-1 is a widely used curve depicting the relationship between sediment delivery ratio and drainage area.

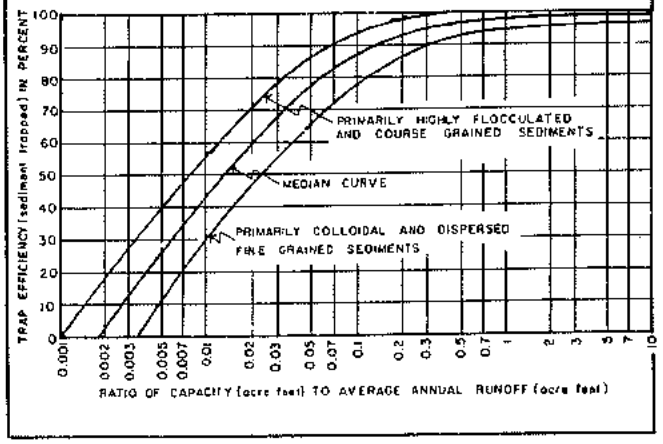
Figure 5-1. Relationship Between Drainage Area and Sediment Delivery Ratio



Sediment accumulation in a reservoir is dependent on the sediment delivery to the reservoir and on the trap efficiency. How the accumulated sediment will be distributed within the reservoir depends upon the character of the inflowing sediment, the operation of the reservoir, and other factors.

Trap efficiency is the amount (in percent) of sediment delivered to the site that will remain in the reservoir. It is a function of detention storage time, sediment characteristics, inflow characteristics and other factors. Trap efficiency can be estimated (using Figure 5-2) on the basis of the ratio of the reservoir capacity in acre-feet to the average annual inflow in acre-feet.

Figure 5-2. Trap Efficiency of Reservoirs



2. *Reservoir Sedimentation Survey Method*

Reservoir sedimentation surveys are excellent sources of data for establishing sediment yields to reservoirs. Reservoir deposition and sediment yield are not synonymous. To obtain the sediment yield to a surveyed reservoir, the measured deposition in that reservoir must be divided by its estimated trap efficiency. This takes into account the portion of the sediment inflow that passes through the reservoir and is not deposited. The use of the rate of deposition, established by a sedimentation survey, implies that both the sediment yield rate and the trap efficiency of the reservoir being designed are the same as that of the surveyed reservoir.

Results of available reservoir sedimentation surveys should be reviewed for design purposes. Table 5-3 lists several reservoirs in North Dakota for which sedimentation surveys have been conducted.

If no reservoirs representative of the area have been surveyed, it may be advisable to conduct sedimentation surveys on reservoirs in the area that are at least 10 years old. It is important that the period of sedimentation record be long enough to be representative of average conditions.

It is also important that the history of reservoirs considered for sediment surveys be known. Sediment removal or drying, or changes in spillway elevations affect sediment volume and distribution.

The reservoir drainage areas on which sedimentation surveys have been made for specific sediment design must be similar in topography, soils, and land use to those drainage areas for which information is desired. In addition, if the measured rates are to be applied directly, the size of the drainage areas of the surveyed reservoirs should not be less than one-half nor more than twice that of the structures being designed. For drainage areas outside these limitations, the annual sediment yield may be adjusted for design use on the basis of the drainage areas to the 0.8 power in the following manner:

$$Y_e = Y_m \left(\frac{A_e}{A_m}\right)^{0.8}$$

Where: Y_e = sediment yield to structure being designed (in tons per year)

Y_m = sediment yield to the surveyed reservoir (in tons per year); measured annual deposition ÷ trap efficiency of surveyed reservoir

A_e = drainage area of reservoir being designed

Where: A_m = drainage area of surveyed reservoir

Table 5-3. Reservoir Sedimentation Surveys

Reservoir	County	Location Sec.	Twp.	Range	Drainage Area (Sq. Mi.)	Sediment (Tons per sq. Mi. per Year)	Sediment (Acre-feet per Year per Sq. Mi.)
Blabon[1]	Steele	3	145	56	1.22	875.0	0.5
Dougherty[1]	Walsh	31	157	57	20.2	18.8	0.01
Gustafson Bros.[1]	Walsh	23	157	57	3.75	77.0	0.04
Gwinner[1]	Sargent	11	132	56	0.222	372.0	0.2
Northern Pacific Railroad[1]	Cass	25	140	54	12.16	39.6	0.02
Melvin Bellerud[1]	Walsh	26	157	57	1.125	114.7	0.07
Milton WPA Dam[1]	Cavalier	31	160	57	42.4	51.5	0.03
Norby Dam[1]	Sargent	20	129	54	0.183	184.0	0.11
Sioux Railroad Reservoir[1]	Walsh	13	157	57	16.86	18.9	0.01
Bald Hill Dam[1]	Barnes	18	141	58	1,979.0	245.0	0.15
Homme Dam[1]	Walsh	19	157	55	229.0	441.0	0.25
Van Oosting Dam[2]	Oliver	6	143	82	1.76	593.3	0.34
Mount Carmel[2]	Cavalier	28	163	59	61.9	104.5	0.06
Erie Dam[2] (Brewer Lake)	Cass	20	142	53	11.15	392.0	0.22
Kropp Farms Dam[2]	Stutsman	14	141	63	2.77	113.3	0.06
Bosserman Irrigation Dam[2]	Golden Valley	2	137	105	37.2	226.5	0.13
Sterling Dam[2]	Burleigh	4	138	76	23.87	33.4	0.02
Upper Turtle Watershed Detention Dam #6[2]	Grand Forks	23	152	56	11.18	34.9	0.02

[1] Souris-Red-Rainy River Basin Comprehensive Study, 1972.

[2] USDA, Soil Conservation Service, Carlson, Carl.

D. Geotechnical Exploration

Geotechnical explorations of potential dam sites must be adequate to determine: (1) the suitability of the foundation and abutments for an earthfill embankment and reservoir; (2) the foundation treatment (preparation) measures required; (3) the excavation slopes of the cutoff trench; (4) the embankment design; and (5) the availability and characteristics of the borrow area materials for the embankment. The explorations should include classification of soils, determination of physical properties, location and extent of soil and rock strata and the variations in ground water levels.

The magnitude of the geotechnical exploration program is governed principally by the complexity of the foundation problems and the design classification of the project. Generally, design class I and II dams may only require two or three augered holes along the centerline of the dam, and two or three augered holes in the proposed borrow area and/or emergency spillway. The centerline auger holes should be 10 or more feet deep, depending on the materials encountered. Usually, no samples are taken and the materials are field classified. If problems are detected, a more extensive program should be undertaken.

Design class III, IV, and V dams require detailed geotechnical explorations. In the preliminary stages of these projects, reconnaissance surveys are undertaken to determine the general suitability of the potential dam sites. The reconnaissance surveys are often completed on several dam locations to determine the most suitable sites. The detailed surveys are made to determine the final dam location and, as quantitatively as possible, determine the geologic conditions that will be encountered during construction.

1. Reconnaissance Surveys

To determine the most suitable site for a dam, reconnaissance surveys are made. These surveys consist of a review of existing geologic information and a visit to the site by an experienced geologist or engineer. The survey normally does not include exploration drilling. The reconnaissance survey is aimed at determining topographically suitable locations and determining the limits of the exploration program. The most common sources of existing information are 7½ minute topographic quadrangle maps, county ground water reports, detailed soils survey reports, aerial photographs and other relevant reports.

The general physiographic features that should be noted include the shapes and types of valleys, the gradients and stages of erosion development, and the terraces (if present along with the valleys). The origin of the terraces is significant, regardless of whether they result from uplift, meandering, structural control, glaciation or landslide.

Observations of ground-water conditions should be recorded. Springs, wells, ephemeral streams, swamps, or other evidences of ground water aid in establishing the water table and the effects of ground water in the area. The reservoir area and road cuts in the vicinity should be examined for stability and strata identification.

2. Detailed Surveys

Reconnaissance commonly brings to light defects disqualifying some of the sites. As the next step, detailed studies are conducted at the more favorable sites. These studies must determine whether there are geological conditions that will affect the stability and

success of the dam and whether these conditions will require special design considerations during foundation preparation and construction.

At this stage of the examination, preliminary cross sections of the valley at potential dam sites should be surveyed and plotted. The drawing of the cross sections may show where more geologic information is needed.

After the surficial explorations, a drilling program can be planned to obtain supplemental geological data. The location of drill holes can also be determined to obtain maximum information. Field exploration is often completed in phases, with the data analyzed between each drilling phase.

A systematic search for suitable construction material for the dam is an important part of the survey. Because of the large volume required for most projects, long haul distances might be prohibitively expensive. Pits and other locations of filter material and riprap should be inventoried, both qualitatively and quantitatively.

3. Soil Classification

Knowledge of soil classification, including typical engineering properties of soil groups, is especially valuable when prospecting for earth materials or investigating foundations for structures. When adequate safety factors are provided, proper soil classification can be used to estimate numerical values of engineering characteristics of soils for use in small dams.

The Unified Soil Classification System is recommended for use in the design and construction of dams. Figure 5-3, the Unified Soil Classification Chart, gives the essentials of the classification system for soils.

In addition to proper classification, it is important to include an adequate description of the soil in reports or logs of explorations. The classification chart contains the information required for describing soils, citing several examples.

4. Sampling

The purposes and uses of samples are numerous. They are required to properly identify and classify soil or rock. They are essential for field density and moisture determinations. Samples are also used in laboratory tests of earth materials, concrete aggregate, filter material, and riprap. To a large degree, samples document the results of explorations for foundations, abutments and construction materials for dams. Obviously, erroneous conclusions will be drawn if the samples are not truly representative of the explorations.

Samples are broadly classified as disturbed or relatively undisturbed. Disturbed samples are those in which no effort is made to maintain the soil structure. Such samples may be secured for general observation and inspection, soil classification, moisture determination, or to obtain compaction characteristics. Relatively undisturbed samples vary from moderately disturbed split-barrel samples to almost completely undisturbed handcut samples. The importance of obtaining representative samples cannot be overemphasized. This requires considerable care because of the variations in natural deposits of earth materials. Representative samples are comparatively easy to secure in trenches, test pits, and cutbanks because the various undisturbed strata can be inspected visually. Bore holes, however, do not permit a visual inspection of the profile. It is also more difficult to secure representative samples by use of bore holes.

Samples may be either individual or composite. An individual sample is a single sample representing one stratum or type of soil. A group of individual samples, representing all the strata from a single test pit, may be combined in the same ratio as the thicknesses of the strata from which the samples were taken to form a composite sample. A sample may also be composited to any desired ratio of the soil types involved. It is usually preferable to obtain individual samples from each stratum of a soil deposit rather than to composite the sample in the field, since the most desirable depth and method of borrow excavation may be determined by trying several composite samples in the laboratory.

The sizes of samples required depend on the nature of the laboratory tests which may be required. The size of the samples will be determined by the laboratory doing the soil mechanics testing. Table 5-4 may be used as a guide.

Disturbed samples should be placed in bags or other suitable containers which will prevent loss of moisture and the fine fraction of the soil. Samples of silty and clayey soils proposed for borrow which are obtained for laboratory Atterberg limits test and Proctor compaction tests should be protected against drying and should be shipped in waterproof bags or other suitable containers to retain the natural moisture.

5. Special Consideration

Certain geologic conditions require special consideration beyond the minimum explorations. They are:

(a) subsidence — the potential for surface subsidence due to past or future solid, liquid (including ground water) or gaseous mineral extraction. In certain relatively dry fine-grained colluvial soils in southwestern North Dakota, sudden subsidence may take place upon saturation and loading. Suspected soils should be examined and brought to the attention of the designer;

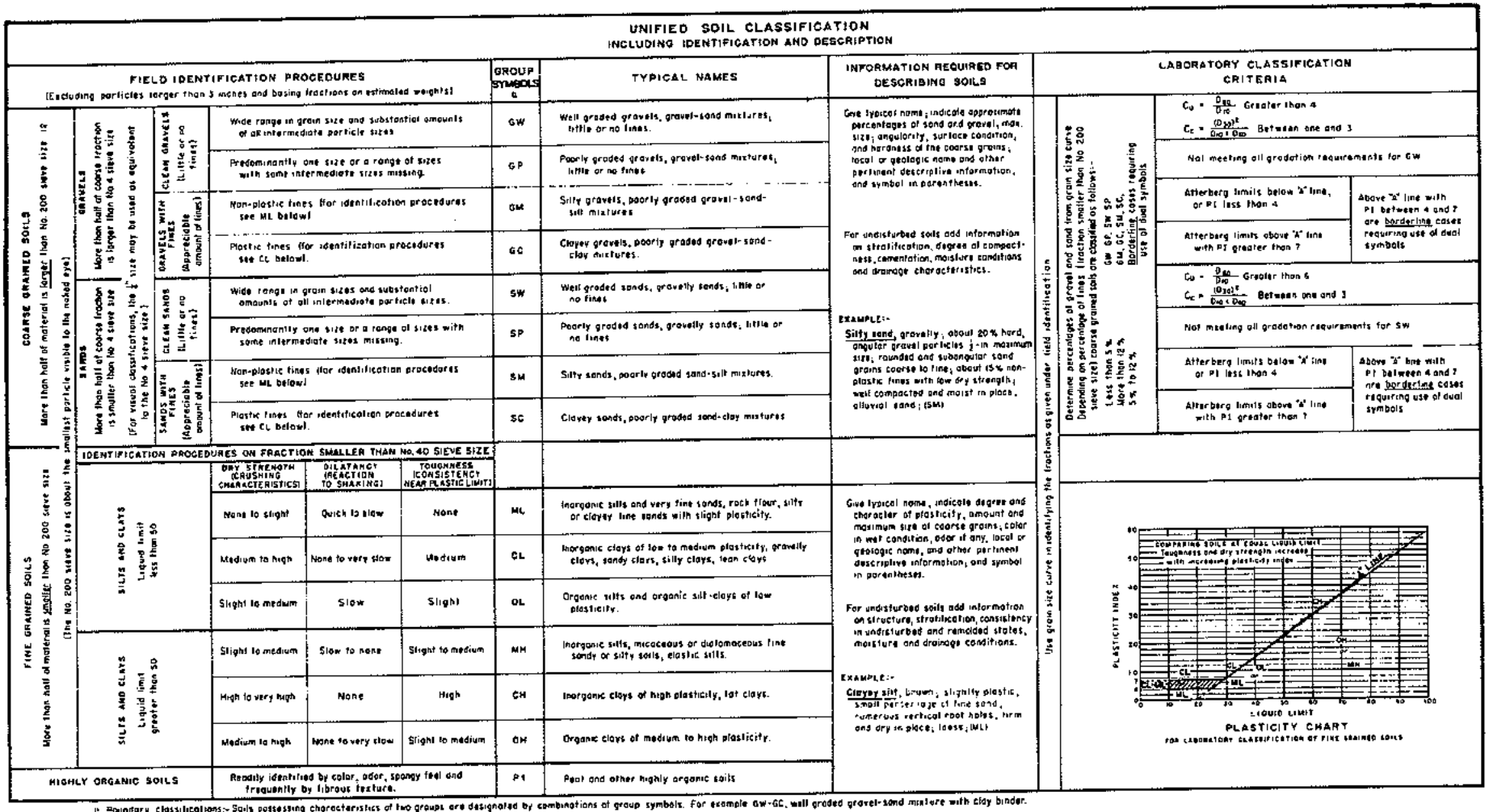
(b) emergency spillways — relatively large dams with emergency spillways in soft rock or cemented soil materials that cannot be classified as soil nor as rock as generally defined for engineering purposes, and spillways in rock with defects require special and individual evaluation;

(c) mass movements — landslides and landslide potential at dam and reservoir sites, especially those in shales. Summarize the history of mass movement in the project area. Emergency spillway cuts and full reservoir effects must be given careful consideration;

(d) multi-purpose dams — the ground water and hydraulic characteristics of the entire reservoir area should be evaluated for leakage, and water budgets developed to determine if reservoir sealing is needed; and

(e) other — special studies and evaluations may be necessary where shales, dispersive soils, coal seams, and artesian water occur at a site. The economic and physical impacts of the pre-emption of mineral deposit, sand, gravel, coal, and oil by a reservoir should also be evaluated.

Figure 5-3. Unified Soil Classification Chart



UNIFIED SOIL CLASSIFICATION
INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3 inches and basing fractions on estimated weights)				GROUP SYMBOLS	TYPICAL NAMES	INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA
COARSE GRAINED SOILS: More than half of material is larger than No. 200 sieve size (The No. 200 sieve size is about the smallest particle visible to the naked eye)	GRAVELS: More than half of coarse fraction is larger than No. 4 sieve size (For visual classifications, the ¼" size may be used as equivalent to the No. 4 sieve size.)	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW	Well graded gravels, gravel-sand mixtures, little or no fines.	Give typical name; indicate approximate percentages of sand and gravel, max. size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information, and symbol in parentheses. For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics. EXAMPLE:- Silty sand, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine; about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM)	Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows:- Less than 5%: GW, GP, SW, SP More than 12%: GM, GC, SM, SC 5% to 12%: Borderline cases requiring use of dual symbols $C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3 Not meeting all gradation requirements for GW Atterberg limits below "A" line, or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols Atterberg limits above "A" line with PI greater than 7 $C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3 Not meeting all gradation requirements for SW Atterberg limits below "A" line or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols Atterberg limits above "A" line with PI greater than 7
			Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.		
		GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures		
			Plastic fines (for identification procedures see CL below).	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.		
	SANDS: More than half of coarse fraction is smaller than No. 4 sieve size	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.	SW	Well graded sands, gravelly sands, little or no fines		
			Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines		
		SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	SM	Silty sands, poorly graded sand-silt mixtures.		
			Plastic fines (for identification procedures see CL below).	SC	Clayey sands, poorly graded sand-clay mixtures		
FINE GRAINED SOILS: More than half of material is smaller than No. 200 sieve size (The No. 200 sieve size is about the smallest particle visible to the naked eye)	IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN No. 40 SIEVE SIZE						
		DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)			
	SILTS AND CLAYS: Liquid limit less than 50	None to slight	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.	Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains; color in wet condition, odor if any, local or geologic name, and other pertinent descriptive information; and symbol in parentheses. For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions. EXAMPLE:- Clayey silt, brown; slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place; loess; (ML)
		Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity.	
	SILTS AND CLAYS: Liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	
		High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays.	
		Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity.	
HIGHLY ORGANIC SOILS		Readily identified by color, odor, spongy feel and frequently by fibrous texture.			PT	Peat and other highly organic soils	

Use grain size curve in identifying the fractions as given under field identification

PLASTICITY CHART
FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS

(a) Boundary classifications:- Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well graded gravel-sand mixture with clay binder.
(b) All sieve sizes on this chart are U.S. standard.

ADOPTED BY - CORPS OF ENGINEERS AND BUREAU OF RECLAMATION - JANUARY 1952

Table 5-4. Recommended Sizes of Samples

Purpose of Material	Sample Size	Remarks
Individual and composite samples of disturbed earth materials for classification and proctor compaction tests.	Sufficient material, all passing the 3-inch sieve, to yield 75 pounds passing the No. 4 sieve.	Include information relative to the percentage by volume; 3 inches to 5 inches and plus 5 inches.
Soil-rock permeability tests.	300 pounds passing 3-inch sieve.	Air dried.
Relative density test.	150 pounds passing 3-inch sieve.	Air dried.
Moisture samples, inspection samples of soil, soil samples for sulfate determination.	Sealed pint or quart jars (full).	Individual inspection samples should represent range of moisture and type of materials.
Concrete aggregate.	600 pounds of pit-run sand if screened: 200 pounds of sand, 200 pounds of No. 4 to ¾-inch size, and 100 pounds of each of the other sizes produced, 400 pounds of quarry rock proposed for crushed aggregate.	For commercial sources, include data on plant ownership, and service history of concrete made from aggregates.
Riprap.	200 pounds representative of quality or examine at site.	Method of excavation used, location of sources of supply and size range.
In-place density and water content of fine-grained soils above water table.	8 to 12-inch cubes or cylinders.	Sealed in suitable container.

E. Embankment and Foundation Design

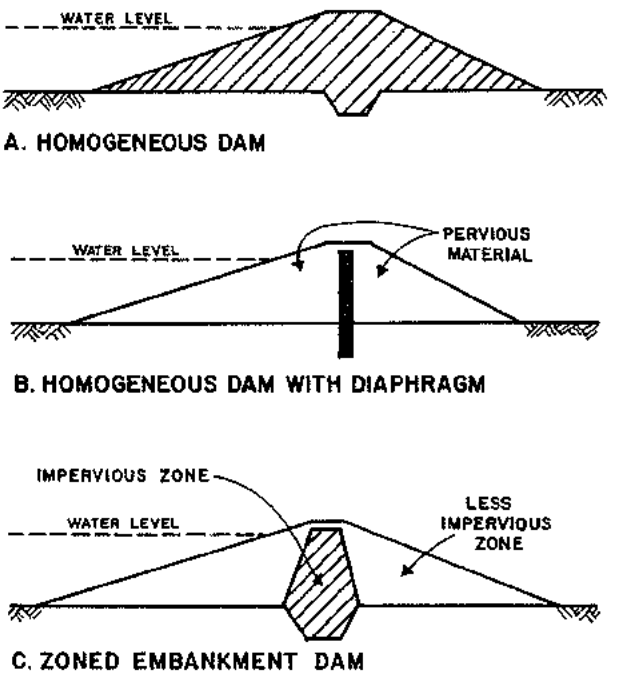
The embankment and foundation design standards are dependent upon the complexity of the individual dam and the design classification of the dam. Generally, design class I and II dams have homogeneous embankments, are constructed without extensive moisture control, and do not have foundation and embankment drains. Design class III dams often require some type of embankment drain, and may require extensive design details. Design class IV and V dams, however, usually require foundation and embankment drains and close control of moisture and density of the fill materials. These dams generally have either a zoned or modified homogeneous embankment. The information in this section was developed to provide general design considerations for all dams along with specific recommendations for design class IV and V dams.

1. Selection of Embankment Type

Rolled earthfill dams are constructed in successive mechanically compacted layers. There are three types: diaphragm, homogeneous, and zoned. Figure 5-4 shows examples of these three types of earth embankment.

With the diaphragm type, the major portion of the embankment consists of a pervious material. A relatively thin diaphragm of impermeable material is provided to form the water barrier. The location of this diaphragm may vary from a blanket on the upstream face to a central vertical barrier. It may be constructed of earth, soil-cement slurry, portland cement concrete, or other material. The blanket or core in an earthfill dam is considered to be a diaphragm if its horizontal thickness at any elevation is less than 10 feet. If the impervious earth zone equals or exceeds this thickness, the design is considered to be of the zoned embankment type. The construction of diaphragm-type earth embankments will be very limited in North Dakota. They should only be

Figure 5-4. Earthfill Embankment Types (drainage systems not shown)



used where the supply of impervious soil is so limited as to preclude the construction of the homogeneous or zoned embankment type of dam.

The homogeneous type of embankment is composed of a single type of material. The material comprising the dam must be sufficiently impervious to provide an adequate water barrier, and the slopes must be relatively flat for stability. The downstream slope of a homogeneous dam may eventually be affected by seepage to a height of roughly one-third the depth of the reservoir pool.

A common type of rolled earthfill dam has a central impervious core, and is flanked by zones of material considerably more pervious. The pervious zones enclose, support, and protect the impervious core; the upstream pervious zone affords stability against rapid drawdown; and the downstream pervious zone acts as a drain to control the line of seepage. For most effective control of seepage, the pervious sections should have, if possible, a progressive increase in permeability from the center to the outer slopes.

The type of rolled-fill dam section selected will primarily be determined by the materials found on the site. Where impervious material is in extremely short supply, a diaphragm type of section may be the only practical alternative. Where the only soil material on the site is impervious, the situation may dictate a homogeneous or modified homogeneous section. Where the materials on the site contain both pervious and impervious materials, the zoned section will probably be preferable because it generally allows steeper embankment slopes.

The designer will have to consider the type of materials which will be excavated from the cutoff trench and the emergency spillway, how these materials can best be used in the embankment design, and what configuration of materials used will result in the most economical section.

2. Foundation Cutoffs

Many of the rolled-earth dam sites contain foundations consisting of alluvial deposits of pervious sand and gravel or shale chips at or near the surface with an impervious stratum of rock, clay, or shale at a greater depth. A positive cutoff is recommended where the impervious stratum joins the foundation with the base of the impervious portion of the embankment. A positive cutoff is desirable, particularly where the water in storage is used for irrigation, municipal or industrial water supply.

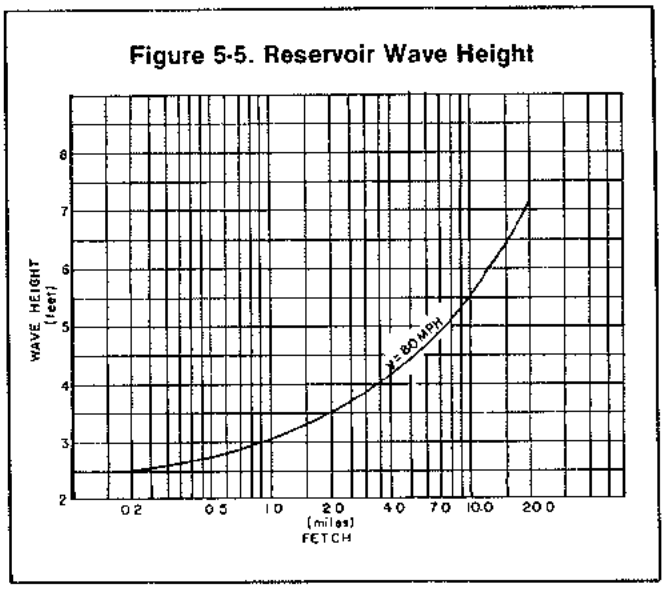
Where a positive cutoff is impractical because of the depth to an impervious stratum, a partial cutoff may provide foundation stability and reduce seepage losses to acceptable levels. Regardless of the foundation conditions, the only way to determine the economical feasibility of a positive cutoff or various percentages of partial cutoff is to make a seepage analysis and water balance.

3. Height

The design height of an earth embankment should be sufficient to prevent overtopping during passage of either the freeboard hydrograph (see Table 5-1, page 5), or the velocity hydrograph, plus the freeboard required for wave action, whichever is larger. The design height of the dam should be increased by the amount needed to compensate for settlement. Therefore, the suggested dam height is equal to the greater of the following: (1) the elevation at the normal water level, plus the increase in water level resulting from a freeboard hydrograph event, plus an allowance for settlement; or (2) the elevation at the normal water level, plus the increase in water level resulting from velocity hydrograph event, plus an allowance for wave action, plus an allowance for settlement. The height of reservoir waves are a function of the length of the fetch and the velocity of the wind. Figure 5-5 shows the reservoir wave height based on fetch and an 80 mile per hour wind velocity. The following formula can be used to determine the wave height for other wind velocities:

$H_W = 2.5 + 0.17\sqrt{VF} - \sqrt[4]{F}$, where:
H_W = height of the wave in feet
V = wind velocity in miles per hour
F = length of the fetch in miles

Figure 5-5. Reservoir Wave Height



4. Top Width

The recommended minimum top width of the embankment is shown in Table 5-5.

The width may be greater than those shown above in order to accommodate embankment zoning, provide

Table 5-5. Suggested Minimum Top Width of Embankment

Dam Height (H) (Feet)	Top Width (Feet)
14 or less	8
15 - 19	10
20 - 24	12
25 - 34	14
35 - 95	(H + 35)/5
Over 95	26

roadway access and traffic safety and/or provide structural stability.

When the embankment top is used as a public roadway, the minimum width should be 16 feet for one-way and 26 feet for two-way traffic. Guard rails or other safety measures may be required and should meet the requirements of the state and county highway departments.

5. Berming

There are several reasons for the installation of berms on rolled-fill embankments. Berms may be needed to provide stability to the structure, particularly where the foundation is soft and weak. In this case, the berm or berms may be of considerable width.

Berms may be placed on either the upstream, downstream, or both faces of a dam to provide access to trash racks and instrumentation. Normally, the upstream face of the dam will have protection against destructive wave action and will require no additional protection against water draining off the embankment. However, the downstream face for dams over about 30 feet in height probably will require drainage berms to dispose of the embankment drainage without eroding the downstream face of the embankment. Downstream drainage berms can be thought of as terraces. They are designed to break up the length of the slope and should be analyzed as a terrace. The greater the length of the embankment, the closer the berms should be spaced and, conversely, the shorter the embankment, the further the berms may be spaced apart.

Surface drainage on the abutments and valley floor is easily overlooked in the design of earth dams. This may result in gullying at the contact of the embankment with earth abutments from which vegetation has been removed during the construction operations. This can be controlled by sod chutes, by a pipe outlet or by constructing a gutter along the contact consisting of coarse aggregate or small stones. An analysis should be made to make sure the expected velocities do not move the aggregate used to construct the gutter. Filter cloth should be installed under the rock material.

6. Foundation and Embankment Drainage

The impervious portion of an earthfill dam provides resistance to seepage which creates a reservoir. Soil varies in permeability, but even the tightest clays are porous and cannot prevent all seepage. Therefore, seepage control is a major concern in dam design. The filter and drainage system must have adequate permeability but still control piping through the embankment.

The percolation of reservoir water through the impervious section depends on the fluctuations of the reservoir level, the degree of permeability of the impervious material in the horizontal and vertical directions, the amount of remaining pore-water pressures caused by compressive forces during construction, and the element of time. The upper surface of seepage is called the phreatic surface; in a cross section it is referred to as a phreatic line. Although the soil may be saturated by capillarity above this line, giving rise to a "line of saturation," seepage is limited to the portion below the phreatic line.

Several terms will be used in this section:

Interceptor Drain — a drain that physically intercepts flow paths or fully penetrates water bearing strata.

Pressure Relief Drain — a drain that produces an area of low pressure to which water will flow from adjacent areas of higher pressure.

Filter Material — filter cloth or a layer or combination of layers of pervious materials designed and installed in such a manner as to provide for water movement, yet control movement of solid particles due to flowing water.

Drain Material — sand, gravel or rock that has specific gradation limits designed for required permeability and internal stability.

Base Material — any material (embankment, backfill, foundation, or other filter layer) through which water moves into a drainage system.

Coefficient of Permeability — the rate of discharge of water under laminar flow conditions through a unit cross-sectional area of a porous medium under a unity hydraulic gradient.

Drains are included in embankments and foundations for two basic reasons:

(a) to prevent piping by controlling migration of soil particles under seepage flow; and

(b) to control pressure build-up by providing adequate capacity to carry the seepage flow.

There are no hard and fast rules for selecting a reasonable margin of safety for drain design. Judgment in this respect must be related to: (1) past experience with similar materials, (2) the detail used in site investigations and testing programs, and (3) the limitations of analyses in representing site conditions.

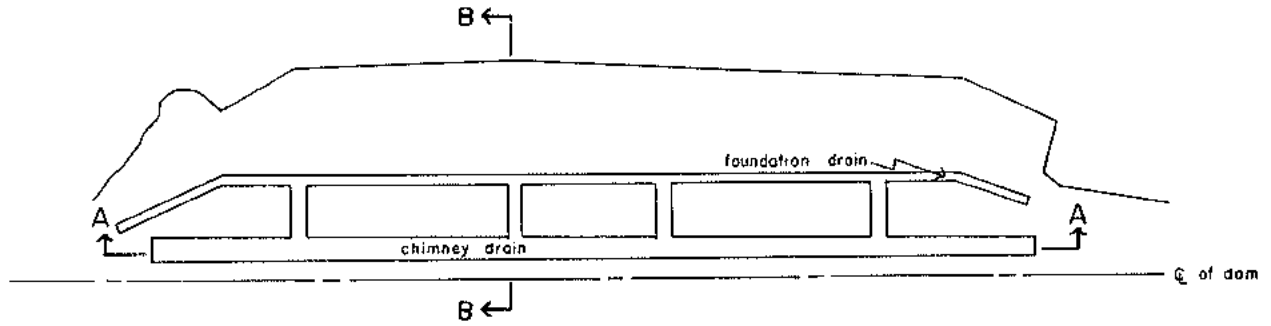
Where extensive drainage is required, the drainage cost can be a substantial part of the construction cost. For this reason, the designer should be aware of the availability of pervious materials on or near the construction site. Designing the drain to utilize local materials can result in substantial savings, even when processing is required.

Four types of drains and the site conditions are discussed below:

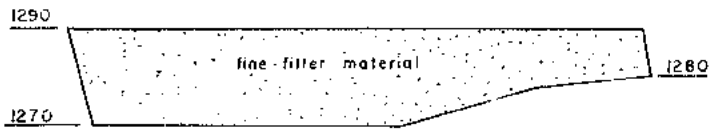
Chimney drains are primarily interceptors that provide positive control of embankment seepage. In this case, water that percolates through the soil is intercepted to ensure that seepage does not occur in materials downstream from the drain.

Chimney drains are applicable where the downstream embankment material cannot be allowed to saturate. The variability of soils in many borrow sources is so great that the engineering properties of the resulting fill cannot be determined with any reasonable degree of accuracy. It may be more economical to place these materials in a "random fill" zone downstream from a positive drain than to waste or disregard them. Materials suspect of undergoing marked and unpredictable changes upon saturation should be placed where they cannot become saturated. Soils containing concentrations of soluble salts and degradable shale derivatives are examples. Middle Branch Park River Detention Dam 10, designed by the Soil Conservation Service, utilizes a chimney drain (Figure 5-6).

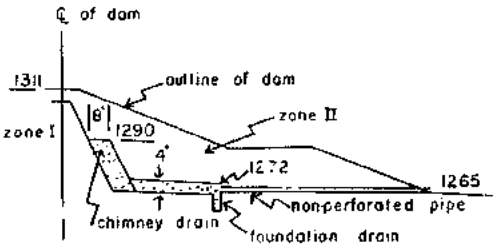
Figure 5-6. Chimney and Foundation Drain System (Middle Branch Park River Watershed Dam, #10-SCS)



PLAN VIEW CHIMNEY DRAIN AND FOUNDATION DRAIN



SECTION A-A. PROFILE OF CHIMNEY DRAIN



SECTION B-B

Chimney drains are also applicable where embankment materials are susceptible to cracking. In this case, water which comes primarily through cracks within the embankment is intercepted to prevent piping and to ensure the overall safety of the dam.

Another type of internal drain is the horizontal blanket drain. The horizontal blanket drain is primarily a pressure relief drain placed in the downstream area of an embankment. Horizontal blanket drains are applicable when: (1) there is no significant difference between the vertical and horizontal permeability of the embankment or the foundation; (2) when bedrock is pervious (drain placed directly on bedrock); or (3) when a good bond cannot be obtained between impervious bedrock and the embankment. Figure 5-7 shows a horizontal blanket drain.

Another type of drain is the foundation drain. The foundation drain is primarily a pressure relief drain. It is most effective when it penetrates all pervious strata. Foundation drains are applicable when the horizontal permeability of the foundation is significantly greater than the vertical permeability. It is often used to relieve pressure from foundation aquifers or to control pipeable foundation materials. Dead Colt Creek Dam near Lisbon, North Dakota utilizes a foundation drain (Figure 5-8).

The final type of drain is pressure relief wells. These wells are generally located near the downstream toe of an embankment for accessibility. Relief wells are particularly adapted for control of pressures from confined and alluvial aquifers that are too deep to drain with foundation drains. Pressure relief wells are often used

Figure 5-7. Filter Blanket and Toe Drain System

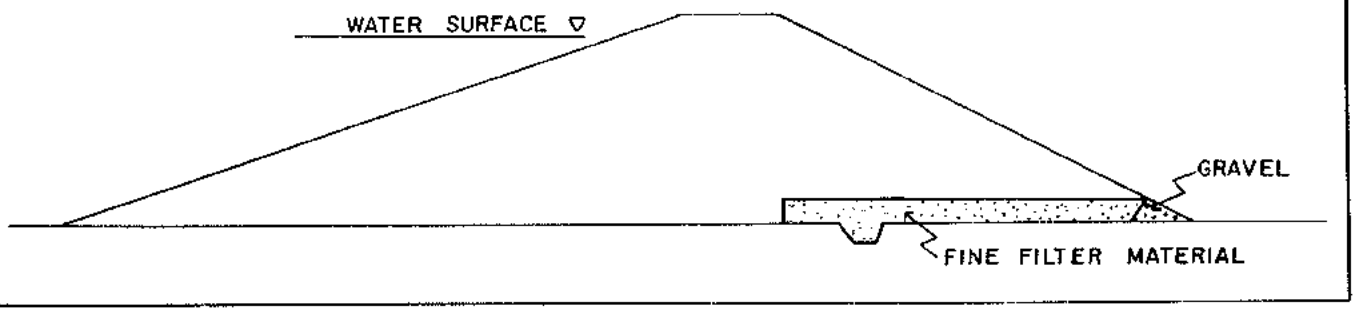
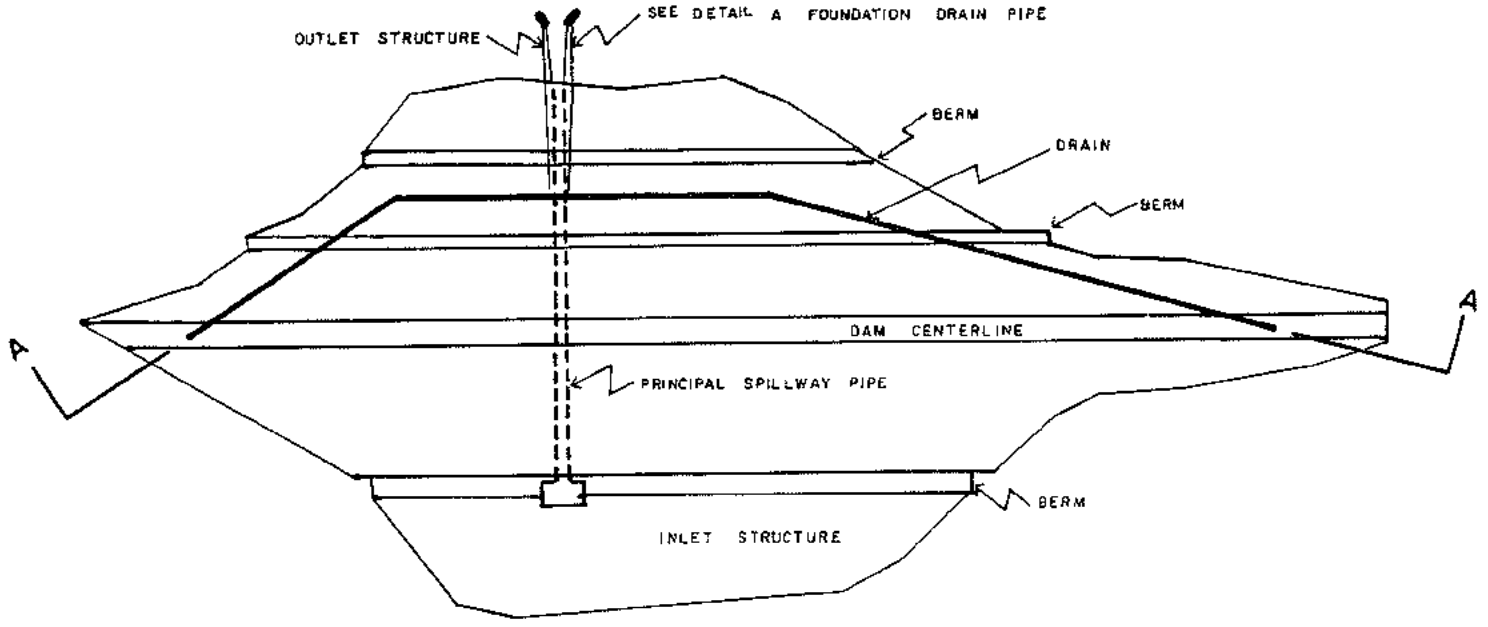
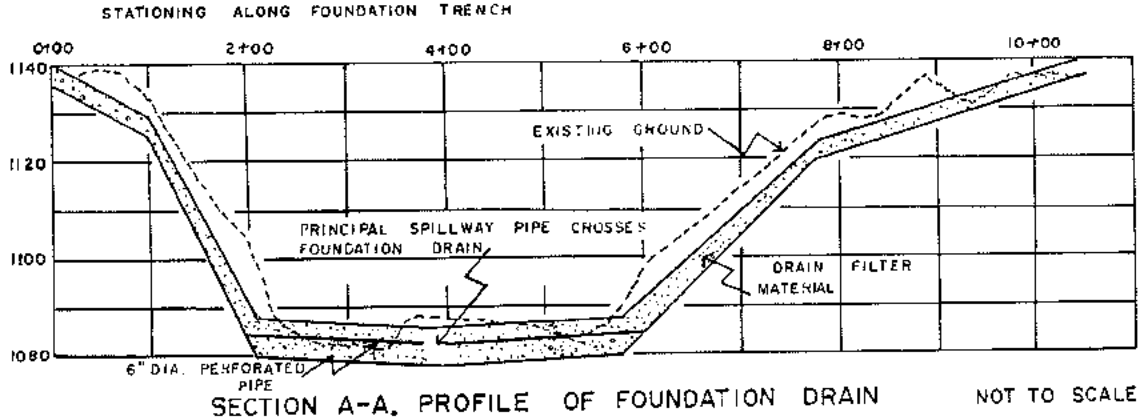


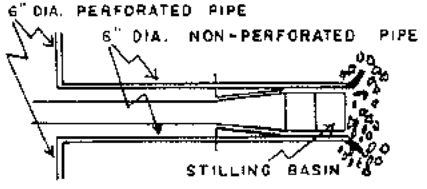
Figure 5-8. Foundation Drain System
(Dead Colt Creek Dam: Lisbon, ND)



PLAN OF FOUNDATION DRAIN
NOT TO SCALE



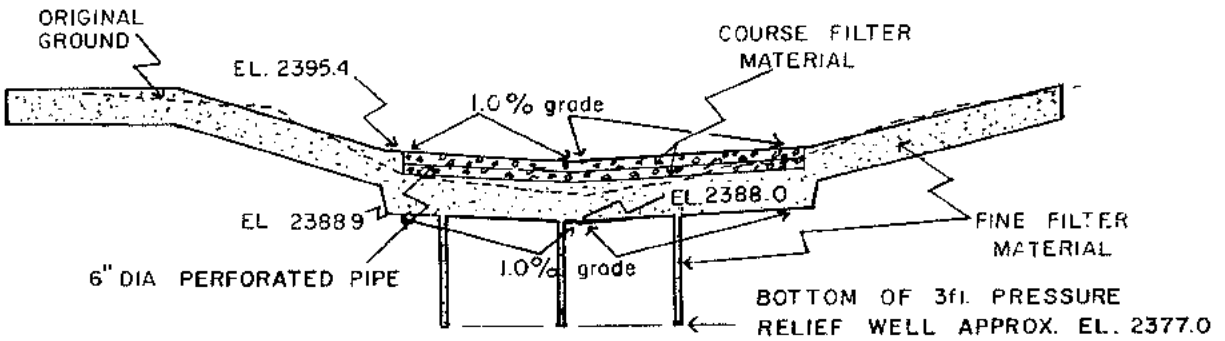
SECTION A-A. PROFILE OF FOUNDATION DRAIN NOT TO SCALE



FOUNDATION DRAIN PIPE

DETAIL "A" NOT TO SCALE

Figure 5-9. Pressure Relief Wells and Foundation Drain (Mott Dam, ND)



in conjunction with the foundation drain as shown in Figure 5-9.

Drain outlets are needed to conduct the accumulated seepage from the embankment or foundation drain to a controlled discharge point. It is recommended that separate outlets be provided for foundation, abutment, embankment and structure drains for ease of monitoring.

There are several special situations which do not conveniently fit any of the four types of drains discussed above. These are:

(a) Embankment Zones — When an embankment zone is to function as a drain, material placed in that zone must meet the permeability and piping requirements for drain material. On-site materials generally contain enough fines to limit permeability. Permeability determinations and flow nets will provide guidance on the effectiveness of these materials for drainage zones.

(b) Springs — It may be necessary to increase the capacity of drains to accommodate flow from springs. In many cases, it is desirable to provide separate drainage outlets for springs.

(c) External Abutment Drains — Drains outside the limits of an embankment should be designed by the procedures used for drains placed under embankments.

(d) Abutment Well Drains — These are either horizontal or slanted wells for drainage of deeply fractured rock abutments and other deep, pervious abutment materials. Design procedures are beyond the scope of this handbook. For detailed information on site investigation requirements and design procedures and considerations, consult soil mechanics textbooks or specialized manuals, and soil mechanics notes issued by the Bureau of Reclamation, Corps of Engineers, or Soil Conservation Service.

Two recent, excellent discussions on this subject are part of the Journal of Geotechnical Engineering, Vol. 110, No. 6, June, 1984. These papers, authored by Sherard, Dunnigan, and Talbot, are entitled: "Basic Properties of Sand and Gravel Filters" and "Filters for Silts and Clays."

7. Structural Stability

Potential failure from sliding, sloughing or rotation should be analyzed and documented. Embankment and foundation design and geotechnical exploration should be consistent with the complexity of the site and the potential for failure. Anticipated settlement, seepage, and cracking should also be considered and documented.

A seismic coefficient of 0.05 should be used for the entire state of North Dakota in a slope stability analysis. The seismic coefficient is the fraction of a weight to be used as a horizontal force in a quasi-static analysis.

At the present time, various procedures are available for calculating the factors of safety of embankment sections. Generally, the basic methods include either the circular arc or the sliding wedge method or both. However, in lieu of the circular arc, the logarithmic spiral method and the sliding wedge method may be modified by use of various arcs, lines of radii of curvature, or composite curves.

The slope stability criteria used in this manual is that used by the SCS. Other agencies or textbooks have excellent discussions and criteria for slope stability, although they often use different nomenclature. The nomenclature used by the SCS for the various shear tests and that commonly used by the geotechnical profession are shown in Table 5-6.

Analyses are to be made for the conditions that are most critical during the design life of the structure. Conditions analyzed are based on various water and loading conditions of the embankment and foundation. The following conditions should be considered: (1) end of construction; (2) steady seepage; (3) rapid drawdown; and (4) seismic. For each case, the analysis should be based on the shear strengths shown in Table 5-7. Minimum safety factors for each condition are also shown in the table. The factor of safety calculations should be based on the ratio of the shear strength available to the shear strength mobilized.

Table 5-6. Nomenclature of Shear Strength Tests

Test Condition	Common Literature Description	Reference for Suggested Test Procedure
Unconsolidated, Undrained	UU or Q	ASTM D2850
Consolidated, Undrained	CU or R	[1] [2]
Consolidated, Undrained with Pore Pressures Measured	CU or R	[1] [2]
Consolidated, Drained	CD[3] or S	[1] [2]

[1] Lambe, T. W., "Soil Testing for Engineers," John Wiley, New York, 1951.

[2] U.S. Army Corps of Engineers, "Laboratory Soils Testing," EM 1110-2-1906, Washington, D.C, 1970.

[3] If the CD tests are run slow enough, the shear strength parameters obtained may be used in lieu of CU parameters.

8. Protection of Embankment Surface

It is generally necessary to provide some protection to the upstream face of a dam. Design class I and II dams seldom need more than vegetative protection on the upsteam face. The orientation and length of the permanent pool, the purpose of the reservoir, and the duration of stages in flood control pools all affect the need for and the type of embankment protection.

Protection for design class III, IV and V dams may consist of rock riprap, either dumped or hand-placed, soil cement, scoria or combinations of the above. Scoria is generally not used if rock is available as it breaks down easily through weathering and requires considerable maintenance. Rock riprap should consist of hard durable rock, well graded, placed at a minimum thickness of 18 inches on 6 inches of well-graded gravel or a layer of engineering fabric (filter cloth).

Judgment is required in the design of the vertical height of the riprap. The ultimate in protection would be to riprap the face of the dam from the toe to the crest, which has been done on some large Corps projects in North Dakota. This is expensive and may not be justified on smaller dams. An alternative for protection above the principal spillway would be to riprap the portion of the embankment that would be underwater for a 48-hour period during the principal spillway design event (Table 5-1, page 5), plus an allowance for wave height (Figure 5-5, page 13). Steep embankment slopes and erodible soils may require additional protection.

The protection below the normal pool elevation is dependent upon several factors including the purpose of the reservoir and the base flow of the inflow stream. A water supply reservoir will generally have a wide range of stages during the year due to withdrawals. A recreation dam on a stream with a base flow may only require riprap from three feet below the permanent reservoir elevation. The same type of reservoir on a stream with little base flow may require that the riprap extend six or more feet below the permanent elevation. Recreation reservoirs are subject to wave action from boats and water-skiers and, therefore, it is necessary to provide adequate riprap above and below the normal reservoir water level.

Recommended references on slope protection include the Soil Conservation Service Technical Release No. 56, "A Guide for Design and/or Layout of Vegetative Wave Protection for Earth Dam Embankments," and No. 69, "Riprap for Slope Protection Against Wave Action."

9. Instrumentation

Instrumentation can significantly improve the overall safety of a dam by providing continuous surveillance of the structure. Instrumentation is normally associated with large - high hazard dams, but it is also used in dams with unusual design features. The State Engineer recommends that instrumentation be incorporated into all class V dams and that it be considered for all class IV dams.

Instrumentation refers to the method and equipment used to make physical measurements of dams. Instrumentations is not, however, a substitute for inspection, but is a supplement to visual observations and inspections. Visual examinations are aided by monitoring instruments that measure seepage and leakage through and around the embankment, movements of the embankment and foundation, and water levels and pressures within the embankment and the foundation. Adequate records of such measurement devices, along with the visual observations, should be maintained. To be effective, these records should be continuous and periodically reviewed by a professional engineer versed in the design and vulnerability of embankment structures. These reviewers should be able to distinguish the important indicators from the unimportant. A tendency toward change in behavior of the dam should signal a need for further review and analyses.

Measurements and readings should be taken frequently during construction and after completion of the project. The number of measurements may be reduced if the structure performs satisfactorily. If the structure shows any tendency toward weakness or unsatisfactory performance, the time interval between measurements should be shortened appropriately to provide analytic data that can warn of impending problems. Post-construction monitoring should continue for several cycles of reservoir operation to document cyclic changes.

There are three general types of instruments used to monitor dams. These include seepage monitoring instruments, embankment movement instruments and water pressure instruments (piezometers). Table 5-8 provides additional information on various monitoring instruments.

a) Seepage and Leakage

All dams will leak to varying degrees, but every leak should be monitored and recorded. If there is a flow, the quantity flowing should be measured by creating a drop and installing a pipe, a v-notched weir, a weir, or a flume. A record should be kept of the discharge and the reservoir elevation. Toe and/or foundation drains should

Table 5-7. Slope Stability Criteria for Dams (Dam Design Class III, IV, and V only)

Design Condition	Primary Assumption	Remarks	Shear Strength To Be Used 1/2/	Minimum Factor of Safety (Dam Design Class)
I. End of construction	Significant construction pore pressures expected	1. Embankment containing impervious soils at water contents equal to or greater than the optimum water content and/or 2. Saturated impervious foundation strata too thick to consolidate during construction	UU	1.4 (all classes) (1.3 is acceptable for embankments on strong foundations, i.e., the failure surface is located entirely in the embankment)
	For soil zones where significant construction pore pressure is not expected	pervious embankment zones and/or foundation strata	$\overline{CU}$ or CD	
II. Rapid drawdown	Drawdown from the emergency spillway crest to the crest of the lowest gated or ungated outlet	Failure surface can be confined to the embankment or extend into the foundation if low permeability soils are involved	Use alternative 1 or 2 below 1. Lowest shear strength from composite envelope of CU and $\overline{CU}$, or 2. Most limiting of CU 3/ and $\overline{CU}$	1.2 (all classes)
III. Steady seepage without seismic forces	1. Water surface at the principal spillway 2. Phreatic surface fully developed through the embankment	Failure plane confined to the embankment only	$\overline{CU}$ or CD	1.5 (class IV, V) 1.4 (class III)
	3. Piezometric surface for estimating uplift in saturated soil zones is determined with reservoir at the emergency spillway crest	Failure plane extends into the foundation	Most limiting 3/ of four combinations as follows: Comb. No. 1: Found Soil CU, Emb. Soil CU Comb. No. 2: Found Soil CU, Emb. Soil $\overline{CU}$ Comb. No. 3: Found Soil $\overline{CU}$, Emb. Soil $\overline{CU}$ Comb. No. 4: Found Soil $\overline{CU}$, Emb. Soil CU	1.4 (all classes) 1.4 1.5 1.5
IV. Steady seepage with seismic forces	1. Water surface at the crest of the principal spillway 2. Phreatic surface fully developed through the embankment	Failure plane may be confined to the embankment or may extend into the foundation	Most limiting 3/ of four combinations as follows: Comb. No. 1: Found Soil CU, Emb. Soil CU Comb. No. 2: Found Soil CU, Emb. Soil $\overline{CU}$ Comb. No. 3: Found Soil $\overline{CU}$, Emb. Soil $\overline{CU}$ Comb. No. 4: Found Soil $\overline{CU}$, Emb. Soil CU	1.0 (all classes) 1.0 1.1 1.1

1/ Always use $\overline{CU}$ or CD shear strength for pervious soil zones within the foundation or embankment.

2/ Use infinite slope stability analysis whenever the C or $\overline{C}$ intercept strength is zero for free draining soils that are tested to simulate low confining pressures. This situation exists for failure planes located near the embankment surface.

3/ Most limiting is the combination resulting the lowest factor of safety. Some combinations may be eliminated by inspection and judgement. Additional combinations may be necessary for some stratified foundations.

Table 5-8. Monitoring Instruments

Type	Purpose and Use	Remarks
1. Piezometers		
a) observation wells (hydraulic piezometer)	measures water height in a free stand pipe or vertical tube as a result of water pressure at the openings in the stand pipe.	a, b, c, e, j, and k
b) electronic piezometer	measures pore water pressure by deflecting a calibrated membrane and the deflection is measured electronically to give water pressure. It provides a check on seepage conditions and performance of the drainage system.	a, c, d, g, h, i, and j
c) gas pressure piezometer	measures pore water pressure by balancing it with pressurized gas in a calibrating unit. It also provides a check on seepage conditions and performance of the drainage system.	a, c, d, g, h, i, j, and l
2. Inclinometers	it is a vertical tube placed in the embankment after construction, and used to monitor internal displacements or movements within the embankment or foundation of usually higher dams. These movements will undoubtedly be detected before the effects appear on the surface. The system uses special casting with grooves on the inside at the quarter points.	c, f, and j
3. Triangulation and trilateration	iron pins and concrete monuments usually installed along an upper edge of the embankment and/or along a downstream slope. survey instruments are used to note location and elevations. Sometimes a base line can be set up and also points on the downstream slope of a dam. These distances can be checked then with an EDM.	
4. Tiltmeters	use to measure internal deformation rotational and tilting.	b, c, i, and j
5. Earth pressure cells	measures earth pressures at contact plane between soil and structure.	c, d, and j

REMARKS

a) can be used to determine phreatic line when a set of wells runs perpendicular to centerline.
b) can be installed after dam is completed.
c) the reservoir elevation should also be recorded.
d) usually installed during construction.
e) should be capped when not being read.
f) relatively expensive to install and monitor.
g) can be installed in the original foundation.
h) has a better response to small pressure changes than an observation well.
i) an engineer should be consulted to evaluate the soils and supervise the installation of piezometers.
j) each instrument reading should be plotted, graphed and compared to previous readings.
k) observation wells may be read in the following ways:
   (1) measuring tape with weight — record depth and length wetted from known top of case elevation;
   (2) placing air pipe and gage into well. Pressure indicates depth of water above lower end of pipe;
   (3) a graduated electric cord and current meter;
   (4) sonic sounder and recorder;
   (5) pressure transducer; and
   (6) float and recording drum.
l) gas appears to be more trouble-free than the electronic.

also be monitored and recorded along with the reservoir elevation. Any wet spots should be noted and the location, size and condition recorded.

b) Embankment Movements

Considerable movement of embankment dams can be anticipated during and immediately after construction. Much of the movement may be attributed to foundation settlement under the loading of the embankment. The embankment will also move as the reservoir is filled for the first time and may periodically cycle movements as the reservoir is emptied and filled in succeeding seasons. Movements are determined by periodic measurements of monuments placed in or on the structure and abutments. For existing dams, monumentation to measure movements is usually limited to the crest and downstream slopes. The monuments usually consist of steel rods or surveyor's markers imbedded in concrete placed in excavations on the embankment of the abutments. Differences in elevation and location of the monuments are measured by transit and level surveys of the monuments.

Measurements of the locations of the monuments on the surface of the embankment should be such that changes in both vertical and horizontal locations are measured. The measurements should be reduced to graphical displays of changes in vertical location, changes in horizontal location along the axis of the embankment, and changes in horizontal location transverse to the axis of the embankment (upstream and downstream). The water surface elevation in the reservoir at the time of measurement of the monument is important and should be recorded along with the

monument location data. Whenever possible the monuments should be tied to a bench mark that is outside the influence of the dam and reservoir. Monuments should be located such that they are not damaged by normal traffic or operations.

c) Piezometric Pressures

A primary indicator of the performance of an embankment is the water pressure distribution within the structure and its foundation. Water pressures in the embankments are measured by piezometers. There are basically three types of piezometers in common usage: (1) a hydraulic piezometer in which the water pressure is obtained directly by measuring the elevation of water standing in a pipe or vertical tube; (2) an electronic piezometer in which the water pressure deflects a calibrated membrane and the deflection is measured electronically to give the water pressure; and (3) a gas pressure unit in which the water pressure is measured by balancing it with a pressurized gas in a calibrated unit.

Piezometers should be installed in an embankment structure so that the location of the free water surface or phreatic line can be determined. The line of piezometers would be perpendicular to the longitudinal axis of the embankment. In large structures there may be several lines of piezometers, while in smaller structures and existing dams perhaps one line would be adequate.

F. Principal Spillway Design

1. General

The design standards and criteria for the principal spillway are primarily dependent on the dam design classification and purpose. Design classification I and II dams may not require a principal spillway, only a grassed emergency spillway. The requirement for a principal spillway on a small dam is more dependent on the drainage area and on the presence of base flow. If a class I or II dam does not need a principal spillway, it is advisable to include a small pipe to protect the vegetation in the emergency spillway from long duration flows. This pipe should be large enough to pass the normal summer flows.

It is suggested that the class III, IV, and V dams be designed in accordance with the hydrologic criteria shown in Table 5-1, page 5. In addition to these criteria, the following must be considered in determining the design capacity: (1) the purpose of the dam; (2) the amount of storage provided by the retarding pool; (3) the kind of emergency spillway; (4) the stream channel capacity and stability downstream; (5) the potential damage from prolonged storage in the retarding pool; (6) the potential damage from prolonged high outflow rates; (7) the possibility of substantial runoff from two or more storms before the retarding pool has emptied; (8) the limitations imposed by water rights or other legal requirements; (9) the environmental concerns; (10) the planned or potential alterations of the channel downstream; (11) the planned or potential development of the downstream floodplain; and (12) the necessity to pass base and flood flows during construction.

In addition to the principal and emergency spillways, downstream water rights may require a low level riparian outlet or an alternative method of water release. The required discharge capacity and frequency of use will normally determine the type of riparian release.

Corrugated metal pipes (CMP) are not recommended for design classification IV and V dams. When used in smaller dams, the CMP should be coated for longer life. The use of corrugated metal is more advisable for use in dry dams than dams with permanent storage. Design classification IV and V dams normally require concrete principal spillways — monolithic concrete box, concrete pipe, steel cylinder concrete pipe or a concrete chute.

The quality and type of concrete used in dams is also dependent on the design classification. Generally, 3,000 psi concrete is adequate for classes I, II and III dams. Air entrained 4,000 psi concrete is suggested for design class IV and V dams.

2. Types of Principal Spillways

There are two general types of principal spillways commonly used in North Dakota, a conduit (pipe or box culvert) and a chute spillway. Heart Butte Dam near Elgin, North Dakota, utilizes a conduit type main spillway (See Figure 5-10). Figure 5-11 shows the chute spillway system for Epping Dam in North Dakota.

a. Conduit Principal Spillway

Conduit spillways consist of an inlet structure, a closed discharge pipe or box culvert and an outlet structure or plunge pool. A conduit spillway can be used advantageously on most dams in North Dakota. One advantage of this type of spillway is that near maximum capacity is attained at relatively low heads. This characteristic makes the spillway ideal for use where the maximum spillway outflow is to be limited. However, there is little increase in capacity at higher reservoir levels.

The inlet structure should be designed: to maintain the reservoir pool level near the inlet crest elevation during low flood periods; to establish full pipe flow at as low a head as practical; and to operate without excessive surging, vibration, or vortex action. This requires the inlet to have a larger cross-sectional area than the main conduit.

Inlet structures should be designed to exclude trash too large to pass freely through the spillway and the outlet structure. Trash racks should be designed to provide positive protection against clogging of the spillway under any operating level. The average velocity of flow through a clean trash rack should not exceed 2.5 feet per second under the full range of stage and discharge. Velocity should be computed on the basis of the net area of opening through the rack.

If the inlet structure is used to keep the sediment pool drained, the trash rack or riser should extend above the anticipated sediment elevation. The velocity through the net area of the trash rack should not exceed two feet per second when the water surface is five feet above the top of the trash rack or riser inlet.

For small design class I and II dams and for dry dams, the inlet structure may consist of only a flared section or a hooded-inlet to improve the hydraulic efficiency of the conduit entrance. An inlet weir box is commonly

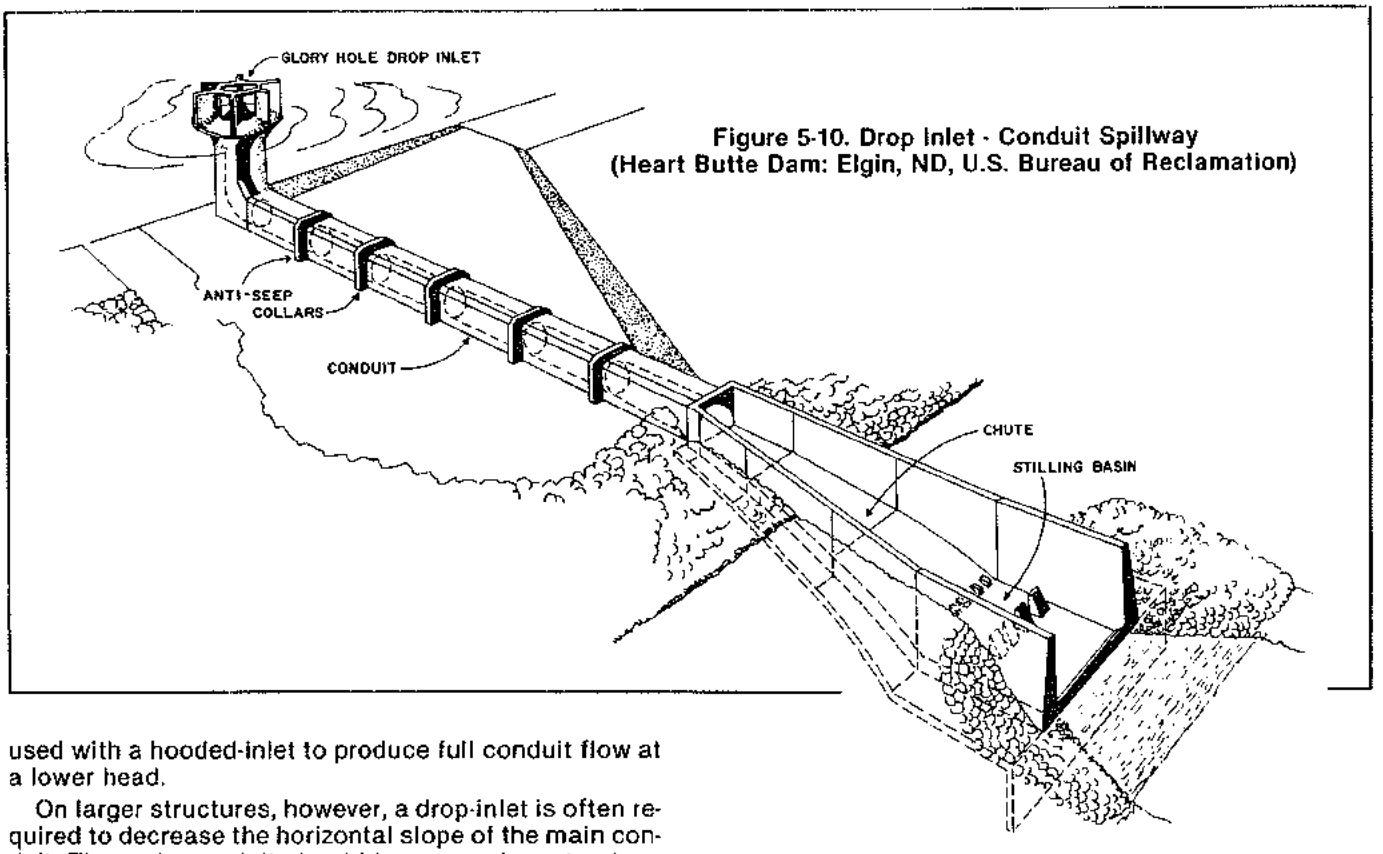


Figure 5-10. Drop Inlet - Conduit Spillway (Heart Butte Dam: Elgin, ND, U.S. Bureau of Reclamation)

used with a hooded-inlet to produce full conduit flow at a lower head.

On larger structures, however, a drop-inlet is often required to decrease the horizontal slope of the main conduit. The main conduit should have an adequate slope to ensure free drainage of all sections of the conduit including camber, but the maximum slope should not exceed five percent. The drop-inlet structure should be designed to structurally withstand all water, earth, ice, and earthquake loads to which they may be subjected. Figure 5-12 shows the drop-inlet structure for Dead Colt Creek Dam located near Lisbon, North Dakota.

Standard drop-inlet structures have been developed by the Soil Conservation Service. These have an inside width equal to the diameter of the conduit and an inside length equal to three times the diameter of the conduit. All closed conduit spillways designed for pressure flow require adequate anti-vortex devices.

The conduit should be straight in alignment when viewed in plan. Changes from straight alignment should be accomplished by watertight angle changes at joints or by special elbows having a radius equal to or greater than the diameter of the conduit. Thrust blocks are to be provided if special pipe elbows are used. Thrust blocks distribute the thrust caused by change in direction, providing for the maximum possible discharge.

Discharge characteristics of the drop-inlet spillway may vary with the range of the head. The control will shift according to the relative discharge capacities of the weir, the transition, and the conduit. Therefore, hydraulic model testing should be considered if the maximum total head on the spillway is more than 40 feet or if the conduit velocity exceeds 40 feet per second.

Conduits under earth embankments must support the external loads with an adequate factor of safety. They must withstand the internal hydraulic pressure without leakage under full external load and settlement and

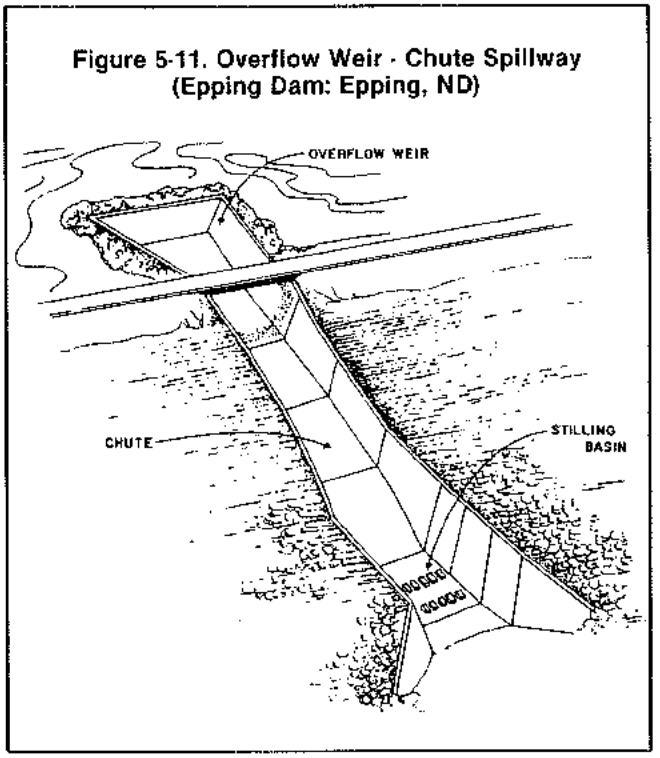
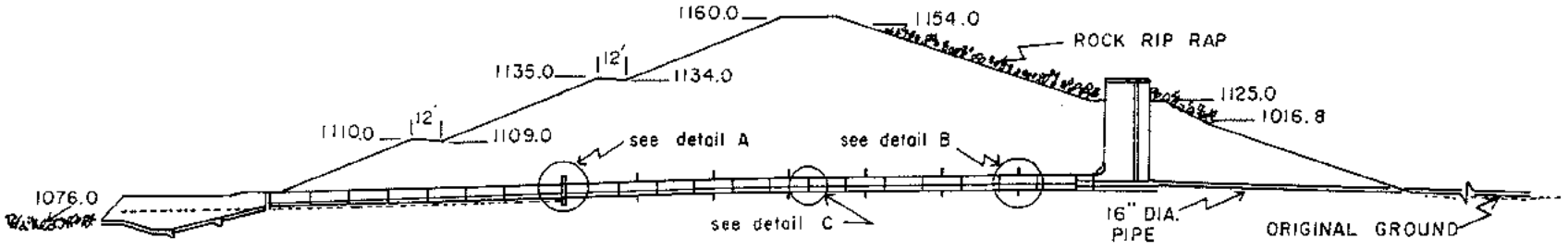


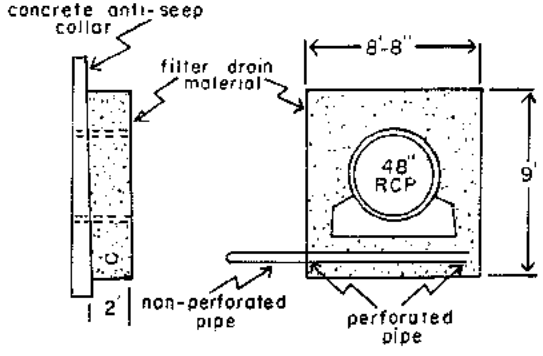
Figure 5-11. Overflow Weir - Chute Spillway (Epping Dam: Epping, ND)

convey water at the design velocity without damage to the interior surface of the conduit. Rigid principal spillway conduits should be designed as positive projecting conduits.

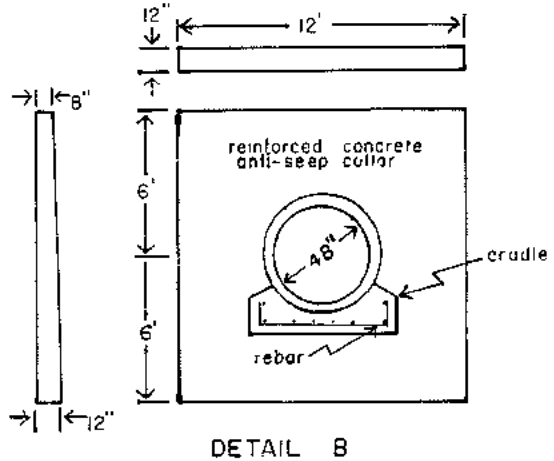
Figure 5-12. Conduit Spillway with Anti-Seep Collar and Concrete Cradle (Dead Colt Creek Dam: Lisbon, ND)



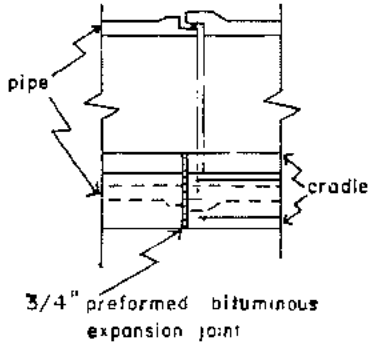
EMBANKMENT ELEVATION VIEW
(not to scale)



DETAIL A
CONDUIT FILTER DRAIN
(not to scale)



DETAIL B
ANTI-SEEP COLLAR
AND CONCRETE CRADLE
(not to scale)



DETAIL C
PIPE AND CRADLE JOINT
(side view)
(not to scale)

The material used for the conduit should be determined by the size of the dam, the economic life of the dam, and the relative ease of replacement. Class IV and V dams should utilize precast reinforced concrete pipe or cast-in-place rectangular reinforced concrete box culverts.

Concrete cradles are recommended under all concrete pipes. It is important to articulate the cradle at all joints. Figure 5-12 shows the concrete cradle design for the Dead Colt Creek Dam near Lisbon, North Dakota.

If corrugated metal pipes are used in larger dams, the joints should be electrically bridged on the outside of the pipe with insulated copper wire, No. 6 AWG or larger, securely attached to the uncoated pipe metal at both sides of the joint. The wire should have a tough waterproof insulation designed for direct burial, with a rating of at least 600 volts. Bare wire and exposed pipe metal at the point of connection should be thoroughly coated with a coating equivalent to the original pipe coating, to prevent the entry of moisture.

Geophysical exploration utilizing electrical resistivity and pH (soil acidity) of the subgrade and backfill materials to be adjacent to the conduit should be made. Resistivity measurements should be made on saturated samples. Cathodic protection should be provided for corrugated steel pipe in soil whose resistivity in a saturated condition is less than 4000 ohms cm or whose pH is lower than five.

Conduits should be designed and constructed to remain watertight under maximum anticipated hydrostatic head and maximum probable joint opening, including the effects of joint rotation and the required margin of safety. The required joint extensibility in concrete pipes is equal to the unit horizontal strain in the earth adjacent to the conduit, multiplied by the length (in inches) of the section of conduits between joints, plus the extension (in inches) due to calculated joint rotation, plus a margin of safety. A margin of safety of not less than 0.5 inch should be used.

The required joint extensibility, plus the maximum permissible joint gap, equals the required joint length. The required joint extensibility depends on the maximum potential foundation consolidation under the spillway barrel. For class IV and V dams, the consolidation should be estimated from adequate foundation borings and samples, soil mechanics laboratory tests, and engineering analysis. For class II dams, where undisturbed foundation samples are not taken for other purposes, approximate procedures based on soil classification and experience may be used for estimating foundation consolidation.

Only joints incorporating a round rubber gasket set in a positive groove should be used on precast concrete pipe conduits. Concrete pipe should have steel joint rings providing rubber to steel contact in the joint.

Articulation of the conduit (freedom for required rotation) should be provided at each joint in the conduit, at the junction of the conduit with the riser and at any outlet structure.

Piping and seepage control around the conduit is an important consideration. For many years, anti-seep collars were required on conduits passing through earth embankment dams. Although no longer used in all dams, anti-seep collars are still an acceptable method for seepage control. When used, the anti-seep collars should be designed such to extend the seepage path by 15 percent through the saturated zone. The major disadvantage of anti-seep collars is that it is difficult to compact earth directly against the concrete structure. A large amount of compaction by hand labor is needed. An alternative to anti-seep collars is a filter drain around a section of the conduit. However, conduit filter drains still require manual compaction around the conduit.

The Dead Colt Creek Dam utilizes both anti-seep collars and a conduit filter drain. Figure 5-12 also shows the embankment and principal spillway of the project including details of the anti-seep collars and the conduit filter drain.

Foundation drains and embankment chimney drains that meet the minimum size and location limits are sufficient without a separate filter drain. The use of anti-seep collars is recommended if a drainage system is not utilized in the structure.

When spillway flows drop from the reservoir pool level to the downstream outlet channel level, the static head is converted to kinetic energy. This energy manifests itself in the form of high velocities which, if not impeded, results in erosion. Means of returning the flow to the river without serious scour or erosion to the toe of the dam or damage to adjacent structures must be provided.

The choice of the type of outlet structure should be based on a careful consideration of all site and flow conditions that may affect operation and energy dissipation. The following guidelines should be considered in selecting the type of outlet structure:

- Cantilever outlet and plunge pools may be installed where their use does not create a piping hazard in the foundation, and where they are compatible with other conditions. Plunge pools are to be designed to dissipate the energy and to be stable. Unless the pool is to be in bedrock or very erosion resistant materials, riprap will be necessary to ensure stability.

  Cantilever outlets should be supported on bents or piers and are to extend a minimum of eight feet beyond the bents or piers. The bents are to be located downstream from the intersection of the downstream slope of the earth embankment, with the grade line of the channel below the dam. They should extend below the lowest elevation anticipated in the plunge pool. The invert of the cantilever outlet should be at least one foot above the tailwater elevation at maximum discharge.
- Saint Anthony Falls (SAF) basins may be used where they are economical and where there is adequate control of tailwater. Care must be taken to ensure that the outlet channel is properly designed and is constructed in accordance with the design. Riprap may be required to ensure that the design tailwater is maintained.
- Impact basins may be used when positive measures are taken to prevent large debris from entering the conduit.

b. Chute Spillway

Chute spillways ordinarily consist of an entrance

channel, a control structure and an outlet channel. The U.S. Bureau of Reclamation's "Design of Small Dams" is an excellent reference.

Favorable factors influencing the selection of chute spillways are: the simplicity of their design and construction, their adaptability to almost any foundation condition, the overall economy obtained by using the spillway excavation in the embankment, and the high discharge-head ratio possible. The disadvantages to chute spillways stem primarily from settlement and uplift problems which may require structure drainage. Chute spillways provide only very limited flood control advantages.

G. Emergency (Secondary) Spillway Design

1. Location

Emergency spillways, whenever possible, should be located away from the dam in an undisturbed area. Topographic saddles generally make good sites. The layout and profile of vegetated or earth spillways should provide a maximum bulk of material to ensure safety against breaching of the spillway during the passage of the freeboard hydrograph.

2. Design Considerations

Excavated spillways consist of three elements: the inlet channel (sometimes referred to as the forebay), the control section, and the exit channel.

The relationship between the water surface elevation in the reservoir and the discharge through the emergency spillway should be evaluated by computing the head losses in the inlet channel upstream of the control section. If a control section is not used, the spillway should be evaluated by computing the water surface profile through the full length of the spillway. Bernoulli's equation and Manning's formula should be used to evaluate friction losses, compute water surface profiles and determine velocities. Subcritical flow exists in the inlet channel. The flow conditions change to critical in the control section.

It is recommended that the inlet channel be level for a minimum distance of 30 feet upstream from the control section. This level part of the inlet channel should be the same width as the exit channel, and its centerline should be straight and coincide with the centerline of the exit channel. A curved centerline is permissible in the inlet channel upstream from the level section, but it must be tangent to the centerline of the level section.

The centerline of the exit channel must be straight and perpendicular to the control section for a distance equal to at least one-half of the maximum base width of the dam. Curvature may be introduced below this point, provided that the flowing water will not impede on the dam should the channel fail at the curve.

The exit channel should be as long as is reasonably practical. It should be of sufficient slope to ensure supercritical flow for all discharges greater than 25 percent of the freeboard hydrograph flows. It is also recommended that the ground-water level be determined in the emergency spillway area. If the ground-water table is at or near the surface, or if the emergency spillway outlet channel intercepts the water table, a drainage system may be necessary.

The maximum velocity limitations for vegetated channels apply to the exit channel (See Table 5-2, page 6). They should not be exceeded in the reach, where an exit channel failure might cause the flow to impinge on the toe of the dam. The velocity limitations are based on the maximum discharge in routing the velocity hydrograph, and on the assumption that uniform flow conditions exist in the exit channel.

H. Design Documentation

All dams that require a construction permit application will also require a minimum amount of documentation. The documentation will be commensurate with the dam classification. The State Engineer may request additional information on a case-by-case basis.

The minimum requirements for class I and II dams include:

- site location map;
- drawings showing dam height, top width, side slopes, and the size, location and elevation of the spillways;
- hydrology runoff computations including drainage area, watershed time of concentration, and other information;
- description of soils analysis; and
- specifications or reference to standard specifications.

It is suggested that a Design Documentation Folder be completed for all class III, IV and V dams designed by those engineering organizations and firms involved in dam design in North Dakota. The level of documentation required by the State Engineer in the review of the permits will vary with the dam design class and other factors. The following is an example outline of a Design Documentation Folder.

DESIGN DOCUMENTATION FOLDER

INDEX

General

- Preliminary Investigation Report
- Structure classification (including a narrative to justify classification)
- Copies of permits

Hydrology

- Watershed map (USGS quad map)
- Runoff infiltration parameter computations
- Time of concentration computations
- Routing parameter computations
- Hydrologic model results
- Historical flood data, if available
- Runoff yield studies, if needed

Hydraulics

- Water surface profiles for tailwater calculations and outlet channel stability check
- Breach routings (class IV and V only)
- Any special routings made for structure evaluation or structure discharges less than the design discharge (For example: check drop spillway design and tailwater at 25, 50 and 75 percent of peak design discharge.)
- Reservoir operation plan, if needed

Geology

- General geology of the area
- Soils explorations
  - — centerline of dam
  - — conduit location
  - — emergency spillway cut
  - — borrow area(s)
- Sediment capacity calculations

Soil Mechanics

- Soil mechanics report
- Slope stability analysis
  - — Design assumptions (full drawdown upstream, steady seepage downstream or drained downstream slope)
  - — Shear strength (from shear testing, correlated from previous dams, based upon geologic descriptions)
- Seepage analysis, as needed
- Foundation settlement (percent consolidation used for each layer)
- Foundation treatment (trench depths, stripping depth, removal of pockets, bedrock treatment)
- Analysis of borrow material (expected compacted values and strengths)
- Construction
  - — compaction and moisture requirements
  - — specific equipment or construction techniques
  - — critical inspection points
- Instrumentation of embankment, as needed

Structural Design

- Uplift calculations
- Overturning calculations, if needed
- Structural design calculations (reinforced concrete, steel or wood design)
- Loading checks on standard details
- Pipe joint elongation calculations
- Camber calculations
- Structure instrumentation plans, as needed

Site Protection and Restoration

- Landscape considerations of visual resource and visual resource quality, as needed
- Biological considerations (water quality, wildlife habitat, fish development), as needed
- Vegetation and seeding requirements
- Temporary and permanent erosion control measures

Quantity Calculations

Include quantity calculations for all individual elements including appropriate sketches and cross sections

Project Plans and Specifications

- Bid proposal
- Complete set of construction drawings and specifications
- Engineer's cost estimate
- Construction schedule

CHAPTER VI:

Modification of Existing Structures

There are several events that might require dam modification. Additional storage may be required for a variety of reasons: modification may be desirable for aesthetic reasons when the area adjacent to the dam has or will become developed; unsafe conditions may have developed in some part of the dam; or compelling new standards are imposed by a regulatory agency. This chapter outlines suggested procedures in investigating modifications to existing structures.

The suggested criteria in Chapter V also applies to the modification of existing dams. It may not be practical, however, to strictly follow the new dam standards with existing structures. Therefore, the State Engineer will consider several factors in the review of existing dams including: the design class and hazard category, the overall safety of the dam prior to and with the modification, and the added cost of the new dam criteria.

A. Land Rights

When the modification of a structure is being considered, the land rights and easements must be thoroughly reviewed for adequacy. Utilities may make new or additional easements necessary, particularly if the area is or has been developed. Additional easements may be required for access roads and for new borrow or disposal areas.

B. Hydrology

The hydrology suggestions outlined in Section B, Chapter V should be followed, if possible, when modifying existing dams. In addition, there are other considerations that are specific to existing dams.

The drainage areas of many existing structures were determined from maps of less detail than the USGS 7½ minute quadrangle maps. Therefore, original drainage area should be reviewed for accuracy. Over the years, diversions may have been constructed, resulting in a larger or smaller drainage area. People enjoy living near water areas and often will construct their homes near reservoirs. This development adds more impervious area such as driveways, parking areas and roofs. This may not only increase the runoff, but may cause a change in peak rates.

Before beginning any hydrologic or hydraulic analysis, a review should be made of any available design records for the dam and spillway. Information such as discharge rating curves or tables, storage capacity, and pertinent dimensions of spillways and outlets should be obtained. Any changes in tailwater condition since the original design should be determined. The procedures used in the design of the spillway(s) should be compared with currently accepted techniques and criteria. If it is evident that the original design basis gave results substantially in accord with current practices, further investigation may be limited to verify that the existing project meets the adopted design objectives. If the results are considerably different from what would be acceptable today, then a revised flood study is required. Storm events that have caused secondary spillway flow during the life of the dam should be analyzed.

If the dam that is proposed for modification stores permanent water for some beneficial use, the reliability of the runoff yield should be reviewed, particularly if additional beneficial storage is to be added.

C. Sediment Storage

A sediment survey of the existing reservoir should be conducted to determine the amount of sediment that has accumulated to date. Future land use should be carefully considered. If the land in the watershed may be developed for residential or other urban uses, strict developmental requirements are needed, or increased storage is needed for sediment allocation. It may be necessary to install sediment basins to reduce sediment delivery to the reservoir.

D. Geological Explorations

The existing embankment and abutments shall be thoroughly examined for cracking, slumping or sloughing and piping. Dye tests or other techniques to locate the source of excessive seeps may be necessary. The downstream area shall be examined for seeps or boils. Borings should be made in the embankment to classify and determine the in-place density of material and the location of the phreatic line. If the dam is to be raised, the original foundation investigation and reports should be thoroughly reviewed for adequacy. If an original foundation report is not available, borings should be made through the embankment and into the foundation to determine its suitability for the increased loadings.

Explorations in the borrow area(s) should be made to determine that there are sufficient quantities available and that the strength and density of the material is adequate. In-place moisture content of the borrow material should be determined.

E. Embankment Design

For embankment dams, the major non-hydraulic causes of failure involve foundation structural instability or foundation seepage stability. Closely associated defects are excessive settlement, slope erosion, malfunctioning drains, problems at the abutments or at the foundation/embankment interface, tree growth, and rodent activity.

Each different defect may require different remedial measures. An excellent list of defects and their possible causes are contained in the publication "Safety of Existing Dams — Evaluation and Improvement," National Academy Press, Washington, D.C., 1983, page 220.

If an existing dam is to be modified, the embankment design must be thoroughly reviewed. In all probability, additional height cannot be added without a modification of the slopes. The same is true regarding increasing the top width.

Stability assessments should utilize in situ properties of the structure, its foundation and pertinent geologic information. "As Built" records should be reviewed along with other geologic information.

Geologic information that should be considered includes groundwater and seepage conditions, lithology, stratigraphy, and geologic details. Foundations may present problems where they contain adversely oriented joints, slickensides or fissured material, faults, seams of soft materials, or weak layers. Such defects along with excess pore water pressures may contribute to instability. Special tests may be necessary to determine physical properties of particular materials. The results of stability analyses afford a means of evaluating the structure's existing resistance to failure and also the effects of any proposed modifications. When possible, results of stability analyses should be reviewed for compatibility with performance experience.

The loading conditions for which the modified or repaired dam should be investigated, along with the minimum factors of safety, are:

1. Rapid drawdown from spillway crest elevation — 1.2.
2. Partial pool with assumed horizontal steady seepage saturation — 1.5.
3. Steady seepage from spillway crest or top of gates with the horizontal permeability to vertical permeability ratio assumed as a minimum of nine — 1.5.
4. Earthquake (cases 2 and 3 with seismic loading) — 1.0.

Modifications to the original seepage design should consider conditions observed in the field inspections and piezometer instrumentation. A seepage analysis should consider the horizontal and vertical permeability ratios resulting from both natural deposition and compaction placement of materials.

The embankment should be carefully examined for activity by burrowing animals. Where the embankment slopes are being modified, the riprap should be removed as well as all of the vegetation. The old slope should be scarified and watered prior to placement of new fill material. Upon completion of the modification the new slope would be seeded and riprapped as appropriate.

F. Principal Spillway Design

The original principal spillway plans should be thoroughly reviewed and field checked to see that the spillway was built as designed. The interior of the principal spillway should be visually inspected by physically entering the conduit or by use of video equipment.

The location and depth of any pools of water should be located on the plans. Pools indicate the absence of camber. The present condition and expected life of the conduit should be noted. Where possible, joint gaps should be measured. If the dam is modified, new joint separation estimates should be calculated.

Inlet modifications shall be carefully planned and designed. When the riser is to be raised, the footings should be checked to see that they are adequate for the additional load. Special attention should be given to the joints between the inlet and the conduit and drawdown facilities.

Barrel repairs or modifications should be commensurate with the importance of the dam. Where damage is sufficiently severe, as when a metal conduit is severely corroded, it may be necessary to remove it and replace it. If the joints have become excessively elongated, it may be necessary to fill the gaps or, in severe cases, to line the entire barrel with a suitable casing.

The outlet conditions should be thoroughly inspected. The scour hole or plunge pool should be measured to determine the amount of lateral extension. If the plunge pool had originally been riprapped, the amount and condition of the riprap should be assessed.

Where the outlet consists of a mechanical energy dissipator, certain elements need careful review. Joint openings should be examined for the integrity of the water stop material. All drains should be examined for defects. The outlet channel should be measured to assure that it will provide the proper tailwater elevation. If modification of the dam would either increase or decrease the principal spillway peak flows, the outlet channel should be reevaluated.

The drawdown facilities should be checked to determine whether the gate seals and operates in a smooth manner. When drawdown facilities are to be added, care should be taken so the hydraulics are compatible with the existing system.

G. Emergency Spillway Design

If the dam is modified, it may be necessary to completely renovate the emergency spillway system. The vegetative cover should be retained, if possible, particularly in the exit section. If evidence of gullying is observed, transverse barriers of erosion resistant material should be installed. If meandering has taken place on the emergency spillway floor, small (4" to 9" high) lateral dikes should be installed. The original freeboard and emergency spillway hydrographs should be reviewed and updated prior to routing through the structure.

H. Design Documentation

Design documentation for modifying existing structures should be as thorough as for new dam design. The design documentation contained in Chapter V, Section H, is suggested.

CHAPTER VII:

Construction Drawings and Specifications

This chapter sets forth the suggested formats for construction drawings and specifications. Design classification I and II dams require less detailed drawings and specifications. For small dams, the SCS uses a hydraulic data sheet for construction drawings (Form ND-ENG-16), and a small booklet for specifications. Form ND-ENG-16 is included in Appendix B. Design class III, IV, and V dams require detailed drawings and specifications. The following two sections are suggested outlines of information to be included on the construction drawings and in the specifications.

A. Construction Drawings

1. Cover sheet

a. title of the project
b. site location map
c. list of cooperators and/or sponsors
d. generally physical informational data such as drainage area, height, etc.
e. index of drawings
f. signature block

2. Watershed Boundary Map

a. structures located and identified, including existing structures
b. farm boundaries
c. landowners' names
d. watershed boundary
e. north arrow and scale
f. section, township and range numbers
g. existing roads and highway numbers

3. Site Maps

a. plan view of site including embankment, emergency spillway, and reservoir area
b. topography of structure site including all topographic features
c. land ownership
d. base lines
e. centerline of embankment and emergency spillway
f. property lines and fence lines
g. construction limits
h. utility lines and pipelines
i. roads, highways and railroads (with names)
j. bench marks
k. borrow areas and waste areas
l. clearing and grubbing areas
m. waterways, diversions, and channel improvements
n. wells
o. fence removal and/or construction
p. scale and north arrow

4. Plan View Sheets

a. plan view of structure site including embankment, principal spillway and emergency spillway
b. topography of structure site including all topographic features
c. stationing along centerline of dam and emergency spillway
d. cross sections
e. soil borings
f. embankment drainage
g. sodding areas
h. topsoil spreading areas
i. scale and north arrow

5. Profile Sheets

a. embankment
b. principal spillway
c. emergency spillway
d. channel improvement, waterways, and diversions
e. outlet channel
f. structural drainage system

6. Cross-Section Sheets

a. embankment and trenches
b. emergency spillway
c. borrow area
d. outlet channel
e. soil borings
f. structural drainage system

7. Structural Detail Sheets

a. structure layout
b. principal spillway
c. barrel and appurtenances
d. inlet-riser, trash rack, safety guard
e. drainage system
f. fence layout and details

8. Standard Detail Sheets

9. Topography for Erosion Control During Construction

a. temporary and permanent diversions
b. bypass channels and sediment traps
c. sediment basins and grade control structures

10. Details for Erosion Control During Construction

a. profile for diversion and bypass channels
b. typical cross sections of diversions, channels, structures and dikes
c. sections along centerline of principal spillway for all sediment and erosion control structures
d. vertical inlet details if needed

B. Specifications

Standard specifications of the U.S. Soil Conservation Service and the North Dakota State Water Commission may be utilized in the preparation of specifications. The specifications will be in the form of a booklet with a cover that identifies the structure, its location, the owner, the name of the preparer and the date.

The first inside sheet is an index list of construction and material specifications. The specifications booklet may incorporate special provisions and other contract details. The specifications may incorporate, by reference, "Standard Specifications for Water Resource Facilities," (North Dakota State Water Commission), as well as ASTM, ASSHTO or other appropriate specifications. It is also recommended that an "Items of Work and Construction Details Section," be included that shows details not covered in the reference specifications, such as methods of measuring quantities. The specifications should be numbered in a manner that can be readily followed by the contractor and inspection personnel during construction operations.

CHAPTER VIII:

Construction Inspections, Records and Completion Documents

The purpose of this chapter is to provide general information on construction inspection, record keeping and completion documents. In many regards, these requirements may be the most important part of dam construction. The best design and specifications mean little if they are not adhered to during construction and documented after construction.

A. Inspections

1. Construction Work Inspections

Construction inspections ensure that the work complies with the project design and specifications. The level of inspection is dependent upon the design classification of the dam and on the type of work being performed. A construction inspected plan will be required for all class IV and V dams. Design classification III, IV and V dams may require continuous inspections, whereas class I and II dams may require only periodic inspections. The level of inspections can also vary with different construction phases. Continuous inspections are suggested for any work in which the quality cannot be accurately determined after the fact and for any work that cannot be readily replaced if rejected. The engineer-designer should designate those items that are to receive full-time inspection. Work items of this type include (but are not limited to): foundation evacuation in which depth must be determined during the course of work, foundation excavation underwater, pile driving, placing compacted earth fill, structural backfill, placing drain fill and filters, placing riprap, placing and bedding pipe, mixing and placing concrete and pneumatically applied mortar, mixing and placing asphaltic concrete, installing relief wells, and performing acceptance tests of machinery and equipment.

Periodic inspection may suffice for certain other types of work, depending on circumstances prevailing at a site. Works of this type may include (but are not limited to): dewatering the work site, clearing, clearing and grubbing, stripping, structure removal, open channel excavation, borrow pit excavation, form construction, placement of steel reinforcement, metal fabrication, timber fabrication, installing water control gates, painting, installing fences, sodding, mulching, and general cleanup. It must be recognized that continuous inspection of such items may be required because of local complications, such as complex site conditions, erratic soil deposits, remote site location, nature of the construction schedule, or contractor's attitude or ability.

The number of samples to be taken and tested varies with the material, the amounts being placed during a designated period, the results of previous tests and the experience and qualifications of the contractor and his work force. In general, concrete and earthwork are the two primary categories that require samples and/or tests.

Concrete requires at least three test cylinders, one slump test and one air entrainment test for each pour. As a guideline, samples should be taken (at random) from at least one third of the redi mix or batch mix delivered to the site. If past test results show borderline strengths and/or air content, etc., each batch should be sampled until the engineer and inspector are satisfied that the quality is satisfactory and uniform.

Earthwork tests are dependent upon the design classification of the dam. The specifications for a class I or II dam may call for machine compaction and visual inspection by a competent inspector. A class III dam may require density and moisture control. At least two moisture density tests should be run per day, averaging one test per 400 to 500 yards.

A large class IV or V dam may have six or more hauling units, with placement of several thousand yards per day. A systematic program of field compaction control should be established and executed, involving determinations of compaction densities and water contents. Sufficient density and moisture tests must be taken to verify the adequate compaction and uniform moisture distribution for each lift during placement and compaction operations. Special emphasis may be required for critical zones within a zoned embankment.

Careful inspection of backfill around imbedded items such as pipe is required on all classes of dams.

Information on inspection, sampling, testing and recording forms are available from numerous sources, including the SWC and the SCS.

2. Material Inspection

Materials used in the construction of earth dams generally fall into one of three categories:

(a) manufactured material such as pipe, reinforcing steel, etc.;

(b) concrete including aggregate, cement, water and admixtures; and

(c) natural materials such as earthfill, sand, gravel, rock riprap, sod and grass seed.

Most manufactured products, including concrete admixtures and cement materials, may be accepted based on certifications furnished by the manufacturer. The manufacturer is to furnish, on request, certifications and test results on the material(s) in question.

Inspection at the factory may be required for special items or major items of mechanical or electrical equip-

ment. Inspection at or near the site of work is required for all materials and work for which compliance with specification requirements can be partially or completely verified by on-site examination and testing. This inspection may take the form of:

(a) examinations, measurements, and tests performed by an inspector at the site of work;

(b) laboratory testing of samples of materials obtained or prepared at the site of work, or at local points of supply; and

(c) periodic inspection of local concrete mixing plants, including operation of these plants.

Some materials must be inspected at the work site. They are:

(a) earthfill materials, rock for fill or riprap, aggregates for concrete or asphaltic concrete, and drain fill materials;

(b) upgraded wood products (such as round timber, wood piles, and posts);

(c) materials manufactured at or near the site of work (such as concrete, pneumatically applied mortar, asphaltic concrete, and concrete piles); and

(d) any other materials such as vegetative materials that may not be accepted on the basis of certification.

3. State Engineer Monitoring

The State Engineer (or designee) will make frequent inspections to determine progress and conformance to construction drawings and specifications. When requested by the consulting engineer or local sponsoring agency, the State Engineer will consider, on a project-by-project basis, uniform scheduling of construction reviews.

Failure of the contractor to conform to the drawings and/or specifications for any cause on any structure may cause rejection and removal of that portion of the work failing to meet requirements. When the SWC is involved in cost-sharing on a project, an agreement between the local sponsors and the SWC shall be executed prior to contract award, setting forth the responsibilities of each — financially and physically — in monitoring the construction of the dam.

B. Records

1. Job Diary

A job diary is to be maintained for each dam to provide a history of the work. Entries are to be made daily or, when continuous inspection is not required, whenever the engineer or inspector are on the job.

Bound job diaries will be required on all dams where a formal contract is entered into between the contractor and the local sponsors and/or the SWC. The SCS uses a bound job diary which may prove of value as a guide. (See Appendix C for example format.)

The job diary is the pertinent history of the project, beginning with the showing of the site to prospective bidders, and concluding with the completion of the job. The diary should be on hand at all times and entries should be completed as the events occur. The following items should be recorded in the job diary on a daily basis: weather, work hours, work force, equipment on site and used, work completed, tests, time delays, cause of delays, rejected work, problems, instructions given to the contractor, job-related visitors, and other significant items.

Photographs are an extremely important part of construction inspections and documentation. It is necessary to have photographic documentation of significant construction conditions, deficiencies, and safety or health violations. Photographs may be included as supplemental information on the job diary.

2. Change Orders

During the progress of the work, the engineer or technician in charge of construction must be sensitive to developments that seem to be significantly different from those assumed in the design. When these developments occur, construction inspection personnel are not to alter the design or allow the contractor to continue construction, until the individual with design approval authority has evaluated the condition and made any adjustments necessary in the plans and specifications.

The contractor should not be allowed to proceed with any of the changed work until a written change order has been approved by the appropriate person(s). (See SWC Form No. 194, Appendix C.) When the SWC is cost-sharing, the project agreement shall designate those persons with authority to execute change orders.

C. Completion Documents

1. As-Built Plans

As-built plans that represent the structure as it was actually constructed may be necessary: to evaluate the structure's design and operation, to provide evidence in legal matters, and to facilitate efficient maintenance or modification. As-built plans and completion reports are suggested for all design class III, IV and V dams. The importance of as-built plans cannot be overstressed. Often the only information available on certain components is what is shown on the as-built plans. The minimum requirement of as-built plans is a documentation of all changes that are not clearly visible after construction.

A complete set of full-size construction plans should be kept at the work site for recording changes. All changes during construction must be recorded on the drawings to indicate as-built conditions. If a structure is altered at any time after its completion, the as-built plans are to be retrieved and revised to indicate the alterations and then are to be processed in the same way as original as-built plans.

Structural or dimensional changes are to be illustrated in detail in order to provide a complete, readable, and true record. Upon completion of the project, the elevations of several of the structural components should be shown including the inlet and outlet structures and the foundation drain outlets. The elevation and gap measurements of the joints in the principal spillway conduit should be shown at the time of installation.

Geologic conditions revealed during construction that differ significantly from those in the geologic

report are to be recorded on the as-built plans. Examples of differences are elevation of rock surfaces, type of rock or soil, joint orientation and openings, or ground-water elevation.

As-built geology should also include:

(a) as-built profile of the core trench;

(b) as-built profile of the pipe trench; and

(c) changes in materials different from those indicated by the logs on the geologic profile shown on the plans for construction. This would include, but is not limited to, borrow, core trench, pipe trench, drains, etc.

It is also recommended that the as-built include a detailed description of the vertical and horizontal control points. These points should be plotted on the appropriate sheets.

The as-built plans should be certified by the design engineer. Copies of the as-built plans shall be furnished to the State Engineer and the primary local sponsoring organization having the responsibility for operation and maintenance.

2. Completion Report

A completion report should be prepared for all class III, IV and V design dams. The report should be in narrative form, giving a chronological history (including pictures or slides) of the construction of the dam, starting with the date of award and the name of successful contractor. It should include a short description of problems encountered, solutions to the problems and any other pertinent information.

CHAPTER IX:

Operations, Inspections and Maintenance

The designer shall prepare an Operation and Maintenance (O&M) plan for all design class III, IV and V dams. The O&M plan shall be tailored to the specific dam. It will generally not be necessary to provide a detailed O&M plan for design class I and II dams. The following should be considered in the preparation of an O&M plan.

OPERATIONS AND MAINTENANCE PLAN

I. OPERATIONS

The owner will be responsible for operating the dam in compliance with applicable federal, state and local laws.

II. INSPECTIONS

There are two types of dam inspections. Routine inspections are directed at observing changes from the as-built condition. Post storm or emergency inspections are directed at surveying storm damages and/or possible deficiencies.

All inspections are the responsibility of the owner(s) and must be made by properly trained people. In general, it is recommended that a design class III dam be inspected every two years, and class IV and V dams once a year. In addition, all dams should be inspected if the emergency spillway is used, or if possible deficiencies are noted. The designer should develop an inspection checklist for the dam (see Appendix D). It is suggested the State Engineer be contacted for possible assistance prior to the inspection of a class III, IV or V dam. All monitoring instruments should be read and the results recorded.

III. MAINTENANCE

The Operation and Maintenance Plan should include specific maintenance measures for the dam. The maintenance measures should be consistent with the dam's original design and the as-built conditions. The maintenance plans should address:

1. vegetation,
2. embankment and structural items,
3. materials,
4. photograph documentation, and
5. monitoring instruments.

CHAPTER X:

Emergency Action Plans

It is intended that the guidelines for the design, construction, operation and maintenance, and inspection of dams will minimize the risk of future dam failures Nevertheless, it must be recognized that despite the adequacy of dam design guidelines and their implementation, the possibility of dam failure still exists. Although the probability of failure is small, pre-planning is required to identify conditions which could lead to failure and to minimize the extent and effects of a failure. This section describes recommended procedures for reacting to an emergency or unsafe condition created by the threat of a dam failure. The action categories and other recommendations listed are only general guidelines. The owner and design engineer should develop an Emergency Action Plan and make a determination of the Categories of Action. The owner should periodically update the action plan.

This section is based on three primary suggestions: The first is that an Emergency Action Plan be developed for all classes of dams. The level of detail included in each plan should be commensurate with the hazard category of the dam. The second suggestion is that two Categories of Action be developed that trigger action by the dam owner. Conditions listed as "Category of Action I" are considered extremely severe occurrences that present an immediate danger to the dam and to downstream areas. Therefore, any Category I condition should immediately activate the Emergency Action Plan. The conditions listed as "Category of Action II" present a potential, but not necessarily immediate, danger to the structure. The Category II conditions could, however, develop into a more serious problem. Therefore, a qualified engineer should be immediately notified and a prompt inspection should be made of any structure with Category II conditions. Examples of Categories of Action are listed in Appendix E.

The third recommendation is that the dam owners and dam design engineers coordinate with the appropriate local emergency management organization. This coordination will ensure that the Emergency Action Plan properly interfaces with local emergency operations warning plans and with local government response and support activities. The State Division of Emergency Management can provide general guidance in the preparation of the plan.

An Emergency Action Plan is a clear, concise plan of action to be followed in the event of a failure or an impending dam failure. Any condition listed as Category of Action I should automatically activate the Emergency Action Plan. The dam owner is responsible for drafting the plan, providing copies to the participants and activating the plan.

A. Emergency Action Plan (Class I and II Dams)

An Emergency Action Plan for design class I and II dams may be only a notification list of individuals and agencies to be contacted upon dam failure. The plan should contain the names, addresses and phone numbers of a few key contacts. At a minimum, the list should include the local water resource board, the Office of State Engineer, the engineering firm or agency that designed the structure (if applicable), the State Division of Emergency Management, the local emergency management coordinator, and downstream landowners that may be affected.

B. Emergency Action Plan (Class III and IV Dams)

The Emergency Action Plan for class III and IV dams includes a downstream inundation map, a detailed notification list and a list of contractors and others that could provide assistance during a failure or a possible failure condition. The notification list should include downstream residents (listed in order beginning with those affected first), the dam design engineer or agency, the local water resource board, the Office of State Engineer, State Division of Emergency Management, the local emergency management coordinator, and various other emergency services. A sample directory is included in Appendix E.

The list of downstream residents with phone numbers should be shown on a downstream inundation map. The map should be equivalent to the USGS 7½ minute quadrangle maps. The map should extend a minimum distance of 10 miles downstream or until the stream enters a significantly larger stream or river that would quickly attenuate the flood levels. The map should show the locations of residents indexed to the notification directory, along with roads, bridges and anything else that may suffer significant damage because of a dam break.

C. Emergency Action Plan (Class V Dams)

The Emergency Action Plan for a design class V dam needs to be adequately detailed, well-organized and well-prepared. The notification directory needs to be completed in detail. The inundation map needs to be based on the results of a dam break routing procedure. The routing procedure must extend downstream to a

point where the floodwaters are within the channel banks or the threat of resident inundation no longer exists. The inundation map for class V dams should be adequately detailed, identifying dwellings and significant features that are likely to be affected. The maps should also show the estimated travel time and depth at selected locations.

Downstream warning systems should be considered for all design class V dams, with the precise procedure detailed in the Emergency Action Plan. Existing local government emergency operation plans for warning should be consulted for proper interface and inclusion of downstream warning procedures. The plan should be reviewed with downstream individuals and entities.

The Emergency Action Plan Directory must be reviewed and updated, if necessary, on a yearly basis by the dam owner. The North Dakota Division of Emergency Management should be furnished an annual status report of the Emergency Action Plan Directory, including modifications.

CHAPTER XI:

Glossary

ABUTMENT — The part of the valley side against which the dam is constructed. Right and left abutments are those on respective sides of an observer when viewed looking downstream.

ANNUAL RUNOFF — The total discharge of a stream for a year, usually expressed in inches, depth or acre-feet.

ANTECEDENT MOISTURE CONDITION (AMC) — The degree of wetness of the soil in a watershed at the beginning of a storm. (See Section 4, National Engineering Handbook, SCS.)

ANTI-SEEP COLLAR — A projecting collar, usually of concrete, built around the outside of a pipe, tunnel, or conduit, under an embankment dam, to lengthen the seepage path along the outer surface of the conduit.

AXIS OF DAM — The plane or curved surface, arbitrarily chosen by a designer, appearing as a line, in plan or in cross section, to which the horizontal dimensions of the dam can be referred.

BACKWATER — The resulting high water surface in a given stream due to a downstream restriction or a high stage in an intersecting stream.

BAFFLE BLOCK — A block of concrete or concrete and steel constructed in a channel or a stilling basin to dissipate the energy of water flowing at a high velocity.

BASE WIDTH — The maximum thickness or width of a dam measured horizontally between upstream and downstream faces, and normal to the axis of the dam, but excluding projections for outlets, etc.

BASE FLOW — The sustained discharge which persists after storm runoff has been depleted. It is usually derived from ground-water discharge or gradual snow or ice melt over extended periods of time, but need not be continuous flow.

BERM — A horizontal step or bench in the sloping profile of an embankment dam.

BLANKET —

DRAINAGE BLANKET — A drainage layer placed directly over the foundation material.

GROUT BLANKET — Consolidating a layer of the foundation to achieve greater impermeability and/or strength by injecting grout.

UPSTREAM BLANKET — An impervious layer placed on the reservoir floor or on the abutments upstream of a dam. In the case of an embankment dam, the blanket may be connected to the impermeable element in the dam.

CONDUIT — A closed channel to convey the discharge through or under a dam.

CONDUIT FILTER DRAIN — A pervious filter drain around a conduit for the purpose of seepage control. The filter drain is often tied into other drain systems in the foundation or embankment. It is an alternative to anti-seep collars.

CONSERVATION STORAGE — The water that is impounded for consumptive uses such as municipal, industrial, irrigation, stockwater and non-consumptive uses such as lake evaporation and seepage. Conservation storage does not include flood or sediment storage.

COFFERDAM — A temporary structure enclosing all or part of the construction area so that construction can proceed in the dry. A diversion cofferdam diverts a river into a pipe, channel, or tunnel.

CONTROL SECTION — The section where flow passes through critical depth.

CORE (IMPERVIOUS CORE) (IMPERVIOUS ZONE) — A zone of material of low permeability in an embankment dam; hence the terms central core, inclined core, puddle clay core, and rolled clay core.

CREST LENGTH — The developed length of the top of the dam.

DAM — An artificial barrier, together with any associated spillways and appurtenant works, across a watercourse or natural drainage area, which does or may impound or divert water.

DAM HEIGHT — The distance between the stream channel bottom at the centerline of the dam to the top of the settled embankment.

DAMAGE REACH — A length of floodplain or valley selected for damage evaluation.

DEAD STORAGE — The storage that lies below the invert of the lowest outlet and that, therefore, cannot be withdrawn from the reservoir without pumping.

DESIGN LIFE — A period of time during which a dam is designed to perform its assigned functions satisfactorily.

DIAPHRAGM — A cutoff wall, or core wall, made of relatively impervious material such as asphaltic concrete, concrete, or earth.

DRAINAGE AREA (WATERSHED) — The area that drains naturally to a particular point on a river, stream or creek.

DRAINAGE WELLS (PRESSURE RELIEF WELLS) — Vertical wells or boreholes usually downstream of impervious cores, grout curtains, or cutoffs, designed to collect and control seepage through or under a dam, so as to reduce uplift pressures under or within a dam. A line of such wells forms a drainage curtain.

DRAWDOWN — The lowering of water surface level due to release of water from the reservoir.

DRAWDOWN PIPE — A pipe through the embankment that allows for water releases below the principal spillway level.

DRY DAM (DETENTION DAM) — A dam that has an ungated outlet positioned so that essentially all stored water will be drained from the reservoir by gravity. The reservoir will normally be dry.

ECONOMIC LIFE — The period of time during which economic benefits accrue to a dam.

EARTHFILL DAM — A dam constructed of excavated natural earth material obtained from a borrow area.

HOMOGENEOUS EARTHFILL DAM — A dam constructed of similar earth material throughout, except for possible inclusion of internal drains or drainage blankets. Used to differentiate from a zoned earthfill dam.

ZONED EARTHFILL DAM — A dam, the thickness of which is composed of zones of selected material having different degrees of porosity, permeability, and density.

EMERGENCY ACTION PLAN — A predetermined plan of action to be taken to reduce the potential for property damage and loss of lives in an area affected by a dam break.

EMERGENCY SPILLWAY (SECONDARY) — The spillway designed to convey excess water through, over or around a dam.

EMERGENCY SPILLWAY SYSTEM — A single emergency spillway or combination of emergency spillways designed to work together.

EXIT CHANNEL — An open channel spillway, located downstream from the control section, which conducts the flow to a point where it may be released without jeopardizing the dam.

FACE — With reference to a structure, the external surface that limits the structure, e.g., the face of a wall or a dam.

FETCH — The straight line distance between a dam and the farthest reservoir shore. The fetch is one of the factors used in calculating wave heights in a reservoir.

FILTER (FILTER ZONE) — A band or zone of granular material that is incorporated in a dam and is graded (either naturally or by selection) so as to allow seepage to flow across or down the filter without causing the migration of material from zones adjacent to the filter.

FLASHBOARDS — Lengths of timber, concrete, or steel placed on the crest of a spillway to raise the retention water level but that may be quickly removed in the event of a flood, either by a tripping device or by a deliberately designed failure of the flashboards or their supports.

FLOOD FREQUENCY — An expression or measure of how often a hydrologic event of a given size or magnitude should, on an average, be equaled or exceeded. For example, a 50-year frequency flood (two percent chance) should be equaled or exceeded, on the average, once in 50 years.

FLOODPLAIN — An area adjoining a body of water or natural stream that has been or may be covered by floodwater.

FLOOD ROUTING — Computation of the changes in the rise and fall in stream flow as a flood moves downstream. The results provide hydrographs of flow versus time at given points on the stream or in a reservoir.

FLOOD STAGE — The stage or elevation in which overflow of the natural banks of a stream or body of water begins in the reach or area.

FLOOD STORAGE — Floodwater storage in a reservoir. In a floodwater retarding reservoir, the temporary storage between the crests of the principal and emergency spillways.

FOUNDATION OF DAM — The natural material on which the dam structure is placed.

FREEBOARD HYDROGRAPH — The hydrograph used to establish the minimum settled elevation of the top of the dam. It is also used to evaluate the structural integrity of the spillway system.

GROIN — That area along the contact (or intersection) of the face of a dam with the abutments.

GROSS STORAGE CAPACITY — The gross capacity of a reservoir from the river bed up to maximum controlled retention water level. It includes active, inactive, and dead storage.

GROUT CAP — A concrete pad or wall constructed to facilitate subsequent pressure grouting of the grout curtain beneath the grout cap.

GROUT CURTAIN — A barrier to reduce seepage under a dam, produced by injecting grout into a vertical zone, usually narrow in horizontal width, in the foundation.

HYDROGRAPH — A graphical representation of discharge, stage, volume, or other hydraulic property (with respect to time) for a particular point on a stream.

HYDROLOGIC SOIL-COVER COMPLEX (CURVE NUMBER) — A combination of hydrologic soil group and a type of cover. Each complex is assigned a runoff curve number (CN) that indicates that runoff potential.

HYDROLOGIC SOIL GROUP — A group of soils having the same runoff potential under similar storm and cover conditions.

INLET CHANNEL — An open channel in a spillway system upstream from the control section.

JOINT EXTENSIBILITY — The amount a pipe joint can be extended from the fully engaged position without losing strength or watertightness. In case of rubber gasket joints, it is measured from the center of the gasket to the point of flare of the bell ring (or collar) when the joint is fully closed.

JOINT GAP — The longitudinal dimension between the end face of the spigot end of a pipe joint and the corresponding face of the bell end of the connecting pipe. It does not include the beveled portion designed for sealing compounds.

LAG (OR LAG TIME) — The time from the centroid of rainfall to the peak of the hydrograph. It can be estimated from time of concentration as $0.6T_C$.

LOW-LEVEL OUTLET — A gated opening from the reservoir, generally used for lowering the reservoir or for providing downstream releases.

MAXIMUM WATER LEVEL — The maximum water level, including the flood surcharge the dam is designed to withstand.

MINIMUM OPERATING LEVEL — The lowest level to which the reservoir is drawn down under normal operating conditions. The lower limit of active storage.

NAPPE — The free-falling stream from a weir or spillway.

NORMAL WATER LEVEL — For a reservoir with a fixed overflow sill, it is the water level at the lowest ungated spillway sill. For a reservoir which is controlled wholly or partly by movable gates, or by other means, it is the maximum water level under normal operation conditions.

PEAK FLOW — The maximum instantaneous discharge that occurs during a flood. It is coincident with the peak of a flood hydrograph.

PERMANENT STORAGE — Water impounded for consumptive uses such as municipal, industrial, irrigation, stockwater; and non-consumptive uses such as recreation, and fish and wildlife, including the storage lying below the lowest ungated outlet.

PERVIOUS ZONE — A part of the cross section of an embankment dam comprising material of high permeability.

PHREATIC SURFACE — The free surface of ground water at atmospheric pressure.

PIEZOMETER — An instrument for measuring pore water pressure within soil, rock, or concrete.

PIPING — The progressive development of internal erosion by seepage, appearing downstream as a hole or seam discharging water that contains soil particles.

PLUNGE BASIN (PLUNGE POOL) — A natural or sometimes artifically created pool that dissipates the energy of free-falling water.

PRINCIPAL SPILLWAY — The lowest ungated spillway designed to convey water from the reservoir at uncontrolled release rates.

PRINCIPAL SPILLWAY HYDROGRAPH — The hydrograph used to determine the minimum crest elevation of the emergency spillway. It is used to establish the principal spillway capacity, and to determine the associated minimum floodwater retarding storage.

PROBABLE MAXIMUM FLOOD (PMF) — The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are possible in the region.

PROBABLE MAXIMUM PRECIPITATION (PMP) — The maximum amount of precipitation that can be expected to occur on a drainage basis for varying durations.

RETARDING OR DETENTION POOL — The portion of the reservoir allotted to the temporary impoundment of floodwater. Its upper limit is the elevation of the crest of the emergency spillway.

RESERVOIR AREA — The surface area of a reservoir when filled to a controlled retention water level.

RIPRAP — A layer of large stones, broken rock, or precast blocks placed in random fashion on the upstream slope of an embankment dam, on a reservoir shore, or on the sides of a channel, as a protection against wave and ice action.

RISK ASSESSMENT — As applied to dam safety, the process of identifying the likelihood and consequences of dam failure to provide the basis for informed decisions on a course of action.

RUNOFF YIELD — The portion of precipitation (including snowmelt) that flows across the land surface and contributes to stream or flood flow.

SEDIMENT STORAGE — The portion of the reservoir allotted to the accumulation of submerged sediment during the design life of the dam.

SLOPE PROTECTION — The protection of an embankment slope against wave action or erosion.

SLURRY TRENCH — A narrow excavation whose sides are supported by a slurry made of mud, clay, or cement and mud, filling the excavation. Sometimes used to describe the cutoff itself.

SPILLWAY — An open or closed channel, conduit or drop structure used to convey water from a reservoir. It may contain gates, either manually or automatically controlled, to regulate the discharge of water.

STILLING BASIN — A basin constructed so as to dissipate the energy of fast-flowing water, e.g., from a spillway or bottom outlet, and to protect the river bed from erosion.

STOPLOGS — Large logs or timbers or steel beams placed on top of each other with their ends held in guides on each side of a channel or conduit.

STORAGE — The capacity of the reservoir below the elevation of the crest of the emergency spillway.

STORAGE INDICATION METHOD — A name often given to a flood-routing method also often called the Puls method (after Louis G. Puls) — though it is actually a variation of the method devised by Puls.

STREAM REACH — A length of stream channel selected for use in hydraulic or other computations.

STRUCTURAL HEIGHT — The distance between the lowest point in the excavated foundation (excluding narrow fault zones) and the top of the dam.

TIME OF CONCENTRATION (T_c) — The time it takes water from the most distant point (hydraulically) to reach a watershed outlet. T_c varies, but it is often used as a constant.

TOE OF DAM — The junction of the dam with the ground surface. For an embankment dam, the junction of the upstream face with ground surface is called the upstream toe, and the junction of the downstream face with the ground is referred to as the downstream toe.

TOP OF DAM — The elevation of the uppermost surface of a dam.

TOP WIDTH — The thickness or width of the top of the dam.

TRASH RACK — A screen located at an intake to prevent the ingress of floating or submerged debris.

UNGATED OUTLET — The outlet that allows uncontrolled flow through, around or over a dam, e.g., the crest of a weir box, the invert of a pipe inlet, or the crest of the emergency spillway on a dam without a principal spillway.

UPLIFT — (a) The upward water pressure in the pores of a material or on the base of a structure, (b) An upward force caused by frost heave or wind force.

VELOCITY SPILLWAY HYDROGRAPH — The hydrograph used to establish the dimensions of the emergency spillway.

VEGETATED SPILLWAY — The vegetated open channel spillway in earth materials.

WATERSHED COMPUTER MODEL — A mathematical representation of a drainage basin within which flood flows are computed with the aid of a computer. Represents the flow process over time using time steps.

WEIR — A wall structure built across a stream or incorporated into the inlet portion of the principal spillway of a dam to maintain an upstream water level.

CHAPTER XII:

Bibliography

A. General References

- American Society of Civil Engineering, "Current Trends in Design and Construction of Embankment Dams."
- McCann, M.W. Jr., Shah, H.C., and Franzini, J.B., "Application of Risk Analysis to the Assessment of Dam Safety," Stanford University, 1983.
- National Academy Press, "Safety of Existing Dams: Evaluation and Improvement," 1983.
- Sherard, James L. et al., "Earth and Earth Rock Dams," James Wiley and Sons, 1963.
- U.S. Army Corps of Engineers, "Design and Construction of Safe Dams," (film).
- U.S. Bureau of Reclamation, "Design of Small Dams," Government Printing Office, Washington, D.C.
- U.S. Bureau of Reclamation, "Earth Manual," Government Printing Office, Washington, D.C.
- U.S. Soil Conservation Service, Agricultural Handbook 590. "Ponds-Planning, Design, Construction."
- U.S. Soil Conservation Service, "National Engineering Manual, Title 210," 1980.
- U.S. Soil Conservation Service, Technical Release 40. "Index of SCS National Engineering Technical Materials."
- U.S. Soil Conservation Service, Technical Release 60. "Earth Dams and Reservoirs."

B. Emergency Action Plan Reference

- U.S. Federal Emergency Management Agency, "Emergency Action Planning Guidelines for Dams," 1985.

C. Hydrology and Hydraulics References

- Chow, V.T., "Open-Channel Hydraulics," McGraw-Hill, New York, 1959.
- National Academy Press, "Safety of Dams: Flood and Earthquake Criteria," 1985.
- U.S. Federal Emergency Management Agency, "The National Weather Service Simplified Dam Break Flood Forecasting Model."
- U.S. National Weather Service and Corps of Engineers, Hydrometeorological Report No. 51, "Probable Maximum Precipitation Estimates, U.S. East of 105th Meridian," 1978.
- U.S. National Weather Service and Corps of Engineers, Hydrometeorological Report No. 52, "Application of Probable Maximum Precipitation Estimates, U.S. East of 105th Meridian," 1982.
- U.S. Soil Conservation Service, "National Engineering Handbook No. 4, Hydrology."
- U.S. Soil Conservation Service, "North Dakota Hydrology Manual."
- U.S. Soil Conservation Service, Technical Release 12, "Procedure-Sediment Storage Requirements for Reservoirs."
- U.S. Soil Conservation Service, Technical Release 55, "Urban Hydrology for Small Watersheds."

D. Maintenance References

- Colorado State Engineer's Office, "Dam Safety Manual," June 1983.
- U.S. Army Corps of Engineers, "Recommended Guidelines for Safety Inspection of Dams."
- U.S. Bureau of Reclamation, "Safety Evaluation of Existing Dams (SEED)," 1980.

E. Soils and Embankment Design References

- American Society for Testing and Materials
  - Designation C-127 — Specific Gravity and Absorption of Coarse Aggregate.
  - Designation D-422 — Particle Size, Analysis of Soils, Hydrometer.
  - Designation D-698 — Standard Methods of Test for Moisture — Density of Soils and Soil Aggregate Mixtures Using 5.5 lb. Rammer and 12-inch Drop.
  - Designation D-854 — Specific Gravity of Soils.
  - Designation D-1557 — Standard Methods of Test for Moisture — Density of Soils and Soil Aggregate Mixtures Using 10 lb. Rammer and 18-inch Drop.
  - Designation D-2166 — Unconfined Compressive Strength of Cohesive Soils.
  - Designation D-2435 — One Dimensional Consolidation Properties of Soils.
  - Designation D-2850 — Unconsolidated, Undrained Strength of Cohesive Soils in Triaxial Compression.
  - Designation D-3080 — Direct Shear Test of Soils.
  - Designation D-4318 — Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
- California Department of Public Works, Division of Highways, "Bank and Shore Protection in California Highway Practice," 1960.
- North Dakota State Water Commission, "Standard Specifications for Water Resource Facilities," Information Series 6, 1974.
- Lambe, T.W., "Soil Testing for Engineers," John Wiley, New York, 1951.
- Sherard, Dunnigan and Talbot, "Filters for Silts and Clays," ASCE Journal of Geotechnical Engineering, V110, No. 6, 1974.
- Sherard, Dunnigan and Talbot, "Basic Properties of Sand and Gravel Filters," ASCE Journal of Geotechnical Engineering, V110, No. 6, June 1984.
- U.S. Army Corps of Engineers, "Laboratory Soil Testing," EM 110-2-1906, Washington, D.C., 1970.
- U.S. Army Corps of Engineers, "Permeability Tests with Consolidometer," Appendix VII, Engineering Manual EM 1110-2-1906, November 1970.
- U.S. Soil Conservation Service, "National Engineering Handbook Section 8, Engineering Geology."

- U.S. Soil Conservation Service, Soil Mechanics Notes.
  - No. 3. "Soil Mechanics Considerations for Embankment Drains."
  - No. 5. "Flow Net Construction and Use," October 1975.
  - No. 7. "The Mechanics of Seepage Analysis," October 1979.
  - No. 8. "Soil Mechanics Testing," September 1980.
- U.S. Soil Conservation Service, Technical Release 56, "A Guide for Design and/or Layout of Vegetative Wave Protection for Earth Dam Embankments."
- U.S. Soil Conservation Service, Technical Release 69, "Riprap for Slope Protection Against Wave Action."
- U.S. Army Corps of Engineers, "Laboratory Soil Testing," EM 1110-2-1906, Washington, D.C., 1970.

F. Structural, Concrete and Steel References

- American Institute of Steele Construction, Inc., "Manual of Steel Construction," New York, 1973.
- Concrete Reinforcing Steel Institute, "CRSI Handbook," Chicago, Illinois, 1980.
- U.S. Bureau of Reclamation, "Concrete Manual," Government Printing Office, Washington, D.C.
- Wang, C.K., and Salmon, C., "Reinforced Concrete Design," Harper and Row, New York, 1979.

APPENDIX A

1. Application for Permit to Construct or Enlarge a Dam or Reservoir

2. Application for Conditional Water Permit

APPLICATION / NOTIFICATION TO CONSTRUCT OR MODIFY DAM, DIKE, RING DIKE OR OTHER WATER RESOURCE FACILITY

Office of State Engineer
900 East Boulevard - Bismarck, ND 58505
SFN 51695 (6-98)

OFFICIAL USE ONLY

I,the undersigned, do hereby submit the following information to the Office of the State Engineer for their determination and use as a filing of information required under North Dakola Century Code 61-04-02 or as an application to construct or modify a facility under NDCC 61-16.1-38.

No._____

A. GENERAL INFORMATION:

(1) This Application/Notification must include a map from an actual survey, aerial photo or topographic map. The size of the map shall be 8 1/2 by 11 inches. The map shall have a north arrow and approx. scale. If in the opinion of the State Engineer, the map does not contain information to properly evaluate the project, it will be returned.

(2) The proposed facility is:

- ❒ Dam (Complete Section A & B)
- ❒ Dike (Complete Section A & C)
- ❒ Ring Dike (Complete Section A & C)
- ❒ Diversion Ditch (Complete Section A & E)
- ❒ Restoration (Complete Section A & D)
- ❒ Stock Pond (Complete Section A & E
- ❒ Lagoon/waste storage ponds (Complete Section A & E)
- ❒ Sediment Pond (Complete Section A & E)
- ❒ Creations (Complete Section A & B)
- ❒ Other (Complete Section A & E)

(3) Is this Application/Notification for modification of an existing structure? ❒ Yes ❒ No

If so, when was existing structure constructed? _____ By whom_____

(4) Project Located in_____Water Resource District.

(5) Legal description to the nearest forty-acre tract:_____1/4_____1/4 Sec._____Twp. _____Rge._____

(Optional) Latitude_____Longitude_____

(6) Is the dam and reservoir, dike, diversion ditch, lagoon/pond entirely on Applicant's land? ❒ Yes ❒ No

(if not, applicant must have landowner's permission to construct facility or structure.

Copies of all easements should be filed with these application/notification sheets.)

(7) The facility will be built under the supervision of _____

and will conform to the attached.

(8) Waterway on which structure is or will be located:_____

(9) A tributary to:_____, _____

NDCC:

61-16.1-38. Permit to construct or modify dam, dike, or other device required - Penalty - Emergency.

No dikes, dams, or other devices for water conservation, flood control regulation, watershed improvement, or storage of water which are capable of retaining, obstructing, or diverting more than twelve and one-half acre-feet [15416.52 cubic meters] of water may be constructed within any district except in accordance with the provisions of this chapter. An application for the construction of any dike, dam, or other device, along with complete plans and specifications, must be presented first to the state engineer. After receipt, the state engineer shall consider the application in such detail as the state engineer deems necessary and proper. The state engineer shall refuse to allow the construction of any unsafe or improper dike, dam, or other device which would interfere with the orderly control of the water resources of the district, or may order such changes, conditions, or modifications as in the judgment of the state engineer may be necessary for safety or the protection of property. Within forty-five days after receipt of the application, except in unique or complex situations, the state engineer shall complete the state engineer's initial review of the application and forward the application, along with any changes, conditions, or modifications, to the water resource board of the district within which the contemplated project is located. The board thereupon shall consider, within forty-five days, the application, and suggest any changes, conditions, or modifications to the state engineer. If the application meets with the board's approval, the board shall forward the approved application to the state engineer. The state engineer shall make the final decision on the application and forward that decision to the applicant and the local water resource board. The state engineer may issue temporary permits for dikes, dams, or other devices in cases of an emergency. Any person constructing a dam, dike, or other device, which is capable of retaining, obstructing, or diverting more than twelve and one-half acre-feet [15418.52 cubic meters] of water, without first securing a permit to do so, as required by this section, is liable for all damages proximately caused by the dam, dike, or other device, and is guilty of a class B misdemeanor.

61-04-02. Permit for beneficial use of water required.

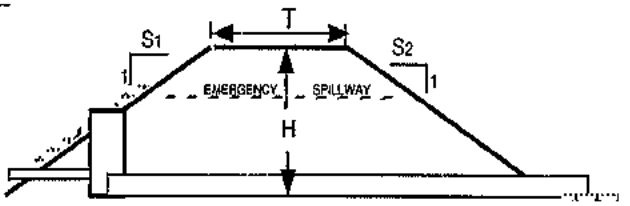
Any person, before commencing any construction for the purpose of appropriating waters of the state or before taking waters of the state from any constructed works, shall first secure a water permit from the state engineer unless such construction or taking from such constructed works is for domestic or livestock purposes or for fish, wildlife, and other recreational uses or unless otherwise provided by law. However, immediately upon completing any constructed works for domestic or livestock purposes or for fish, wildlife, and other recreational uses the water user shall notify the state engineer of the location and acre-feet [1233.48 cubic meters] capacity of such constructed works, dams, or dugouts. Regardless of proposed use, however, all water users shall secure a water permit prior to constructing an impoundment capable of retaining more than twelve and one-half acre-feet [15418.52 cubic meters] of water or the construction of a well from which more than twelve and one-half acre-feet [15418.52 cubic meters] of water per year will be appropriated. In those cases where a permit is not required of a landowner or the landowner's lessee to appropriate less than twelve and one-half acre-feet [15418.52 cubic meters] of water from any source for domestic or livestock purposes or for fish, wildlife, and other recreational uses, those appropriators may apply for water permits in order to clearly establish a priority date; the state engineer may waive any fee or hearing for such applications. An applicant for a water permit to irrigate need not be the owner of the land to be irrigated.

B. DAMS:

(1) Drainage area above dam _____ sq. mi.,_____acres

(2) Purpose: _____

(3) Geometric description of dam



a. Maximum height (H)_____ ft.,_____ msl

b. Top width (T)_____ ft.

c. Side slope: upstream (S_1)_____:1

downstream (S_2)_____:1

d. Dimensions of principal spillway _____

e. Dimensions of emergency spillway _____

f. Type and dimensions of control gate _____

g. Type of outlet protection _____

h. Size of draw down pipe _____

	ELEVATION	RESERVOIR SURFACE AREA (acres)	RESERVOIR CAPACITY (acre-feet)
TOP OF DAM			*
EMERGENCY SPILLWAY			
PRINCIPAL SPILLWAY			
DRAWDOWN PIPE			
STREAMBED AT DAM			

* If Reservoir Capacity is 12 1/2 acre feet or greater at top of Dam, a complete set of plans and specifications must be submitted with and made part of this application/notification. The filing of this application/notification and its approval in no way relieves the landowner(s) from any responsibility or liability for damages from the construction, operation or failure of this structure.

C. DIKE:

(1) Is this application/notification for the construction of a ring dike? ☐ Yes ☐ No

If so, will the ring dike tie into existing? ☐ dike ☐ roadway ☐ high ground ☐ other _____

(2) Purpose: _____

(3) Area of land to be protected by dike: _____ Acres

(4) Description of Dike:

a. Dike length_____feet

b. Dike design:

1. Top width (T) _____feet

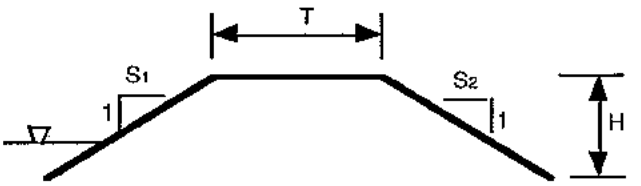
2. Side slope upstream (S_1) _____:1

downstream (S_2) _____:1

3. Maximum height (H) _____feet.

Minimum height _____feet

4. Embankment erosion protection_____



(5) Will the dike flood or adversely affect adjacent, upstream or downstream land? ☐ Yes ☐ No

If so, have flowage easements been obtained? ☐ Yes ☐ No (If flowage easements have been obtained, attach copies and describe provisions of easements, and names of grantors)

(6) Is the proposed dike a result of a township-wide, county-wide, or other water management plan? ☐ Yes ☐ No If so, please describe on attached sheet.

D. WETLAND RESTORATION:

(1) The proposed wetlands are _____ Temporary _____ Permanent

(2) Drainage area above the structure _____ Acres

(3) Are the dam/ditch plug and restored wetland entirely on the applicants land? ☐ Yes ☐ No

If not, land rights are needed to construct dam/ditch plug and flood land. Copies of all easement should be included.

(4) Is this project mitigation for another project? ☐ Yes ☐ No (if yes, describe project)_____

_____

(5) Describe the proposed operation plan for the wetland. _____

_____

(6) If restored wetland volume is less than 12.5 acre-feet at top of structure, provide heights and length of structure in feet, surface area in acres, and volume in acre-feet for each restored wetland within each section.

(7) If restored wetland is greater than 12.5 acre-feet at top of structure provide information below for each restored wetland and complete Section B.

	OVERFLOW ELEVATION (feet)	VOLUME (acre-feet)	SURFACE AREA (acres)
EXISTING			
NATURAL			
PROPOSED			
TOP OF STRUCTURE			

E. OTHER WATER RESOURCE FACILITY:

(1) Design Data:

a. Pond, Lagoon or Dugout

1. Surface area_____ acres
2. Maximum storage _____ acre-feet
3. Maximum depth of water_____ feet
4. Maximum height of embankment above ground _____ feet

b. Diversion Ditch

1. Length of ditch _____feet
2. Bottom width _____feet
3. Side slope _____feet
4. Maximum cut _____feet
5. Gradient _____foot/foot

(2) Description of other project, if not a Pond, Lagoon, Dugout, or Diversion ditch:_____

_____

_____

(3) Waterway into which resevoir would discharge, if drained: _____

ADDITIONAL INFORMATION AND COMMENTS

_____

_____

_____

_____

A permit is granted only upon final decision by the state engineer after review by the water resource district in which the dam, dike, or other device is located. The following definitions apply:

1. Waterway-- include any natural or artificial lake, pond, slough, river,stream, brook,coulee, creek, rill, swale, canal, channel, or ditch.
2. Dam - a structure built across a waterway capable of retaining water.
3. Dike - a structure built along or adjacent to a waterway capable of diverting water.
4. Ring Dike - a structure built around an area such as a farm site or village.
5. Other Device - Includes but is not limited to a division ditch, dugout, lagoon, and holding ponds.

If failure of the project will result in substantial damage to property or loss of life the affidavit of Design Engineer Section will need to be completed.

AFFIDAVIT OF DESIGN ENGINEER

I, _____, a registered professional engineer in the State of North Dakota, designed or directly supervised the design of the dam and reservoir as described in this application and on attached sheets, and construction will be approved by me according to the specifications and data shown in this application and data sheets attached hereto. Dated this _____day of _____ 19____.

The filing of this application/notification in no way relieves the landowner from any responsibility or liability for damages from the construction, operation or failure of the project.

Date Submitted:_____ Name (Print or Type): _____

(Land Owner)

Signed:_____ Address: _____

(Owner of the land on which the project / is located or legal entity sponsoring project)

_____

Phone No. (___)-_____

Application No._____

STATE OF NORTH DAKOTA
APPLICATION FOR CONDITIONAL WATER PERMIT

NOTE: Use one application for each type of source (ground water, surface water). Check all appropriate boxes and fill in each blank line. If the question is not applicable to your proposed development, enter NA (not applicable). If more space is necessary, attach additional sheets.

(PLEASE TYPE OR PRINT IN INK)

1. Name of Applicant _____

Mailing Address _____

City _____ State _____ Zip _____

Home Phone _____ Other Phone _____

2. Source of water supply: ☐ ground water ☐ surface water

If surface water: (a) stream _____ a tributary of _____

_____

(b) If new impoundment — _____1/4_____1/4 Sec._____, Twp._____, Rge. ____

(c) If existing impoundment, give name _____

3. Point of diversion:

(1) _____1/4 of Section_____Township_____N., Range_____W.,_____County

Additional points of diversion, if any:

(2) _____1/4 of Section_____Township_____N., Range_____W.,_____County

(3) _____1/4 of Section_____Township_____N., Range_____W.,_____County

(4) _____1/4 of Section_____Township_____N., Range_____W.,_____County

4. Amount of water requested:

(a) Annual use from points listed in Item 3 above, rate of diversion, and period of use:

_____acre-feet at_____ cfs / gpm from_____to_____inclusive
(AMOUNT) (RATE) (MONTH-DAY) (MONTH-DAY)

(b) If Impoundment:_____acre-feet storage out of which_____acre-feet will be used to offset evaporative losses.

(c) Total annual use requested (sum of annual use from 4a and evaporation from 4b):

_____acre-feet

5. Proposed construction:

Proposed starting date _____

Anticipated completion date _____

6. Description of proposed beneficial water uses:

(a) Irrigation (if applicable)

(1) Method of irrigation: ☐ gravity ☐ sprinkler ☐ waterspreading

(2) Project will involve new irrigated land: ☐ Yes ☐ No

(3) Project will involve supplemental water to existing irrigation: ☐ Yes ☐ No

(4) Description of land to be irrigated (show lot numbers where applicable):

SEC.	TWP.	RGE.	NE1/4				NW1/4				SW1/4				SE1/4				TOTAL
			NE1/4	NW1/4	SW1/4	SE1/4	NE1/4	NW1/4	SW1/4	SE1/4	NE1/4	NW1/4	SW1/4	SE1/4	NE1/4	NW1/4	SW1/4	SE1/4	
TOTAL NUMBER OF ACRES TO BE IRRIGATED:																			

(b) Non-irrigation use (if applicable):

Municipal _____ Recreation _____

Rural-Domestic _____ Fish and Wildlife _____

Industrial _____ Other (please specify) _____

7. Ownership:

(a) Property owner at the point of diversion: _____

(b) Property owner at the place of use: _____

(c) If either (a) or (b) above are other than the applicant, describe the arrangement enabling the applicant to make this filing: _____

_____

_____

8. State law requires that cities and landowners within a one-mile radius of the proposed point of diversion be advised of this application. A completed "Notice of Application" will be forwarded to you upon receipt of this application. Therefore, please indicate the number of landowners and cities which you must notify:

_____

9. *THE APPLICANT CERTIFIES THAT THE STATEMENTS APPEARING HEREIN ARE TO THE BEST OF HIS KNOWLEDGE TRUE AND CORRECT:*

_____
(SIGNATURE) (DATE)

_____
(SIGNATURE) (DATE)

_____
(SIGNATURE) (DATE)

Signature of the applicant(s) must be exactly as in item 1. If more than one applicant is shown, all must sign.

NOTE: Mail the completed application, along with the required map and application fee to:

STATE ENGINEER
State Office Building
900 East Boulevard
Bismarck, ND 58505-0850

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

ND-ENG-16
5/83
(File Code - 210-11)

HYDRAULIC DATA SHEET

Owner/Operator _____ Address _____

County _____ Date _____

TYPE: Stockwater_____ Irrigation_____ Recreation_____ Fish_____ Wildlife_____
Other (specify)_____
(For multipurpose structure, check purposes)
*DRAINAGE AREA:_____ acres. HAZARD CATEGORY_____. DESIGN CLASSIFICATION_____

RESERVOIR AREA

1. Maximum depth = D = _____ft.
2. Depth over 1000 sq.ft. of area _____ ft.
3. Surface area = SA = _____ ac. (estimated _____ computed _____)
4. Storage capacity in reservoir _____ ac.ft.
   ((1/3 D x SA) or from storage table)

* ~~Category I _____ II _____~~

PRINCIPAL SPILLWAY

1. Category I: required capacity = $\frac{\text{drainage area (ac.)}}{640}$ x 7 = _____c.f.s.
2. Category II: peak discharge (Q)* _____c.f.s. (required capacity)
3. Type of spillway: hood_____ hood with weir box_____ drop inlet_____
4. Weir length_____ft. (riser diameter_____ inches)
   (weir box_____ ft. x _____ ft.)
5. Barrel diameter _____ inches; length _____ ft.
6. H_w = _____ ft. Q_w = _____c.f.s.
7. Hor = _____ ft. Qor = _____ c.f.s.
8. H_{ob} = _____ ft. Q_{ob} = _____ c.f.s.
9. H_b = _____ ft. Q_b = _____ c.f.s.
10. Principal spillway capacity _____c.f.s. (must equal or exceed 1 or 2)
    (lesser of 6, 7, 8 or 9)

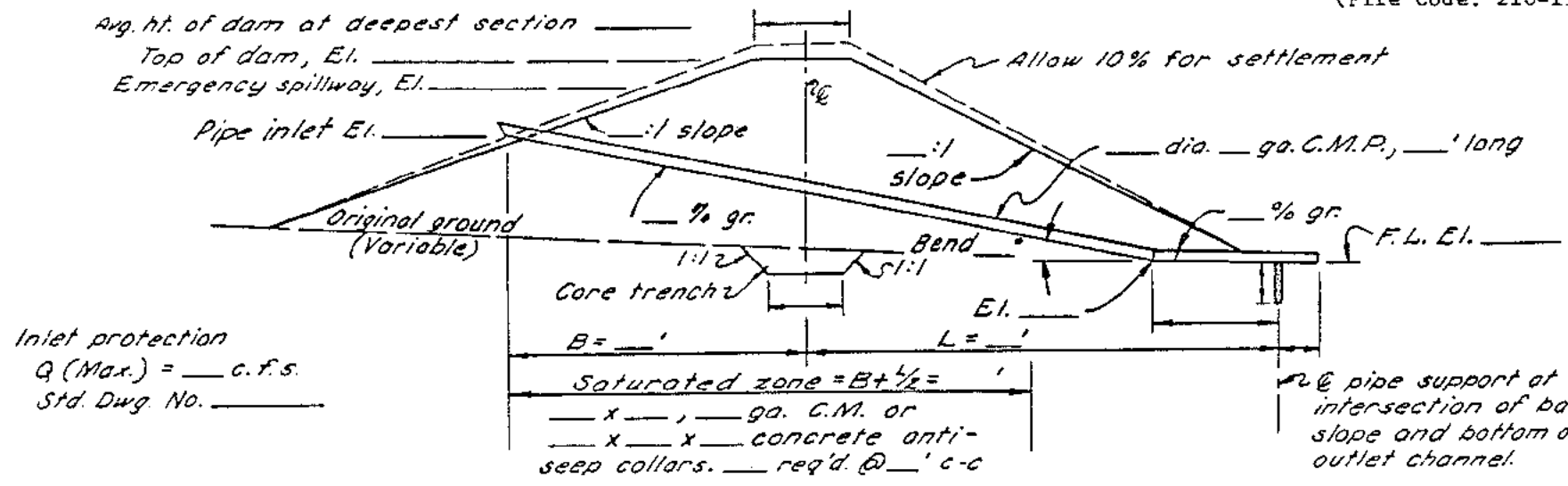
EMERGENCY SPILLWAY

1. Peak discharge (Q) _____ c.f.s.*
2. Shaped spillway design
   a. Depth of water above ES crest H_p = _____ ft.
   b. Total length of spillway L = _____ ft.
   c. Length of level section _____ft.
   d. S_o = _____
   e. Discharge per foot of width** q = _____ c.f.s.
   f. Design width W=Q/q = _____ ft.
   g. SS = _____ : 1
3. Natural spillway design
   a. Top width of spillway at design flow depth _____ ft.
   b. Cross sectional area at flow depth _____ sq.ft.
   c. Mean depth = $\frac{\text{cross sectional area}}{\text{top width}}$ = _____ ft.
   d. S_o = _____
   e. Crest length (approx. level section) _____ ft.
   f. Design capacity (Q)* _____ c.f.s.

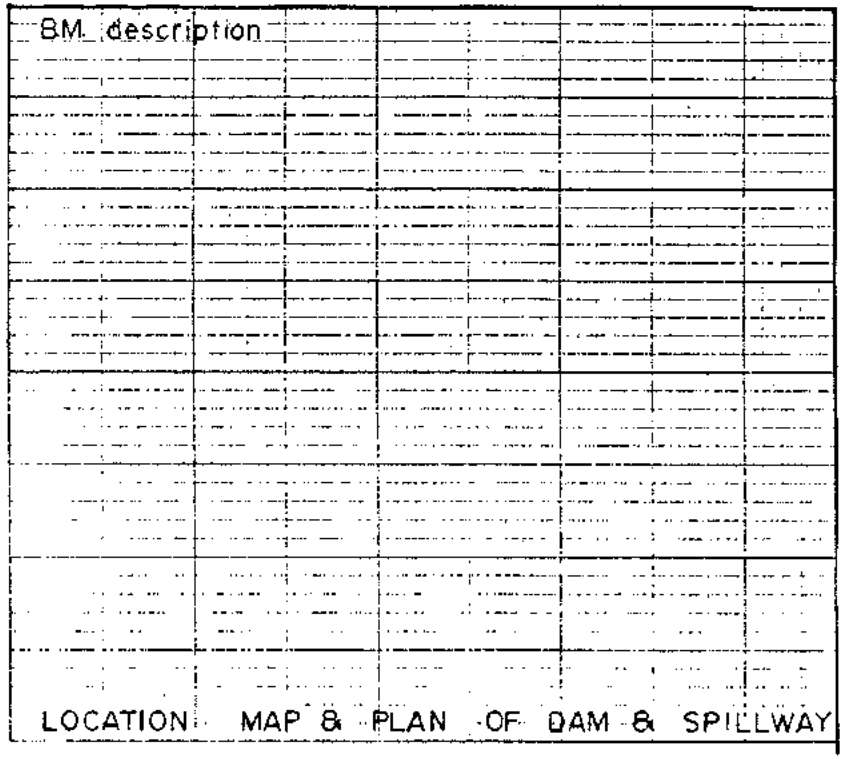
* THIS FORM WAS MODIFIED BY THE AUTHORS OF THIS HANDBOOK

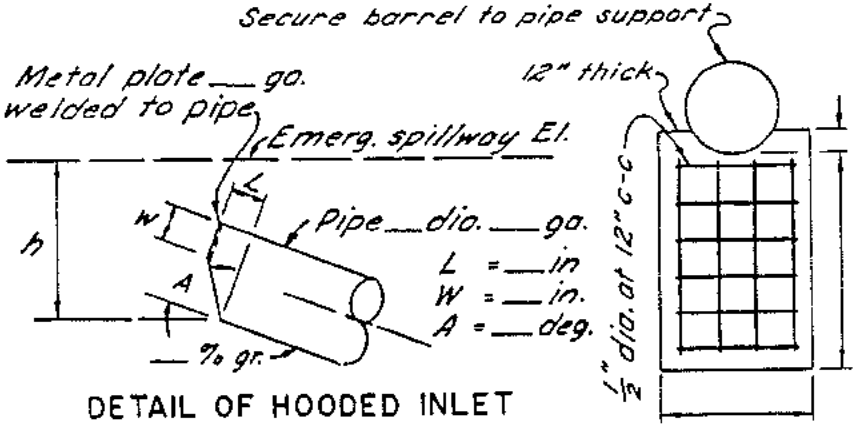
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

ND-ENG-16A
5/83
(File Code: 210-11)



SECTION ℄ DROP INLET





DETAIL OF HOODED INLET

SUPPORT

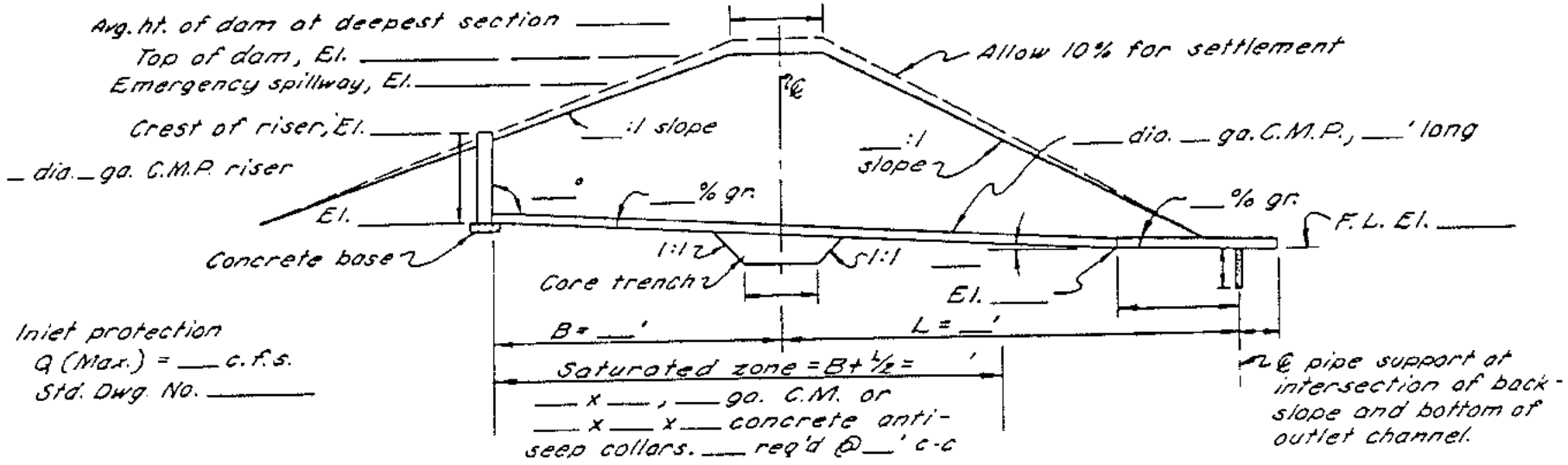
For detail of concrete slab of inlet, see drawing 5,L-17,040

Compiled
Checked
Date
Drawing No.

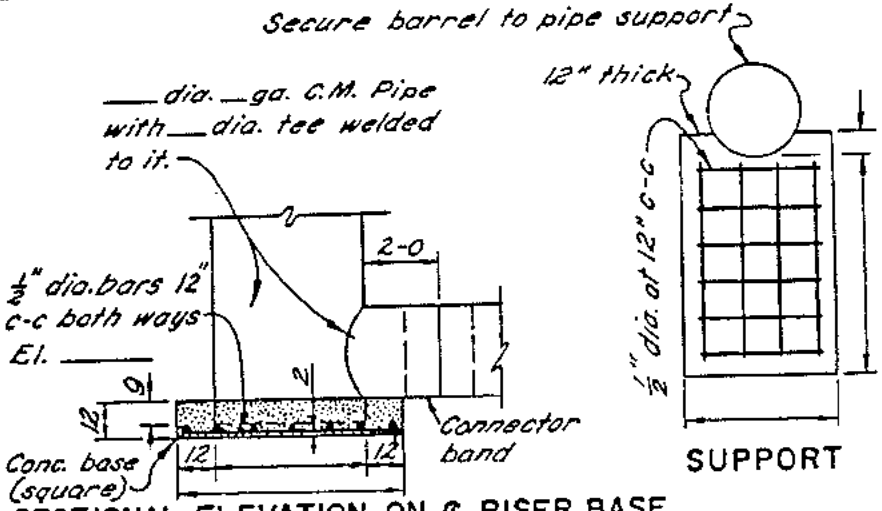
PLAN FOR: HOOD INLET STRUCTURE

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

ND-ENG-16B
5/83
(File Code: 210-11)



SECTION ℄ DROP INLET



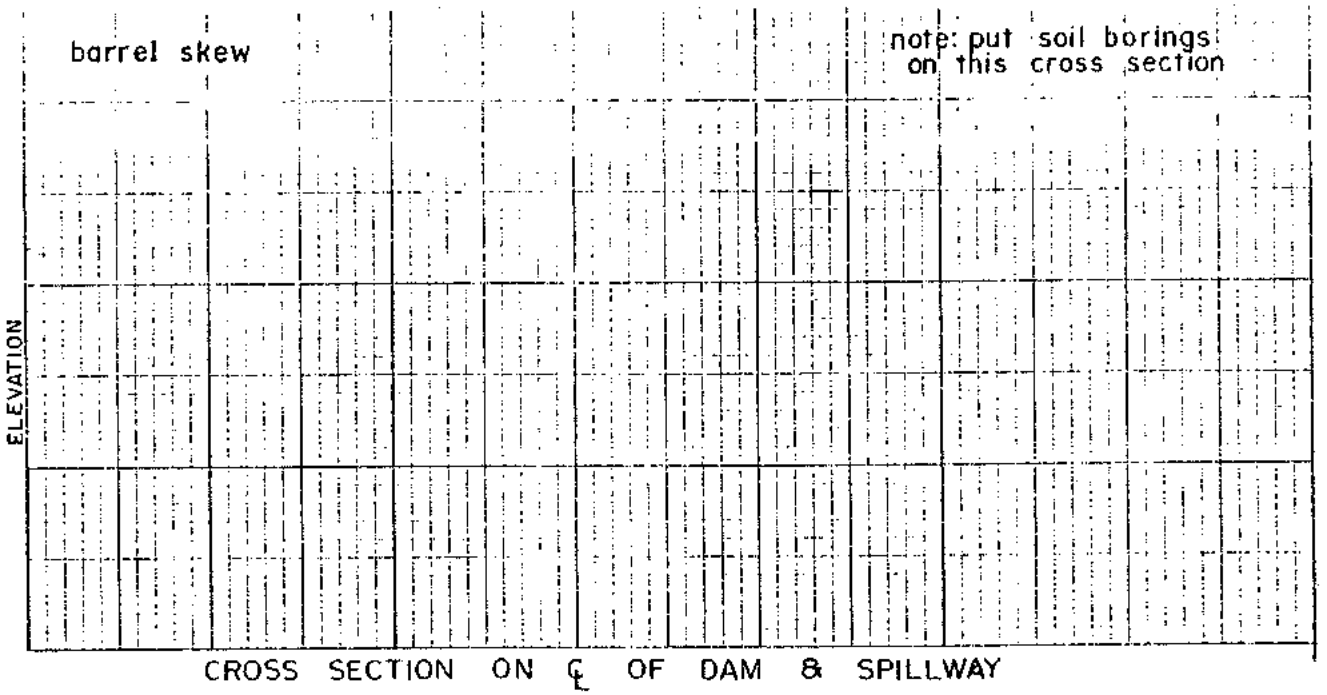
SECTIONAL ELEVATION ON ℄ RISER BASE

BM description

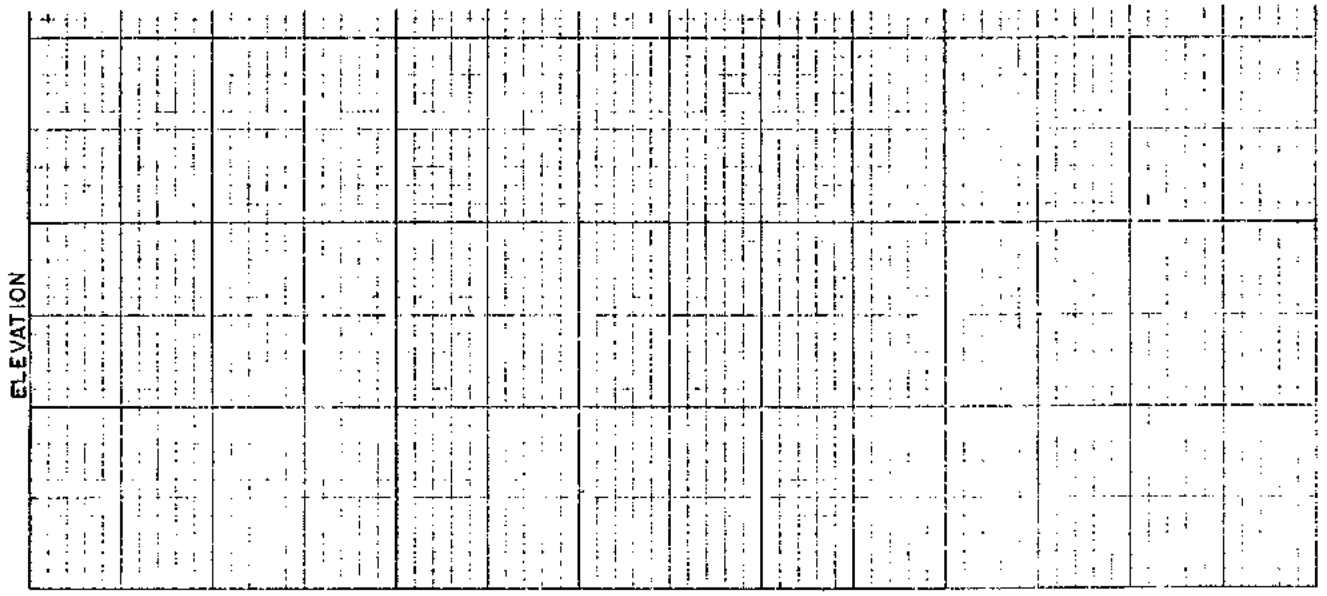
LOCATION MAP & PLAN OF DAM & SPILLWAY

Compiled
Checked
Drawing No.
Date

PLAN FOR: DROP INLET STRUCTURE



CROSS SECTION ON ℄ OF DAM & SPILLWAY



PROFILE OF GULLY & CROSS SECTION OF DAM

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY Design	QUANTITY As built	SPECIFICATIONS
Embankment (attach computation sheets)	Cu.Yd.			
Excavation (attach computation sheets)	Cu.Yd.			
_____pipe; dia. _____in.	Lin.ft.			
_____pipe; dia. _____in.	Lin.ft.			
___ft. x ___ft. antiseep collars ___ga.	Each			
_____type trash rack	Each			
Elbow_____degrees (where required)	Each			
Concrete (class _____)	Cu.Yd.			
Reinforcing steel	Lb.			
Valve: type_____ size_____	Each			
Fencing: type _____	Rods			
Riser and stub (see detail)	Each			
Riprap_____	Cu.Yd.			
Other (specify)				
_____				
_____				
_____				

APPENDIX C

1. USDA-Soil Conservation Service "Job Diary"

2. North Dakota State Water Commission "Change Order"

JOB DIARY

Book No. ____

_____
(Site number or Project)

_____
(Subwatershed)

_____
(Watershed)

Contract No. _____

Date of contract _____

Contractor _____

_____

_____

Date work started _____

Date work completed _____

Landowner(s) _____

_____

_____

INSTRUCTIONS

The JOB DIARY is the pertinent history of the project beginning with the showing of the site to prospective bidders and concluding with the completion of the job. Keep the diary at hand at all times; make complete, legible entries as events occur and sign them.

Pages are provided in the front of the diary for (1) listing the information in the bid schedule, (2) listing the data for material certification and (3) keeping the equipment operating record. Note: To keep the "Type and size of unit" column visible for the pages following it, fold the right-hand sheet back on itself to expose that page in two half-page segments.

Use one numbered page for each shift in which the contractor performs work. Make appropriate entries to record weather, rainfall, duration of work, force used, quantities of work accomplished, and the narrative record. Include in the narrative record, instructions given the contractor, notation of stakes set, measurements taken, tests made, equipment and material delivered to or removed from the site, time lost, cause of delays, rejected work, problems, etc. Show the time of other Service employees on the site and the work they performed. Record the names and purpose of job related visitors. Note pertinent points of discussions between landowners and contractors or their supervisory personnel.

Additional ruled pages are provided in the back for supplemental narrative. Cross-reference the supplemental entries; date and sign them. See Chapter 7 of the Watershed Protection Handbook for more detailed instructions.

BID SCHEDULE

ITEM NO.	WORK OR MATERIAL	QUANTITY	UNIT	UNIT PRICE

MATERIAL CERTIFICATION RECORD

BID ITEM NO.	MATERIAL OR EQUIPMENT	CONTRACT Ref. Spec.	CERTIFICATION	
			Date Prep.	Date Rec.

EQUIPMENT OPERATING RECORD (Hours/Day or Shift)

EQUIP. NO.	TYPE AND SIZE OF UNIT	REPORT NUMBER								

NORTH DAKOTA STATE WATER COMMISSION

Change

Project No.

Order No.

County

Contract dated

for

To

Contractor,

North Dakota

This change is made under the terms of or is supplemental to your present contract and, if and when approved, you are ordered to perform the work in accordance with the additions, changes, or alterations hereinafter described.

EXPLANATION OF CHANGE IN PLAN RECOMMENDED

Spec. No.	Item of Work	Unit	Orig. -|- or— Prev. Change Quantity	Revised Quantity	Increase Quantity	Decrease Quantity	Unit Price	Increase Amount	Decrease Amount

Note—Quantities shown are not necessarily pay quantities and are subject to change.

This order — Total Increase $ Total decrease $ Net increase or decrease $

Total Original Contract Amt. $ Total increase or decrease to date $

I hereby accept this order both as to work to be performed and prices on which payment shall be based.

For Contractor

Other Parties to Contract:

APPROVED

(Signature) (Title)

(Signature) (Title)

Date

Construction Engineer

Design Division

APPROVED

Chief Engineer

Date

CHANGE ORDER

SWC Form #194 DIST : CONTRACTOR, OTHERS, CONST ENGR , ACCT., FILE 500-6-72 61

APPENDIX D

Dam Inspection Checklist

INSPECTION CHECKLIST

NAME OF DAM:

COUNTY:

OWNER:

INVENTORY NO.:

HAZARD CATEGORY:

TYPE OF DAM:

DATE INSPECTED:

WEATHER:

TEMPERATURE:

POOL ELEVATION:

TAILWATER ELEVATION:

STAGE 1 CREST ELEVATION:

DIRECTIONS: MARK AN "X" IN THE YES OR NO COLUMN. IF AN ITEM DOES NOT APPLY, WRITE "NA" IN THE REMARKS COLUMN.

ITEM	YES	NO	REMARKS
EMBANKMENT			
1. UPSTREAM SLOPE			
A. Deficient grass cover			
B. Any erosion or slides			
C. Are trees growing on slope			
D. Longitudinal cracks			
E. Transverse cracks			
F. Deficient riprap protection			
G. Any stone deterioration			
H. Visual depressions or bulges			
I. Visual settlements			
J. Burrows			
2. CREST			
A. Any visual settlements			
B. Misalignment			
C. Cracking			
D. Are trees growing on crest			
3. DOWNSTREAM SLOPE			
A. Deficient grass cover			
B. Any erosion or slides			
C. Are trees growing on slope			
D. Longitudinal cracks			
E. Transverse cracks			
F. Visual depressions or bulges			
G. Visual settlements			
H. Burrows			

ITEM	YES	NO	REMARKS
4. DRAINAGE OR SEEPAGE CONTROL			
A. Is the toe drain flowing			
B. Are the relief wells flowing			
C. Are boils present			
D. Is seepage present			
5. ABUTMENTS			
A. Any erosion			
B. Visual differential movement			
C. Any cracks noted			
D. Is seepage present			
E. Any slides			
RESERVOIR AREA			
1. Slides in reservoir area			
2. Debris producing areas in watershed			
3. Sediment producing areas in watershed			
4. Depressions, sinkholes or vortices in reservoir area			
5. Low ridges/saddles allowing overflow from reservoir			
6. Structures below elevation of maximum surcharge storage			

ITEM	YES	NO	REMARKS
SPILLWAY			
1. APPROACH CHANNEL			
A. Eroding or backcutting			
B. Sloughing			
C. Restricted by vegetation			
D. Obstructed with debris			
E. Silted in			
2. CONTROL STRUCTURE			
A. Does concrete show:			
1. Spalling			
2. Cracking			
3. Erosion			
4. Scaling			
5. Exposed reinforcement			
B. Do joints show:			
1. Displacement or offset			
2. Loss of joint material			
3. Leakage			
C. If spillway is earth cut			
1. Are slopes eroding			
2. Are slopes sloughing			
3. Is crest eroding			
D. If controlled spillway			
1. Are gates bent/broken			
2. Are they corroded/rusted			
3. Are controls, hoists, etc. in need of repair			
4. Not maintained			
5. Not Operated Periodically			
6. Date last operated			
7. When closed, do they leak			
E. Is weir in poor condition			
F. Where is control structure			

ITEM	YES	NO	REMARKS
3. CONVEYANCE STRUCTURE (SPILLWAY CONT)			
A. If structure is concrete			
1. Do concrete surfaces show:			
a. Spalling			
b. Cracking			
c. Erosion			
d. Scaling			
e. Exposed reinforcement			
2. Do joints show:			
a. Displacement or offset			
b. Loss of joint material			
c. Leakage			
B. For an unlined channel			
1. Does channel show erosion			
2. Side slopes show sloughing			
3. Is channel poorly protected with vegetation/riprap			
4. TERMINAL STRUCTURE			
A. Do concrete surfaces show:			
1. Spalling			
2. Cracking			
3. Erosion			
4. Scaling			
5. Exposed reinforcement			
B. Do joints show:			
1. Displacement			
2. Loss of joint material			
3. Leakage			
C. Do energy dissipators show:			
1. Signs of deterioration			
2. Are they covered w/debris			
3. Signs of inadequacy			
5. OUTLET CHANNEL			
A. Is the channel:			
1. Eroding or backcutting			
2. Sloughing			
3. Obstructed			
4. Inadequately riprapped			

ITEM	YES	NO	REMARKS
OUTLET WORKS			
1. APPROACH CHANNEL			
A. Eroding or backcutting			
B. Sloughing			
C. Restricted by vegetation			
D. Obstructed with debris			
E. Silted in			
2. INTAKE STRUCTURE			
A. Do concrete surfaces show:			
1. Spalling			
2. Cracking			
3. Erosion			
4. Scaling			
5. Exposed reinforcement			
B. Do joints show:			
1. Displacement or offset			
2. Loss of joint material			
3. Leakage			
C. Metal Appurtenances			
1. Corrosion present			
2. Breakage present			
3. Anchor system poorly secured			
D. Obstructed by silt & debris			
3. CONVEYANCE STRUCTURE			
A. If structure is concrete			
1. Do concrete surfaces show:			
a. Spalling			
b. Cracking			
c. Erosion			
d. Scaling			
e. Exposed reinforcement			
2. Do joints show:			
a. Displacement or offset			
b. Loss of joint material			
c. Leakage			
B. If conduit is metal			
1. Is corrosion present			
2. Protective coating deficient			
3. Is the conduit misaligned			

ITEM	YES	NO	REMARKS
4. CONTROL STRUCTURE (OUTLET WORKS CONT)			
A. Are service gates in need of repair			
B. Emergency gates/stop logs in need of repair			
C. Are control valves in need of repair			
D. Are they bent/broken			
E. Are they corroded/rusted			
F. Not maintained			
G. Unoperational			
H. When closed, do they leak			
I. Date last operated			
J. Is cold water return not operational			
K. Is the low level outlet not operational			
5. TERMINAL STRUCTURE			
A. Do concrete surfaces show:			
1. Spalling			
2. Cracking			
3. Erosion			
4. Scaling			
5. Exposed reinforcement			
B. Do joints show:			
1. Displacement			
2. Loss of joint material			
3. Leakage			
C. Do the energy dissipators:			
1. Show signs of deterioration			
2. Covered with debris			
3. Show signs of inadequacy			
6. OUTLET CHANNEL			
A. Is the channel:			
1. Eroding or backcutting			
2. Sloughing			
3. Obstructed			
4. Poorly riprapped			

ITEM	YES	NO	REMARKS
DOWNSTREAM AREA			
1. Bridges or culverts that may restrict discharge			
2. Other obstructions which interfere with discharge			
3. Channel headcutting			
4. Downstream floodwalls, levies dikes			
5. Reservoir-connected "springs"			
6. Buildings in flood plain			
7. Overnight recreational sites			
8. Public access sites			
PROJECT AREA			
1. SITE ACCESS			
A. Roads to site inadequate			
B. Unreliable under all weather conditions			
C. Unreliable at all reservoir & river stages			
2. SPILLWAY AND OUTLET CONTROL ACCESS			
A. Are catwalks, ladders, bridges insecurely anchored			
B. Are they unsafe			
C. Are they below elevation of high water			
INSTRUMENTATION			
1. List type(s) of instrumentation			
2. In poor condition			
3. Not read periodically			
4. Is data unavailable			
Notes: List upstream dams			
List downstream dams			
List any high water mark			
(Elev)			

APPENDIX E

1. Example Categories of Action

2. Emergency Action Plan Directory

EXAMPLE CATEGORIES OF ACTION

CATEGORY I - Failure or Impending Failure Conditions
(THE EMERGENCY ACTION PLAN WILL BE ACTIVATED IF ANY OF THE FOLLOWING CONDITIONS ARE NOTED)

1. embankment is overtopped by flood waters;
2. slides on the embankment slopes and a reservoir water level near the embankment crest;
3. flows through the embankment, foundation, or abutments;
4. large - cloudy seepage;
5. failure of appurtenant structures such as principal outlet works or spillway;
6. mass movement of the dam on its foundation such as spreading or mass sliding failure; and
7. severe erosion in the principal spillway area.

CATEGORY II - Potential Failure Conditions
(AN IMMEDIATE INSPECTION BY A QUALIFIED ENGINEER IS REQUIRED IF ANY OF THE FOLLOWING CONDITIONS ARE NOTED)

1. extremely high water level (a specific level should be determined for each dam);
2. erosion from wave action caused by high winds;
3. landslide, or slides in the upstream or downstream slopes of the embankment;
4. emergency spillway erosion;
5. excessive settlement of embankment;
6. slumping or cracking of dam or abutments;
7. new springs, seeps or boggy areas in the embankment or abutment areas;
8. abnormal instrumentation readings;
9. severe storms; and
10. demonstrations or sabotage.

EMERGENCY ACTION PLAN DIRECTORY *

(Include Items as Appropriate)

OWNERS REPRESENTATIVES RESPONSIBLE FOR PLANNED ACTION & CONTACT LOCATION

Name	Position	Address	Phone
1.			
2.			

CITY OF

Name	Position	Address	Phone
1.			
2.			

COUNTY SHERIFF

Name	Position	Address	Phone
1.			
2.			

OFFICE OF STATE ENGINEER

Name	Position	Address	Phone
Vernon Fahy	State Engineer	900 E. Boulevard Bismarck, ND 58505	224-2750
Edgar Schmidt	Dam Safety Coordinator	900 E. Boulevard Bismarck, ND 58505	224-2750

DIVISION OF EMERGENCY MANAGEMENT

Name	Position	Address	Phone
1.			
2.			

LOCAL EMERGENCY MANAGEMENT ORGANIZATION

1. _____

2. _____

* For Design Classification III, IV, and V Dams

AMBULANCE SERVICE

Name	Position	Address	Phone
1.			
2.			

HELICOPTER SERVICE

Name	Position	Address	Phone
1.			
2.			

DIVING SERVICE

Name	Position	Address	Phone
1.			
2.			

OTHER

Name	Position	Address	Phone
1.			
2.			

PERSONS DOWNSTREAM AFFECTED BY FLOOD WATERS

Name	Address	Phone	No. of Residents
1.			
2.			
3.			
4.			
5.			

E.34. Ohio



OHIO DAM SAFETY LAWS AND REGULATIONS 2007

Citation

Ohio Dam Safety Laws are found in the Ohio Revised Code – (ORC) Title XV (enacted Oct. 10, 1963 and last amended March 2007. Administrative rules enacted by the Division of Water of the Department of Natural Resources supplement the permit and inspection laws and reflect Division of Water policy and procedures in carrying out the intent of the law (enacted April 15, 1972, revised Oct. 15, 1981, December 9, 1999, and May 15, 2006).

History

Construction of dams in Ohio dates back to the early 1800s when reservoirs were built to supply water to a state canal system used for agricultural trade and commerce.

Legislation encouraging construction of dams in response to droughts was enacted in 1937, but the forerunner of Ohio's current dam safety laws was enacted in 1963, when the Ohio Department of Natural Resources Division of Water became involved in dam safety. This law required construction permits for new dams.

In 1969, following the failure of several dams in northeast Ohio, the General Assembly revised the law to include periodic inspections of existing structures.

Definitions/Dam Classification

Dams are defined as any artificial barrier together with any appurtenant works, which either does or may impound water or other liquefied material. Upground reservoirs and lagoons are considered to be dams. A fill or structure intended solely for highway or railroad use that does not permanently impound water or other liquefied material as determined by the chief is not considered a dam (Administrative Rules Chapter 3-1501:21-3-01[E]).

Dam height means the vertical dimension as measured from the elevation of the natural stream bed, watercourse, or lowest ground elevation at the downstream or outside toe of a dam to the elevation of the top of the dam (Administrative Rules Chapter 3-1501:21-3-01[I]).

Classification criteria for dams are found in the Administrative Rules Chapter 13-1501:21-13-01.

(1) A dam shall be placed in *class I* when sudden failure of the dam would result in probable loss of human life or structural collapse of at least one residence or one commercial or industrial business. Dams having a total storage volume greater than five thousand acre-feet or a height of greater than sixty feet shall be placed in class I.

(2) Dams having a total storage volume greater than five hundred acre-feet or a height of greater than forty feet shall be placed in *class II*. A dam shall be placed in class II when failure of the dam would result in at least one of the following conditions, but loss of human life is not probable.

(a) Disruption of a public water supply or wastewater treatment facility, release of

health hazardous industrial or commercial waste, or other health hazards.
(b) Flooding of residential, commercial, industrial, or publicly owned structures.
(c) Flooding of high-value property.
(d) Damage or disruption to major roads including but not limited to interstate and state highways, and the only access to residential or other critical areas such as hospitals, nursing homes, or correctional facilities as determined by the chief.
(e) Damage or disruption to railroads~~,~~ or public utilities.
(f) Damage to downstream class I, II or III dams or levees, or other dams or levees of high value. Damage to dams or levees can include, but is not limited to, overtopping of the structure.

(3) Dams having a height of greater than twenty-five feet or a total storage volume greater than fifty acre-feet shall be placed in *class III*. A dam shall be placed in class III when sudden failure of the dam would result in at least one of the following conditions, but loss of human life is not probable.

(a) Property losses including but not limited to rural buildings not otherwise described in paragraph (A) of this rule, and class IV dams and levees not otherwise listed as high-value property in paragraph (A) of this rule. At the request of the dam owner, the chief may exempt dams from the criterion of this paragraph if the dam owner owns the potentially affected property.

(b) Damage or disruption to local roads including but not limited to roads not otherwise listed as major roads in paragraph (A) of this rule.

(4) When sudden failure of the dam would result in property losses restricted mainly to the dam and rural lands, and loss of human life is not probable, the dam may be placed in *class IV*. Dams which are twenty-five feet or less in height and have a total storage volume of fifty acre-feet or less may be placed in class IV. Class IV dams are exempt from the permit requirements of section 1521.06 of the Revised Code pursuant to paragraph (C) of rule 1501:21-19-01 of the Administrative Code.

(B) All pertinent information including any unusual circumstances shall be considered by the chief in establishing an appropriate classification for a dam. Probable future development of the area downstream from the dam that would be affected by its failure shall be considered. Completed downstream hazard mitigation such as acquisition, removal or protection of downstream property may also be considered. However, the above criteria shall in no way preclude the chief's requirement of greater safety in the interest of life, health, or property.

Design Criteria

Hydrologic:

The magnitude of the design flood for each dam shall be set by the chief and determined from actual streamflow and flood frequency records or from synthetic hydrologic criteria based on current publications prepared by the division, the United States army corps of engineers, the United States geologic survey, the national oceanic and atmospheric administration, or others acceptable to the chief.

The minimum design flood will be:

(1) For class I dams, the probable maximum flood or the critical flood;
(2) For class II dams, fifty percent of the probable maximum flood or the critical flood; and,
(3) For class III dams, twenty-five percent of the probable maximum flood or the critical flood.

Seismic:

Seismic design criteria for dams are included in the general design requirements of paragraph (A) of Administrative Rule 1501:21-13-08.

(A) The safety factors for the various elements of the dam shall conform to good engineering practice as approved by the chief. The safety factors and the design standards that are used by the applicant shall agree with the approved design assumptions.

Jurisdiction/Powers of Department

Sections 1521.06-064 of the ORC place the authority for implementation of the dam safety laws within the Division of Water of the Department of Natural Resources.

Section 1521.06 requires that persons or governmental agencies desiring to construct certain dams must obtain a construction permit from the chief of the Division of Water. The Chief has the power to approve or disapprove an application.

Sections 119.01 to 119.13 of the ORC give the Chief of the Division of Water the power to prescribe rules and regulations.

Section 1521.062 of the ORC gives the Chief the power to call for remedial measures, as he deems necessary to safeguard life, health, or property.

If the owner fails to perform such repairs, maintenance, remedial measures, or other measures within the required time period as may have been ordered by the chief, the chief has the right to cite noncompliance and seek judicial measures to have the structure removed or the deficiencies corrected at the expense of the owner. (Administrative Rules 1501:21-21-05).

Permit/Approval Process

Before a construction permit may be issued, three copies of the plans and specifications, including a detailed cost estimate, for the proposed construction, prepared by a registered professional engineer, together with a fee (graduated scale – based on the estimated cost of construction) and the bond or other security required by section 1521.061 of the ORC, shall be filed with the chief. The chief shall within 30 days from the date of the receipt of the application, fee, and bond or other security, issue or deny a permit for the construction or may issue a permit conditioned upon the making of such changes in the plans and specifications for the construction as the chief considers advisable if the chief ~~he~~ determines that the construction of the proposed dam would endanger life, health, or property. If the permit is denied, the bond or other security is returned to the applicant.

After the construction is completed in accordance with the terms of the permit and the plans and specifications, the chief will approve the construction. One year later, if no evidence of non-compliance is evident, the bond is released (ORC 1521.06). As required by Section 1521.063 of the ORC, the owner is then required to pay an annual fee to the Division based on the classification and size of the dam. Owners of pre-permit, Class I, II, and III dams must also pay an annual fee.

Required spillway design standards are found in the Administrative Rules Section 1501:21-13-03 through -05.

Dam construction, including remedial work, is to be paid for by the owner (Administrative Rules 1501:21-21-05).

Repair, Improvement, Alteration, or Removal

Before commencing the repair, improvement, alteration, or removal of a dam or levee, the owner shall file an application including plans, specifications, and other required information, and shall secure written approval of the application by the Chief. Emergency actions by the owner required to safeguard life, health, or property are exempt from this requirement (ORC 1521.062 F).

Fees

Fees on a graduated scale, based on estimated construction costs, are required to obtain construction permits.

Owners of pre-permit, Class I, II, and III dams must also pay an annual fee based on dam classification and size.

Inspection Process

Pursuant to Section 1521.062 of the ORC, periodic inspections will be made by the chief of all class I, II, and III dams to ensure that continued operation and use of the dam does not constitute a hazard to life, health, or property. The chief may make, as deemed necessary, periodic inspections of Class IV dams (Administrative Rules 1501:21-21-01). Section 1521.064 of the ORC provides for the exemption of certain dams from inspection if they meet specific criteria established by the Division of Water. The Rules do not specify any inspection fees to be paid by the owner.

An operation, maintenance and inspection manual is required for all Class I, II and III dams. The manual will include a program for regular inspection, maintenance, and monitoring by the owner or operator (Administrative Rules 1501:21-15-06).

An emergency action plan is required for all class I, II and III structures. The emergency action plan for all class I structures shall include but not be limited to an inundation map of the critical routing reach. An inundation map may also be required for class II and III dams as designated by the chief. The required detail of this map depends upon the complexity of the downstream hazard and shall be acceptable to the chief. (Administrative Rule 1501:21-15-07)

The owner is required to have a licensed, professional engineer perform all inspections

(Administrative Rules 1501-21-3-02).

The chief may make inspections during construction as deemed necessary to insure that the structure is being built in compliance with the approved plans and specifications (Administrative Rules 1501:21-17-01).

Frequency of Inspections

Hazard Classification	*Inspection Cycle*
High	Not to exceed 5 years
Significant	Not to exceed 5 years
Low	Not to exceed 5 years

Violations/Penalties

If the owner fails to perform repairs, maintenance, remedial measures, or other measures as mandated by the chief, the chief shall so notify the owner of the noncompliance and of the chief's intention to remove or correct the unsafe structure, at the expense of the owner, pursuant to section 1521.062 of the ORC. Such cost is a lien upon such lands from the date of entry and shall be collected as other taxes and returned to the division (Administrative Rules 1501:21-21-05). Section 1521.99 of the ORC establishes penalties for violations of Section 1521.06 and 1521.062.

Emergencies

The chief of the Division of Water is empowered to take charge of a dam safety emergency to protect life, property, and health. If the condition of any dam is found, in the judgment of the chief, to be so dangerous to the safety of life, health, or property as not to permit time for the issuance and enforcement of an order relative to repair, maintenance, or operation, the chief shall employ any of the following remedial means necessary to protect life, health, and property.

(1) Lower the water level of the lake or reservoir by releasing water;
(2) Completely drain the lake or reservoir;
(3) Take such other measures or actions as the chief considers necessary to safeguard life, health, and property.

The chief shall continue in full charge and control of the dam or levee until the structure is rendered safe. The cost of the remedy shall be recoverable from the owner of the structure by appropriate action in a court of competent jurisdiction.

Liability

Pursuant to the provisions of section 1521.062 of the ORC, the owner of a dam shall be responsible for the continued safe operation and use of the structure so that it does not constitute a hazard to life, health, or property.

In the interest of safeguarding life, health, or property, the chief may require the owner to prepare a written manual detailing the operation, maintenance, and inspection procedures necessary for the continued safe operation of the dam (Administrative Rules 1501:21-21-04).

Oversight

All orders of the chief are subject to appeal pursuant to sections 1521.06, -.062, and 119.01 to 119.13 of the ORC. Filing of an appeal does not automatically stay the effectiveness of the orders of the chief (Administrative Rules 1501:21-23-01).

Miscellaneous

The following dams are exempt from the construction permit requirement (Administrative Rules 1501:21-19-01):

- Dams constructed under Chapter 1513 ORC (coal mine impoundments).
- Dams, regardless of height, which have a storage capacity of not more than 15 acre-feet.
- Dams less than 10 feet in height, with a storage capacity of not more than 50 acre-feet.
- Dams designed and constructed by the United States Army Corps of Engineers.
- Dams constructed by the state of Ohio, Department of Natural Resources.
- Dams placed by the chief in class IV under rules 1501:21-13-01 of the Administrative Rules.
- Modifications or repairs to existing dams provided that the modifications or repairs do not constitute an enlargement to the structure as defined under rule 1501:21-3-01 of the Administrative Rules.

Other Publications

- *An Operation, Maintenance, and Inspection Manual*
- *Guidelines for Developing EAPs and Operation and Maintenance Manuals*
- Dam Safety Related Fact Sheets (available on Ohio Web Page): *Lake Drains, Rodent Control, Trees and Brush, Classification, Failures, Seepage, Concrete Repair Techniques, Inspection of Concrete Structures, Construction Permits for Dams, Design and Maintenance of Trashracks, Probable Maximum Flood, Annual Fee, Construction Permits for Levees, Open Channel Spillways (Earth and Rock), Inspection Exemption, Embankment Instabilities, Ground Cover, Open Channel Spillways (Concrete Chutes and Weirs), Outlet Erosion Control Structures, Upstream Slope Protection, Spillway Conduit System Problems, Problems with Concrete Materials, Problems with Metal Materials, Problems with Plastic Materials, Critical Flood Guidelines, Remediation Alternatives.*
- Dam and Levee Construction Related Forms:
  Application for a Permit to Construct a Dam, Dike or Levee in the State of Ohio
  Instructions for Application for a Permit to Construct a Dam Dike or Levee in the State of Ohio
  Preliminary Design Report Requirements 1501:21-05-02
  Revised Construction Permit Filing Fees
  Performance Bond

State Web Site: http://www.dnr.state.oh.us/water

Publications (all)
Fact Sheets (all topics)
Newsletters & Reports
Stream Management Guide Fact Sheets
Nonpoint Source Pollution Investigations

Maps (all)
Flood Maps
Ground Water Resource Maps
Pollution Potential Maps
Potentiometric Surface Maps
Statewide Aquifer Maps

Data
Well Log Filing
Well Logs Searches
GIS Data
Observation Well Data

Mailing Address:
ODNR Division of Soil & Water Resources
2045 Morse Road, B-2
Columbus, Ohio 43229-6693

Contact Us

Fact Sheet Index by Program Area

Subject Area	No.	Title	Content Description	Revision Date
Canals	4	The Ohio Canal System	ODNR canal history, laws, administration, public benefits	Aug/5/92
Canals	41	Ohio & Erie Canal/Hydraulic Operations	History & details of canal lakes and diversions with flow diagrams	March/28/97
Conservation	1	Water Efficiency at Home	Household water saving devices and methods	Dec/18/06
Conservation	2	Water Efficiency in Your Own Back Yard	Yard, plants, and lawn watering methods	Jul/2/92
Dams	26	Dam Safety: Lake Drains	Definition, Types, Use, Maintenance of lake drains	July/28/99
Dams	27	Dam Safety: Rodent Control	Rodent damage to dams and control measures	Sept/17/08
Dams	28	Dam Safety: Trees and Brush	Damage to dams from trees and brush, proper maintenance	Feb/08/02
Dams	29	Dam Safety: Classification	Classification of dams in Ohio	July/06/04
Dams	30	Dam Safety: Failures	Cause of earthen dam failures	Jun/22/94
Dams	31	Dam Safety: Seepage	Detection, control, and monitoring of seepage through dams	Jun/22/94
Dams	32	Dam Safety: Concrete Repair Techniques	Techniques for repair of deteriorated concrete structures	July/28/99
Dams	33	Dam Safety: Inspection of Concrete Structures	Inspection of concrete structures for dams	July/28/99
Dams	34	Dam Safety: Construction Permits for Dams	What structures require permits and how to apply	Jun/22/94
Dams	37	Dam Safety: Probable Maximum Flood	Estimate methodology and implications of floods on dam design	April/7/95
Dams	38	Dam Safety: Design and Maintenance of Trashracks	Trashrack design considerations for pipe and riser spillways	July/20/95
Dams	39	Dam Safety: Annual Fee	How to calculate the annual dam safety fee	June/09/2010
Dams	48	Dam Safety: Construction Permits for Levees	Which levees require permits and how to apply	Dec/13/06
Dams	49	Dam Safety: Open Channel Spillways (Earth and Rock)	Design rules, materials, and maintenance issues	July/28/99
Dams	51	Dam Safety: Outlet Erosion Control Structures (Stilling Basins)	Methods of protecting spillway outlets from erosion	Feb/29/99
Dams	52	Dam Safety: Upstream Slope Protection	Methods of protecting the upstream slope of a dam from wave erosion	July/28/99
Dams	53	Dam Safety: Embankment Instabilities	Detection and repair of cracks, slides, and depressions	July/28/99
Dams	54	Dam Safety: Ground Cover	Establishing and maintaining proper vegetation on dams	July/28/99
Dams	55	Dam Safety: Spillway Conduit System Problems	Monitoring and repair of spillway conduit systems	July/28/99
Dams	56	Dam Safety: Problems with Concrete Materials	Monitoring of concrete structures	July/28/99
Dams	57	Dam Safety: Problems with Metal Materials	Monitoring and controlling corrosion of metals	March/24/01
Dams	58	Dam Safety: Problems with Plastic (Polymer) Materials	Inspection and monitoring of plastics	July/28/99

Dams	59	Dam Safety: Open Channel Spillways (Concrete Chutes and Weirs)	Design, maintenance, and monitoring of concrete chutes and weirs	July/28/99
Dams	60	Dam Safety: Critical Flood Design Criteria	Lowering Your Dam's Design Flood Using Critical Flood Analysis	Nov/04/99
Dams	61	Dam Safety: Inspection Exemption	Criteria, and Procedures to Apply for an Inspection Exemption	Jan/29/01
Dams	63	Dam Safety: Remediation Alternatives	Options for dam owners who failed to acquire construction permits or modify the dam to meet code.	May/20/02
Flood	12	Floods and Flood Damage Prevention	Ohio flood history, regulatory goals, floodplain definitions	July/02/02
Flood	13	Facts About Flood Insurance	National Flood Insurance Program benefits/participation	July/02/02
Flood	21	How to Obtain Flood Maps	Producer, distributors, types of, IDs of, costs, how to pay	July/08/02
Flood	36	Facts About Floodproofing (NOT AVAILABLE)	Damage costs, methods, structures, national insurance standards	N/A
Flood	40	Post?Disaster Floodplain Management	Post flood preventive and recovery issues for floodplain managers	July/08/02
Flood	42	Community Rating System and Flood Hazard Mitigation	Reduce flood insurance rates through CRS qualifying activities	Oct/14/97
Flood	50	Natural Benefits of Floodplains	Why floodplains are valuable...	April/11/05
Flood	66	Understanding Your Flood Risk	How to interpret risk in FEMA Special Flood Hazard Area	Feb/15/08
Ground Water	9	Evaluating Ground Water Pollution Potential in Ohio	GWPP mapping program, methods, uses, status map	Jan/12/04
Ground Water	10	Ground Water Resources Mapping in Ohio	GWR mapping methods, uses, description of program, status	Jan/12/04
Ground Water	20	Ground Water Level Monitoring in Ohio	Well network history, uses annual cycles, influences on	Jan/8/93
Ground Water	24	What's Ground Water?	Terms defined, GW occurrence, aquifer differences in Ohio	Oct/20/93
Ground Water	43	Surface Water and Ground Water Interaction	Relationships between surface and ground waters	June1/95
Ground Water	44	What is Nonpoint Source Pollution	Defines terms, problems, and processes of NPS pollution	June1/95
Ground Water	45	Individual Practices to Protect Ground Water Quality	How you can help protect your water quality	June1/95
Ground Water	47	Ground Water Quality	Water quality of naturally occurring aquifers	June1/95
Ground Water	65	Potentiometric Surface Mapping in Ohio	Defines P-Surface Maps, their Production and Use	July 1/05
Planning	22	Community Water Supply Planning in Ohio	Past, future, current study plans, need for ongoing planning	Oct/15/93
Planning	25	Ohio's Conservancy Districts	Ohio district addresses, history, functions	March/07/07
Services of	17	Services of the Ground Water Resources Section	Description of publications and technical assistance	Jan/8/93
Water Cycle	18	The Hydrologic Cycle	Earth's water movement through sea, land & air	Sep/2/93
Water Cycle	11	Precipitation in Ohio	Annual and Long Term Precipitation Trends	Oct/15/92
Wells	3	Water Efficiency for Private Well Owners	Private well construction/management/maintenance	July/2/92
Wells	5	Well Abandonment Regulations	ODH and Ohio EPA Well abandonment regulations	July/22/02
Wells	6	Properly Sealing Unused Wells	Well sealing benefits and methods	Dec/16/92
Wells	7	What is a Well Screen?	Well screen defined, use, benefits, selection	Jan/8/93
			Electronic storage & retrieval of well log	

Wells	8	Well Log Computerization	data & images	Sep/5/92
Wells	14	Well Construction Materials and Techniques	Casing types, depth, regulations, geologic considerations	Dec/16/92
Wells	15	Before You Have a Well Drilled	Geologic, construction & contractor considerations	Dec/16/92
Wells	16	How to Read Well Log and Drilling Reports	Detailed explanation of well log elements	Dec/31/93
Wells	19	Dry Driven Grout Method	Methods of grouting cable tool drilled wells	Nov/23/93
Wells	23	When Does a Well Log Need to be Filed?	Well defined, types of wells, info required, laws, penalties	Oct/1/93
Wells	35	Low Yielding Wells	Household water needs & how to meet them w/low yield well	Jan/9/95
Wells	46	Well Construction in a Buried Valley	Well construction techniques for buried valley aquifers	June1/95
Wells	62	Understanding Your Water Well	Terms and procedures regarding construction, use and maintenance	July/03/01
Wells	64	Using GPS for Well Location on Well Logs	How to fill in the Geographic Coordinates on a Well Log and Drilling Report from GPS readings	Feb/03/03

Ohio Department of Natural Resources
Division of Water Fact Sheet

Fact Sheet 95–37

Dam Safety: Probable Maximum Flood

Uncontrolled flood waters are one of the most powerful and destructive forces in nature. Dams that are not designed to withstand major storms may be destroyed by them, increasing flood damage downstream. This damage is too often catastrophic. In order to protect lives and property downstream, the Ohio Administrative Code requires that dams be constructed to safely handle an appropriate percentage of the Probable Maximum Flood (PMF). This percentage varies according to the height of the dam, size of the impoundment, and extent and severity of damage possible upon failure. The requirements established in Ohio are similar to those used in other states, and historical records of significant storms and dam failures this century verify that the design criteria are reasonable.

Definitions

The Probable Maximum Precipitation (PMP) is the greatest depth (amount) of precipitation, for a given storm duration, that is theoretically possible for a particular area and geographic location.

The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular drainage area.

Historical Storms in Ohio and Dam Failures

Storms which have caused severe flooding and included precipitation amounts that reached a significant percentage of the PMP have occurred in Ohio this century. Flood waters from these storms caused the failure of dams and other structures. Many dam failures are considered disasters because they cause great harm, damage, or serious and sudden misfortune. Because of the rapid and unexpected manner in which dam failures can occur, they are judged to be as serious as earthquakes and tornadoes.

A storm approaching two thirds of the PMP struck north-central Ohio in the summer of 1969. Some small areas within the region were inundated with 14 inches of rain in 12 hours. Three large dams and many small farm-pond dams failed. Almost all the failures were caused by water overtopping the dams.

In 1990, severe flash floods destroyed eighty residences near the town of Shadyside in southeast Ohio. Twenty six people died. In this instance, the amount of precipitation did not constitute a high percentage of the PMP, yet the flood waters which resulted were deep and powerful.

The potential for damage due to dam failures is increasing along with the increase of residential and commercial development downstream of dams. In many cases, existing dams will need to be modified to keep downstream areas safe from disaster.

Recent Notable U.S. Dam Failures

Year	Name	Location	Deaths	Damage
1972	Buffalo Creek Dam	West Virginia	125	$400 million
1972	Canyon Lake Dam	South Dakota	139	$60 million
1976	Teton Dam	Idaho	11	$400 million
1977	Taccoa Falls Dam	Georgia	39	$30 milllion
1982	Lawn Lake Dam	Colorado	3	$21 million

Classification of Ohio Dams

Dams in Ohio are divided into four classes based on the storage volume of the impoundment, dam height and potential downstream hazard (how far downstream the residences are, etc.). These criteria were chosen because they affect the extent and severity of downstream damage possible upon failure. The percentage of the PMF that a dam must be designed to withstand depends upon its classification. Dams that could cause loss of human life if they fail must be designed to handle 100 percent of the PMF. More details about the classification system can be found in the Ohio Administrative Code and Fact Sheet No. 94-29.

Development of the PMP

Scientists use both meteorological methods and historical records to determine the greatest amount of precipitation which is theoretically possible within a region. The historical data consists of point precipitation amounts measured at rain gages throughout the region being studied, or a region with very similar meteorologic and topographic characteristics. These rainfall data are subsequently maximized through "moisture maximization" and other numerical methods. Moisture maximization

Continued on back!

is a process in which the maximum possible atmospheric moisture for a region is applied to rainfall data from a historic storm. This process increases the rainfall depths, bringing them closer to their potential maximum.

Probable maximum precipitation amounts vary slightly throughout Ohio because of variations in topography and meteorology. The PMP is greatest in the southern portion of the state. Furthermore, not all storms have the same duration. Using the methods mentioned above, the PMP has been determined for different storm periods, generally ranging from six to seventy two hours.

Development of the PMF

The Probable Maximum Flood is the flood which is a direct result of the Probable Maximum Precipitation. However, drainage areas with the same PMP may have different PMFs. This is possible because the amount of flooding which results from a given rainfall amount depends upon the characteristics of the drainage basin. For this reason, the PMF, not the PMP, must be used as a design criterion for a dam. Some important characteristics include soil type, land use, size and shape of the watershed, and average watershed slope. Both the volume and rate of runoff are affected. For example, water will run off of steep slopes more quickly than gentle ones. More water will infiltrate sandy soils than clay.

Any other questions, comments concerns, or fact sheet requests, should be directed to the Division of Water at the following address:

Ohio Department of Natural Resources
Division of Water
Dam Safety Engineering Program
2045 Morse Road
Columbus, Ohio 43229-6693
Voice: (614) 265-6731 Fax: (614) 447-9503
Website: http://www.dnr.state.oh.us/water

All-season Probable Maximum Precipitation (in inches) **for 6-hour duration, 10-square mile area.**



Adapted from HMR–51, National Weather Service, 1978.

Ohio Department of Natural Resources
Division of Water Fact Sheet

Fact Sheet 99–60

Dam Safety: Critical Flood Design Criteria

Ohio's Dam Safety Rules require dams to pass floods through their spillways without endangering the safety of the dam. The magnitude of the design flood is directly related to the classification of the dam - which in turn is related to the dam's downstream hazard and/or the dam's height. The greater the downstream hazard, i.e., loss of human life, high-value property, etc., the larger the design flood.

Definitions

The probable Maximum Precipitation (PMP) is the greatest depth (amount) of precipitation for a given storm duration, that is theoretically possible for a particular area and geographic location. The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular drainage area.

Classification of Ohio Dams

Dams in Ohio are divided into four classes based on the storage volume of the impoundment, dam height, and potential downstream hazard (how far downstream residences, businesses are, etc.). More details about the classification system can be found in the Dam Safety: Classification of Structures Fact Sheet No. 94-29.

Critical Flood Design Criteria

Specific guidelines are available for preparing a critical flood engineering analysis. This analysis must be performed by a professional engineer licensed in the State of Ohio. The guidelines can be downloaded from the Division of Water's world wide web site, (http://www.dnr.state.oh.us/odnr/water/temp/dartrlsa.html), or you can request a copy by calling our office directly.

Could the Critical Flood Analysis Make a Difference for My Dam?

The critical flood criteria were developed to make Ohio's Dam Safety Rules more flexible in recognizing that some dams fall outside of the typical parameters used in designing spillway capacity. Specifically, for those circumstances where the size of the dam, its downstream hazard, drainage area, and downstream topography are such that traditional flood design standards do not accurately account for the downstream hazard, critical flood criteria allow for a reduction of up to 60% of the design flood.

For example, let's look at a Class I dam. This type of dam is required to safely pass the 100% PMF through its spillway system without endangering the safety of the dam. As rain falls onto a dam's watershed, some of the rainfall will infiltrate into the ground, some will evaporate, and most of it will runoff across the ground into the pond or lake. The water level in the impoundment will begin to rise while simultaneously flowing through the dam's spillway(s). As water exits the dam's spillway(s), the downstream channel will begin to fill and flow accordingly. For most dams, the downstream channel will likely fill with some water, but most of the water flows downstream without backing up significantly. For those few cases where the downstream channel fills rapidly to the point where water rises dramatically and failure of the dam would have no additional significant increase in elevations of floods downstream, the design flood can be reduced. In other words, there may be a point, say 50% of the PMF (the critical flood in this case), where designing for additional flood capacity for the dam is no longer reasonable. If the dam were to fail, the downstream hazard would not be further adversely effected. In this case, the spillway system may be designed for half of what it would have been originally designed, therefore saving dollars without increasing the hazard to the downstream area.

What is the Maximum Reduction in Design Flood?

The design flood can be reduced approximately up to 60% for each class of dam:

Class I	100% PMF down to no less than 40% PMF
Class II	50% PMF down to no less than 20% PMF
Class III	25% PMF down to no less than 100 Year

Continued on back!

What Factors Should I Consider Before Proceeding With an Analysis?

The cost of the analysis can be thousands of dollars. Let's assume that a dam inspection by our engineers reveals that a dam is deficient in its ability to pass the design flood. It would be beneficial to have an analysis performed if the design flood was reduced enough so that the spillway system did not need to be upgraded or replaced. Let's assume that upgrading the spillway system costs $50,000. If the cost of the critical flood analysis was $5,000, the cost of the critical flood analysis would be warranted.

Sometimes it can be straightforward to predict whether or not an analysis would be beneficial. However, in those cases where it may not be clear, other options should be considered. For example, if room exists in one of the dam's abutments to excavate an emergency spillway or perhaps enlarge an existing emergency spillway, it may be more cost effective to do so. There is always a risk in running an analysis and finding out that the reduction in design flood is insignificant and the spillway system enlargement is still required.

A critical flood analysis approved by our office means that a reduced design flood is acceptable for your dam. Please note that a reduction in the design flood for your dam may increase the risk of failure or damage to your dam. This could result in an economical burden on the dam owner. This risk should be closely considered!

How Can I Apply for the Critical Flood Reduction?

A request for consideration must be submitted to the Chief of the Division of Water. The request must be accompanied by supporting calculations based upon an analysis performed by a professional engineer registered in the State of Ohio. The engineer's analysis must conform to the critical flood guidelines provided by the Division of Water.

Before applying, it is best to call and speak with an engineer in the Division's Dam Safety Engineering Program.

What Restrictions Are There?

A critical flood reduction based upon planned evacuation, probability of inhabitation, or monetary recovery of property damage will not be considered. In other words, guaranteeing that a downstream residence or business will be evacuated during a dam failure will not be considered. In situations where the downstream hazard may or may not be inhabited, such as in the case of a campground, rental property, hotel, and so forth, the probability of inhabitation will not be considered. Also, understanding that failure of a dam will damage downstream property and guaranteeing that the damages will be paid for will also not be considered. Finally, if the downstream hazard were to change, the critical flood exemption could be nullified.

Any other questions, comments concerns, or fact sheet requests, should be directed to the Division of Water at the following address:

Ohio Department of Natural Resources
Division of Water
Dam Safety Engineering Program
2045 Morse Road
Columbus, Ohio 43229-6693
Voice: (614) 265-6731 Fax: (614) 447-9503
Website: http://www.dnr.state.oh.us/water

Critical Flood Guidelines

Purpose of the “critical flood” rule is to recognize that in certain situations, overtopping dam failures may be insignificant in how much damage they cause to downstream areas. It is based on the assumption that if all downstream flood damages occur due to a base-flow flood that is less than the regulatory design flood for the dam, then requiring additional spillway capacity above this flood to satisfy the design flood requirement would therefore, not be necessary. For this outcome, a flood of lesser size may exists that would show a more measurable impact than the regulatory design flood for the dam. The measurable impact that occurs to downstream areas from any hypothetical base-flow flood, given the dam fails, must be greater than the amount occurred for the same flood, given the dam does not fail, before the flood can be labeled as critical. The term “base-flow” flood, used throughout this document, refers to a starting flood condition in which an action or undertaking is made and should not be misinterpreted as groundwater flow.

The importance as to the dam's value and benefits it provides to the owner and the community must always be evaluated before subjecting the dam to possible overtopping and failure by a flood that is less than the required design flood for the structure. An incremental damage analysis may be used to determine the inflow design (critical) flood that is less than the minimum requirements of 1501:21-13-02. The flood will be based upon a comparison of two flood simulations occurring with the dam in question present: one, a base-flow flood that has a size that would cause failure of the dam, but has been modeled without any effects from a dam failure (Condition A), two, the same flood, but modeled to include the dam-break discharges based on the most severe hypothetical dam failure that is possible (Condition B). These flood simulations are routed downstream through a reach that has been determined to be the recipient of the potential floodwater damages. The spillway capacity and inflow design flood will be acceptable where it can be shown that the dam failure flood (Condition B) would cause no expected additional loss of life and would not cause significant incremental flood damages downstream of the dam. Additional potential for loss of life, health or property in the critical routing reach is expected if the incremental depth of flow between the dam failure and non-failure floods is greater than 2.0 feet or the product of the average floodplain flow velocity and the incremental depth is greater than 7.0 feet^2/second.

The design for the critical flood must be for specific site conditions and based on a quantitative and relative impact analysis of the downstream critical routing reach. The owner must submit to the chief, in writing, a request for consideration of the critical flood as the design flood. This request must be accompanied by appropriate supporting calculations. The chief will not consider risk assessment based upon planned evacuation, probability of inhabitation, or monetary recovery of property damage.

The scope of the critical flood analysis will identify the flooding source, upstream and downstream limits of the stream reach to be studied, and the applicable hydrologic and hydraulic methodology to be used. The scope may require completion of any or all of the following work items:

I. Field surveys to obtain data for stream and adjacent floodplain cross sections and other structures that may affect the hydraulics of the study reach.

II. Hydrologic analyses to determine stream peak discharges for the dam's design flood and any floods of a lesser magnitude used in the process of determining the inflow design flood for the dam.

III. Hydraulic analyses to determine dam failure discharges, flood elevations and floodplain stream and channel velocities at critical locations along the study reach.

IV. Development of a flood inundation map for the critical structures within the study reach using topographic work maps of the floodplains.

General Requirements:

1. A critical flood study conducted in accordance with Ohio Administrative Code (OAC) Rule 1501:21-13-02 shall include a written statement of purpose and scope of the analysis.

2. The analysis shall identify the flooding source, recurrence intervals for all flood events that were analyzed, upstream and downstream limits of stream reach to be studied, and the applicable hydrologic and hydraulic methodology to be used. This scope of the study may include, but not be limited to, completion of any or all of the following work items:

    a. Preparation of topographic work maps of the floodplains within the study area. The maps must identify elevations of the critical structures that are affected by the flood study.

    b. Field surveys to obtain data for stream cross sections and other hydraulic parameters (i.e., Manning's "n", Expansion and Contraction coefficients, etc.).

    c. Hydrologic analysis to determine discharge rates used in flood routings for the various flood frequencies used to substantiate the critical flood flows.

    d. Hydraulic analysis to determine dam failure discharges, flood elevations, floodplain boundaries, and stream channel and floodplain velocities. Calculations to determine the dam failure discharges must include a sensitivity study on the set of boundary conditions established for the dam breach analysis. This study is required for obtaining the most severe hydraulic condition during a catastrophic dam failure that is theoretically possible. Dam breach parameters used in the critical flood analysis shall be based on suggested values established by the U. S. Army Corps of Engineers, or the Federal Energy Regulatory Commission, unless otherwise approved by the chief.

e. Compilation of other flood study technical documentation used in the analysis.

f. Preparation of a critical flood report with flood profiles and work maps of the floodplain.

3. A "critical flood" study conducted in accordance with OAC Rule 1501:21-13-02 shall be completed under supervision of a registered professional engineer who is qualified to do flood study work.

Data Acquisition and Mapping

1. Topographic mapping for critical flood studies conducted in accordance with OAC Rule 1501:21-13-02 shall conform to the following standards:

A. Mapping shall be done by photogrammetric methods and/or topographic surveying. If topographic mapping is based solely on field surveys, map accuracy requirements shall be the same as those required by photogrammetric methods.

B. Map scale may vary but should not exceed one inch equals 1000 feet for the study area.

C. Contour intervals shall not exceed 5 feet for the appropriate terrain. Intermediate one-foot contour intervals may be required for special cases such as unusually flat terrain.

D. Elevations used in the flood study shall correspond to the National Geodetic vertical datum of 1929 or, when available, the successor North American vertical datum of 1983. Elevation reference marks and temporary reference points established for the study shall be tied by survey to at least one official bench mark of the datum for which the exact elevation to the nearest hundredth of a foot has been obtained.

Data Standards and Procedures

1. The following standards and procedures shall apply to hydrologic data used in a critical flood determination study conducted in accordance with OAC Rule 1501:21-13-02.

A. Hydrologic data shall be from official government sources except as approved by the chief. Use of unofficial data sources, such as high-water marks, shall be dependent on reliability of the data.

B. Stream flow data used for calibrating the hydrologic model shall be from official government records such as published by the United States Geological Survey.

C. Precipitation data shall be from official government records such as published by the National Weather Service.

D. Watershed data shall be from official maps, survey documents, and aerial photography generated by pertinent government agencies. Sufficient field observations shall be made to interpret maps and photographs and identify any significant changes in watershed conditions since source materials were completed.

2. The following standards and procedures shall apply to channel and valley cross sections used in the critical flood study conducted in accordance with OAC Rule 1501:21-13-02:

A. Each cross section must span the entire floodplain for each of the appropriate discharges used in the flood study. The cross sections must represent the particular stream reach from which it was taken. Local irregularities in ground surface that are not representative of reaches shall be avoided in surveys.

B. Cross-section alignment shall be perpendicular to the direction of flow. Cross-sections may consist of straight, curved or zigzag segments as needed to achieve proper alignment.

C. Horizontal stations for the cross-section shall correspond to the distance measured to the nearest foot along the straight, curved or zigzag alignment of the cross-section.

D. Cross-section elevations shall be determined at all significant breaks in ground slope and at points where significant changes in hydraulic characteristics of the floodplain occur. Additional points shall be included, as appropriate, using the following criteria as a guide:

1. The distance between channel reach stations should be such that the depth of flow at the next neighboring cross-section downstream does not increase more than 20 percent.

2. No adjacent horizontal points in the overbank areas shall be separated by more than 10 percent of the complete valley and channel cross-section width.

3. No adjacent horizontal points in the main channel shall be separated by more than 20 percent of the main channel width or 2 feet, whichever is greater.

4. Elevations of above water portions of cross-sections shall be determined by field surveys or photogrammetric techniques, when reliable data of sufficient accuracy cannot be obtained from available sources. Elevation of below water portion of cross-

sections shall be determined by field survey except where reliable data of sufficient accuracy can be obtained from available sources. Field surveys shall normally be accomplished by differential leveling or a differential global positioning system.

3. The following standards and procedures shall apply to channel and overbank reaches used in the critical flood analysis conducted in accordance with OAC Rule 1501:21-13-02:

A. Channel reach length shall be the distance between cross sections as measured along the principal flow line of the stream channel at the flood stage.

B. Channel and overbank reach lengths between stream cross-sections shall be determined by field surveys or distance measurements on topographic work maps. Design drawings for bridges and hydraulc structures shall be used to obtain reach lengths if available.

4. The following standards and procedures shall apply to roughness coefficients used in the critical flood analysis conducted in accordance with OAC Rule 1501:21-13-02:

A. Roughness coefficients shall be determined by field inspection of channel and overbank areas. Consideration shall be given to variation in roughness at various flood stages. Aerial photographs, when available, shall be used to supplement field observations.

B. Roughness coefficients obtained from any previous work shall be field checked for accuracy and updated, if they do not reflect current conditions.

5. The following standards and procedures shall apply to bridges and hydraulic structures data used in the critical flood analysis conducted in accordance with OAC Rule 1501:21-13-02:

A. Dimensions and elevations of all bridges and hydraulic structures including below water sections shall be obtained from construction drawings and/or by field survey measurements.

B. Bridges and hydraulic structures data obtained from documents shall be field checked in sufficient detail to verify that the data are for the correct structure and match as-built conditions.

C. No dimensions or elevations for bridges and hydraulic structures shall be determined by photogrammetric methods. Photographs shall be used to supplement and document field observations or hydraulic structures.

6. The following standards and procedures shall apply to the dam failure analyses data used in

the critical flood study conducted in accordance with OAC Rule 1501:21-13-02:

A. All boundary conditions used in the dam failure analysis must be supported by sound engineering assumptions and supporting field data obtained for the dam. A sensitivity analysis shall be required by varying the input boundary conditions used in a dam break model as a means of converging on the worst case dam failure modeling scenarios. The maximum discharges obtained from the dam failure analysis shall be used for the basis of determining downstream impact on the critical routing reach.

B. Parameters used to estimate the erosiveness of the soils shall be field checked in sufficient detail to verify their validity in use. Each boundary condition used in the development of the dam failure model shall be supported by sound engineering assumptions.

Hydrologic Requirements

1. Hydrologic analyses for the critical flood determination conducted in accordance with OAC Rule 1501:21-13-02 shall require a determination of the base-flow flood discharges and dam failure discharges at appropriate stream stations downstream of the dam. The criteria used to establish the initial base-flow flood discharge for a class I dam is the probable maximum flood, for a class II dam, 50 percent of the probable maximum flood, and for a class III dam, 25 percent of the probable maximum flood. The dam failure discharges are determined by doing a breach analysis for the dam and combining the resulting breach hydrograph for the worst case failure condition with the base-flow flood hydrograph established for the dam.

A. Flood peak discharge estimates shall be determined for the downstream terminus of the stream reach studied and at all upstream stations where significant changes in peak discharge occur due to reduction in tributary drainage area and other factors.

B. Flood peak discharge estimates established for the study area by previous work shall be acceptable for use in flood studies provided that parameters used to make previous estimates remain valid for existing conditions, methodologies are consistent with standard engineering practices and guidelines, and accuracy of estimate is within confidence limits approved by the chief.

2. Methodology for calculating discharges conducted for critical flood analyses in accordance with OAC Rule 1501:21-13-02 shall conform to the following standards:

A. A rainfall-runoff model (e.g., HEC-1) shall be used to estimate the flood peak discharges used in the critical flood analysis. The model shall be calibrated as

appropriate and conform to the following standards:

1. Models shall normally be based on unit-graph theory as embodied in unit-graph procedures of the Natural Resources Conservation Service, United States Geological Survey, and United States Army Corps of Engineers. Use of an alternate runoff simulation modeling procedure must be approved by the chief.

2. Drainage areas and sub-basin areas for unit graphs shall have reasonable uniform hydrologic characteristics.

3. Durations of storm rainfall shall be the duration resulting in the largest discharges for the stream reach being studied.

4. Rainfall amounts for storm events of different duration and frequency shall be estimates as published by the National Weather Service or other approved source.

5. Point-Rainfall estimates shall be adjusted using area-depth relationships when the area of the modeled drainage basin exceeds ten square miles.

6. Rainfall distribution shall be an appropriate pattern such as national weather service median time distributions, miller distribution, or Natural Resources Conservation Service Type II storm pattern.

7. Methodology used to estimate flood peak discharges shall include procedures that account for urbanization, surface mining, regulation, and valley storage when these are significant factors affecting flood flows. Urbanization and surface mining shall be considered to be significant factors whenever more than 30 percent of the watershed is affected by these land use activities. Allowances for effects of urbanization on flood peaks shall be made by appropriate procedures such as those developed by the United States Geological Survey and the Natural Resources Conservation Service. Effects of Regulation and Valley Storage shall be accounted for by reservoir and stream routing techniques as appropriate.

8. When applicable, flood peak discharge estimates used in the critical flood analysis shall be checked for reasonableness by comparison with other flood peak data such as: actual flood peak discharges recorded for similar drainage basins, peak discharge estimates from other studies of similar basins, and estimates from alternative modeling techniques.

Hydraulic Requirements

Hydrologic analyses for the critical flood determination conducted in accordance with OAC Rule 1501:21-13-02 shall conform to the following standards:

1. Water-surface profiles shall be determined by step-backwater procedure whenever applicable together with other pertinent hydraulic formulae. Computer programs used for water surface profile analysis shall be step-backwater algorithms such as the United States Army Corps of Engineers's HEC-RAS program.

2. Dam failure discharges shall be determined by a flood routing program equipped with dam failure analysis routines and/or a specific dynamic reservoir routing program such as the Boss Dambreak program.

3. Initial water-surface elevation used in step-backwater analysis shall be based on normal depth or determined from stage-discharge rating at a control section. If normal depth is used to determine initial water-surface elevation, the modeling shall include at least three initial cross sections beyond the terminus of the stream reach where actual flood elevations are required to allow for iterative convergence of flood profile.

4. Models shall be calibrated using measured profiles and reliable high-water marks of past floods when such information is available. Models shall match known high-water marks within plus or minus 0.5 foot.

5. Any cases where computation of water-surface profiles may require use of two-dimensional computer modeling, dynamic wave routing or other special analysis shall be approved by the chief.

6. Location, alignment and subdivision of channel and floodplain cross-sections used in stream modeling shall be based on field observations and careful examination of topographic maps and aerial photographs. Cross-sections shall be typical of adjacent upstream and downstream reaches. A minimum of four cross-sections is required for the critical flood analysis.

7. Cross-sections shall be located where needed to account for changes in dimensions and roughness of the channel and floodplain. Cross-sections shall be located at all significant breaks in channel grade. Channel reach length between cross-sections shall be short enough to avoid excessive change in conveyance, velocity head, or energy loss.

8. Alignment of cross-sections shall normally be perpendicular to direction of flow in channels and overbank areas. For streams with severe meanders, where the majority of stream flow deviates from the channel, the alignment of cross-sections shall be perpendicular to the center of mass of the flow.

9. Floodplain and channel cross-sections shall be subdivided into at least channel and overbank

areas for analysis. Additional subdivisions may be required depending on the specific cross-section. Ineffective flow areas shall be excluded from cross-sections as appropriate to insure accurate modeling of stream flow.

10. Modeling of existing channel constrictions shall include a sufficient number of upstream and downstream cross-sections to accurately model flow lines.

11. Modeling of bridges and culverts using routines in step-backwater computer programs shall require at least four cross sections. Sections shall be located at the upstream and downstream sides of the structures and at appropriate distances upstream and downstream of the structures to properly model transitions and ineffective flow areas. Additional cross-sections shall be used as needed to establish starting water elevation and evaluate upstream and downstream impacts. Options in step-backwater programs for direct input of bridge and culvert profiles based on hydraulic charts and other sources may be used when appropriate.

12. Modeling of developed floodplain areas with buildings shall normally be based on adjustment of roughness coefficients by procedures such as those developed by the United States Geological Survey. In cases where it involves a single building or a limited number of buildings, these structures may be modeled using at least four cross-sections to model the blocked portion of the floodplain, ineffective flow areas, and open areas upstream and downstream of the buildings.

13. Split flow analysis shall be considered when stream flows divide around an island or overflow the banks of the main stream and take a different flow path. The analysis shall address the reduction in flow in the downstream reach when overflows leave the main channel and enter another basin. Acceptance of the procedures used in the split flow analysis will be required by the chief on a case by case basis.

14. Modeling of tributary streams shall proceed from initial water-surface elevations determined from normal depth on the main stream unless coincident peak situation applies or tributary flow depth is higher than the corresponding main stream event.

Flood Study Report

1. The critical flood analysis conducted in accordance with OAC Rule 1501:21-13-02 shall be summarized in a flood study report. Contents of the report shall include all applicable narratives and exhibit items detailed under this guideline.

2. Reports of the critical flood analysis shall contain a narrative text that is organized into thefollowing sections: Introduction, Area Studied, Hydrologic Analysis, Hydraulic Analysis, and Summary of Impact.

A. The introductory section of critical flood reports shall state the purpose of the study, cite the authority for the work, summarize the scope of the work, and discuss study requirements.

B. The area studied section of the critical flood report shall describe the location of the study area, flooding source, and define the critical routing reach for the dam.

C. The hydrologic analysis section of the critical flood report shall discuss the following items:

1. Methodology and adequacy for current study of flood discharge estimates for the flooding source.

2. Methodology used to compute peak discharge estimates for flooding source and document sources of hydrologic data.

3. Include a summary of discharges in a table that gives the following information: name of flooding source, location point on stream, drainage area in square miles, and the various flood frequency peak discharges for the with and without dam failure conditions.

4. Review any historical flood information for the flooding source and discuss comparative flood peak estimates based on alternative methodology as appropriate.

C. The hydraulic analysis section of the critical flood report shall discuss the following items:

1. Methodology used to generate flood profiles for the study reach.

2. Discuss methodology, engineering assumptions, and the hydraulic parameters for their adequacy in the development of the dam failure discharges.

3. Discuss methodology and field procedures used to generate flood profiles including: how cross sections were obtained, how channel and overbank reach lengths were determined, how roughness factors were estimated, how dimensions of hydraulic structures were obtained, how water surface elevations were computed, and how starting water elevations were determined.

4. Describe the concepts and procedures used to comply with the no impact requirements for critical flood determination.

5. Describe methods used to evaluate the hydraulic impact of a dam failure flood on

the critical routing reach, and summarize results of the hydraulic analysis.

3. Reports of the critical flood analysis, conducted in accordance with OAC Rule 1501:21-13-02 may include, but not be limited to the following exhibits: work maps, flood profiles, and photographs.

A. Work maps shall contain coverage of the critical routing reach and all potential affected structures.

1. Each work map shall be identified with the following information: date map was prepared, map bar scale, north arrow, source of base map and date, whether map is one of several maps, and a legend, if applicable, indicating any symbols used for identifcation purposes on the map.

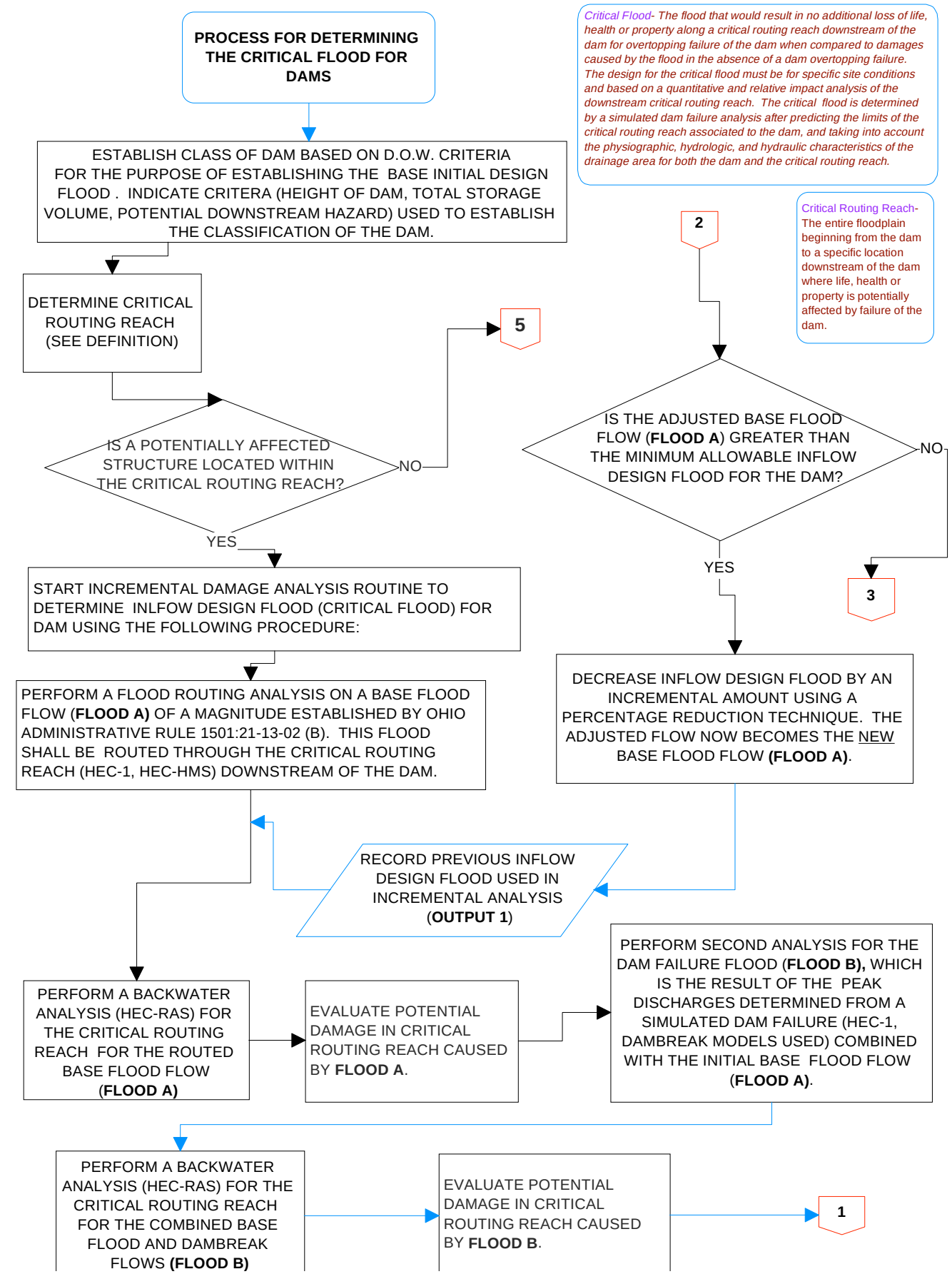
2. Work maps shall show existing topographic contours, low-water outline of streams and lakes, cross sections, boundaries of floodplains associated with the critical flood discharges.

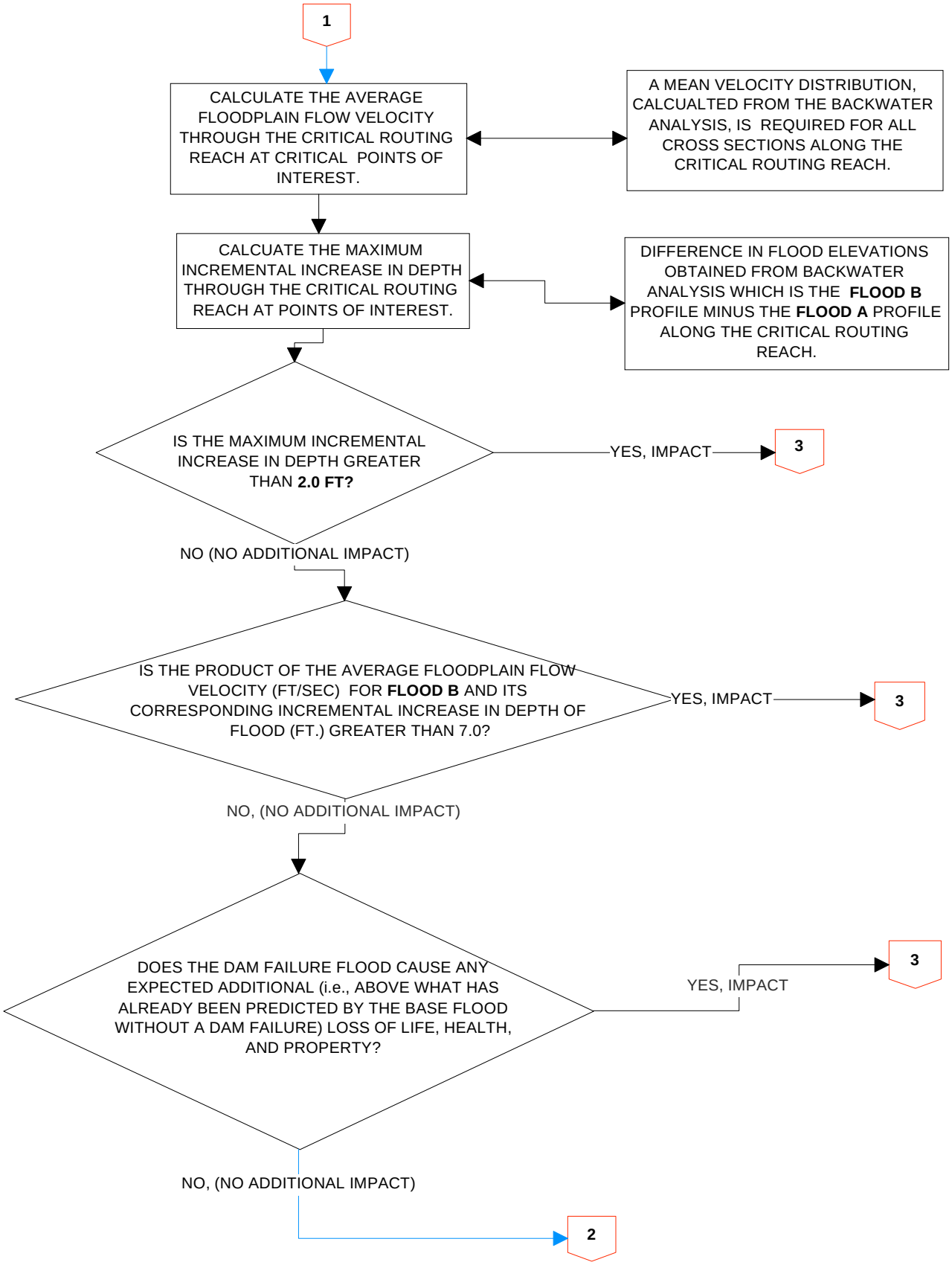
B. Flood profiles shall be prepared for all flood recurrence interval events studied.

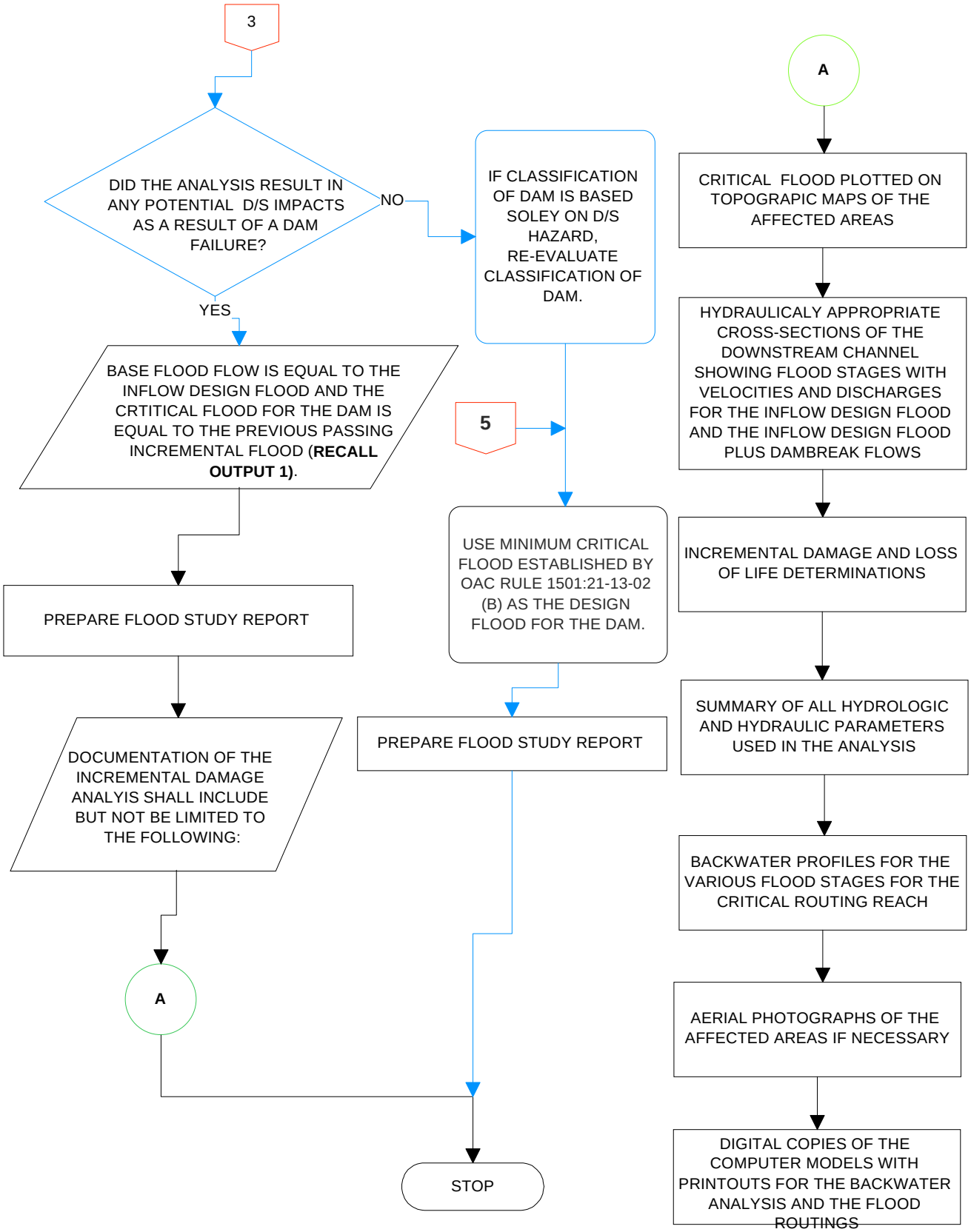
C. Photographs may be used in the critical flood analysis report to supplement text material and provide documentation of observed field conditions at the time of the study. Photographs may include views of the critical routing reach and its overbank areas, hydraulic structures, any structures in the floodplain that are potentially affected by the dam failure discharges, and other significant features of the landscape.

D. A certification page signed and stamped by the registered professional engineer in charge of the study. The engineer shall certify that the data for the physical parameters use in the critical flood study represent actual field conditions.

E. Submittals to the chief of reports and technical documentation of critical flood studies conducted in accordance with OAC Rule 1501:21-13-02 shall be accompanied by a cover letter identifying the report, its purpose, and any action requested of the chief.


PROCESS FOR DETERMINING THE CRITICAL FLOOD FOR DAMS
Critical Flood- The flood that would result in no additional loss of life, health or property along a critical routing reach downstream of the dam for overtopping failure of the dam when compared to damages caused by the flood in the absence of a dam overtopping failure. The design for the critical flood must be for specific site conditions and based on a quantitative and relative impact analysis of the downstream critical routing reach. The critical flood is determined by a simulated dam failure analysis after predicting the limits of the critical routing reach associated to the dam, and taking into account the physiographic, hydrologic, and hydraulic characteristics of the drainage area for both the dam and the critical routing reach.
ESTABLISH CLASS OF DAM BASED ON D.O.W. CRITERIA FOR THE PURPOSE OF ESTABLISHING THE BASE INITIAL DESIGN FLOOD . INDICATE CRITERA (HEIGHT OF DAM, TOTAL STORAGE VOLUME, POTENTIAL DOWNSTREAM HAZARD) USED TO ESTABLISH THE CLASSIFICATION OF THE DAM.
Critical Routing Reach- The entire floodplain beginning from the dam to a specific location downstream of the dam where life, health or property is potentially affected by failure of the dam.
2
DETERMINE CRITICAL ROUTING REACH (SEE DEFINITION)
5
IS A POTENTIALLY AFFECTED STRUCTURE LOCATED WITHIN THE CRITICAL ROUTING REACH?
NO
YES
IS THE ADJUSTED BASE FLOOD FLOW (FLOOD A) GREATER THAN THE MINIMUM ALLOWABLE INFLOW DESIGN FLOOD FOR THE DAM?
NO
YES
3
START INCREMENTAL DAMAGE ANALYSIS ROUTINE TO DETERMINE INLFOW DESIGN FLOOD (CRITICAL FLOOD) FOR DAM USING THE FOLLOWING PROCEDURE:
PERFORM A FLOOD ROUTING ANALYSIS ON A BASE FLOOD FLOW (FLOOD A) OF A MAGNITUDE ESTABLISHED BY OHIO ADMINISTRATIVE RULE 1501:21-13-02 (B). THIS FLOOD SHALL BE ROUTED THROUGH THE CRITICAL ROUTING REACH (HEC-1, HEC-HMS) DOWNSTREAM OF THE DAM.
DECREASE INFLOW DESIGN FLOOD BY AN INCREMENTAL AMOUNT USING A PERCENTAGE REDUCTION TECHNIQUE. THE ADJUSTED FLOW NOW BECOMES THE NEW BASE FLOOD FLOW (FLOOD A).
RECORD PREVIOUS INFLOW DESIGN FLOOD USED IN INCREMENTAL ANALYSIS (OUTPUT 1)
PERFORM A BACKWATER ANALYSIS (HEC-RAS) FOR THE CRITICAL ROUTING REACH FOR THE ROUTED BASE FLOOD FLOW (FLOOD A)
EVALUATE POTENTIAL DAMAGE IN CRITICAL ROUTING REACH CAUSED BY FLOOD A.
PERFORM SECOND ANALYSIS FOR THE DAM FAILURE FLOOD (FLOOD B), WHICH IS THE RESULT OF THE PEAK DISCHARGES DETERMINED FROM A SIMULATED DAM FAILURE (HEC-1, DAMBREAK MODELS USED) COMBINED WITH THE INITIAL BASE FLOOD FLOW (FLOOD A).
PERFORM A BACKWATER ANALYSIS (HEC-RAS) FOR THE CRITICAL ROUTING REACH FOR THE COMBINED BASE FLOOD AND DAMBREAK FLOWS (FLOOD B)
EVALUATE POTENTIAL DAMAGE IN CRITICAL ROUTING REACH CAUSED BY FLOOD B.
1


1
CALCULATE THE AVERAGE FLOODPLAIN FLOW VELOCITY THROUGH THE CRITICAL ROUTING REACH AT CRITICAL POINTS OF INTEREST.
A MEAN VELOCITY DISTRIBUTION, CALCUALTED FROM THE BACKWATER ANALYSIS, IS REQUIRED FOR ALL CROSS SECTIONS ALONG THE CRITICAL ROUTING REACH.
CALCUATE THE MAXIMUM INCREMENTAL INCREASE IN DEPTH THROUGH THE CRITICAL ROUTING REACH AT POINTS OF INTEREST.
DIFFERENCE IN FLOOD ELEVATIONS OBTAINED FROM BACKWATER ANALYSIS WHICH IS THE FLOOD B PROFILE MINUS THE FLOOD A PROFILE ALONG THE CRITICAL ROUTING REACH.
IS THE MAXIMUM INCREMENTAL INCREASE IN DEPTH GREATER THAN 2.0 FT?
YES, IMPACT
3
NO (NO ADDITIONAL IMPACT)
IS THE PRODUCT OF THE AVERAGE FLOODPLAIN FLOW VELOCITY (FT/SEC) FOR FLOOD B AND ITS CORRESPONDING INCREMENTAL INCREASE IN DEPTH OF FLOOD (FT.) GREATER THAN 7.0?
YES, IMPACT
3
NO, (NO ADDITIONAL IMPACT)
DOES THE DAM FAILURE FLOOD CAUSE ANY EXPECTED ADDITIONAL (i.e., ABOVE WHAT HAS ALREADY BEEN PREDICTED BY THE BASE FLOOD WITHOUT A DAM FAILURE) LOSS OF LIFE, HEALTH, AND PROPERTY?
YES, IMPACT
3
NO, (NO ADDITIONAL IMPACT)
2


3
DID THE ANALYSIS RESULT IN ANY POTENTIAL D/S IMPACTS AS A RESULT OF A DAM FAILURE?
NO
YES
IF CLASSIFICATION OF DAM IS BASED SOLEY ON D/S HAZARD, RE-EVALUATE CLASSIFICATION OF DAM.
BASE FLOOD FLOW IS EQUAL TO THE INFLOW DESIGN FLOOD AND THE CRTITICAL FLOOD FOR THE DAM IS EQUAL TO THE PREVIOUS PASSING INCREMENTAL FLOOD (RECALL OUTPUT 1).
5
PREPARE FLOOD STUDY REPORT
USE MINIMUM CRITICAL FLOOD ESTABLISHED BY OAC RULE 1501:21-13-02 (B) AS THE DESIGN FLOOD FOR THE DAM.
DOCUMENTATION OF THE INCREMENTAL DAMAGE ANALYIS SHALL INCLUDE BUT NOT BE LIMITED TO THE FOLLOWING:
PREPARE FLOOD STUDY REPORT
A
STOP
A
CRITICAL FLOOD PLOTTED ON TOPOGRAPIC MAPS OF THE AFFECTED AREAS
HYDRAULICALY APPROPRIATE CROSS-SECTIONS OF THE DOWNSTREAM CHANNEL SHOWING FLOOD STAGES WITH VELOCITIES AND DISCHARGES FOR THE INFLOW DESIGN FLOOD AND THE INFLOW DESIGN FLOOD PLUS DAMBREAK FLOWS
INCREMENTAL DAMAGE AND LOSS OF LIFE DETERMINATIONS
SUMMARY OF ALL HYDROLOGIC AND HYDRAULIC PARAMETERS USED IN THE ANALYSIS
BACKWATER PROFILES FOR THE VARIOUS FLOOD STAGES FOR THE CRITICAL ROUTING REACH
AERIAL PHOTOGRAPHS OF THE AFFECTED AREAS IF NECESSARY
DIGITAL COPIES OF THE COMPUTER MODELS WITH PRINTOUTS FOR THE BACKWATER ANALYSIS AND THE FLOOD ROUTINGS

Ohio Department of Natural Resources
Division of Water Fact Sheet

Fact Sheet 99–60

Dam Safety: Critical Flood Design Criteria

Ohio's Dam Safety Rules require dams to pass floods through their spillways without endangering the safety of the dam. The magnitude of the design flood is directly related to the classification of the dam - which in turn is related to the dam's downstream hazard and/or the dam's height. The greater the downstream hazard, i.e., loss of human life, high-value property, etc., the larger the design flood.

Definitions

The probable Maximum Precipitation (PMP) is the greatest depth (amount) of precipitation for a given storm duration, that is theoretically possible for a particular area and geographic location. The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular drainage area.

Classification of Ohio Dams

Dams in Ohio are divided into four classes based on the storage volume of the impoundment, dam height, and potential downstream hazard (how far downstream residences, businesses are, etc.). More details about the classification system can be found in the Dam Safety: Classification of Structures Fact Sheet No. 94-29.

Critical Flood Design Criteria

Specific guidelines are available for preparing a critical flood engineering analysis. This analysis must be performed by a professional engineer licensed in the State of Ohio. The guidelines can be downloaded from the Division of Water's world wide web site, (http://www.dnr.state.oh.us/odnr/water/temp/dartrlsa.html), or you can request a copy by calling our office directly.

Could the Critical Flood Analysis Make a Difference for My Dam?

The critical flood criteria were developed to make Ohio's Dam Safety Rules more flexible in recognizing that some dams fall outside of the typical parameters used in designing spillway capacity. Specifically, for those circumstances where the size of the dam, its downstream hazard, drainage area, and downstream topography are such that traditional flood design standards do not accurately account for the downstream hazard, critical flood criteria allow for a reduction of up to 60% of the design flood.

For example, let's look at a Class I dam. This type of dam is required to safely pass the 100% PMF through its spillway system without endangering the safety of the dam. As rain falls onto a dam's watershed, some of the rainfall will infiltrate into the ground, some will evaporate, and most of it will runoff across the ground into the pond or lake. The water level in the impoundment will begin to rise while simultaneously flowing through the dam's spillway(s). As water exits the dam's spillway(s), the downstream channel will begin to fill and flow accordingly. For most dams, the downstream channel will likely fill with some water, but most of the water flows downstream without backing up significantly. For those few cases where the downstream channel fills rapidly to the point where water rises dramatically and failure of the dam would have no additional significant increase in elevations of floods downstream, the design flood can be reduced. In other words, there may be a point, say 50% of the PMF (the critical flood in this case), where designing for additional flood capacity for the dam is no longer reasonable. If the dam were to fail, the downstream hazard would not be further adversely effected. In this case, the spillway system may be designed for half of what it would have been originally designed, therefore saving dollars without increasing the hazard to the downstream area.

What is the Maximum Reduction in Design Flood?

The design flood can be reduced approximately up to 60% for each class of dam:

Class I	100% PMF down to no less than 40% PMF
Class II	50% PMF down to no less than 20% PMF
Class III	25% PMF down to no less than 100 Year

Continued on back!

What Factors Should I Consider Before Proceeding With an Analysis?

The cost of the analysis can be thousands of dollars. Let's assume that a dam inspection by our engineers reveals that a dam is deficient in its ability to pass the design flood. It would be beneficial to have an analysis performed if the design flood was reduced enough so that the spillway system did not need to be upgraded or replaced. Let's assume that upgrading the spillway system costs $50,000. If the cost of the critical flood analysis was $5,000, the cost of the critical flood analysis would be warranted.

Sometimes it can be straightforward to predict whether or not an analysis would be beneficial. However, in those cases where it may not be clear, other options should be considered. For example, if room exists in one of the dam's abutments to excavate an emergency spillway or perhaps enlarge an existing emergency spillway, it may be more cost effective to do so. There is always a risk in running an analysis and finding out that the reduction in design flood is insignificant and the spillway system enlargement is still required.

A critical flood analysis approved by our office means that a reduced design flood is acceptable for your dam. Please note that a reduction in the design flood for your dam may increase the risk of failure or damage to your dam. This could result in an economical burden on the dam owner. This risk should be closely considered!

How Can I Apply for the Critical Flood Reduction?

A request for consideration must be submitted to the Chief of the Division of Water. The request must be accompanied by supporting calculations based upon an analysis performed by a professional engineer registered in the State of Ohio. The engineer's analysis must conform to the critical flood guidelines provided by the Division of Water.

Before applying, it is best to call and speak with an engineer in the Division's Dam Safety Engineering Program.

What Restrictions Are There?

A critical flood reduction based upon planned evacuation, probability of inhabitation, or monetary recovery of property damage will not be considered. In other words, guaranteeing that a downstream residence or business will be evacuated during a dam failure will not be considered. In situations where the downstream hazard may or may not be inhabited, such as in the case of a campground, rental property, hotel, and so forth, the probability of inhabitation will not be considered. Also, understanding that failure of a dam will damage downstream property and guaranteeing that the damages will be paid for will also not be considered. Finally, if the downstream hazard were to change, the critical flood exemption could be nullified.

Any other questions, comments concerns, or fact sheet requests, should be directed to the Division of Water at the following address:

Ohio Department of Natural Resources
Division of Water
Dam Safety Engineering Program
2045 Morse Road
Columbus, Ohio 43229-6693
Voice: (614) 265-6731 Fax: (614) 447-9503
Website: http://www.dnr.state.oh.us/water

E.35. Oklahoma



UNOFFICIAL

TITLE 785. OKLAHOMA WATER RESOURCES BOARD
CHAPTER 25. DAMS AND RESERVOIRS

Introduction:

This document contains permanent amendments to Chapter 25 adopted by the Oklahoma Water Resources Board that became effective May 27, 2010. Also, this document was prepared by Oklahoma Water Resources Board staff as a convenience to the reader, and is not a copy of the official Title 785 of the Oklahoma Administrative Code. The rules in the official Oklahoma Administrative Code control if there are any discrepancies between the Code and this document.

Subchapter		Section
1.	General Provisions	785:25-1-1
3.	Responsibility, Classification and Design Standards	785:25-3-1
5.	Applications and Approval of Construction	785:25-5-1
7.	Post Approval Actions	785:25-7-1
9.	Actions After Construction	785:25-9-1
11.	Administrative Penalties and Procedures	785:25-11-1

[**Authority**: 82 O.S., Sections 105.25 – 105.27 and 1085.2]
[**Source**: Codified 12-31-91]

SUBCHAPTER 1. GENERAL PROVISIONS

Section
785:25-1-1. Purpose
785:25-1-2. Definitions
785:25-1-3. Violations and penalties
785:25-1-4. Variances and waivers

785:25-1-1. Purpose

The rules of this Chapter on reservoir requirements and safety of dams set forth minimum standards for construction and maintenance of dams based on size and hazard classification, application requirements for approval of plans and specifications, and inspection requirements. These rules are adopted pursuant to 82 O.S. 1981, §§105.27, 110.1 et seq. (Oklahoma Dam Safety Act) and 1085.2(7), and Public Law 92-367, 92nd Congress, H.R. 15951, approved August 8, 1972 (33 U.S.C. 467 et seq.). Under no circumstances shall the rules in this Chapter be construed to deprive or limit the Oklahoma Water Resources Board of any exercise of powers, duties, and jurisdiction conferred by law nor to limit or restrict the amount or character of data or information which may be required from any owner of any dam for the proper administration of the law.
[**Source**: Amended at 10 Ok Reg 3287, eff 6-25-93]

785:25-1-2. Definitions

The following words and terms, when used in this Chapter, shall have the following meaning, unless the context clearly indicates otherwise:

"Alteration" means only such alteration as may affect the safety of a dam or reservoir.

"Application" means a formal request to the Board and the first step required by law to acquire the right to perform or engage in activities regulated by the Board.

"Board" means and refers to the Oklahoma Water Resources Board or any employee or agent or staff member thereof.

"Breach analysis" means an engineering analysis to determine the area that would be inundated by the failure of a dam.

"Dam" means any artificial barrier, together with appurtenant works, which does or may impound or divert water.

"Enlargement" means any change in or addition to an existing dam or reservoir which raises or may raise the water storage elevation of the water impounded by the dam or reservoir.

"Failure" with respect to a dam means any uncontrolled release of water.

"Gully plug" means any grade stabilization structure that has less than five acre-feet of water storage available below the principal spillway elevation and less than 50 acre-feet of storage volume below the emergency spillway elevation.

"Interested party" means party.

"Loss of human life" means the human fatalities that would result from a failure of the dam, excluding the occasional passer-by or recreationist and without considering evacuation or other emergency actions.

"Notice by publication" means unless otherwise specifically provided, publication in a daily or weekly newspaper of general circulation once a week or two (2) consecutive weeks (minimum seven day interval).

"Owner" *means any person who, jointly or severally, owns, controls, maintains, manages, or proposes to construct a dam or reservoir, and includes those shown by records of the county registrar of deeds to have some interest, fee, easement, or otherwise, in the land on which the dam and lake lie and may also include those persons who may derive a direct pecuniary benefit from the existence of the lake* [82:110.3].

"Party" means a person or agency named and participating, or properly seeking and entitled by law to participate, in hearings other than hearings on Board rules, regulations and standards.

"Person" *means any individual, firm, partnership, association, corporation, any trust formed for the benefit of an individual, business or any public entity, federal agency, state agency, the State or any political subdivision thereof, municipalities, and any other legal entity* [82:110.3].

"Repairs" means only such repairs as may affect the safety of a dam or reservoir.

"Reservoir" means any surface depression which contains or will contain the water impounded by a dam.

"Statistical twenty-four (24) hour, fifty (50) year storm" means a storm of twenty-four (24) hour duration with a probable recurrence interval of once in fifty (50) years as defined by the National Weather Service in Technical Paper Number 40, "Rainfall Frequency Atlas of the United States," May 1961, and subsequent amendments, or equivalent regional or state rainfall probability information developed therefrom.

"Water storage elevation" means that elevation of water surface which may be obtained by the temporary or permanent storage of water. This elevation is normally the lowest point on the top of the dam.

[**Source**: Amended at 10 Ok Reg 3287, eff 6-25-93; Amended at 11 Ok Reg 2931, eff 6-13-94]

785:25-1-3. Violations and penalties

(a) Under Section 105.20 of Title 82 of the Oklahoma Statutes, the continued use of works which are unsafe, after receiving notice to repair, and the refusal to change unsafe works when directed to do so, or the injury or obstruction of waterworks shall be a misdemeanor and each day such violation continues shall be a separate violation.

(b) Under the Oklahoma Dam Safety Act (82 O.S. Supp. 1992, §§110.1 et seq.), the Board is authorized to issue emergency orders without prior notice and hearing and orders after notice and hearing requiring an owner to take action as necessary to put a dam in safe condition. In addition, the Board may impose administrative penalties against owners of dams who fail,

refuse or neglect to comply with the provisions of the Oklahoma Dam Safety Act. Procedures for imposition of such penalties are found in Subchapter 11 of this Chapter.
[**Source**: Amended at 10 Ok Reg 3287, eff 6-25-93]

785:25-1-4. Variances and waivers

Applicants who request a variance or waiver to rules specified in this chapter must demonstrate, and shall bear the burden of demonstrating that operations under the variance will equal or exceed the protections accorded by the particular rule for which the variance is sought. The variance may also be granted if the Board finds that the cost of compliance with the rule without a variance would impose significant expense without providing for additional safety of the construction for which the variance or waiver is sought, and integrity of the dam will not be adversely affected. The Board may require that a registered professional engineer certify that the variance or waiver being requested will not adversely affect the integrity of the dam.
[**Source**: Added at 21 Ok Reg 2625, eff 7-1-2004]

SUBCHAPTER 3. RESPONSIBILITY, CLASSIFICATION AND DESIGN STANDARDS

Section

785:25-3-1. Dams subject to Board's jurisdiction
785:25-3-2. Owner's responsibility
785:25-3-3. Classification of size and hazard potential
785:25-3-4. Dams considered unsafe and menace to life and property
785:25-3-5. Minimum design standards (other than spillway)
785:25-3-6. Minimum spillway performance standards
785:25-3-7. Minimum outlet conduit capacities
785:25-3-8. Measuring devices
785:25-3-9. Prohibited construction
785:25-3-10. Prohibited vegetation
785:35-3-11. Minimum safety factors

785:25-3-1. Dams subject to Board's jurisdiction

(a) *Dams, together with appurtenant works, which meet the following alternative criterion are subject to the provisions of* [82:110.4] the Oklahoma Dam Safety Act and this Chapter of the Board's rules:

(1) *Dams which are or will be twenty-five (25) feet or more in height from the natural bed of the stream or watercourse at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the top of the dam* [82:110.4]; or

(2) Dams which have or will have an impounding capacity of fifty (50) acre-feet or more [82:110.4];

provided, however, any barrier to the flow of water which does or may impound water and which is or will be not in excess of six (6) feet in height, regardless of storage capacity, or which has or will have a storage capacity not in excess of fifteen (15) acre-feet, regardless of height, shall not be subject to regulation . . . unless it is determined to have a high hazard potential classification under these rules [82:110.4] or except as hereinafter provided. The figure in Appendix A of this Chapter presents a graphic illustration of the height and storage criteria reviewed to determine the Board's authority relating to dams.

(b) *No barrier to the flow of water determined by the Board to be designated primarily for roadfill shall be subject to regulation under this* [82:110.4] Chapter.

(c) *Gully plugs are not subject to regulation under this* [82:110.4] chapter of the Board's rules.

(d) *Dams constructed by any agency of the United States Government shall not be subject to regulation under this Chapter during or after construction while such dams remain under the supervision of any officer or agency of the United States* [82:110.4]
[**Source**: Amended at 10 Ok Reg 3287, eff 6-25-93; Amended at 11 Ok Reg 2931, eff 6-13-94]

785:25-3-2. Owner's responsibility

(a) **General**.

(1) Owners of dams to which the provisions of this Chapter apply shall have the responsibility to provide for the safety of such works by making any necessary changes to put the works in a safe condition.

(2) Such responsibility includes but is not necessarily limited to the following: the filing of an application to construct, enlarge, alter or repair the dam pursuant to Subchapter 5, the modification of the dam to meet applicable minimum requirements in this Subchapter, and the adequate maintenance, operation, and inspection of an existing dam.

(b) **Multiple owners.**

(1) When there is more than one owner of a dam, the Board shall consider all such owners responsible for the safety of such dam unless evidence to the contrary shows otherwise.

(2) The Board shall provide copies of inspection reports to at least one owner of record at the Board and shall provide notice of hearing on dam safety related matters to such owner with an instruction that the notice shall be delivered or mailed to all owners.

(3) Unless otherwise agreed by all the owners and the Board, the Board may, after such notice and hearing, order all the owners to take whatever remedial action is necessary to put the dam in a safe condition.

(4) The Board will not attempt to delineate levels of responsibility or allocate particular items of action among the owners.

(c) **Transfer of ownership**. Upon transfer of ownership of the works, the new owner shall notify the Board of such transfer.

[**Source:** Amended at 9 Ok Reg 1675, eff 5-11-92; Amended at 14 Ok Reg 2766, eff 7-1-97]

785:25-3-3. Classification of size and hazard potential

(a) All dams shall be classified as to size and for potential hazards as follows:

(1) **Size Classification of Dams**. The size classification shall be based on the following chart:

(A) Small:
(i) Storage – less than10,000 Ac-Ft.
(ii) Height – less than 50 Ft.

(B) Intermediate:
(i) Storage – between 10,000 and 50,000 Ac-Ft.
(ii) Height – between 50 and 100 Ft.

(C) Large:
(i) Storage – over 50,000 Ac-Ft.
(ii) Height – over 100 Ft.

(2) **Hazard-Potential Classification of Dams**. The hazard-potential classification of a dam is determined by the downstream risk in the event of a failure, without regard to the physical condition of the dam, as follows:

(A) **Low.** Dams assigned the low hazard-potential classification are those where failure would result in no probable loss of human life and low economic losses.

(B) **Significant.** Dams assigned the significant hazard-potential classification are those dams where failure would result in no probable loss of human life but can cause economic loss or disruption of lifeline facilities.

(C) **High.** Dams assigned the high hazard-potential classification are those where failure will probably cause loss of human life.

(b) **Hazard classification subject to regulation and change.**

(1) For dams which were inventoried in the National Safety of Dams program authorized under 33 U.S.C. 467 et seq., and for which "Phase I" reports pursuant to said inventory were prepared, the hazard classifications set forth in such "Phase I" reports shall be presumed accurate. If the owner of the dam disagrees with the hazard classification, the owner shall have the burden to show that such hazard classification is inaccurate and should be changed.

(2) At the discretion of the Board, any proposed or existing dam considered to have classification of a high hazard potential may be subject to regulation regardless of size or impounding capacity.

(3) The hazard potential classification may change as the area downstream from a dam develops and the dam may be reclassified from time to time under the provisions of 785:25-9-10 and 785:25-9-11.

[**Source**: Amended at 11 Ok Reg 2931, eff 6-13-94]

785:25-3-4. Dams considered unsafe and menace to life and property

(a) In determining whether a dam is *unsafe and a menace to life and property* [82:105.27] under the provisions of Section 105.27 of Title 82 of the Oklahoma Statutes and the corrective actions necessary to put a dam in a safe condition, the Board shall review the requirements set forth in rules of this Chapter, and recommendations on matters which directly affect the integrity of dams set forth in DESIGN OF SMALL DAMS (1977) and DESIGN OF GRAVITY DAMS (1976), published by the U.S. Department Interior Bureau of Reclamation (BOR), ENGINEERING AND DESIGN MANUALS, SERIES EM-1110, published by the U.S. Department of the Army, Corp of Engineers (COE), the ENGINEERING FIELD MANUAL and TECHNICAL RELEASE NO. 60, published by the U.S. Department of Agriculture, Natural Resources Conservation Service, or equivalent recommendations.

(b) Existing dams which are in imminent peril of failure shall be considered *unsafe and a menace to life and property* [82:105.27] under the provisions of Section 105.27 of Title 82 of the Oklahoma Statutes.

[**Source**: Amended at 9 Ok Reg 1676, eff 5-11-92; Amended at 10 Ok Reg 3287, eff 6-25-93; Amended at 14 Ok Reg 2766, eff 7-1-97]

785:25-3-5. Minimum design standards (other than spillway)

(a) The construction of the downstream embankment slope shall not be steeper than 3 horizontal units to each 1 vertical unit (3:1) to provide adequate factors of safety against sliding, sloughing or rotation in the embankment and foundation, unless a stability analysis is performed which shows a steeper slope provides an adequate factor of safety.

(b) Except as otherwise provided in this Chapter, all dams must be designed by methods, procedures and criteria that meet or exceed acceptable dam safety engineering practices, including those found in the federal agency publications referenced in 785:25-3-4.

785:25-3-6. Minimum spillways performance standards

(a) **General performance standards**

(1) Except as otherwise provided in this Chapter, all dams must meet or exceed the following performance standards as determined by analysis of plans and specifications for the dam and existing site conditions.

(2) Owners of existing dams which do not meet the following performance standards must make necessary changes in the dam to meet the applicable performance standards.

(3) The discharge capacity and/or storage capacity of the project shall be capable of passing the indicated spillway design flood without infringing on the minimum freeboard requirements, provided that a design which includes overtopping of the dam may be authorized if specifically approved by the Board.

(4) The minimum performance standards expressed as magnitude of spillway design flood and minimum freeboard will be assigned to the various size and hazard potential classification determined under 785:25-3-3 as follows:

(b) **Minimum Performance Standards**

MINIMUM SPILLWAY

SIZE	HAZARD	DESIGN FLOOD	MINIMUM FREEBOARD
Small	Low	25% PMF	0 Feet
Small	Significant	40% PMF	0 Feet
Small	High	50% PMF	1 Foot
Intermediate	Low	25% PMF	1 Foot
Intermediate	Significant	50% PMF	1 Foot
Intermediate	High	75% PMF	3 Feet
Large	Low	50% PMF	1 Foot
Large	Significant	75% PMF	1 Foot
Large	High	100% PMF	3 Feet

(c) **Amending minimum freeboard**. The minimum freeboard requirements may be amended by the Board on a case-by-case basis for good cause shown by the owner.

(d) **Probable maximum flood.**

(1) PMF means and refers to the Probable Maximum Flood and is defined as the flood that may be expected from the most severe combination of critical meterorologic and hydrologic conditions that are reasonably possible in the region as listed in Hydrometeorological Report No. 51, National Weather Service.

(2) Since design floods are usually determined by using mathematical computations through computer modeling and since several different acceptable models are available, flood design calculations must fall within plus/minus 5% PMF of the Board's current model results.

(3) The PMF storm should be of appropriate duration to adequately reflect the size and hydrologic characteristics of the watershed in which the dam is located.

(e) **PMF on dam designated for regulation.** A dam which the Board has determined is subject to regulation because of its high hazard potential, although otherwise considered too small, shall be required to safely pass 25% PMF with no minimum freeboard.
(f) **Dams constructed prior to June 13, 1973.** Any dam constructed prior to June 13, 1973 and which is classified as intermediate size and high hazard potential according to 785:25-3-3 shall be required to pass a minimum design of 50% of the PMF. Any dam constructed prior to June 13, 1973 and which is classified as large size and high hazard potential according to 785:25-3-3 shall be required to pass a minimum design flood of 75% of the PMF.
[**Source**: Amended at 9 Ok Reg 1676, eff 5-11-92; Amended at 12 Ok Reg 2687, eff 7-1-95]

785:25-3-7. Minimum outlet conduit capacities
(a) **Requirements for outlet conduit capacity shall be as follows:**
(1) All dams subject to the Board's jurisdiction shall have at least one outlet conduit of sufficient capacity to prevent interference with natural streamflow and injury of downstream appropriators and domestic users. Absent evidence to the contrary, the minimum size of the outlet conduits shall be as set forth in subsection (d) of this section.
(2) The height of the outlet conduit shall be no more than five feet (5') above the natural stream channel unless otherwise ordered by the Board. The capacity of the reservoir below the outlet conduit shall be designated as the inactive pool.
(b) **Conduit operation**. All conduits shall be gate- or valve-operated on the upstream side and shall be maintained in an operable condition at all times.
(c) **Conduit design life.** The design life expectancy of the conduit shall be equal to or greater than the design life of the dam.
(d) **Minimum size outlet conduit requirements.** The outlet conduit must be of sufficient size to draw down the entire reservoir to the inactive pool within twenty (20) days, provided that minimum size outlet requirements are as follows:
(1) For less than 100 acre-feet normal pool capacity (at principal spillway), the minimum size of conduit is 6-inch pipe.
(2) For 101 to 150 acre-feet normal pool capacity (at principal spillway), the minimum size of outlet conduit is 8-inch pipe.
(3) For 151 to 200 acre-feet normal pool capacity (at principal spillway), the minimum size of outlet conduit is 10-inch pipe.
(4) For 201-250 acre-feet normal pool capacity (at principal spillway), the minimum size of outlet conduit is 12-inch pipe.
(5) For 251-300 acre-feet normal pool capacity (at principal spillway), the minimum size of outlet conduit is 14-inch pipe.
(6) For 301-350 acre-feet normal pool capacity (at principal spillway), the minimum size of outlet conduit is 15-inch pipe.
(7) For 351-500 acre-feet normal pool capacity (at principal spillway), the minimum size of outlet conduit is 16-inch pipe.
(8) For more than 500 acre-feet normal pool capacity (at principal spillway), the minimum size of outlet conduit is 24-inch pipe.
(e) **Amendments of minimum requirements for good cause.** Minimum size requirements may be amended by the Board for good cause. However, conduit must be of sufficient size to draw down the entire reservoir to the inactive pool within a period of not more than twenty (20) days.
[**Source**: Amended at 21 Ok Reg 2625, eff 7-1-2004]

785:25-3-8. Measuring devices
When required by the Board, measuring devices capable of providing an accurate water measurement must be provided to measure the flow of the stream above and below the

reservoir. Permanent staff gages may be required to be placed near the outlet of the reservoir and such other locations as specified by the Board and such gages shall be plainly marked in feet and tenths of feet.

785:25-3-9. Prohibited construction

No construction or excavation other than that necessary for the operation, maintenance, investigation and monitoring of the dam and reservoir, shall be allowed on a dam or spillway structure or within fifty (50) feet from the line where such dam or spillway structure meets the natural grade unless otherwise ordered by the Board after a showing by substantial, competent evidence that the proposed construction will not affect the integrity of the dam or spillway structure.

[**Source**: Amended at 9 Ok Reg 1676, eff 5-11-92]

785:25-3-10. Prohibited vegetation and erosion

Trees and heavy vegetation shall be removed from the slopes and crest of earthen embankments and emergency spillway area. Trees and heavy vegetation shall also be removed from an area a minimum distance from the toe of the embankment of 30 feet. Dams shall be maintained such that internal or external erosion is prevented. If erosion is present it shall be repaired utilizing appropriate engineering practices.

785:25-3-11. Minimum safety factors

As a guide for use by the Board and by engineers designing new dams, assessing the condition of existing dams or proposing modifications to existing dams, the following safety factors shall be utilized for:

(1) Embankment dams:

LOADING CONDITION	MINIMUM FACTOR OF SAFETY*
Steady seepage at emergency spillway crest	1.5
Rapid drawdown from principal spillway	1.2
Earthquake – reservoir at emergency spillway crest for downstream slope, reservoir at principal spillway for upstream slope	1.0

*The minimum factor of safety is calculated by the ratio of available shear strength stress required for stable equilibrium

(2) Concrete dams or concrete portions thereof.

LOADING	MINIMUM

CONDITION	FACTOR OF SAFETY ** (by hazard classification of dam)	
Principal spillway level	High and Significant 2.25	Low 2.0
Inflow design flood at maximum pool level	1.75	1.25
Principal spillway level with earthquake	greater than 1.0	greater than 1.0

** These minimum factors of safety apply to the calculations of stress and the shear friction factor of safety within the structure of the rock/concrete interface and foundation
[**Source**: Amended at 11 Ok Reg 2931, eff 6-13-94]

SUBCHAPTER 5. APPLICATIONS AND APPROVAL OF CONSTRUCTION

Section
785:25-5-1. Application and fee required
785:25-5-2. Plans to be prepared by registered professional engineer
785:25-5-3. Content of plans and specifications
785:25-5-4. Additional report information
785:25-5-5. Notice of hearing
785:25-5-6. Affidavit of notice publication
785:25-5-7. Protest
785:25-5-8. Approval or denial of application

785:25-5-1. Application and fee required

(a) **General**.

(1) Any person who shall desire to construct, enlarge, alter, remove or repair any dam under the Board's jurisdiction shall submit an application upon printed forms which will be furnished by the Board upon request.

(2) For the purposes of this subchapter, repair shall not be deemed to include routine normal maintenance.

(3) The maps, plans, drawings, and specifications of the proposed work along with the required fee shall form a part of the application.

(4) The application and attachments shall be filed in duplicate.

(5) Notwithstanding the provisions of paragraph (1) of this subsection, *an owner who proposes to construct a new dam classified as having a low hazard potential that will be used primarily for agriculture purposes, and will be designed or constructed with the assistance of a local conservation district or federal agriculture related agency, shall be required only to notify the Board of such construction* and file a notice of completion in accordance with 785:25-7-6 [82:110.5].

(b) **Signature of applicant.** The application shall be signed as follows:

(1) If the applicant is an individual, the application shall be signed by the applicant or his duly appointed agent, who shall present satisfactory evidence of his authority to represent the applicant.

(2) A joint application shall be signed by each applicant or his duly authorized agent, provided that a joint application by husband and wife may be signed by either party (joint applicants are required to select one among them to act for and represent the others in dealing with the Board).

(3) If the application is by a partnership, the applicant shall be designated by the firm name followed by the words "A Partnership" and the application shall be signed by each of the general partners or, if signed by one partner or other agent, a written statement of the agent's authorization to make the application, signed by the other parties of interest, shall be attached to the application.

(4) In the case of an estate or guardianship, the application shall be signed by the duly appointed guardian or representative of the estate, and a certified copy of the letter issued by the court shall be attached to the application.

(5) In the case of a water district, county, municipality, etc., the application shall be signed by a duly authorized official, and a certified copy of the resolution or other authorization to make the application shall be attached.

(6) In the case of a private corporation, the application shall be signed by a duly authorized person and, if not attested by the secretary or assistant secretary, a copy of the authorization shall be attached to the application.

(c) **Notary public required**. All applicants shall subscribe and swear to the application before a Notary Public, who shall also sign his name and affix his seal to the application.

(d) **Water rights**. Water rights requested or required in connection with a planned dam or reservoir may be approved based on preliminary information, however, no construction, enlargement, alternation or repair shall proceed until the application required by this Section has been submitted and approved in accordance with the rules of this subchapter and until the water rights required are approved.

[**Source**: Amended at 10 Ok Reg 3287, eff 6-25-93; Amended at 14 Ok Reg 2766, eff 7-1-97]

785:25-5-2. Plans to be prepared by registered professional engineer

Plans and specifications shall be prepared by a Registered Professional Engineer (59 O.S. 1981, §§475.1 and 475.15) who shall have training and/or experience concerning the analysis, design, and/or construction of dams and reservoirs, or by an engineer of any United States governmental agency acting in his official capacity (82 O.S. 1981, §105.27). However, if it is found that a project does not concern or involve the public welfare or the safeguarding of life, health or property, this requirement may be waived by the Board.

785:25-5-3. Content of plans and specifications

(a) The plans and specifications shall, as a minimum, include the following:

(1) A topographic map of the dam site showing the location of spillway and outlet works. The map shall also show all contiguous property and the owners thereof. The topographic maps for low hazard dams are not required to show test borings, test pits and borrow pits.

(2) A profile along the dam axis showing the location, elevation, depth of borings or test pits including logs or bore holes and/or test pits, provided that plans and specifications for low hazard dams are not required to contain such a profile.

(3) A maximum cross-section of the dam showing elevation and width of crest, slopes of upstream and downstream faces, thickness of riprap, zoning of earth embankment, location of cutoff and bonding trenches, elevations, size and type of outlet conduit, valves and operating mechanism.

(4) Area and capacity curves of the proposed reservoir.
(5) Detailed drawings showing plans, cross and longitudinal sections of the outlet conduits, valves and controls for operating the same, and trash racks.
(6) The discharge capacity in cubic feet per second of the spillway for each foot in water depth above the spillway crest up to the maximum high water level and the formula used in making such determinations.
(7) Detailed plans of spillway structures, cross-section of the channel leading to and from the spillway, spillway profile, and procedures for operation of the spillway structure.
(8) For high hazard potential classified dams, a breach analysis, and a map showing the breach inundation area utilizing guidelines provide by the Board.
(9) A requirement, during the period of construction, for supervision by an engineer as required in 785:25-7-2.
(10) A provision that the plans and specifications may not be substantially changed or changed in any material respect without prior written consent of the Board.
(11) A provision stating in detail all matters necessary to ensure that construction is accomplished in a responsible manner and that needed control is exercised by an engineer as required in 785:25-7-2 to ensure construction of a safe structure.

(b) The size of all plans and maps filed shall not be more than 11" x 17" and shall be drawn with an adequate number of views, in proper dimensions, and to a sufficiently large scale so that the plans and maps may be readily interpreted and studied. In addition to the plans and maps required to be filed, if plans and maps larger than 11" x 17" are submitted for review purposes, the larger plans and maps will not be retained by the Board.

785:25-5-4. Additional report information

An engineer's report giving details necessary for analysis of the structure and appurtenants shall be submitted with the plans and specifications. Included as a part of the report shall be the following:

(1) Formula and assumptions used in design:
(2) Hydrologic data used in determining runoff from the drainage areas including copies of any records that the applicant has of flood flows and precipitation for the region;
(3) Foundation and materials investigations; and
(4) All other information which would aid in evaluating the design.

785:25-5-5. Notice of application

(a) **Notice preparation**

(1) After an application has been duly filed and accepted, the Board may require that applicants for permits involving significant and high hazard-potential dams publish notice as it instructs. If such notice is required, a notice will be prepared by the Board and include information describing the application, the name and address of the applicant and opportunities for public comment.
(2) The notice will be mailed to the applicant with a letter of instructions as to the publication. Prior to publication the applicant shall check the notice for any errors.

(b) **Publication in newspaper**

(1) The notice of application, if required, shall be published once a week for two (2) consecutive weeks on the dates designated by the Board in a newspaper having general circulation in the county where the dam is located.
(2) The last notice shall be published at least ten (10) days prior to the hearing date.
(3) The applicant shall bear the cost of publication and shall see that the notice is reproduced accurately in the newspaper.
(4) If the Board instructs the applicant to mail notice, such mailing shall be by certified mail, return receipt requested.

[**Source**: Amended at 9 Ok Reg 1677, eff 5-11-92]

785:25-5-6. Affidavit of notice publication and mailing

(a) **Affidavit of publication required.** If the Board has required publication of notice, then the applicant shall file the sworn statement of the publisher with the Board before the application is considered by the Board. The affidavit shall state the dates on which the notice was published in the newspaper.

(b) **Failure to furnish affidavit.** Failure to furnish evidence of publication or of mailing of the notice in the manner required on or before the date the Board considers the application or may be deemed evidence of abandonment of the application.

[**Source**: Amended at 9 Ok Reg 1677, eff 5-11-92]

785:25-5-7. Public Comment

(a) Any interested person may submit written comments on any application.

(b) If the Board determines there is significant public interest in an application, it may schedule a public meeting to receive oral comments. Any interested person may appear and present comments.

(c) The Board shall consider the public comments when evaluating the application, and shall respond or prepare and publish a response to those comments, and may direct the applicant to respond.

[**Source**: Amended at 9 Ok Reg 1677, eff 5-11-92]

785:25-5-8. Approval or denial of application.

(a) After evaluating the application, if it is determined that the proposed construction, enlargement, alteration, or repair of any dam is safe and not a menace to life and property and is in conformity with all statutory requirements and the rules in this Chapter, said application shall be approved by the Board upon such conditions as the Board may prescribe.

(b) If it is determined that the proposed construction, enlargement, alteration, or repair of any dam is *unsafe and a menace to life and property*, [82:105.2] said application shall be denied by the Board.

(c) The applicant shall be notified in writing of the Board's decision

(d) If the application is approved, no impoundment of water by the dam may be made until all additional requirements of these rules and regulations are met unless the approved construction is for an existing dam and the construction may be carried out without emptying the water in the reservoir.

(e) The applicant shall commence construction within two (2) years after the date of approval of the plans and specifications or the approval will be deemed to have lapsed and shall thereafter be null and void, provided that the applicant may request an extension of time to commence such construction and if the extension is granted, the approval will not be deemed to lapse during the time extended.

SUBCHAPTER 7. POST APPROVAL ACTIONS

Section

785:25-7-1. Inspection during construction
785:25-7-2. Inspection fee
785:25-7-3. Deficiencies during and after construction
785:25-7-4. Supervision of construction by owner
785:25-7-5. Changes to plans and specifications after approval
785:25-7-6. Notice of completion and filing of supplementary drawings or descriptive matter
785:25-7-7. Warning and evacuation plans
785:25-7-8. Certificate of completion

785:25-7-1. Inspection during construction

During the construction, enlargement, repair, alteration, or removal of any dam or reservoir, periodic inspections may be made by the Board and the owner shall be required to perform at his expense such works or tests as necessary to disclose information sufficient to enable the Board to determine that substantial conformity with approved plans and specifications is being secured, which shall include adequate inspection, at owner's expense, to satisfy the Board of substantial compliance to approved plans, drawings, and specifications.

785:25-7-2. Inspection fee

(a) Fees for any such inspection must be paid by the owner upon submission of an itemized statement by the Board.

(b) Fees for inspections not paid by the owner within thirty (30) days after notice by the Board, *shall be a lien against any property of such owner, to be recovered by suit instituted by the District Attorney of the county at the request of the Board.* Such liens *shall be superior in right to all mortgages or other encumbrances, except ad valorem tax liens, placed upon the land and the water appurtenant thereto or used in connection therewith*. [82:105:27]

785:25-7-3. Deficiencies during and after construction

(a) If, after any inspections, investigations, or examinations, or at any time after completion, it is found that amendments, modifications, or changes to the work performed pursuant to the approved plans and specifications are necessary to protect life and insure safety of the dam or to meet acceptable dam safety engineering practices, including those found in references set forth in 785:25-3-4, the owners shall be required to submit a revised application.

(b) If conditions are revealed which will not permit the construction of a safe dam or reservoir, the prior approval may be revoked or modified by the Board after notice and hearing.

(c) After the inspection, investigation, or examination, the Board shall, in a report to the owner, specify the deficiencies and allow a reasonable time for correcting the deficiencies.

[**Source**: Amended at 9 Ok Reg 1677, eff 5-11-92]

785:25-7-4. Supervision of construction by owner

After receiving approval of plans and specification, supervision of construction by the owner shall be as follows:

(1) The work of construction, enlargement, repair, alteration or removal of dam or reservoir, for which approved application, plans, drawings, and specifications are required, shall be under the responsible charge of an engineer as defined in 785:25-5-2 who shall certify, upon completion and prior to impoundment of any waters, that such construction, enlargement, repair, alteration, or removal was done in accordance with approved plans, drawings, and specifications.

(2) Final approval in writing by a United States governmental agency shall be required for those structures designed by and/or constructed under the supervision of personnel of that agency.

785:25-7-5. Changes to plans and specifications after approval

(a) If during construction, enlargement, repair, alteration, or removal of any dam or reservoir, it is found that amendments, modifications, or changes that increase the normal or maximum water elevations, increase spillway releases or discharges, or that increase potential damages downstream will need to be made to the plans and specifications as previously approved by the Board, an amended application including maps, plans, drawings, and specifications shall be submitted to the Board for approval.

(b) The owner may be required to publish notice of the date, place and time when the Board will consider the matter as was done for the original application.
(c) Other amendments, modifications or changes shown in as-built plans and specifications may be accepted by Board staff.
[**Source**: Amended at 9 Ok Reg 1677, eff 5-11-92]

785:25-7-6. Notice of completion and filing of supplementary drawings or descriptive matter

Immediately upon completion of a new dam or reservoir or enlargement or repair of a dam or reservoir, the owner shall give notice of completion and as soon thereafter as possible shall file supplementary drawings or descriptive matter showing or describing the dam or reservoir as actually constructed, including the following:

(1) A record of all grout holes and grouting;
(2) A record of permanent location points and bench marks;
(3) A record of tests of concrete soils, or other materials used in the construction of the dam or reservoir; and
(4) Any other items which may be of permanent value and have a hearing on the safety and performance of the dam or reservoir.

785:25-7-7. Emergency action plans

(a) Owners of existing or proposed dams classified as high hazard potential, regardless of the size of such dams, and any other dam as determined by the Board, shall create and maintain an EAP that utilizes the recommendations, as determined by the Board, of the "Federal Guidelines for Dam Safety, Emergency Action Planning for Dam Owners," published August 2004 by the Federal Emergency Management Agency. The owner shall submit a copy of the EAP to the Board.
(b) Owners shall annually review their EAPs to assure they are still accurate and applicable, and submit any updates to the EAPs to the Board.

785:25-7-8. Certificate of completion

(a) **Issuance; revocation; amendments.**
Certificates of completion shall be issued and may be revoked or amended as follows:

(1) Upon filing of notice of completion of works by the applicant, the Board shall, within sixty (60) days, inspect or cause the dam to be inspected. The Executive Director shall approve the issuance of a certificate of completion if, based on the certification from the engineer in the Notice of Completion, the dam or reservoir is safe to impound water within the limitations prescribed in the certificate. However, no certificate of completion shall be issued until receipt of fee for certificate and all invoiced filing and inspection fees.
(2) Every certificate of completion issued shall contain *the date of approval of plans and specifications for the dam, date construction was completed on said dam, and* [82:110.8] any such terms and conditions as the Board may prescribe. The Board may revoke any such certificate whenever it is determined that the dam constitutes a danger to life and property. Whenever such action is necessary to safeguard life and property, the terms and conditions of any such certificate may be amended and a new certificate issued containing the revised terms and conditions.
(3) *Certificates of completion of works from the . . . Board shall be required before any water may be impounded by a new dam or before water may be impounded at an elevation higher than that previously authorized by the Board at an existing dam which has been modified* [82:110.8]

(b) **Notice and action.** After the issuance of the certificate of completion, the Board shall provide notice to the owner, allowing opportunity for a hearing, prior to the issuance of any order revoking or modifying the previous Board certificate.
[**Source**: Amended at 10 Ok Reg 3287, eff 6-25-93]

SUBCHAPTER 9. ACTIONS AFTER CONSTRUCTION

Section
785:25-9-1. Inspections of dams
785:25-9-2. Records and reports of owner
785:25-9-3. Correcting deficiencies (not creating imminent peril)
785:25-9-4. Notice and action (Revoked)
785:25-9-5. Correction of deficiencies creating imminent peril
785:25-9-6. Request for inspection of dams by other parties
785:25-9-7. Recovery of costs and expenses
785:25-9-8. Emergency repairs

785:25-9-1. Inspections of dams

(a) **Oversight vested in Board.** Oversight of the maintenance and operation of constructed dams and reservoirs insofar as necessary to safeguard life and property from injury by reason of the failure thereof is vested in the Board.
(b) **Periodic inspections.** Except for low hazard potential dams, owners are required to have their dams inspected by qualified persons periodically according to a schedule prepared by the Board to meet the requirements of paragraphs (1) and (2) of this subsection and shall include review of the Emergency Action Plan and of the operation and maintenance manual to assure they are still accurate and applicable. Periodic inspections of dams shall be scheduled according to hazard potential classifications as follows:

(1) High hazard. High hazard potential dams shall be inspected at least once annually.

(2) Significant hazard. Significant hazard shall be inspected at least once every three years.

(3) Low hazard. Low hazard potential dams shall be inspected at least once every five years, which inspection shall be conducted by the owner and shall consist of a review of the hazard classification on forms provided by the Board.

(c) **Expense of periodic inspections.** Periodic inspections shall be at the owner's expense (except for low hazard potential periodic inspections) and shall be conducted by a Registered Professional Engineer hired by the owner who shall have training and/or construction of dams and reservoirs, or by an engineer of any United States governmental agency acting in his official capacity. Provided that inspections of low hazard classification dams may be conducted by persons who are not Registered Professional Engineers but who are trained in inspecting dams. If a periodic inspection is conducted by the owner or his representative, a written inspection report shall be submitted to the Board not later than 30 days after the inspection and shall contain information as set forth in a Board's hazard verification report.
(d) **Unscheduled inspections.** Unscheduled (non-periodic) inspections such, as those conducted in response to complaints, after major heavy precipitation events or in emergency situations, may be conducted by Board staff, or the Board may require the owner to conduct and unscheduled inspection at the owner's expense. No fee for such inspection shall be due, provided that a request for inspection by other parties shall be governed by 785:25-9-6.
(e) **United States dams not subject to inspection**. Any dam *constructed by the United States or its duly authorized agencies shall not be subject to inspection while under the supervision of officers or the United States.* [82:105.27]
(f) **Board to notify when inspection due; violation.** The Board shall notify persons shown by its records to own the dam of the date the periodic inspection of the dam is due. Such notice

shall require the owner to advise the Board by a date specified when an engineer retained by the owner will conduct the inspection. Failure to so notify the Board or to have the inspection completed shall constitute a violation of Board rules.
[**Source:** Amended at 10 Ok Reg 3287, eff 6-25-93; Amended at 11 Ok Reg 2931, eff 6-13-94; Amended at 12 Ok Reg 2687, eff 7-1-95]

785:25-9-2. Records and reports of owner
(a) The owner of a dam or reservoir or his agent shall fully and promptly advise the Board by telephone or any sudden or unprecedented flood or unusual or alarming circumstances or occurrence affecting the safety of the dam or reservoir. Within ten (10) days after such flood event or circumstance, the owner or owner's agent shall provide a written report of any damages to the dam and of the need to make any repairs.
(b) The Board may require owners to keep records of and to report on maintenance, and staffing of any dam or reservoir if, in the opinion of the Board, such records and reports are necessary to safeguard life and property.
[**Source:** Amended at 10 Ok Reg 3287, eff 6-25-93]

785:25-9-3. Correction of deficiencies (not creating imminent peril)
(a) *When an owner fails, neglects or refuses to comply with* the Oklahoma Dam Safety Act, rules of this chapter, *or orders of the . . . Board, and there is no imminent peril to the public health or welfare shown* the Board *may, after notice and opportunity for hearing, issue an order requiring such owner to take whatever action the Board deems necessary to place the dam in a safe condition, meet the requirements of* the Oklahoma Dam Safety Act, *rules of the Board, or the previous orders of the Board* [82:110.10].
(b) Actions which can be ordered *may include but are not limited to lowering the level of or removing all water in the reservoir, providing an adequate warning to the public downstream, repair or modification of the existing dam after having the appropriate application for approval of plans and specifications granted, cease all construction work on a dam, and implementation of an appropriate operation and maintenance plan* [82:110.10].
(c) If after such hearing it shall be determined to order such amendments, modifications or changes, the owner shall submit, if necessary under 785:25-5-1, plans and specifications for Board approval. Upon approval of the plans and specifications, the Board shall direct the time within which such modification, alteration, or construction shall be completed.
(d) In determining whether amendments, modifications or changes are necessary to protect life and insure safety of the dam, the Board shall take into consideration the possibility that the dam and reservoir might be endangered by overtopping, seepage, settlement, erosion, cracking, earth movement, or other conditions which exist in any area in the vicinity of the dam or reservoir.
(e) Amendments, modifications or changes may include routine maintenance items that do not require plans and specifications, such as removal of trees on an earthen embankment, establishing vegetation cover to prevent erosion, or updating a warning and evacuation plan, etc. Amendments, modifications or changes may also include alterations or repairs which require submittal and approval of plans and specifications, including but not limited to changing the spillway design capacity, rebuilding embankments, etc.
[**Source:** Amended at 9 ok Reg 1678, eff 5-11-92; Amended at 10 Ok Reg 3287, eff 6-25-93]

785:25-9-4. Notice and action (Revoked)
[**Source**: Revoked at 10 Ok Reg 3287, eff 6-25-93]
Agency Note (1): The language in 785:25-9-4 has been moved to 785:25-7-8(c).

785:25-9-5. Correction of deficiencies creating imminent peril

(a) *When an owner fails, neglects or refuses to comply with* the Oklahoma Dam Safety Act, rules of this Chapter, *or orders of the Board, and there is an imminent peril to the public health or welfare shown, the Executive Director of the Board, or Assistant Director in the absence of the Executive Director, may, without notice or opportunity for hearing, issue an emergency order requiring such owner to take actions the Board deems necessary to place the dam in a safe condition. Such emergency order shall indicate the finding of imminent peril and shall specify the actions that are to be taken immediately. The order shall also specify a time and place for hearing to be held after such actions are taken.* [82:110.10]. In determining whether an imminent peril to the public health or welfare exists, the Board may consider the following:

(1) The condition of any dam or reservoir is so dangerous to the safety of life or property as not to permit time for the issuance and enforcement of an order after notice and hearing relative to maintenance or operation;

(2) Passing imminent floods threaten the safety of any dam or reservoir.

(b) The Board may, if the owner cannot be served or is otherwise unable to act, immediately employ remedial measures. The remedial measures the Board may take in such an emergency include but is not limited to any of the following:

(1) Lower the water level by releasing water from the reservoir;

(2) Completely empty the reservoir, or

(3) Take such other steps as may be essential to safeguard life and property.

(c) The cost and expenses of the remedial measures taken by the Board, including cost of any work done to render a dam or reservoir or its appurtenances safe, shall be recoverable by the State from the owner by action brought by the Board in the district court of the district wherein the dam or reservoir or any part thereof is situated.

[**Source**: Amended at 10 Ok Reg 3287, eff 6-25-93]

785:25-9-6. Request for inspection of dams by other parties

Upon the request of any party, accompanied by the estimated cost of inspection, the Board shall cause any alleged unsafe works to be inspected. If the works are *found to be unsafe, the money deposited by such party shall be refunded and the fee for inspection shall be paid by the owner of such works*. [82:105.27]

[**Source:** Amended at 11 Ok Reg 2931, eff 6-13-94]

785:25-9-7. Recovery of costs and expenses

The costs and expenses incurred by the Board for inspection of any dam found to be unsafe *shall be paid by the owner of such works and if not paid by the owner of the dam within thirty (30) days after the decision of the Board shall be a lien against any property of such owner and be recoverable by the State from the owner by suit instituted by the District Attorney of the county at the request of the Board.* Such *liens shall be superior in right to all mortgages or encumbrances, except ad valorem tax liens placed upon the land and the water appurtenant thereto or used in connection therewith*. [82:105.27]

785:25-9-8. Emergency repairs

(a) If conditions exist which may cause loss of life if repairs are not made immediately, emergency repairs may be made by the owner without prior submittal of the plans and specifications required under 785:25-5-1.

(b) The Board shall be notified of the emergency and the repairs to be made within 48 hours and plans and specifications shall be furnished to the Board for review as required in 785:25-5-1 as soon as possible.

785:25-9-9. Breach analysis for existing dams

If an existing dam does not have a breach analysis, and a failure might put lives at risk downstream, then after the next regularly scheduled inspection the Board's Engineer may direct the owner to provide a breach analysis and breach inundation map, utilizing modeling and analysis guidelines provided by the Board, and according to a reasonable schedule of compliance.

785:25-9-10. Reclassification of the hazard-potential class of a dam

(a) The Board may reclassify the hazard-potential classification of a dam at any time based on an inspection and downstream hazard evaluation.

(b) If the Board determines that the hazard-potential class of a dam should be increased to a greater hazard-potential classification, then the Board shall notify the owner of that finding and of the upgrade options that are available, and set a reasonable deadline, based on the circumstances, for the owner to:

(1) file an application to upgrade the dam to meet the requirements for a greater hazard-potential classification; or

(2) seek an individual proceeding to contest the finding: or

(3) perform a breach analysis and inundation mapping or, for existing dams that lack a breach analysis, through the use of acceptable mathematical computations applied to the downstream area from the dam to a point where the necessary design flood and breach is contained within the main stream channel, utilize modeling and analysis guidelines provided by the Board to show the dam should not be reclassified to the greater hazard-potential classification.

785:25-9-11. Upgrading dams due to downstream development

(a) **Alternatives.** Instead of upgrading the dam using structural methods, an owner may seek to implement alternative methods. Such alternative methods shall include but is not limited to the following:

(1) a current breach analysis and hydrologic study that demonstrates a lesser hazard-potential classification is correct; or

(2) a current breach analysis and design flood analyses that demonstrate existing downstream developments would not be adversely affected by more than one foot difference between breach and non-breach simulations in the affected area, or records showing the downstream development has been dedicated to non-residential and non-commercial use; or

(3) a plan to permanently remove the dam.

(b) **Schedule of Compliance.** An owner may seek a compliance schedule with the Board that sets the timeframes for various stages of work to be performed. In considering such applications to upgrade on a compliance schedule the Board shall evaluate whether the current dam will not significantly affect the public safety during the compliance period.

SUBCHAPTER 11. ADMINISTRATIVE PENALTIES AND PROCEDURES

Section

785:25-11-1. Applicability and authority
785:25-11-2. Notice of violation and proposed assessment
785:25-11-3. Determined amount of penalty
785:25-11-4. Procedures for penalty assessment

785:25-11-1. Applicability and authority

(a) *The Board may impose administrative penalties against owners of dams who fail, refuse or neglect to comply with the provisions of* the Oklahoma Dam Safety Act, rules of the Board

promulgated pursuant to the Oklahoma Dam Safety Act, and *orders of the Board. Such administrative penalties shall be imposed only after notice and opportunity for hearing on the proposed imposition of such penalties* [82:110.10].
(b) *The notice and opportunity for hearing required by this* Section *may be combined with the notice and hearing required in* [82:110.10] 785:25-9-3.
(c) The penalties *shall not exceed Five Hundred Dollars ($500.00) per day for each violation* [82:110.10].
(d) *Each day a violation continues shall constitute a separate violation* [82:110.10]
[**Source**: Added at 10 Ok Reg 3287, eff 6-25-93]

785:25-11-2. Notice of violation and proposed assessment

The notice of proposed assessment of administrative penalties shall inform the respondent of the provisions of the Oklahoma Dam Safety Act or of the rule or order of the Board at issue and the proposed amount of the penalty. A letter, petition, notice of violation, consent order or final order may constitute a notice of proposed assessment for purposes of initiating administrative penalty proceedings if it meets the requirements of this section.
[**Source:** Added at 10 Ok Reg 3287, eff 6-25-93]

785:25-11-3. Determining amount of penalty

In setting the administrative penalty amount, the Board may consider the following:

(1) The nature, duration and number of previous instances of failure by respondent to comply with requirements of law relating to dam safety and requirements of Board rules and orders.

(2) The efforts of the owner to correct deficiencies or other instances of failure to comply with the requirements of Board rules and orders subject of the proposed penalty.

(3) The cost of carrying out actions required to meet the requirements of law and Board rules and orders;

(4) The size and hazard classification of the dam;

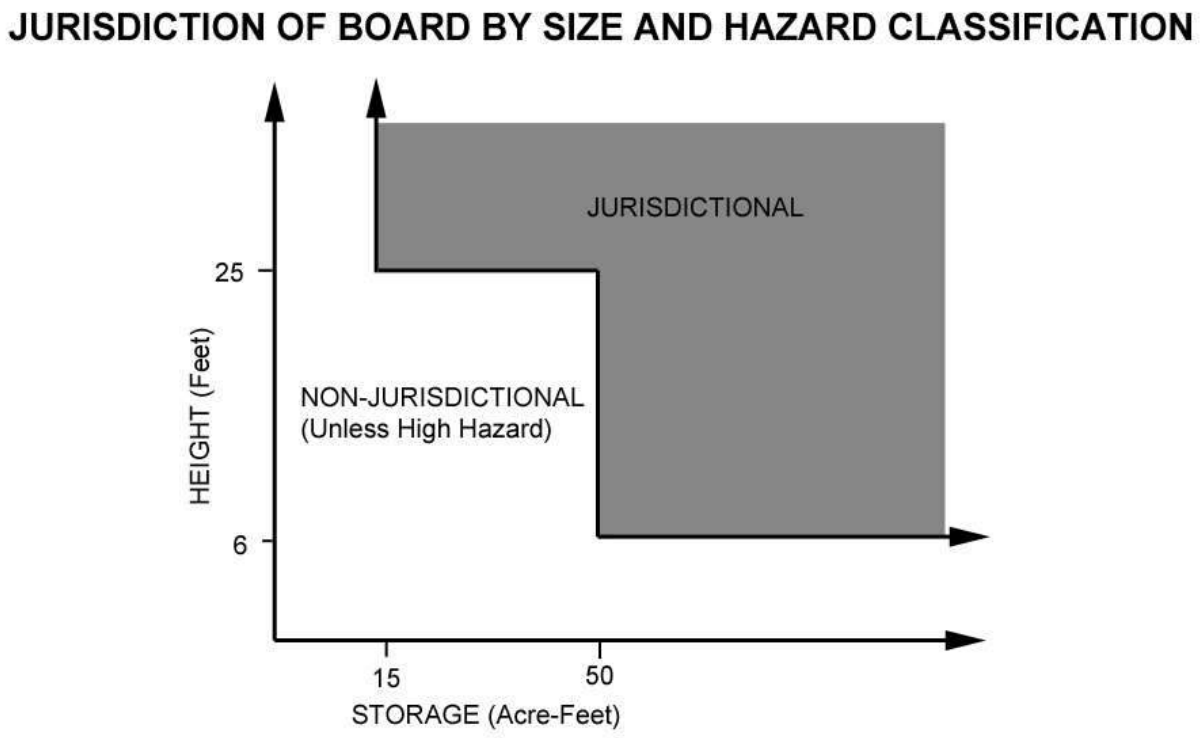
(5) Other factors deemed appropriate by the Board.

[**Source**: Added at 10 Ok Reg 3287, eff 6-25-93]

785:25-11-4. Procedures for penalty assessment

(a) The notice of proposed assessment of administrative penalties shall specify a time, date and place of a hearing.
(b) Failure of respondent to appear at the hearing shall be deemed to constitute an agreement with the imposition of the penalty in the amount proposed as set forth in the notice, and proposed findings, conclusions and order shall not be prepared in that instance. The Board and respondent may also agree to an informal disposition of the matter. In either situations, the matter shall be presented to the Board for consideration of entering a final order assessing the administrative penalty.
(c) The administrative penalty is due and payable immediately upon issuance of the final order, unless otherwise provided therein.
(d) If the Board believes that violations are continuing after issuance of the administrative penalty order, it may seek the issuance of additional orders to assess penalties occurring in the period after issuance of the previous assessment orders.
[**Source**: Added at 10 Ok Reg 3287, eff 6-25-93]

APPENDIX A.
JURISDICTION OF BOARD BY SIZE AND HAZARD CLASSIFICATION



Dam Safety • FACT SHEET

OWRB
the water agency

The Oklahoma Water Resources Board (OWRB) coordinates the state's Oklahoma Dam Safety Program to ensure the safety of more than 4,600 of our dams in the state, especially those that could impact downstream life and property. The most common requirements of the Dam Safety Program are:

* Yearly inspections for "High-hazard" dams (likely to cause loss of human life)
* Inspections every 3 years for "Significant-hazard" dams (likely to cause high economic loss)
* Inspections every 5 years for "Low-hazard" dams (likely to cause minimal economic loss)
* Application to construct a new dam
* Approval of plans for modification of an existing dam
* Emergency Action Plan for High-hazard dams (see below)

Training - The Dam Safety Program coordinates periodic training sessions and workshops on dam safety issues and regulations for dam owners and engineers. OWRB strongly encourages such persons to attend these valuable sessions (schedules are posted on our website*)

Liability - It is important to be aware that any person or company that owns, operates, or maintains a dam is liable for some or all damages due to a failure of that dam even if an unsafe condition existed prior to a new dam owner's term of ownership. Thus, the potential owner must carefully inspect the structural integrity of any dam prior to purchase and then inspect, maintain, and repair it thereafter.

Small Dams - Construction application may not be necessary if the dam will be less than 25 feet in height above the stream bed or if the lake impounded by the dam will less than 50 acre-feet of water; however, approval is required irregardless of size if there are houses or habitable structures located below the dam.

If you plan to construct a dam always check with a professional engineer, the NRCS, or with the OWRB Dam Safety Program engineer before you begin construction to determine if you need to file an application with the State.

Emergency Action Plans

It is the responsibility of each high-hazard dam owner to develop an Emergency Action Plan (EAP) tailored specifically to that dam. The EAP assigns critical roles including surveillance, notification, and identification of the dam break flood zone as well as develop a critical contact list in order to protect downstream lives and property. A written EAP must be submitted to and approved by the OWRB and subsequently filed with the local Civil Defense authorities. The OWRB publication, "Emergency Action Plan Guidelines for High Hazard–Potential Dams" is strongly recommended for dam owners. The Guideline and a fillable EAP form are available on OWRB's website*.

Dam Safety Inspections

The regular inspection of dams is the heart of your care and maintenance program. Early detection and remedy are essential for preserving the integrity of the dam. Technical inspections must be performed by professional engineers familiar with the design and construction of dams and should include assessments of structure safety.

Maintenance inspections are performed more frequently than technical inspections in order to detect, at an early stage, any developments that may be detrimental to the dam. Downstream hazard verification inspections must also be performed to determine if there has been any construction of homes, building, or other structures downstream of their dam which could raise the dam's hazard classification. This has important implications for the dam owner as it could result in a change of how often the dam must be inspected and require structural modifications to the dam.



NRCS Sugar Creek Site # 44 dam, Caddo Cnty, OK washed out from heavy rains

For further information, OWRB Dam Safety publications and online forms visit our website at:

*** www.owrb.ok.gov/damsafety.php**

OKLAHOMA

Citation

Oklahoma dam safety laws are contained in 82 O.S. § 110, last amended in 1992. Regulations are found in the Oklahoma Water Resources Board Rules, Chapter 25, originally adopted in 1973 and last revised in 1997.

Definitions/Dam Classifications

Dam means any artificial barrier, together with appurtenant works, which does or may impound or divert water (Rules 785:25-1-2). A dam is regulated if it is 25 feet or more in height or has an impounding capacity of 50 acre-feet or more. No obstruction determined to be designated primarily for road fill shall be considered a dam (Rules 785:25-3-1[6]).

Dam height is measured from the natural bed of the stream or watercourse at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum possible water storage elevation.

Dam classifications are based on size of the structure and the potential for hazards (Rules 785:25-3-3).

Size Classification

Size	Maximum Storage (ac-ft)	Maximum Height (ft)
Small	less than 10,000	less than 50
Intermediate	between 10,000 - 50,000	between 50 - 100
Large	greater than 50,000	greater than 100

Hazard Potential Classification

Category	Loss of Life	Economic Loss
Low	none	minimal
Significant	none	appreciable
High	yes	excessive

Jurisdiction/Powers of Department

State dams fall under the jurisdiction of the Oklahoma Water Resources Board, hereafter referred to as "the Board". Title 82 of the Oklahoma Statutes 1981, section 1085.2, as amended, requires the Board to adopt rules and regulations deemed necessary to the exercise of any powers conferred upon it.

The Board is empowered to issue permits and review and approve applications for the construction, enlargement, alteration, or repair of any dam (Rules 785:25-5-1). The Board's responsibility over dams shall be limited to dams with a height of twenty-five feet or more, or those with an impounding capacity of fifty acre-feet or more (Rules 785:25-3-1).

The Board is empowered to inspect dams during construction (Rules 785:25-7-1) and after construction is completed (Rules 785:25-7-3). The Board has the power to cite noncompliance and call for remedial work (Rules Chapter VII730.4) and may invoke judicial actions if necessary (Rules 785:25-11-1).

The Board has the power to immediately employ remedial measures in the event of a dam emergency (Rules 785:25-9-5).

Permit/Approval Process

A filing fee must be submitted with each application to construct, enlarge, alter, or repair a dam, based on estimated cost of construction (Rules Chapter III305.5).

Estimated Cost	Filing Fee
$20,000 or less	$ 100.00
$20,001-$99,999	$200.00
$100,000-$999 999	$500.00
$1,000,000 or more	$1,000.00

Plans and specifications are to be prepared by a registered professional engineer (Rules 785:25-5-2).

Applicants for a permit must submit an application upon printed forms, which will be furnished by the Board upon request. The maps, plans, drawings, and specifications of the proposed work along with the filing fee shall form part of the application (Rules 785:25-5-1).

In addition, an engineer's report giving details necessary for analysis of the structure and appurtenances shall be submitted with the plans and specifications (Rules 785:25-5-4). After an application has been filed, a notice will be prepared by the Board setting forth the time, date, and place for hearing the application. Protests regarding the application may be heard at this time. The Board will then render its decision (Rules 785:25-5-7).

Rules 785:25-3-5 and 785:25-3-6 establish minimum design standards as well as minimum spillway performance standards which all dams are required to meet. The owner is required to pay all fees and is responsible for any remedial work (Rules 785:25-9-5).

Inspection Process

State

Supervision over the maintenance and operation of constructed dams and reservoirs insofar as necessary to safeguard life and property is vested in the Board (Rules 785:25-9-1). The rules give the Board responsibility for carrying out routine inspections of every dam under their jurisdiction. Periodic inspections of dams shall be scheduled according to hazard classification as follows:

High Hazard - At least once annually
Significant Hazard - At least once every three years
Low Hazard - At least once every five years

Costs and expense incurred by the Board for inspecting a dam found to be unsafe are the responsibility of the owner. A lien shall be placed on the property if the owner does not pay within 30 days of the Board's decision and expenses shall be recovered by suit.

Owner

Periodic inspections shall be at the owner's expense and shall be conducted by Board staff, a registered professional engineer, or an engineer of any United States governmental agency acting in his official capacity. Some low hazard dams may be exempt from the periodic inspection (Rules 785:25-9-1). Rule 785-25-9-2 requires the owner or his agent to "fully and promptly advise the Board of any sudden or unprecedented flood or unusual or alarming circumstances or occurrence affecting the safety of the dam or reservoir".

During the construction, enlargement, repair, alteration, or removal of any dam, periodic inspections may be made by the Board and the owner shall be required to perform at his expense such works or tests as necessary to disclose information sufficient to enable the Board to determine that substantial conformity with approved plans and specifications is being secured (Rules 785:25-7-1).

Violations/Penalties

Every person shall be guilty of a misdemeanor who violates any of the provisions of the laws or of any order, rule, or regulation of the Board issued pursuant thereto, where a copy of the order, rule, or regulation has been served upon said person by certified mail and said person fails to comply therewith within the time provided, or within ten days of such service if not otherwise provided. In the event of a continuing violation, each day that the violation continues constitutes a separate offense (Rules 785:25-1-3).

Emergencies

The Board may, without notice and hearing issue an emergency order requiring remedial measures to be taken necessary to protect life and property. If the owner cannot be served or is otherwise unable to act, the Board may immediately employ remedial measures. In applying remedial measures, the Board may in emergency do or cause to be done any of the following:

(a) Lower the water level by releasing water from the reservoir,

(b) Completely empty the reservoir, or

(c) Take such other steps as may be essential to safeguard life and property.

The cost and expenses of the remedial means, including cost of any work done to render a dam safe, shall be recoverable by the State from the owner by action brought by the Board in the district court of the district wherein the dam is situated (Rules 785:25-9-5).

Rule 785:25-7-7 requires owners of existing or proposed dams classified as high hazard to provide an adequate warning system and evacuation plan to protect downstream lives and property. The plan is to be approved by and filed with the local Civil Defense authorities. The plan must also be filed with the Board.

Liability

Owners of dams have the responsibility to provide for the safety of such works by making any necessary changes to put the works in a safe condition (Rule 785:25-11-1).

Title 51.05 Supp. 1990 Section 155 exempts the state from liability if a loss or claim results from inspection power including the failure to make an inspection or the completion of an inadequate or negligent inspection.

Oversight

As allowed by and subject to compliance with the requirements imposed under the Oklahoma Administrative Procedures Act (75 O.S. 1981, Sections 301326), any interested party may request rehearing, reopening or reconsideration of any final Board action, decision or Order (Rule 785:4-9-3).

Miscellaneous

Dams constructed by the United States or its duly authorized agencies shall not be subject to inspection while under the supervision of the officers of the United States (Rules 785:25-9-1).

E.36. Oregon



Secretary of State home | State Archives home

Oregon State Archives

800 Summer St NE Salem OR 97310
503 373 0701 | Mon-Fri: 8am-4:45pm

Oregon Administrative Rules

alpha links | numerical links | bulletins | filing resources | rules coordinators | about oars | search oars | buy oars | ors

The Oregon Administrative Rules contain OARs filed through October 15, 2010

WATER RESOURCES DEPARTMENT

DIVISION 20

DAM SAFETY

690-020-0000

Purpose and Applicability

(1) These rules describe the standards and requirements under which the department will administer and enforce the design, construction, maintenance, inspection, and fees regarding dams in Oregon. The purpose is to provide the guidance necessary for dams to be constructed and operated in a manner that will ensure the protection of life and property and to provide the department with the resources necessary to manage and support the construction and safe operation of dams in accordance with these rules.

(2) These rules apply to:

(a) Dams that are not subject to ORS 540.350–540.390 as described in 540.400.

(b) Dams that are subject to ORS 540.350–540.390 and which exceed the statutory limits as described in ORS 540.400(1) & (2).

(3) These rules do not apply to metal or reinforced concrete water storage tanks or various types of tanks that are part of water treatment facilities.

Stat. Auth.: ORS 540.350 - 540.400, 536.050
Stats. Implemented: ORS 183, 540, 536
Hist.: WRD 12-1986, f. & ef. 10-3-86; WRD 12-1994, f. & cert. ef. 11-7-94; Renumbered from 690-020-0021, WRD 7-2009, f. 12-7-09, cert. ef. 1-1-10

690-020-0021 [Renumbered to **690-020-0000**]

690-020-0022

Definitions

The following definitions apply in OAR 690, Division 20:

(1) “Abutment” means a natural valley or canyon side against which the dam is built;

(2) “Acre-foot” means the equivalent volume of one acre covered with one foot of water (325,900 gallons);

(3) “Conduit” means a closed conveyance used to release water through a dam;

(4) “Cutoff Trench” means a trench excavated beneath the dam foundation and backfilled with low permeability material to retard water seepage;

(5) “Dam” means a hydraulic structure built above the natural ground grade line that is used to impound water. Dams include wastewater lagoons and other hydraulic structures that store water, attenuate floods, and divert water into canals;

(6) “Dam Crest” means the top of the dam;

(7) “Department” means the Oregon Water Resources Department;

(8) “Director” means the Director of the Oregon Water Resources Department;

(9) “Embankment” means an engineered earth fill;

(10) “Emergency Spillway” means an overflow structure constructed to bypass flood water and prevent overtopping the dam crest. Often, dams have two spillways. The lower elevation spillway that spills first is referred to as the principle spillway. The higher elevation spillway is referred to as the emergency spillway;

(11) “Foundation” means the ground surface upon which a dam is constructed;

(12) “Freeboard” means the vertical distance between the designed high-water level in the reservoir and the dam crest;

(13) “Gate” or “Valve” means a permanent device for regulating water flow through the dam;

(14) “Hazard Rating” means the rating established by the department for a large dam that pertains to the potential level and degree of damage to life and property downstream of a dam in the event dam failure results in a catastrophic release of water;

(15) “Large Dam” for dam safety purposes, means a dam with a height of 10 feet or more and impounding 3,000,000 gallons (9.2 acre-feet) or more of water;

(16) “Significant dam work” means an activity to repair, rehabilitate, enlarge or otherwise alter a dam in which: 1) at least 30% of the fill material is impacted by the activity, 2) a spillway is being enlarged or repaired that affects the height or hydraulics of the spillway, 3) dam height and/or reservoir size is being increased, 4) a low level outlet conduit or inlet gate is being reworked with excavation or 5) any other activity that could affect the integrity of the dam or its auxiliary works;

(17) “Small dam” for dam safety purposes, means a dam with a height of less than 10 feet or impounding less than 3,000,000 gallons (9.2 acre-feet) of water; and

(18) “Tank” means a fully-enclosed (bottom and sides) hydraulic structure made from metal, reinforced concrete, rigid fiberglass, or plastic that provides its own water-sealing and structural stability.

Stat. Auth.: ORS 183 & 540
Stats. Implemented: ORS 183 & 540, 536
Hist.: WRD 12-1986, f. & ef. 10-3-86; WRD 7-2009, f. 12-7-09, cert. ef. 1-1-10

690-020-0025

General Requirements for all Dams

(1) The director may require any information or data in addition to that outlined herein which the director finds necessary for determining the safety of the proposed structure.

(2) Whenever possible, precipitation and runoff records shall be submitted as part of the design for new or significant dam work on existing dams. If records are not available for the basin in which the dam is located, the hydrological/hydraulic criteria used in the design shall be submitted.

(3) The director may include as part of any permit to construct a dam limitations and conditions that pertain to construction, operation, maintenance, and the protection of lives and property. These limitations and conditions become, by reference, part of the certificate and remain in effect throughout the life of the water right.

(4) Approved plans and specifications for construction are, by reference, considered limitations and conditions placed on the water right permit and water right certificate. The director retains the authority to place additional limitations and conditions on the water right relative to operation and maintenance.

(5) Dams constructed or operated in violation of limitations and conditions included in the permit or certificate are subject to

restricted use and permit cancellation procedures. The certificate affirms the applicant's right to store water subject to the limitations and conditions therein.

(6) An outlet conduit with a minimum diameter of 8" must be installed in any instream reservoir to permit drainage of the reservoir and for passage of flow to downstream prior rights. The director may waive this requirement if the director determines that the conduit is not needed for dam safety and will not be needed to pass flow for the benefit of other water rights, minimum perennial streamflows, or if the director determines an adequate alternative for passing flow is provided. Adequate alternatives must be capable of passing flow in sufficient quantity to satisfy downstream needs, and can include pumps, by-pass channels and siphons. Conduit material should be chosen based on design and site condition requirements. Acceptable conduit materials include reinforced concrete cylinder pipe; cast-in-place, reinforced concrete; appropriate PVC; concrete-encased corrugated metal pipe or plastic pipe; ductile iron; and cast iron. All joints should be water tight. The conduit valve should be installed at the upstream end and should be industry-manufactured with specifications consistent to the applied usage. Special provisions should be made for pressure conduits gated on the downstream end.

(7) The department shall determine the height of a dam by calculating the vertical distance (measured in feet) between the center point of the dam crest relative to and above the stream channel and the lower of either the natural soil surface that was in place prior to the construction of the dam or where a channel incision exists, the bottom of the channel incision. This measurement is to be taken at the maximum section along the dam’s longitudinal axis.

(8) The department shall determine water impoundment volumes (in acre-feet or millions of gallons) as follows:

(a) For dams impounding water for an authorized beneficial use, the impoundment volume indicated in the area-capacity curve from the bottom of the reservoir to the spillway crest. For dams with multiple spillways, ‘spillway crest’ is referring to the crest of the principle or lower elevation spillway.

(b) For wastewater treatment lagoons, the impoundment volume indicated in the wastewater lagoon plans and specifications, and

(c) For diversion or flood control dams, the impoundment volume calculated at full reservoir at the dam emergency (highest elevation) spillway crest level.

Stat. Auth.: ORS 540.350 - 540.400
Stats. Implemented: ORS 183, 536 & 543
Hist.: WRD 3, f. & ef. 2-18-77; WRD 12-1986, f. & ef. 10-3-86; WRD 12-1994, f. & cert. ef. 11-7-94; WRD 7-2009, f. 12-7-09, cert. ef. 1-1-10

690-020-0029

Small Dams, Recommended Minimum Standards

The following information is presented for the applicant's assistance in constructing small earthfill dams:

(1) It is recommended that the crest width of the dam be not less than 8 feet.

(2) It is recommended that the upstream slope of the dam be no steeper than 3:1.

(3) It is recommended that the downstream slope of the dam be no steeper than 2:1.

(4) It is recommended that the spillway channel be constructed around the dam, not over the top of the fill. The spillway is commonly excavated in natural material and, if necessary, lined to prevent erosion. The spillway should be large enough to pass the 50-year flood flow without overtopping the dam. Assistance is available from the department in sizing the spillway. Flow passing through the spillway should be returned to the creek channel at a sufficient distance downstream to prevent erosion of the dam’s embankment.

(5) It is recommended that all brush, stumps, roots, and organic matter should be cleared from the area to be occupied by the dam. All such material should also be removed from the borrow area.

(6) It is recommended that the outlet pipe be encased with concrete or other method to allow for proper compaction and the prevention of uncontrolled seepage.

(7) Embankment material should be spread parallel with the dam axis in layers not exceeding eight inches in thickness and adequately compacted with sheepfoot roller or other similar equipment.

(8) It is recommended that prior to construction the dam owner have the dam’s potential hazard to downstream properties studied

using methods listed in 690-020-0100. It is recommended that any dam with a potential significant or high hazard rating be designed by a registered engineer familiar with dam engineering. It is advisable for any dam nearing or surpassing the dam height or storage thresholds for a “large dam” to be designed by a registered engineer.

Stat. Auth.: ORS 183 & 540
Stats. Implemented: ORS 183 & 540
Hist.: WRD 12-1986, f. & ef. 10-3-86; WRD 7-2009, f. 12-7-09, cert. ef. 1-1-10

690-020-0035

Dams Over the Statutory Limits; Minimum Engineering Design Requirements

All maps, plans, and specifications for the construction of new large dams or significant dam work for existing large dams, must be prepared by a professional engineer licensed to practice in the State of Oregon.

(2) Before initiating design, the engineer shall obtain design criteria from the department.

(3) No newly constructed large dam shall be permitted to store water until written approval is received from the department. Approval will be given after construction has been completed and is certified by the supervising engineer to have been constructed in accordance with the approved plans and specifications.

(4) Design documents shall include the following:

(a) Plans:

(A) Plans for dams submitted for approval must accurately portray the work to be accomplished and be of sufficient detail to adequately define all features of the project. Plans must be submitted on good-quality mylar or vellum and must be neatly and accurately drawn to a scale sufficiently large, with an adequate number of views, for the drawing to be readily interpreted. To meet the requirements of this subsection, the director may allow plans for dams to be submitted electronically. The format of the plans in terms of file type, projection and other details must be approved by the department.

(B) Several sheets may be used to eliminate the necessity of large bulky drawings. No map or plan should be larger than 24 x 36 inches. The following information will be required:

(i) A contour map of the reservoir site which will show the location of the dam by quarter-quarter section, township, range and tax lot; and the name and location of the stream flowing through the reservoir. Government survey lines must be indicated on this

map, along with a survey tie to the dam axis from a government land corner. Area and capacity curves and/or tables of the proposed reservoir must be shown;

(ii) A map of the drainage basin showing the location of the dam and reservoir and the streams within the drainage area. This map may be prepared from existing reliable topographical maps and it must include: the number of square miles of drainage area; a brief description of the area; the percentage of bare and timbered lands; and general characteristics of the watershed, whether precipitous, rolling, or comparatively flat. The estimated discharge as well as the spillway capacity at different reservoir water levels should also be provided in the plans or specifications. Extraneous information can also be included in specifications or a separate hydrology report as to not clutter up the map;

(iii) A topographic map of the dam site with contour intervals not to exceed 5 feet. A plan of the dam should be superimposed on this map showing the location of spillways, outlet conduits, and other relevant auxiliary structures;

(iv) A profile of the dam site taken on the axis of the dam and a profile of the spillway along its axis. The profile should also show the location of the outlet conduit and spillway. A log showing the classification of materials encountered below the surface as shown by test pits or borings;

(v) A cross section of the dam at maximum section showing complete details and dimensions;

(vi) Plans showing sections of the outlet conduit, control works, and spillways. These sections should be in sufficient number and detail to make definite all features of the structure.

(b) Specifications. All plans for dams must be accompanied by construction and material specifications:

(A) The specifications shall describe in detail the methods and/or performance criteria to be followed in performing each class of

work and shall set forth the requirements for the various types of material to be used in permanent construction;

(B) The specifications must contain a provision for supervision by the engineer during construction and for inspection by the director or director's authorized representative at any time during the construction period;

(C) The specifications must also contain a provision to the effect that plans or specifications shall not be altered or changed without the written approval of the director or the director's authorized representative.

(5) Construction: Construction should be supervised by an engineer licensed to practice in Oregon. As a minimum the following notices and construction reports shall be submitted to the Department:

(a) Notice of beginning of construction;

(b) Notice of intent to begin placement of fill materials;

(c) Completion report including test results, "as-built" drawings, and certificate of completion in accordance with approved plans and specifications.

(6) During the design process for any newly constructed dams or for significant dam work to existing dams that involves potentially changing the volume or rate of water released during failure, the dam owner or owner's representative must submit to the department an inundation analysis using methods described in 690-020-100. The department shall use this analysis to determine the hazard rating of the dam in accordance with 690-020-100.

(a) If a dam is rated as high hazard, an emergency action plan is required and the plan must be reviewed and approved by the department.

(b) The inundation/evacuation map for the dam must be developed using methods described in 690-020-100(2) and must be reviewed and approved by the department.

Stat. Auth.: ORS 540.350 - 540.400
Stats. Implemented: ORS 183, 536 & 540
Hist.: WRD 3, f. & ef. 2-18-77; WRD 12-1986, f. & ef. 10-3-86; WRD 12-1994, f. & cert. ef. 11-7-94; WRD 7-2009, f. 12-7-09, cert. ef. 1-1-10

690-020-0039 [Renumbered to **690-020-0050**]

690-020-0050

Enforcement Procedures

The director shall maintain a program of inspecting existing dams. When any structure is found to be in violation of the terms and conditions of the permit or certificate or directly threatens life or property, or when any structure is found where lack of maintenance or unauthorized alterations could lead to a direct threat to life or property, the department shall notify the owner in writing of the violation and the action necessary to bring the structure up to design, operation, or maintenance standards. Failure by the owner to perform the required action may result in proceedings for one or more of the following:

(1) Notice and opportunity for a contested case hearing as provided for in ORS 540.350(5).

(2) Cancellation of the permit.

(3) Posting of the structure to prevent storage or to limit operation until the owner has complied with the requested action required to fulfill conditions of the permit or certificate.

(4) Instituting legal action by the District Attorney or Attorney General to have the facility declared a public nuisance.

(5) Issuance of an order to prevent storage or to breach the embankment as provided for in ORS 540.370.

(6) Any other enforcement action permitted by law.

Stat. Auth.: ORS 183 & 540
Stats. Implemented: ORS 183 & 540
Hist.: WRD 12-1986, f. & ef. 10-3-86; Renumbered from 690-020-0039, WRD 7-2009, f. 12-7-09, cert. ef. 1-1-10

690-020-0100

Hazard Rating

(1) Hazard ratings for “large dams” are classified by the department as “high hazard”, “significant hazard”, or “low hazard” as follows:

(a) High Hazard: This rating indicates that if the dam fails there is a strong plausibility for loss of life. The plausibility is established because of inhabited infrastructure (such as homes and business) downstream that would be inundated to such a degree see 690-020-0100(2)(d) for specific criteria that it would put the person who inhabits the structure in jeopardy. Any factor that puts a strong probability of people being downstream in an inundation area of a dam failure shall be considered. The department shall endeavor to inspect this class of dams on an annual basis.

(b) Significant Hazard: This rating indicates that if a dam fails, infrastructure (such as roads, power lines or other largely uninhabited buildings) would be damaged or destroyed due to inundation and flooding. The department shall endeavor to inspect this class of dams at least once every three years.

(c) Low Hazard: This rating indicates that if the dam fails there is little plausibility for loss of life, and human infrastructure that could be affected by inundation downstream is minor or non-existent. The department shall endeavor to inspect this class of dams at least once every six years.

(2) The department shall utilize inundation of infrastructure study results as a primary factor to determine the hazard rating of dams. Methods and modeling acceptable for inundation of infrastructure studies include:

(a) Hydraulic Modeling: Use of one-, two-, or three-dimensional modeling software (such as HEC-RAS, FLO-2D or MIKE) and hydrologic, topographic, and other data to estimate inundation of infrastructure downstream of dams.

(b) Hydrologic Routing Modeling: Use of modeling software such as HEC-HMS with hydrologic routing methods such as the Muskingum and Modified-Puls methods along with hydrologic and topographic data.

(c) Simplified Methods such as SMPDBK and the Washington State Method: “Dam Breach Analysis and Downstream Hazard Classification” may be used. A dam owner may request information on these methods from the department. Use of these or other simplified methods is only to be used in hazard ratings for dams, not for emergency action planning.

(d) Depth of inundation to trigger different hazard ratings: A depth of at least two feet over the finished floors of buildings or road surface of infrastructure is required to establish a “high hazard” rating. Any depth of water over the floorboards of structural buildings such as homes, barns, pump houses or storage sheds can establish a “significant hazard” rating. For roads, a depth of two feet or evidence of depth and velocity capable of creating damage can be used to establish a “significant hazard” rating.

(e) Specific data, methods and results for all methods must be reviewed and approved by the department prior to revising a hazard rating.

(3) The hazard rating of a dam shall remain in effect until the rating is revised by the department using one of the methods described in section 2. A dam owner may request that the department revise a hazard rating. The owner must provide information in support of the request. If the supporting information includes results and/or analysis using the methods described in subsections 2(a) or (b), the information must be prepared by an engineer licensed in Oregon and familiar with hydraulic and hydrologic modeling; if the information includes results and/or analysis using the methods described in subsection 2(c), the information must be prepared by a licensed engineer or a practicing hydrologist familiar with hydraulic and hydrologic calculations.

(4) Exceptions to Hazard rating methods:

(a) Small dams are not assigned a hazard rating.

(b) Situations in which there are heavy recreational or other uses downstream, a dam may be rated as “high hazard” because of probable loss of life regardless of downstream infrastructure presence.

Stat. Auth.: ORS 183 & 540
Stats. Implemented: ORS 183 & 536, 540
Hist.: WRD 7-2009, f. 12-7-09, cert. ef. 1-1-10

690-020-0200

Fees for Dams

(1) Owners of a large dam shall submit to the department an annual fee in the amount and on the basis established under ORS 536.050.

(2) Dam owners who fail to pay an annual fee on or before six months after the billing date may be required to pay a late fee in the amount established under ORS 536.050.

(3) If a dam owner fails to pay the annual fee or late fee charged by the department, the department may, after giving the dam owner notice by certified mail, place a lien on the real property where the dam is located for the fees owed by the dam owner.

(4) Dams that are subject to the annual fee include dams partially or wholly in the State of Oregon that meet the definition of ”dam” under OAR 690-020-0020.

(5) Multiple large dams connected together and separated only by embankments or other manmade materials (common with sewage lagoons) will count as one dam for fee purposes.

(6) Owners Exempt from Fee Requirements include:

(a) Owners of a “small dam”,

(b) Owners whose dams that are directly controlled or regulated for safety by an agency of the U.S. Federal Government and the agency that controls or regulates the dam has its own safety program that meets the following criteria:

(A) The program must allow for control of the design and construction process for dams under their control with licensed engineers designing and reviewing any major design or repair. Copies of all design drawings and construction records should be forwarded to the department for tracking and archival purposes.

(B) The program must have a regular dam inspection program that is either conducted by or directly supervised by a licensed engineer with expertise in dam safety. Formal documented dam inspections for high hazard dams should occur at least once per year. For significant hazard dams, inspections shall occur at least once every 3 years and for low hazard dams, once every 6 years. Other more frequent inspections and reports on dam conditions may be necessary depending on the condition of individual dams. Copies of mutually agreed upon inspections and reports should be forwarded to the department for archival and tracking purposes.

(C) The federal agency in charge of the dam via regulation or control must also have a regular maintenance program or be able to require maintenance activity from the regulated party that will address problems discovered in the inspection program.

(D) The federal agency must have a memorandum of understanding or agreement with the department that outlines how the federal agency meets the criteria in paragraphs (b)(A)–(C), and must agree to meet at least annually with the department to review the state of the federal program for continued exemption purposes.

Stat. Auth.: ORS 536.050
Stats. Implemented: ORS 536.050
Hist.: WRD 7-2009, f. 12-7-09, cert. ef. 1-1-10

The official copy of an Oregon Administrative Rule is contained in the Administrative Order filed at the Archives Division, 800 Summer St. NE, Salem, Oregon 97310. Any discrepancies with the published version are satisfied in favor of the Administrative Order. The Oregon Administrative Rules and the Oregon Bulletin are copyrighted by the Oregon Secretary of State. Terms and Conditions of Use

Alphabetical Index by Agency Name

Numerical Index by OAR Chapter Number

Search the Text of the OARs

Questions about Administrative Rules?

Link to the Oregon Revised Statutes (ORS)

Return to Oregon State Archives Home Page



Dam Safety in Oregon

A General Guide

STATE OF OREGON
WRD
WATER RESOURCES DEPARTMENT



State of Oregon
Water Resources Department
725 Summer Street NE, Suite A
Salem, Oregon 97301
(503) 986-0900
www.wrd.state.or.us
March 2007

Contents

Dam Safety in Oregon

History of the Dam Safety Program.....1
Responsibilities and Duties.....3
Hazard Classifications.....7
Permitting.....10
Applying for a Permit to Use Water.....11
Preparing the Reservoir Application.....13
How an Application is Processed.....13
Dams Under Statutory Limits.....14
Dams Over Statutory Limits.....15
Dam Inspection.....19
Rating Criteria.....20
Inspection Form.....21
Enforcement.....23

Appendices

Statutory Authority.....25
Dam Components.....26
Glossary.....30

Contact Us

Oregon Water Resources Department

www.wrd.state.or.us - Dam Safety website, forms, and administrative information. The website is updated regularly with news and events.

Federal Emergency Management Agency

www.fema.gov - US government agency dedicated to disaster mitigation, preparedness, and response and recovery planning. Links can be found on their website to Dam Safety and the FEMA Emergency Action Plan. This website is regularly updated with current emergency related news.

Association of State Dam Safety Officials

www.damsafety.org - ASDSO is a non-profit organization of state and federal dam safety regulators, dam owners and operators, engineering consultants, manufacturers and suppliers, and others interested in dam safety. ASDSO's vision is to lead the US dam safety community with a strong, unified voice and effective programs and policies towards furtherance of dam safety.

Bureau of Reclamation

www.usbr.gov - The Bureau of Reclamation is the second largest supplier of wholesale water and hydroelectric power in the American West. They promote water conservation, recycling, and reuse. The Bureau of Reclamation is a contemporary water management agency with a strategic plan outlining numerous programs, initiatives, and activities that will help meet new water needs and balance the multitude of competing uses of water in the west.

US Army Corps of Engineers

www.usace.army.mil - Their mission is to provide quality, responsive engineering services to the nation including planning, designing, building, and operating water resources and other civil works projects. Navigation, flood control, environmental protection, and disaster response links are updated regularly.

Purpose

Dam safety is an important issue of which the public needs to be familiar. This booklet has been designed to cover topics that will benefit the public, engineers, dam owners, and watermasters. This booklet also covers Oregon's laws pertaining to dams and a glossary of commonly used terms.

History

of the Dam Safety Program

Dam safety laws in Oregon were first adopted in 1909, and then modified in 1927, and again in 1929 following the catastrophic failure of California's St. Francis Dam, when the statutes were amended to their present form, more or less. Initially, the review of design plans and specifications was conducted by the State Engineer, and then by a staff engineer in the State Engineer's Office. This one person operation continued until 1956 when the staff was increased to two-full time engineers.

In 1975, further amendments to Oregon water laws merged the State Engineer's Office and the Water Resources Board, forming the Water Resources Department and changing the title of the department head from "State Engineer" to "Water Resources Director". The State Water Policy Review Board and oversight committee was also created, consisting of 7 members from the public appointed by the Governor. As a consequence, the authority to take enforcement actions for protection of human life and property related to Dam Safety was transferred from the State Engineer to the Water Resources Director.

An inspection technician was added to the Dam Safety Program in 1978. Also, Dam Safety added five engineers with funding provided by Congress. A direct result of the increased funding allowed completion of 50 Phase I Inspections Reports for existing high hazard, non-federal dams within the state. In 1982, the program ended as federal funding was eliminated. All but two of the engineering positions and the inspection technician position were also eliminated.

The name of the State Water Policy Review Board was changed to the Water

Resources Commission in 1983, and to it was given new responsibilities for policy decisions, rule making, and management of the agency. Shortly thereafter, the Commission delegated much of its new found authority back to the Director's Office. Until this time, Dam Safety had existed as a separate, stand alone unit.

Later, Dam Safety was combined with the Enforcement Division within the agency. The program was reduced to a single Dam Safety Engineer and one technician. Watermasters were assigned routine inspection duties for existing dams in addition to their other water distribution and regulation assignments. Additionally, other program areas were assigned to the remaining Dam Safety Engineer, including Hydroelectric Facility licensing and Hydrographics.

In 1990, the agency was reorganized so that Dam Safety was combined with Computer Services, GIS, Hydrographics, Hydrology, and Groundwater to form the Technical Services Division. The Hydroelectric Licensing section was moved into the Water Rights Division, however the Dam Safety Engineer was still required to manage a division with about 35 employees.

In 1993, an engineer was hired as Dam Safety Coordinator to upgrade and replace the technician position that was eliminated due to retirement. For a short while, the Technical Services Division was combined with the Field Services Division, but then reverted to the previous arrangement that placed Dam Safety in the Technical Services Division. At present, the Dam Safety Engineer also serves as Division Administrator. The Dam Safety Coordinator is responsible for the management of the Dam Safety Program.

Responsibility

Duties of the Dam Safety Program

The Dam Safety Program is responsible statewide for the review and approval of dam designs, scheduling inspections of existing dams and reservoirs, conducting site inspections of new dam construction, and maintaining both the National Dam Inventory (NID) and the state database.

It is important to realize that the ultimate responsibility for the continued safe operation of any dam or reservoir rests entirely with the dam owner(s). Oregon does not require proof of insurance before a reservoir is filled with water. Typically, water right holders own the land upon which most dams and reservoirs are built. In cases where there are no associated water rights or where the water right holder does not own the real property where the structure is situated, the State presumes the land owner also to be the owner of the dam.

"To serve the public by practicing and promoting responsible water management."
Water Resources Department Mission Statement

The Dam Safety Coordinator provides assistance to watermasters and to owners and operators of dams when questions or situations arise that require engineering advice or training. Other duties include hazard assessment of existing structures, review of emergency management plans, and review of water right transactions (applications, permits, certificates) to assure that appropriate conditions are met that will help to provide safety for downstream life and property.

The Dam Safety Coordinator also performs all regular clerical and office support duties. The state is divided into four regions and twenty watermaster districts. In addition to their duties relating to regulation of water use and distribution, the watermasters assist with performing routine and regularly scheduled inspections of low hazard dams and reservoirs within their respective districts according to a schedule prepared and updated by the Dam Safety Coordinator.



Approximately 8 to 10 percent of each watermaster's time is allocated toward dam and reservoir inspections. At present, nearly 1300 dams and reservoirs are inspected at an interval of 1 to 5 years. Of those, more than 100 structures are owned, operated, or supervised by federal organizations who also maintain active dam safety programs. Some examples of these federal organizations are the Corps of Engineers, Bureau of Reclamation, and certain hydroelectric power generating facilities licensed by the Federal Energy Regulatory Commission (FERC). The Oregon Water Resources Department participates with the respective federal agencies in the inspection of those structures.

Responsibility

For more information about the National Flood Insurance Program (NFIP), visit the website:
www.floodsmart.gov

The National Flood Insurance Program (NFIP) provides federally backed flood insurance in communities that comply with minimum standards for floodplain management. As an incentive, standard homeowners and commercial property located within a designated "flood zone" can receive an insurance premium rate reduction based on various activities that communities voluntarily undertake to reduce flood losses. Once enrolled in the NFIP, each participating community is evaluated based upon the number of credit points earned according to prerequisite activities listed under the NFIP's Community Rating System (CRS). Depending on the total number of credit points, the CRS assigns a community to one of 10 classes. A maximum 45% insurance premium discount is possible if all CRS criteria are satisfied.

For more information about the Association of State Dam Safety Officials (ASDSO), visit the website:
www.damsafety.org

Under CRS Activity 630, a participating community will automatically receive up to 75 credit points if their respective state has a dam safety program that meets certain criteria based on the Model Dam Safety Program recommended by the Association of State Dam Safety Officials (ASDSO). Information and guidelines contained as key components of the

Model State Dam Safety Program are broken into the following chapters:

I. Legislation and Regulations

II. Permitting, Design Approval and Authorization to Impound

III. Inspection

IV. Enforcement

V. Emergency Response

VI. Program Staff and Funding

VII. Program Staff and Dam Owner Education and Training

VIII. Dam Safety Program Public Relations Plan

Presently, the Oregon dam safety program does not have authority to take corrective or emergency action if a dam owner fails to comply with an Order. Therefore, Oregon communities participating in the NFIP do not receive any credit points for the state dam safety program. In order for communities to receive this additional credit, all of the elements listed in the Model Dam Safety Program must also be included in the state's program.



What Constitutes a Dam?

"Dam" is not specifically defined in any of Oregon's statutes or rules. Regardless of a legal definition per Oregon law, a dam is taken here to mean: "any artificial barrier, including appurtenant works, that impounds or diverts the flow of water." *(See Glossary)*

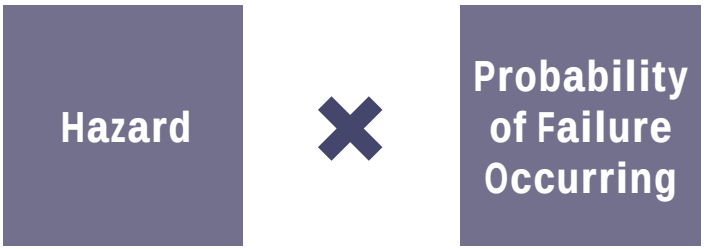
Hazard vs. Risk

When considering hazard in terms of dam classification, it is important to realize that the term "Hazard" is not the same as "Risk". For example, a large dam may be rated a high hazard structure because its location is such that a catastrophic failure and sudden release of water could adversely threaten downstream life and property. However, the same dam also could be at low risk for failure because it is conservatively engineered, receives regular inspections, and is exceptionally well maintained. Thus, its probability for failure is very low. In other words, risk is the product of hazard multiplied by the probability that a failure will occur.



Another example to illustrate this concept would be a smaller sized irrigation reservoir located miles from human habitation. In this situation, the dam is rated a low hazard structure because of its location, but it could be at high risk for failure because it was not properly designed by an engineer, it has never been inspected, and it is poorly maintained.

It is important to realize that a dam's hazard rating does not define the physical condition of the structure. Instead, "Hazard" is the definition that is used to estimate the amount of damage that could occur in the event the dam were to suddenly fail and release the contents of its reservoir. For that reason, any dam that is rated a high hazard structure must be properly designed, regularly inspected, and maintained in the best condition at all times because the consequences of a failure are just too great to ignore. All reasonable methods must be implemented to reduce the *risk of failure* for high hazard dams.



Ratings

Hazard Classifications

Oregon Dam Safety has divided existing dams into three hazard classifications. Each rating is an estimate of the potential consequences to downstream life and property that would result from a catastrophic dam failure.

Low

Low hazard dams are scheduled to be inspected every 4 to 5 years depending on the owner's ability to maintain the dam. A sudden or rapidly developing failure of the dam or a sudden uncontrolled release of stored water from the reservoir would not appear to threaten human life. Downstream property damage would be limited primarily to the stream channel.

Significant

Significant hazard dams are scheduled to be inspected every 2 to 3 years depending on the condition of the dam, and the owner's ability to provide upkeep, the maintenance record, or the outward appearance of the dam. A sudden or rapidly developing failure of the dam or a sudden uncontrolled release of stored water would most likely result in significant property damage, and/or the potential for causing the indirect loss of human life.

High

High hazard dams are scheduled to be inspected on an annual basis, alternating between seasons. A sudden or rapidly developing failure of the dam or a sudden uncontrolled release of stored water would likely result in direct loss of human life. Severe and/or widespread property damage would also be expected to occur.

Permits

Reservoir Permits and the Permitting Process

Under Oregon law, all water belongs to the public. With few exceptions, any person wishing to appropriate and store surface water or ground water must first obtain a permit from the Water Resources Department. The water right, once developed, is considered to be a type of property right and is attached to the land where it was established. Consequently, real property with an attached water right may be several miles from the actual source of water. In Oregon, landowners with water flowing past, through, or below their property do not automatically have a right to use that water.

Reservoir applications and other forms can be found on the web: *www.wrd.state.or.us*

Oregon's water laws are based on the Principal of *Prior Appropriation*. This means the first person to obtain a water right on a stream is the last to be shut off in times of low streamflows. In water-short times, the water right holder with the oldest date of priority can demand the water specified in their water right regardless of the needs of junior users. If there is a surplus beyond the needs of the senior right holder, the water right holder with the next oldest priority date can take as much as necessary to satisfy needs under their right and so on down the line until there is no surplus or until all rights are satisfied. The date of application for a permit to use water usually becomes the priority date of the right. Generally, storage water rights have a junior priority date. For that reason, reservoirs are typically filled during the non-irrigation season from excess winter stream flow.

Oregon's Water Code

four fundamental provisions

1. Beneficial purpose without waste
Surface or ground water may be legally diverted for use only if it is used for a beneficial purpose without waste.

2. Priority
The water right priority date determines who gets water in a time of shortage. The more senior the water right, the longer water is available in a time of shortage.

3. Appurtenancy
Generally, a water right is attached to the land described in the right, as long as the water is used. If the land is sold, the water right goes with the land to the new owner.

4. Must be used
Once established, a water right must be used as provided in the right at least once every five years. With some exceptions established in law, after five consecutive years of non-use, the right is considered forfeited and is subject to cancellation.

Applying for a Permit to Use Water

Oregon law requires a Reservoir Permit from the Water Resources Department to store water in an above-ground reservoir. Additionally, a separate permit is needed to apply the stored water to a beneficial use. In most instances, two applications for permits are usually required for above ground reservoirs, those being:

- A *primary* application for reservoir storage of a given volume of water, including both ground water and stream flow and pumped ground water sources.

- A *secondary* application to appropriate surface water or to use water from a reservoir in excess of the amount that was needed to initially fill the reservoir. A secondary application is required to maintain the level of water in the reservoir and to replenish the amount of stored water lost due to evaporation and/or seepage.

Obtaining a permit is a critical hurdle in obtaining a water right. A reservoir permit is the authorization necessary from the State of Oregon via the Water Resources Department to store water. With few exceptions, any existing or proposed hydraulic structure for storage of water requires a permit, regardless of its height or capacity.

- The Alternate Review Application Process for a Water Right Permit pertains to a pond or reservoir of any storage capacity with a dam height less than 10 feet. If the dam is 10 feet or greater, the maximum amount of water stored under the Alternate Review Process must be less than 9.2 acre feet.

- The Standard Review Application Process is for any reservoir that is both greater than or equal to 9.2 acre feet and with a dam height of 10 feet or greater. With few exceptions, engineered plans and technical specifications must be submitted for review and approval before a Reservoir Permit will be issued for these larger sized structures.

Preparing the Reservoir Application

All entries should be typewritten or neatly printed with dark ink. The appropriate filing fee(s) shall accompany each application at the time of submittal. All items must be completed even though portions of the required information may appear on supplemental maps or drawings. Incomplete applications will be returned to the applicant, and will not be assigned a priority date until they are determined to be complete.

How an Application is Processed

Once a completed application has been received, the Department must provide public notice of the application within 60 days. The purpose of the public notice is to allow the public the opportunity to submit detailed, legally obtained information to the Department for consideration as to whether or not the application would be injurious to existing water rights. The Department also notifies other state agencies including the Oregon Department of Fish and Wildlife (ODFW). ODFW provides comments as appropriate regarding potential impact to existing fishery resources. All comments must be submitted within 60 days of the public notice.

Even if there are no fish living in the stream, the Department is required to notify ODFW of all applications.

Within the prescribed 60-day period, if the Department does not find injury to existing water rights or is notified about detrimental impacts to existing fishery resources, then the Department may issue a Final Order that will

allow issuance of a permit within 180 days of the priority date. Because of the processing timelines set forth in ORS 537.409, the Department suggests applicants make certain to file an application prior to scheduling excavation work or expending a large amount of money.

Nonstatutory (Small) Dams Not Subject to Design Review

Nonstatutory dams, those that are less than 10 feet in height or that impound less than 9.2 acre feet, do not require design approval and construction oversight by the Water Resources Department. Nonetheless, a permit to store water is likely required. The local watermaster can assist in filing an application for a permit to store water for these smaller structures.

It is recommended that earthen embankment dams less than 10 feet in height or less than 9.2 acre feet storage capacity have a crest width no less than 8 feet, an upstream slope no steeper than 3:1, and a downstream slope no steeper than 2:1. An emergency spillway channel should be constructed around the dam, not over the top of the fill, and lined to prevent erosion. The spillway should be able to withstand the 50-year flood flow without overtopping the dam. It should also direct the passing flow downstream to prevent erosion of the embankment.

For best results, all brush, stumps, roots, and organic matter should be cleared from the borrow area and beneath the dam. Only fill materials consisting of non-organic and cohesive soils adjusted in moisture to optimum water content should be used for construction of the dam. Individual layers should not exceed 8 inches in thickness and should be compacted with a sheepsfoot roller or similar equipment. Fill material should be placed in thin layers parallel with the long axis of the dam.

Statutory Sized (Large) Dams

The following list is a summary of the minimum requirements for examination and approval of design plans and technical specifications for construction of dams greater than or equal to 10 feet in height and that impound 9.2 acre feet or more of storage. **A licensed professional engineer must prepare these design documents and submit them for approval prior to construction.**

1. Vicinity Map

- Location of dam and reservoir in relation to township, range, and quarter-quarter section, together with a survey tie (bearing and distance) from a benchmark on the dam to an established government land corner.
- Watershed map that delineates the contributing drainage area into the reservoir.
- Access roads, significant land features, urban areas, or downstream development.
- Borrow areas, quarries, utilities, and property lines within project boundaries.

2. Plan View of Dam and Appurtenances

- Topographic contour map, maximum 2-foot interval.
- Locate by station the primary outlet and auxiliary or emergency spillway; if applicable, include toe drains, filters, log boom, or fish by-pass facilities.
- Area/Capacity Diagram or stage/storage data tabulating hydraulic depth versus corresponding surface area and reservoir storage capacity.
- Locations of field exploration or subsurface investigation including bore holes, test pits, excavations, trenches, monitoring wells, and other invasive methods.

3. Profile Parallel to Centerline Axis of Dam

- Existing ground surface and thickness of stripping or grubbing.
- Grade line for cutoff trench and/or excavation for foundation.
- Bedrock or foundation material contacts.
- Crest elevation of dam; include camber if applicable.
- Locate by station the primary outlet and auxiliary or emergency spillway; if applicable, include toe drains, filters, log boom, or fish by-pass facilities.

4. Sectional View of Dam at Maximum Section

- Upstream and downstream slopes, including erosion control or armoring.
- Dam dimensions and elevations; X (width) and Y (height) coordinates.
- Emergency spillway crest elevation and spillway channel grade line(s).
- Water surface elevations, including normal pool and flood maximum.
- Interior material zones and/or internal filters.
- Invert elevations of outlet conduit, toe drains, and other internal piping.
- Existing ground surface and thickness of stripping or grubbing.
- Cutoff trench and/or excavation for foundation, with dimensions.

5. Emergency Spillway Detail Drawing

- Both a sectional and profile view.
- Elevations and dimensions at all stations where channel configuration or grade lines transition or otherwise change.
- Dimensions and elevations for stilling basin or other flow and energy dissipaters, including both formed-in-place concrete or constructed channel armoring.
- Elevations and dimensions of flow control mechanisms such as flash boards, stop logs, lift or tainter gates, or channel splitters.

6. Outlet Conduit and/or Primary Spillway Detail Drawing

- Cross section showing sizes, dimensions, and type(s) of material, including concrete encasement and/or pipe bedding.
- Draw down curve, flow rating information, or discharge capacity data.
- Longitudinal section (profile) illustrating configuration and position of conduit and all joints, flanges, or other connections.

7. Outlet Works Detail Drawing

- Operating gates or valves, and guard gates or valves; if manufactured, list the name, model number, supplier, etc.
- Base block or anchor, pedestals, operating stem and/or lift mechanism.
- Fish screen, trash rack, or other clog prevention device.

8. Technical Data

- All elevations referenced to established benchmark, such as MSL or NGVD.
- Hydrologic report or calculations verifying adequacy of emergency spillway at 100-year storm (1% flow) or PMF as appropriate.
- Summary report of foundation investigation which may include site geology, ground water hydrology, drill logs, test pits, laboratory test results and geotechnical stability analysis for rapid drawdown, flood loading and/or seismic analysis as appropriate.
- Bid package or a complete set of technical specifications for design, manufacture, placement, and testing of construction materials or material components as appropriate.

9. Operation and Maintenance Manual

(Significant and High Hazard Dams)

- Preventative maintenance schedule, contact information, storage/release schedule.

10. Emergency Action Plan

(High Hazard Dams)

- Dam failure/breach analysis for both sunny day and storm scenario.
- Downstream inundation maps for sunny day and storm failure scenarios.
- Monitoring and/or warning systems, notification charts, and evacuation procedure(s).

Inspection

Process of Inspecting Dams

No person shall construct any dam that is 10 feet or greater in height and stores 9.2 acre feet or more, unless the Department has made an examination of the site and of the plans and specifications and other features involved in the construction of such works, and has approved them in writing. (ORS 540.350; amended 1981)

Periodic inspection of existing hydraulic structures for protection of public safety is part of the Oregon Dam Safety Program. However, Oregon laws do not specify the frequency of inspections. The inspections are made under the supervision of the Dam Safety Coordinator.

Many dam owners do not realize their responsibility and liability toward the downstream public and environment.

If a person residing on or owning land in the neighborhood of any dam after completion, or in the course of construction, applies to the Director desiring inspection of the works, the Director may order an inspection, or he may make such order on his own motion. If the inspection is deemed justified by the Director, he may require that the owner pay all or part of the expenses for the inspection. (ORS 540.390)

If a potential risk is discovered during an inspection or the structure is determined to be unsafe, the owner of the dam is notified and requested to take necessary action to prevent failure of the dam. Owners are expected to maintain their hydraulic structure in a safe and responsible manner and make proper repairs to keep it operational.

Rating Criteria

Very Good Condition

a. No apparent problems; new or newly replaced.
b. Well maintained and supervised.
c. No need for increased maintenance or monitoring activities.

Acceptable Condition

a. Fully functional and trouble-free operation.
b. Increased maintenance or monitoring may be necessary.
c. Letter to owner may be appropriate to advise of maintenance/monitoring.

Unsatisfactory Condition

a. Marginally functional under normal conditions, but could be a potential problem under extreme loading or operating conditions not routinely experienced.
b. Intensive maintenance program necessary to prevent further deterioration.
c. Minor repair, rehabilitation, or restoration may be necessary in addition to increased maintenance or monitoring activities.

Repair or Replace

a. Non-functional, defective, or missing component.
b. Deterioration has progressed beyond ability of maintenance program or owner's willingness to adequately restore to design conditions.
c. Major repair or rehabilitation necessary to restore dam, spillway, or appurtenant works to original design or to standards acceptable to OWRD Dam Safety.

State of Oregon
Water Resources Department
725 Summer Street NE, Suite A
Salem, Oregon 97301-1266
(503) 986-0900

Dam Safety
Inspection Form

Name of Dam or Reservoir: _____ Date: _____
Permit/Certificate: _____ District: _____ NID: _____ File: _____
Height: _____ Storage: _____ Photo Attached: _____ Hazard: ☐ Low ☐ Medium ☐ High EAP: _____
Inspector: _____ Weather: _____ Score: _____

Prior inspection: Next inspection:

Component	Observation and Remarks	Rating
I. Primary Dam	☐ Earthen ☐ Rock Zoned ☐ Concrete ☐ Other	
Upstream slope		
Crest		
Downstream slope		
Right abutment		
Left abutment		
Toe		
Auxiliary dam/dike??	Yes ☐ No ☐ If "Yes", include on separate inspection form.	

II. Reservoir	Pool level/elevation:	Point of reference:	
Floating debris/trash			
Landslides/erosion			
Log boom			

III. Instrumentation	**Flow Rate**	**Water Level**	**Description/Condition**	
Toe drains				
Weirs/flumes				
Monitoring wells				
Other				

Go to *www.wrd.state.or.us* to find WRD forms.

Name of Dam or Reservoir: Date:

IV. Primary Outlet	☐ Manual	☐ Power Assist	☐ Other	
Trickle tube				
Inlet structure				
Outlet structure				
Control works/stem				
Low level conduit	Diameter:			
Valve/sluice gate	Date last fully cycled. Month:		Year:	
Trash rack				
Secondary outlet??	Yes ☐ No ☐ If "Yes", include on separate inspection form.			

V. Emergency Spillway	☐ Earthen/Sod	☐ Rock	☐ Concrete	☐ Other	
Flashboards					
Control gate					
Approach channel					
Discharge channel					
Stilling basin					
Auxiliary spillway??	Yes ☐ No ☐ If "Yes", include on separate inspection form.				

VI. Security		
Fencing, signage		
Vehicle access road		
On Site Dam Tender	Yes ☐ No ☐ Name:	
Emergency Plan	Yes ☐ No ☐ Not required ☐	

Rating Criteria: Observed Structural or Mechanical Condition

5 – Very Good 4 – Acceptable 3 – Unsatisfactory 1 – Repair or Replace

10/2005 DMS

Enforcement

Enforcement Procedures

The Dam Safety Program maintains an inventory of existing hydraulic structures that exceed statutory height and storage criteria. When, during the course of inspection of any of the inventoried dams, a particular structure is discovered to be in violation of safety conditions that would adversely affect or threaten downstream life and property, the Director may act to cause the dam owner to remedy the situation.

Upon discovery of a safety hazard that poses a threat to life or property, the Department may notify the owner in writing of the hazard and action(s) necessary to return to the project and appurtenant works to safe design, mechanical operational, or maintenance standards. Failure by the owner to perform the required action may result in proceedings for one or more of the following scenarios:

1. Notice and opportunity for a contested case hearing. [As provided for in ORS 540.350(5).]
2. Cancellation of the permit for failure to make a satisfactory Claim of Beneficial Use.
3. Posting of the structure to prevent storage or to limit operation until the owner has complied with the requested action.
4. Instituting legal action by the District Attorney or Attorney General to have the facility declared a public nuisance.
5. Issuance of an order to prevent storage or to breach the dam. [As provided for in ORS 540.370.]
6. Any other enforcement action permitted by law.

Check out **ORS 183** and **ORS 540** for more information about dam safety enforcement.

Appendices

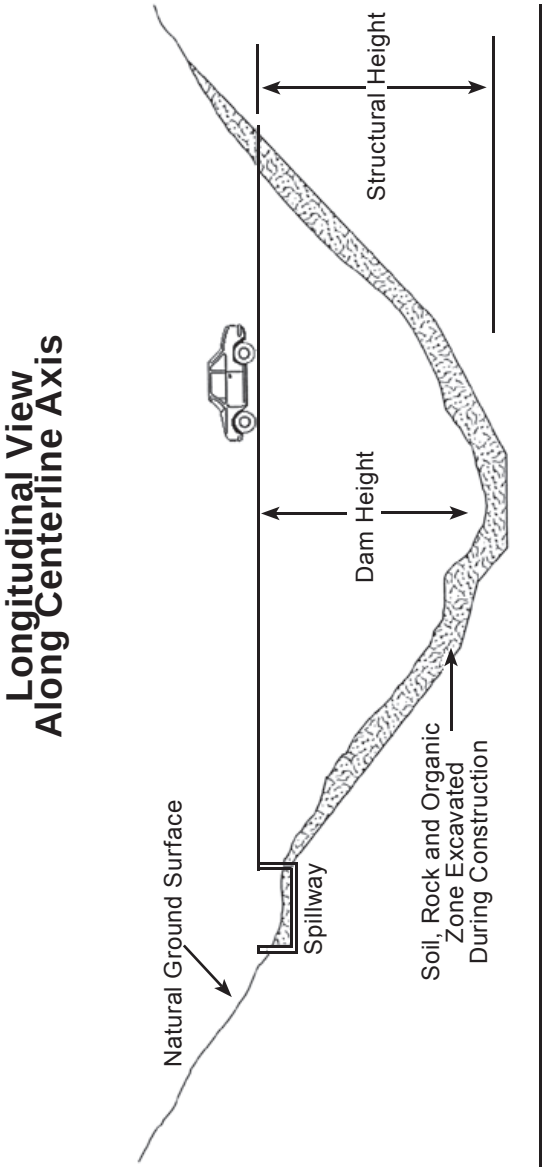
Statutory Authority

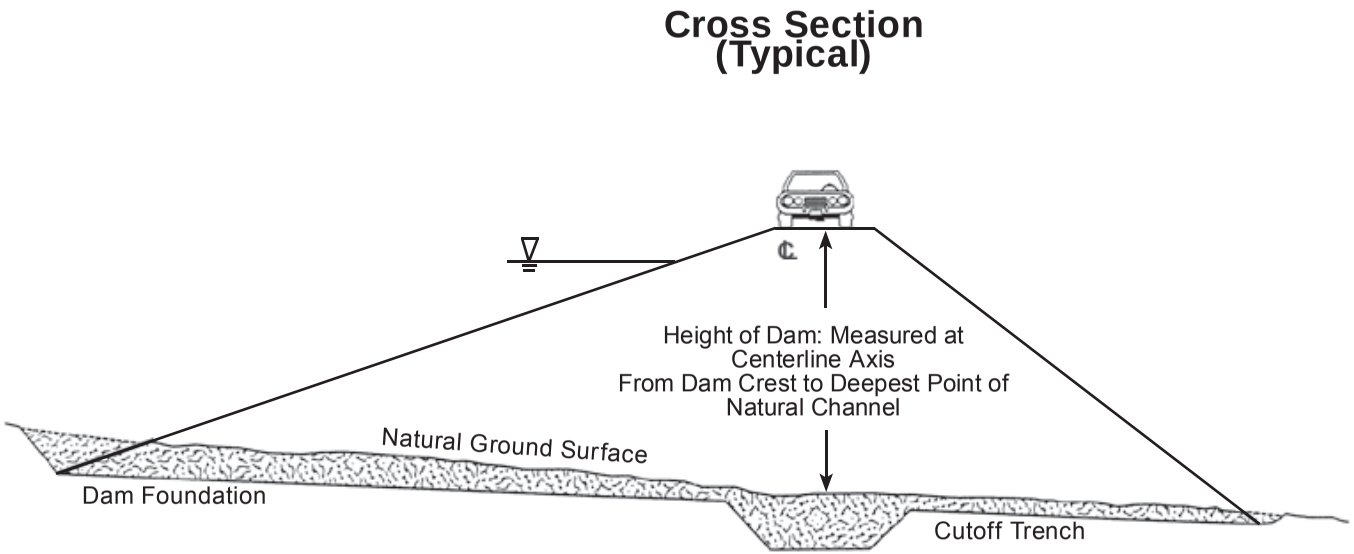
Oregon Revised Statutes pertaining to dams, reservoirs, and dam safety, specifically and generally:

ORS 537.190
ORS 537.211
ORS 537.248
ORS 537.400
ORS 537.409
ORS 537.420
ORS 540.340
ORS 540.350
ORS 540.360
ORS 540.370
ORS 540.380
ORS 540.390
ORS 540.400
ORS 541.050
ORS 541.060
ORS 541.510
ORS 541.515
ORS 541.520
ORS 541.525
ORS 541.530
ORS 541.540
ORS 541.545

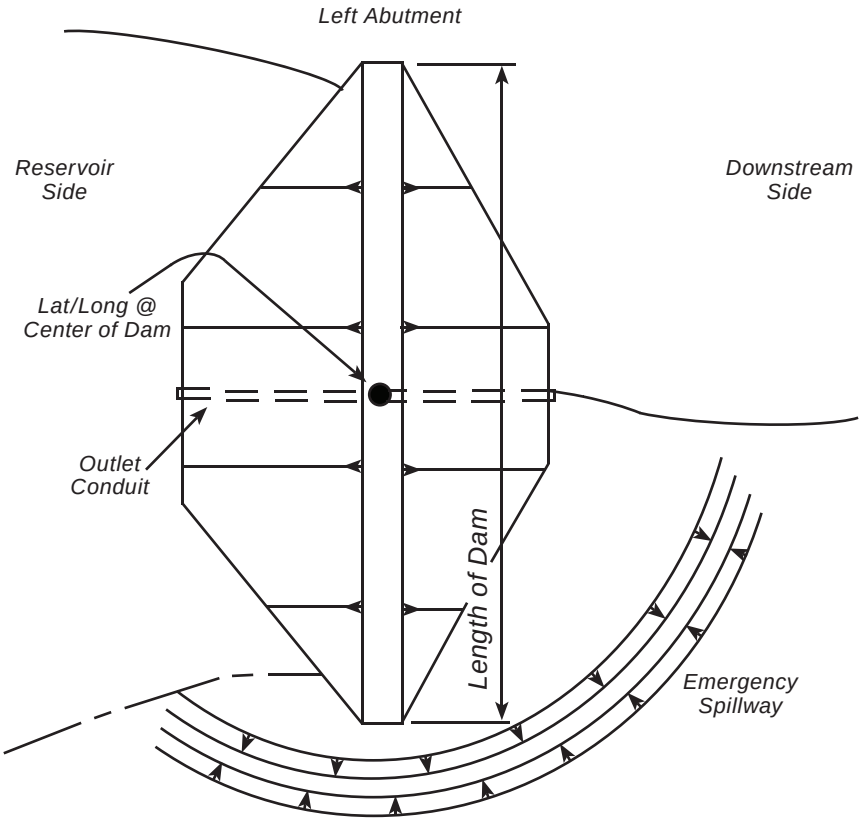
Go to *www.wrd.state.or.us* for more information about Oregon water laws.

Dam Components




Cross Section
(Typical)
Height of Dam: Measured at
Centerline Axis
From Dam Crest to Deepest Point of
Natural Channel
Natural Ground Surface
Dam Foundation
Cutoff Trench

Dam Plans

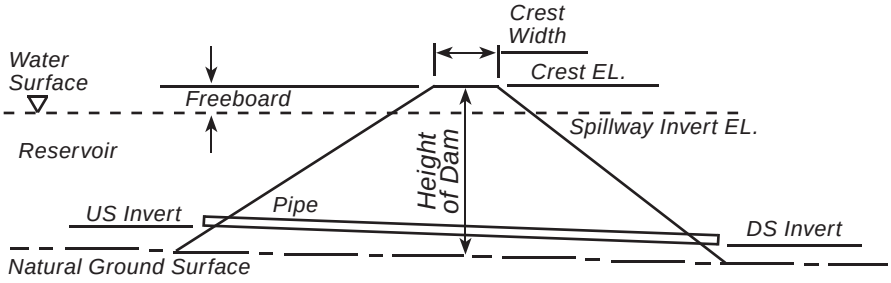


Plan (Typical)

Dam Plans

Measured Dimensions

Length of Dam Between Abutments
Dam Crest Elevation
Dam Crest Width
Emergency Spillway Crest Elevation
Maximum Dam Height
Principle Spillway Inlet Elevation
Principle Spillway Outlet Elevation
Freeboard



Section

Glossary

Abutment: That part of the valley wall against which a dam is constructed. The left and right abutments of dams are defined with the observer viewing the dam looking in the downstream direction, unless otherwise indicated.

Acre foot: The volume or amount of water needed to cover 1 acre (43,560 square feet) 1 foot deep (325,851 gallons).

Breach: An eroded opening through a dam or spillway that drains the reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional opening which allows uncontrollable discharge from the reservoir.

Channel: A general term for any natural or artificial facility for conveying water.

Cohesionless Soil: A soil possessing little or no shear strength when unconfined (sand).

Cohesive Soil: A soil that exhibits considerable shear strength when unconfined (clay).

Collar: A thin collar placed at uniform intervals along an outlet conduit to retard water seepage.

Compaction: Mechanical action to increase the density of a soil by reducing the number or size of internal voids.

Conduit: A closed conveyance pipe used to release water through a dam.

Contested Case: A legal proceeding before an agency.

Core: A zone of low permeability material in an embankment dam. The core is sometimes referred to as central core, rolled clay core, or impervious zone.

Cutoff Trench: A trench excavated beneath the dam foundation and backfilled with impermeable material to retard water seepage under the dam.

Dam: An artificial barrier across a watercourse or valley for creating a reservoir, diverting water from a channel, or creating hydraulic head. "Any artificial barrier, including appurtenant works, that impounds or diverts the flow of water."

Dam Crest: The top surface of the dam.

Glossary

Dam Failure: Catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water.

Dike: An artificial protective barrier or obstacle designed to prevent flooding of adjacent land surrounded by water.

Drain: A pipe or similar feature that collects and directs water to a specified location.

Embankment: An engineered earth fill.

Emergency Action Plan: A formal plan of procedures to alleviate risk during construction of or after completion of a dam, or to reduce the consequences to life and property that would result from a dam failure. Also, a plan of action to be taken to reduce the potential for property damage and loss of life in an area affected by a dam failure or large flood.

Filter: A material or zone of materials designed to provide drainage without causing movement or erosion of the individual particles comprising the filter.

Final Order: Final agency action expressed in writing.

Flashboard (Stoplogs): Planed timber or steel beams that are physically placed on top of each other in a channel or an outlet so as to adjust the flow of water. Flashboards often are an alternative to gates or valves in low-head situations.

Flood: A temporary rise in water levels resulting in inundation of areas not normally covered by water. May be expressed in terms of probability of exceedance per year, such as 1 percent chance flood, or expressed as a fraction of the probable maximum flood or other referenced flood of record.

Flood Frequency: Refers to the probability (expressed in percentage) that a flood will occur in a given year, example 20%, 10% ,or 1%.

Flood, Probable Maximum (PMF): The largest flood that is estimated for a selected location on a stream resulting from the probable maximum precipitation storm (PMP) in combination with extreme runoff conditions.

Flood Surcharge: The storage volume between the top of the active reservoir storage and the design maximum water level.

Foundation: The ground surface upon which a dam is constructed.

Freeboard: The vertical distance between the design high-water level in the reservoir and the dam crest.

Gate: A movable, watertight barrier for the control of water flowing through a pipe or channel. (See Valves)

Groin: The area along the contact (or intersection) of the face of a dam with the abutments.

Hazard Classification: The rating for a dam based on the potential consequences of failure. The rating considers the aggregate damage to downstream life and property that failure of the dam could cause.

Height: The maximum vertical distance from natural ground surface to the top of a dam.

Hydrograph: A graph showing, for a given point on a stream or conduit, the discharge, stage, velocity, available power, or other properties of water with respect to time.

Hydrologic Connection: Condition where water can move between a surface water source and an adjacent sub-surface aquifer.

Impervious: Not allowing liquid to pass through; waterproof.

Instream Flow: Minimum quantity of water necessary to support the public use requested by an agency.

Inundation Map: A map delineating the area that would be flooded by a particular flood event. It includes the ground surfaces downstream of a dam showing the estimated encroachment by water released because of failure of a dam or from abnormal flows released through a dam's spillway.

Invert: Elevation at the bottom of a pipe, conduit, or culvert.

Levee: An artificial protective barrier built adjacent to a waterway to prevent flooding of bordering land.

Maximum Water Surface: The highest acceptable water surface elevation with all factors affecting the safety of the structure considered. It is the highest water surface elevation resulting from a computed routing of the inflow design flood through the reservoir under established operating criteria. This surface is also the top of a surcharge capacity.

Glossary

Minimum Streamflow: A rate of flow established by administrative rule necessary to support aquatic life or minimize pollution.

Normal Water Surface: The highest elevation at which water is normally stored, or the design surface elevation which the reservoir is expected to be operated.

Order: Agency action expressed orally or in writing directed to a named person or persons; includes any agency decision issued in connection with a contested case hearing.

Outlet Works: A device to provide controlled releases from a reservoir.

Piping: A characteristic type of erosion of embankment or foundation material (soil) due to leakage. The action of water passing through a soil mass resulting in removal of particles leading to the development of channels or "pipes".

Precipitation, Probable Max (PMP): The greatest amount of precipitation possible resulting from a specified size storm occurring during a distinct period of time at a particular geographic location.

Reservoir: A body of water impounded by a dam or other artificial construction in which water can be stored.

Reservoir Surface Area: Ground surface area covered by water when a reservoir is filled to a specified level.

Risk: The relationship between the consequences resulting from an adverse event and its probability of occurrence.

Seepage: The slow movement or percolation of water through a permeable medium; specifically, flow through small cracks, voids, or interstices in a dam, abutment, or foundation.

Soil: Sediments or other unconsolidated and non-cemented aggregations of particles produced by the chemical/mechanical disintegration of rocks.

Spillway: A structure over or through which flow is discharged from a reservoir. If the rate of flow is controlled by mechanical means such as gates, it is considered a controlled spillway. If the geometry of the spillway is the only control, then it is defined as an uncontrolled spillway.

Spillway, Auxiliary: Any secondary spillway that is designed to be operated very infrequently or only in anticipation of extreme climactic events.

Spillway, Emergency: A spillway that is designed to provide additional protection against overtopping of dams and is intended for use under extreme conditions such as misoperation or malfunction of the service spillway or other emergency conditions.

Spillway, Primary: A spillway that is designed to provide continuous or frequent regulated or unregulated releases from a reservoir without significant damage to either the dam or its appurtenant structures.

Storage: The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of flood wave through a natural stream channel.

Storage, Active (Normal): The volume of the reservoir that is readily available for beneficial use such as power generation, irrigation, flood control, water supply, fish culture, and others.

Storage, Dead: The volume of water that lies below the invert of the lowest outlet and that cannot readily be withdrawn from the reservoir.

Toe of Dam: Those portions of a dam slope that intersect natural ground surface, either upstream or downstream.

Top of Dam (Crest): The elevation of the uppermost surface of a dam, usually a road or walkway excluding any parapet wall, railing, etc.

Valves: Valves, as distinguished from gates, are constructed so that the closing member remains in the water passageway for all operating positions.

Void: Open spaces inside soil, rock or concrete that may be filled with air or water or some other gas or liquid.

Watermaster: Field representative (1 of 20 statewide) authorized by statute to regulate established water rights according to Oregon's water laws, based on the principle of prior appropriation.



State of Oregon
Water Resources Department
725 Summer Street NE, Suite A
Salem, Oregon 97301
(503) 986-0900
www.wrd.state.or.us

E.37. Pennsylvania



CHAPTER 105. DAM SAFETY AND WATERWAY MANAGEMENT

Subchap.		Sec.
A.	GENERAL PROVISIONS	105.1
B.	DAMS AND RESERVOIRS	105.71
C.	CULVERTS AND BRIDGES	105.141
D.	STREAM ENCLOSURES	105.181
E.	CHANNEL CHANGES AND DREDGING FOR FACILITY CONSTRUCTION AND MAINTENANCE	105.221
F.	FILLS, LEVEES, FLOODWALLS AND STREAMBANK RETAINING DEVICES	105.251
G.	STREAM CROSSINGS, OUTFALLS AND HEADWALLS	105.291
H.	DOCKS, WHARVES AND BULKHEADS	105.321
I.	COMMERCIAL DREDGING	105.361
J.	DISCHARGES OF DREDGED OR FILL MATERIAL	105.391
K.	DISBURSEMENTS OF MONEYS FROM THE DAMS AND ENCROACHMENTS FUND	105.431
L.	GENERAL PERMITS	105.441
M.	STATEMENTS OF POLICY	105.451

Authority

The provisions of this Chapter 105 issued under section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); sections 5 and 402 of The Clean Streams Law (35 P. S. §§ 691.5 and 691.402); sections 302 and 402 of the Flood Plain Management Act (32 P. S. §§ 679.302 and 679.402); and sections 5, 7, 10, 11 and 17 of the Dam Safety and Encroachments Act (32 P. S. §§ 693.5, 693.7, 693.10, 693.11 and 693.17), unless otherwise noted.

Source

The provisions of this Chapter 105 rescinded and readopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843, unless otherwise noted. Immediately preceding text appears at serial pages (38843), (47970) to (47983), (38854) to (38859), (47990) to (47994), (38864), (38865), (47996) to (47998), (38868) to (38891) and (49597) to (49598).

Notes of Decisions

The Department regulations providing for exception to maximum peak particle velocity and noise requirements during surface mining blasting operations in close proximity to certain structures were unreasonable since they made a distinction between ownership of the structure at the location of the blasting. *Department of Environmental Resources v. Croner, Inc.*, 618 A.2d 1135 (Pa. Cmwlth. 1992).

Cross References

This chapter cited in 25 Pa. Code § 71.21 (relating to content of official plans); 25 Pa. Code § 77.459 (relating to stream diversions, water obstructions and encroachments); 25 Pa. Code § 77.523 (relating to water obstructions and encroachments); 25 Pa. Code § 77.527 (relating to sedimentation controls); 25 Pa. Code § 77.531 (relating to dams, ponds, embankments and impoundments—design, construction and maintenance); 25 Pa. Code § 77.631 (relating to general requirements); 25 Pa. Code § 86.6 (relating to extraction of coal incidental to government-financed construction or government-financed reclamation projects); 25 Pa. Code § 87.71 (relating to stream diversions, water obstructions and encroachments); 25 Pa. Code § 87.73 (relating to dams, ponds, embankments and impoundments); 25 Pa. Code § 87.104 (relating to stream channel diversions); 25 Pa. Code § 87.108 (relating to hydrologic balance: sedimentation ponds); 25Pa. Code § 87.112 (relating to hydrologic balance: dams, ponds, embankments and impoundments—design, construction and maintenance); 25 Pa. Code § 87.160 (relating to haul roads and access roads); 25 Pa. Code § 88.51 (relating to stream diversions, obstructions and encroachments); 25 Pa. Code § 88.53 (relating to

dams, ponds, embankments and impoundments); 25 Pa. Code § 88.94 (relating to hydrologic balance: stream diversions); 25 Pa. Code § 88.102 (relating to hydrologic balance: dams, ponds, embankments and impoundments—design, construction and maintenance); 25 Pa. Code § 88.103 (relating to hydrologic balance: coal processing waste dams and embankments); 25 Pa. Code § 88.138 (relating to haul roads and access roads: general); 25 Pa. Code § 88.189 (relating to hydrologic balance: stream diversions); 25 Pa. Code § 88.197 (relating to hydrologic balance: ponds, embankments and impoundments—design, construction and maintenance); 25 Pa. Code § 88.198 (relating to hydrologic balance: coal processing waste dams and embankments); 25 Pa. Code § 88.231 (relating to haul roads and access roads: general); 25 Pa. Code § 88.294 (relating to hydrologic balance: stream diversions); 25 Pa. Code § 88.298 (relating to hydrologic balance: sedimentation ponds); 25 Pa. Code § 88.302 (relating to hydrologic balance: dams, ponds, embankments and impoundments—design, construction and maintenance); 25 Pa. Code § 88.303 (relating to hydrologic balance: coal processing waste dams and embankments); 25 Pa. Code § 88.335 (relating to haul roads and access roads: general); 25 Pa. Code § 89.26 (relating to roads); 25 Pa. Code § 89.56 (relating to stream channel diversions); 25 Pa. Code § 89.111 (relating to large impoundments); 25 Pa. Code § 90.36 (relating to stream diversions, water obstructions and encroachments); 25 Pa. Code § 90.105 (relating to stream channel diversions); 25 Pa. Code § 90.108 (relating to hydrologic balance: sedimentation ponds); 25 Pa. Code § 90.112 (relating to hydrologic balance: dams, ponds, embankments and impoundments—design, construction and maintenance); 25 Pa. Code § 90.122 (relating to coal refuse disposal); 25 Pa. Code § 90.134 (relating to haul roads and access roads: general); 25 Pa. Code § 90.202 (relating to general requirements); 25 Pa. Code § 90.205 (relating to alternatives analysis); 25 Pa. Code § 92.17 (relating to other chapters applicable); 25 Pa. Code § 96.3 (relating to water quality protection requirements); 25 Pa. Code § 102.14 (relating to riparian buffer requirements); 25 Pa. Code Chapter 105 Appendix J (relating to abandoned mine reclamation; general permit BDWW-GP-10); 25 Pa. Code § 236.128 (relating to natural resources); 25 Pa. Code § 236.147 (relating to surface geology and hydrology); 25 Pa. Code § 245.234 (relating to siting requirements); 25 Pa. Code § 250.1 (relating to definitions); 25 Pa. Code § 250.309 (relating to MSCs for surface water); 25 Pa. Code § 250.406 (relating to relationship to surface water quality requirements); 25 Pa. Code § 271.915 (relating to management practices); 25 Pa. Code § 273.202 (relating to areas where municipal waste landfills are prohibited); 25 Pa. Code § 273.213 (relating to access roads); 25 Pa. Code § 273.243 (relating to sedimentation ponds); 25 Pa. Code § 273.244 (relating to discharge structures); 25 Pa. Code § 277.202 (relating to areas where construction/demolition waste landfills are prohibited); 25 Pa. Code § 277.213 (relating to access roads); 25 Pa. Code § 277.242 (relating to soil erosion and sedimentation control); 25 Pa. Code § 277.243 (relating to sedimentation ponds); 25 Pa. Code § 277.244 (relating to discharge structures); 25 Pa. Code § 279.202 (relating to areas where transfer facilities are prohibited); 25 Pa. Code § 279.213 (relating to access roads); 25 Pa. Code § 279.232 (relating to soil erosion and sedimentation control); 25 Pa. Code § 281.202 (relating to areas where general composting facilities are prohibited); 25 Pa. Code § 281.212 (relating to access roads); 25 Pa. Code § 281.252 (relating to soil erosion and sedimentation control); 25 Pa. Code § 281.253 (relating to sedimentation ponds); 25 Pa. Code § 283.213 (relating to access roads); 25 Pa. Code § 283.232 (relating to soil erosion and sedimentation control); 25 Pa. Code § 285.123 (relating to impoundments—general); 25 Pa. Code § 288.213 (relating to access roads); 25 Pa. Code § 288.243 (relating to sedimentation ponds); 25 Pa. Code § 288.244 (relating to discharge structures); 25 Pa. Code § 288.422 (relating to areas where Class I residual waste landfills are prohibited); 25 Pa. Code § 288.522 (relating to areas where Class II residual waste landfills are prohibited); 25 Pa. Code § 288.622 (relating to areas where Class III residual waste landfills are prohibited); 25 Pa. Code § 289.223 (relating to access roads); 25 Pa. Code § 289.253 (relating to sedimentation ponds); 25 Pa. Code § 289.254 (relating to discharge structures); 25 Pa. Code § 289.422 (relating to areas where Class I residual waste disposal impoundments are prohibited); 25 Pa. Code § 289.522 (relating to areas where Class II residual waste disposal impoundments are prohibited); 25 Pa. Code § 293.202 (relating to areas where transfer facilities areprohibited); 25 Pa. Code § 293.213 (relating to access roads); 25 Pa. Code § 293.232 (relating to soil erosion and sedimentation control); 25 Pa. Code § 295.202 (relating to areas where composting facilities are prohibited); 25 Pa. Code § 295.212 (relating to access roads); 25 Pa. Code § 295.252 (relating to soil erosion and sedimentation control); 25 Pa. Code § 295.253 (relating to sedimentation

Copyright © 2010 Commonwealth of Pennsylvania

ponds); 25 Pa. Code § 297.202 (relating to areas where incinerators and other processing facilities are prohibited);
25 Pa. Code § 297.213 (relating to access roads); 25 Pa. Code § 297.232 (relating to soil erosion and sedimentation control); 25 Pa. Code § 299.141 (relating to scope); 25 Pa. Code § 299.142 (relating to general requirements); 58 Pa. Code § 51.61 (relating to permits required for disturbance of waterways or watersheds); and 67 Pa. Code § 459.10a (relating to bridge occupancy).

Subchapter A. GENERAL PROVISIONS

GENERAL

Sec.
105.1. Definitions.
105.2. Purposes.
105.3. Scope.
105.4. Delegations to local agencies.

PERMIT APPLICATIONS

105.11. Permit requirements.
105.12. Waiver of permit requirements.
105.13. Permit applications—information and fees.
105.14. Review of applications.
105.15. Environmental assessment.
105.16. Environmental social and economic balancing.
105.17. Wetlands.
105.18. [Reserved].
105.18a. Permitting of structures and activities in wetlands.
105.19. Complete applications.
105.20. Proof of financial responsibility.
105.20a. Wetland replacement criteria.

PERMIT ISSUANCE, TRANSFER AND REVOCATION

105.21. Criteria for permit issuance and denial.
105.21a. Public notice.
105.22. [Reserved].
105.23. Compliance with other applicable statutes.
105.24. Coordination of permits.
105.25. Transfer of permits.
105.26. Revocation and suspension of permits.
105.27. [Reserved].
105.28. [Reserved].
105.29. [Reserved].
105.29a. Burden of proof.
105.30. [Reserved].

SUBMERGED LANDS OF THE COMMONWEALTH—LICENSES AND ANNUAL CHARGES

105.31. Property rights.
105.32. Projects—proper purpose.
105.33. Licenses for public service corporations.
105.34. Navigation and public trust.
105.35. Charges for use and occupation of submerged lands of this Commonwealth.
105.36. [Reserved].
105.37. [Reserved].
105.38. [Reserved].
105.39. [Reserved].
105.40. [Reserved].

CONSTRUCTION REQUIREMENTS AND PROCEDURES

105.41. Notices and reports.
105.42. Acknowledgement of conditions.
105.43. Time limits.
105.44. Implementation of work according to specifications.
105.45. Inspections.
105.46. Implementation of erosion and sedimentation control plans.
105.46a. Collection and disposal of waste materials.
105.47. Removal of structures.

OPERATION, MAINTENANCE AND INSPECTION

105.51. Operation and maintenance.
105.52. Inspection.
105.53. Inspections by owners and inspection reports.
105.54. Monitoring systems.

INVESTIGATION AND CORRECTION OF UNSAFE CONDITIONS—EMERGENCY PROCEDURES

105.61. Procedures for investigations.
105.62. Correction of unsafe conditions.
105.63. Emergency procedures.
105.64. Emergency permit.

GENERAL

§ 105.1. Definitions.

The following words and terms, when used in this chapter, have the following meanings, unless the context clearly indicates otherwise:

Act—The Dam Safety and Encroachments Act (32 P. S. §§ 693.1—693.27).

Along—Touching or contiguous; to be in contact with; to abut upon.

Copyright © 2010 Commonwealth of Pennsylvania

Appurtenant works—Structures or materials incident to or annexed to dams or water obstructions which are built or maintained in connection with the dams or water obstructions and are essential to their proper functioning. For dams, the term includes, but is not limited to:

(i) Structures such as spillways, either in the dam or separate therefrom.

(ii) Low level outlet works.

(iii) Conduits such as tunnels, pipelines or penstocks through the dam or its abutments.

Archaeological site—A known site of archaeological significance based on the Comprehensive State Plan for Conservation of Archaeological Resources. The Comprehensive State Plan is available from the Historic and Museum Commission, Bureau of Historic Preservation, Box 1026, Harrisburg, Pennsylvania 17108.

Body of water—A natural or artificial lake, pond, reservoir, swamp, marsh or wetland.

Bridge—A structure and its appurtenant works erected over the regulated waters of this Commonwealth.

Commercially navigable waters of the Delaware River and its navigable tributaries—Portions of the Delaware River from the Delaware border in the south to the railroad bridge at Morrisville in the north; the Schuylkill River below Fairmount Dam; Chester Creek below Ninth Street; Crum Creek below the Route 291 (Industrial Highway) Bridge; Darby Creek below 84th Street; Neshaminy Creek below the Route 13 Bridge; Pennypack Creek below the Frankford Avenue Bridge; and Ridley Creek below the Baltimore and Ohio Railroad Bridge in Chester.

Construct—To erect, build, place or deposit including preliminary preparation of a site for construction.

Course—The path taken by a stream, floodway or body of water.

Cross section—The area from the top of the bank to the top of the opposite bank of a stream or body of water as cut by a vertical plane passed at a right angle to the course of the stream.

Culvert—A structure with appurtenant works which carries a stream under or through an embankment or fill.

Current—The rate or velocity of flow of water in a stream, floodway or body of water.

Dam—An artificial barrier, together with its appurtenant works, constructed for the purpose of impounding or storing water or another fluid or semifluid, or a refuse bank, fill or structure for highway, railroad or other purposes which does or may impound water or another fluid or semifluid.

Design flood—A specified discharge for which the hydraulic capacity of a structure is designed.

Discharge of dredged material—An addition, deposit, disposal or discharge of dredged material into the regulated waters of this Commonwealth including, but not limited to, the addition of dredged material to a specific disposal site located in the regulated waters of this Commonwealth and the runoff or overflow of dredged material from a contained land or water disposal area. The term does not include plowing, cultivating, seeding and harvesting for the production of food, fiber and forest products.

Discharge of fill material—

(i) An addition, deposit, disposal or discharge of fill into the regulated waters of this Commonwealth, including, but not limited to, the following types of construction:

(A) Fill that is necessary for the construction of a structure in a regulated water of this Commonwealth.

(B) A structure or impoundment requiring rock, sand, soil or other material for its construction.

(C) Site-development fills for recreational, industrial, commercial, residential and other uses.

(D) Causeways or roadfills.

(E) Dams and dikes.

(F) Artificial islands.

(G) Property protection or reclamation devices, such as riprap, groins, seawalls, breakwaters and revetments.

(H) Levees.

(I) Fill for structures such as sewage treatment facilities.

(J) Intake and outfall pipes associated with power plants and subaqueous utility lines.

(K) Artificial reefs.

(ii) The term does not include plowing, cultivating, seeding and harvesting for the production of food, fiber and forest products.

Dredge—To remove sand, gravel, mud or other materials from the beds of regulated waters of this Commonwealth.

Dredged material—A material that is excavated or dredged from the regulated waters of this Commonwealth.

Encroachment—A structure or activity which changes, expands or diminishes the course, current or cross section of a watercourse, floodway or body of water.

FEMA—The Federal Emergency Management Agency.

Fill—Sand, gravel, earth or other material placed or deposited to form an embankment or raise the elevation of the land surface. The term includes material used to replace an area with aquatic life with dry land or to change the bottom elevation of a regulated water of this Commonwealth.

Copyright © 1996 Commonwealth of Pennsylvania

Flood—A general but temporary condition of partial or complete inundation of normally dry land areas from the overflow of streams, rivers or other waters of this Commonwealth.

Floodplain—The lands adjoining a river or stream that have been or may be expected to be inundated by flood waters in a 100-year frequency flood.

Floodway—The channel of the watercourse and portions of the adjoining floodplains which are reasonably required to carry and discharge the 100-year frequency flood. Unless otherwise specified, the boundary of the floodway is as indicated on maps and flood insurance studies provided by FEMA. In an area where no FEMA maps or studies have defined the boundary of the 100-year frequency floodway, it is assumed, absent evidence to the contrary, that the floodway extends from the stream to 50 feet from the top of the bank of the stream.

Freeboard—The vertical distance between the water surface elevation experienced during the design flood and the crest elevation of a dam levee, floodwall or other embankment.

Height of dam—The vertical measurement expressed in feet as measured from the downstream toe of the dam at its lowest point to the elevation of the top of the dam.

High hazard dam—A dam so located as to endanger populated areas downstream by its failure.

Inundation area—The land area subject to flood waters as the result of failure of a dam.

Levee—An earth embankment or ridge constructed along a water course or body of water to confine water within prescribed limits; the term is also known as a dike.

Limited Power and Water Supply Act—The act of June 14, 1923 (P. L. 700, No. 293) (32 P. S. §§ 621—625); and the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. §§ 591—600).

Maintenance dredging—Dredging conducted as part of construction of a dam, water obstruction or encroachment, and periodic dredging conducted to accomplish one or more of the following purposes:

(i) Maintain adequate depths for navigation.

(ii) Assure proper passage of ice and flood flows.

(iii) Preserve the safety, stability and proper operation of the dam, water obstruction or encroachment.

Mitigation—

(i) An action undertaken to accomplish one or more of the following:

(A) Avoid and minimize impacts by limiting the degree or magnitude of the action and its implementation.

(B) Rectify the impact by repairing, rehabilitating or restoring the impacted environment.

(C) Reduce or eliminate the impact over time by preservation and maintenance operations during the life of the action.

(ii) If the impact cannot be eliminated by following clauses (A)—(C), compensate for the impact by replacing the environment impacted by the project or by providing substitute resources or environments.

Normal pool elevation—

(i) For bodies of water which have no structural measures to regulate height of water, the height of water at ordinary stages of low water unaffected by drought.

(ii) For structurally regulated bodies of water, the elevation of the spillway, outlet control or dam crest which maintains the body of water at a specified height.

(iii) This term does not apply to wetlands.

100-year frequency flood—The flood magnitude expected to be equaled or exceeded on the average of once in 100 years; it may also be expressed as the flood having a 1.0% chance of being equaled or exceeded in a given year.

Operation—Elements of the use, control and functioning of a dam, water obstruction or encroachment during the lifetime of the dam, water obstruction or encroachment, including its removal, which may affect primarily the storage, release or flow of water; the structural safety of a dam, water obstruction or encroachment; or navigation, with due consideration of the other purposes of the act.

Ordinary low water mark—The water surface elevation at ordinary stages of low water, unaffected by drought and unchanged by artificial means.

Owner—A person who owns, controls, operates, maintains or manages a dam or reservoir, water obstruction or encroachment.

PMF—Probable maximum flood—The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in an area. The PMF is derived from the probable maximum precipitation (PMP) as determined on the basis of data obtained from the National Oceanographic and Atmospheric Administration (NOAA).

Parcel—A portion of land formally set forth and described in a conveyance.

Person—A natural person, partnership, association, corporation, public utility, municipality, municipal authority, political subdivision of the Commonwealth, receiver or trustee and a department, board, commission or authority of the Commonwealth.

Political subdivision—A county, city, borough, incorporated town, township, school district, authority or other governmental unit or a combination thereof acting jointly.

Public service corporation or *public utility*—A corporation, association or other corporate body having the powers and privileges of corporations not possessed by individuals or partnerships which entity renders a public utility service. The term does not include a municipality or municipal authority.

Copyright © 1996 Commonwealth of Pennsylvania

Public service line—The term includes, but is not limited to, electric transmission lines, gas pipelines, telephone lines, water lines, railroad trackage and other facilities owned or operated by public service corporations.

Public utility service—The rendering of one or more of the following services for the public:

(i) Gas, electricity or steam production, generation, transmission or distribution.

(ii) Water diversion, pumping, impoundment or distribution.

(iii) Railroad transportation of passengers or property.

(iv) Operation of a canal, turnpike, tunnel, bridge, wharf or similar structure.

(v) Transportation of natural or artificial gas, crude oil, gasoline or petroleum products, materials for refrigeration or other fluid substances by pipeline or conduit.

(vi) Telephone or telegraph communications.

(vii) Sewage collection, treatment or disposal.

Regulated waters of this Commonwealth—Watercourses, streams or bodies of water and their floodways wholly or partly within or forming part of the boundary of this Commonwealth.

Replacement—The construction of a new wetland or restoration of a previously destroyed wetland, or both.

Reservoir—A natural or artificial basin, which contains or will contain the water or other fluid or semifluid impounded by a dam.

Safety—Security from the risk or threat of significant loss or injury to life, health, property and the environment.

Small projects—Water obstructions or encroachments located in a stream or floodplain which will have an insignificant impact on safety and protection of life, health, property and the environment.

Spillway—A device which safely conveys the design flood of a dam without endangering its safety or integrity.

Storage capacity—The volume as expressed in acre-feet of the impounded water to the maximum storage level, that is, the top of the dam.

Stormwater management facilities—anmade measures designed and constructed to convey stormwater runoff away from structures or improved land uses, or to control, detain or manage stormwater runoff to avoid or reduce downstream damages. The term includes, but is not limited to, transportation and related facility drainage systems and manmade stormwater detention basins. The term does not include replacement wetlands or major dams and reservoirs constructed for water supply, recreation, river basin flood control or other regional or basin-wide purposes.

Stream—A watercourse.

Stream crossings—A pipeline, aerial cable or similar structure which is placed in, along, under, across or over the regulated waters of this Commonwealth.

Stream enclosure—A bridge, culvert or other structure in excess of 100 feet in length upstream to downstream which encloses a regulated water of this Commonwealth.

Submerged lands of this Commonwealth—Waters and permanently or periodically inundated lands owned by the Commonwealth, including lands in the beds of navigable lakes and rivers and beds of streams declared public highways which are owned and held in trust by the Commonwealth.

U.S.G.S.—United States Geological Survey.

Watercourse—A channel or conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

Water obstruction—

(i) A dike, bridge, culvert, wall, wingwall, fill, pier, wharf, embankment, abutment or other structure located in, along or across or projecting into a watercourse, floodway or body of water.

(ii) In the case of ponds, lakes and reservoirs, a water obstruction is considered to be in or along the body of water if, at normal pool elevation, the water obstruction is either in the water or adjacent to and abutting the water's edge.

Water Obstructions Act—The act of June 25, 1913 (P. L. 555, No. 355) (32 P. S. §§ 681—691), repealed by section 27 of the act of October 23, 1979 (P. L. 204, No. 70) (32 P. S. § 693.27).

Wetland functions—Include, but are not limited to, the following:

(i) Serving natural biological functions, including food chain production; general habitat; and nesting, spawning, rearing and resting sites for aquatic or land species.

(ii) Providing areas for study of the environment or as sanctuaries or refuges.

(iii) Maintaining natural drainage characteristics, sedimentation patterns, salinity distribution, flushing characteristics, natural water filtration processes, current patterns or other environmental characteristics.

(iv) Shielding other areas from wave action, erosion or storm damage.

(v) Serving as a storage area for storm and flood waters.

(vi) Providing a groundwater discharge area that maintains minimum baseflows.

(vii) Serving as a prime natural recharge area where surface water and groundwater are directly interconnected.

(viii) Preventing pollution.

(ix) Providing recreation.

Wetlands—Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal

Copyright © 1996 Commonwealth of Pennsylvania

circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas.

Wild trout streams—A stream classified as supporting naturally reproducing trout populations by the Fish Commission. For a list of wild trout streams, the Fish Commission can be contacted at: Fish Commission, Bureau of Fisheries, Division of Fisheries Management, 450 Robinson Lane, Bellefonte, Pennsylvania 16823-9616.

Authority

The provisions of this § 105.1 amended under the Dam and Safety Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.1 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended October 6, 1978, effective October 7, 1978, 8 Pa.B. 2723; amended November 2, 1979, effective November 3, 1979, 9 Pa.B. 3640; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended February 18, 1983, effective February 19, 1983, 13 Pa.B. 781; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (139040), (117637) to (117640) and (141411).

Cross References

This section cited in 25 Pa. Code § 96.3 (relating to water quality protection requirements); 25 Pa. Code § 105.13 (relating to permit applications—information and fees); 25 Pa. Code § 105.14 (relating to review of applications); 25 Pa. Code § 105.20a (relating to wetland replacement criteria); 25 Pa. Code § 105.53 (relating to inspections by owners and inspection reports); and 25 Pa. Code § 105.452 (relating to status of prior converted cropland—statement of policy).

§ 105.2. Purposes.

The purposes of this chapter are to:

(1) Provide for the comprehensive regulation and supervision of dams, reservoirs, water obstructions and encroachments in the Commonwealth in order to protect the health, safety, welfare and property of the people.

(2) Assure proper planning, design, construction, maintenance, monitoring and supervision of dams and reservoirs, including preventive measures necessary to provide an adequate margin of safety.

(3) Assure proper planning, design, construction, maintenance and monitoring of water obstructions and encroachments, in order to prevent unreasonable interference with water flow and to protect navigation.

(4) Protect the natural resources, environmental rights and values secured by PA. CONST. art. I, § 27 and conserve and protect the water quality, natural regime and carrying capacity of watercourses.

Source

The provisions of this § 105.2 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 27, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (47975).

§ 105.3. Scope.

(a) The following structures or activities are regulated under the act and section 302 of the Flood Plain Management Act (32 P. S. § 679.302):

(1) Dams on a natural or artificial watercourse, other than those licensed under the Federal Power Act (16 U.S.C.A. §§ 791a—825s), where one or more of the following occur:

(i) The contributory drainage area exceeds 100 acres.

(ii) The greatest depth of water measured by upstream toe of the dam at maximum storage elevation exceeds 15 feet.

(iii) The impounding capacity at maximum storage elevation exceeds 50 acre-feet.

(2) Dams used for the storage of water not located on a watercourse and which have no contributory drainage where the greatest depth of water measured at upstream toe of the dam at maximum storage elevation exceeds 15 feet and the impounding capacity at maximum storage elevation exceeds 50 acre-feet.

(3) Dams used for the storage of fluids or semifluids other than water, the escape of which may result in air, water or land pollution or in danger to persons or property.

(4) Water obstructions and encroachments other than dams located in, along or across, or projecting into a watercourse, floodway or body of water, whether temporary or permanent.

(5) Flood control projects constructed, owned or maintained by a governmental unit.

(b) For the purposes of this chapter, the Department's jurisdiction in and along Lake Erie will be defined by the high water elevation of 572.8 feet International Great Lakes Datum (IGLD) and low water elevation of 568.6 IGLD. Dams, water obstructions and encroachments constructed between elevation 572.8 IGLD and elevation 568.6 IGLD require a permit under section 6 of the act (32 P. S. § 693.6). Dams, water obstructions and encroachments constructed lakeward of elevation 568.6 IGLD require both a permit under section 6 of the act and a Submerged Lands License Agreement under section 15 of the act (32 P. S. § 693.15).

(c) The environmental assessment conducted under this chapter is applicable to dams, water obstructions and encroachments for which a permit or approval is required under this chapter.

Copyright © 2005 Commonwealth of Pennsylvania

Authority

The provisions of this § 105.3 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.3 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended October 6, 1978, effective October 7, 1978, 8 Pa.B. 2723; amended November 2, 1979, effective November 3, 1979, 9 Pa.B. 3640; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (141412) and (117643).

Notes of Decisions

Fill site must be sufficiently close to wetlands so as to be ''along'' them in order to invoke jurisdiction in action under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1—693.27). *Game Commission v. Department of Environmental Resources*, 509 A.2d 877 (Pa. Cmwlth. 1986); appeal granted 521 A.2d 934 (Pa. 1987); affirmed 555 A.2d 812 (Pa. 1989).

Cross References

This section cited in 25 Pa. Code § 105.71 (relating to scope); 25 Pa. Code § 105.141 (relating to scope); 25 Pa. Code § 105.181 (relating to scope); 25 Pa. Code § 105.221 (relating to scope); 25 Pa. Code § 105.251 (relating to scope); 25 Pa. Code § 105.291 (relating to scope); 25 Pa. Code § 105.321 (relating to scope); 25 Pa. Code § 105.361 (relating to scope); and 25 Pa. Code § 105.391 (relating to scope).

§ 105.4. Delegations to local agencies.

(a) Under section 17 of the act (32 P. S. § 693.17) and subject to this section, the Department may by written agreement delegate to a county conservation district or other county agency one or more of its regulatory functions including enforcement and the power to permit, inspect and monitor specified categories of water obstructions and encroachments.

(b) No delegation may be made of the authority to issue permits for a water obstruction or encroachment constructed, owned or maintained by the Commonwealth, a political subdivision or a public utility. Delegations may be made of the powers to inspect and monitor the activities, if the Department retains final authority to approve or disapprove permits, and concurrent authority to inspect, monitor and enforce the act.

(c) To the extent delegated by the agreement, the delegations may include the authority to enforce the act and this chapter and to exercise other powers and duties otherwise vested in the Department to implement the act with respect to the categories of water obstructions and encroachments covered by the delegation.

(d) A delegation agreement shall:

(1) Specify the powers and duties to be performed by the delegated agency.

(2) Specify the categories of water obstructions and encroachment activities to be covered by the delegated agency.

(3) Provide for the commitment by the delegated agency of sufficient trained staff and resources to perform the powers and duties to be delegated.

(4) Require the delegated agency to maintain records of activities performed under the delegation.

(5) Provide for monitoring and supervision by the Department of performance by the delegated agency of the functions delegated under the agreement.

(e) A permit for a water obstruction or encroachment issued by a delegated agency is subject to review by the Department, unless the right of review is waived by the Department. A permit issued by a delegated agency shall become effective 30 days following the receipt of notice by the Department of issuance, unless the permit is disapproved by the Department or an appeal is filed with the Department under section 17 of the act (32 P. S. § 693.17).

(f) When the Department delegates one or more of its regulatory functions to a local agency, the Department will retain the concurrent power to inspect and monitor categories of water obstructions and encroachments and to enforce the act and this chapter.

Authority

The provisions of this § 105.4 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.4 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117643) to (117644).

Cross References

This section cited in 25 Pa. Code § 105.446 (relating to procedure for issuance).

PERMIT APPLICATIONS

§ 105.11. Permit requirements.

(a) A person may not construct, operate, maintain, modify, enlarge or abandon a dam, water obstruction or encroachment without first obtaining a written permit from the Department.

(b) An existing dam, water obstruction or encroachment constructed under a license or permit issued in compliance with the act of June 8, 1907 (P. L. 496, No. 322) (53 P. S. § 16834 note and 55 P. S. §§ 332.1 and 332.2) or the Water Obstructions Act, shall be deemed to comply with the construction and operating

Copyright © 2008 Commonwealth of Pennsylvania

permit requirements of this section. These projects shall, after September 27, 1980, comply with the operating, maintenance, monitoring and other requirements of this chapter.

(c) The owner of an existing dam, water obstruction or encroachment who does not hold a permit issued under the act of June 8, 1907 (P. L. 496, No. 322) or the Water Obstructions Act shall apply for and receive a permit to operate and maintain the facility under the act on or before January 1, 1981. For purposes of this subsection, a limited power permit issued under the Limited Power and Water Supply Act will be deemed to have been issued under the Water Obstructions Act. These projects shall comply with the operating, maintenance, monitoring and other requirements established under the act.

(d) A permit issued by the Department after July 1, 1979 for the construction and operation of a water obstruction or encroachment shall incorporate authorization for normal repairs and maintenance of permitted structures conducted within the original specifications for the water obstruction or encroachment. A repair or maintenance involving modification of the water obstruction or encroachment from its original specifications and a repair or reconstruction involving a substantial portion of the structure shall require the prior written permit of the Department under subsection (a).

(e) A dam, water obstruction or encroachment or modification thereof, constructed or authorized pursuant to the terms of a permit issued under this chapter prior to October 12, 1991, shall be deemed to comply with the construction permit requirements of this subchapter. These projects shall, after October 12, 1991, comply with the operating, maintenance, monitoring and other requirements of this chapter.

Authority

The provisions of this § 105.11 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.11 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117644) to (117645).

Notes of Decisions

Cause of Action

A builder's allegation that the township approved a subdivision plan in the absence of a permit from the Department of Environmental Protection is not a cognizable cause of action because it is the Department which enforces this regulation, not the local agency; furthermore, this regulation does not create a private cause of action. *Shafer v. Waite*, 43 D. & C. 4th 91 (1999).

Failure to Obtain Permit

Appellant, who placed fill on his land without a permit which constituted an unlawful encroachment on wetlands in violation of the law, could not claim Department of Environment Protection's issuing of compliance order effected an unconstitutional, regulatory taking of property rights because Appellant failed to apply for a permit. *Baehler v. Department of Environmental Protection*, 863 A.2d 57, 59—60 (Pa. Cmwlth. 2004).

Cross References

This section cited in 25 Pa. Code § 105.14 (relating to review of applications); 25 Pa. Code § 105.52 (relating to inspection); and 25 Pa. Code § 105.443 (relating to nature of a general permit; substitution for individual applications and permits).

§ 105.12. Waiver of permit requirements.

(a) Under section 7 of the act (32 P. S. § 693.7), the requirements for a permit are waived for the following structures or activities, regardless of when commenced. If the Department upon complaint or investigation finds that a structure or activity which is eligible for a waiver, has a significant effect upon safety or the protection of life, health, property or the environment, the Department may require the owner of the structure to apply for and obtain a permit under this chapter.

(1) A dam not exceeding 3 feet in height in a stream not exceeding 50 feet in width, except wild trout streams designated by the Fish Commission.

(2) A water obstruction in a stream or floodway with a drainage area of 100 acres or less. This waiver does not apply to wetlands located in the floodway.

(3) An aerial crossing of a nonnavigable stream or wetland by electric, telephone or communications lines which are not located in a Federal wilderness area or watercourse or body of water designated as a wild or scenic river under the Wild and Scenic Rivers Act of 1968 (16 U.S.C.A. §§ 1271—1287) or the Pennsylvania Scenic Rivers Act (32 P. S. §§ 820.21—820.29). This waiver applies to one or more wires attached aboveground to single poles. This does not apply to the maintenance and construction of towers, roads or other water obstructions or encroachments.

(4) A dam subject to the requirements of the Mine Safety and Health Administration, 30 CFR 77.216-1 and 77.216-2 (relating to water, sediment or slurry impoundments and impounding structures; identification; and water, sediment, or slurry impoundments or impounding structures; minimum plan requirements; changes or modifications; certification), if the Department determines on the basis of preliminary data submitted by the applicant that the dam is of Size Classification C and Hazard Potential Classification 3 as defined in § 105.91 (relating to classification of dams and reservoirs) and is not located in a watercourse or body of water designated as a wild and scenic river under the Wild and Scenic Rivers Act of 1968 or the Pennsylvania Scenic Rivers Act.

(5) A water obstruction or encroachment located in, along, across or projecting into a wetland or impoundment, constructed and maintained for the purpose of treating acid mine drainage, sewage or other waste, if the wetland or impoundment is a treatment facility constructed under a valid permit issued by the Department under the Surface Mining Conservation and Reclamation Act (52 P. S. §§ 1396.1—1396.31), The Clean Streams Law (35 P. S. §§ 691.1—691.1001), the Noncoal Surface Mining Conservation and Reclamation Act (52 P. S. §§ 3301—3326), the Solid Waste Management Act (35 P. S. §§ 6018.101—6018.1003), the Oil and Gas Act (58 P. S. §§ 601.101—601.605) and the Pennsylvania Sewage Facilities Act (35 P. S. §§ 750.1—750.20).

Copyright © 2008 Commonwealth of Pennsylvania

(6) A water obstruction or encroachment located in, along, across or projecting into a stormwater management facility or an erosion and sedimentation pollution control facility which meets the requirements in Chapter 102 (relating to erosion and sediment control), if the facility was constructed and continues to be maintained for the designated purpose.

(7) Maintenance of field drainage systems that were constructed and continue to be used for crop production. Crop production includes:

(i) Plowing, cultivating, seeding, grazing or harvesting.

(ii) Crop rotation.

(iii) Government set aside programs.

(8) Plowing, cultivating, seeding or harvesting for crop production.

(9) Construction and maintenance of ford crossings of streams for individual private personal use which require only grading of banks for approach roads and the placement of not more than 12 inches of gravel for roadway stability. Fords may not be used for commercial purposes and shall cross the regulated waters of this Commonwealth in the most direct manner. This waiver does not apply in exceptional value streams as listed under Chapter 93 (relating to water quality standards) or in wild trout streams.

(10) A navigational aid or marker, buoy, float, ramp or other device or structure for which a permit has been issued by the Fish Commission under 30 Pa.C.S. § 5123(a)(7) (relating to general boating regulations).

(11) The removal of abandoned dams, water obstructions and encroachments if the Department determines in writing on the basis of data, information or plans submitted by the applicant that the removal of the abandoned dam water obstruction or encroachment cannot imperil life or property, have significant effect on coastal resources or have an adverse impact on the environment, and the plans provide for restoration and stabilization of the project area.

(12) The construction, operation or removal of staff gages, water recording devices, water quality testing devices, including, but not limited to, sensors, intake tubes, weirs and small buildings which contain required instruments and similar scientific structures.

(13) A bridge or culvert purchased from an operating railroad company subsequent to the abandonment of the railroad line, track, spur or branch pursuant to the approval of the Interstate Commerce Commission. Major maintenance or reconstruction, or stream dredging may not be undertaken until the new owner obtains a permit under this chapter.

(14) The maintenance of an artificial pond or reservoir to its original storage capacity where:

(i) The contributory drainage area is less than or equal to 100 acres.

(ii) The greatest depth of water at maximum storage elevation is less than or equal to 15 feet.

(iii) The impounding capacity at maximum storage elevation is less than or equal to 50 acre feet.

(15) The construction and maintenance of an encroachment or water obstruction on an abandoned mining site, where the Department has issued a notice of intent to forfeit the bond for a mining activity permitted after July 1982.

(16) Restoration activities undertaken and conducted pursuant to a restoration plan which has been approved, in writing, by the Department.

(b) The requirements for a permit for existing structures or activities, as provided in section 6(c) of the act (32 P. S. § 693.6(c)), are waived for the following structures or activities, if construction was completed prior to July 1, 1979. If the Department upon complaint or investigation finds that a structure or activity which is eligible for a waiver, has a significant effect upon safety or the protection of life, health, property or the environment, the Department may require the owner of the structure or activity to apply for and obtain a permit under this chapter.

(1) A dam not exceeding 5 feet in height in a nonnavigable stream operated and maintained for water supply purposes.

(2) A dam which the Department determines, on the basis of preliminary data submitted by the applicant, is of Size Classification C and Hazard Potential Classification 3, as defined in § 105.91 and does not have a significant effect on coastal resources or an adverse impact on the environment.

(3) A fill not located on navigable lakes and navigable rivers.

(4) A streambank retaining device.

(5) A stream crossing other than a crossing located on submerged lands of this Commonwealth and a crossing by pipelines for conveyance of petroleum products and gas.

(6) An outfall, headwall or water intake structure.

(7) A culvert, bridge or stream enclosure on a watercourse where the drainage area above the culvert, bridge or stream enclosure is 5 square miles or less.

(c) Structures and activities shall meet the construction, operation, maintenance, monitoring and other requirements of this chapter. No other permits which may be required under a law other than the act are waived by this section.

Authority

The provisions of this § 105.12 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.12 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117645) to (117647).

Copyright © 2000 Commonwealth of Pennsylvania

Cross References

This section cited in 25 Pa. Code § 105.15 (relating to environmental assessment); 25 Pa. Code § 105.21a (relating to public notice); 25 Pa. Code § 105.71 (relating to scope); 25 Pa. Code § 105.141 (relating to scope); 25 Pa. Code § 105.181 (relating to scope); 25 Pa. Code § 105.221 (relating to scope); 25 Pa. Code § 105.251 (relating to scope); 25 Pa. Code § 105.291 (relating to scope); 25 Pa. Code § 105.321 (relating to scope); 25 Pa. Code § 105.361 (relating to scope); and 25 Pa. Code § 105.391 (relating to scope).

§ 105.13. Permit applications—information and fees.

(a) Application for permits under this chapter shall be submitted to the Department, in writing, upon forms provided by the Department. Applicants are encouraged to request a meeting with the Department prior to submission of their applications.

(b) An application for a permit under this chapter, except applications submitted by Federal, State, county or municipal agencies or a municipal authority for a dam, water obstruction or encroachment shall be accompanied by a check payable to ''Commonwealth of Pennsylvania'' in accordance with the following schedule:

(1) *Dams.*

Class A $3000	(Based on Size Classification as defined in § 105.91)
Class B $2500	
Class C $1500	

(2) *Water obstructions and encroachments.*

Stream enclosures	$350
Channel changes	$300
Commercial dredging	$300
Peat extraction	$750
Fills, levees, floodwalls	$350
Bridges and other water obstructions and encroachments	$200
Small projects	$100

(c) A single application may be submitted or a single permit may be issued for multiple structures and activities which are part of a single project or facility or part of related projects and facilities, located in a single county, constructed, operated or maintained by the same persons. When a single application covers multiple structures or activities other than a single structure and related maintenance dredging, the application fee shall be the sum of fees in subsection (b) for the applicable structures and activities. Stream crossings located within a single county for the installation of a public service line shall be treated as a single structure or activity but the application fee shall be the sum of fees for each stream crossing.

(d) An application for a permit shall be accompanied by information, maps, plans, specifications, design analyses, test reports and other data specifically

required by this chapter and additional information as required by the Department to determine compliance with this chapter.

(1) For all permit applications, except small projects, this information shall include, but is not limited to, the following:

(i) *A site plan.* A site plan shall include:

(A) A complete demarcation of the floodplains and regulated waters of this Commonwealth on the site. The wetlands shall be identified and delineated in accordance with the Department's Wetland Delineation Policy as published at § 105.451 (relating to identification and delineation of wetlands—statement of policy).

(B) Existing roads, utility lines, lots, other manmade structures and natural features such as contour lines and drainage patterns.

(C) Proposed structures or activities included in the project, which shall be identified by labeling.

(D) A scale of one inch equals 200 feet or larger.

(E) A north arrow.

(F) The name of the persons who prepared the plan, and the date and name of the applicants.

(G) A cross sectional view of the regulated waters to be impacted before and after the structure or activity is constructed.

(ii) *A location map.* The location map shall be of a scale factor of 1:24000 (standard U.S.G.S. Topographic Map). The location map shall show all natural features including the names and boundaries of regulated waters of this Commonwealth, natural areas, wildlife sanctuaries, natural landmarks, political boundaries, locations of public water supplies and other geographical or physical features including cultural, archeological and historical landmarks within 1 mile of the site. U.S.G.S. maps may be reviewed at County Conservation District Offices or obtained by writing to: United States Geological Survey Map Distribution, Box 25286 Federal Center, Denver, CO 80225.

(iii) *Project description.* A narrative of the project shall be provided which includes, but is not limited to:

(A) A description of the proposed structure or activity.

(B) The project purpose.

(C) The effect the project will have on public health, safety or the environment.

(D) A statement on water dependency. A project is water dependent when the project requires access or proximity to or siting within water to fulfill the basic purposes of the project.

(iv) *Color photographs.* Color photographs of the proposed site shall be submitted. The photos shall accurately depict the project area and provide a relative scale of the project to the surrounding area and a map showing the location and orientation of each photograph.

Copyright © 1996 Commonwealth of Pennsylvania

(v) *Stormwater management analysis.* If a watershed stormwater management plan has been prepared or adopted under the Stormwater Management Act (32 P. S. §§ 680.1—680.17), an analysis of the project's impact on the Stormwater Management Plan and a letter from the county or municipality commenting on the analysis shall be included.

(vi) *Floodplain management analysis*. If the proposed dam, water obstruction or encroachment is located within a floodway delineated on a FEMA map, include an analysis of the project's impact on the floodway delineation and water surface profiles and a letter from the municipality commenting on the analysis.

(vii) *Risk assessment.* If the stormwater or the floodplain management analysis conducted in subparagraphs (v) and (vi) indicates increases in peak rates of runoff or flood elevations, include a description of property and land uses which may be affected and an analysis of the degree of increased risk to life, property and the environment.

(viii) *Alternatives analysis.* A detailed analysis of alternatives to the proposed action, including alternative locations, routings or designs to avoid or minimize adverse environmental impacts.

(ix) *Mitigation plan.* Actions to be taken in accordance with the definition of mitigation in this chapter.

(x) *Impacts analysis.* A detailed analysis of the potential impacts, to the extent applicable, of the proposed project on water quality, stream flow, fish and wildlife, aquatic habitat, Federal and State forests, parks, recreation, instream and downstream water uses, prime farmlands, areas or structures of historic significance, streams which are identified candidates for or are included within the Federal or State wild and scenic river systems and other relevant significant environmental factors. If a project will affect wetlands the project description shall also include:

(A) A narrative of the delineation process supported by the appropriate data sheets and copies of appropriate soil maps and descriptions from soil conservation service soil surveys. Soil conservation service soil surveys may be obtained from the county conservation district offices.

(B) An analysis of whether the wetland is exceptional value as classified in § 105.17 (relating to wetlands).

(C) A statement on water dependency. A project is water dependent when the project requires access or proximity to or siting within water to fulfill the basic purposes of the project.

(2) An application for a project which will affect less than 1 acre of wetland where the wetland is not exceptional value wetland shall also include a description of functions and values of the existing wetlands to be impacted by the project, as defined in § 105.1 (relating to definitions).

(3) An application for a project which may have an affect on an exceptional value wetland or on 1 or more acres of wetland shall also include an

assessment of the wetland functions and values using a methodology accepted by the Department and a survey, conducted by a licensed professional land surveyor, of the wetland boundary as delineated and of the property lines of the parcel where the project is located.

(e) A permit application for small projects located in streams or floodplains shall be accompanied by the following information. This permit application may not be used for projects located in wetlands. If upon review the Department determines that more information is required to determine whether a small project will have an insignificant impact on safety and protection of life, health, property or the environment, the Department may require the applicant to submit additional information and processing fees required by this chapter.

(1) *A site plan.* A site plan shall include:

(i) The floodplains and regulated waters of this Commonwealth on the site, including wetlands, existing roads, utility lines, lots, other manmade structures, natural features such as slopes and drainage patterns, proposed structures or activities included in the project.

(ii) The names of the persons who prepared the plan.

(iii) The date and the name of applicants.

(iv) A north arrow.

(2) *A cross sectional view.* A cross sectional view of the affected regulated waters of this Commonwealth before and after the structure or activity is constructed.

(3) *A location map.* A map showing the geographic location of the project. U.S.G.S. topographic maps, FEMA maps or municipal maps are acceptable. FEMA and municipal maps may be obtained from local government offices. U.S.G.S. maps may be reviewed at county conservation district offices or obtained by writing to: United States Geological Survey Map Distribution, Box 25286 Federal Center, Denver, CO 80225.

(4) *Project description.* A narrative of the project shall be provided which includes, but is not limited to:

(i) A description of the proposed structure or activity.

(ii) The project purpose.

(iii) The effect the project will have on public health, safety or the environment.

(iv) The project's need to be in or in close proximity to water.

(5) *Color photographs.* Color photographs of the proposed site shall be submitted. The photos shall accurately depict the project area and provide a relative scale of the project to the surrounding area and a map showing the location and orientation of each photograph.

(f) Except for small projects, an application for a permit under this chapter shall be accompanied by proof of an application for an Earth Disturbance Permit or an erosion and sedimentation control plan for activities in the stream and earthmoving activities. The plan shall conform to the requirements contained in

Copyright © 1996 Commonwealth of Pennsylvania

Chapter 102 (relating to erosion and sediment control) and shall include a copy of a letter from the conservation district in the county where the project is located indicating that the district has reviewed the erosion and sediment control plan of the applicant and considered it to be satisfactory, if applicable. Earthmoving activities, including small projects, shall be conducted pursuant to an earth disturbance plan.

(g) An application shall be submitted by the person who owns or has primary responsibility for the proposed dam or reservoir, water obstruction or encroachment. If an application is submitted by a person with primary responsibility for the structure or activity, the owner of a dam or reservoir, water obstruction or encroachment will not thereby be relieved of legal duties or responsibilities for the structure or activity as imposed by the act or this chapter.

(h) An application shall be signed by the owners of the dam or reservoir, water obstruction or encroachment, or the persons exercising primary responsibility for the dam or reservoir, water obstruction or encroachment. In the case of a partnership, one or more members of the partnership authorized to sign on behalf of the entire partnership shall sign the application. In the case of a corporation, it shall be signed by the president, vice president or other responsible official empowered to sign for the corporation. In the case of a political subdivision, it shall be signed by the chief officers of the political subdivision or other responsible official empowered to sign for the political subdivision, with the seal affixed and attested by the clerk.

(i) Plans, specifications and reports accompanying applications for any category of dams, or for bridges and other water obstructions or encroachments which would pose a threat to human life or substantial potential risk to property shall be affixed with the seal of a registered professional engineer and a certification, signed by the registered professional engineer, which shall read as follows:

> ''I (name) do hereby certify pursuant to the penalties of 18 Pa.C.S.A. Sec. 4904 to the best of my knowledge, information and belief, that the information contained in the accompanying plans, specifications and reports has been prepared in accordance with accepted engineering practice, is true and correct, and is in conformance with Chapter 105 of the rules and regulations of the Department of Environmental Resources.''

(j) The Department may waive the specific information requirements of this section in writing, in the record of decision, if upon review of the permit application, the Department finds that specific information is not necessary to review the application.

Authority

The provisions of this § 105.13 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.13 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117647) to (117649).

Notes of Decisions

Needs Analysis

Where the applicant failed to submit a proper alternatives/justification analysis and parking needs could have been met elsewhere, the Environmental Hearing Board concluded that petitioner did not justify the need to fill wetlands. *Hatchard v. Department of Environmental Resources*, 612 A.2d 621 (Pa. Cmwlth. 1992).

Cross References

This section cited in 25 Pa. Code § 105.15 (relating to environmental assessment); 25 Pa. Code § 105.81 (relating to permit applications for construction and modification of dams and reservoirs); 25 Pa. Code § 105.82 (relating to permit applications for operation and maintenance of existing dams and reservoirs); 25 Pa. Code § 105.151 (relating to permit applications for construction or modification of culverts and bridges); 25 Pa. Code § 105.152 (relating to permit applications for operation and maintenance of existing culverts and bridges); 25 Pa. Code § 105.191 (relating to permit applications for construction or modification of stream enclosures); 25 Pa. Code § 105.192 (relating to permit applications for operation and maintenance of existing stream enclosures); 25 Pa. Code § 105.231 (relating to permit applications for construction or modification of channel changes and dredging for facility construction and maintenance); 25 Pa. Code § 105.261 (relating to permit applications for construction or modification of fills, levees, floodwalls and streambank retaining devices); 25 Pa. Code § 105.262 (relating to permit applications for existing fills, levees, floodwalls and streambank retaining devices); 25 Pa. Code § 105.301 (relating to permit applications for construction or modification); 25 Pa. Code § 105.302 (relating to permit applications for existing stream crossings by pipelines for conveyance of petroleum products and gas); 25 Pa. Code § 105.331 (relating to permit applications); 25 Pa. Code § 105.371 (relating to permits: content of application); and 25 Pa. Code § 105.401 (relating to permit applications).

§ 105.14. Review of applications.

(a) An application will be reviewed to determine the proposed project's effect on health, safety and the environment, in accordance with prevailing practices in the engineering profession and in accordance with current environmental principles.

(b) In reviewing a permit application under this chapter for construction or substantial modification of a dam or reservoir, water obstruction or encroachment, the Department will use the following factors to make a determination of impact:

(1) Potential threats to life or property created by the dam, water obstruction or encroachment.

(2) Potential threats to safe navigation created by the dam, water obstruction or encroachment.

(3) The effect of the dam, water obstruction or encroachment on the property or riparian rights of owners above, below or adjacent to the project.

Copyright © 2005 Commonwealth of Pennsylvania

(4) The effect of the dam, water obstruction or encroachment on regimen and ecology of the watercourse or other body of water, water quality, stream flow, fish and wildlife, aquatic habitat, instream and downstream uses and other significant environmental factors.

(5) The impacts of the dam, water obstruction or encroachment on nearby natural areas, wildlife sanctuaries, public water supplies, other geographical or physical features including cultural, archaeological and historical landmarks, National wildlife refuges, National natural landmarks, National, State or local parks or recreation areas or National, State or local historical sites.

(6) Compliance by the dam, water obstruction or encroachment with applicable laws administered by the Department, the Fish Commission and river basin commissions created by interstate compact.

(7) The extent to which a project is water dependent and thereby requires access or proximity to or siting within water to fulfill the basic purposes of the project. The dependency shall be based on the demonstrated unavailability of any alternative location, route or design and the use of location, route or design to avoid or minimize the adverse impact of the dam, water obstruction or encroachment upon the environment and protect the public natural resources of the Commonwealth.

(8) Present conditions and the effects of reasonably foreseeable future development within the affected watershed above and below the dam, water obstruction or encroachment:

(i) A dam, water obstruction or encroachment shall be designed, constructed and operated to assure adequacy and compliance with this chapter, taking into account reasonably foreseeable development within the watershed.

(ii) In assessing the impact of future development upon a dam, water obstruction or encroachment, the Department may require the applicant to submit data regarding estimated development potentials and municipal, county and regional planning related to the affected watershed.

(9) Consistency with State and local floodplain and stormwater management programs, the State Water Plan and the Coastal Zone Management Plan.

(10) Consistency with the designations of wild, scenic and recreational streams under the Wild and Scenic Rivers Act of 1968 (16 U.S.C.A. §§ 1271—1287) or the Pennsylvania Scenic Rivers Act (32 P. S. §§ 820.21—820.29), including identified 1-A candidates.

(11) Consistency with State antidegradation requirements contained in Chapters 93, 95 and 102 (relating to water quality standards; wastewater treatment requirements; and erosion and sediment control) and the Clean Water Act (33 U.S.C.A. §§ 1251—1376).

(12) Secondary impacts associated with but not the direct result of the construction or substantial modification of the dam or reservoir, water obstruction or encroachment in the area of the project and in areas adjacent thereto and

future impacts associated with dams, water obstructions or encroachments, the construction of which would result in the need for additional dams, water obstructions or encroachments to fulfill the project purpose.

(13) For dams, water obstructions or encroachments in, along, across or projecting into a wetland, as defined in § 105.1 (relating to definitions), the Department will also consider the impact on the wetlands values and functions in making a determination of adverse impact.

(14) The cumulative impact of this project and other potential or existing projects. In evaluating the cumulative impact, the Department will consider whether numerous piecemeal changes may result in a major impairment of the wetland resources. The Department will evaluate a particular wetland site for which an application is made with the recognition that it is part of a complete and interrelated wetland area.

(c) In reviewing a permit application under § 105.11(c) (relating to permit requirements) and section 6(c) of the act (32 P. S. § 693.6(c)) for the operation and maintenance of an existing dam, water obstruction or encroachment, the Department will use the following factors:

(1) Potential threats to life, property or safe navigation created by the continuing operation or maintenance of the project.

(2) Adverse impact on stream flow, water quality or the environment which might be reduced or mitigated by reasonable changes in the operation of the project.

(3) Compliance of the operation and maintenance of the project with applicable laws administered by the Department, the Fish Commission and river basin commissions created by interstate compact.

(d) The Department may review a permit application for the operation and maintenance of existing projects without regard to the design criteria and construction requirements in Subchapters B—J. If the Department finds that an existing dam, water obstruction or encroachment is unsafe or adversely affects property or the environment, it may consider application of criteria and requirements reasonably necessary to correct the conditions.

Authority

The provisions of this § 105.14 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.14 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117649) to (117651).

Copyright © 2005 Commonwealth of Pennsylvania

Notes of Decisions

Reservoir was not an ''available'' alternative supplemental cooling water source within the meaning of 25 Pa. Code § 105.14(b)(7) where there was substantial evidence to support conclusion that such use of the reservoir was technically not feasible, there were legal impediments to such use and it would be unfair to give all unallocated water to one consumptive user. *Del-Aware Unlimited, Inc. v. Department of Environmental Resources*, 508 A.2d 348 (Pa. Cmwlth. 1986); appeal denied 523 A.2d 1132 (Pa. 1986).

Cross References

This section cited in 25 Pa. Code § 105.15 (relating to environmental assessment); 25 Pa. Code § 105.18a (relating to permitting of structures and activities in wetlands); 25 Pa. Code § 105.82 (relating to permit applications for operation and maintenance of existing dams and reservoirs); and 25 Pa. Code § 105.442 (relating to authorization for general permits).

§ 105.15. Environmental assessment.

(a) A person may not construct, operate, maintain, modify, enlarge or abandon the following categories of structures or activities until an environmental assessment has been approved in writing by the Department. The environmental assessment shall be on a form provided by the Department and shall include the following information:

(1) For dams, water obstructions or encroachments permitted under this chapter, the Department will base its evaluation on the information required by § 105.13 (relating to permit applications—information and fees) and the factors included in § 105.14(b) (relating to review of applications) and this section.

(2) For dams, water obstructions or encroachments located in, along or projecting into a wetland for which a permit is not otherwise required under this chapter, the Department will base its evaluation on the information required by § 105.13(d) and the factors included in § 105.14(b) and this section.

(3) For dams located in, along or projecting into an exceptional value water as defined in Chapter 93 (relating to water quality standards) for which a permit is not otherwise required under this chapter, the Department will base its evaluation on the information required by the factors included in § 95.1 (relating to general requirements) and §§ 105.13(d) and 105.14(b) and the following information submitted by the applicant:

(i) The surface area of the impoundment.

(ii) The height of the dam.

(iii) The mean depth and maximum depth of the stream at the location of the dam.

(iv) A description of the release structure.

(v) The rate of a conservation release.

(vi) The design of bypass structures.

(vii) The use of the dam.

(viii) The material used for construction of the dam.

(b) For structures or activities where water quality certification is required under section 401 of The Clean Water Act (33 U.S.C.A. § 1341), an applicant requesting water quality certification under section 401 shall prepare and submit to the Department for review, an environmental assessment containing the information required by subsection (a) for every dam, water obstruction or encroachment located in, along, across or projecting into the regulated water of this Commonwealth.

(c) Based on the results of the environmental assessment required under subsection (a), the Department may require the applicant to undertake further studies and submit additional information, analyses and reports as found necessary by the Department.

(d) The environmental assessment has been conducted by the Department for all general permits, categories of structures and activities listed in § 105.12(a)(1)—(10) and (12)—(15) (relating to waiver of permit requirements). The environmental assessment has also been conducted for the structures or activities listed in § 105.12(b) or for which water quality certification has been granted for a Nationwide permit regulating the structure or activity and the environmental assessment requirements have been deemed satisfied.

Authority

The provisions of this § 105.15 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.15 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117651) to (117652).

Cross References

This section cited in 25 Pa. Code § 96.3 (relating to quality protection requirements); 25 Pa. Code § 105.18a (relating to permitting of structures and activities in wetlands); and 25 Pa. Code § 105.442 (relating to authorization for general permits).

§ 105.16. Environmental, social and economic balancing.

(a) If the Department determines that there may be an impact on natural, scenic, historic or aesthetic values of the environment, the Department will consult with the applicant to examine ways to reduce the adverse environmental impact. If, after consideration of mitigation measures, the Department finds that the adverse environmental impact will occur, the Department will evaluate the public benefits of the project to determine whether the public benefits outweigh the environmental harm.

Copyright © 2008 Commonwealth of Pennsylvania

(b) An application for a permit for a structure or activity which the Department determines will have an adverse impact on the environment or public natural resources will not be approved by the Department unless the applicant demonstrates and the Department finds that the public benefits of the proposed project outweigh the harm to the environment and public natural resources. Public benefits include, but are not limited to:

(1) Correction and prevention of pollution.

(2) Protection of public health and safety.

(3) Reduction of flood damages.

(4) Development of energy resources.

(5) Creation or preservation of significant employment.

(6) Provision of public utility services.

(7) Other essential social and economic development which benefits a substantial portion of the public.

(c) An application for a permit will not be approved by the Department in the following areas unless the applicant demonstrates and the Department finds that the project will not have an adverse impact upon the public natural resources:

(1) A project located in or within 100 feet of a watercourse or body of water that has been designated as a National or State wild or scenic river in accordance with the Wild and Scenic Rivers Act of 1968 (16 U.S.C.A. §§ 1271—1287) or the Pennsylvania Scenic Rivers Act (32 P. S. §§ 820.21—820.29).

(2) A project located in or within 100 feet of a Federal wilderness area designated in accordance with the Wilderness Act (16 U.S.C.A. §§ 1131—1136) or the Federal Eastern Wilderness Act of 1975 (16 U.S.C.A. § 1132).

(3) A project located within an area which serves as a habitat of a threatened or endangered species protected by the Endangered Species Act of 1973 (7 U.S.C.A. § 136; 16 U.S.C.A. §§ 4601-9, 460k-1, 668dd, 715i, 715a, 1362, 1371, 1372, 1402 and 1531—1543) or for a species which has been designated as a threatened or endangered species under the Wild Resource Conservation Act (32 P. S. §§ 5301—5314), 30 Pa.C.S. (relating to the Fish and Boat Code) or 34 Pa.C.S. (relating to the Game and Wildlife Code).

(4) A project located in waters designated as exceptional value in Chapter 93 (relating to water quality standards).

(d) In reviewing permit applications, it will be the policy of the Department to encourage activities that protect the natural condition of the watercourses or other body of water.

(e) This section does not apply to dams, water obstructions or encroachments located in, along, across or projecting into wetlands. These structures or activities will be evaluated under §§ 105.17 and 105.18a—105.20.

Authority

The provisions of this § 105.16 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.16 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117652) to (117654).

Notes of Decisions

Because the petitioner failed to utilize available alternatives, the Department was not required to consider the petitioner's proposed mitigation measures. *Hatchard v. Department of Environmental Resources*, 612 A.2d 621 (Pa. Cmwlth. 1992).

Cross References

This section cited in 25 Pa. Code § 105.442 (relating to authorization for general permits).

§ 105.17. Wetlands.

Wetlands are a valuable public natural resource. This chapter will be construed broadly to protect this valuable resource.

(1) *Exceptional value wetlands.* This category of wetlands deserves special protection. Exceptional value wetlands are wetlands that exhibit one or more of the following characteristics:

(i) Wetlands which serve as habitat for fauna or flora listed as ''threatened'' or ''endangered'' under the Endangered Species Act of 1973 (7 U.S.C.A. § 136; 16 U.S.C.A. §§ 4601-9, 460k-1, 668dd, 715i, 715a, 1362, 1371, 1372, 1402 and 1531—1543), the Wild Resource Conservation Act (32 P. S. §§ 5301—5314), 30 Pa.C.S. (relating to the Fish and Boat Code) or 34 Pa.C.S. (relating to the Game and Wildlife Code).

(ii) Wetlands that are hydrologically connected to or located within 1/2-mile of wetlands identified under subparagraph (i) and that maintain the habitat of the threatened or endangered species within the wetland identified under subparagraph (i).

(iii) Wetlands that are located in or along the floodplain of the reach of a wild trout stream or waters listed as exceptional value under Chapter 93 (relating to water quality standards) and the floodplain of streams tributary thereto, or wetlands within the corridor of a watercourse or body of water that has been designated as a National wild or scenic river in accordance with the Wild and Scenic Rivers Act of 1968 (16 U.S.C.A. §§ 1271—1287) or designated as wild or scenic under the Pennsylvania Scenic Rivers Act (32 P. S. §§ 820.21—820.29).

Copyright © 1996 Commonwealth of Pennsylvania

(iv) Wetlands located along an existing public or private drinking water supply, including both surface water and groundwater sources, that maintain the quality or quantity of the drinking water supply.

(v) Wetlands located in areas designated by the Department as ''natural'' or ''wild'' areas within State forest or park lands, wetlands located in areas designated as Federal wilderness areas under the Wilderness Act (16 U.S.C.A. §§ 1131—1136) or the Federal Eastern Wilderness Act of 1975 (16 U.S.C.A. § 1132) or wetlands located in areas designated as National natural landmarks by the Secretary of the Interior under the Historic Sites Act of 1935 (16 U.S.C.A. §§ 461—467).

(2) *Other wetlands.* This category includes wetlands not categorized as exceptional value wetlands.

(3) *Permits.* The Department will maintain a list of permit decisions involving wetlands. This list will be a matter of public record and will be available for inspection at the Department's offices.

Authority

The provisions of this § 105.17 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.17 adopted November 2, 1979, effective November 3, 1979, 9 Pa.B. 3640; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117654) and (126083).

Cross References

This section cited in 7 Pa. Code § 130d.1 (relating to definitions); 7 Pa. Code § 130d.45 (relating to prohibited applications); 25 Pa. Code § 93.1 (relating to definitions); 25 Pa. Code § 96.3 (relating to water quality protection requirements); 25 Pa. Code § 105.13 (relating to permit applications—information and fees); 25 Pa. Code § 105.16 (relating to environmental, social and economic balancing); 25 Pa. Code § 105.442 (relating to authorization for general permits); 25 Pa. Code Chapter 105 Appendix E (relating to utility line stream crossings; general permit BDWM-GP-5); 25 Pa. Code Chapter 105 Appendix H (relating to temporary road crossings; general permit BDWM-GP-8); 25 Pa. Code § 250.1 (relating to definitions); 25 Pa. Code § 250.311 (relating to evaluation of ecological receptors); 25 Pa. Code § 271.915 (relating to management practices); 25 Pa. Code § 273.202 (relating to areas where municipal waste landfills are prohibited); 25 Pa. Code § 275.202 (relating to areas where the land application of sewage sludge is prohibited); § 277.202 (relating to areas where construction/demolition waste landfills are prohibited); 25 Pa. Code § 279.202 (relating to areas where transfer facilities are prohibited); 25 Pa. Code § 281.202 (relating to areas where general composting facilities are prohibited); and 25 Pa. Code § 283.202 (relating to areas where resource recovery facilities and other processing facilities are prohibited).

§ 105.18. [Reserved].

Source

The provisions of this § 105.18 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; reserved February 18, 1983, February 19, 1983, 13 Pa.B. 781. Immediately preceding text appears at serial pages (59026) to (59027).

§ 105.18a. Permitting of structures and activities in wetlands.

(a) *Exceptional value wetlands.* Except as provided for in subsection (c), the Department will not grant a permit under this chapter for a dam, water obstruction or encroachment located in, along, across or projecting into an exceptional value wetland, or otherwise affecting an exceptional value wetland, unless the applicant affirmatively demonstrates in writing and the Department issues a written finding that the following requirements are met:

(1) The dam, water obstruction or encroachment will not have an adverse impact on the wetland, as determined in accordance with §§ 105.14(b) and 105.15 (relating to review of applications; and environmental assessment).

(2) The project is water-dependent. A project is water-dependent when the project requires access or proximity to or siting within the wetland to fulfill the basic purposes of the project.

(3) There is no practicable alternative to the proposed project that would not involve a wetland or that would have less effect on the wetland, and not have other significant adverse effects on the environment. An alternative is practicable if it is available and capable of being carried out after taking into consideration construction cost, existing technology and logistics. An area not presently owned by the applicant which could reasonably be obtained, utilized, expanded or managed to fulfill the basic purpose of the project shall be considered as a practicable alternative.

(4) The project will not cause or contribute to a violation of an applicable State water quality standard.

(5) The project will not cause or contribute to pollution of groundwater or surface water resources or diminution of resources sufficient to interfere with their uses.

(6) The cumulative effect of this project and other projects will not result in the impairment of the Commonwealth's exceptional value wetland resources.

(7) The applicant shall replace affected wetlands in accordance with § 105.20a (relating to wetland replacement criteria).

(b) *Other wetlands.* Except as provided for in subsection (c), the Department will not grant a permit under this chapter for a dam, water obstruction or encroachment in, along, across or projecting into the wetland which is not an exceptional value wetland, or otherwise affecting the wetland, unless the appli-

Copyright © 2005 Commonwealth of Pennsylvania

cant affirmatively demonstrates in writing and the Department issues a written finding that the following requirements are met:

(1) The project will not have a significant adverse impact on the wetland, as determined in accordance with §§ 105.14(b) and 105.15. The determination of whether an adverse impact is significant includes an evaluation of the following factors:

(i) The areal extent of the wetland impacts.

(ii) The wetland's values and functions.

(iii) Whether the affected wetlands values and functions are unique to the area or region.

(iv) Comments from other State and Federal environmental agencies concerning the scope and effect of the impact.

(2) Adverse environmental impacts on the wetland will be avoided or reduced to the maximum extent possible.

(3) There is no practicable alternative to the proposed project that would not involve a wetland or that would have less adverse impact on the wetland, and that would not have other significant adverse impacts on the environment. An alternative is practicable if it is available and capable of being carried out after taking into consideration construction cost, existing technology and logistics. An area not presently owned by the applicant which could reasonably be obtained, utilized, expanded or managed to fulfill the basic purpose of the proposed project shall be considered as a practical alternative.

(i) It shall be a rebuttable presumption that there is a practicable alternative, not involving a wetland, to a nonwater-dependent project, and that the alternative would have less adverse impact on the wetland.

(ii) To rebut the presumption, an applicant for a permit under this chapter shall demonstrate with reliable and convincing evidence and documentation and the Department will issue a written finding that the following statements are true:

(A) The basic project purpose cannot be accomplished utilizing one or more other sites that would avoid, or result in less, adverse impact on the wetland.

(B) A reduction in the size, scope, configuration or density of the project as proposed and alternative designs to that of the project as proposed that would avoid, or result in fewer or less severe, adverse impacts on a wetland will not accomplish the basic purpose of the project.

(4) The project will not cause or contribute to a violation of an applicable State water quality standard.

(5) The project will not cause or contribute to pollution of groundwater or surface water resources or diminution of the resources sufficient to interfere with their uses.

(6) The cumulative effect of this project and other projects will not result in a major impairment of this Commonwealth's wetland resources.

(7) The applicant will replace the affected wetlands to compensate for unavoidable impacts, in accordance with § 105.20a.

(c) The Department will not grant a permit under this chapter for a dam, water obstruction or encroachment which has a significant adverse impact on a wetland unless the applicant affirmatively demonstrates and the Department finds in writing that a project is necessary to abate a substantial threat to the public health or safety and that the requirements of subsection (b)(2)—(7) are met.

Source

The provisions of this § 105.18a adopted October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911.

Cross References

This section cited in 25 Pa. Code § 96.3 (relating to water quality protection requirements); and 25 Pa. Code § 105.16 (relating to environmental, social and economic balancing).

§ 105.19. Complete applications.

(a) An application for a permit is not complete until the necessary information and requirements under the act and this chapter, including proof of financial responsibility, have been satisfied by the applicant.

(b) When the Department determines that an application is incomplete or contains insufficient information to determine compliance with this chapter, it will notify the applicant in writing. The applicant shall then have 60 days to complete the application or the Department will consider the application to be withdrawn by the applicant. Requests for a specific extension may be sought by the applicant in writing. The applicant will be notified in writing when an application is considered withdrawn. When an application is considered withdrawn, the Department will close the application file and take no further action to review the file, unless the applicant requests the file to be reopened after submitting the previously identified information to complete the application and a new fee. Fees will not be refunded after an application is withdrawn.

Authority

The provisions of this § 105.19 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1—693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.19 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (126083) to (126084).

Copyright © 2005 Commonwealth of Pennsylvania

Cross References

This section cited in 25 Pa. Code § 105.16 (relating to environmental, social and economic balancing).

§ 105.20. Proof of financial responsibility.

(a) Prior to the approval of a permit under this chapter for construction or modification of a dam, water obstruction or encroachment which may present a substantial potential risk to life or property, the Department will require proof of financial responsibility or security for continued operation and maintenance during the lifetime of the facility. Dams, water obstructions or encroachments which may be subject to the proof of financial responsibility include, but are not limited to, Category 1 dams, Hazard Potential Classification, as defined in § 105.91 (relating to classification of dams and reservoirs) stream enclosures, bridges, levees, fills and floodwalls.

(b) As proof of responsibility or security, the Department may require one or more of the following:

(1) A certificate of public convenience from the Pennsylvania Public Utility Commission if the owner of the proposed facility is subject to regulation under 66 Pa.C.S. (relating to the Public Utility Code).

(2) Ownership or management of the facility by an agency of the Federal, State, county or municipal government or of an interstate compact.

(3) A bond or other legal device of a form acceptable to the Department, payable to the Commonwealth, which guarantees proper construction, repair, operation and maintenance, inspection and monitoring, and removal if necessary of the facility. The amount of bond or legal device shall be sufficient to cover the costs of entry, repair, correction, operation, maintenance, inspection, monitoring or removal of the facility by the Commonwealth in the event of failure of the owner to comply with orders of the Department, terms and conditions of the permit, this chapter and the act and section 302 of the Flood Plain Management Act (32 P. S. § 679.302).

Authority

The provisions of this § 105.20 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1—693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.20 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (126083) to (126084).

Cross References

This section cited in 25 Pa. Code § 105.16 (relating to environmental, social and economic balancing); 25 Pa. Code § 105.21 (relating to criteria for permit issuance and denial); 25 Pa. Code § 105.25 (relating to transfer of permits); and 25 Pa. Code § 105.442 (relating to authorization for general permits).

§ 105.20a. Wetland replacement criteria.

(a) Wetlands replacement shall meet the following general criteria:

(1) *Area ratio.* The wetland shall be replaced at a minimum area ratio of replacement acres to affected acres of 1:1. The Department may require the area ratio to exceed 1:1 based on a determination of the area affected and the functions and values which will be destroyed or adversely affected by the project. For structures or activities constructed without a permit, and for which mitigation, as defined in § 105.1 (relating to definitions), cannot be achieved, the wetland shall be replaced at a minimum area ratio of 2:1 (replacement acres: affected acres). The Department may require the area ratio to exceed 2:1 based on a determination of the area affected and the functions and values which were destroyed or adversely affected by the project.

(2) *Function and value replacement.* Functions and values that are physically and biologically the same as those that are lost shall be replaced at a minimum ratio of 1:1. The Department may require the functions and values ratio to exceed 1:1 based on the area affected and on the functions and values which will be destroyed as adversely affected by the project and the replacement ratio. For structures or activities constructed without a permit, and for which mitigation, as defined in § 105.1, cannot be achieved, the wetland shall be replaced at a minimum area ratio of 2:1. The Department may require the area ratio to exceed 2:1 based on a determination of the area affected and the functions and values which were destroyed or adversely affected by the project.

(3) *Siting criteria.* Replacement shall be located adjacent to the impacted wetland unless an alternative replacement site is approved by the Department. Alternative replacement sites will generally not be approved unless the replacement site is located within the same watershed as the wetland being replaced or within the designated boundaries of the coastal zone management area where the loss occurs.

(b) In addition to the general criteria in subsection (a), the Department will use its guidelines entitled ''*Design Criteria for Wetlands Replacement*'' in making decisions under this section. These guidelines provide for design, flexibility and utilization of best available technology in environmental engineering. These guidelines are available from the Division of Rivers and Wetlands Conservation, Post Office Box 8761, Harrisburg, Pennsylvania 17105-8761.

Copyright © 1996 Commonwealth of Pennsylvania

Authority

The provisions of this § 105.20a issued under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.20a adopted October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911.

Cross References

This section cited in 25 Pa. Code § 96.3 (relating to water quality protection requirements); 25 Pa. Code § 105.18a (relating to permitting of structures and activities in wetlands); and 25 Pa. Code § 105.21 (relating to criteria for permit issuance and denial).

PERMIT ISSUANCE, TRANSFER AND REVOCATION

§ 105.21. Criteria for permit issuance and denial.

(a) In addition to the other requirements of this chapter, a permit application will not be approved unless the applicant demonstrates that the following conditions are met:

(1) The application is complete and accurate.

(2) The proposed project or action complies with the standards and criteria of this title and with other laws administered by the Department, the Fish Commission and river basin commissions created by interstate compact.

(3) The proposed project or action will adequately protect public health, safety and the environment.

(4) The proposed project or action is consistent with the environmental rights and values secured by Pa. Const. Art. I, § 27 and with the duties of the Commonwealth as trustee to conserve and maintain public natural resources of this Commonwealth.

(5) The applicant has not been found to be in continuing violation of this title or other laws administered by the Department, the Fish Commission or a river basin commission, including, but not limited to, a violation of an adjudication and order, agreement, consent order or decree, whether or not the applicant's violation resulted in an order or civil penalty assessment.

(6) The applicant has submitted adequate proof of financial responsibility, if required under § 105.20 (relating to proof of financial responsibility).

(b) A permit issued under this chapter shall be subject to the general and special conditions regarding construction, operation, maintenance, inspection and monitoring of a project or action that the Department may deem necessary to assure compliance with the requirements and purposes of this chapter, the act, the Flood Plain Management Act (32 P. S. §§ 679.101—679.601) and other laws

administered by the Department, the Fish Commission and river basin commissions created by interstate compact.

(c) The Department may not issue a permit to operate and maintain a dam, water obstruction or encroachment constructed without a permit unless one of the following is met:

(1) The Department determines that the structure or activity complies with the standards and criteria of this title, including replacement in accordance with § 105.20a (relating to wetland replacement criteria), and with other laws administered by the Department, the Fish Commission and river basin commissions created by interstate compact.

(2) The Department determines that the structure or activity does not comply with the standards and criteria of this title and with other laws administered by the Department, the Fish Commission and river basin commissions created by interstate compact, that the effect on wetlands will be mitigated, and at least one of the following is met:

(i) Restoration would cause destruction of a dwelling occupied by a person who had no role in the planning or construction of the project.

(ii) Restoration may result in more long term damage than would be caused by allowing the project to remain in place.

(iii) Restoration would be unsuccessful due to material changes in the condition of the site and its surrounding area.

(iv) There are extraordinary circumstances which preclude restoration.

(d) The reason for denial of a permit application and appeal procedures shall be communicated in writing to the applicant.

(e) In an appeal from a Department action concerning a permit application to operate and maintain a dam, water obstruction or encroachment, the applicant has the burden of proving that there is no reasonable basis for the Department's action.

Authority

The provisions of this § 105.21 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.21 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended November 2, 1979, effective November 3, 1979, 9 Pa.B. 3640; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial page (117657).

Copyright © 2001 Commonwealth of Pennsylvania

Notes of Decisions

The terms and conditions attached to a dredging permit are terms and conditions of the permit, as authorized under this section rather than rules and regulations. *Warren Sand and Gravel Co. v. Department of Environmental Resources*, 341 A.2d 556 (Pa. Cmwlth. 1975).

Cross References

This section cited in 25 Pa. Code § 105.442 (relating to authorization for general permits).

§ 105.21a. Public notice.

Except for dams, water obstructions and encroachments authorized under §§ 105.12, 105.64 and Subchapter L (relating to waiver of permit requirements; emergency permit; and general permits), or as small projects, the Department will publish a notice in the *Pennsylvania Bulletin* upon receipt of an application and again upon the issuance or denial of a permit by the Department.

Authority

The provisions of this § 105.21a issued under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.21a adopted October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911.

§ 105.22. [Reserved].

Source

The provisions of this § 105.22 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 12, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; reserved October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117657) to (117658).

§ 105.23. Compliance with other applicable statutes.

Receipt of a permit under the provisions of this chapter shall not relieve the permittee of the obligation of complying with Federal, interstate compact and State laws, regulations and standards applicable to the construction, operation or maintenance of the dam or water obstruction.

Source

The provisions of this § 105.23 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (47982).

§ 105.24. Coordination of permits.

(a) The Department will establish a system to coordinate the application for and issuance of permits under this chapter with permit processes conducted under other statutes and regulations administered by the Department and with permit processes administered by other Federal and State agencies.

(b) When possible, the Department will develop joint permit application forms to facilitate the submission of information on related activities of a project regulated under statutes and regulations administered by the Department and other Federal and State agencies, to reduce duplicate and repetitious application requirements. The joint application forms shall be used in lieu of individual applications for the required permits, except for small projects.

Authority

The provisions of this § 105.24 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Notes of Decisions

The EHB did err in determining that DER did not abuse its discretion by soliciting comments from the Fish and Boating Commission and other agencies when reviewing the petitioner's permit. *Hatchard v. Department of Environmental Resources*, 612 A.2d 621 (Pa. Cmwlth. 1992).

Source

The provisions of this § 105.24 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended October 6, 1978, effective October 7, 1978, 8 Pa.B. 2723; amended November 2, 1979, effective November 3, 1979, 9 Pa.B. 3640; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial page (117658).

§ 105.25. Transfer of permits.

(a) A permit may be transferred to a new owner if there is a change of ownership of the dam, water obstruction or encroachment.

(b) A permit may be transferred only upon application to and approval by the Department. An application for transfer shall be submitted upon forms provided by the Department.

(c) A permit may not be transferred if a violation of this chapter exists at the time of application for transfer unless the transfer will expedite correction of the violation.

(d) The new owner shall expressly agree to abide by the permit conditions and shall, if applicable:

(1) Provide the Department with proof of financial responsibility and security in accordance with § 105.20 (relating to proof of financial responsibility).

Copyright © 1997 Commonwealth of Pennsylvania

(2) Obtain a license, easement, right-of-way or other interest in the submerged lands of this Commonwealth in accordance with §§ 105.31—105.35 (relating to submerged lands of the Commonwealth—licenses and annual charges).

(e) The original permittee will not be relieved of an obligation to comply with this chapter, the terms and conditions of the permit or an order issued by the Department until the transfer has been approved.

(f) Upon receipt of the approved application for transfer, the applicant shall affix the approved application for transfer to the original permit. The approved application for transfer shall become part of, and remain affixed to, the original permit, until the Department issues a new permit.

Authority

The provisions of this § 105.25 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.25 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117658) to (117659).

§ 105.26. Revocation and suspension of permits.

(a) Failure to comply with a provision of this chapter, an order of the Department, or a term or condition of a permit issued under this chapter will be cause for the Department to revoke or suspend a permit.

(b) The Department will issue to the permittee a written notice of the suspension or revocation of a permit. The notice shall be subject to the procedure for appeal and hearing before the Environmental Hearing Board as provided by section 24 of the act (32 P. S. § 693.24); section 1921-A of The Administrative Code of 1929 (71 P. S. § 510-21), and 2 Pa.C.S. §§ 501—508 and 701—704 (relating to the Administrative Agency Law).

Source

The provisions of this § 105.26 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38854).

§ 105.27. [Reserved].

Source

The provisions of this § 105.27 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38854).

§ 105.28. [Reserved].

Source

The provisions of this § 105.28 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38854) to (38855).

§ 105.29. [Reserved].

Source

The provisions of this § 105.29 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38855).

§ 105.29a. Burden of proof.

In a civil or administrative action taken by the Department under this chapter, the person against whom the action has been taken has the burden of proof to demonstrate that the project complies with the act and this chapter.

Authority

The provisions of this § 105.29a issued under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.29a adopted October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911.

§ 105.30. [Reserved].

Source

The provisions of this § 105.30 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38855).

SUBMERGED LANDS OF THE COMMONWEALTH—LICENSES AND ANNUAL CHARGES

§ 105.31. Property rights.

(a) Except as provided in §§ 105.32 and 105.33 (relating to projects—proper purpose; and licenses for public service corporations), no permit issued under this chapter may give real or personal property rights nor grant exclusive privileges; nor may it be construed to grant or confer a right, title, easement or interest in, to or over lands belonging to this Commonwealth.

(b) No permit for a dam, water obstruction or encroachment to occupy submerged lands of the Commonwealth will be issued by the Department until the applicant has first obtained one of the following:

Copyright © 2005 Commonwealth of Pennsylvania

(1) An easement, right-of-way, license or lease from the Department under section 15 of the act (32 P. S. § 693.15) and § 105.32.

(2) A license under section 514 of The Administrative Code of 1929 (71 P. S. § 194) and § 105.33.

(3) A license, easement, right-of-way or other interest in the submerged lands of this Commonwealth granted under specific statutory authority from the General Assembly.

(c) For purposes of this section, to occupy submerged lands of this Commonwealth includes:

(1) The placement of a physical structure on, under or over submerged lands of this Commonwealth.

(2) The use or control of the space overlying submerged lands of this Commonwealth, associated with use of a structure with the regularity and in a manner that substantially restrict or prevent navigation, fishing, recreation or other public trust uses by the general public on or over the lands.

Source

The provisions of this § 105.31 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38855).

Cross References

The provisions of this § 105.25 (relating to transfer of permits).

§ 105.32. Projects—proper purpose.

(a) If the applicant does not have an estate or interest in the submerged lands of this Commonwealth under other specific authority from the General Assembly at the time of application for a permit under the act, the Department may, with the approval of the Governor, grant an easement, right-of-way, license or lease to occupy submerged lands of this Commonwealth in a navigable lake or river or stream declared a public highway for a dam, water obstruction or encroachment regulated under this chapter which is constructed for the purpose of:

(1) Improving navigation or public transportation.

(2) Recreation, fishing or other public trust purposes.

(3) Protecting public safety or the environment.

(4) Providing water supply, energy production or waste treatment.

(5) Providing a public utility service by a government agency or subdivision, public utility or electric cooperative.

(6) Other activities which require access to water.

(b) The total area of land which any such project may occupy under one or more easements, rights-of-way, licenses or leases granted by the Department under this section may not exceed 25 acres.

Source

The provisions of this § 105.32 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38855) to (38856).

Cross References

This section cited in 25 Pa. Code § 105.25 (relating to transfer of permits); 25 Pa. Code § 105.31 (relating to property rights); and 25 Pa. Code § 105.35 (relating to charges for use and occupation of submerged lands of this Commonwealth).

§ 105.33. Licenses for public service corporations.

In accordance with section 514 of The Administrative Code of 1929 (71 P. S. § 194), a permit issued to a public service corporation to place a public service line upon, in or over submerged land of this Commonwealth will incorporate a license for the privilege of crossing Commonwealth lands.

Source

The provisions of this § 105.33 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (4577) to (4578).

Cross References

This section cited in 25 Pa. Code § 105.25 (relating to transfer of permits); and 25 Pa. Code § 105.31 (relating to property rights).

§ 105.34. Navigation and public trust.

No easement, right-of-way, lease or license will be granted by the Department if it may adversely affect navigation or significantly impair the right in lands of the public held in trust by this Commonwealth.

Source

The provisions of this § 105.34 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (4578).

Cross References

This section cited in 25 Pa. Code § 105.25 (relating to transfer of permits).

§ 105.35. Charges for use and occupation of submerged lands of this Commonwealth.

(a) Except as provided in subsections (b) and (c), the following charges apply to the granting of an easement, right-of-way, license or lease to occupy submerged lands of this Commonwealth issued under section 15 of the act (32 P. S. § 693.15) and § 105.32 (relating to projects—proper purpose):

Copyright © 2005 Commonwealth of Pennsylvania

(1) For commercial utility and other dams, water obstructions and encroachments except as listed in subsection (c), annual license charges:

(i) For areas occupied by facilities, $50 per tenth of an acre.

(ii) For barge fleeting and mooring areas, $10 per tenth of an acre.

(iii) Minimum annual charge, $250.

(2) For private recreation docks, owned and used solely by the owners of adjacent riparian property, unless the project is otherwise authorized by a general permit issued under section 7 of the act (32 P. S. § 693.7), an annual charge of $250.

(b) Licenses for public service lines crossing or occupying submerged lands of this Commonwealth, issued under section 15 of the act or section 514 of The Administrative Code of 1929 (71 P. S. § 194) are subject to the following schedule of annual charges:

Length of Crossings (in feet)	*Charges (in dollars)*
Less than 500	$250
500 to 999	500
1000 to 1499	1000
1500 to 1999	1500
2000 to 2499	2000
2500 to 2999	2500
3000 to 3499	3000
3500 to 3999	3500
4000 to 4499	4000
4500 to 4999	4500
5000 and over	5000

(c) Charges may not be imposed under section 15 of the act or section 514 of The Administrative Code of 1929 for the following categories of activities and structures:

(1) An activity or structure constructed, owned or operated by a department, commission or agency of the Commonwealth or the Federal government.

(2) A project or activity constructed, or operated primarily for the benefit of a State building or a State institution.

(3) A flood control project constructed, owned or operated by an agency of the Commonwealth, the Federal government or a municipality.

(4) A project or activity constructed, owned or operated by a political subdivision of the Commonwealth which provides potable water supply, sewage disposal or other similar services necessary for public health and welfare, or in connection with a service for which no fees or charges other than general taxes are imposed.

(5) A facility to provide access to the general public to water for recreational boating, fishing, hunting, swimming or other recreation where the access is provided without charge or on a nonprofit basis.

(6) A structure or facility constructed and operated exclusively to improve fish habitat, under a cooperative agreement with the Fish Commission.

(7) A private recreational dock constructed under a general permit.

(d) The annual charges imposed in subsections (a) and (b) may be revised by the EQB after approval by the Governor and reasonable notice to the holder of a license issued under this section.

(e) This section does not apply to a crossing contiguous to or in a State park or State forest lands. Easements for the crossings shall be administered in accordance with section 514 of The Administrative Code of 1929 and the park and forest land management practices of the Department.

(f) The removal of sand, gravel and other valuable minerals from submerged lands of this Commonwealth are subject to the royalty and agreement provisions established under section 1908-A of The Administrative Code of 1929 (71 P. S. § 510-8).

Authority

The provisions of this § 105.35 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.35 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117662) to (117664).

Cross References

This section cited in 25 Pa. Code § 105.25 (relating to transfer of permits).

§ 105.36. [Reserved].

Source

The provisions of this § 105.36 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229. Immediately preceding text appears at serial page (4579).

Copyright © 2005 Commonwealth of Pennsylvania

§ 105.37. [Reserved].

Source

The provisions of this § 105.37 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229. Immediately preceding text appears at serial page (4579).

§ 105.38. [Reserved].

Source

The provisions of this § 105.38 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229. Immediately preceding text appears at serial pages (4579) to (4580).

§ 105.39. [Reserved].

Source

The provisions of this § 105.39 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229. Immediately preceding text appears at serial page (4580).

§ 105.40. [Reserved].

Source

The provisions of this § 105.40 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229. Immediately preceding text appears at serial page (4580).

CONSTRUCTION REQUIREMENTS AND PROCEDURES

§ 105.41. Notices and reports.

(a) The permittee shall notify the Department, in writing, of the proposed time for commencement of work at least 15 days prior to the commencement of construction.

(b) The Department may require submission of the reports as it deems necessary on the status of construction.

Authority

The provisions of this § 105.41 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.41 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial page (117665).

Cross References

This section cited in 25 Pa. Code § 105.445 (relating to waiver of certain requirements).

§ 105.42. Acknowledgment of conditions.

(a) Upon receipt of a permit, the permittee shall sign the permit thereby expressly certifying the permittee's acceptance of, and agreement to comply with, the terms and conditions of the permit. The permittee shall return a signed copy of the permit to the Department. The permit will not be effective until the signed copy of the permit is received by the Department.

(b) The permittee shall fully inform the engineer or contractor responsible for the supervision and conduct of work covered by a permit issued under this chapter of the terms, conditions, restrictions and covenants of the permit.

(c) Prior to the commencement of construction, the permittee shall file with the Department in writing, on a form provided by the Department, a statement signed by the permittee and an individual responsible for the supervision or conduct of the construction work acknowledging and accepting the general and special conditions contained in the permit. Unless the acknowledgment and acceptance have been filed, the permit is void.

(d) A copy of the permit and the acknowledgment shall be available at the work site for inspection upon request by an officer or agent of the Department or another Federal, State, county or municipal agency.

Authority

The provisions of this § 105.42 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.42 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117665) to (117666).

Cross References

This section cited in 25 Pa. Code § 105.445 (relating to waiver of certain requirements).

Copyright © 2005 Commonwealth of Pennsylvania

§ 105.43. Time limits.

(a) The Department will set time limits for the commencement and completion of work under a permit issued under this chapter that it deems reasonable and appropriate to carry out the purposes of this chapter.

(b) If the work is not completed on or before the dates set by the Department, unless extended by the Department in writing, the permit shall become void without further notification being required.

Source

The provisions of this § 105.43 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended effective September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (4581).

§ 105.44. Implementation of work according to specifications.

(a) Work undertaken under a permit issued under this chapter shall be conducted in accordance with the maps, plans, profiles and specifications as approved by the Department.

(b) No changes in the maps, plans, profiles and specifications for work covered by a permit which would affect the waterway area or structural stability of the project may be made except with the written approval of the Department. Upon written approval by the Department, the changes shall become part of the permit.

(c) The Department will have the right during the progress of work to require changes or modifications in the maps, plans, profiles and specifications for work covered under a permit it may determine are necessary and proper to protect public health, public safety and the environment.

Source

The provisions of this § 105.44 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.45. Inspections.

Work, structures and land covered under a permit issued under this chapter shall at all times be subject to inspection by representatives of the Department, and the permittee shall allow representatives of the Department to enter a property, premises or place associated with the permit for the purposes of the inspection.

Source

The provisions of this § 105.45 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.46. Implementation of erosion and sedimentation control plans.

(a) During the construction of a dam, water obstruction or encroachment, the permittee shall follow the erosion and sedimentation control plan prepared in accordance with Chapter 102 (relating to erosion and sediment control) and submitted with and approved as part of his application.

(b) Construction shall be done in a manner so as to minimize erosion of banks and bed of the stream and disturbance of the regimen of the stream.

Source

The provisions of this § 105.46 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.46a. Collection and disposal of waste materials.

Waste materials, scrap or excess construction materials shall be collected, stored and disposed of in accordance with the Solid Waste Management Act (35 P. S. §§ 6018.101—6018.1003), the Municipal Waste Planning, Recycling and Waste Reduction Act (53 P. S. §§ 4000.101—4000.1904), The Clean Streams Law (35 P. S. §§ 691.1—691.1001) and related rules and regulations.

Authority

The provisions of this § 105.46a issued under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.46a adopted October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911.

§ 105.47. Removal of structures.

(a) If construction work has not been completed within the time specified in the permit and the time limit specified in the permit has not been extended in writing by the Department or if a permit has been revoked for any reason, the permittee shall, at his own expense and in a manner that the Department may prescribe, remove all or any portion of the work as the Department requires and restore the water course and floodplain to their former condition.

Copyright © 2005 Commonwealth of Pennsylvania

(b) Prior to discontinuing use or abandonment, the owner of a structure covered by this chapter, regardless of whether or not it was constructed under a permit from this Department or its predecessors, shall remove all or part of the facility and take other actions as are necessary to protect safety and the environment in accordance with a permit issued by the Department.

Source

The provisions of this § 105.47 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

OPERATION, MAINTENANCE AND INSPECTION

§ 105.51. Operation and maintenance.

The permittee or owner of a dam, water obstruction or encroachment shall operate and maintain the facility and appurtenant structures in a safe condition in accordance with permit terms and conditions and the provisions of this chapter so that the facility cannot imperil life, health, safety or property located above or below the facility.

Source

The provisions of this § 105.51 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38858).

Cross References

This section cited in 25 Pa. Code § 105.131 (relating to operation and monitoring plans).

§ 105.52. Inspection.

Regardless of the date of construction of a dam, water obstruction or encroachment or whether or not it was permitted by the Department or its predecessors, it shall be the duty of the permittee or owner of a dam, water obstruction or encroachment to evaluate the safety of the facility and appurtenant structures and to modify the facility in accordance with the permit requirements of § 105.11 (relating to permit requirements) to ensure protection of life and property in accordance with changed conditions and current safety criteria.

Source

The provisions of this § 105.52 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Cross References

This section cited in 25 Pa. Code § 105.131 (relating to operation and monitoring plans).

§ 105.53. Inspections by owners and inspection reports.

The permittee or owner of a dam, water obstruction or encroachment shall inspect the facility and appurtenant works according to the following schedule:

(1) Dams, reservoirs and their appurtenant works shall be inspected at least once every 3 months.

(2) For Category 1 dams and Category 2 dams as classified in § 105.91 (relating to classification of dams and reservoirs), which are defined as high hazard dams in § 105.1 (relating to definitions), annual reports regarding the condition of the dam, certified by a registered professional engineer, shall be submitted to the Department on or before December 31 of each year. More frequent reports of dam conditions may be required by the Department if in its discretion conditions indicate the reports are necessary to assure adequate protection of health, safety and property.

(3) For local flood protection projects, annual reports regarding the condition of the flood protection facility shall be submitted to the Department on or before December 31 of each year.

(4) The owner of a water obstruction or encroachment shall conduct periodic inspections to ensure the safe operation, monitoring and maintenance of the facility in accordance with this title, terms and conditions of the permit and approved operating or monitoring plans.

(5) The owner shall retain records of the inspections, including records of actions taken to correct conditions found in the inspections. Copies of the records shall be provided to the Department on request.

(6) The Department may, through terms and conditions of the permit or by request at any time, require the owner to submit certified reports regarding the condition of the facility to the Department.

(7) In lieu of inspections conducted by the owner and certified reports submitted by the owner, the Department may accept reports of equivalent inspections conducted and prepared by governmental agencies. In addition, the Department may accept equivalent inspection reports certified by the owner and submitted to other governmental agencies.

Authority

The provisions of this § 105.53 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.53 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117668) to (117669).

Copyright © 1996 Commonwealth of Pennsylvania

Cross References

This section cited in 25 Pa. Code § 105.131 (relating to operation and monitoring plans); 25 Pa. Code § 105.132 (relating to inspection); 25 Pa. Code § 105.281 (relating to maintenance and repair of levees or floodwalls); and 25 Pa. Code § 105.445 (relating to waiver of certain requirements).

§ 105.54. Monitoring systems.

The permittee or owner of a dam, water obstruction or encroachment shall set up and implement monitoring systems that are required by the Department in the terms and conditions of the permit.

Source

The provisions of this § 105.54 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Cross References

This section cited in 25 Pa. Code § 105.131 (relating to operation and monitoring plans).

INVESTIGATION AND CORRECTION OF UNSAFE CONDITIONS—EMERGENCY PROCEDURES

§ 105.61. Procedures for investigations.

The Department may, if it finds there is reasonable cause to suspect the existence of conditions adversely affecting the safety of a dam, water obstruction or encroachment, order the owner to conduct investigations, studies, tests and analyses that may be required to properly evaluate the safety of the structure. The investigations, studies, tests and analyses shall be accomplished under the supervision of a registered professional engineer, experienced in the design, construction, operation and maintenance of the facilities and approved by the Department, and shall be accomplished in accordance with methods the Department may prescribe. Failure to provide the investigation results to the Department on request will constitute adequate grounds for revocation or suspension of a permit.

Source

The provisions of this § 105.61 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38858) to (38860) and (47990).

§ 105.62. Correction of unsafe conditions.

(a) If the Department determines that a dam, water obstruction or encroachment is unsafe or adversely affects property or the environment or has not been properly constructed, operated, monitored or maintained in compliance with legal requirements, it may require the owner of the facility to repair, alter, maintain or

remove the facility or take other actions necessary to carry out the purposes of this chapter within the time prescribed by the Department.

(b) The Department or its authorized agents may enter and conduct investigations, tests and analyses and take corrective action required to carry out the purposes of this chapter if one or more of the following conditions exist:

(1) The owner cannot be ascertained or found.

(2) The owner refuses or fails to comply with an order issued by the Department under section 14 of the act (32 P. S. § 693.14) or this section.

(3) The condition of the facility is so dangerous as to require immediate remedial action.

(c) The Department may recover from the owner, in the name of the Commonwealth, the expenses incurred in taking the action described in subsection (b) in the same manner as debts are recoverable by law.

Source

The provisions of this § 105.62 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; added September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (4584).

§ 105.63. Emergency procedures.

(a) The permittee or owner of a dam, water obstruction or encroachment shall immediately notify the Department and responsible authorities in adjacent and downstream communities, including emergency management authorities, of a condition which may threaten the safety of the facility and take necessary actions to protect life and property, including action required under an emergency plan or Department order issued under the act.

(b) The permittee or owner of a dam or reservoir shall immediately notify the Department and responsible emergency management authorities in adjacent and downstream communities of conditions which may indicate a potential dam hazard emergency including, but not limited to, one or more of the following conditions:

(1) Sliding of upstream or downstream slopes or abutments contiguous to the dam.

(2) Sudden subsidence of the crest of the dam.

(3) Longitudinal or transverse cracking of the crest of the dam.

(4) Unusual release of water from the downstream face or toe of the dam.

(5) Other unusual conditions at the downstream slope of the dam.

(6) Significant landslides in the reservoir area.

(c) In case of emergency, telephone calls should be directed to the Pennsylvania Emergency Management Agency at (717) 783-8150 or the Department's emergency number at (717) 787-4343.

Copyright © 1996 Commonwealth of Pennsylvania

Authority

The provisions of this § 105.63 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.63 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117671) to (117672).

Cross References

This section cited in 25 Pa. Code § 105.135 (relating to dam hazard emergencies).

§ 105.64. Emergency permit.

The Department may issue emergency permits if it finds that immediate remedial action is necessary to alleviate an imminent threat to life, property or the environment.

(1) The emergency permit will be provided in writing, on a form developed for this purpose.

(2) The emergency permit will contain conditions as the Department determines appropriate.

(3) The Department may institute proceedings, legal or administrative, that it deems appropriate for violations of the emergency permit or conditions of the emergency permit.

(4) If the municipality in which the emergency occurs has waived notice, the emergency permit is effective immediately. If notice has not been waived by the municipality, the emergency permit is effective 30 days after notice is sent to the municipality in which the emergency occurred. The emergency permit will expire in 30 days unless extended in writing by the Department.

(*Editor's Note*: The act of August 14, 1991 (P. L. ___ , No. 35) supersedes the first two sentences of § 105.64(4).)

Authority

The provisions of this § 105.64 issued under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1—693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.64 adopted October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911.

Cross References

This section cited in 25 Pa. Code § 105.21a (relating to public notice).

Subchapter B. DAMS AND RESERVOIRS

GENERAL PROVISIONS

Sec.
105.71. Scope.
105.72. [Reserved].
105.73. [Reserved].
105.74. [Reserved].
105.75. [Reserved].
105.76. [Reserved].
105.77. [Reserved].
105.78. [Reserved].
105.79. [Reserved].

PERMITS

105.81. Permit applications for construction and modification of dams and reservoirs.
105.82. Permit applications for operation and maintenance of existing dams and reservoirs.
105.83—105.87. [Reserved].

CLASSIFICATION AND DESIGN CRITERIA

105.91. Classification of dams and reservoirs.
105.92. Foundations.
105.93. Design stress.
105.94. Spillways.
105.95. Freeboard.
105.96. Outlet works.
105.97. Stability of structure.
105.98. Design flood criteria.
105.99. Dams in subdivision developments.

CONSTRUCTION REQUIREMENTS AND PROCEDURES

105.101. Notices and reports.
105.102. Personnel and supervision.
105.103. Weather and ground conditions.
105.104. Removal and disposal of vegetation.
105.105. [Reserved].
105.106. Activities and facilities on the construction site.
105.107. Completion certificate and final plans.

Copyright © 1999 Commonwealth of Pennsylvania

WATER STORAGE AND DISCHARGE

105.111. Commencement of water storage.
105.112. Stream flow during construction, filling and repair.
105.113. Releases.
105.114. [Reserved].

PROTECTION AND RESTORATION OF AQUATIC LIFE

105.121. Fishways.
105.122. Drawdown of impounded waters.
105.123. Restoration of aquatic life.
105.124. [Reserved].
105.125. [Reserved].

OPERATION, MAINTENANCE AND EMERGENCIES

105.131. Operation and monitoring plans.
105.132. Inspection.
105.133. Directed repairs.
105.134. Emergency warning system and operation plan.
105.135. Dam hazard emergencies.
105.136. Unsafe dams.

Cross References

This subchapter cited in 25 Pa. Code § 105.14 (relating to review of applications).

GENERAL PROVISIONS

§ 105.71. Scope.

Except as provided in §§ 105.3 and 105.12 (relating to scope; and waiver of permit requirements), this subchapter governs the construction, alteration, enlargement, repair, maintenance, operation and removal of a dam or reservoir regulated under the act.

Source

The provisions of this § 105.71 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended November 29, 1974, effective December 16, 1974, 4 Pa.B. 2452; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (47990) to (47991).

§ 105.72. [Reserved].

Source

The provisions of this § 105.72 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (47991).

§ 105.73. [Reserved].

Source

The provisions of this § 105.73 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended November 29, 1974, effective December 16, 1974, 4 Pa.B. 2452 amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (47991).

§ 105.74. [Reserved].

Source

The provisions of this § 105.74 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (47992).

§ 105.75. [Reserved].

Source

The provisions of this § 105.75 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (47992).

§ 105.76. [Reserved].

Source

The provisions of this § 105.76 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (47992).

§ 105.77. [Reserved].

Source

The provisions of this § 105.77 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (47992) to (47993).

§ 105.78. [Reserved].

Source

The provisions of this § 105.78 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (47993) to (47994).

Copyright © 1999 Commonwealth of Pennsylvania

§ 105.79. [Reserved]

Source

The provisions of this § 105.79 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (47994).

PERMITS

§ 105.81. Permit applications for construction and modification of dams and reservoirs.

(a) In addition to the information required by § 105.13 (relating to permit applications—information and fees), permit applications under this subchapter for the construction or modification of dams and reservoirs shall give the following information:

(1) The name and address of the applicant.

(2) The location, type, size, height and purpose of the proposed dam and reservoir and appurtenant works.

(3) For projects involving storage of fluids or semifluids other than water, information concerning the chemical content, viscosity and other pertinent physical characteristics of the fluid or semifluid impounded.

(4) The storage capacity and reservoir surface areas for normal pool and maximum high water.

(5) Plans for purposed permanent monitoring of performance by instrument installations in the dam, including the purposes of the instrumentation. If no instrumentation is considered necessary, reasons for this judgment may be stated.

(6) As accurately as may be readily obtained, the area of the drainage basin, pertinent rainfall and streamflow records, and flood flow records and estimates.

(7) The proposed time for commencement and anticipated completion of construction.

(8) The method and schedule of operation of the dam including an emergency warning system and operation plan if required under § 105.134 (relating to emergency action plan).

(9) Plans for control of erosion and water pollution during the anticipated construction operations including plans for adequate measures to limit the erosion of the soil from exposed slopes after completion of construction. The plans shall indicate that adequate control measures will be taken during construction to protect the quality of stream flow below the project site. The application shall include a copy of a letter from the conservation district in the county where the project is located indicating that the district reviewed the erosion and sediment control plan of the applicant and considers it to be satisfactory.

(10) Proof of title or adequate flowage easements for land area below the top of the dam elevation that is subject to inundation.

(11) Other information the Department may require.

(b) The application shall be accompanied by a design report, construction plans and specifications, in sufficient detail to evaluate the safety, adequacy and suitability of the proposed work.

(c) The applicant shall conduct and submit the results of the investigations and tests as the Department, in its judgment, believes are necessary to determine the safety, adequacy and suitability of design, including but not limited to:

(1) Data concerning subsoil and rock foundation conditions and the materials entering into the construction of the dam or reservoir.

(2) Data concerning exploratory pits, drilling, coring and tests to determine seepage rates.

(3) Data concerning the strength tests necessary to measure the physical properties and behavior of foundation and embankment materials at the dam or reservoir site.

(4) Data concerning the geology of the dam or reservoir area, indicating possible hazards such as faults, weak seams and joints.

(5) Data concerning availability and quality of construction materials.

(6) Other information as may be necessary, including the design calculations for the dam, which shall be made available to the Department on request.

(d) Plans and specifications and the results of tests or investigations shall be prepared under the supervision of and certified by a registered professional engineer experienced in dam design and construction and assisted by qualified engineers, geologists and other specialists, when necessary.

Source

The provisions of this § 105.81 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 12, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (47994) and (38864).

§ 105.82. Permit applications for operation and maintenance of existing dams and reservoirs.

(a) In addition to information required by §§ 105.13 and 105.14 (relating to permit applications—information and fees; and review of applications), a permit application for the operation and maintenance of existing dams and reservoirs shall give the following information:

(1) The name and address of the applicant.

(2) The location, type, size, height and purpose of the existing dam and reservoir and appurtenant works.

Copyright © 1996 Commonwealth of Pennsylvania

(3) For projects involving storage of fluids or semifluids other than water, information concerning the chemical and physical characteristics of the fluid or semifluid impounded.

(4) The storage capacity and reservoir surface areas for normal pool and maximum high water.

(5) A description of facilities and plans for monitoring the performance of the dam.

(6) Information on the area of the drainage basin, rainfall and stream flow records, and flood flow records and estimates, when available.

(7) Information readily available regarding the foundation, specifications and construction of the dam.

(8) The method and schedule of operation of the dam, if deemed necessary by the Department.

(9) The emergency warning plan for the dam or reservoir, if completed, or work plan to prepare and submit an emergency warning plan in accordance with §§ 105.131 and 105.134 (relating to operation and monitoring plans; and emergency action plan).

(10) Proof of title or flowage easements for land areas below the top of the dam elevation that is subject to inundation.

(11) Reports of the most recent inspections of the dam conducted by the owner or by the State or Federal government agencies.

(12) Other information as the Department may require.

(b) The Department may waive or modify one or more of the application content requirements set forth in subsection (a) if the information required is not available and is not essential to determining the safety of the dam or reservoir or compliance by the dam or reservoir with the requirements of this chapter.

Source

The provisions of this § 105.82 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38864).

§ 105.83. [Reserved].

Source

The provisions of this § 105.83 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38864).

§ 105.84. [Reserved].

Source

The provisions of this § 105.84 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38864).

§ 105.85. [Reserved].

Source

The provisions of this § 105.85 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38864) to (38865).

§ 105.86. [Reserved].

Source

The provisions of this § 105.86 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38865).

§ 105.87. [Reserved].

Source

The provisions of this § 105.87 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38865).

CLASSIFICATION AND DESIGN CRITERIA

§ 105.91. Classification of dams and reservoirs.

(a) A dam or reservoir shall be classified in accordance with size and the hazard potential which might occur in the event of an operational or structural failure. In approving a hazard potential classification, the Department will consider, without limitation:

(1) The height of the dam and storage capacity of the reservoir.

(2) The physical characteristics and extent of actual and projected development of the dam site and downstream areas.

(3) The relationship of the site to existing or projected industrial, commercial and residential areas and other land uses downstream which may be affected by a dam failure.

(b) The following shall be the classifications and descriptions as used in this subchapter:

Copyright © 2005 Commonwealth of Pennsylvania

SIZE CLASSIFICATION*

Class	*Impoundment Storage (Acre Feet)*	*Dam Height (Feet)*
A	Equal to or greater than 50,000	Equal to or greater than 100
B	Less than 50,000 but greater than 1000	Less than 100 but greater than 40
C	Equal to or less than 1000	Equal to or less than 40

*Note: Size classification may be determined by either storage or height of structure, whichever gives the higher category.

HAZARD POTENTIAL CLASSIFICATION

Extent of Development

Category	*Loss of Life*	*Economic Loss*
1	Substantial	Excessive (extensive residential, commercial, agricultural and substantial public inconvenience)
2	Few (no rural communities or urban developments and no more than a small number of habitable structures)	Appreciable (damage to private or public property and short duration public inconvenience)
3	None expected (no permanent structure for human habitation)	Minimal (undeveloped or occasional structures with no significant effect on public inconvenience)

Authority

The provisions of this § 105.91 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.91 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117680) and (149139).

Cross References

This section cited in 25 Pa. Code § 87.112 (relating to hydrologic balance: dams, ponds, embankments and impoundments—design, construction and maintenance); 25 Pa. Code § 90.112 (relating to hydrologic balance: dams, ponds, embankments and impoundments—design, construction and maintenance); 25 Pa. Code § 105.12 (relating to waiver of permit requirements); 25 Pa. Code § 105.13 (relating to permit applications—information and fees); 25 Pa. Code § 105.20 (relating to proof of financial responsibility); 25 Pa. Code § 105.53 (relating to inspections by owners and inspection reports); 25 Pa. Code § 105.98 (relating to design flood criteria); and 25 Pa. Code § 105.442 (relating to authorization for general permits).

§ 105.92. Foundations.

(a) The foundation of a dam or reservoir shall be stable under all probable conditions.

(b) In analyzing the stability of the foundation of a proposed or existing dam or reservoir, the applicant shall consider all of the following factors:

(1) The seismic forces at the site.

(2) The shearing strength of the foundation.

(3) Settlement and subsidence.

(4) Leakage, permeability and solubility.

Source

The provisions of this § 105.92 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38865).

§ 105.93. Design stress.

In the construction of dams and reservoirs, allowable stresses shall conform to the current standards accepted by the engineering profession.

Source

The provisions of this § 105.93 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 12, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (47996).

§ 105.94. Spillways.

(a) Every dam shall be provided with a spillway system which is capable of safely conveying the design flood of the dam without endangering the safety or integrity of the dam.

(b) Each spillway shall include a satisfactory means of dissipating the energy flow at its outlet to assure conveyance of flow without endangering the safety and integrity of the dam or the natural environment of the stream.

Copyright © 1996 Commonwealth of Pennsylvania

Source

The provisions of this § 105.94 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; added September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (4588).

§ 105.95. Freeboard.

Sufficient freeboard may be required to prevent overtopping of the dam and to allow for wave and ice action.

Authority

The provisions of this § 105.95 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.95 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; added September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial page (149140).

§ 105.96. Outlet works.

(a) Dams shall include a device to permit the draining of the reservoir within a reasonable period of time as determined by the Department unless the Department determines that an outlet works is not feasible for a specific dam.

(b) In determining the reasonable time period for drainage of the reservoir, the Department may consider, without limitation, the following factors:

(1) The damage potential posed by possible failure of the dam.

(2) The risk and nature of potential failure and the time likely to be available to avert the failure after notice of conditions threatening the safety or stability of the dam.

(3) The purpose of the dam and reservoir.

(4) The capacity and stability of available drainage courses to convey the waters released from the reservoir in the event of emergency drainage.

(5) The influence of rapid drawdown on the stability of the dam, its appurtenant works and the upstream natural slopes of the reservoir.

(c) Each outlet works shall include a means of dissipating the energy of flow at its outlet to assure conveyance of flow without endangering the safety and integrity of the dam or the natural environment of the stream.

Source

The provisions of this § 105.96 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.97. Stability of structure.

(a) Dams shall be structurally sound and shall be constructed of sound and durable materials. The completed structure shall be stable under all probable conditions of operation.

(b) In reviewing the stability of a structure, the Department may consider, without limitation, the following:

(1) The physical properties of the materials available for construction.

(2) The seismic and hydraulic forces affecting the structure.

(3) The methods of construction.

(4) The conditions of operation of the dam and reservoir.

Source

The provisions of this § 105.97 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.98. Design flood criteria.

(a) The discharge capacity or storage capacity, or both, shall be capable of safely accommodating the recommended design flood for the size and hazard potential classification of the dam as determined by § 105.91 (relating to classification of dams and reservoirs). The design flood is intended to represent the largest flood that need be considered in the evaluation of a given project. When a range of design flood is indicated, the magnitude that most closely relates to the size and hazard potential shall be selected. Design flood criteria shall be as indicated in the following table:

Size and Hazard Potential Classification	*Design Flood*
A-1.A-2.B-1	PMF
A-3,B-2, C-1	1/2 PMF to PMF
B-3, C-2	100 year to 1/2 PMF
C-3	50 year to 100 year frequency

(b) The Department may, in its discretion, require consideration of a minimum design flood for a class of dams or reservoirs in excess of that set forth in subsection (a) when it can be demonstrated that the design flood requirement is necessary and appropriate to provide for the integrity of the dam or reservoir and to protect life and property with an adequate margin of safety.

(c) The Department may, in its discretion, consider a reduced design flood for a class of dams or reservoirs when it can be demonstrated that the design flood provides for the integrity of the dam or reservoir and protects life and property with an adequate margin of safety.

Copyright © 1996 Commonwealth of Pennsylvania

Source

The provisions of this § 105.98 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.99. Dams in subdivision developments.

Whenever a dam or reservoir is proposed to be constructed in or as a part of an existing or proposed subdivision development, the Department will include in the permit the conditions as are necessary to prevent construction of structures on lands which may be subject to flooding caused by the maximum pool of the dam and to require the permittee to adequately inform potential buyers or lessees of the restrictions.

Source

The provisions of this § 105.99 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

CONSTRUCTION REQUIREMENTS AND PROCEDURES

§ 105.101. Notices and reports.

At least 15 days prior to commencement of construction, the permittee shall notify the Department, in writing, of the proposed time for commencement of work. Thereafter, a detailed report on the status of construction shall be submitted monthly to the Department of Environmental Resources; Division of Dam Safety; Post Office Box 2357, Harrisburg, Pennsylvania 17120, until construction work has been completed.

Source

The provisions of this § 105.101 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (47996).

Cross References

This section cited in 25 Pa. Code § 105.445 (relating to waiver of certain requirements).

§ 105.102. Personnel and supervision.

(a) Work shall be conducted under the oversight and supervision of a competent engineer approved by the Department, and the engineer or a competent representative shall be on the work site during significant construction activities until the completion of the dam.

(b) The permittee shall file with the Department at least 15 days prior to the commencement of construction a statement setting forth the name of the contractors conducting the work authorized by the permit and the names and employers of personnel responsible for the supervision of construction.

Source

The provisions of this § 105.102 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (47997).

Cross References

This section cited in 25 Pa. Code § 105.445 (relating to waiver of certain requirements).

§ 105.103. Weather and ground conditions.

(a) No earth or other embankment material which is in a frozen condition may be covered or placed in embankments.

(b) Masonry and concrete may not be placed in freezing weather except under conditions approved by the Department.

Source

The provisions of this § 105.103 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (47997).

§ 105.104. Removal and disposal of vegetation.

(a) Work shall be conducted in such a manner as to minimize the destruction of or damage to trees and other vegetation on and adjacent to the construction site.

(b) Vegetation cleared and removed from the site shall be disposed of in accordance with all applicable laws and regulations.

Source

The provisions of this § 105.104 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (4591) to (4592).

§ 105.105. [Reserved].

Source

The provisions of this § 105.105 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; reserved October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial page (117685).

§ 105.106. Activities and facilities on the construction site.

Activities and facilities on the construction site shall be conducted and operated in such manner as to avoid pollution of the air and waters of this Commonwealth and in accordance with applicable laws and the provisions of this title.

Copyright © 1996 Commonwealth of Pennsylvania

Source

The provisions of this § 105.106 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.107. Completion certificate and final plans.

(a) Within 30 days after the completion of work authorized by permit issued under this subchapter, the permittee shall file with the Department a certified statement signed by the supervising engineer and by the permittee that work has been performed in accordance with the terms and conditions of the permit; with the approved maps, plans, profiles and specifications; and with applicable laws and the provisions of this title.

(b) Within 90 days after the completion of work, the permittee shall file with the Department a set of final ''as built'' plans for the project, showing changes from the original plans and specifications.

Source

The provisions of this § 105.107 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Cross References

This section cited in 25 Pa. Code § 105.445 (relating to waiver of certain requirements).

WATER STORAGE AND DISCHARGE

§ 105.111. Commencement of water storage.

The permittee shall notify the Department, in writing, at least 1 week in advance of the date proposed for the commencement of water storage in the reservoir or pond created by the dam for which the permit is issued. The Department may, at its discretion, require that a representative of the Department be at the site before or during the filling of the pond or reservoir.

Source

The provisions of this § 105.111 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (47997) to (47998).

Cross References

This section cited in 25 Pa. Code § 105.445 (relating to waiver of certain requirements).

§ 105.112. Stream flow during construction, filling and repair.

During the period of construction, alteration, enlargement or repair and during the period that the pond or reservoir is being filled, the permittee shall allow a

sufficient flow of water, as determined by the Department, into the stream below the dam to support fish and other aquatic life and to preserve the water quality in the stream.

Source

The provisions of this § 105.112 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (47998) and (38868).

§ 105.113. Releases.

(a) The Department will impose general and special conditions regarding release rates in a permit for a dam or reservoir that it deems necessary to maintain stream flows for the purposes of protection of public health, water quality control, conservation of fisheries and aquatic habitat, improvement of recreation and protection of instream and downstream water uses. The appropriate release rates for the dams and reservoirs shall be established in accordance with subsections (b) and (c).

(b) For dams or reservoirs constructed after August 28, 1978:

(1) The minimum release rate unless modified in accordance with paragraph (2) shall be the average consecutive 7 day flow having a recurrence interval of once in 10 years (Q 7-10) plus an additional release rate determined by the following formula:

Release rate (csm)	=	Q7-10 + PDF(.25 csm—Q7-10 csm)
where PDF	=	the percentage factor based on the storage capacity of the reservoir measured as percent of average annual runoff retained in the reservoir. This factor is explained in Planning Principles, State Water Plan SWP-1 (March, 1975).
.25 csm	=	.25 cubic feet per second of flow per square mile of watershed.
Q7-10csm	=	The seven-day, ten-year flow, in cubic feet per second per square mile of watershed.

The minimum release rate determined by this formula shall not exceed 0.25 cubic feet per square mile of watershed.

(2) The Department may modify the minimum release rate, or provide variable schedules or releases considering the following factors:

(i) The purposes stated in subsection (a).

(ii) Particular stream requirements, including the particular needs of instream and downstream water uses and riparian rights.

(iii) The particular uses and purposes of the dam or reservoir.

Copyright © 1996 Commonwealth of Pennsylvania

(iv) The particular engineering, hydrologic and economic factors affecting the ability of the dam or reservoir to provide the releases.

(c) For dams and reservoirs constructed prior to August 28, 1978, the Department will determine a reasonable schedule for release rates, considering all of the following:

(1) The purposes stated in subsection (a) and the particular needs of instream and downstream water uses on the affected stream.

(2) The capacity of existing release works at the dam and feasibility of potential modification of the release works.

(3) The yield of the reservoir, and its capability to meet release requirements and satisfy the purposes and uses of the reservoir.

(d) Every dam shall at all times be operated in such manner as to allow the required flow of water into the stream below the dam as established under this section, and as otherwise necessary to support fish and other aquatic life and to assure compliance with the water quality criteria set forth in Chapter 93 (relating to water quality standards) and to provide for other instream uses for the affected stream.

Source

The provisions of this § 105.113 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38868) to (38870).

§ 105.114. [Reserved].

Source

The provisions of this § 105.114 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38870) to (38871).

PROTECTION AND RESTORATION OF AQUATIC LIFE

§ 105.121. Fishways.

Upon the request of the Fish Commission, the permittee shall install and maintain chutes, slopes, fishways, gates or other devices that the Fish Commission may require under sections 185—187 of The Fish Law of 1959 (30 P. S. §§ 185—187) (Repealed).

Source

The provisions of this § 105.121 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38871) to (38872).

§ 105.122. Drawdown of impounded waters.

Impounded waters which are inhabited by fish may not be drawn down except with the written approval of the Fish Commission issued under section 191 of The Fish Law of 1959 (30 P. S. § 191) (Repealed).

Source

The provisions of this § 105.122 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38872).

Cross References

This section cited in 25 Pa. Code § 105.131 (relating to operation and monitoring plans).

§ 105.123. Restoration of aquatic life.

If the Department finds that construction of a dam or reservoir has so substantially disrupted aquatic life as to preclude natural restoration of the stream ecology within a reasonable period of time, the permittee shall be required to submit and implement a plan to restore the aquatic life of the stream to its prior condition, to the maximum extent possible. The plan shall be subject to review and modification by the Department in consultation with the Fish Commission and shall include but not be limited to:

(1) Placement of bed gravel.
(2) Stabilization of banks and bed.
(3) Installation of stream improvement devices.
(4) Revegetation of stream and banks.
(5) Stocking of fish and other aquatic life.

Source

The provisions of this § 105.123 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (4594).

§ 105.124. [Reserved].

Source

The provisions of this § 105.124 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229. Immediately preceding text appears at serial page (4594).

Copyright © 1996 Commonwealth of Pennsylvania

§ 105.125. [Reserved].

Source

The provisions of this § 105.125 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229. Immediately preceding text appears at serial page (4594).

OPERATION, MAINTENANCE AND EMERGENCIES

§ 105.131. Operation and monitoring plans.

(a) In addition to the requirements of §§ 105.51—105.54 (relating to operation, maintenance and inspection), the permittee or owner of a dam or reservoir shall follow the method and schedule of operation of the dam or reservoir, including the emergency action plan if required by § 105.134 (relating to emergency action plan), as approved by the Department and shall implement a plan approved by the Department for permanent monitoring of performance by instrument installation in the dam.

(b) A permittee or owner of a dam or reservoir may not modify or cease implementation of all or part of the approved plans and methods of operation or monitoring without the prior approval of the Department.

(c) The permittee or owner of a dam or reservoir shall operate and maintain the dam in accordance with the authorized plans and specifications. Normal repairs and maintenance of the dam and the reservoir's design storage capacity will not require further authorization except as provided in § 105.122 (relating to drawdown of impounded waters).

Authority

The provisions of this § 105.131 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.131 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial page (117690).

Cross References

This section cited in 25 Pa. Code § 105.82 (relating to permit applications for operation and maintenance of existing dams and reservoirs).

§ 105.132. Inspection.

The permittee or owner of a dam or reservoir shall follow the inspection schedule set forth in § 105.53 (relating to inspections by owners and inspection reports).

Source

The provisions of this § 105.132 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (4595).

§ 105.133. Directed repairs.

The permittee shall immediately take steps that the Department may prescribe as necessary to preserve the structural stability and integrity of the dam and protect health, safety and property.

Source

The provisions of this § 105.133 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.134. Emergency action plan.

(a) The owner of a dam or reservoir that may cause loss of life or serious damage to property if a failure of the dam occurs, shall develop an emergency action plan to be followed in the event of a dam hazard emergency. The emergency action plan shall be submitted to and approved by the Department and local emergency management officials prior to commencement of water storage in the reservoir or pond created by the dam during any stage of construction of the dam. The emergency action plan shall, at a minimum, contain the following elements:

(1) An identification of the area below the dam which may be threatened with loss of life or serious damage to property if a failure of the dam occurs.

(2) A listing of key municipal and emergency management officials and their telephone numbers. The list shall be readily available at the dam site near a telephone or other means of communication, if available.

(3) An identification of handicapped or other persons who may have difficulty evacuating the area which may be threatened if a failure of the dam occurs. Procedures for identifying and evacuating these people in a dam hazard emergency shall be developed in cooperation with local and emergency management officials.

(b) For an existing dam or reservoir that may cause loss of life or serious damage to property if failure of the dam occurs, an emergency action plan shall be submitted to and approved by the Department and local emergency management officials.

Copyright © 1996 Commonwealth of Pennsylvania

(c) In addition to the requirements in subsections (a) and (b), the owner of a high hazard dam shall post notices in public places in areas that may be affected by the failure of the dam; for example, areas where public water or sewage service may be interrupted. The notice shall indicate that copies of the emergency action plan are available for review at the appropriate county and municipal emergency management offices. Also, the notice shall be posted by the owner in the following public places within each political subdivision situated within the inundation area downstream of the dam:

(1) The city, borough or township building.
(2) The police department offices.
(3) The fire company halls.
(4) The tax collector's office.

Authority

The provisions of this § 105.134 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.134 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117691) to (117692).

Cross References

This section cited in 25 Pa. Code § 105.81 (relating to permit applications for construction and modification of dams and reservoirs); 25 Pa. Code § 105.82 (relating to permit applications for operation and maintenance of existing dams and reservoirs); 25 Pa. Code § 105.131 (relating to operation and monitoring plans); and 25 Pa. Code § 105.135 (relating to dam hazard emergencies).

§ 105.135. Dam hazard emergencies.

(a) For the purposes of this section, a dam hazard emergency means a condition which the Department, permittee or owner of the dam reasonably finds constitutes an imminent threat to life or property above or below a dam, whether arising from the condition of the dam and appurtenant works or extraordinary natural conditions, affecting the safety and stability of the dam, including, but not limited to, flood, earthquake, fire and ice jam.

(b) The emergency procedures and the emergency warning system and operation plan required by §§ 105.63 and 105.134 (relating to emergency procedures; and emergency action plan) shall be followed by the permittee and owner of a dam or reservoir in the event of an actual or potential dam hazard emergency.

(c) If a dam hazard emergency exists, the Department and the permittee or owner of the dam shall immediately notify appropriate emergency management officials of the existence of the hazard and request the authorities to initiate

appropriate action to assure protection of life and property; and the permittee or owner shall immediately take the steps as are necessary to prevent dam failure or loss of life or property, including, but not limited to, the following:

(1) Draw down of the reservoir.

(2) Reinforcement of the dam structure.

(3) Breach or removal of the dam.

(4) Removal of debris.

(5) Repair or installation of structures necessary to assure the stability and safety of the dam.

(d) The Department, upon determining that a dam hazard emergency exists, will notify the owner immediately to take steps the Department determines are necessary to prevent dam failure or loss of life or property.

Source

The provisions of this § 105.135 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Cross References

This section cited in 25 Pa. Code § 105.136 (relating to unsafe dams).

§ 105.136. Unsafe dams.

(a) For purposes of this section, an unsafe dam means a dam which meets one or more of the following criteria:

(1) A dam with deficiencies of such a nature that if not corrected could result in the failure of the dam with subsequent loss of lives or substantial property damage. This determination is based on good engineering judgment or the application of the guidelines established for the National Dam Inspection Program.

(2) A dam classified as unsafe under the National Dam Inspection Program.

(3) A dam declared as unsafe by the Department.

(b) The owner of an unsafe dam shall do the following:

(1) Immediately notify the Department upon receipt of any information indicating the dam is unsafe.

(2) Drain the dam as approved or required by the Department.

(3) Within time limits established by the Department, submit a plan for removal of the dam, a plan for repair of the dam or an application for a permit authorizing modification of the dam under subsection (c).

(4) Following approval of the plan or permit by the Department, undertake and complete actions to remove or repair the dam or implement the modifications to the dam within the time limits set by the Department.

(c) The Department may issue a permit for modification of an unsafe dam, under section 9 of the act (32 P. S. § 693.9), which authorizes the owner of an

Copyright © 1996 Commonwealth of Pennsylvania

unsafe dam to modify the dam within the time prescribed in the permit to meet the requirements of the act and this chapter. The permit shall be conditioned upon:

(1) Compliance by the owner of the dam with a prescribed schedule for correction or modification of the unsafe condition within the shortest time period technically feasible and economically achievable.

(2) Implementation by the owner of the dam of measures deemed necessary by the Department to reduce risks to health and safety pending correction or modification of the unsafe condition, including but not limited to special provisions relating to operation, emergency planning, monitoring and warning systems, and development of an alternative source of water supply if the dam serves as a water supply dam.

(d) In determining whether to require removal of an unsafe dam or to permit the owner to modify the dam, the Department will consider whether there is a substantial adverse impact to the public health and safety which will result from the draining and removal of the dam, and whether that adverse impact outweighs the danger to public health and safety, which outweighing will result in allowing the unsafe dam to remain until it has been modified.

(e) At the discretion of the Department, a public hearing may be held in the affected area prior to the issuance of a permit authorizing modification of an unsafe dam over a period of more than 6 months, to inform affected communities of the risks which may result from allowing the unsafe dam to remain standing or to impound water during the time necessary to complete the modifications.

(f) If the Department finds that conditions upon which the permit authorizing modification was issued have substantially changed or that the owner does not meet the schedule for modification contained in the permit, the Department will review the status of the dam. An extension of the time period for completion of a modification may be issued by the Department if the owner has proceeded in good faith with the previous schedule of modification and the requirements of subsections (c) and (d) are met.

(g) Nothing in this section may be construed to limit the power of the Department to take immediate action, prior to public hearing, to do one or more of the following:

(1) Revoke or suspend a permit where deemed necessary by the Department to protect public health and safety.

(2) Order correction or abatement of a dam hazard emergency under § 105.135 (relating to dam hazard emergencies)

(3) Take another action authorized by law.

Source

The provisions of this § 105.136 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Subchapter C. CULVERTS AND BRIDGES

GENERAL PROVISIONS

Sec.
105.141. Scope.
105.142. Applicability of stream enclosure rules.
105.143. [Reserved].
105.144. [Reserved].
105.145. [Reserved].
105.146. [Reserved].

PERMITS

105.151. Permit applications for construction or modification of culverts and bridges.
105.152. Permit applications for operation and maintenance of existing culverts and bridges.
105.153. [Reserved].
105.154. [Reserved].
105.155. [Reserved].
105.156. [Reserved].
105.157. [Reserved].
105.158. [Reserved].

DESIGN CRITERIA FOR CONSTRUCTION OR MODIFICATION

105.161. Hydraulic capacity.
105.162. Multiple pipes and spans.
105.163. Bridge piers.
105.164. Bridge abutments.
105.165. Height of bridges and culverts.
105.166. Placement of culverts.

OPERATION AND MAINTENANCE

105.171. Maintenance.
105.172. Inadequate or collapsed structures.

Cross References

This subchapter cited in 25 Pa. Code § 105.14 (relating to review of applications); and 25 Pa. Code § 105.315 (relating to aerial crossings).

GENERAL PROVISIONS

§ 105.141. Scope.

Except as provided in §§ 105.3 and 105.12 (relating to scope; and waiver of permit requirements), this subchapter governs the construction, alteration,

(207734) No. 255 Feb. 96

Copyright © 1996 Commonwealth of Pennsylvania

enlargement, repair, maintenance and removal of a bridge or culvert located in, along or across, or projecting into the regulated waters of this Commonwealth.

Source

The provisions of this § 105.141 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38872) to (38873).

§ 105.142. Applicability of stream enclosure rules.

A culvert of greater than 100 feet in upstream to downstream length shall be considered to be a stream enclosure, subject to Subchapter D (relating to stream enclosures).

Source

The provisions of this § 105.142 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38873).

§ 105.143. [Reserved].

Source

The provisions of this § 105.143 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38873).

§ 105.144. [Reserved].

Source

The provisions of this § 105.144 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38874).

§ 105.145. [Reserved].

Source

The provisions of this § 105.145 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38874).

§ 105.146. [Reserved].

Source

The provisions of this § 105.146 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38874).

PERMITS

§ 105.151. Permit applications for construction or modification of culverts and bridges.

In addition to the information required under § 105.13 (relating to permit applications—information and fees), applications for permits under this subchapter for the construction or modification of culverts and bridges shall contain the following:

(1) Plans showing the location, type, size and height of the proposed bridge or culvert and detailing the topographic features, elevations and structures so as to enable an appraisal of the hazard potential of the structure.

(2) A description of the character of the stream bed and banks and a profile of the stream for a reasonable distance above and below the proposed site, showing slopes of bed, normal water surface and flood water surface.

(3) A hydrologic and hydraulic analysis which shall include: data on size, shape and characteristics of the watershed; the amount and frequency of the design flood; the hydraulic capacity of the structure; the hydraulic capacity of the channel upstream and downstream; and, where flooding is a problem, flood damage and backwater analysis.

(4) Other information as the Department may require.

Source

The provisions of this § 105.151 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38874) to (38875).

§ 105.152. Permit applications for operation and maintenance of existing culverts and bridges.

(a) In addition to information required by § 105.13 (relating to permit applications—information and fees), a permit application for the operation and maintenance of existing culverts and bridges shall give the following information:

(1) Plans showing the location, type, size and height of the existing bridge or culvert and detailing the topographic features, elevations and structures so as to enable an appraisal of the hazard potential of the structure.

Copyright © 1996 Commonwealth of Pennsylvania

(2) A description of the character of the stream bed and banks and a profile of the stream for a reasonable distance above and below the existing site showing slopes of bed, normal water surface and flood water surface.

(3) Other information as the Department may require.

Source

The provisions of this § 105.152 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; amended August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38875) to (38876).

§ 105.153. [Reserved].

Source

The provisions of this § 105.153 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229. Immediately preceding text appears at serial page (4597).

§ 105.154. [Reserved].

Source

The provisions of this § 105.154 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229. Immediately preceding text appears at serial page (4597).

§ 105.155. [Reserved].

Source

The provisions of this § 105.155 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229. Immediately preceding text appears at serial page (4597).

§ 105.156. [Reserved].

Source

The provisions of this § 105.156 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229. Immediately preceding text appears at serial page (4598).

§ 105.157. [Reserved].

Source

The provisions of this § 105.157 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229. Immediately preceding text appears at serial page (4598).

§ 105.158. [Reserved].

Source

The provisions of this § 105.158 adopted September 10, 1971, effective September 11, 1971, 1 Pa.B. 1804; reserved August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229. Immediately preceding text appears at serial page (4598).

DESIGN CRITERIA FOR CONSTRUCTION OR MODIFICATION

§ 105.161. Hydraulic capacity.

(a) Bridges and culverts shall be designed and constructed in accordance with the following criteria:

(1) The structure shall pass flood flows without loss of stability.

(2) The structure may not create or constitute a hazard to life or property, or both.

(3) The structure may not materially alter the natural regimen of the stream.

(4) The structure may not so increase velocity or direct flow in a manner which results in erosion of stream beds and banks.

(5) The structure may not significantly increase water surface elevations.

(6) The structure shall be consistent with local flood plain management programs.

(b) In determining flood flows and frequencies for purposes of this subchapter, hydrologic analysis shall be by methods generally accepted in the engineering profession.

(c) The general criteria for design flows are as follows:

(1) Rural area—25-year frequency flood flow.

(2) Suburban area—50-year frequency flood flow.

(3) Urban area—100-year frequency flood flow.

(d) The determination of flood flows for design shall be made with reasonable consideration of development which may alter the runoff characteristics of the watershed during the anticipated life of the structure. Specific design requirements in subsection (c) may be varied to fit the conditions at the site and the requirements of flood plain management regulations and ordinances.

(e) The structures shall pass the 100-year frequency flood with less than a 1.0-foot increase in the natural unobstructed 100-year water surface elevation, except where the structure would be located in a floodway which is delineated on a FEMA map, in which case no increase in the 100-year water surface elevation will be permitted. Exceptions to this criteria may be approved by the Department if the applicant prepares a risk assessment which demonstrates, and the Department finds, that the structure will not significantly increase the flooding threat to life and property or the environment, and if applicable, is consistent with municipal floodplain management programs adopted under the National Flood Insurance

Copyright © 1996 Commonwealth of Pennsylvania

Program and a FEMA Flood Insurance Study. This information may be obtained from the Department of Community Affairs, Floodplain Management Division, Forum Building, Harrisburg, Pennsylvania 17120.

Authority

The provisions of this § 105.161 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.161 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial page (117699).

§ 105.162. Multiple pipes and spans.

Multiple pipes and multiple span bridges and culverts which may tend to collect debris, contribute to the formation of ice jams and increase head losses shall be avoided to the maximum practicable extent. Crossings of less than 15 feet shall be by one span, except where conditions make it impractical to effect the crossing without multiple spans.

Source

The provisions of this § 105.162 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.163. Bridge piers.

(a) Bridge piers shall be kept to a minimum in number and cross-sectional area and shall be designed to offer the least obstruction to the passage of water and ice, consistent with safety.

(b) Bridge piers in channels subject to unstable or super critical flow shall require special investigation and shall be so designed as to prevent the creation of excessive backwater and waves downstream of the pier.

Source

The provisions of this § 105.163 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.164. Bridge abutments.

(a) Bridge abutments shall be set well into the banks in such manner as to assure minimal increase in flood elevations.

(b) Bridge abutments shall be aligned with the flow of the stream. The Department may require, in its discretion, the construction of wing walls at the upstream side of the bridge to assist in directing flood flows through the bridge opening.

Source

The provisions of this § 105.164 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.165. Height of bridges and culverts.

Bridges and culverts shall be of sufficient height and clearance to allow the use of the stream or other body of water in its customary manner.

Source

The provisions of this § 105.165 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.166. Placement of culverts.

(a) Culverts shall be aligned with the stream flow.

(b) Culverts shall be of sufficient width to minimize narrowing of the stream channel.

(c) The upstream side of culverts shall be protected by wing walls or other structures sufficient to assist in directing flood flows to and through the culvert opening.

Source

The provisions of this § 105.166 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

OPERATION AND MAINTENANCE

§ 105.171. Maintenance.

(a) The owner or permittee of a culvert or bridge is responsible for maintaining the structure opening thereof in good repair and assuring that flood carrying capacity of the structure is maintained. The owner or permittee shall inspect the opening and approach of the culvert or bridge at regular intervals of not less than once each year and shall, after obtaining the verbal or written approval of the Department, remove silt and debris which might obstruct the flow of water through the structure. It shall be assumed that the flow of water is obstructed when there has been a reduction of the effective area of the structure opening of greater than 10%. Debris shall be disposed of in accordance with the Solid Waste Management Act (35 P. S. §§ 6018.101—6018.1003), the Municipal Waste Planning, Recycling and Waste Reduction Act (53 P. S. §§ 4000.101—4000.1904) and The Clean Streams Law (35 P. S. §§ 691.1—691.1001).

Copyright © 1996 Commonwealth of Pennsylvania

(b) Cleaning and maintenance operations shall be conducted to minimize erosion and sedimentation resulting therefrom.

(c) Removal of silt and debris from the stream channel for the purposes of culvert or bridge maintenance shall be accomplished in accordance with the *Standards for Channel Cleaning at Bridges and Culverts*. A copy of this document can be obtained from the Bureau of Dams and Waterway Management, Division of Waterways and Stormwater Management, Post Office Box 8554, Harrisburg, Pennsylvania 17105-8554.

Authority

The provisions of this § 105.171 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.171 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial page (117701).

Cross References

This section cited in 25 Pa. Code § 105.211 (relating to maintenance).

§ 105.172. Inadequate or collapsed structures.

(a) The owner or permittee of a bridge or culvert shall immediately inform the Department of the collapse of the structure or a portion thereof or of the existence of unusual conditions threatening the structural integrity of the bridge or culvert, including, but not limited to, the following:

(1) Undercutting of piers or abutments.

(2) Excessive cracking of bridge or culvert surfacing.

(3) Severe deterioration of piers and supports.

(4) Diversion of all or part of the stream flow through a channel not within the normal span of the structure.

(b) Whenever a bridge or culvert or a portion thereof has collapsed or is in imminent danger thereof, the owner or permittee thereof shall immediately remove the collapsed portions to an area outside the floodplain of the stream and do one of the following:

(1) Completely remove the structure.

(2) Repair the structure in accordance with plans submitted to and approved by the Department.

(c) If the Department finds that the inadequate size, improper placement, collapse or imminent collapse of a bridge or culvert creates an immediate danger of stream obstruction and a hazard to life or property which not to permit the issu-

ance of an order or notice to the owner or permittee or if the owner or permittee cannot be readily contacted in sufficient time to assure adequate protection of life or property, the Department may exercise its powers under section 14 of the act (32 P. S. § 693.14) to remove or repair the conditions and take the actions it deems necessary to protect life and property and recover the cost and expense thereof from the owner or permittee.

Source

The provisions of this § 105.172 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Cross References

This section cited in 25 Pa. Code § 105.211 (relating to maintenance).

Subchapter D. STREAM ENCLOSURES

GENERAL PROVISIONS

Sec.
105.181. Scope.
105.182. [Reserved].

PERMITS

105.191. Permit applications for construction or modification of stream enclosures.
105.192. Permit applications for operation and maintenance of existing stream enclosures.

CRITERIA FOR APPROVAL OF CONSTRUCTION OR MODIFICATION

105.201. Hydraulic capacity.
105.202. Local government approval.

MAINTENANCE

105.211. Maintenance.

Cross References

This subchapter cited in 25 Pa. Code § 105.14 (relating to review of applications); and 25 Pa. Code § 105.142 (relating to applicability of stream enclosure rules).

Copyright © 1996 Commonwealth of Pennsylvania

GENERAL PROVISIONS

§ 105.181. Scope.

Except as provided in §§ 105.3 and 105.12 (relating to scope; and waiver of permit requirements), this subchapter applies to the construction, alteration, enlargement, repair and removal of a stream enclosure or a culvert in regulated waters of this Commonwealth of upstream to downstream length in excess of 100 feet.

Source

The provisions of this § 105.181 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38877) to (38878).

§ 105.182. [Reserved].

Source

The provisions of this § 105.182 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38878).

PERMITS

§ 105.191. Permit applications for construction or modification of stream enclosures.

In addition to the information required by § 105.13 (relating to permit applications—information and fees), applications for permits under this subchapter for the construction and modification of stream enclosures shall contain the following information:

(1) The location, type, size and height of the proposed stream enclosure.

(2) A profile of the stream for a reasonable distance above and below the proposed site showing slopes of bed, normal water surface and flood water surface.

(3) Estimates of flood frequencies and flood flows at the site of the proposed structure, including such information as can be reasonably obtained regarding actual rainfall and flood flow records on the stream.

(4) An analysis of the hydraulic capacity of the proposed structure.

(5) A description of the purposes of the proposed structure.

(6) A complete listing and description of other enclosures and culverts, bridges, dams and other water obstructions located a reasonable distance upstream and downstream of the proposed enclosure.

(7) Proof of title or adequate flowage and other easements for lands included in the site of the proposed structure, including lands which may be subject to flooding by backwater from the structure during a 100-year flood.

(8) Other information as the Department may require.

Source

The provisions of this § 105.191 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38878).

§ 105.192. Permit applications for operation and maintenance of existing stream enclosures.

(a) In addition to information required by § 105.13 (relating to permit applications—information and fees), a permit application for the operation and maintenance of existing stream enclosures shall give the following information:

(1) The location, type, size and height of the proposed stream enclosure.

(2) A profile of the stream for a reasonable distance above and below the existing site.

(3) An analysis of the hydraulic capacity of the existing structure.

(4) A description of the purposes of the existing structure.

(5) Other information the Department may require.

Source

The provisions of this § 105.192 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

CRITERIA FOR APPROVAL OF CONSTRUCTION OR MODIFICATION

§ 105.201. Hydraulic capacity.

(a) A stream enclosure shall be designed and constructed to pass the flows from a flood of 100-year frequency, with no more than a 1.0-foot increase in the 100-year water surface elevation over the water surface elevation of the natural unimpeded 100-year flow, except where the stream enclosure would be located in a floodway which is delineated on a FEMA map in which case no increase in the 100-year water surface elevation will be permitted. The 100-year discharge shall be based upon the degree of development of the contributing watershed projected throughout the lifetime of the structure. The Department may require capacity in excess of that necessary to carry the flows from a 100-year flood if it determines the capacity is necessary to protect the structure or to assure the safety of life and property upstream or downstream of the enclosure.

(b) An exception to the criteria of subsection (a) may be approved by the Department if the applicant prepares a risk assessment which demonstrates, and the Department finds, that the structure will not significantly increase the flooding threat to life, property or the environment, and if applicable, is consistent with municipal floodplain management programs adopted pursuant to the National Flood Insurance Program and a FEMA Flood Insurance Study. This information

Copyright © 1996 Commonwealth of Pennsylvania

can be obtained from the Department of Community Affairs, Floodplain Management Division, Forum Building, Harrisburg, Pennsylvania 17120.

Authority

The provisions of this § 105.201 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.201 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117704) to (117705).

§ 105.202. Local government approval.

No political subdivision may issue a building or other permit which allows for the construction of a stream enclosure unless and until the Department has approved the enclosure.

Source

The provisions of this § 105.202 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

MAINTENANCE

§ 105.211. Maintenance.

(a) Stream enclosures shall be maintained in accordance with §§ 105.171 and 105.172 (relating to maintenance; and inadequate or collapsed structures).

(b) Stream enclosures shall include provisions for adequate access to allow maintenance of the entire length of the enclosure. The access points shall be protected, to the maximum extent possible, in a manner which will prevent the entrance of unauthorized persons.

Source

The provisions of this § 105.211 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38879) to (38880).

Subchapter E. CHANNEL CHANGES AND DREDGING FOR FACILITY CONSTRUCTION AND MAINTENANCE

Sec.
105.221. Scope.
105.222. [Reserved].
105.223. [Reserved].
105.224. [Reserved].

PERMITS

105.231. Permit applications for construction or modification of channel changes and dredging for facility construction and maintenance.
105.232. Maintenance dredging.
105.233. Removal of sand, gravel and other valuable minerals.

CRITERIA FOR APPROVAL FOR CONSTRUCTION OR MODIFICATION

105.241. Flood effect.
105.242. Channel alignment and cross section.
105.243. Temperature of water and shading.
105.244. Protection of fish life.
105.245. Disposal of waste materials.

Cross References

This subchapter cited in 25 Pa. Code § 105.14 (relating to review of applications).

CONSTRUCTION AND MAINTENANCE

§ 105.221. Scope.

Except as provided in §§ 105.3 and 105.12 (relating to scope; and waiver of permit requirements), this subchapter applies to channel changes in the regulated waters of this Commonwealth, and to dredging in the regulated waters of this Commonwealth conducted for purposes of construction, operation or maintenance of a dam, water obstruction or encroachment.

Source

The provisions of this § 105.221 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38880).

§ 105.222. [Reserved].

Source

The provisions of this § 105.222 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38880).

Copyright © 1999 Commonwealth of Pennsylvania

§ 105.223. [Reserved].

Source

The provisions of this § 105.223 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38880).

§ 105.224. [Reserved].

Source

The provisions of this § 105.224 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38881).

PERMITS

§ 105.231. Permit applications for construction or modification of channel changes and dredging for facility construction and maintenance.

(a) *Construction or modification of channel changes.* Construction or modification of channel changes includes the following:

(1) In addition to the information required by § 105.13 (relating to permit applications—information and fees), permit applications under this subchapter for the construction or modification of channel changes shall contain the following information:

(i) The location and length of the proposed channel change.

(ii) A stream profile for a reasonable distance upstream and downstream of the proposed change, showing bed slopes, normal water surface and depths, flood water surfaces, existing obstructions and the location of public and industrial water supply intake.

(iii) Cross-channel sections necessary to indicate the scope of the proposed work.

(iv) Estimates of flood frequencies and flood flows at the site of the proposed channel change, including information reasonably available regarding actual rainfall and flood flow records on the stream.

(v) A description of the purposes of the proposed channel change.

(vi) A plan for the disposal of excavated material.

(vii) Proof of title or adequate flowage and other easements for lands included in the site of the proposed channel change.

(2) The Department may require additional information or waive one or more of the requirements of paragraph (1) in specific cases.

(b) *Dredging.* Dredging includes the following:

(1) In addition to the information required by § 105.13, permit applications for dredging for facility construction and maintenance under this subchapter shall contain the following information:

(i) The location and area of the proposed dredging.

(ii) A stream profile for a reasonable distance upstream and downstream of the proposed dredging showing normal water surface and depths.

(iii) A description of the equipment to be employed in the dredging operation and a plan for the disposal of the dredge soil.

(iv) Proof of title or easements for lands included in the site of the proposed dredging.

(2) The Department may require additional information or waive one or more of the requirements of paragraph (1) in specific cases.

Source

The provisions of this § 105.231 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38882).

Notes of Decisions

Dredging

The terms and conditions attached to a dredging permit are terms and conditions of the permit, rather than rules and regulations. *Warren Sand and Gravel Co. v. Department of Environmental Resources*, 341 A.2d 556 (Pa. Cmwlth. 1975).

Editor's Note: Chapter 105 has been extensively amended since this case was decided. The case actually referred to §§ 105.21 and 105.77.

§ 105.232. Maintenance dredging.

Permits issued for the construction, operation and maintenance of water obstruction or encroachment shall include specific authorization for maintenance dredging.

Source

The provisions of this § 105.232 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.233. Removal of sand, gravel and other valuable minerals.

The removal of sand, gravel or other valuable minerals from submerged lands of this Commonwealth in quantities which are commercially usable or marketable, in conjunction with a channel change or dredging permitted under this chapter, shall be subject to the royalty and agreement provisions of the act of July 31, 1970 (P. L. 699, No. 225) and the act of December 3, 1970 (P. L. 834, No. 275) (71 P. S. § 468) (repealed).

Source

The provisions of this § 105.233 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Copyright © 2000 Commonwealth of Pennsylvania

Cross References

This section cited in 25 Pa. Code Chapter 105, Appendix C (relating to bank rehabilitation and protection; general permit BDWW-GP-3).

CRITERIA FOR APPROVAL FOR CONSTRUCTION OR MODIFICATION

§ 105.241. Flood effect.

No channel change which creates a flooding potential greater than that created by the natural conditions of the existing channel will be approved.

Source

The provisions of this § 105.241 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (3882) to (3883).

§ 105.242. Channel alignment and cross section.

(a) Abrupt bends in channel changes are prohibited, unless necessitated by the alignment of existing bridges or encroachments.

(b) The relocated channel shall rejoin the natural channel of the stream at a point on the permittee's property to insure that alignment of stream flow at the downstream property line is identical to the flow alignment prior to the channel change.

(c) A grade of the changed channel shall not be significantly greater than or significantly less than the grade of the original channel, unless the length of the relocated channel requires.

(d) Where the width of a channel change is greater than the width of the preexisting channel, provision shall be made to assure proper depth and velocity of normal flows, subchannels and installation of stream habitat improvement devices.

(e) In streams having substantial fisheries value, provision shall be made in channel changes to maintain existing pool-riffle ratios.

Source

The provisions of this § 105.242 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.243. Temperature of water and shading.

Channel changes shall be so designed and implemented to assure that the water temperature does not substantially increase over that in the preexisting channel. Where necessary, provisions shall be made to provide adequate shading of the relocated channel to duplicate, to the maximum extent possible, the preexisting conditions.

Source

The provisions of this § 105.243 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.244. Protection of fish life.

A low flow channel and habitat improvement device will be required when, in the opinion of the Fish Commission, it is necessary to provide a satisfactory channel for maintenance of fish life.

Source

The provisions of this § 105.244 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.245. Disposal of waste materials.

(a) Discharge of dredged material into the regulated waters of this Commonwealth shall be subject to Subchapter J (relating to discharges of dredged and fill material).

(b) Dredged spoil and sludge deposits collected during the operation shall be deposited in a location and a manner approved by the Department.

(c) Bilge, ballast or wastewater from dredging operations shall not be discharged to the stream without removal of oils, petroleum products or toxic or hazardous compounds as defined by the Conservation and Recovery Act of 1976 (42 U.S.C.A. §§ 6901—6986) in a manner approved by the Department.

Source

The provisions of this § 105.245 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Subchapter F. FILLS, LEVEES, FLOODWALLS AND STREAMBANK RETAINING DEVICES

GENERAL PROVISIONS

Sec.
105.251. Scope.
105.252. [Reserved].
105.253. [Reserved].
105.254. [Reserved].
105.255. [Reserved].
105.256. [Reserved].

Copyright © 1996 Commonwealth of Pennsylvania

PERMITS

105.261. Permit applications for construction or modification of fills, levees, floodwalls and streambank retaining devices.
105.262. Permit applications for existing fills, levees, floodwalls and streambank retaining devices.

DESIGN CRITERIA FOR APPROVAL FOR CONSTRUCTION OR MODIFICATION

105.271. General criteria.
105.272. Waste materials.
105.273. Slopes.
105.274. Top width of levees.
105.275. Interior drainage.
105.276. Freeboard allowance.

MAINTENANCE AND REPAIR

105.281. Maintenance and repair of levees or floodwalls.
105.282. Maintenance of fills.

Cross References

This subchapter cited in 25 Pa. Code § 105.14 (relating to review of applications).

GENERAL PROVISIONS

§ 105.251. Scope

Except as provided in §§ 105.3 and 105.12 (relating to scope; and waiver of permit requirements), this subchapter applies to the construction, alteration, enlargement, repair or removal of fills, levees, floodwalls and streambank retaining walls located in or along the regulated waters of this Commonwealth.

Source

The provisions of this § 105.251 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38883).

§ 105.252. [Reserved].

Source

The provisions of this § 105.252 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38883).

§ 105.253. [Reserved].

Source

The provisions of this § 105.253 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38884).

§ 105.254. [Reserved].

Source

The provisions of this § 105.254 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38884).

§ 105.255. [Reserved].

Source

The provisions of this § 105.255 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38884).

§ 105.256. [Reserved].

Source

The provisions of this § 105.256 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38884).

PERMITS

§ 105.261. Permit applications for construction or modification of fills, levees, floodwalls and streambank retaining devices.

In addition to the information required by § 105.13 (relating to permit applications—information and fees), applications for permits for construction or modification of structures under this subchapter shall contain the following information:

(1) A plan detailing the location of the structures and properties 1000 feet upstream and downstream of the proposed fill, levee or similar structure and within the flood plain of the flood of record on both sides of the stream or body of water.

(2) Basement and first floor elevations of structures indicated on the plan required by paragraph (1).

(3) A complete hydraulic and hydrologic report on the proposed project, including, if the Department so requires, a backwater analysis of the project.

Copyright © 1996 Commonwealth of Pennsylvania

(4) Complete cross sections of the stream and floodway of the flood or record.

(5) Stream profiles showing the bed slope and the normal and flood water elevations for points sufficiently upstream and downstream in effect on the project.

(6) The type of materials to be used on the fill, levee or similar structure.

(7) Plans for the protection of the fill, levee or similar structure from erosion, both during and after construction.

(8) The design flood for the fill, levee or similar structure.

(9) A copy of the local flood plain management regulations or ordinances.

(10) Plans for interior drainage.

(11) Other information as the Department may require.

Source

The provisions of this § 105.261 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38884).

§ 105.262. Permit applications for existing fills, levees, floodwalls and streambank retaining devices.

In addition to the information required by § 105.13 (relating to permit applications—information and fees), applications for permits for existing structures under this subchapter shall contain the following information:

(1) A plan detailing the location of the existing fill, levee, floodwall or streambank retaining device.

(2) Cross sections of the stream and floodway.

(3) The type of all materials used in the fill, levee, floodwall or streambank retaining device.

(4) Plans of interior drainage, if available.

(5) Other information as the Department may require.

Source

The provisions of this § 105.262 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38884) to (38885).

DESIGN CRITERIA FOR APPROVAL FOR CONSTRUCTION OR MODIFICATION

§ 105.271. General criteria.

(a) An application for a proposed levee, fill or similar structure in or along the regulated waters of this Commonwealth will not be approved by the Department where one or more of the following will occur:

(1) It will increase flood heights, either on the opposite bank or upstream and flood easements or flood protection has not been provided.

(2) It will create erosive velocities in the stream and appropriate protection has not been provided.

(3) It will increase flood damages downstream through a loss of flood plain storage.

(b) An application for a proposed levee, fill or similar structure within the floodway of a regulated water of this Commonwealth will not be approved by the Department unless the applicant demonstrates that the project is consistent with local floodplain management programs.

Source

The provisions of this § 105.271 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38885).

§ 105.272. Waste materials.

Waste materials of any type may not be used in the construction of fills, levees or similar structures, except under the Solid Waste Management Act (35 P. S. §§ 6018.101—6018.1003), the Municipal Waste Planning, Recycling and Waste Reduction Act (53 P. S. §§ 4000.101—4000.1904) and related rules and regulations.

Authority

The provisions of this § 105.272 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.272 adopted September 27, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial page (117714).

§ 105.273. Slopes.

The slope of a fill, levee or similar structure shall not be steeper than two horizontal to one vertical, unless special circumstances are demonstrated and adequate steps are taken to assure permanent stabilization of the slope.

Source

The provisions of this § 105.273 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Copyright © 1996 Commonwealth of Pennsylvania

§ 105.274. Top width of levees.

The top width of a levee shall not be less than 10 feet.

Source

The provisions of this § 105.274 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.275. Interior drainage.

Adequate facilities shall be provided to drain the interior area behind the levee or floodwall.

Source

The provisions of this § 105.275 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.276. Freeboard allowance.

The height of a levee or floodwall shall provide an allowance for freeboard above the design flood of the structure.

Source

The provisions of this § 105.276 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

MAINTENANCE AND REPAIR

§ 105.281. Maintenance and repair of levees or floodwalls.

(a) The owner of a levee or floodwall shall inspect the levee or floodwall and appurtenant structures, including drainage facilities, at least annually and shall comply with § 105.53 (relating to inspections by owners and inspection reports).

(b) Trees and other vegetation with deep roots shall not be allowed on a levee used for flood control purposes, and vegetation shall at all times be controlled.

Source

The provisions of this § 105.281 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38885).

§ 105.282. Maintenance of fills.

Fills shall at all times be maintained in a manner to prevent erosion and to assure the stability of the slopes.

Source

The provisions of this § 105.282 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Subchapter G. STREAM CROSSINGS, OUTFALLS AND HEADWALLS

GENERAL PROVISIONS

Sec.
105.291. Scope.
105.292. [Reserved].
105.293. [Reserved].
105.294. [Reserved].

PERMITS

105.301. Permit applications for construction or modification.
105.302. Permit applications for existing stream crossings by pipelines for conveyance of petroleum products and gas.

CRITERIA FOR APPROVAL OF CONSTRUCTION OR MODIFICATION

105.311. General criteria.
105.312. Cover material.
105.313. Pipelines under stream beds.
105.314. Pipelines along streams.
105.315. Aerial crossings.

Cross References

This subchapter cited in 25 Pa. Code § 105.14 (relating to review of applications).

GENERAL PROVISIONS

§ 105.291. Scope.

Except as provided in §§ 105.3 and 105.12 (relating to scope; and waiver of permit requirements), this subchapter applies to stream crossings, outfalls, headwalls, pipelines, aerial crossings and other analogous structures which are placed in, along, across, over or under the regulated waters of this Commonwealth.

Source

The provisions of this § 105.291 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38886).

§ 105.292. [Reserved].

Source

The provisions of this § 105.292 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38886).

Copyright © 1999 Commonwealth of Pennsylvania

§ 105.293. [Reserved].

Source

The provisions of this § 105.293 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38887).

§ 105.294. [Reserved].

Source

The provisions of this § 105.294 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38887).

PERMITS

§ 105.301. Permit applications for construction or modification.

In addition to the information required under § 105.13 (relating to permit applications—information and fees), applications for stream crossings shall contain the following, where applicable:

(1) The shore lines of the affected body of water, including both high and low water marks.

(2) Existing structures and stream crossings in the vicinity of the proposed crossings.

(3) The alignment of the proposed pipe or cable.

(4) The depth of the proposed pipe or cable and the clear depth below the data plane to be afforded by the pipe or cable in navigable channels.

(5) A cross section of the stream from bank to bank with the location of the stream crossing to be affixed thereon.

(6) In the case of outfalls, the discharge capacity of the structures.

(7) A statement indicating the purpose of the proposed stream crossing.

(8) The amount and type of cover material.

(9) Adequate provisions for shut-off in the event of break or rupture.

(10) Other information as the Department may require.

Source

The provisions of this § 105.301 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38888).

§ 105.302. Permit applications for existing stream crossings by pipelines for conveyance of petroleum products and gas.

In addition to the information required under § 105.13 (relating to permit applications—information and fees), applications for existing stream crossings by pipelines for conveyance of petroleum products and gas shall contain the following:

(1) The shore lines of the affected body of water, including both high and low water marks.

(2) The alignment and depth of the pipe or cable, and the clear depth below the data plane afforded by the pipe in navigable channels.

(3) A cross section of the stream from bank to bank with the location of the pipeline affixed thereon.

(4) The amount and type of cover material.

(5) Provisions for shut-off in the event of break or rupture.

(6) Other information as the Department may require.

Source

The provisions of this § 105.302 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

CRITERIA FOR APPROVAL OF CONSTRUCTION OR MODIFICATION

§ 105.311. General criteria.

In evaluating applications for stream crossings, outfalls, headwalls, pipelines, aerial crossings and other analogous structures, the Department will not approve an application if one or more of the following is true:

(1) The stream crossings are placed in such a manner as to be displaced by flood waters.

(2) The stream crossing alters the cross section of the stream and its banks.

(3) There is unnecessary paralleling or crossing of streams by pipelines or cables.

(4) Pipelines or cables are placed on the bed of streams.

Source

The provisions of this § 105.311 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38888).

§ 105.312. Cover material.

No waste material of any type may be used as cover material for stream crossings.

Copyright © 1996 Commonwealth of Pennsylvania

Source

The provisions of this § 105.312 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38888).

§ 105.313. Pipelines under stream beds.

(a) Pipelines under stream beds shall be located such that there will be a minimum of 3 feet of cover between the top of the pipe or encasement and the lowest point in the stream bed; provided, that if the pipeline is in rock, it shall have the depth of granular soil plus 6 inches for cover, but never less than 1 foot of total cover.

(b) Pipelines under the stream bed shall be as near to horizontal as possible.

(c) The Department may require additional information or waive the requirements of subsection (a) in specific cases.

Source

The provisions of this § 105.313 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.314. Pipelines along streams.

Pipelines along streams shall be located a sufficient distance away from the bank to prevent damage to the bank as a result of erosion; pipelines shall be located a minimum of 25 feet away from the streambank unless other erosion protection measures are approved by the Department.

Source

The provisions of this § 105.314 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.315. Aerial crossings.

Aerial crossings shall comply with the criteria of Subchapter C (pertaining to culverts and bridges) with regard to hydraulic capacity, height and clearance.

Authority

The provisions of this § 105.315 issued under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.315 adopted October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911.

Subchapter H. DOCKS, WHARVES AND BULKHEADS

GENERAL PROVISIONS

Sec.
105.321. Scope.

PERMITS

105.331. Permit applications.
105.332. Riparian property.

CRITERIA FOR APPROVAL

105.341. Passage of ice and flood waters.

OPERATION AND MAINTENANCE

105.351. Removal of structure.
105.352. [Reserved].

Cross References

This subchapter cited in 25 Pa. Code § 105.14 (relating to review of applications).

GENERAL PROVISIONS

§ 105.321. Scope.

Except as provided in §§ 105.3 and 105.12 (relating to scope; and waiver of permit requirements), this subchapter applies to the construction, operation and maintenance of docks, wharves and bulkheads in the regulated waters of this Commonwealth.

Source

The provisions of this § 105.321 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38889).

PERMITS

§ 105.331. Permit applications.

In addition to the information required under § 105.13 (relating to permit applications—information and fees), applications for new and existing docks, wharves and bulkheads shall contain the following information:

(1) The exact location of the structure.

Copyright © 1996 Commonwealth of Pennsylvania

(2) A plan showing the dimensions of the structure, and if applicable, the dimensions of the mooring area.

(3) A plan indicating the relation of the structure and mooring area to the banks and channel, neighboring structures and mooring areas, the navigation channel and the normal pool elevation or ordinary low water mark.

(4) Cross sections indicating elevations of structures, location of pilings and water depth.

(5) The purposes for which the structure will be used.

(6) Other information the Department may require.

Authority

The provisions of this § 105.331 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.331 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial page (117720).

§ 105.332. Riparian property.

When an applicant proposes location of a structure on or in front of riparian property not owned by the applicant, the applicant shall obtain and furnish to the Department notarized and signed releases from the owners of the affected riparian property.

Source

The provisions of this § 105.332 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

CRITERIA FOR APPROVAL

§ 105.341. Passage of ice and flood waters.

Structures shall be able to pass flood waters and ice without property damage and without increasing the upstream flood hazard.

Source

The provisions of this § 105.341 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38890).

OPERATION AND MAINTENANCE

§ 105.351. Removal of structure.

Upon termination of the useful life of the structure, the owner shall remove it completely and restore the banks.

Source

The provisions of this § 105.351 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38890) to (38891).

§ 105.352. [Reserved].

Source

The provisions of this § 105.352 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38891).

Subchapter I. COMMERCIAL DREDGING

GENERAL PROVISIONS

Sec.
105.361. Scope.
105.362. [Reserved].
105.363. [Reserved].
105.364. [Reserved].
105.365. [Reserved].

PERMITS

105.371. Permits: content of application.
105.372. Prior requisite approvals.

OPERATIONAL CRITERIA

105.381. Location of dredging.
105.382. Washing and classification of materials.
105.383. Disposal of waste materials.
105.384. Protection of stream users.
105.385. Reporting.

Cross References

This subchapter cited in 25 Pa. Code § 105.14 (relating to review of applications).

Copyright © 1996 Commonwealth of Pennsylvania

GENERAL PROVISIONS

§ 105.361. Scope.

Except as provided in §§ 105.3 and 105.12 (relating to scope; and waiver of permit requirements), this subchapter applies to dredging in the regulated waters of this Commonwealth for sand, gravel and other minerals for the purposes of commercial exploitation. This subchapter shall not be construed to restrict the Department in managing the Commonwealth's proprietary interests under the act of July 31, 1970 (P. L. 699, No. 225) (71 P. S. § 468) (repealed), repealed by the act of December 3, 1970 (P. L. 834, No. 275); section 15 of the act (32 P. S. § 693.15); and section 1908-A(3) of The Administrative Code of 1929 (71 P. S. § 510-8(3)), from exercising its discretion to issue or not to issue permit agreements or to impose terms and conditions in permit agreements that it deems to be in the best interests of the Commonwealth; in the event, however, that the Department issues a permit agreement conveying the Commonwealth's proprietary interests in a deposit of sand, gravel or other minerals, this subchapter constitutes the minimum requirements for dredging under the Commonwealth's regulatory authority under the act.

Source

The provisions of this § 105.361 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial pages (38891) to (38892).

§ 105.362. [Reserved].

Source

The provisions of this § 105.362 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38892).

§ 105.363. [Reserved].

Source

The provisions of this § 105.363 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38892).

§ 105.364. [Reserved].

Source

The provisions of this § 105.364 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38892).

§ 105.365. [Reserved].

Source

The provisions of this § 105.365 adopted August 11, 1978, effective August 28, 1978, 8 Pa.B. 2229; reserved September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843. Immediately preceding text appears at serial page (38893).

PERMITS

§ 105.371. Permits: content of application.

In addition to the requirements of § 105.13 (relating to permit applications—information and fees), applications for commercial dredging permits shall contain the following information:

(1) The delineation of areas to be dredged, with reference to river miles of distances from fixed reference points or sufficient courses and distances referenced to permanent shore points to allow a fix to be made on the boundary points of a dredging area in a lake.

(2) Stream depths in the proposed dredging area if known or approximate estimated depths, if accurate measures are not available.

(3) The equipment to be employed in the dredging operation and its capabilities.

(4) The proposed rate of production.

(5) The location of public and industrial water supply intakes.

(6) A plan for the disposal of solid waste, dredge spoil and sewage from the dredging vessel.

(7) Other information as the Department may require.

Source

The provisions of this § 105.371 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.372. Prior requisite approvals.

Provided the other requirements of this subchapter are met, approval by the Department of dredging permit applications is conditioned upon the applicant's obtaining a permit/agreement under the act of July 31, 1970 (P. L. 699, No. 225) (71 P. S. § 468) (repealed), repealed by the act of December 3, 1970 (P. L. 834, No. 275) or an interest in land under section 15 of the act (32 P. S. § 693.15), where the bed of the regulated waters is owned by the Commonwealth.

Source

The provisions of this § 105.372 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Copyright © 1996 Commonwealth of Pennsylvania

OPERATIONAL CRITERIA

§ 105.381. Location of dredging.

(a) Dredging may not occur within 500 feet of a bridge pier or abutment.

(b) Dredging may not occur within 5000 feet above a public water supply intake unless the applicant can satisfactorily demonstrate to the Department that drinking water standards for turbidity will not be exceeded and no other adverse effects on the operations of a water user will occur. Water supplies within 5 miles downstream of the dredging operation shall be notified of proposed dredging or start up, or both, of operations. The applicant/permittee shall provide proof of the notification.

(c) Dredging may not occur within a distance of the channel or island shore line at normal pool less than the depth of the dredging, but in no event, less than 125 feet.

(d) Dredging may not occur in reaches of streams where water levels are controlled by dams if the water depth is less than 6 feet at normal pool.

(e) Dredging may not occur in, encroach upon or cause siltation in areas of riffles or shallow pools whenever the areas are contributing to the sustenance of game fish or endangered species in a free-flowing reach of a stream. Game fish includes species and varieties defined as such by 30 Pa.C.S. § 102 (relating to definitions). Endangered species include those species so defined by the Fish Commission, under 30 Pa.C.S. § 102 or defined by 50 CFR 17.12 (relating to endangered and threatened plants). A free-flowing reach of a stream includes a reach, segment or area of a stream except where a pool has been created by a dam.

Authority

The provisions of this § 105.381 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.381 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117724) to (117725).

Notes of Decisions

In remanding and ordering a new trial to determine whether a dredging company violated its permit by dredging too close to shore, the Court noted that the Department of Environmental Resources is authorized to impose conditions which preclude dredging within an established distance from the shore and that such conditions under statute and regulations, 71 P. S. § 510-8 and 25 Pa. Code § 150.381(c), impose a binding duty of care upon parties to a dredging contract. *Hawthorne v. Dravo Corp.* 460 A.2d 266 (Pa. Super. 1983).

§ 105.382. Washing and classification of materials.

Wash water from the classification process may not be returned to the stream, unless a permit in accordance with The Clean Streams Law (35 P. S. §§ 691.1—691.1001) has been obtained.

Source

The provisions of this § 105.382 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended February 1, 1985, effective February 2, 1985, 15 Pa.B. 361. Immediately preceding text appears at serial page (82601).

§ 105.383. Disposal of waste materials.

(a) The permittee shall not throw, discharge or deposit or cause or permit to be thrown, discharged or deposited from or out of a ship, barge or other floating craft employed in the dredging operation any refuse matter, including oil and petroleum products.

(b) Bilge, ballast or wastewater pumped from barges shall not be discharged to the stream without acceptable removal of oils or toxic compounds in a manner approved by the Department.

(c) Discharge of dredged material into the regulated waters of this Commonwealth is subject to Subchapter J (relating to discharges of dredged or fill material).

(d) Dredge spoil and sludge deposits collected during the operation shall be deposited in a location and a manner approved by the Department.

(e) Litter, refuse and sanitary waste from dredging vessels shall be disposed of in a manner approved by the Department.

Source

The provisions of this § 105.383 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.384. Protection of stream users.

(a) A dock or portage shall be constructed around the upstream face of the operation in order to facilitate navigation of small craft where the dredging operation will substantially obstruct the waterway.

(b) The permittee shall post signs 1000 feet upstream of where the dredge is operating and 500 feet from the downstream end of the dredging area warning users of the stream that dredging operations are in progress; the warnings shall be in large block printing, readable at a distance of 300 feet, and contain the warning, ''DANGER, DREDGING 1000 FEET AHEAD'' or ''DANGER, DREDGING 500 FEET AHEAD.''

Source

The provisions of this § 105.384 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Copyright © 1996 Commonwealth of Pennsylvania

§ 105.385. Reporting.

The permittee shall submit to the Department an annual report indicating the amount of sand, gravel or other minerals dredged from the stream bed during the preceding calendar year.

Source

The provisions of this § 105.385 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Subchapter J. DISCHARGES OF DREDGED OR FILL MATERIAL

GENERAL PROVISIONS

Sec.
105.391. Scope.

PERMITS

105.401. Permit applications.

CRITERIA FOR APPROVAL

105.411. General criteria.

OPERATION AND MAINTENANCE

105.421. General.
105.422. Use of heavy equipment.
105.423. Removal of temporary fill.

Cross References

This subchapter cited in 25 Pa. Code § 105.14 (relating to review of applications); 25 Pa. Code § 105.245 (relating to disposal of waste materials); and 25 Pa. Code § 105.383 (relating to disposal of waste materials).

GENERAL PROVISIONS

§ 105.391. Scope.

Except as provided in §§ 105.3 and 105.12 (relating to scope; and waiver of permit requirements), this subchapter applies to the discharge of dredged or fill material into the regulated waters of this Commonwealth.

Source

The provisions of this § 105.391 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

PERMITS

§ 105.401. Permit applications.

In addition to the requirements of § 105.13 (relating to permit applications—information and fees) and other applicable requirements of this chapter, applications for discharges of dredged or fill material into the regulated waters of this Commonwealth shall contain the following information:

(1) The location of a public water supply intake located within 1 mile upstream and 10 miles downstream.

(2) The location of areas of shell-fish production.

(3) The impact of the activity upon a threatened or endangered species as identified under the Endangered Species Act of 1973 (7 U.S.C.A. § 136; 16 U.S.C.A. §§ 460l-9, 460k-1, 668dd, 715i, 715a, 1362, 1371, 1372, 1402 and 1531—1543), and the critical habitat of the species.

(4) The impact of the activity upon those species of aquatic life indigenous to the waterbody.

(5) The amount of percentage of the discharge that will consist of toxic material regulated under section 6 of the Toxic Substances Control Act (15 U.S.C.A. § 2605) or hazardous materials as defined by the Resource Conservation and Recovery Act of 1976 (42 U.S.C.A. §§ 6901—6986) in other than trace quantities.

(6) Other information as the Department may require.

Source

The provisions of this § 105.401 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

CRITERIA FOR APPROVAL

§ 105.411. General criteria.

The Department will not approve an application to discharge dredged or fill material into regulated waters of this Commonwealth, unless the applicant demonstrates to the Department a public benefit which outweighs the damage to the public natural resources, if one or more of the following is true:

(1) The discharge is to a spawning area during spawning season.

(2) The discharge would restrict or impede the movement of aquatic species indigenous to the waters or the passage of normal or expected high flows or cause the relocation of the waters unless the primary purpose of the fill is to impound waters.

Copyright © 1996 Commonwealth of Pennsylvania

(3) The discharge is into regulated waters of this Commonwealth, except wetlands, which are breeding, feeding or nesting areas for migratory water birds.

Authority

The provisions of this § 105.411 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.411 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial page (117728).

OPERATION AND MAINTENANCE

§ 105.421. General.

Discharges of dredged or fill material shall be properly maintained to prevent erosion and other types of pollution.

Source

The provisions of this § 105.421 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.422. Use of heavy equipment.

Heavy equipment used in wetlands shall be placed on mats where practicable.

Source

The provisions of this § 105.422 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

§ 105.423. Removal of temporary fill.

Temporary fill shall be completely removed.

Source

The provisions of this § 105.423 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Subchapter K. DISBURSEMENTS OF MONIES FROM THE DAMS AND ENCROACHMENTS FUND

Sec.
105.431. General provisions.
105.432. Authorization for disbursement.

§ 105.431. General provisions.

(a) Fines collected under the penal provisions of the act and civil penalties collected under the act shall be paid into the treasury of the Commonwealth in a special fund known as the Dams and Encroachments Fund.

(b) Moneys paid into the Dams and Encroachments Fund may be disbursed at the discretion of the Department for use in the elimination of hazards to life, property and the environment resulting from unsafe dams, water obstructions and encroachments. The moneys shall be available for use by the Bureau of Dams and Waterway Management in addition to funds otherwise available to it.

(c) For purposes of this chapter, the full and normal range of activities of the Bureau will be considered to contribute to the elimination of hazards from unsafe dams, water obstructions and encroachments under subsection (b). Disbursement of moneys from the Dams and Encroachments Fund moneys may therefore be made for, but will not be limited to, the following purposes:

(1) Conducting investigations, tests and analyses as required to carry out the purposes of the act, including costs of entry; testing and sampling; and examining books, papers and records.

(2) Undertaking corrective action, repair work or removal to eliminate an actual or potentially dangerous or hazardous condition of a dam, water obstruction or encroachment as provided under section 14(c) of the act (32 P. S. § 693.14(c)).

(3) Purchasing contractual services and consultation from firms and individuals with relevant expertise in the field of safety of dams, water obstructions and encroachments.

(4) Purchasing materials, equipment, services and travel necessary for personnel training and provision of information and educational materials on the safety of dams, water obstructions and encroachments to schools, colleges, institutions and citizens.

(5) Covering extraordinary costs of litigation arising out of the enforcement of dam safety and encroachments laws of the Commonwealth, such as the printing of briefs and records, taking of depositions and expert witness fees.

Authority

The provisions of this § 105.431 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1—693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and

Copyright © 1996 Commonwealth of Pennsylvania

1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.431 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117729) to (117730).

Cross References

This section cited in 25 Pa. Code § 105.432 (relating to authorization for disbursement).

§ 105.432. Authorization for disbursement.

The Director of the Bureau of Dams and Waterway Management will authorize the use of monies disbursed from the Dams and Encroachments Fund consistent with the established policies and procedures of the Department. For disbursements from the fund not falling within the explicit categories established in § 105.431 (relating to general provisions), the Director of the Bureau of Dams and Waterway Management will submit a request to the Secretary of the Department requesting an authorization to disburse the funds for the project in question.

Source

The provisions of this § 105.432 adopted September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843.

Subchapter L. GENERAL PERMITS

Sec.
105.441. Scope.
105.442. Authorization for general permits.
105.443. Nature of a general permit; substitution for individual applications and permits.
105.444. Contents of general permits.
105.445. Waiver of certain requirements.
105.446. Procedure for issuance.
105.447. Registration requirements.
105.448. Determination of applicability of a general permit.
105.449. Compliance with permit conditions, regulations and laws.

Cross References

This subchapter cited in 25 Pa. Code § 105.21a (relating to public notice).

§ 105.441. Scope.

This subchapter applies to the issuance of general permits by the Department under section 7(b)—(d) of the act (32 P. S. § 693.7(b)—(d)).

Source

The provisions of this § 105.441 adopted January 2, 1981, effective January 3, 1981, 11 Pa.B. 9.

Cross References

This section cited in 25 Pa. Code Chapter 105 Appendix A (relating to fish enhancement structure; general permit BDWW-GP-1); 25 Pa. Code Chapter 105 Appendix B (relating to private recreational docks; general permit BDWW-GP-2); 25 Pa. Code Chapter 105 Appendix C (relating to bank rehabilitation and protection; general permit BDWW-GP-3); 25 Pa. Code Chapter 105 Appendix D (relating to Bureau of Dams and Waterway Management; general permit BDWM-GP-4); 25 Pa. Code

Chapter 105 Appendix E (relating to utility line stream crossings; general permit BDWM-GP-5); 25 Pa. Code Chapter 105 Appendix F (relating to agricultural crossings and ramps; general permit BDWM-GP-6); 25 Pa. Code Chapter 105 Appendix G (relating to minor road crossings; general permit BDWM-GP-7); 25 Pa. Code Chapter 105 Appendix H (relating to temporary road crossings; general permit BDWM-GP-8); 25 Pa. Code Chapter 105 Appendix I (relating to agricultural activities; general permit BDWM-GP-9); 25 Pa. Code Chapter 105 Appendix J (relating to abandoned mine reclamation; general permit BDWW-GP-10); and 25 Pa. Code Chapter 105 Appendix O (relating to private residential construction in wetlands; general permit BDWW-GP-15).

§ 105.442. Authorization for general permits.

(a) In accordance with this subchapter, the Department may issue general permits on a regional or Statewide basis for a category of dam, water obstruction or encroachment if the Department determines the following:

(1) The projects in the category are similar in nature.

(2) The projects in the category can be adequately regulated utilizing standardized specifications and conditions, including reference to specific criteria and requirements adopted by another Federal or State agency which adequately regulate the particular category of dam, water obstruction or encroachment.

(3) The projects which are in the category and meet the specifications and conditions will comply with the requirements for permit issuance in §§ 105.14—105.17 and 105.21 and the standards and requirements for design, construction, operation, maintenance and monitoring in this chapter.

(b) General permits issued under this subchapter may be issued on a Statewide basis or limited to specific watersheds, particular categories of streams or designated geographic regions.

(c) The Department will not issue a general permit for the following:

(1) A dam in size classifications A or B or hazard potential classifications 1 or 2, as defined in § 105.91 (relating to classification of dams or reservoirs).

(2) A dam used for storage of fluids or semifluids other than water the escape of which may result in air, water or land pollution or in danger to persons or property unless the impoundment created by the dam is otherwise adequately regulated by another program requiring individual permits issued by the Department or another Federal or State agency.

(3) A dam, water obstruction or encroachment which may present a substantial risk to life and property, requiring proof of financial responsibility under § 105.20 (relating to proof of financial responsibility).

Authority

The provisions of this § 105.442 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1–693.27); The Clean Streams Law (35 P. S. §§ 691.1—691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101—679.601).

Source

The provisions of this § 105.442 adopted January 2, 1981, effective January 3, 1981, 11 Pa.B. 9; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (156661) to (156662).

Copyright © 2005 Commonwealth of Pennsylvania

Cross References

This section cited in 25 Pa. Code Chapter 105 Appendix A (relating to fish enhancement structure; general permit BDWW-GP-1); 25 Pa. Code Chapter 105 Appendix B (relating to private recreational docks; general permit BDWW-GP-2); 25 Pa. Code Chapter 105 Appendix C (relating to bank rehabilitation and protection; general permit BDWW-GP-3); 25 Pa. Code Chapter 105 Appendix D (relating to Bureau of Dams and Waterway Management; general permit BDWM-GP-4); 25 Pa. Code Chapter 105 Appendix E (relating to utility line stream crossings; general permit BDWM-GP-5); 25 Pa. Code Chapter 105 Appendix F (relating to agricultural crossings and ramps; general permit BDWM-GP-6); 25 Pa. Code Chapter 105 Appendix G (relating to minor road crossings; general permit BDWM-GP-7); 25 Pa. Code Chapter 105 Appendix H (relating to temporary road crossings; general permit BDWM-GP-8); 25 Pa. Code Chapter 105 Appendix I (relating to agricultural activities; BDWM-GP-9); 25 Pa. Code Chapter 105 Appendix J (relating to abandoned mine reclamation; general permit BDWW-GP-10); and 25 Pa. Code Chapter 105 Appendix O (relating to private residential construction in wetlands; general permit BDWW-GP-15).

§ 105.443. Nature of a general permit; substitution for individual applications and permits.

(a) When the Department issues a general permit for a specified category of dam, water obstruction or encroachment on either a regional or Statewide basis, persons who intend to construct, operate, maintain, modify, enlarge or abandon a dam, water obstruction or encroachment in accordance with the specifications and conditions of the general permit may do so without filing an individual application for, and first obtaining, an individual permit.

(b) Use of an applicable general permit shall satisfy the permit requirements set forth in § 105.11 (relating to permit requirements), so long as:

(1) Activities are conducted in accordance with the specifications and conditions of the applicable general permit.

(2) The owner of the dam, water obstruction or encroachment complies with the registration requirements set forth in the general permits, as authorized by § 105.448 (relating to determination of applicability of a general permit).

Source

The provisions of this § 105.443 adopted January 2, 1981, effective January 3, 1981, 11 Pa.B. 9.

Cross References

This section cited in 25 Pa. Code Chapter 105 Appendix A (relating to fish enhancement structure; general permit BDWW-GP-1); 25 Pa. Code Chapter 105 Appendix B (relating to private recreational docks; general permit BDWW-GP-2); 25 Pa. Code Chapter 105 Appendix C (relating to bank rehabilitation and protection; general permit BDWW-GP-3); 25 Pa. Code Chapter 105 Appendix D (relating to Bureau of Dams and Waterway Management; general permit BDWM-GP-4); 25 Pa. Code Chapter 105 Appendix E (relating to utility line stream crossings; general permit BDWM-GP-5); 25 Pa. Code Chapter 105 Appendix F (relating to agricultural crossings and ramps; general permit BDWM-GP-6); 25 Pa. Code Chapter 105 Appendix G (relating to minor road crossings; general permit BDWM-GP-7); 25 Pa. Code Chapter 105 Appendix H (relating to temporary road crossings; general permit BDWM-GP-8); 25 Pa. Code Chapter 105 Appendix I (relating to agricultural activities; BDWM-GP-9); 25 Pa. Code Chapter 105 Appendix J (relating to abandoned mine reclamation; gen-

eral permit BDWW-GP-10); and 25 Pa. Code Chapter 105 Appendix O (relating to private residential construction in wetlands; general permit BDWW-GP-15).

§ 105.444. Contents of general permits.

Each general permit issued by the Department will include, but not be limited to, the following contents:

(1) A concise description of the category of dam, water obstruction or encroachment covered by the general permit, including exceptions to that category.

(2) A specification of the watersheds, streams or geographic areas where the general permit is effective.

(3) A set of standardized specifications or plans for the particular category of dam, water obstruction or encroachment or a reference to specific criteria and requirements adopted by another Federal or State agency which adequately regulates the particular category of dam, water obstruction or encroachment.

(4) A set of conditions governing the construction, operation, maintenance, inspection and monitoring of the projects covered by the general permit as are necessary to assure compliance with the act and this chapter and with other laws administered by the Department, the Fish Commission and a river basin commission created by interstate compact.

(5) A specification of registration requirements, if any, established under § 105.447 (relating to registration requirements).

Source

The provisions of this § 105.444 adopted January 2, 1981, effective January 3, 1981, 11 Pa.B. 9.

Cross References

This section cited in 25 Pa. Code Chapter 105 Appendix A (relating to fish enhancement structure; general permit BDWW-GP-1); 25 Pa. Code Chapter 105 Appendix B (relating to private recreational docks; general permit BDWW-GP-2); 25 Pa. Code Chapter 105 Appendix C (relating to bank rehabilitation and protection; general permit BDWW-GP-3); 25 Pa. Code Chapter 105 Appendix D (relating to Bureau of Dams and Waterway Management; general permit BDWM-GP-4); 25 Pa. Code Chapter 105 Appendix E (relating to utility line stream crossings; general permit BDWM-GP-5); 25 Pa. Code Chapter 105 Appendix F (relating to agricultural crossings and ramps; general permit BDWM-GP-6); 25 Pa. Code Chapter 105 Appendix G (relating to minor road crossings; general permit BDWM-GP-7); 25 Pa. Code Chapter 105 Appendix H (relating to temporary road crossings; general permit BDWM-GP-8); 25 Pa. Code Chapter 105 Appendix I (relating to agricultural activities; general permit BDWM-GP-9); 25 Pa. Code Chapter 105 Appendix J (relating to abandoned mine reclamation; general permit BDWW-GP-10); and 25 Pa. Code Chapter 105 Appendix O (relating to private residential construction in wetlands; general permit BDWW-GP-15).

§ 105.445. Waiver of certain requirements.

In issuing a general permit, the Department may waive the procedural requirements of any or all of the following sections of this chapter as applied to a particular category of dams, water obstructions or encroachments covered by the general permit:

Copyright © 2005 Commonwealth of Pennsylvania

(1) Section 105.41 (relating to notices and reports).

(2) Section 105.42 (relating to acknowledgment of conditions).

(3) Section 105.53 (relating to inspections by owners and inspection reports).

(4) Section 105.101 (relating to notices and reports).

(5) Section 105.102(b) (relating to personnel and supervision).

(6) Section 105.107 (relating to completion certificate and final plans).

(7) Section 105.111 (relating to commencement of water storage).

Source

The provisions of this § 105.445 adopted January 2, 1981, effective January 3, 1981, 11 Pa.B. 9.

Cross References

This section cited in 25 Pa. Code § 105.449 (relating to compliance with permit conditions, regulations and laws); 25 Pa. Code Chapter 105 Appendix A (relating to fish enhancement structure; general permit BDWW-GP-1); 25 Pa. Code Chapter 105 Appendix B (relating to private recreational docks; general permit BDWW-GP-2); 25 Pa. Code Chapter 105 Appendix C (relating to bank rehabilitation and protection; general permit BDWW-GP-3); 25 Pa. Code Chapter 105 Appendix D (relating to Bureau of Dams and Waterway Management; general permit BDWM-GP-4); 25 Pa. Code Chapter 105 Appendix E (relating to utility line stream crossings; general permit BDWM-GP-5); 25 Pa. Code Chapter 105 Appendix F (relating to agricultural crossings and ramps; general permit BDWM-GP-6); 25 Pa. Code Chapter 105 Appendix G (relating to minor road crossings; general permit BDWM-GP-7); 25 Pa. Code Chapter 105 Appendix H (relating to temporary road crossings; general permit BDWM-GP-8); 25 Pa. Code Chapter 105 Appendix I (relating to agricultural activities; general permit BDWM-GP-9); 25 Pa. Code Chapter 105 Appendix J (relating to abandoned mine reclamation; general permit BDWW-GP-10); and 25 Pa. Code Chapter 105 Appendix O (relating to private residential construction in wetlands; general permit BDWW-GP-15).

§ 105.446. Procedure for issuance.

(a) At least 60 days prior to issuance of a general permit, the Department will:

(1) Publish notice in the *Pennsylvania Bulletin* of intent to issue a general permit, including the text of the proposed general permit and locations for obtaining standardized plans.

(2) Provide written notice of the proposed general permit to the United States Army Corps of Engineers; the United States Coast Guard; the United States Fish and Wildlife Service; the United States Environmental Protection Agency; the Fish Commission; the Game Commission; applicable river basin commissions created by interstate compact; county agencies holding delegations under § 105.4 (relating to delegations to local agencies) and other interested Federal, State or interstate agencies.

(b) An opportunity shall be provided for interested members of the public, Federal and State agencies to provide written comments on a proposed general permit.

(c) The Department may, at its discretion, hold a public hearing on a proposed general permit for the purposes of gathering information and comments.

(d) General permits issued by the Department will be published in the *Pennsylvania Bulletin* at least 30 days prior to the effective date of the permits, as required by section 7(d) of the Dam Safety and Encroachments Act (32 P. S. § 693.7(d)).

Authority

The provisions of this § 105.446 amended under section 5 of the Dam Safety and Encroachments Act (32 P. S. § 693.5).

Source

The provisions of this § 105.446 adopted January 2, 1981, effective January 3, 1981, 11 Pa.B. 9; amended February 18, 1983, effective February 19, 1983, 13 Pa.B. 781. Immediately preceding text appears at serial pages (59051) and (59052).

Cross References

This section cited in 25 Pa. Code Chapter 105 Appendix A (relating to fish enhancement structure; general permit BDWW-GP-1); 25 Pa. Code Chapter 105 Appendix B (relating to private recreational docks; general permit BDWW-GP-2); 25 Pa. Code Chapter 105 Appendix C (relating to bank rehabilitation and protection; general permit BDWW-GP-3); 25 Pa. Code Chapter 105 Appendix D (relating to Bureau of Dams and Waterway Management; general permit BDWM-GP-4); 25 Pa. Code Chapter 105 Appendix E (relating to utility line stream crossings; general permit BDWM-GP-5); 25 Pa. Code Chapter 105 Appendix F (relating to agricultural crossings and ramps; general permit BDWM-GP-6); 25 Pa. Code Chapter 105 Appendix G (relating to minor road crossings; general permit BDWM-GP-7); 25 Pa. Code Chapter 105 Appendix H (relating to temporary road crossings; general permit BDWM-GP-8); 25 Pa. Code Chapter 105 Appendix I (relating to agricultural activities; general permit BDWM-GP-9); 25 Pa. Code Chapter 105 Appendix J (relating to abandoned mine reclamation; general permit BDWW-GP-10); and 25 Pa. Code Chapter 105 Appendix O (relating to private residential construction in wetlands; general permit BDWW-GP-15).

§ 105.447. Registration requirements.

(a) The Department will require the registration of a project constructed, operated, maintained, modified or enlarged under a general permit, within a specified time limit.

(b) Registration requirements and time limits, if any, shall be set forth in the general permit governing each category of dam, water obstruction or encroachment.

(c) Registration statements shall set forth:

(1) The name and address of the person responsible for the project.

(2) The location of the project.

(3) The name or number of the general permit being utilized for the project.

(d) For a project requiring registration under this section, an amended registration shall be filed if there is a change of ownership of the dam, water obstruction or encroachment.

Copyright © 2005 Commonwealth of Pennsylvania

Source

The provisions of this § 105.447 adopted January 2, 1981, effective January 3, 1981, 11 Pa.B. 9.

Cross References

This section cited in 25 Pa. Code § 105.444 (relating to contents of general permits); 25 Pa. Code Chapter 105 Appendix A (relating to fish enhancement structure; general permit BDWW-GP-1); 25 Pa. Code Chapter 105 Appendix B (relating to private recreational docks; general permit BDWW-GP-2); 25 Pa. Code Chapter 105 Appendix C (relating to bank rehabilitation and protection; general permit BDWW-GP-3); 25 Pa. Code Chapter 105 Appendix D (relating to Bureau of Dams and Waterway Management; general permit BDWM-GP-4); 25 Pa. Code Chapter 105 Appendix E (relating to utility line stream crossings; general permit BDWM-GP-5); 25 Pa. Code Chapter 105 Appendix F (relating to agricultural crossings and ramps; general permit BDWM-GP-6); 25 Pa. Code Chapter 105 Appendix G (relating to minor road crossings; general permit BDWM-GP-7); 25 Pa. Code Chapter 105 Appendix H (relating to temporary road crossings; general permit BDWM-GP-8); 25 Pa. Code Chapter 105 Appendix I (relating to agricultural activities; general permit BDWM-GP-9); 25 Pa. Code Chapter 105 Appendix J (relating to abandoned mine reclamation; general permit BDWW-GP-10); and 25 Pa. Code Chapter 105 Appendix O (relating to private residential construction in wetlands; general permit BDWW-GP-15).

§ 105.448. Determination of applicability of a general permit.

(a) A person who desires to utilize a general permit issued under this subchapter, but is uncertain as to the potential application of the general permit to a particular proposed dam, water obstruction or encroachment, should consult with the Department. The Department may issue a determination as to whether the general permit applies to the proposed dam, water obstruction or encroachment.

(b) A request for a determination of the applicability of a general permit may not be considered a permit application for purposes of this chapter, and no application fee will be charged.

Source

The provisions of this § 105.448 adopted January 2, 1981, effective January 3, 1981, 11 Pa.B. 9.

Cross References

This section cited in 25 Pa. Code § 105.443 (relating to nature of a general permit; substitution for individual applications and permits); 25 Pa. Code Chapter 105 Appendix A (relating to fish enhancement structure; general permit BDWW-GP-1); 25 Pa. Code Chapter 105 Appendix B (relating to private recreational docks; general permit BDWW-GP-2); 25 Pa. Code Chapter 105 Appendix C (relating to bank rehabilitation and protection; general permit BDWW-GP-3); 25 Pa. Code Chapter 105 Appendix D (relating to Bureau of Dams and Waterway Management; general permit BDWM-GP-4); 25 Pa. Code Chapter 105 Appendix E (relating to utility line stream crossings; general permit BDWM-GP-5); 25 Pa. Code Chapter 105 Appendix F (relating to agricultural crossings and ramps; general permit BDWM-GP-6); 25 Pa. Code Chapter 105 Appendix G (relating to minor road crossings; general permit BDWM-GP-7); 25 Pa. Code Chapter 105 Appendix H (relating to temporary road crossings; general permit BDWM-GP-8); 25 Pa. Code Chapter 105 Appendix I (relating to agricultural activities; general permit BDWM-GP-9); 25 Pa. Code Chapter 105 Appendix J (relating to abandoned mine reclamation; general permit BDWW-GP-10); and 25 Pa. Code Chapter 105 Appendix O (relating to private residential construction in wetlands; general permit BDWW-GP-15).

§ 105.449. Compliance with permit conditions, regulations and laws.

A person who constructs, operates, maintains, modifies, enlarges or abandons a dam, water obstruction or encroachment under a general permit shall comply with the terms and conditions of the general permit, with this chapter, except as expressly waived under § 105.445 (relating to waiver of certain requirements), and with the Flood Plain Management Act (32 P. S. §§ 679.101—679.601), and other applicable laws, to the same extent as if the dam, water obstruction or encroachment were covered by an individual permit.

Source

The provisions of this § 105.449 adopted January 2, 1981, effective January 3, 1981, 11 Pa.B. 9.

Cross References

This section cited in 25 Pa. Code Chapter 105 Appendix A (relating to fish enhancement structure; general permit BDWW-GP-1); 25 Pa. Code Chapter 105 Appendix B (relating to private recreational docks; general permit BDWW-GP-2); 25 Pa. Code Chapter 105 Appendix C (relating to bank rehabilitation and protection; general permit BDWW-GP-3); 25 Pa. Code Chapter 105 Appendix D (relating to Bureau of Dams and Waterway Management; general permit BDWM-GP-4); 25 Pa. Code Chapter 105 Appendix E (relating to utility line stream crossings; general permit BDWM-GP-5); 25 Pa. Code Chapter 105 Appendix F (relating to agricultural crossings and ramps; general permit BDWM-GP-6); 25 Pa. Code Chapter 105 Appendix G (relating to minor road crossings; general per-

Copyright © 2005 Commonwealth of Pennsylvania

mit BDWM-GP-7); 25 Pa. Code Chapter 105 Appendix H (relating to temporary road crossings; general permit BDWM-GP-8); 25 Pa. Code Chapter 105 Appendix I (relating to agricultural activities; general permit BDWM-GP-9); 25 Pa. Code Chapter 105 Appendix J (relating to abandoned mine reclamation; general permit BDWW-GP-10); and 25 Pa. Code Chapter 105 Appendix O (relating to private residential construction in wetlands; general permit BDWW-GP-15).

Subchapter M. STATEMENTS OF POLICY

WETLANDS

Sec.
105.451. Identification and delineation of wetlands—statement of policy.
105.452. Status of prior converted cropland—statement of policy.

WETLANDS

§ 105.451. Identification and delineation of wetlands—statement of policy.

(a) This section sets forth the policy of the Department as to the methodology to be used for the identification and delineation of wetlands.

(b) The use of some delineation method is necessary in order to administer, implement, enforce and determine compliance with the act, The Clean Streams Law (35 P. S. §§ 691.1—691.1001), the Solid Waste Management Act (35 P. S. §§ 6018.101—6018.1003), the Surface Mining Conservation and Reclamation Act (52 P. S. §§ 1396.1—1396.31), the Pennsylvania Sewage Facilities Act (35 P. S. §§ 750.1—750.20), the Oil and Gas Act (58 P. S. §§ 601.101—601.605) and other applicable statutes administered by the Department and regulations promulgated under these statutes.

(c) The Department adopts and incorporates by reference the 1987 *Corps of Engineers Wetland Delineation Manual (Technical Report Y-87-1)* along with the guidance provided by the United States Army Corps of Engineers, Major General Arthur E. Williams' memorandum dated 6 March 1992, *Clarification and Interpretation of the 1987 Manual* and any subsequent changes as the methodology to be used for identifying and delineating wetlands in this Commonwealth. The 1987 *Corps Wetland Delineation Manual*, Publication No. ADA 176734 is available from the National Technical Information Service (NTIS), Springfield, VA 21161, or telephone: (703) 487-4650. Copies of the Supplemental Guidance issued by the Corps concerning use of the 1987 Manual, (that is, the October 7, 1991, Questions and Answers, and the March 6, 1992, Clarification and Interpretation Memorandum) as well as the Administration's Wetlands Plan of August 24, 1993, may be obtained by contacting the regulatory branch of a local Corps District, or the EPA Wetlands Hotline at (800) 832-7828. For more information, con-

tact Pennsylvania Department of Environmental Protection, Bureau of Dams, Waterways and Wetlands, Post Office Box 8554, Harrisburg, Pennsylvania 17105-8554, telephone (717) 787-6827.

Source

The provisions of this § 105.451 adopted October 27, 1989, effective December 27, 1989, 19 Pa.B. 4612; amended February 2, 1996, effective February 3, 1996, 26 Pa.B. 494. Immediately preceding text appears at serial pages (207778) to (207781).

Cross References

This section cited in 25 Pa. Code § 96.3 (relating to water quality protection requirements); and 25 Pa. Code § 105.13 (relating to permit applications—information and fees).

§ 105.452. Status of prior converted cropland—statement of policy.

(a) This section sets forth the policy of the Department as to the status of prior converted cropland in this Commonwealth.

(b) The use of some procedure for determining wetlands is necessary in order to administer, implement, enforce and determine compliance with the act, The Clean Streams Law (35 P. S. §§ 691.1—691.1001), the Solid Waste Management Act (35 P. S. §§ 6018.101—6018.1003), the Surface Mining Conservation and Reclamation Act (52 P. S. §§ 1396.1—1396.31), the Pennsylvania Sewage Facilities Act (35 P. S. §§ 750.1—750.20), the Oil and Gas Act (58 P. S. §§ 601.101—601.605) and other applicable statutes administered by the Department and regulations promulgated under these statutes.

(c) Naturally occurring events may result in either creation or alteration of wetlands. It is necessary to determine whether alterations to an area have resulted in changes that are now ''normal circumstances'' of the particular area. The Department recognizes ''prior converted cropland,'' as defined in the *National Food Security Act Manual* (180-V-NFSAM, Third Edition, March 1994), as ''normal circumstances'' as the term is used in the definition of wetlands in § 105.1 (relating to definitions). These prior converted croplands are not regulated as wetlands under the Commonwealth's Wetland Protection Program contained in this chapter. Prior converted cropland is defined in the *National Food Security Act Manual*, as wetlands that were drained, dredged, filled, leveled or otherwise manipulated, including the removal of woody vegetation, before December 23, 1985, and have not been abandoned, for the purpose of, or to have the effect of making the production of an agricultural commodity possible, and an agricultural commodity was planted or produced at least once prior to December 23, 1985.

(1) Abandonment is the cessation of cropping, forage production or management on prior converted cropland for 5 consecutive years, so that:

(i) Wetland criteria are met.

(ii) The area has not been enrolled in a conservation set-aside program.

Copyright © 2001 Commonwealth of Pennsylvania

(iii) The area was not enrolled in a State or Federal wetland restoration program other than the Wetland Reserve Program.

(2) Prior converted cropland may also be considered abandoned if the landowner provides written intent to abandon the area and wetland criteria are met.

(d) This policy change does not affect the exemption for plowing, cultivating, seeding and harvesting for the production of food, fiber and forest products or the waiver for maintenance of field drainage systems found at § 105.12(a)(7) and (8) (relating to waiver of permit requirements).

Source

The provisions of this § 105.452 adopted February 2, 1996, effective February 3, 1996, 26 Pa.B. 494.

APPENDIX A
FISH ENHANCEMENT STRUCTURES; GENERAL PERMIT BDWW-GP-1

Editor's Note: The following permit was published in the *Pennsylvania Bulletin* as a Notice and is codified under 1 Pa. Code § 3.1(a)(9) (relating to contents of *Code*) as a document which the Legislative Reference Bureau finds to be general and permanent in nature. See §§ 105.441—105.449 (relating to general permits) for the regulations governing this permit.

Table of Contents

Instructions for Using the General Permit
Part One: Applies Specifically to BDWW-GP-1
A. General Description and Fees
B. Sites and Conditions Where this General Permit Does Not Apply
C. Definitions Applicable to this General Permit
D. Project Design and Construction Criteria
E. Cooperative Adopt-A-Stream Program—Special Procedures
F. Authority and Continuing Authorization
Part Two: Applies to BDWW-GP-1 and Other BDWW General Permits
A. Registration of Proposed Use of General Permits
B. Denial of Authorization
C. Standard Definitions for General Permits
D. Preconstruction Requirements for all Projects
E. Other Preconstruction Requirements Where Applicable
F. Standard Provisions of the General Permit
Attachments:
Drawing No. 1—Sample Location Map
Exhibit A—Offices of the Pennsylvania Fish and Boat Commission
Exhibit B—Offices of the Department of Environmental Resources

Exhibit C—County Conservation Districts
Exhibit D—Notification to Use (Registration Form)
Supplement No. 1—Request for Search of Pennsylvania Natural Diversity Index

INSTRUCTIONS FOR USING THE GENERAL PERMIT
BDWW-GP-1
Fish Habitat Enhancement Structures

Prior to Registration to Use:

1. Carefully review the definitions and requirements of the General Permit (Part One and Part Two) to determine if your project can qualify for authorization under this General Permit. Refer to Part One, Section B regarding area restrictions and Part One, Section D regarding criteria. If your project cannot be authorized under the General Permit, you may request approval of an individual permit by submitting an application to the appropriate Soils and Waterways Section in the Regional Office as listed on Exhibit B.

2. Contact the Pennsylvania Fish and Boat Commission, Division of Environmental Services or Division of Property Services at address and telephone number shown on Exhibit A to select a suitable structure and obtain Pennsylvania Fish and Boat Commission approval on Exhibit D. For the Cooperative Adopt-A-Stream Program, the Pennsylvania Fish and Boat Commission will also register the use of the General Permit on behalf of the project sponsor.

3. Locate your project on a United States Geological Survey (U.S.G.S.) 7 1/2 Minute Quadrangle Map (Commonly called ''topographic maps,'' U.S.G.S. Qudarangle may be available from local merchants dealing in books, hunting supplies and camping equipment.) and prepare a project Location Map, utilizing a photocopy of the U.S.G.S. Quadrangle Map.

4. Complete the top portion of the attached Supplement No. 1 (Pennsylvania Natural Diversity Inventory Form). You will not be authorized to use the General Permit until Supplement No. 1 has been processed to check for potential impacts to rare and endangered species. Therefore, to avoid possible project delays or unnecessary design costs, you are advised to submit Supplement No. 1 for processing prior to General Permit registration. To do so, follow the written instructions on the Supplement No. 1 form. The Department will complete the bottom portion of the form and return it to you, generally within a period of 2 weeks. You must have copies of Supplement No. 1 (whether processed or not) for submission as attachments when you register to use the General Permit.

5. For any earthmoving activity (For the definition of earthmoving activity, see Part Two, Section C.) associated with your project, prepare an Erosion and Sedimentation Control Plan which must be reviewed and determined satisfactory by the County Conservation District in the county where your project is located. The required Erosion and Sedimentation Control Plan must be prepared and sub-

Copyright © 1996 Commonwealth of Pennsylvania

mitted to the Conservation District for review prior to or concurrent with your registration to use the General Permit.

The Registration Procedure:

6. Fill in all information on the Notification to Use form (Exhibit D) and make multiple copies. Send one copy each to the municipality and the county in which the project is located.

7. To register use of the General Permit, prepare a complete registration ''package'' consisting of:

—Two Copies of Notification to Use form (Exhibit D)

—Two copies of the Location Map

—Two copies of the Supplement No. 1 form

Send these items to either:

—The County Conservation District for projects located in all counties where there is a delegation agreement (see Exhibit C).

—OR—

—The Soils and Waterways Section having responsibility for the counties where there is no delegation agreement with the County Conservation District (see Exhibit B).

8. If you are also applying for an individual Water Obstruction and Encroachment Permit to authorize related work, you may register to use the General Permit in conjunction with your individual permit application. See Part Two, Section A, Item 2.

Before and During Construction:

9. Do not begin work until:

a. You have received an acknowledgement from the Soils and Waterways Section or County Conservation District that your Exhibit D notification has been received and registered.

b. Your Erosion and Sedimentation Control Plan has been reviewed and determined to be satisfactory by the County Conservation District.

c. You have notified the Pennsylvania Fish and Boat Commission and the County Conservation District 10 days prior to start of construction (see Part Two, Section D).

d. You have obtained any other Federal, State or local permits which may be required.

e. You have complied with any other applicable pre-construction requirements as listed in Part Two, Section E.

f. You have provided written notifications to the municipalities and county where the projects are located prior to the start of construction.

10. During construction of your project, you are responsible for adhering to all terms and conditions of the General Permit, including your approved Erosion and Sedimentation Control Plan and all applicable design and construction criteria in Part One, Section D.

PART ONE

A. General Description and Fees—The Department of Environmental Resources hereby authorizes, by General Permit, subject to the terms and criteria set forth, the installation, operation and maintenance of fish habitat enhancement structures in the regulated waters of this Commonwealth. There is no registration fee required for a project authorized under this General Permit.

B. Sites and Conditions Where this General Permit Does Not Apply—This General Permit does not apply and is not valid in the following sitautions. Where the General Permit is not applicable, you may request approval of an individual permit by submitting an application to the appropriate Soils and Waterways Section in the Regional Office (see Exhibit B).

1. Historic, cultural or archaeological sites as identified in the latest published version of the Pennsylvania Inventory of Historical Places or the National Register of Historical Places. This information is available from the Pennsylvania Historical and Museum Commission, Box 1026, Harrisburg, PA 17108-1026, telephone (717) 787-3362.

2. Sites identified in the latest published version of the National Registry of Natural Landmarks.

3. Construction activities in stocked trout streams from March 1 through June 15, in wild trout streams from October 1 through December 31, and in Lake Erie tributaries from March 1 through June 15 and from September 1 through December 31, unless approval is obtained from the Pennsylvania Fish and Boat Commission's Division of Environmental Services (see Exhibit A). Stocked and wild trout stream locations are compiled by the Commission's Division of Fisheries Management (see Exhibit A).

4. Wetlands.

5. Projects located where there would be an impact on species of special concern listed under the Endangered Species Act of 1973, the Wild Resources Conservation Act, the Fish and Boat Code or the Game and Wildlife Code. Records regarding species of special concern are maintained in a computer database called the ''Pennsylvania Natural Diversity Inventory'' (PNDI). To verify that there will be no such impacts for a specific project, the Department requires submission of the attachment Supplement No. 1 form.

6. Areas in or within 100 feet of a watercourse designated wild in the National or State Scenic Rivers system in accordance with the National Wild and Scenic Rivers Act of 1968 or the Pennsylvania Scenic Rivers Act. For

Copyright © 1996 Commonwealth of Pennsylvania

details on scenic river classifications, contact the DER Pennsylvania Scenic Rivers Program, P. O. Box 8475, Harrisburg, PA 17105-8475, telephone (717) 787-2316.

C. Definitions Applicable to this General Permit—The following words and terms, when used in this General Permit, have the following meanings:

Fish Habitat Enhancement Structures—Structures consisting of deflectors, low flow channel structures, channel blocks, mud sills, boulders, felled shoreline trees, special tire structures, brush structures, rubble reefs, half-log structures, elevated boulder structures and spawning/nursery structures placed in streams, lakes, ponds or reservoirs as developed and approved by the Pennsylvania Fish and Boat Commission.

Reservoir—A natural or artificial basin which contains or will contain the water or other fluid or semifluid impounded by a dam.

D. Project Design and Construction Criteria

1. *Pennsylvania Fish and Boat Commission Approval*—The owner must contact the Pennsylvania Fish and Boat Commission's Division of Property Services or Division of Environmental Services (see Exhibit A) to select a Fish Habitat Enhancement Structure suitable for his individual situation and obtain the required approval of the Pennsylvania Fish and Boat Commission to install the structure as required on the Notification to Use form (Exhibit D).

2. Fish Habitat Enhancement Structures shall be designed and constructed to preclude interference with normal fish migration.

3. Stream flow will not be constructed to a degree greater than the most narrow natural point of the stream in the immediate vicinity of the work within 500 feet upstream or downstream of the project site.

4. Fish Habitat Enhancement Structures located in stream channels shall not extend more than 3 feet above the normal stream bed. Tire structures are prohibited in stream channels.

5. Any archaeological artifacts discovered during the performance of work authorized under this General Permit must be adequately protected and their discovery promptly reported to the Director, Bureau of Historic Preservation, Pennsylvania Historical and Museum Commission, P. O. Box 1026, Harrisburg, PA 17108-1026, telephone (717) 787-2891.

6. Each Fish Habitat Enhancement Structure shall be constructed in such a way so that it does not hinder recreational navigation.

7. Excess fill or excavated and dredged material from the construction of a Fish Habitat Enhancement Structure shall be deposited outside of the adjacent floodplain, wetlands and other regulated waters of this Commonwealth and stabilized immediately in accordance with the Erosion and Sedimentation Control Plan. Waste materials, scrap or excess construction materials shall be collected, stored and disposed of in accordance with the Solid Waste Management Act and related rules and regulations.

8. Fish Habitat Enhancement Structures shall be maintained in a safe and functional condition. This includes the removal of debris. Where maintenance requires excavation or dredging, an Erosion and Sedimentation Control Plan must be reviewed and determined adequate by the County Conservation District in which the activity is located. Disposal of dredged material shall be in accordance with Item 7.

9. Only a clean, nonpolluting, rock material shall be used as fill material in order to minimize excessive turbidity by leaching of fines as well as to preclude the entrance of potentially polluted materials to the watercourse by natural runoff.

10. Slag is not authorized for use under this General Permit unless it qualifies as a co-product which is suitable for the specific use.

11. Construction of a Fish Habitat Enhancement Structure shall take place during periods coinciding with low stream flows.

12. Construction and other activities authorized by this General Permit shall be performed in a manner that minimizes use of equipment within the stream channel or body of water.

13. To the greatest extent possible, the project shall be designed and constructed in a manner which will (a) prevent permanent or long-term adverse changes in water quality, (b) minimize alterations in natural aquatic habitat and (c) maintain natural stream flow velocities and mixing patterns.

E. Cooperative Adopt-A-Stream Program—Special Procedures—The Pennsylvania Fish and Boat Commission is authorized to register the use of this General Permit on behalf of sponsors and landowners who participate in the Commission's Cooperative Adopt-A-Stream Program. To register use of the General Permit for Adopt-A-Stream projects, the Commission shall utilize a modified version of Exhibit D which has been approved by the Department and the U. S. Army Corps of Engineers. The standard attachments to Exhibit D, as specified in Part Two, Section A, are not required to register the use of this General Permit for a Cooperative Adopt-A-Stream Project.

F. Authority and Continuing Authorization—Authorization of this General Permit is under section 7 of the Dam Safety and Encroachments Act (32 P. S. §§ 693.1—693.27) and the rules and regulations promulgated thereunder at 25 Pa. Code §§ 105.441—105.449 (relating to general permits). This General Permit shall authorize the continued operation and maintenance of fish habitat enhancement structures previously authorized by General Permit BDWW-GP-1 (Fish Enhancement Structures) issued on July 25, 1981, and reauthorized on August 29, 1987 and October 7, 1989.

Copyright © 1996 Commonwealth of Pennsylvania

EXHIBIT D

FOR DEPT. USE ONLY

ACKNOWLEDGED:
DATE _____
GP _____

NOTIFICATION TO USE
BDWW-GP-1
Fish Habitat Enhancement Structures

1. I/We, _____
(owner name(s))
hereby notify the Department of Environmental Resources of our intent to install

_____
(description of fish habitat enhancement structure)
in accordance with the conditions of this General Permit at a point _____

_____
(describe location)

on _____
(name of stream or body of water)

in _____ , _____
(municipality) (county)

2. I/We have attached a LOCATION MAP (similar to that shown on Drawing No. 1 indicating where the fish habitat enhancement structure will be installed) and a copy of SUPPLEMENT NO. 1.

3. I/We have enclosed duplicate copies of EXHIBIT D, the LOCATION MAP and SUPPLEMENT NO. 1.

4. I/We certify that copies of this notification were sent this day _____(date)_____

to _____ , and _____
(municipality) (County-Commissioner's Office)

5. I/We certify that an EROSION AND SEDIMENTATION CONTROL PLAN for this project has been submitted for review to the _____ County Conservation District on _____(date)_____ .

Signed by: _____ _____
(print name) (owner address)

_____ _____
(owner signature) (city/state/zip code)

_____ _____
(title, if applicable) (owner telephone number)

6. I/We hereby notify the Department also of our intention to install a temporary road crossing in accordance with the terms of BDWW-GP-8, Temporary Road Crossings, during the installation of the fish habitat enhancement structure (if applicable).

Signed: _____

(207787) No. 255 Feb. 96

Approval—The Pennsylvania Fish and Boat Commission hereby approves the installation of the aforementioned fish habitat enhancement structure in this individual situation.

(Signature) (Date)

Send to address on Exhibit B or delegated Conservation District on Exhibit C

PART TWO

A. Registration of Proposed Use of General Permits

1. Standard Procedure

Prior to construction, the owner shall submit the following items to the DER Soils and Waterways Section in the appropriate Regional Office or the delegated County Conservation District where the project is located (see Exhibits B and C).

(a) Two copies of the Notification to Use form (Exhibit D), one copy with original signatures.

(b) Two copies of a location map (see Drawing No. 1).

(c) Two copies of the Supplement No. 1 form.

(d) Two copies of any other items required in the Instructions and Part One (if applicable).

The owner is required to send additional copies of Exhibit D to the municipality and the County Board of Commissioners where the project is located. Also, as part of the registration, the owner shall certify that an Erosion and Sedimentation Control Plan has been submitted for review to the County Conservation District in which the work will be performed. The owner is not authorized to use the General Permit until he has notified the DER Soils and Waterways Section of the appropriate Regional Office or the appropriate delegated County Conservation District and received an acknowledgement of that notification. The Department's acknowledgement serves as registration to use this General Permit. The owner may not begin work until all preconstruction requirements of this General Permit have been completed.

Registration for the use of this General Permit must be sent to the County Conservation District in counties where the District has a delegation agreement with the Department of Environmental Resources. To determine whether this alternate registration procedure currently applies for your location, refer to Exhibit C and/or contact the appropriate DER Soils and Waterways Section or County Conservation District.

2. In Conjunction with a Water Obstruction and Encroachment Permit Application.

When an activity or structure authorized by the General Permit is an integral part of a larger project which requires an individual Water Obstruction and Encroachment permit, intent to use the General Permit may be registered by

Copyright © 1996 Commonwealth of Pennsylvania

attaching copies of the Notification to Use form (Exhibit D) to the individual permit application, and clearly identifying, in the permit application narrative and/or on site plans, any structure or activity which will be constructed in accordance with the terms and conditions of the General Permit. The Department's acknowledgement of the General Permit registration will be included in the individual permit, and upon issuance of the permit the owner may begin work on the structure or activity authorized by the General Permit. Where applicable, this registration procedure is preferred and recommended by the Department, because written authorization for a project can be combined into one action and the associated documentation can be maintained under a single file number.

3. In Conjunction with an Enforcement Action:

The General Permit may also be used, at the discretion of the Department, in conjunction with an enforcement action or settlement of violations, to register regulated activites conducted without prior permit or authorization.

B. Denial of Authorization—The Department shall have the discretion, on a case-by-case basis, to deny, revoke or suspend the authorization to use a General Permit for any project which the Department determines to have a substantial risk to life, health, property or the environment, or otherwise could not be adequately regulated by the provisions of this General Permit.

C. Standard Definitions for General Permits—The terms as used in this General Permit shall have the following meanings:

Body of Water—Any natural or artificial lake, pond, reservoir, swamp, marsh or wetland.

Department—The Department of Environmental Resources.

Earthmoving Activity—Any construction or other activity which disturbs the surface of the land including, but not limited to, excavations, embankments, land development, subdivision development, mineral extraction and the moving, depositing or storing of soil, rock or earth. This includes any excavation or fill within a stream channel.

Erosion and Sedimentation Control Plan—A plan which is designed to minimize accelerated erosion and sedimentation consistent with the requirements of 25 Pa. Code Chapter 102.

Floodway—The channel of the watercourse and portions of the adjoining floodplains which are reasonably required to carry and discharge the 100-year frequency flood. Unless otherwise specified, the boundary of the floodway is as indicated on maps and flood insurance studies provided by the Federal Emergency Management Administration (FEMA). In an area where no FEMA maps or studies have defined the boundary of the 100-year frequency floodway, it is assumed, absent evidence to the contrary, that the floodway extends from the stream to 50 feet from the top of the bank of the stream.

Install—To construct, deposit, place, lay or set in place.

Owner—A person who owns, controls, operates, maintains, or manages a dam or reservoir, water obstruction or encroachment.

Person—A natural person, partnership, association, corporation, public utility, municipality, municipal authority, political subdivision of the Commonwealth, receiver or trustee, and any department, board, commission or authority of the Commonwealth.

Political Subdivision—A county, city, borough, incorporated town, township, school district, authority or other governmental unit or a combination thereof acting jointly.

Regulated Waters of this Commonwealth—Watercourses, streams or bodies of water and their floodways wholly or partly within or forming part of the boundary of this Commonwealth.

Scenic Rivers—Areas in or within 100 feet of a watercourse or body of water designated a component of the Pennsylvania Scenic Rivers System in accordance with the Pennsylvania Scenic Rivers Act (P. L. 1277, Act No. 283 as amended by Act 110, May 7, 1982), or which are 1-A candidate rivers listed in the Pennsylvania Scenic Rivers Inventory.

Stocked Trout Stream—A stream classified as approved trout waters by the Pennsylvania Fish and Boat Commission. For current designations of stocked trout streams, contact the Division of Fisheries Management (see Exhibit A).

Submerged Lands of this Commonwealth—Waters and permanently or periodically inundated lands owned by the Commonwealth, including lands in the beds of navigable lakes and rivers and beds of streams declared public highways which are owned and held in trust by the Commonwealth.

Watercourse—A channel or conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

Wetlands—Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas.

Wild Trout Stream—A stream classified as supporting naturally reproducing trout populations by the Pennsylvania Fish and Boat Commission. For current designations of wild trout streams, contact the Division of Fisheries Management (see Exhibit A).

D. Preconstruction Requirements for All Projects

1. *Other Permits*—Nothing in this General Permit relieves the owner of the obligation of complying with all Federal, Interstate Compact, State and local laws, regulations and standards for the construction, operation or maintenance of the project or activity. The project owner is advised that written authorization from the U. S. Army Corps of Engineers may be required for compliance with Section 404 of the Clean Water Act.

2. *Erosion and Sedimentation Controls*—Work must be done in compliance with Chapter 102 (relating to erosion and sediment control). Prior to construction, an Erosion and Sedimentation Control Plan must be reviewed and determined adequate by the County Conservation District in which the activities are

Copyright © 2000 Commonwealth of Pennsylvania

proposed and implemented prior to, during and after construction. The County Conservation District shall be notified 10 days prior to the start of construction. The project site shall at all times be available for inspection by authorized employees of the County Conservation District. The Erosion and Sedimentation Control Plan shall be available at the site.

3. *Pennsylvania Fish and Boat Commission Notification*—The owners shall notify the Pennsylvania Fish and Boat Commission's Regional Field Office Supervisor (see Exhibit A) responsible for the County where the activities are proposed 10 days prior to start of construction. Written notification is suggested. The project site shall at all times be available for inspection by authorized officers and employes of the Pennsylvania Fish and Boat Commission.

4. *Notification to Operators of Public Water Facilities*—Owners will investigate for drinking water intakes or reservoirs for public water supplies and permitted public bathing beaches within 5 miles downstream of the site of the project. Written notice shall be given at least 10 days prior to construction to the Department and to operators of any such intakes, beaches or reservoirs. This notification shall include expected starting and completion dates for the construction activities. Owners must notify the Department and operators immediately and no longer than 1 hour after the occurrence at the site which results in the release of suspended solids and turbidity to the stream. Public drinking water sources are listed by the DER Bureau of Water Supply and Community Health, and this information is available from each DER Regional Office.

E. Other Preconstruction Requirements Where Applicable

1. *Submerged Lands of this Commonwealth*—This General Permit shall not be effective to authorize any project over, across or occupying submerged lands of this Commonwealth until the owner has obtained a license from the Department authorizing the occupation of such submerged lands issued under section 15 of the Dam Safety and Encroachments Act (32 P. S. § 693.15), section 514 of the Administrative Code of 1929 (71 P. S. § 194), or other applicable laws. Upon receipt of notification from the owner, the Department will review the project to determine if its location is over, across or occupies submerged lands of the Commonwealth. If applicable, the Department will prepare a Submerged Lands License Agreement and forward same to the owner for execution prior to acknowledgement of registration to use the General Permit. No annual charge is required for facilities constructed, owned or operated by a Political Subdivision of the Commonwealth.

2. *Utilization of General Permit BDWW-GP-8, Temporary Road Crossings*—Temporary road crossings of streams and causeways that are necessary for equipment to move back and forth across a stream during construction of a project are authorized by, and must be constructed in accordance with BDWW-GP-8. The owners shall indicate utilization of BDWW-GP-8 on Exhibit D in the space provided. Owners constructing temporary road crossings

in those areas excluded from the application of GP-8 must apply for an individual Water Obstruction and Encroachment Permit for those road crossings.

3. *Use of Explosives*—Prior to the use of explosives in a watercourse or body of water, the permittee shall secure a written permit from the Pennsylvania Fish and Boat Commission, under the Fish and Boat Code, Act 1980-175 Title 30 Pennsylvania Consolidated Statutes, Section 2906. Requests should be directed to the Pennsylvania Fish and Boat Commission, Division of Environmental Services (see Exhibit A).

F. Standard Provisions of the General Permit

1. *Effective Time Period*—This General Permit will remain in effect indefinitely unless specifically modified, suspended or revised by the Department.

2. *Suspension, Modification or Revocation*—The Department may suspend, modify or revoke this General Permit at any time upon notice in the *Pennsylvania Bulletin*.

3. *Project Interference*—This General Permit does not authorize any interference with any existing or proposed local, State, Federal or Federally licensed project, and permittee shall not be entitled to compensation for damage or injury to the work authorized herein which may be caused by or a result of existing or future operations undertaken by the United States or the Commonwealth of Pennsylvania or its Political Subdivisions in the public interest.

4. *Department Inspection*—As a condition of use of this General Permit, and of the owner's authority to conduct the activities authorized by this General Permit, the owner hereby authorizes and consents to allow authorized employes or agents of the Department, without advance notice or a search warrant, at any reasonable time and upon presentation of appropriate credentials, and without delay, to have access to and to inspect all areas where the project is being constructed, operated or maintained. The authorization and consent shall include consent to conduct tests or sampling, to take photographs, to perform measurements, surveys and other tests, to inspect the methods of construction, operation or maintenance, to examine and copy books, papers and records pertinent to any matter under investigation, and to take any other action necessary to assure that the project is constructed, operated or maintained in accordance with the terms and criteria of the General Permit. This General Permit condition is referenced in accordance with Section 16 of the Dam Safety and Encroachments Act, 32 P. S. § 693.16, and in no way limits any other powers granted under the Dam Safety and Encroachments Act.

5. *Activities Not in Accordance with the Terms or Conditions*—If the Department determines, upon inspection, that the construction, operation or maintenance of a project has violated the terms or criteria of this General Permit or of the Chapter 105 Rules and Regulations, the Department may take such actions, legal or administrative, that it may deem to be appropriate.

6. *Structure Removal*—The owners shall remove all or any portion of this project upon written notification to the owner by the Department in the event

Copyright © 2000 Commonwealth of Pennsylvania

the project is causing an adverse impact on public health, safety or the environment, or in any other manner violates the conditions of this General Permit or Chapter 105 Rules and Regulations.

7. *Property Rights*—This General Permit does not authorize trespassing on private property nor convey any property rights, either in real estate or material, or in any exclusive privileges; nor does it authorize any injury to property or invasion of rights or any infringement of Federal, State or local laws or regulations.

8. *Water Quality Certification*—The issuance of this General Permit also constitutes approval of a Water Quality Certification under section 401 of the Federal Clean Water Act (33 U.S.C.A. § 1341).

9. *Other Approvals*—The owners shall secure all other approvals that may be necessary under other Federal, State or local laws or regulations.

10. *Change of Ownership*—If there is a change in ownership of a structure installed in accordance with this General Permit, the new owner is required to register the structure with the Department in accordance with Part Two, Section A, of this General Permit. The new owner shall submit one copy of Exhibit D indicating ''change of ownership'' and one copy of a location map. Additional items required under Part Two, Section A, are not applicable if there are no proposed construction activities.

11. *Signature*—The Notification to Use form for registration to use the General Permit shall be signed by the property owner; the president, vice president or other responsible official of a Corporation; or the chief official for a Government Agency/Political Subdivision. An engineering consultant, contractor or similar agent is not authorized to sign the General Permit registration form on behalf of the owner.

EXHIBIT A
Offices of the Pennsylvania Fish and Boat Commission

Headquarters Address	*County Responsibility*
Northwest Region	
Regional Supervisor P. O. Box 349 1281 Otter Street Franklin, PA 16323 (814) 437-5774	Butler, Clarion, Crawford, Erie, Forest, Lawrence, Mercer, Venango and Warren

Headquarters Address	*County Responsibility*
Southwest Region	
Regional Supervisor R. D. 2, Box 39 Somerset, PA 15501-9311 (814) 445-8974	Allegheny, Armstrong, Beaver, Cambria, Fayette, Greene, Indiana, Somerset, Washington and Westmoreland
Northcentral Region	
Regional Supervisor Box 187 (Fishing Creek Road) Lamar, PA 16848 (717) 726-6056	Cameron, Centre, Clearfield, Clinton, Elk, Jefferson, Lycoming, McKean, Potter, Snyder, Tioga and Union
Southcentral Region	
Regional Supervisor 1704 Pine Road Newville, PA 17241 (717) 486-7087	Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lebanon, Mifflin, Perry and York
Southeast Region	
Regional Supervisor Box 8 Elm, PA 17521 (717) 626-0228	Berks, Bucks, Chester, Delaware, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia and Schuylkill
Northeast Region	
Regional Supervisor Box 88 Sweet Valley, PA 18656 (717) 477-5717	Bradford, Carbon, Columbia, Lackawanna, Luzerne, Monroe, Montour, Northumberland, Pike, Sullivan, Susquehanna, Wayne and Wyoming

Division of Environmental Services
450 Robinson Lane, Bellefonte, PA 16823-9620
(814) 359-5145

Division of Property Services
450 Robinson Lane, Bellefonte, PA 16823-9620
(814) 359-5149

Division of Fisheries Management
450 Robinson Lane, Bellefonte, PA 16823-9620
(814) 359-5110

105-138

Copyright © 1996 Commonwealth of Pennsylvania

EXHIBIT B
Offices of the Department of Environmental Resources

Soils and Waterways Section	*County Responsibility*
Southcentral Regional Office Room 147, One Ararat Boulevard Harrisburg, PA 17110 (717) 541-7901	Adams, Bedford, Berks, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Mifflin, Perry and York
Southeast Regional Office Suite 6010, Lee Park 555 North Lane Conshohocken, PA 19428 (610) 832-6130	Bucks, Chester, Delaware, Montgomery and Philadelphia
Southwest Regional Office 400 Waterfront Drive Pittsburgh, PA 15222-4745 (412) 442-4000	Allegheny, Armstrong, Beaver, Cambria, Fayette, Greene, Indiana, Somerset, Washington and Westmoreland
Northwest Regional Office 190 Adams Road Jamestown, PA 16134 (412) 932-3162	Butler, Clarion, Crawford, Elk, Erie, Forest, Jefferson, Lawrence, McKean, Mercer, Venango and Warren
Northeast Regional Office Cross Valley Centre, Suite 203 667 North River Street Plains, PA 18705-1099 (717) 826-5485	Carbon, Lackawanna, Lehigh, Luzerne, Monroe, Northampton, Pike, Schuylkill, Susquehanna, Wayne and Wyoming
Northcentral Regional Office 200 Pine Street Williamsport, PA 17701 (717) 327-3574	Bradford, Cameron, Centre, Clearfield, Clinton, Columbia, Lycoming, Montour, Northumberland, Potter, Snyder, Sullivan, Tioga and Union

Note: Registration for the use of this General Permit must be sent to the County Conservation District in some counties where the district has a delegation agreement with the Department of Environmental Resources. To determine whether this alternate registration procedure applies for your location, refer to Exhibit C and/or contact the appropriate Soils and Waterways Section or County Conservation District.

EXHIBIT C
County Conservation Districts

Conservation District	*Phone No.*	*Conservation District*	*Phone No.*
*Adams County	717-334-0636	Juniata County	717-436-6919
Allegheny County	412-921-1999	Lackawanna County	717-587-2607
Armstrong County	412-548-3425/3428	Lancaster County	717-299-5361
Beaver County	412-774-7090	Lawrence County	412-652-4512
Bedford County	814-623-6706/8099	Lebanon County	717-272-3377
*Berks County	215-372-4657	Lehigh County	610-820-3398
Blair County	814-696-0877	Luzerne County	717-825-1844/5
*Bradford County	717-265-5539	Lycoming County	717-326-5858
*Bucks County	610-345-7577	McKean County	814-368-9960
*Butler County	412-284-5270/5271	*Mercer County	412-662-2242
*Cambria County	814-472-5440 Ext 588	*Mifflin County	717-248-4695
Cameron County	814-486-3350	*Monroe County	717-629-3060
Carbon County	610-377-4894	Montgomery County	610-489-4506
*Centre County	814-355-6817/6818	*Montour County	717-271-1140
Chester County	610-696-5126	Northampton County	610-746-1971
Clarion County	814-226-4070	Northumberland County	717-988-4224
Clearfield County	814-765-2629	Perry County	717-582-8988
*Clinton County	717-726-3798	*Pike County	717-226-8220
Columbia County	717-784-1310	Potter County	814-274-8411
*Crawford County	814-724-1793	Schuylkill County	717-429-1744
*Cumberland County	717-249-8632	*Snyder County	717-837-0085
*Dauphin County	717-921-8100	Somerset County	814-445-4652
Delaware County	610-892-9484	Sullivan County	717-924-3983
*Elk County	814-776-5373	Susquehanna County	717-278-4600 Ext 280
*Erie County	814-796-4203	*Tioga County	717-724-4812
Fayette County	412-438-4497	*Union County	717-523-8782
Forest County	814-755-3450	*Venango County	814-432-7456
*Franklin County	717-264-8074	Warren County	814-723-7700
Fulton County	717-485-3547	Washington County	412-228-6774
Greene County	412-852-1171 Ext 319	Wayne County	717-253-0930
Huntingdon County	814-627-1627	Westmoreland County	412-837-5271
Indiana County	412-463-7702	*Wyoming County	717-836-2589 or 2993
Jefferson County	814-849-7463	York County	717-771-9430

*County Conservation Districts having delegation agreements with the Bureau of Dams, Waterways and Wetlands for general permit processing as of July 1, 1994.

Copyright © 1996 Commonwealth of Pennsylvania

Source

The provisions of this Appendix A adopted July 24, 1981, effective July 25, 1981, 11 Pa.B. 2636; amended August 28, 1987, effective August 29, 1987, 17 Pa.B. 3569; amended October 6, 1989, effective October 7, 1989, 19 Pa.B. 4328; amended August 5, 1994, effective August 6, 1994, 24 Pa.B. 3899. Immediately preceding text appears at serial pages (162380) to (162390).

APPENDIX B
PRIVATE RECREATIONAL DOCKS; GENERAL PERMIT BDWW-GP-2

Editor's Note: The following permit was published in the *Pennsylvania Bulletin* as a Notice and is codified under 1 Pa. Code § 3.1(a)(9) (relating to contents of *Code*) as a document which the Legislative Reference Bureau finds to be general and permanent in nature. See §§ 105.441—105.449 (relating to general permits) for regulations governing this permit.

Table of Contents

Instructions for Using the General Permit
Part One: Applies Specifically to BDWW-GP-2
A. General Description and Fees
B. Sites and Conditions Where this General Permit Does Not Apply
C. Definitions Applicable to this General Permit
D. Project Design and Construction Criteria for Docks
E. Project Design and Construction Criteria for Boat Launching Ramps
F. Special Provisions Regarding Property Rights
G. Authority and Continuing Authorization
Part Two: Applies to BDWW-GP-2 and Other BDWW General Permits
A. Registration of Proposed Use of General Permits
B. Denial of Authorization
C. Standard Definitions for General Permits
D. Preconstruction Requirements for All Projects
E. Other Preconstruction Requirements Where Applicable
F. Standard Provisions of the General Permit
Attachments:
Drawing No. 1—Sample Location Map
Drawings No. 2 to 5—Sample Projects with Criteria
Exhibit A—Offices of the Pennsylvania Fish and Boat Commission
Exhibit B—Offices of the Department of Environmental Resources
Exhibit C—County Conservation Districts
Exhibit D—Notification to Use (Registration Form)
Supplement No. 1—Request for Search of Pennsylvania Natural Diversity Inventory (Form)

INSTRUCTIONS FOR USING THE GENERAL PERMIT BDWW-GP-2
Small Docks and Boat Launching Ramps

Prior to Registration to Use:

1. Carefully review the definitions and requirements of the General Permit (Part One and Part Two) to determine if your project can qualify for authorization under this General Permit. Refer to Part One, Section B regarding area restrictions and Part One, Sections D and E regarding criteria. If your project cannot be authorized under the General Permit, you may request approval of an individual permit by submitting an application to the appropriate Soils and Waterways Section in the Regional Office as listed on Exhibit B.

2. Locate your project on a United States Geological Survey (U.S.G.S.) 7 1/2 Minute Quadrangle Map (Commonly called ''topographic maps,'' U.S.G.S. Quadrangles may be available from local merchants dealing in books, hunting supplies and camping equipment.) and prepare a project Location Map, utilizing a photocopy of the U.S.G.S. Quadrangle Map.

3. Complete the top portion of the attached Supplement No. 1 (Pennsylvania Natural Diversity Inventory Form). You will not be authorized to use the General Permit until Supplement No. 1 has been processed to check for potential impacts to rare and endangered species. Therefore, to avoid possible project delays or unnecessary design costs, you are advised to submit Supplement No. 1 for processing prior to General Permit registration. To do so, follow the written instructions on the Supplement No. 1 form. The Department will complete the bottom portion of the form and return it to you, generally within a period of 2 weeks. You must have copies of Supplement No. 1 (whether processed or not) for submission as attachments when you register to use the General Permit.

4. Your project may also require a permit from the U. S. Army Corps of Engineers under section 404 of the Federal Clean Water Act, sections 9 and 10 of the Rivers and Harbors Act and/or section 103 of the Marine Protection, Research and Sanctuaries Act. The registration to use this State General Permit does not relieve you of the obligation to comply with, and the State is not authorized to address, these Corps of Engineers' requirements. Therefore, in order to avoid violation of Federal statutes, please contact the appropriate U. S. Corps of Engineers District Office listed below to determine whether a Federal permit is required for your project.

Delaware River Basin

Philadelphia Dist. Corps of Engineers
Wanamaker Bldg., 100 Penn Square East
Philadelphia, PA 19107
(215) 656-6725

Copyright © 1996 Commonwealth of Pennsylvania

Lake Erie Basin

Buffalo Dist. Corps of Engineers
1776 Niagara Street
Buffalo, NY 14207-3199
(716) 879-4104

Ohio River Basin

Pittsburgh Dist. Corps of Engineers
1834 Wm. S. Morehead Federal Bldg.
1000 Liberty Avenue
Pittsburgh, PA 15222
(412) 644-6874

Susquehanna River Basin

Baltimore Dist. Corps of Engineers
P. O. Box 1715
Baltimore, MD 21203-1715
(410) 962-1846 or (717) 726-7757

5. For any earthmoving activity (For the definition of earthmoving activity, see Part Two, Section C.) associated with your project, prepare the Erosion and Sedimentation Control Plan which must be reviewed and determined satisfactory by the County Conservation District in the county where your project is located. The required Erosion and Sedimentation Control Plan must be prepared and submitted to the Conservation District for review prior to or concurrent with your registration to use the General Permit.

The Registration Procedure:

6. Fill in all information on the Notification to Use form (Exhibit D) and make multiple copies. Send one copy each to the municipality and the county in which the project is located.

7. To register use of the General Permit, prepare a complete registration ''package'' consisting of:

—Two Copies of Notification to Use form (Exhibit D)

—Two copies of the Location Map

—Two copies of the Supplement No. 1 form

Send these items to either:

—The County Conservation District for projects located in all counties where there is a delegation agreement (see Exhibit C).

—OR—

—The Soils and Waterways Section having responsibility for the counties where there is no delegation agreement with the County Conservation District (see Exhibit B).

8. If you are also applying for an Individual Water Obstruction and Encroachment Permit to authorize related work, you may register to use the General Permit in conjunction with your individual permit application. See Part Two, Section A, Item 2.

Before and During Construction:

9. Do not begin work until:

a. You have received an acknowledgement from the Soils and Waterways Section or County Conservation District that your Exhibit D notification has been received and registered.

b. Your Erosion and Sedimentation Control Plan has been reviewed and determined to be satisfactory by the County Conservation District.

c. You have notified the Pennsylvania Fish and Boat Commission and the County Conservation District 10 days prior to start of construction. (See Part Two, Section D.).

d. You have obtained any other Federal, State or local permits which may be required.

e. You have complied with any other applicable preconstruction requirements as listed in Part Two, Section E.

f. You have provided written notifications to the municipalities and county where the projects are located prior to the start of construction.

10. During construction of your project, you are responsible for adhering to all terms and conditions of the General Permit, including your approved Erosion and Sedimentation Control Plan and all applicable design and construction criteria in Part One, Sections D and E.

PART ONE

A. General Description and Fees—The Department of Environmental Resources hereby authorizes, by General Permit, subject to the terms and criteria set forth below, the installation, operation, modification and maintenance of small docks and boat launching ramps in and along the regulated waters of this Commonwealth. There is no registration fee required for a project authorized under this General Permit.

B. Sites and Conditions Where this General Permit Does Not Apply—This General Permit does not apply and is not valid in the following situations. Where the General Permit is not applicable, you may request approval of an individual permit by submitting an application to the appropriate Soils and Waterways Section in the Regional Office (see Exhibit B).

1. Historical, cultural or archaeological sites as identified in the latest published version of the Pennsylvania Inventory of Historical Places or the National Register of Historical Places. This information is available from the Pennsylvania Historical and Museum Commission, Box 1026, Harrisburg, PA 17108-1026, telephone (717) 787-3362.

Copyright © 1996 Commonwealth of Pennsylvania

2. Sites identified in the latest published version of the National Registry of Natural Landmarks.

3. Areas in or within 100 feet of a watercourse designated wild in the National or State Scenic Rivers system in accordance with the National Wild and Scenic Rivers Act of 1968 or the Pennsylvania Scenic Rivers Act. For details on scenic river classification, contact the DER Pennsylvania Scenic Rivers Program, P. O. Box 8475, Harrisburg, PA 17105-8475, telephone (717) 787-2316.

4. Construction activities in stocked trout streams from March 1 through June 15, in wild trout streams from October 1 through December 31, and in Lake Erie tributaries from March 1 through June 15 and from September 1 through December 31 unless written approval is obtained from the Pennsylvania Fish and Boat Commission's Division of Environmental Services (see Exhibit A). Stocked and wild trout stream locations are compiled by the Commission's Division of Fishery Management (see Exhibit A).

5. Projects located where there would be an impact on species of special concern listed under the Endangered Species Act of 1973, the Wild Resources Conservation Act, the Fish and Boat Code or the Game and Wildlife Code. Records regarding species of special concern are maintained in a computer database called the ''Pennsylvania Natural Diversity Inventory'' (PNDI). To verify that there will be no such impacts for a specific project, the Department requires submission of the attached Supplement No. 1 form.

6. Streams or waterbodies designated as Exceptional Value Waters as defined and listed in Chapter 93 (related to water quality standards).

7. Projects requiring excavation of mudflats in the tidal waters of the Delaware River.

C. Definitions Applicable to this General Permit—The following words and terms, when used in this General Permit, have the following meanings:

Boat Launching Ramp—A sloping stabilized roadway constructed in and along a stream or lake for the purpose of launching boats from vehicular trailers, including associated walkways for boarding boats and on-grade improvements for access, turning and parking.

Dredge—To remove sand, gravel, mud or other materials from the beds of regulated waters of this Commonwealth.

Fill—Sand, gravel, earth or other material placed or deposited to form an embankment or raise the elevation of the land surface. The term includes material used to replace an area with aquatic life with dry land or to change the bottom elevation of any regulated water of this Commonwealth.

Other Private and Commercial Facilities—Docks and boat launching ramps other than those defined as private recreational docks, public access facilities and public service facilities.

Private Recreational Dock—A dock utilized for private recreational purposes by the riparian land owner.

Public Access Facility—A dock or boat launching ramp for public recreational purposes when the facility is open to the general public and maintained on a nonprofit basis or for use without fee.

Public Service Facility—A dock or boat launching ramp constructed, owned or operated by a political subdivision of the Commonwealth which provides services necessary for public health and welfare, or in connection with a service for which no fees or charges other than general taxes are imposed.

Shoreline—The edge of water in a lake or other body of water at normal pool elevation; the edge of water along a waterway at the ordinary low water level.

Small Dock—A single floating, cantilevered or pile structure constructed within a waterway or other body of water and located on lands or adjacent to riparian lands which are owned or leased by the dock owner. Small docks authorized under this General Permit are classified in four categories based on the proposed use and type of ownership. These categories are (1) private recreational dock, (2) public access facility, (3) public service facility and (4) other private and commercial facilities.

D. Project Design and Construction Criteria for Docks

1. Small Docks may be constructed to any configuration but shall not exceed 750 square feet in surface area, except where other limits apply on navigable rivers of the United States and on Scenic Rivers (see items 1a and 1b which follow).

a. A Federal permit is required from the U. S. Army Corps of Engineers for small dock structures located on rivers and other waterways which are designated Navigable Waters of the United States and regulated under Section 10 of the Rivers and Harbors Act. The small dock surface area and configuration on these navigable waters must be in conformance with any applicable Section 10 permit criteria which may be more restrictive than this General Permit. Size and shape limitations may be subject to change and may vary between Corps District Offices.

b. In waterways which are part of the National or Pennsylvania Scenic Rivers System the total surface area of a small dock shall not exceed 250 square feet.

2. A small dock on a lake shall not extend more than 50 feet from the edge of normal pool elevation. In a river or other stream, a small dock shall not extend more than 20% of the width of the stream; however, it shall in no instance extend more than 100 feet from the ordinary low water mark of a stream.

3. Only one small dock shall be constructed on a given riparian parcel under this General Permit, except where the parcel is common property or where multiple parties have deeded access rights or easements. See Section F, Items 2 and 3 for specific terms regarding multiple use of this General Permit on a given riparian parcel.

Copyright © 1996 Commonwealth of Pennsylvania

4. No part of the small dock structure or associated boat mooring area may extend in front of adjacent riparian properties or otherwise interfere with access and use of the water by adjacent riparian land owners.

5. Each small dock shall be constructed in such a way that it does not hinder commercial or recreational navigation and does not interfere with normal fish migration.

6. Construction and other activities authorized by this General Permit shall be performed in a manner that minimizes use of equipment within the stream channel or body of water.

7. Construction of a small dock on a waterway shall take place during periods coinciding with lower stream flows.

8. Each small dock shall be constructed in such a way as not to obscure any navigation aids or lights for bridges in the area.

9. Small docks shall be maintained in a functional condition which includes the periodic removal of debris.

10. Maintenance dredging to restore original depths is permitted only in the mooring area for boats and is limited to 10 feet beyond the edge of the dock.

11. Dredging for construction purposes is not authorized by this General Permit.

12. This General Permit does not authorize the storage of fuel or the construction of fuel servicing facilities on the small dock.

13. This General Permit does not authorize the construction or modification of a small dock for use as a habitable structure with living facilities such as beds, bathrooms or kitchens.

14. The owner shall employ measures to prevent and control spills of fuels or lubricants into the waterway.

15. Flotation devices, if used, shall be securely fastened to the structure to prevent separation from the small dock.

16. Drums to be utilized as flotation devices that have been previously filled with another substance shall be thoroughly cleaned before use to preclude the possibility of pollution.

17. The small dock structure shall be adequately secured to the shoreline to insure the structure's stability to withstand the effects of wind, stream flows and wave action.

18. Anchorages shall be placed so they do not accelerate erosion or cause degradation of the streambanks.

19. The placement of fill or dredged material into a watercourse, floodway or body of water is not authorized under this General Permit.

20. To the greatest extent possible, the project shall be designed and constructed in a manner which will (a) prevent permanent or long-term changes in water quality, (b) minimize alterations in natural aquatic habitat and (c) maintain natural streamflow velocities and mixing patterns.

21. Archaeological artifacts discovered during the performance of work authorized under this General Permit must be adequately protected and their discovery promptly reported to the Director, Bureau of Historic Preservation, Pennsylvania Historical and Museum Commission, P. O. Box 1026, Harrisburg, PA 17108-1026, telephone (717) 787-2891.

E. Project Design and Construction Criteria for Boat Launching Ramps

1. Boat launching ramps authorized by this General Permit are limited to a maximum width of 20 feet.

2. Boat launching ramps shall be located to minimize streambank excavation and wetland impacts. Boat launching ramps are limited to a maximum length of 100 feet measured from the top of the ramp to the shoreline.

3. Only one boat launching ramp shall be constructed on a given riparian parcel under this General Permit, except where the parcel is common property or where multiple parties have deeded access rights or easements. See Section F, Items 2 and 3 for specific terms regarding multiple use of this General Permit on a given riparian parcel.

4. Construction and other activities authorized by this General Permit shall be performed in a manner that minimizes use of equipment within the stream channel or body of water.

5. Construction of a boat launching ramp along a waterway shall take place during periods when the stream is at low flow.

6. To the greatest extent possible, the project shall be designed and constructed in a manner which will (a) prevent permanent or long-term changes in water quality, (b) minimize alterations in natural aquatic habitat and (c) maintain natural streamflow velocities and mixing patterns.

7. Where required to support boat trailers, the portion of a boat launching ramp located in a streambed or lakebed may be stabilized by clean rock and/or gravel, timber, precast concrete planks or precast concrete slabs (formed onshore and pushed or lifted in place). This stabilization of the bed surface shall be limited to the minimum length necessary for boat launching.

8. Exposed bank areas along the approach ramp shall be stabilized and protected from the erosive action of waves and stream currents.

9. For launching ramps which require associated facilities such as parking lots and turn-around driveways in the floodway along a stream, necessary regrading shall be accomplished without the addition of fill within the regulated floodway. Parking facilities shall be built on existing grade or with minimal grade changes not exceeding 12 inches. Surfaces shall be stabilized with gravel, macadam or concrete. There shall be a volume of soil material removed from the floodway equal to or greater than the volume of construction materials to be used, and there shall be no net loss of conveyance area in the floodway cross-section. Along waterways designated Exceptional Value (EV) or High Quality Waters (HQ) under Chapter 93 Rules and Regulations (relating to

Copyright © 1996 Commonwealth of Pennsylvania

water quality), a 50-foot wide vegetated buffer strip is required between parking facilities and the streambank. Access roads which cross wetlands and improved parking areas in wetlands are not authorized by this General Permit.

10. Boat ramps constructed along Lake Erie shall be located near the western edge of a property to allow space to dispose future dredge material. Material from maintenance dredging of a boat ramp along the shoreline of Lake Erie shall be placed on the shoreline to the east of the removal site.

11. Archaeological artifacts discovered during the performance of work authorized under this General Permit must be adequately protected and their discovery promptly reported to the Director, Bureau of Historic Preservation, Pennsylvania Historical and Museum Commission, P. O. Box 1026, Harrisburg, PA 17108-1026, telephone (717) 787-2891.

F. Special Provisions Regarding Property Rights

1. *Submerged Lands License Agreements and Fees*—As explained in Part Two, Section E, Item 1 of this General Permit, a license agreement is required for projects which are located in certain waters designated navigable or public highways and which are held in trust by the Commonwealth. In accordance with Chapter 105 Rules and Regulations, a minimum annual license fee of $250 is assessed except for the following types of facilities and uses:

a. Private recreational docks constructed under a General Permit.

b. Public Access Facilities provided without charge or on a nonprofit basis.

c. Public Service Facilities provided without fees or charges.

There is no annual fee assessed for the facilities listed above. However, other types of docks or boat launching ramps will require an annual fee when located in Submerged Lands of the Commonwealth. Therefore, the user of this General Permit is required to indicate the type of structure on the Notification to Use form (Exhibit D).

2. *Multiple Use of the General Permit on Common Property*—An association of homeowners or similar group (association) holding title to common property with riparian rights may register to construct and maintain docks on behalf of individual members. The association shall assure that adequate spacing for mooring and access is maintained between docks. Each dock shall be registered by the association and constructed in accordance with the General Permit.

3. *Use of the General Permit where Multiple Parties Hold Access Rights on Riparian Land*—In areas where common use of riparian land is reserved by easement or other deed restrictions, and where there is no homeowners association or similar organization with appropriate authority, each holder (owner) of such easement or deed restriction may register and construct one dock and boat launching ramp under the authority of this General Permit. Owners are mutually responsible to assure that adequate spacing for mooring and access is

maintained between structures. Registering the use of this General Permit does not grant the right to interfere with other eligible users or with the riparian rights of others. Users of this General Permit are solely responsible to mutually resolve any problems of interference or other disagreements on riparian lands where access rights are shared.

G. Authority and Continuing Authorization—Authorization of this General Permit is under section 7 of the Dam Safety and Encroachments Act (32 P. S. § 693.7) and the rules and regulations promulgated thereunder at 25 Pa. Code §§ 105.441—105.449 (relating to general permits). This General Permit shall authorize the continued operation and maintenance of private recreational docks authorized by General Permit BDWM-GP-2 (Private Recreational Docks) issued on December 29, 1990.

EXHIBIT D

NOTIFICATION TO USE
BDWW-GP-2
Small Docks and Boat Launching Ramps

FOR DEPT. USE ONLY

ACKNOWLEDGED:
DATE _____
GP _____

1. I/We, _____
(owner name(s))
hereby notify the Department of Environmental Resources of our intent to install

_____
(description of dock or launching ramp)

at a point _____
(describe location)

in _____
(name of stream or body of water)

in _____ , _____
(municipality) (county)

2. Indicate type of use for the facility (see definitions in Part One, Section C):

_____ private recreational dock
_____ public access facility
_____ public service facility
_____ other private or commercial facility

3. I/We have attached a LOCATION MAP (similar to that shown on Drawing No. 1 indicating where the small dock or boat launching ramp will be installed) and a copy of SUPPLEMENT NO. 1.

3. I/We have enclosed duplicate copies of EXHIBIT D, the LOCATION MAP and SUPPLEMENT NO. 1.

5. I/We certify that copies of this notification were sent this day _____ (date)
to _____ , and _____
(municipality) (County-Commissioner's Office)

Copyright © 1996 Commonwealth of Pennsylvania

6. I/We certify that an EROSION AND SEDIMENTATION CONTROL PLAN for this project has been submitted for review to the _____ County Conservation District on _____ (date) _____ .

Signed by: _____
(print name)

_____
(owner signature)

_____
(title, if applicable)

_____
(owner address)

_____
(city/state/zip code)

_____
(owner telephone number)

Send to address on Exhibit B or delegated County Conservation District on Exhibit C.

(*Editor's Note*: For general requirements, definitions and regional office addresses, see ''Part Two: Applies to BDWW-GP-1 and other BDWW General Permits'' in BDWW-GP-1.

Source

The provisions of this Appendix B adopted December 28, 1990, effective December 29, 1990, 20 Pa.B. 6419; amended August 19, 1994, effective August 20, 1994, 24 Pa.B. 3907. Immediately preceding text appears at serial pages (162391) to (162403).

APPENDIX C
BANK REHABILITATION AND PROTECTION; GENERAL PERMIT BDWW-GP-3

(**Editor's Note:** The following permit was published in the *Pennsylvania Bulletin* as a Notice and is codified under 1 Pa. Code § 3.1(a)(9) (relating to contents of *Code*) as a document which the Legislative Reference Bureau finds to be general and permanent in nature. See §§ 105.441—105.449 (relating to general permits) for regulations governing this permit.

Table of Contents

Instructions for Using the General Permit
Part One: Applies Specifically to BDWW-GP-3

A. General Description and Fees
B. Sites and Conditions Where this General Permit Does Not Apply
C. Definitions Applicable to this General Permit
D. Project Design and Construction Criteria
E. Additional Criteria for Bank Rehabilitation and Protection
F. Additional Criteria for Removal of Gravel Bars
G. Authority and Continuing Authorization

Part Two: Applies to BDWW-GP-3 and Other BDWW General Permits

A. Registration of Proposed Use of General Permits
B. Denial of Authorization
C. Standard Definitions for General Permits

D. Preconstruction Requirements for All Projects
E. Other Preconstruction Requirements Where Applicable
F. Standard Provisions of the General Permit

Attachments:

Drawing No. 1—Sample Location Map
Drawings No. 2 to 14—Sample Projects with Criteria
Exhibit A—Offices of the Pennsylvania Fish and Boat Commission
Exhibit B—Offices of the Department of Environmental Resources
Exhibit C—County Conservation Districts
Exhibit D—Notification to Use (Registration Form)
Supplement No. 1—Request for Search of Pennsylvania Natural Diversity Inventory (Form)

INSTRUCTIONS FOR USING THE GENERAL PERMIT BDWW-GP-3 Bank Rehabilitation, Bank Protection and Gravel Bar Removal

Prior to Registration to Use:

1. Carefully review the definitions and requirements of the General Permit (Part One and Part Two) to determine if your project can qualify for authorization under this General Permit. Refer to Part One, Section B regarding area restrictions and Part One, Sections D, E and F regarding criteria. If your project cannot be authorized under the General Permit, you may request approval of an individual permit by submitting an application to the appropriate Soils and Waterways Section in the Regional Office as listed on Exhibit B.

2. Locate your project on a United States Geological Survey (U.S.G.S.) 7 1/2 Minute Quadrangle Map (Commonly called ''topographic maps,'' U.S.G.S. Quadrangles may be available from local merchants dealing in books, hunting supplies and camping equipment.) and prepare a project Location Map, utilizing a photocopy of the U.S.G.S. Quadrangle Map.

3. Complete the top portion of the attached Supplement No. 1 (Pennsylvania Natural Diversity Inventory Form). You will not be authorized to use the General Permit until Supplement No. 1 has been processed to check for potential impacts to rare and endangered species. Therefore, to avoid possible project delays or unnecessary design costs, you are advised to submit Supplement No. 1 for processing prior to General Permit registration. To do so, follow the written instructions on the Supplement No. 1 form. The Department will complete the bottom portion of the form and return it to you, generally within a period of 2 weeks. You must have copies of Supplement No. 1 (whether processed or not) for submission as attachments when you register to use the General Permit.

Copyright © 1996 Commonwealth of Pennsylvania

4. Your project may also require a permit from the U. S. Army Corps of Engineers under section 404 of the Federal Clean Water Act, sections 9 and 10 of the Rivers and Harbors Act and/or section 103 of the Marine Protection, Research and Sanctuaries Act. The registration to use this State General Permit does not relieve you of the obligation to comply with, and the State is not authorized to address, these Corps of Engineers' requirements. Therefore, in order to avoid violation of Federal statutes, please contact the appropriate U. S. Corps of Engineers District Office listed below to determine whether a Federal permit is required for your project.

Delaware River Basin

Philadelphia Dist. Corps of Engineers
Wanamaker Bldg., 100 Penn Square East
Philadelphia, PA 19107
(215) 656-6725

Ohio River Basin

Pittsburgh Dist. Corps of Engineers
1834 Wm. S. Morehead Federal Bldg.
1000 Liberty Avenue
Pittsburgh, PA 15222
(412) 644-6874

Lake Erie Basin

Buffalo Dist. Corps of Engineers
1776 Niagara Street
Buffalo, NY 14207-3199
(716) 879-4104

Susquehanna River Basin

Baltimore Dist. Corps of Engineers
P. O. Box 1715
Baltimore, MD 21203-1715
(410) 962-1846 or (717) 726-7757

5. For any earthmoving activity (For the definition of earthmoving activity, see Part Two, Section C.) associated with your project, prepare the Erosion and Sedimentation Control Plan which must be reviewed and determined satisfactory by the County Conservation District in the county where your project is located. The required Erosion and Sedimentation Control Plan must be prepared and submitted to the Conservation District for review prior to or concurrent with your registration to use the General Permit.

6. Take color photographs of the project area showing the scope of the project and existing condition of the bank and/or gravel bar. Prepare two sets of these

photos, mount on 8 1/2″x11″ pages and label each photo with a brief description of what is shown and the date photos were taken.

The Registration Procedure:

7. Fill in all information on the Notification to Use form (Exhibit D) and make multiple copies. Send one copy each to the municipality and the county in which the project is located.

8. To register use of the General Permit, prepare a complete registration ''package'' consisting of:

—Two copies of Notification to Use form (Exhibit D)

—Two copies of the Location Map

—Two copies of the Supplement No. 1 form

—Two sets of Color Photographs (mounted with dates and descriptions)

Send these items to either:

—The County Conservation District for projects located in all counties where there is a delegation agreement (See Exhibit C).

—OR—

—The Soils and Waterways Section having responsibility for the counties where there is no delegation agreement with the County Conservation District (see Exhibit B).

9. If you are also applying for an individual Water Obstruction and Encroachment Permit to authorize related work, you may register to use the General Permit in conjunction with your individual permit application (see Part Two, Section A, Item 2).

Before and During Construction:

10. Do not begin work until:

a. You have received an acknowledgement from the Soils and Waterways Section or County Conservation District that your Exhibit D notification has been received and registered.

b. Your Erosion and Sediment Control Plan has been reviewed and determined to be satisfactory by the County Conservation District.

c. You have notified the Pennsylvania Fish and Boat Commission and the County Conservation District 10 days prior to start of construction (Part Two, Section D).

d. You have obtained any other Federal, State or local permits which may be required, including written authorization from the U. S. Army Corps of Engineers for gravel bar removal.

e. You have complied with any other applicable preconstruction requirements as listed in Part Two, Section E.

f. You have provided written notifications to the municipalities and county where the projects are located prior to the start of construction.

Copyright © 1996 Commonwealth of Pennsylvania

11. During construction of your project, you are responsible for adhering to all terms and conditions of the General Permit, including your approved Erosion and Sedimentation Control Plan and all applicable design and construction criteria in Part One, Sections D, E and F.

PART ONE

A. General Description and Fees—The Department of Environmental Resources hereby authorizes, by general permit, subject to the terms and criteria set forth below, the installation, operation, modification and maintenance of bank rehabilitation and protection projects and the removal of gravel bars in and along the regulated waters of this Commonwealth. There is no registration fee required for a project authorized under this General Permit.

B. Sites and Conditions Where this General Permit Does Not Apply—This General Permit does not apply and is not valid in the following situations. Where the General Permit is not applicable, you may request approval of an individual permit by submitting an application to the appropriate Soils and Waterways Section in the Regional Office (See Exhibit B).

1. Historical, cultural or archaeological sites as identified in the latest published version of the Pennsylvania Inventory of Historical Places or the National Register of Historical Places. This information is available from the Pennsylvania Historical and Museum Commission, Box 1026, Harrisburg, PA 17108-1026, telephone (717) 787-3362.

2. Sites identified in the latest published version of the National Registry of Natural Landmarks.

3. Wetlands.

4. Construction activities in stocked trout streams from March 1 through June 15, in wild trout streams from October 1 through December 31, and in Lake Erie tributaries from March 1 through June 15 and from September 1 through December 31, unless approval is obtained from the Pennsylvania Fish and Boat Commission's Division of Environmental Services (See Exhibit A). Stocked and wild trout stream locations are compiled by the Commission's Division of Fisheries Management (see Exhibit A).

5. Projects involving channel relocation, channel realignment or placement of fill to construct berms of levees.

6. Any project having a scope of work which is greater in length than 500 linear feet measured along a single continuous reach of stream channel.

7. Projects involving the installation of tires for bank protection.

8. The removal of vegetated gravel bars.

9. Projects requiring excavation of mudflats in the tidal waters of the Delaware River.

10. Projects located where there would be an impact on species of special concern listed under the Endangered Species Act of 1973, the Wild Resources

Conservation Act, the Fish and Boat Code or the Game and Wildlife Code. Records regarding species of special concern are maintained in a computer database called the ''Pennsylvania Natural Diversity Inventory'' (PNDI). To verify that there will be no such impacts for a specific project, the Department requires submission of the attached Supplement No. 1 form.

11. Areas in or within 100 feet of a watercourse designated wild in the National or State Scenic Rivers system in accordance with the National Wild and Scenic Rivers Act of 1968 or the Pennsylvania Scenic Rivers Act. For details on scenic river classifications, contact the DER Pennsylvania Scenic Rivers Program, P. O. Box 8475, Harrisburg, PA 17105-8475, telephone (717) 787-2316.

12. Gravel bar removal in streams or water bodies designated Exceptional Value Waters as defined and listed in Chapter 93 (related to water quality standards).

C. Definitions Applicable to this General Permit—The following words and terms, when used in this General Permit, have the following meanings:

Bank Rehabilitation and Bank Protection—To restore and/or protect the bank of a stream, lake, pond or reservoir against erosion, scour or sloughing by utilizing any of the following: slope protection, dumped rock protection, cribbing, walls, channel deflectors, vegetative stabilization techniques.

Channel Realignment—Any alteration of the stream channel alignment which involves excavation into an existing stream bank.

Concrete Rubble—Broken concrete in pieces not to exceed 5 feet in length where neither the width or thickness is less than 1/3 its length and all reinforcing is removed flush with the face of the concrete.

Dumped Rock Protection—Sound, durable stone or concrete rubble, insoluble in water and placed by dumping for the purpose of protecting against erosion, scour or sloughing of a bank. To resist transport by flowing water, National Stone Association R-7 is the minimum size rock which shall be used for dumped rock protection.

Filter Layer—Well-graded, hard, durable, non-soluble particles (free from muck, topsoil, organic matter or rubbish) or geotextile fabric, placed under slope protection to prevent the natural soil of the bank from being washed away through the slope protection layer.

Gravel Bars—Alluvial deposits in stream channels, including accumulations of gravel, glacial till, sediment, silt and flood debris, which obstruct and redirect flow, and which are thereby associated with stream bank erosion.

Riprap—A layer, facing or protective mound of stone in random size pieces, selectively placed to prevent erosion, scour or sloughing of a bank.

Slope Protection—A layer or facing of sound, durable rock or similar material (natural or manmade), insoluble in water, selectively placed by hand or machine and sized to resist transport by flowing water.

Copyright © 1996 Commonwealth of Pennsylvania

Vegetated—An area having greater than 50 percent surface coverage of persistent vegetation during the growing season (undisturbed by acts of man). Persistent vegetation is defined as having a predominance of perennial plant species with the exclusion of first year class seedlings of woody vegetation (shrubs and trees). The vegetational groupings to be considered consist of grasslikes, grasses, forbs, vines, shrubs and trees.

D. Project Design and Construction Criteria

1. The use of this General Permit is limited to activities which constitute a single, complete project in and along a continuous reach of stream channel not exceeding 500 feet in length. Multiple registration and use of this General Permit for the purpose of extending a project activity beyond the maximum length is prohibited; however, the Department will consider authorizing more extensive projects upon receipt of an application for an individual Water Obstruction and Encroachment Permit. Because this General Permit authorizes only single, complete projects, repeated projects each require a separate registration of General Permit use.

2. Construction of the bank rehabilitation, bank protection project or removal of a gravel bar should not constrict or increase the normal channel width. The configuration of the shoreline shall remain substantially the same and the work shall align smoothly with, and not project further into the channel than adjacent upstream and downstream banks. The upstream and downstream ends of a bank rehabilitation or bank protection project shall be keyed into the stream bank to ensure stability.

3. Construction and other activities authorized by this General Permit shall be performed in a manner that minimizes use of equipment within the stream channel or body of water.

4. Bank rehabilitation, bank protection and gravel bar removal shall take place during periods when the stream is at low flow.

5. To the greatest extent possible, the project shall be designed and constructed in a manner which will (a) prevent permanent or long-term adverse changes in water quality, (b) minimize alterations in natural aquatic habitat and (c) maintain natural streamflow velocities and mixing patterns.

6. The placement of fill higher than the elevation of the existing stream banks, the construction of levees, the realignment or relocation of the channel, dredging activities in water and excavation below existing water level are not authorized by this General Permit.

7. Bank rehabilitation, bank protection and gravel bar removal projects shall not extend across adjacent property lines without the written permission of all affected property owners.

8. During construction activities, all public and private property including existing vegetation, landscape features and monuments within, along and adjacent to the work area, shall be protected and preserved to the maximum degree

possible. This shall include, but not be limited to, precautions taken to minimize damage, erosion, injury or destruction; prevent pollution; provide protection of all trees and other woody plants; special care being taken to protect the natural vegetation and surroundings to include all natural drainageways, ponds, lakes, wetlands, woods and fields; and storage of materials in such manner to prevent leaching which would be injurious to soils and to plants. Precautions should be taken to prevent damage to pipes, conduits and other underground structures.

9. Archaeological artifacts discovered during the performance of work authorized under this General Permit must be adequately protected and their discovery promptly reported to the Director, Bureau of Historic Preservation, Pennsylvania Historical and Museum Commission, P. O. Box 1026, Harrisburg, PA 17108-1026, telephone (717) 787-2891.

10. As part of the registration to use this General Permit, the owner shall submit duplicate sets of labeled color photographs which show the scope of the project and the existing condition of the bank to be protected and/or the gravel bar to be removed. The two sets of photographs shall be mounted on 8 1/2″x11″ sheets. The date of photography and a written description of what is shown shall be provided for each photograph.

E. Additional Criteria for Bank Rehabilitation and Protection

1. Slope protection and dumped rock protection shall not exceed the placement of a maximum of 1 cubic yard per running foot below the plane of the ordinary high water mark or the high tide line (in order to be consistent with the requirements of the Corps of Engineers). Where slope protection or dumped rock protection is required to be placed in the floodway or floodplain above the plane of the ordinary high water mark or the high tide line, an additional 1 cubic yard per running foot of stream is authorized.

2. Riprap and other types of slope protection, except for vegetative stabilization and dumped stone protection, should be constructed in two layers.

(A) An outer layer of massive particles to resist the forces of moving water.

(1) The outer layer or principal protection layer should consist of well-graded particles. It is recommended that riprap slope protection shall be sized in accordance with the following Table E(2) designated Design Parameters for Riprap.

(2) The protecting layer should be placed to a minimum thickness approximately 6 inches greater than the maximum particle size, or in accordance with the following Table E(2) for riprap design.

(B) An underlying filter layer of fine material or filter fabric.

(1) Satisfactory filter materials are mixtures of gravel and clean sand with about 80% of the material ranging between 2 inches and 1/4 inch. An

Copyright © 1996 Commonwealth of Pennsylvania

alternative is a commercially available geosynthetic filter fabric that will allow drainage without loss of bank material.

(2) The gravel filter layer should be placed to a thickness in accordance with the following Table E(2) for riprap design.

3. Grouting of slope protection or dumped rock protection is not authorized by this General Permit.

Table E(2). Design Parameters for Riprap

NATIONAL STONE ASSOCIATION NUMBER	AVERAGE SIZE OF STONE IN INCHES	RANGE OF STONE SIZE IN INCHES	RECOMMENDED PLACEMENT THICKNESS IN INCHES	RECOMMENDED FILTER THICKNESS IN INCHES	MAXIMUM ALLOWABLE STREAMFLOW VELOCITIES IN FEET PER SECOND	
					1.5 HORIZONTAL TO 1 VERTICAL SLOPE	2 HORIZONTAL TO 1 VERTICAL SLOPE
R-4	6	3 TO 12	15	4	8	10
R-5	9	5 TO 18	24	6	11	12
R-6	12	7 TO 24	30	8	13	14
R-7	15	12 TO 30	36	10	14	16

Copyright © 1996 Commonwealth of Pennsylvania

4. Only clean, nonpolluting materials shall be used for bank rehabilitation and protection projects in order to minimize excessive turbidity by leaching of fines as well as to preclude entrance of undesirable chemical constituents to the watercourse by natural runoff or leaching.

5. Slag is not authorized for use under this General Permit unless it qualifies as a co-product which is suitable for the specific use.

6. Along streams which are classified priority 1-A or designated Scenic Rivers, it is recommended that bank protection and rehabilitation projects shall maintain the natural character of the bank by incorporating vegetation (see Drawing Nos. 11, 12 and 13). However, woody vegetation shall not be incorporated in riprap protection. The use of concrete rubble for dumped rock protection is prohibited along Scenic Rivers.

7. Dumped rock protection shall have a maximum exterior slope of 1.5 horizontal to 1.0 vertical and a minimum top width of 18 inches at the top of the zone to be protected, as shown on Drawing No. 3B. No filter layer is required for dumped rock protection using well-graded rock. National Stone Association R-7 rock is the minimum rock size to be used for dumped rock protection.

8. Slope protection should not be placed with an exterior slope steeper than 1.5 horizontal to 1.0 vertical.

9. For rock riprap installations, a trench must be excavated at the toe of the slope to provide a supporting base. This trench should be extended to an elevation of at least 2 feet below the streambed level and be filled with the same material as the outer protection layer.

10. Immediately following completion of the project all disturbed slopes shall be stabilized to prevent accelerated erosion in accordance with the approved Erosion and Sedimentation Control Plan.

11. Bank rehabilitation and bank protection projects shall be maintained in a functional condition at all times. Periodic removal of debris deposited on the bank project may be necessary.

12. Each bank rehabilitation and bank protection project shall not hinder commercial or recreational navigation nor interfere with the normal migration of fish.

13. Channel deflectors may not extend from the bank into the channel a distance greater than 25% of the total channel width, and may not extend above the normal water flow a distance greater than 6 inches at the streamward tip.

14. The maximum height of a vertical wall authorized under this General Permit is 6 feet measured from the top of wall to the streambed or lakebed adjacent to the wall.

F. Additional Criteria for Removal of Gravel Bars

1. The gravel bar removal shall be completed as a single operation in as short a time period as possible. Such projects shall follow the procedures for

channel restoration projects contained in Chapter 4 of the Department's Erosion and Sediment Pollution Control Program Manual, which is available from the County Conservation District Offices.

2. Removal of a gravel bar shall be limited to periods of low flow; a gravel bar shall be removed only to a depth 6 inches above the water level at time of the project. For streams where there are periods of no flow, depth of gravel bar removal is limited to 6 inches above the elevation of the streambed so as not to disturb the existing low flow channel.

3. The equipment operator or contractor shall be informed of the conditions of this General Permit regarding gravel bar removal and shall be provided with working drawings that clearly show the limits of excavation in accordance with the criteria of this General Permit.

4. Bulldozing of the gravel bar material in or across the stream channel is prohibited. Excavation into a streambed or into a streambank adjacent to a gravel bar is prohibited.

5. Material removed from the stream channel shall be deposited outside regulated waters of the Commonwealth including the floodway and any wetlands adjacent to the project, except when the material is suitable and used for bank reconstruction. When the excavated material is to be used to rebuild opposite streambanks, the material shall be hauled (and not pushed) to the placement location.

6. Clean gravel bar material may be used only as an underlying fill or filter material to reconstruct and stabilize an adjacent streambank where the work can be performed in accordance with Part One, Section E, Item 2 of this General Permit. Gravel bar material used in this manner shall be faced with an outer layer of adequately sized slope protection. Gravel bar material which is removed shall not be used for dumped rock protection as defined in this General Permit.

7. In accordance with § 105.233 of Chapter 105 rules and regulations, the removal of sand, gravel or other minerals from submerged lands of this Commonwealth, in quantities which are commercially usable or marketable, shall require a written agreement from and royalty payments to the Commonwealth.

8. Gravel bar removal on lands owned or administered by the Commonwealth as State Parks, State Game Lands or State Forests shall require prior written approval from the administering agency.

9. Gravel bar removal may have limited long-term benefits where there is a streambank erosion problem. Therefore, the use of bank rehabilitation and bank protection measures in conjunction with gravel bar removal is recommended.

10. The owner is advised that a permit from the U. S. Army Corps of Engineers may be required for gravel bar removal projects (see Instructions, Item 4).

Copyright © 1996 Commonwealth of Pennsylvania

G. Authority and Continuing Authorization—Authorization of this General Permit is under section 7 of the Dam Safety and Encroachment Act (32 P. S. § 693.7) and the rules and regulations promulgated thereunder at 25 Pa. Code §§ 105.441—105.449 (relating to general permits). This General Permit shall authorize the continued operation and maintenance of bank rehabilitation and protection authorized by General Permit BDWM-GP-3 (Bank Rehabilitation and Protection) issued on July 23, 1983, and reauthorized July 23, 1988 and August 20, 1988.

EXHIBIT D

FOR DEPT. USE ONLY

ACKNOWLEDGED:
DATE _____
GP _____

NOTIFICATION TO USE
BDWW-GP-3

Bank Rehabilitation, Bank Protection and Gravel Bar Removal

1. I/We, _____
(owner name(s))
hereby notify the Department of Environmental Resources of our intent to install

_____
(description of bank rehabilitation and protection)
and/or to remove gravel bar material measuring _____ feet by
(length)
_____ feet, in accordance with the terms of this General Permit,
(width, maximum)
across/along _____
(name of stream)
at a point _____
(describe location)
in _____ , _____
(municipality) (county)

2. I/We have attached a LOCATION MAP (similar to that shown on Drawing No. 1 indicating the site of the project and a copy of SUPPLEMENT NO. 1.

3. I/We have enclosed duplicate copies of EXHIBIT D, the LOCATION MAP and SUPPLEMENT NO. 1.

4. I/We have attached two sets (duplicates) of COLOR PHOTOGRAPHS, mounted on 8 1/2″ x 11″ pages, and labeled to show the existing conditions at the project site.

5. I/We certify that copies of this notification were sent this day _____ (date)

to _____ , and _____
(municipality) (County-Commissioner's Office)

6. I/We certify that an EROSION AND SEDIMENTATION CONTROL PLAN for this project has been submitted for review to the _____ County Conservation District on _____ (date) .

Signed by: _____ _____
(print name) (owner signature)

(title, if applicable) (city/state/zip code)

(owner address) (owner telephone number)

7. I/We hereby notify the Department also of our intention to install a temporary road crossing in accordance with the terms of BDWW-GP-8, Temporary Road Crossings, during thebank rehabilitation, bank protection and/or gravel bar removal activities (if applicable).

Signed: _____

Send to address on Exhibit B or delegated County Conservationi District on Exhibit C.

(*Editor's Note*: For general requirements, definitions and regional office addresses, see ''Part Two: Applies to BDWW-GP-1 and other BDWW General Permits'' at BDWW-GP-1.)

Source

The provisions of this Appendix C adopted July 22, 1983, effective July 23, 1983, 13 Pa.B. 2290; amended July 22, 1988, effective July 23, 1988, 18 Pa.B. 3257; amended August 19, 1988, effective August 20, 1988, 18 Pa.B. 3749; amended August 5, 1994, effective August 6, 1994, 24 Pa.B. 3913. Immediately preceding text appears at serial pages (162404) to (162427).

APPENDIX D
BUREAU OF DAMS AND WATERWAY MANAGEMENT; GENERAL PERMIT BDWM-GP-4 (INTAKE AND OUTFALL STRUCTURES)

Editor's Note: The following permit was published in the *Pennsylvania Bulletin* as a Notice and is codified under 1 Pa. Code § 3.1(a)(9) (relating to contents of *Code*) as a document which the Legislative Reference Bureau finds to be general and permanent in nature. See §§ 105.441—105.449 (relating to general permits) for regulations governing this permit.

1. *General Description and Authority*—The Department of Environmental Resources hereby authorizes, by General Permit, subject to the terms and criteria set forth below, the construction, operation and maintenance of intake and outfall structures in, along, across or projecting into the regulated waters of the Commonwealth. This authorization is under section 7 of the Dam Safety and Encroachments Act (32 P. S. § 693.7) and the rules and regulations promulgated thereunder at 25 Pa. Code §§ 105.441—105.449 (relating to general permits).

2. *Denial of Authorization*—The Department shall have the discretion, on a case-by-case basis, to deny, revoke or suspend the authorization to use this general permit for any project which the Department determines to have a substan-

Copyright © 1996 Commonwealth of Pennsylvania

tial risk to life, property or the environment or otherwise could not be adequately regulated by the provisions of this general permit.

3. *Continuing Authorization*—This general permit shall authorize the continued operation and maintenance of outfall structures authorized by general permit BDWM-GP-4 (Outfall Structures) issued on February 4, 1984.

4. *Definitions*—The following terms as used in this General Permit shall have the following meanings:

Body of Water—Any natural or artificial lake, pond, reservoir, swamp, marsh or wetland.

Channel—The bed and banks of a natural stream and/or a man made ditch, canal or conduit which conveys storm water or waste water to a receiving stream or body of water.

Floodway—The channel of the watercourse and those portions of the adjoining floodplains which are reasonably required to carry and discharge the 100-year frequency flood.

Intake—The inlet of a pipe or channel conveying water from a stream or body of water.

Install—To construct, place, lay or set in place.

Outfall—The outlet of a pipe or channel discharging storm water or wastewater into a receiving stream or body of water.

Intake and Outfall Structures—Any intake or outfall in or along a stream or body of water which includes such structures as endwalls, headwalls, splash pads, riprap, ditches, conduits, diffusers and diversions.

Owner—Any person who owns, controls, operates, maintains or manages a dam or reservoir, water obstruction or encroachment.

Person—Any natural person, partnership, association, corporation, public utility, municipality, municipal authority, political subdivision of the Commonwealth, receiver or trustee and any department, board, commission or authority of the Commonwealth.

Regulated Waters of the Commonwealth—All watercourses, streams or bodies of water and their floodways wholly or partly within or forming part of the boundary of this Commonwealth.

Stocked Trout Stream—Streams classified as approved trout waters by the Pennsylvania Fish Commission. Classification may be verified by contacting the Pennsylvania Fish Commission's Regional Office or Division of Environmental Services.

Storm Water—Flows consisting primarily of runoff resulting from a rainfall event and conveyed to a receiving stream or body of water through a pipe or channel.

Submerged Lands of This Commonwealth—All waters and permanently or periodically inundated lands owned by the Commonwealth, including all lands in the beds of navigable lakes and rivers and beds of streams declared public highways which are owned and held in trust by the Commonwealth.

Wastewater—Effluent from a sewage, industrial or water plant, conveyed through a pipe or channel for discharge into a receiving stream or body of water.

Watercourse—Any channel of conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

Wetlands—Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas. The term includes but is not limited to wetland areas listed in the State Water Plan, the United States Forest Service Wetlands Inventory of Pennsylvania, the United States Fish and Wildlife Service Wetlands Inventory Maps, and the Pennsylvania Coastal Zone Management Plan and any wetland area designated by a river basin commission or as defined in this chapter.

Wild Trout Streams—Streams classified as supporting reproducing trout populations by the Pennsylvania Fish Commission. Classification may be verified by contacting the Pennsylvania Fish Commission's Regional Office or Division of Environmental Services.

5. *Submerged Lands of This Commonwealth*—This General Permit shall not be effective to authorize any project occupying submerged lands of this Common-

Copyright © 1996 Commonwealth of Pennsylvania

wealth until the owner has obtained an easement, right of way, license or lease from the Department authorizing the occupation of such submerged lands issued under section 15 of the Dam Safety and Encroachments Act (32 P. S. § 693.15), section 514 of The Administrative Code of 1929 (71 P. S. § 194), or other applicable laws. Upon receipt of notification of proposed use of this general permit from the owner, the Department will review the project for submerged lands and initiate a Submerged Lands License Agreement if applicable.

6. *Specific Areas Where General Permit Does Not Apply*—This General Permit is not authorized in the following areas:

a. Historical, cultural or archaeological sites as identified in the latest published version of the Pennsylvania Inventory of Historical Places or the National Register of Historical Places.

b. Local historical sites officially approved or recognized by a municipality.

c. Sites identified in the latest published version of the National Registry of Natural Landmarks.

d. Areas in or within 100 feet of a watercourse or body of water designated as or nominated for a National or State Wild or Scenic River in accordance with the National Wild and Scenic Rivers Act of 1968 or the Pennsylvania Scenic Rivers Act (32 P. S. §§ 820.21—820.29).

e. Wetlands.

f. These streams or water bodies specified as high-quality (HQ) or Exceptional Value (EV) in Chapter 93 (relating to water quality standards).

g. Stocked trout streams from March 1 through June 15, wild trout streams from October 1 through December 31 and Lake Erie tributaries from September 1 through December 1 unless approval is obtained from the Fish Commission's Division of Environmental Services.

h. Areas within easement lands of any Corps of Engineers or Commonwealth of Pennsylvania constructed local flood protection projects.

7. *Other Permits*—Nothing in this General Permit relieves the owner(s) of the obligation of complying with all Federal, Interstate Compact and State laws, regulations and standards for the construction, operation or maintenance of the intake and outfall structure(s).

8. *Notification of Proposed Use of General Permit*—Prior to construction the owners shall submit Exhibit C along with the required location map to the Bureau of Dams and Waterway Management. A copy of Exhibit C shall also be sent to the municipality and county in which the work will be performed. The owner may not begin work until he has notified the Bureau of Dams and Waterway Management and received an acknowledgement of that notification.

9. *Fees*—There is no fee required for a project authorized under this General Permit.

10. *Effective Time Period*—This General Permit will remain in effect indefinitely unless specifically modified, suspended or revised by the Department.

11. *Suspension, Modification or Revocation*—The Department may suspend, modify or revoke this General Permit at any time upon notice in the *Pennsylvania Bulletin*.

12. *Project Interference*—This General Permit does not authorize any interference with any existing or proposed Local, State, Federal or Federally Licensed Project, and permittee shall not be entitled to compensation for damage or injury to the work authorized herein which may be caused by or a result of existing or future operations undertaken by the United States or the Commonwealth of Pennsylvania or its Political Subdivisions in the public interest.

13. *Criteria*

a. Each intake and outfall structure shall be constructed in such manner so that there is no interference with any navigation on the stream, migration of fish or the passage of flood flows.

b. Intake and outfall structures authorized under this General Permit shall not interfere with stream uses as designated in Chapter 93 of the Department's Rules and Regulations.

c. Intake and outfall structures herein authorized shall be properly maintained which includes the removal of any accumulation of debris.

d. This General Permit is not to be construed as approval of discharges into the receiving stream or body of water which may require certification under section 401(a) of the Federal Water Pollution Control Act (33 U.S.C.A. § 1341(a)) or other relevant State Statutes.

e. This General Permit authorizes the construction only of those outfall structures having a pipe outfall 36 inches in diameter or less.

f. Intake structures shall be properly sized and located so that the intake does not violate the riparian rights of downstream users and does not substantially affect the course, current or cross section of the stream located downstream from the intake structure.

g. Intake structures shall be screened or otherwise properly designed to prevent impingement and entrainment of fish.

h. Any archaeological artifacts discovered during the performance of work authorized under this General Permit must be adequately protected and their discovery promptly reported to the Director, Bureau for Historic Preservation, Pennsylvania Historical and Museum Commission, Post Office Box 1026, Harrisburg, Pennsylvania 17120.

i. Pollution of the waterway with harmful chemicals, fuels, oils, greases, bituminous material, acid and/or other harmful or polluting materials, is prohibited.

j. Owner(s) must investigate for drinking water intakes or reservoirs for public and private water supply users downstream within 5 miles of the site of the intake or outfall structure and other users which may be affected by suspended solids and turbidity increases. Written notice shall be given at least 10 days prior to construction to operators of any such intakes or reservoirs. Own-

Copyright © 1996 Commonwealth of Pennsylvania

er(s) must notify public and private water supply operators immediately and no longer than 1 hour after the occurrence at the site which results in the release of suspended solids and turbidity to the stream.

k. Prior to the use of explosives in a watercourse or body of water the permittee shall secure a written permit from the Pennsylvania Fish Commission, under 30 Pa.C.S. § 2906 (relating to permits for uses of explosives). Requests should be directed to the Pennsylvania Fish Commission, Bureau of Administrative Services, Post Office Box 1673, Harrisburg, Pennsylvania 17120, (717) 657-4522.

14. *Department Inspection*—As a condition of use of this general permit, and of the owner's authority to conduct the activities authorized by this general permit, the owner hereby authorizes and consents to allow authorized employes or agents of the Department, without advance notice or a search warrant, at any reasonable time and upon presentation of appropriate credentials, and without delay, to have access to and to inspect all areas where the project is being constructed, operated or maintained. The authorization and consent shall include consent to conduct tests or sampling, to take photographs, to perform measurements, surveys and other tests, to inspect the methods of construction, operation or maintainance, to examine and copy books, papers and records pertinent to any matter under investigation, and to take any other action necessary to assure that the project is constructed, operated or maintained in accordance with the terms and criteria of the general permit. This general permit condition is included under section 16 of the Dam Safety and Encroachments Act (32 P. S. § 693.16) and in no way limits any other powers granted under the Dam Safety and Encroachments Act.

15. *Activities not in Accordance with the Terms or Criteria*—If the department determines, upon inspection, that the construction, operation or maintenance of a project has violated the terms or criteria of this general permit or of this chapter, the Department may take such actions, legal or administrative, that it may deem to be appropriate.

16. *Structure Removal*—The owner(s) shall remove all or any portion of the intake or outfall structure upon written notification to the owner by the Department in the event the project is causing an adverse impact on public health, safety or the environment or in any other manner violates the conditions of this general permit or this chapter.

17. *Property Rights*—This General Permit does not convey any property rights, either in real estate or material, or any exclusive privileges, nor does it authorize any injury to property or invasion of rights or any infringement of Federal, State or local laws or regulations.

18. *Other Approvals*—The owners shall secure all other approvals that may be necessary under Federal, State or local laws or regulations.

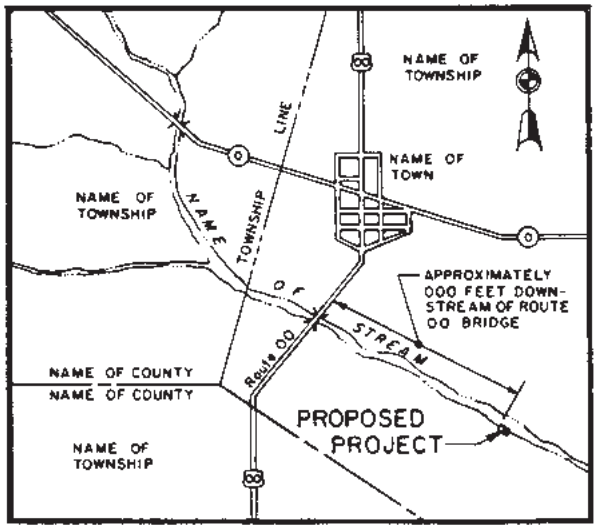
19. *Fish Commission Notification*—The owners shall notify the Fish Commission's Regional Field Office Supervisor, see Exhibit A, responsible for the County where the activities are proposed 10 days prior to start of construction.

Notification by postcard is suggested. The project site shall at all times be available for inspection by authorized officers and employees of the Pennsylvania Fish Commission.

20. *Erosion and Sediment Pollution Controls*—Work must be done in compliance with Chapter 102 (relating to erosion and sediment control). Prior to construction an Erosion and Sediment Pollution Control Plan must be reviewed and determined adequate by the County Conservation District in which the activities are proposed and implemented prior to, during and after construction. The project site shall at all times be available for inspection by authorized employees of the County Conservation District. The Erosion and Sediment Pollution Control Plan shall be available at the site at all times.

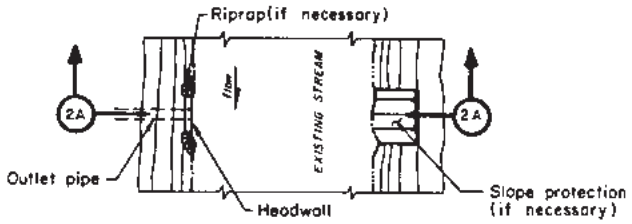
Copyright © 2000 Commonwealth of Pennsylvania

GENERAL PERMIT: B.D.W.M. GP-4
Intake and Outfall Structures
Dwg. No. 1 Sample Location Map

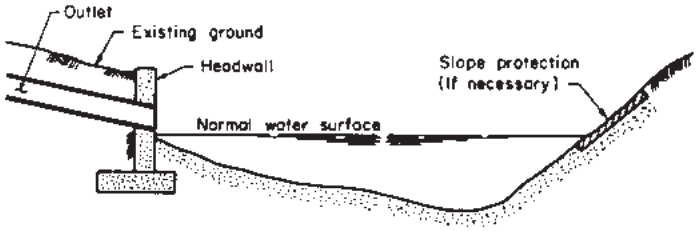


NOTE: Use of U.S.G.S. quadrangle map(s) is recommended.

GENERAL PERMIT: B.D.W.M. GP-4
Intake and Outfall Structures
Dwg. No. 2 Outfall Headwall



PLAN



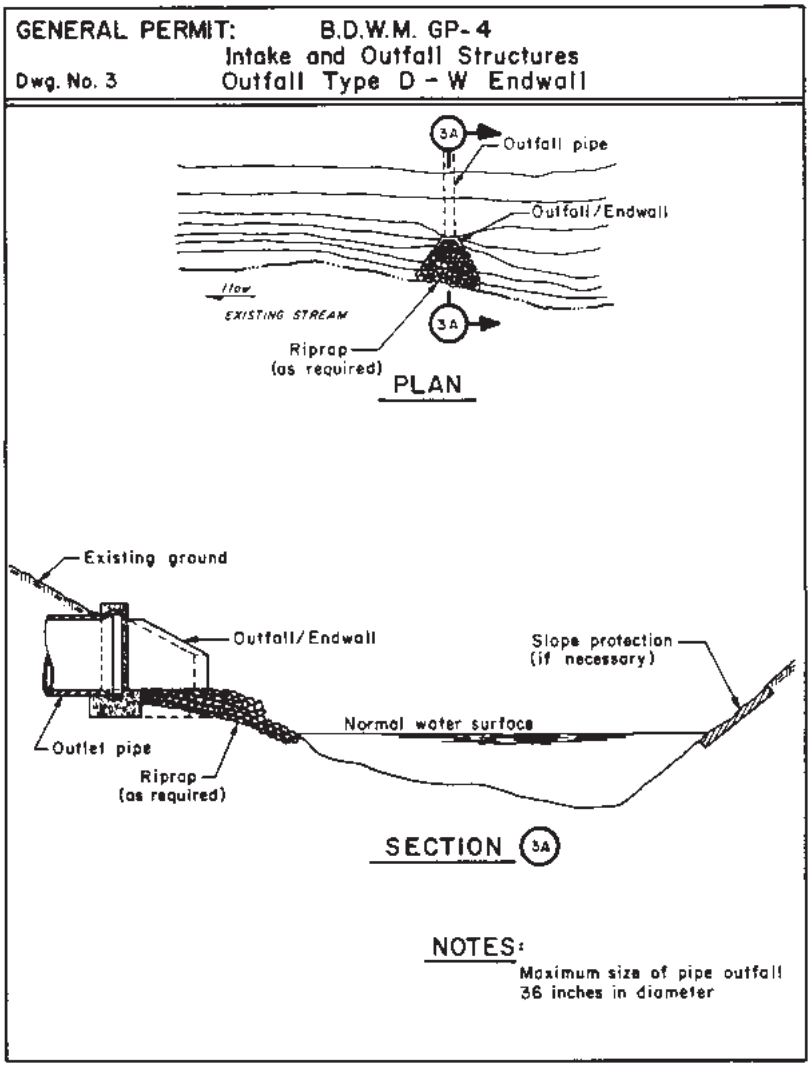
SECTION (2A)

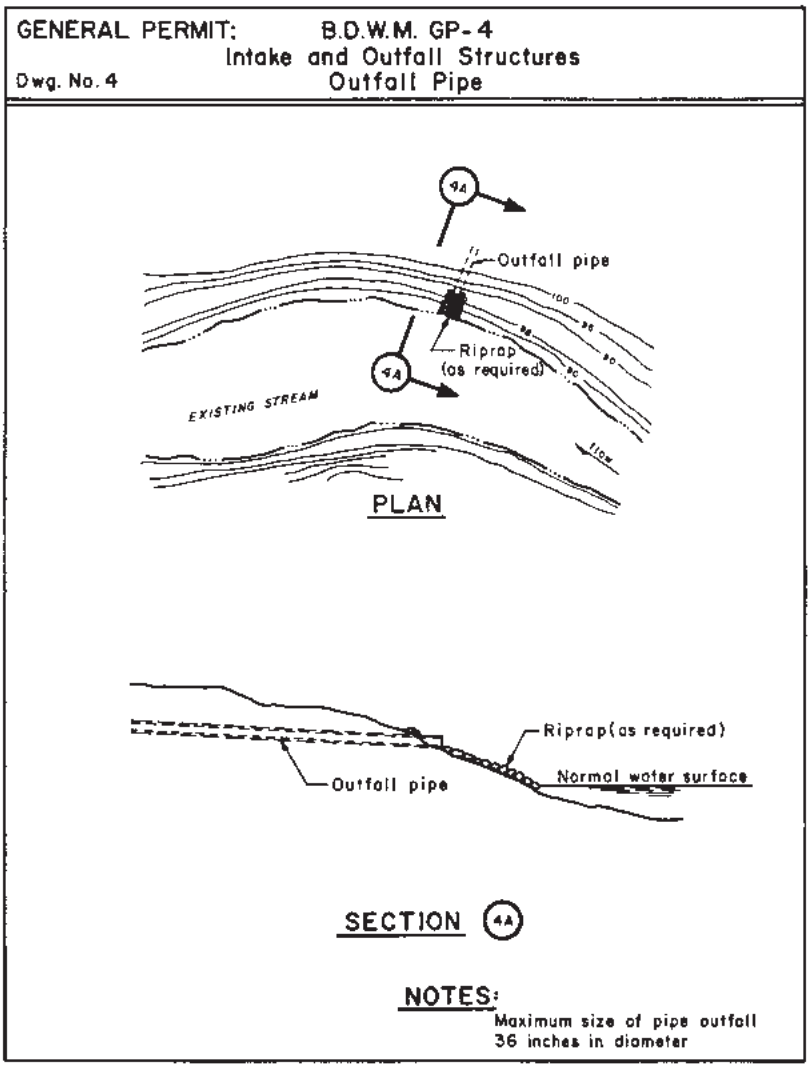
NOTES:

Maximum size of pipe outfall
36 inches in diameter

(207828) No. 255 Feb. 96

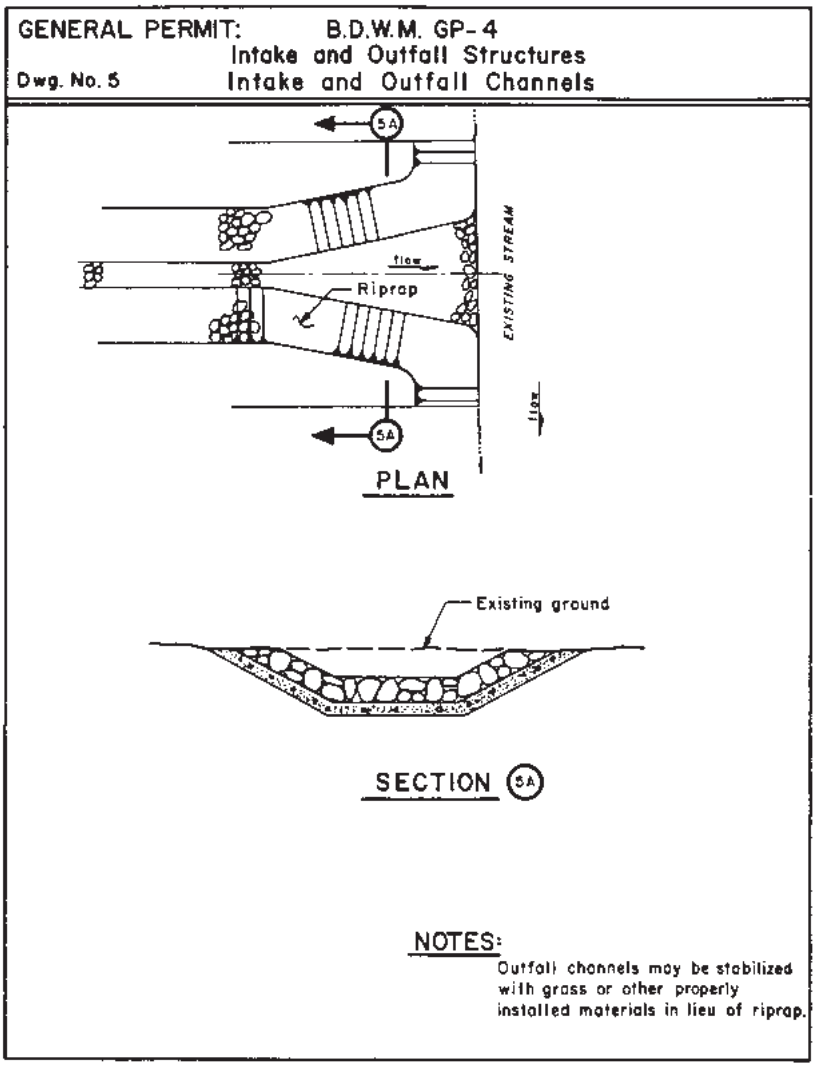
Copyright © 1996 Commonwealth of Pennsylvania


GENERAL PERMIT: B.D.W.M. GP-4
Intake and Outfall Structures
Dwg. No. 3 Outfall Type D-W Endwall
3A
Outfall pipe
Outfall/Endwall
flow
EXISTING STREAM
3A
Riprap
(as required)
PLAN
Existing ground
Outfall/Endwall
Slope protection
(if necessary)
Normal water surface
Outlet pipe
Riprap
(as required)
SECTION 3A
NOTES:
Maximum size of pipe outfall
36 inches in diameter

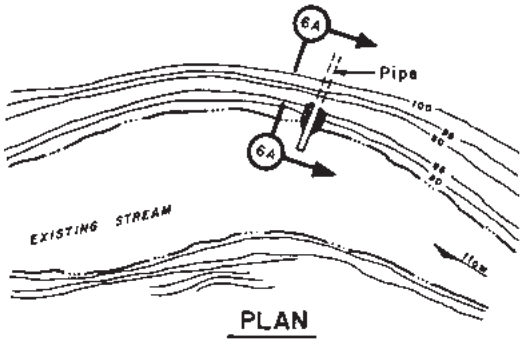


(207830) No. 255 Feb. 96

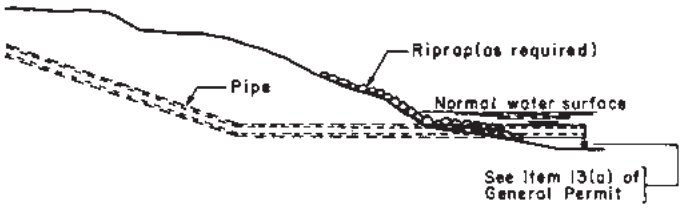
Copyright © 1996 Commonwealth of Pennsylvania


GENERAL PERMIT: B.D.W.M. GP-4
Intake and Outfall Structures
Dwg. No. 5 Intake and Outfall Channels
5A
flow
Riprap
EXISTING STREAM
flow
5A
PLAN
Existing ground
SECTION 5A
NOTES:
Outfall channels may be stabilized with grass or other properly installed materials in lieu of riprap.

GENERAL PERMIT: B.D.W.M. GP-4
Intake and Outfall Structures
Dwg. No. 6 Submerged Intake or Outfall Pipe



PLAN

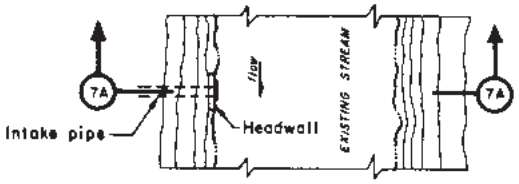


SECTION 6A

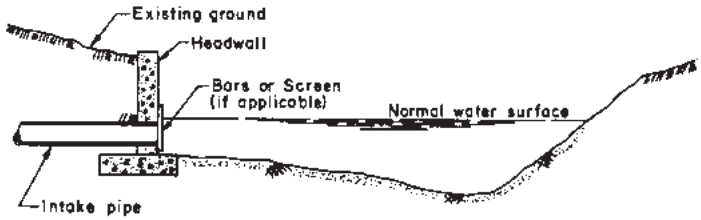
NOTES:
Maximum size of pipe outfall
36 inches in diameter

Copyright © 1996 Commonwealth of Pennsylvania

GENERAL PERMIT: B.D.W.M. GP-4
Intake and Outfall Structures
Dwg. No. 7 Intake Headwall

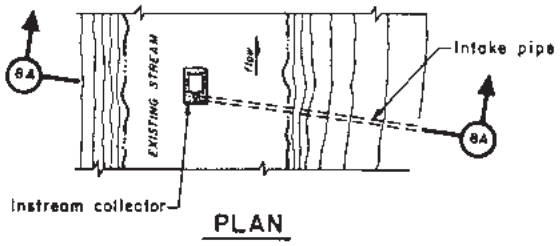


PLAN

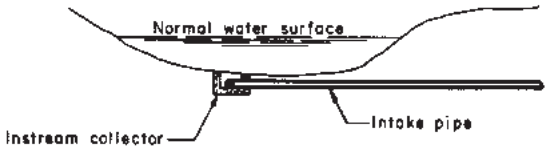


SECTION 7A

GENERAL PERMIT: B.D.W.M. GP-4
Intake and Outfall Structures
Dwg. No. 8 Intake Instream Collector



PLAN



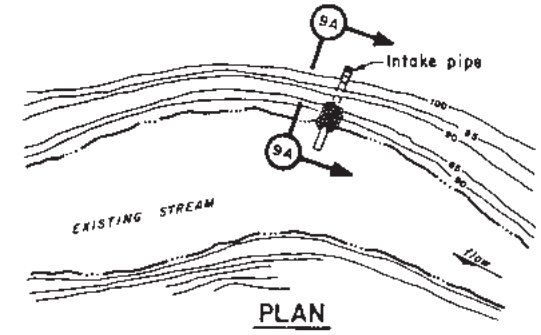
SECTION (8A)

NOTE

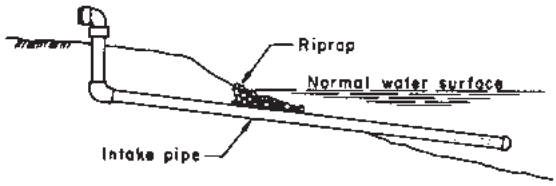
Top of collector shall be flush with streambed.

Copyright © 1996 Commonwealth of Pennsylvania

GENERAL PERMIT: B.D.W.M. GP-4
Intake and Outfall Structures
Dwg. No. 9 Intake



PLAN



SECTION 9A

EXHIBIT A

FISH COMMISSION'S OFFICES

Headquarters Address	*County Responsibility*
NORTHWEST REGION	
Regional Supervisor P. O. Box 349 1281 Otter Street Franklin, Pa. 16323 (814) 437-5774	Butler, Clarion, Crawford, Erie, Forest, Lawrence, Mercer, Venango and Warren
SOUTHWEST REGION	
Regional Supervisor R. D. # 2, Box 39 Somerset, Pa. 15501-9311 (814) 445-8974	Allegheny, Armstrong, Beaver, Cambria, Fayette, Greene, Indiana, Somerset, Washington and Westmoreland
NORTHCENTRAL REGION	
Regional Supervisor Box 187 (Fishing Creek Road) Lamar, Pa. 16848 (717) 726-6056	Cameron, Centre, Clearfield, Clinton, Elk, Jefferson, Lycoming, McKean, Northumberland, Potter, Snyder, Tioga and Union
SOUTHCENTRAL REGION	
Regional Supervisor 1704 Pine Road Newville, Pa. 17241 (717) 486-7087	Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lebanon, Mifflin, Perry and York
SOUTHEAST REGION	
Regional Supervisor Box 8 Elm, Pa. 17521 (717) 626-0228	Berks, Bucks, Chester, Delaware, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia and Schuylkill
NORTHEAST REGION	
Regional Supervisor Box 88 Sweet Valley, Pa. 18656 (717) 477-5717	Bradford, Carbon, Columbia, Lackawanna, Luzerne, Monroe, Montour, Pike, Sullivan, Susquehanna, Wayne and Wyoming

Copyright © 1996 Commonwealth of Pennsylvania

DIVISION OF ENVIRONMENTAL SERVICES
450 Robinson Lane
Bellefonte, Pa. 16823-9616
(814) 359-5145

EXHIBIT B
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF DAMS AND WATERWAY MANAGEMENT

Area Office	*County Responsibility*
Southcentral Area Office Room 149, One Ararat Blvd. P. O. Box 8554 Harrisburg, Pa. 17105-8554 (717) 541-7901	Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Mifflin, Perry and York
Southeast Area Office Suite 6010, Lee Park 555 North Lane Conshohocken, Pa. 19428 (215) 832-6340	Berks, Bucks, Carbon, Chester, Delaware, Lehigh, Northampton, Montgomery, Philadelphia and Schuylkill
Southwest Area Office 482 Route 30, R. D. 1 Clinton, Pa. 15026 (412) 899-2377	Allegheny, Armstrong, Beaver, Butler, Cambria, Fayette, Greene, Indiana, Lawrence, Somerset, Washington and Westmoreland
Northwest Area Office 190 Adams Road Jamestown, Pa. 16134 (412) 932-3162	Clarion, Clearfield, Crawford, Elk, Erie, Forest, Jefferson, McKean, Mercer, Venango and Warren
Northeast Area Office Suite 203, Cross Valley Centre 667 North River Street Plains, Pa. 18705-1099 (717) 826-5485	Bradford, Columbia, Lackawanna, Luzerne, Monroe, Pike, Sullivan, Susquehanna, Wayne and Wyoming
Northcentral Area Office 200 Pine Street Williamsport, Pa. 17701 (717) 327-3574	Cameron, Centre, Clinton, Lycoming, Montour, Northumberland, Potter, Snyder, Tioga and Union

BUREAU OF DAMS AND WATERWAY MANAGEMENT
CENTRAL OFFICE
P. O. Box 8554
Harrisburg, Pa. 17105-8554
(717) 541-7900

EXHIBIT C
Notification to Use
BDWM-GP-4
Intake and Outfall Structures

I/We, _____
(owner name(s))
hereby notify the Bureau of Dams and Waterway Management of our intent to use Drawing No. _____ to install _____
(description of intake or outfall structure)

across/along _____
(name of stream)

at a point _____
(describe location)

_____

in _____ (municipality) , _____ (county) .

I/We have attached a *LOCATION MAP* similar to that shown on Drawing No. 1 indicating where the intake or outfall structure will be installed.

I/We certify that a copy of this notification was sent this day _____
(date)
to _____ (municipality) and _____ (county) where the work will be performed.

Signed: _____
(owner or authorized representative)

_____
(owner address)

_____

_____
(owner telephone number)

1/90
Send to one of the addresses on Exhibit B.

(207838) No. 255 Feb. 96
Copyright © 1996 Commonwealth of Pennsylvania

Source

The provisions of this Appendix D adopted February 3, 1984, effective February 4, 1984, 14 Pa.B. 398; amended May 26, 1989, effective June 26, 1989, 19 Pa.B. 2281. Immediately preceding text appears at serial pages (130002) and (117751) to (117756).

APPENDIX E

UTILITY LINE STREAM CROSSINGS; GENERAL PERMIT BDWM-GP-5

Editor's Note: The following permit was published in the *Pennsylvania Bulletin* as a Notice and is codified under 1 Pa. Code § 3.1(a)(9) (relating to contents of *Code*) as a document which the Legislative Reference Bureau finds to be general and permanent in nature. See §§ 105.441—105.449 (relating to general permits) for regulations governing this permit.

1. *General Description and Authority*—The Department of Environmental Resources hereby authorizes, by general permit, subject to the terms and criteria set forth, the installation, operation and maintenance of utility line stream crossings of the regulated waters of the Commonwealth. This authorization is under section 7 of the Dam Safety and Encroachments Act (32 P. S. § 693.7) and the rules and regulations promulgated thereunder at §§ 105.441—105.449 (relating to general permits).

2. *Denial of Authorization*—The Department shall have the discretion, on a case-by-case basis, to deny, revoke or suspend the authorization to use this general permit for any project which the Department determines to have a substantial risk to life, property or the environment or otherwise could not be adequately regulated by the provisions of this general permit.

3. *Definitions*—The following terms as used in this general permit shall have the following meanings:

Body of Water—Any natural or artificial lake, pond, reservoir, swamp, marsh or wetland.

Floodway—The channel of the watercourse and those portions of the adjoining floodplains which are reasonably required to carry and discharge the 100-year frequency flood.

Install—To construct, deposit, place, lay or set in place.

Owner—Any person who owns, controls, operates, maintains or manages a dam or reservoir, water obstruction or encroachment.

Person—Any natural person, partnership, association, corporation, public utility, municipality, municipal authority, political subdivision of the Commonwealth, receiver or trustee and any department, board, commission or authority of the Commonwealth.

Regulated Waters of the Commonwealth—All watercourses, streams or bodies of water and their floodways wholly or partly within or forming part of the boundary of this Commonwealth.

Reservoir—Any basin, either natural or artificial, which contains or will contain the water or other fluid or semifluid impounded by a dam.

Stocked Trout Stream—Streams classified as approved trout waters by the Fish Commission. Classification may be verified by contacting the Fish Commission's Regional Office or the Division of Environmental Services.

Submerged Lands of this Commonwealth—All waters and permanently or periodically inundated lands owned by the Commonwealth, including all lands in the beds of navigable lakes and rivers and beds of streams declared public highways which are owned and held in trust by the Commonwealth.

Utility Line—Any pipe or pipeline for the transportation of a gaseous, liquid, liquifiable or slurry substance or, any cable, conduit, line or wire for the transmission of electrical energy, telephone, telegraph, radio or television signals, including cathodic corrosion protection.

Watercourse—Any channel of conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

Wetlands—Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adopted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas. The term includes but is not limited to wetland areas listed in the State Water Plan, the United States Forest Service Wetlands Inventory of Pennsylvania, the United States Fish and Wildlife Service Wetlands Inventory Maps, as utilized by the Pennsylvania Coastal Zone Management Program and any wetland area designated by a river basin commission.

Wild Trout Streams—Streams classified as supporting reproducing trout populations by the Fish Commission. Classification may be verified by contacting the Fish Commission's Regional Office or the Division of Environmental Services.

4. *Submerged Lands of this Commonwealth*—This General Permit shall not be effective to authorize any project over, across or occupying submerged lands of this Commonwealth until the owner has obtained a license from the Department authorizing the occupation of such submerged lands issued under section 15 of the Dam Safety and Encroachments Act (32 P. S. § 693.15), section 514 of The Administrative Code of 1929 (71 P. S. § 194), or other applicable laws. Upon receipt of notification from the owner, the Department will review the project to determine if its location is over, across or occupies submerged lands of the Commonwealth.

5. *Specific Areas Where General Permit Does not Apply*—This general permit is not authorized in the following areas:

a. Historic, cultural or archaeological sites as identified in the latest published version of the Pennsylvania Inventory of Historical Places or the National Register of Historical Places.

Copyright © 1996 Commonwealth of Pennsylvania

b. Local historical sites officially approved or recognized by a municipality.

c. Sites identified in the latest published version of the National Registry of Natural Landmarks.

d. Areas in or within 100 feet of a watercourse or body of water designated as or nominated for a National or State Wild or Scenic River in accordance with the National Wild and Scenic Rivers Act of 1968 or the Pennsylvania Scenic Rivers Act (32 P. S. §§ 820.21—820.29).

e. Important wetlands regulated under § 105.17 (relating to wetlands).

f. Wetlands, greater than 10 acres in size.

g. Stocked trout streams from March 1 through June 15, wild trout streams from October 1 through December 31 and Lake Erie tributaries from September 1 through December 1 unless approval is obtained from the Fish Commission's Division of Environmental Services.

h. Reservoirs.

i. Streams or water bodies designated as Exceptional Value Waters as defined and listed in Chapter 93 (relating to water quality standards).

6. *Other Permits*—Nothing in this General Permit relieves the owners of the obligation of complying with all Federal, Interstate Compact and State laws, regulations and standards for the contruction, operation or maintenance of utility lines.

7. *Notification of Proposed Use of General Permit*—Prior to construction the owners shall submit Exhibit B along with the required location map to the Bureau of Dams and Waterway Management. A copy of Exhibit ''B'' shall also be sent to the municipality and county in which the work will be performed. The owner may not begin work until he has notified the Bureau of Dams and Waterway Management and received an acknowledgement of that notification.

8. *Fees*—There is no fee required for a project authorized under this general permit.

9. *Effective Time Period*—This general permit will remain in effect indefinitely unless specifically modified, suspended or revised by the Department.

10. *Suspension, Modification or Revocation*—The Department may suspend, modify or revoke this general permit at any time upon notice in the *Pennsylvania Bulletin*.

11. *Project Interference*—This general permit does not authorize any interference with any existing or proposed Local, State, Federal or Federally Licensed Project; and permittee shall not be entitled to compensation for damage or injury to the work authorized herein which may be caused by or a result of existing or future operations undertaken by the United States, the Commonwealth of Pennsylvania or its Political Subdivisions in the public interest.

12. *Conditions*

a. The maximum size utility line allowed is 36 inches in diameter.

b. All utility lines under streambeds shall be located such that there will be a minimum of 3 feet of cover between the top of the utility line or encasement and the lowest point in the natural contour of the streambed, unless the utility line is in rock, where a minimum cover of 1 foot shall be provided.

c. Trenches excavated for the installation of utility lines shall be the minimum width necessary. As soon as the utility line is installed and tested to ascertain no leakage, appropriate new or previously excavated backfill material shall be placed in the trench and the area restored to its original condition and elevation and stabilized. Backfill material stored in connection with the installation must be properly retained out of the floodway so as to prevent its discharge, washings or runoff from entering the waterway prior to its placement as backfill.

d. Adequate measures shall be used to prevent sedimentation from the trench from entering the stream.

e. The backfilling of the trench in which the pipe will be laid shall be done so as to eliminate the formation of a permanent ridge in the streambed.

f. During construction activities, all public and private property including existing vegetation, landscape features and monuments within, along and adjacent to the work area, shall be protected and preserved to the maximum degree possible. This shall include, but not be limited to, precautions taken to minimize damage, erosion, injury or destruction; prevent pollution; provide protection of all trees and other woody plants; special care being taken to protect the natural vegetation and surroundings to include all natural drainageways, ponds, lakes, swamps, woods and fields; and storage of materials in such a manner to prevent leaching which would be injurious to soils and to plants. Precautions should be taken to prevent damage to pipes, conduits and other underground structures.

g. Archaeological artifacts discovered during the performance of work authorized under this general permit must be adequately protected and their discovery promptly reported to the Director, Bureau of Historic Preservation, Historical and Museum Commission, Post Office Box 1026, Harrisburg, Pennsylvania 17120.

h. Owners shall investigate for drinking water intakes or reservoirs for public and private water supplies within 5 miles downstream of the crossing and written notice shall be given at least 10 days prior to construction to operators of any such intakes or reservoirs. Owners must notify public and private water supply operators immediately and no longer than 1 hour after an occurrence at the crossing site which results in the release of suspended solids and turbidity to the stream.

i. Mats, pads or other similar devices shall be used where crossings of wetland areas by construction equipment cannot be avoided. Original grades through wetlands must be restored after trenching and backfilling. Any excess fill material must be removed from the wetland and not spread onsite. Mound-

Copyright © 1996 Commonwealth of Pennsylvania

ing of fill material to allow for settlement in the trench will be permitted in accordance with best construction methods.

j. Deposition of dredged or excavated materials and all earthwork operations will be carried out in such a way as to minimize erosion of the material and preclude its entering into any wetland adjacent to the utility line crossing.

k. Utility line crossings of streams should be accomplished so that the line is at a right angle to the stream where possible, unless the crossing is installed on an existing bridge.

l. Whenever possible, in accordance with best construction methods utility line crossings are to be made ''in the dry'' by installing sandbag and plastic dams and piping stream flow through the affected area.

m. Prior to the use of explosives in a watercourse or body of water the permittee shall secure a written permit from the Fish Commission, under 30 Pa.C.S. § 2906 (relating to permits for use of explosives). Requests should be directed to the Fish Commission, Bureau of Administrative Services, Post Office Box 1673, Harrisburg, Pennsylvania 17120, (717) 657-4522.

13. *Pollution Incident Prevention and Mitigation*—For projects constructed under the authorization of this general permit which transmit hazardous or toxic material, the owner shall take the following actions to prevent or alleviate the harm from pollution, under the requirements of Chapter 101 (Reserved):

a. Develop and implement a Preparedness, Prevention and Contingency (PPC) Plan in accordance with Departmental guidelines. The Department reserves the right to require the PPC Plan to be revised or amended for any deficiencies subsequently identified by the Department.

b. In the event a pollution incident occurs which causes or threatens to cause surface or groundwater pollution, the owner shall:

(1) Promptly notify the Department by telephone of the location and nature of the danger.

(2) Notify all known downstream users of the water.

(3) Immediately take all necessary steps to prevent injury to property and downstream users and protect waters from pollution or danger of pollution.

(4) Remove any contamination from affected ground or surface water to the extent required by the Department.

14. *Department Inspection*—As a condition of use of this general permit, and of the owner's authority to conduct the activities authorized by this general permit, the owner hereby authorizes and consents to allow authorized employes or agents of the Department, without advance notice or a search warrant, at any reasonable time and upon presentation of appropriate credentials, and without delay, to have access to and to inspect all areas where the project is being constructed, operated or maintained. The authorization and consent shall include consent to conduct tests or sampling, to take photographs, to perform measurements, surveys and other tests, to inspect the methods of construction, operation or maintenance, to examine and copy books, papers and records pertinent to any matter under

investigation, and to take any other action necessary to assure that the project is constructed, operated or maintained in accordance with the terms and criteria of the general permit. This general permit condition is referenced in accordance with section 16 of the Dam Safety and Encroachments Act (32 P. S. § 693.16) and in no way limits any other powers granted under the Dam Safety and Encroachments Act.

15. *Activities not in Accordance with the Terms or Conditions*—If the Department determines, upon inspection, that the construction, operation or maintenance of a project has violated the terms or conditions of this general permit or of this chapter the Department may take such actions, legal or administrative, that it may deem to be appropriate.

16. *Structure Removal*—The owners shall remove all or any portion of the utility line project upon written notification to the owner by the Department in the event the project is causing an adverse impact on public health, safety or the environment or in any other manner violates the conditions of this general permit or this chapter.

17. *Property Rights*—This general permit does not convey any property rights, either in real estate or material, or any exclusive privileges; nor does it authorize any injury to property or invasion of rights or any infringement of Federal, State or local laws or regulations.

18. *Other Approvals*—The owners shall secure all other approvals that may be necessary under other Federal, State or local laws or regulations, including the specific permission of owners of bridges or other structures to which the utility line may be attached.

19. *Fish Commission Notification*—The owners shall notify the Fish Commission's Regional Field Office Supervisor, responsible for the County where the activities are proposed 10 days prior to start of construction. Notification by postcard is suggested. The project site shall at all times be available for inspection by authorized officers and employes of the Fish Commission.

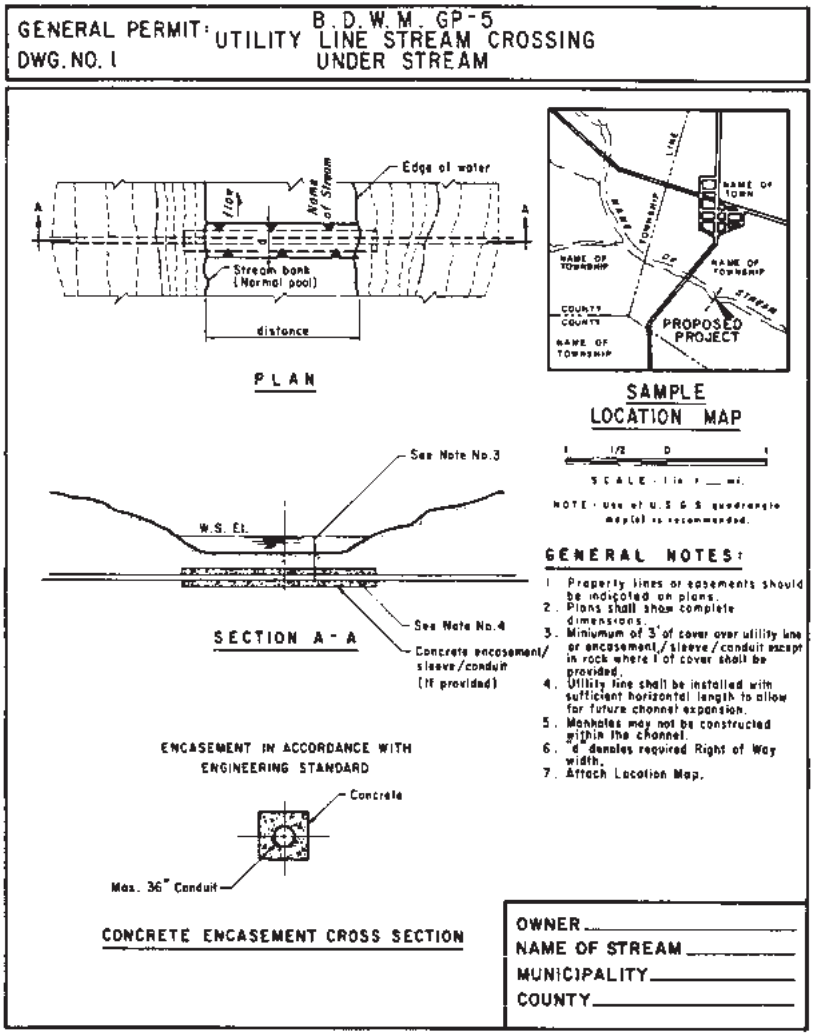
20. *Erosion and Sediment Pollution Controls*—Work must be done in compliance with Chapter 102 (relating to erosion and sediment control). Prior to construction an Erosion and Sediment Pollution Control Plan must be reviewed and determined adequate by the County Conservation District in which the activities are proposed and implemented prior to, during and after construction. The County Conservation District shall be notified 10 days prior to the start of construction. The project site shall at all times be available for inspection by authorized employes of the County Conservation District. The Erosion and Sediment Pollution Control Plan shall be available at the site.

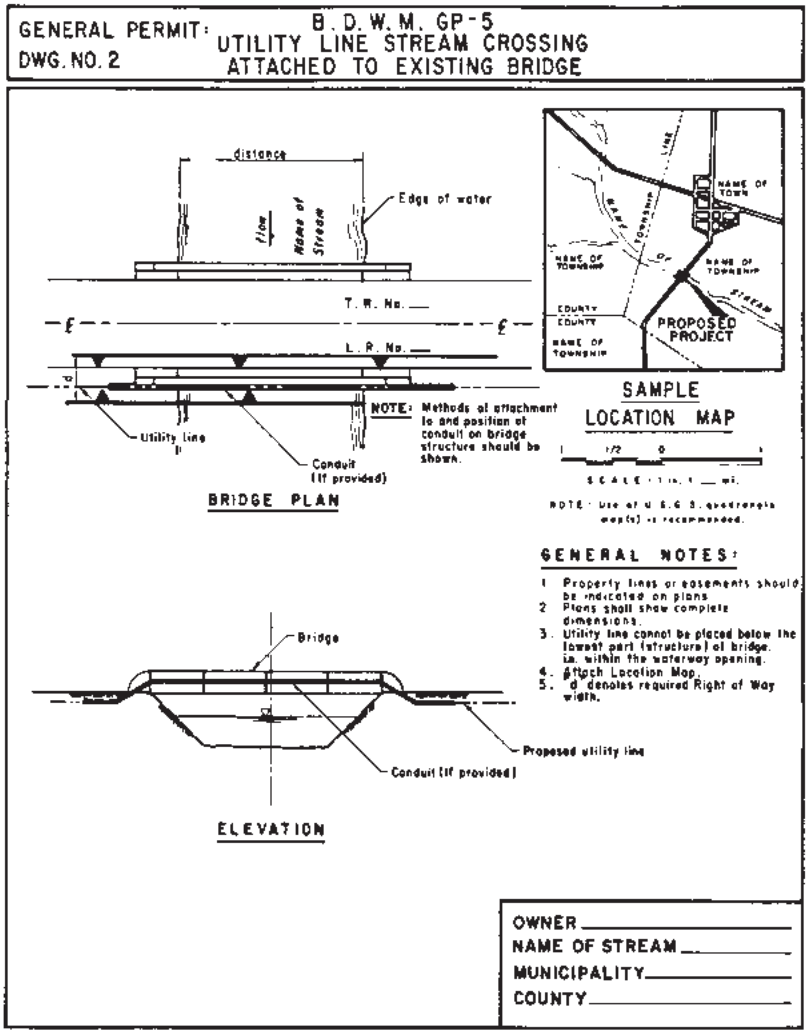
21. *Utilization of General Permit BDWM-GP-8, Temporary Road Crossings*—Temporary road crossings of streams and causeways that are necessary for equipment to move back and forth across a stream and located adjacent to the utility line crossing are authorized by and must be constructed in accor-

Copyright © 2000 Commonwealth of Pennsylvania

dance with BDWM-GP-8. The owners shall indicate utilization of GP-8 on Exhibit B in the space provided. Owners constructing temporary road crossings in those areas excluded from the application of GP-8 must apply for an individual water obstruction permit for those road crossings.

3/90





Copyright © 1996 Commonwealth of Pennsylvania

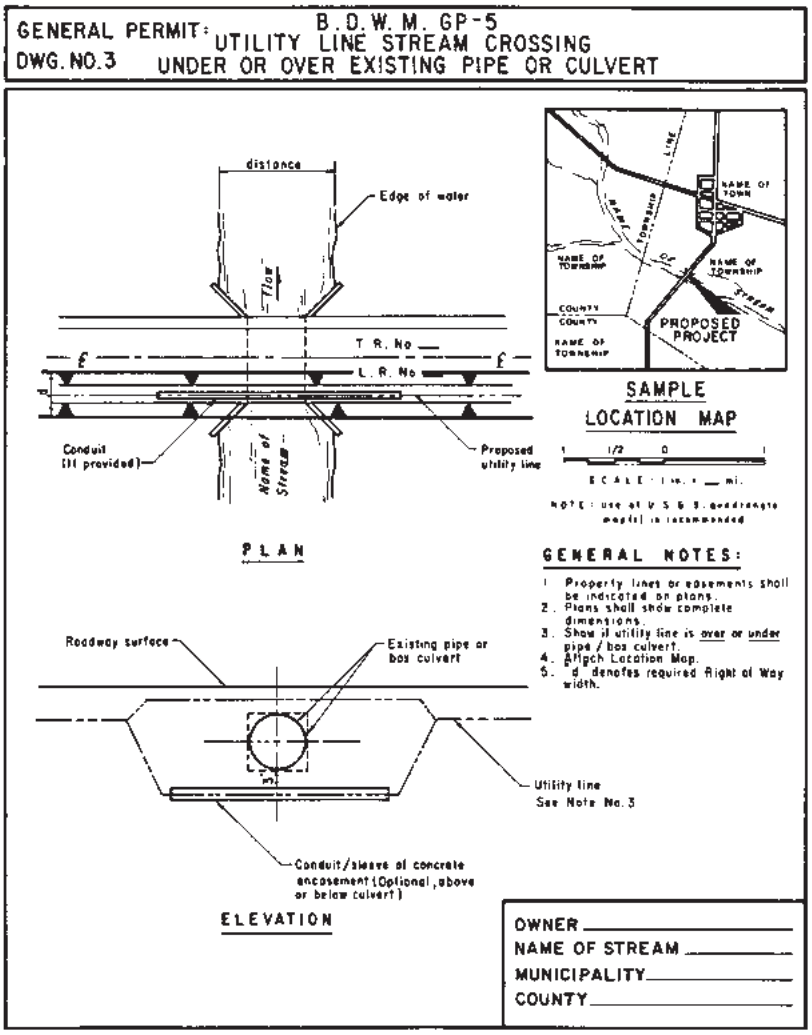

GENERAL PERMIT: B.D.W.M. GP-5
DWG. NO. 3 UTILITY LINE STREAM CROSSING
UNDER OR OVER EXISTING PIPE OR CULVERT
distance
Edge of water
Flow
T. R. No
L. R. No
Conduit (if provided)
Name of Stream
Proposed utility line
PLAN
NAME OF TOWN
NAME OF TOWNSHIP
COUNTY
PROPOSED PROJECT
SAMPLE LOCATION MAP
SCALE
GENERAL NOTES:
1. Property lines or easements shall be indicated on plans.
2. Plans shall show complete dimensions.
3. Show if utility line is over or under pipe / box culvert.
4. Attach Location Map.
5. d denotes required Right of Way width.
Roadway surface
Existing pipe or box culvert
Utility line See Note No. 3
Conduit/sleeve of concrete encasement (Optional, above or below culvert)
ELEVATION
OWNER
NAME OF STREAM
MUNICIPALITY
COUNTY

EXHIBIT A
FISH COMMISSION'S OFFICES

Headquarters Address	*County Responsibility*
NORTHWEST REGION	
Regional Supervisor P. O. Box 349 1281 Otter Street Franklin, Pa. 16323 (814) 437-5774	Butler, Clarion, Crawford, Erie, Forest, Lawrence, Mercer, Venango and Warren
SOUTHWEST REGION	
Regional Supervisor R. D. 2, Box 39 Somerset, Pa. 15501-9311 (814) 445-8974	Allegheny, Armstrong, Beaver, Cambria, Fayette, Greene, Indiana, Somerset, Washington and Westmoreland
NORTHCENTRAL REGION	
Regional Supervisor Box 187 (Fishing Creek Road) Lamar, Pa. 16848 (717) 726-6056	Cameron, Centre, Clearfield, Clinton, Elk, Jefferson, Lycoming, McKean, Northumberland, Potter, Snyder, Tioga and Union
SOUTHCENTRAL REGION	
Regional Supervisor 1704 Pine Road Newville, Pa. 17241 (717) 486-7087	Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lebanon, Mifflin, Perry and York
SOUTHEAST REGION	
Regional Supervisor Box 8 Elm, Pa. 17521 (717) 626-0228	Berks, Bucks, Chester, Delaware, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia and Schuylkill
NORTHEAST REGION	
Regional Supervisor Box 88 Sweet Valley, Pa. 18656 (717) 477-5717	Bradford, Carbon, Columbia, Lackawanna, Luzerne, Monroe, Montour, Pike, Sullivan, Susquehanna, Wayne and Wyoming

Copyright © 1996 Commonwealth of Pennsylvania

DIVISION OF ENVIRONMENTAL SERVICES
Robinson Lane
Bellefonte, Pa. 16823
(814) 359-5145

EXHIBIT B

DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF DAMS AND WATERWAY MANAGEMENT

Area Office	*County Responsibility*
Southcentral Area Office Room 149 One Ararat Boulevard P. O. Box 8554 Harrisburg, Pa. 17105-8554 (717) 541-7901	Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Mifflin, Perry and York
Southeast Area Office Suite 6010, Lee Park 555 North Lane Conshohocken, Pa. 19428 (215) 832-6340	Berks, Bucks, Carbon, Chester, Delaware, Lehigh, Northampton, Montgomery, Philadelphia and Schuylkill
Southwest Area Office 482 Route 30 R. D. 1 Clinton, Pa. 15026 (412) 899-2377	Allegheny, Armstrong, Beaver, Butler, Cambria, Fayette, Greene, Indiana, Lawrence, Somerset, Washington and Westmoreland
Northwest Area Office 190 Adams Road Jamestown, Pa. 16134 (412) 932-3162	Clarion, Clearfield, Crawford, Elk, Erie, Forest, Jefferson, McKean, Mercer, Venango and Warren
Northeast Area Office Suite 203, Cross Valley Centre 667 River Street Plains, Pa. 18705-1099 (717) 826-5485	Bradford, Columbia, Lackawanna, Luzerne, Monroe, Pike, Sullivan, Susquehanna, Wayne and Wyoming
Northcentral Area Office 200 Pine Street Williamsport, Pa. 17701 (717) 327-3574	Cameron, Centre, Clinton, Lycoming, Montour, Northumberland, Potter, Snyder, Tioga and Union

BUREAU OF DAMS AND WATERWAY MANAGEMENT
CENTRAL OFFICE
P. O. Box 8554
Harrisburg, Pa. 17105-8554
(717) 541-7900

EXHIBIT C

Notification to Use
BDWM-GP-5
Utility Line Stream Crossings

I/We, _____ (owner name(s)), hereby notify the Bureau of Dams and Waterway Management of our intent to use Sample Drawing No. _____ to install

_____
(size and description of utility line)

across/along _____
(name of stream, body of water, or wetland)

at a point _____
(describe location)

_____

in _____ (municipality), _____ (county).

I/We have attached a LOCATION MAP similar to that shown on the sample drawings indicating where the utility line will be installed.

I/We certify that a copy of this notification was sent this day _____
(date)

to _____ (municipality), and _____ (county)
in which the work will be performed.

Signed: _____
(owner or authorized representative)

_____
(owner address)

_____

_____
(owner telephone number)

3/90
I/We hereby notify the Bureau that BDWM-GP-8, Temporary Road Crossing will also be utilized during the installation of the utility line.

(207850) No. 255 Feb. 96

Copyright © 1996 Commonwealth of Pennsylvania

Signed: _____

Send to one of the addresses on Exhibit B.

Source

The provisions of this Appendix E adopted January 15, 1988, effective February 16, 1988, 18 Pa.B. 276.

APPENDIX F
AGRICULTURAL CROSSINGS AND RAMPS; GENERAL PERMIT BDWM-GP-6

Editor's Note: The following permit was published in the *Pennsylvania Bulletin* as a Notice and is codified under 1 Pa. Code § 3.1(a)(9) (relating to contents of *Code*) as a document which the Legislative Reference Bureau finds to be general and permanent in nature. See §§ 105.441—105.449 (relating to general permits) for regulations governing this permit.

1. *General Description and Authority*—The Department of Environmental Resources hereby authorizes, by general permit, subject to the terms and criteria set forth, the installation, operation and maintenance of Agricultural Crossings and Ramps in the regulated waters of the Commonwealth. This authorization is pursuant to section 7 of the Dam Safety and Encroachments Act (32 P. S. § 693.7), and the rules and regulations promulgated thereunder at 25 Pa. Code §§ 105.441—105.449 (relating to general permits).

2. *Denial of Authorization*—The Department shall have the discretion, on a case-by-case basis, to deny, revoke or suspend the authorization to use this general permit for any project which the department determines to have a substantial risk to life, property or the environment or otherwise could not be adequately regulated by the provisions of this permit.

3. *Definitions*—The following terms as used in this general permit shall have the following meanings.

Agricultural ramp—The stabilization of the stream bank with stone or timber to provide protection of the stream bank from livestock and agricultural equipment use.

Agricultural crossing—The stabilization of the bed or banks of a stream to provide protection of the bed and banks from livestock and agricultural equipment use.

Body of water—Any natural or artificial lake, pond, reservoir, swamp, marsh or wetland.

FEMA—The Federal Emergency Management Agency.

Floodway—The channel of the watercourse and those portions of the adjoining floodplains which are reasonably required to carry and discharge the 100-year frequency flood. Unless otherwise specified, the boundary of the floodway is as indicated on maps and flood insurance studies provided by FEMA. In an area where no FEMA maps or studies have defined the boundary of the 100-

year frequency floodway, it is assumed, absent evidence to the contrary, that the floodway extends from the stream to 50 feet from the top of the bank of the stream.

Install—To construct, deposit, lay or set in place.

Owner—Any person who owns, controls, operates, maintains, or manages a dam or reservoir, water obstruction, or encroachment.

Person—Any natural person, partnership, association, corporation, public utility, municipality, municipal authority, political subdivision of the Commonwealth, receiver or trustee and any department, board, commission, or authority of the Commonwealth.

Regulated waters of this Commonwealth—All watercourses, streams or bodies of water and their floodways wholly or partly within or forming part of the boundary of this Commonwealth.

Reservoir—A basin, either natural or artificial, which contains or will contain the water or other fluid or semi-fluid impounded by a dam.

Stocked trout stream—Streams classified as approved trout waters by the Pennsylvania Fish Commission. Classification may be verified by contacting the Pennsylvania Fish Commission's Regional Office, Division of Property Services or Division of Environmental Services.

Submerged lands of this Commonwealth—All waters and permanently or periodically inundated lands owned by this Commonwealth, including all lands in the beds of navigable lakes and rivers and beds of streams declared public highways which are owned and held in trust by the Commonwealth.

Watercourse—Any channel or conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

Wetlands—Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs, and similar areas. The term includes but is not limited to wetland areas listed in the State Water Plan, the United States Forest Service Wetlands Inventory of Pennsylvania, the Pennsylvania Coastal Zone Management Plan, and any wetland area designated by a river basin commission (or as defined in this chapter).

Wild trout streams—Streams classified as supporting reproducing trout populations by the Pennsylvania Fish Commission. Classification may be verified by contacting the Pennsylvania Fish Commission's Regional Office, Division of Property Services or Division of Environmental Services.

4. *Submerged Lands of this Commonwealth*—This general permit shall not be effective to authorize any project over, across or occupying submerged lands of this Commonwealth until the owner has obtained a license from the Department authorizing the occupation of such submerged lands issued under section 15 of the Dam Safety and Encroachments Act (32 P. S. § 693.15), section 514 of The Administrative Code of 1929 (71 P. S. § 194) or other applicable laws. Upon

Copyright © 1996 Commonwealth of Pennsylvania

receipt of notification from the owner, the Department will review the project to determine if its location is over, across, or occupies submerged lands of the Commonwealth.

5. *Specific Areas Where General Permit Does Not Apply*

a. Historic, cultural or archaeological sites as identified in the latest published version of the Pennsylvania Inventory of Historical Places or the National Register of Historical Places.

b. Local historical site officially approved or recognized by a municipality.

c. Sites identified in the latest published version of the National Registry of Natural Landmarks.

d. Stocked trout streams from March 1 through June 15, wild trout streams from October 1 through December 31, and Lake Erie tributaries from September 1 through December 1 unless written approval is obtained from the Pennsylvania Fish Commission's Division of Property Services or Division of Environmental Services.

e. Wetlands except those wetlands that are immediately adjacent to or within a watercourse and are an integral part of the construction of the Agricultural Ramp or Crossing.

f. Streams or water bodies designated as Exceptional Value Waters (EV) as defined and listed in Chapter 93 (relating to water quality standards).

6. *Other Permits*—Nothing in this General Permit relieves the owners of the obligation of complying with all Federal, Interstate Compact and State laws, regulations and standards for installation, operation or maintenance of Agricultural Crossings and Ramps.

7. *Notification of Proposed Use of General Permit*—Prior to construction the owner shall submit Exhibit C along with the required location map to the Bureau of Dams and Waterway Management. A copy of Exhibit C shall be sent to the municipality and county in which the work will be performed. THE OWNER MAY NOT BEGIN WORK UNTIL HE HAS NOTIFIED THE BUREAU OF DAMS AND WATERWAY MANAGEMENT AND RECEIVED ACKNOWLEDGEMENT OF THE NOTIFICATION.

8. *Change of Ownership*—If there is a change in ownership of an agricultural crossing or ramp installed in accordance with this general permit, the new owner is required to register the structure with the Department in accordance with Item 7.

9. *Fees*—There is no fee required for a project authorized under this general permit.

10. *Effective Time Period*—This general permit will remain in effect indefinitely unless specifically modified, suspended, or revised by the Department.

11. *Suspension, Modification or Revocation*—The Department may suspend, modify, or revoke this general permit at any time upon notice in the *Pennsylvania Bulletin*.

12. *Project Interference*—This general permit does not authorize any interference with any existing or proposed Local, State, Federal or Federally License Project, and permittees shall not be entitled to compensation for damage or injury to the work authorized herein which may be caused by or a result of existing or future operations.

13. *Conditions.*

a. The Pennsylvania Fish Commission Division of Property Services, United States Department of Agriculture Soil Conservation Service or respective County Conservation District may be able to provide technical assistance in locating appropriate sites for agricultural crossings and ramps.

b. The agricultural crossing or ramp shall be completed within 30 days from the start of its construction. All disturbed areas shall be stabilized within 5 days.

c. Construction of the crossing or ramp should not alter the normal channel width. The configuration of the stream bank shall remain substantially the same and the work shall blend with adjacent upstream and downstream banks.

d. Each agricultural crossing and ramp shall be installed in such a way that it does not hinder recreational navigation nor interfere with the normal migration of fish.

e. Written notice shall be given to operators of drinking water intakes or reservoirs for public and private water supplies and permitted public bathing beaches within 5 miles downstream of the crossing or ramp at least 10 days prior to construction of the crossing. Owner(s) must notify operators immediately and no longer than 1 hour following the release of suspended solids and turbidity to the stream due to any construction activity.

f. Structures authorized by this general permit shall be maintained in a safe and functional condition including necessary debris removal.

g. Only clean, nonpolluting, granular materials shall be used as fill material in order to minimize excessive turbidity by leaching of fines as well as to preclude the entrance of potentially polluted materials to the watercourse by natural runoff.

h. Slag may not be used as a substitute for stone.

i. Dredged or excavated materials may not be deposited in wetlands or within the limits of the floodway or any area affected by floods.

j. Prior to the use of explosives in a watercourse or body of water the permittee shall secure a written permit from the Pennsylvania Fish Commission, under 30 Pa.C.S. § 2906 (relating to permits for use of explosives). Requests should be directed to the Fish Commission, Division of Environmental Services (See Exhibit A).

k. Agricultural crossings and ramps shall be installed at a right angle to the stream flow.

Copyright © 1996 Commonwealth of Pennsylvania

l. Agricultural crossings and ramps must be keyed into the stream bank(s) or bed which may be accomplished by trenching or by machine weight running on the stone fill.

m. Agricultural crossings and ramps should be no steeper than 4:1.

n. Skidding of timber across ramps and crossings is prohibited.

o. Interior stone for crossings and ramps shall be of a diameter to fill the voids that will encourage livestock use.

p. Exterior frame stone for crossings and ramps shall be of sufficient diameter to resist transport by normal high flows and require deeper keying into the stream bank or bed.

q. Stone placed for agricultural crossings shall not exceed 12 inches in height above the natural streambed.

r. The placement of fill higher than the elevation of the existing stream banks, the realignment of the channel or the dredging of a watercourse is not authorized by this general permit.

s. Grouting of stone is not authorized by this general permit.

t. Agricultural crossings and ramps that are to be utilized by livestock shall include fencing or other barriers to direct the livestock to the crossing or ramp and to control the movement within the crossing or ramp.

u. Roadways leading to or from an agricultural crossing or ramp that are to be constructed in wetlands are not authorized by this general permit.

v. Archaeological artifacts discovered during the performance of the work authorized under this general permit must be adequately protected and their discovery promptly reported to the Director, Bureau of Historic Preservation, Pennsylvania Historical Museum, Post Office Box 1026, Harrisburg, Pennsylvania 17108-1026.

14. *Department Inspection*—As a condition of use of this general permit, and of the owner's authority to conduct the activities authorized by this general permit, the owner hereby authorizes and consents to allow authorized employees or agents of the Department, without advance notice or search warrant, at any reasonable time and upon presentation of appropriate credentials, and without delay, to have access to and to inspect all areas where the project is being constructed, operated or maintained. The authorization and consent shall include consent to conduct tests or sampling, to take photographs, to perform measurements, surveys and other tests, to inspect the methods of construction, operation or maintenance, to examine and copy books, papers and records pertinent to any matter under investigation, and to take any other action necessary to assure that the project is constructed, operated or maintained in accordance with the terms and criteria of the general permit. This general permit condition is referenced in accordance with section 16 of the Dam Safety and Encroachments Act (32 P. S. § 693.16), and in no way limits any other powers granted under the Dam Safety and Encroachments Act.

15. *Activities not in Accordance with the Terms or Conditions*—If the Department determines, upon inspection, that the construction, operation, or maintenance of a project has violated the terms or criteria of this general permit or of this chapter, the Department may take such actions, legal or administrative, that it may deem to be appropriate.

16. *Structure Removal*—The owner(s) shall remove all or any portion of the agricultural structures upon written notification to the owner by the Department in the event the project is causing an adverse impact on public health, safety or the environment or in any other manner violates the conditions of this general permit or this chapter.

17. *Property Rights*—This general permit does not convey any property rights, either in real estate or material, or in any exclusive privileges; nor does it authorize any injury to property or invasion of rights or any infringement of Federal, State, or Local laws or regulations.

18. *Other Approvals*—The owner(s) shall secure all other approvals that may be necessary under Federal, State, or Local laws or regulations.

19. *Fish Commission Notification*—The owner(s) shall notify the Pennsylvania Fish Commission's Regional Law Enforcement Field Office Supervisor (see Exhibit ''A'') responsible for the county where the activities are proposed 10 days prior to start of construction. Written notification is suggested. The project site shall at all times be available for inspection by authorized officers and employees of the Pennsylvania Fish Commission.

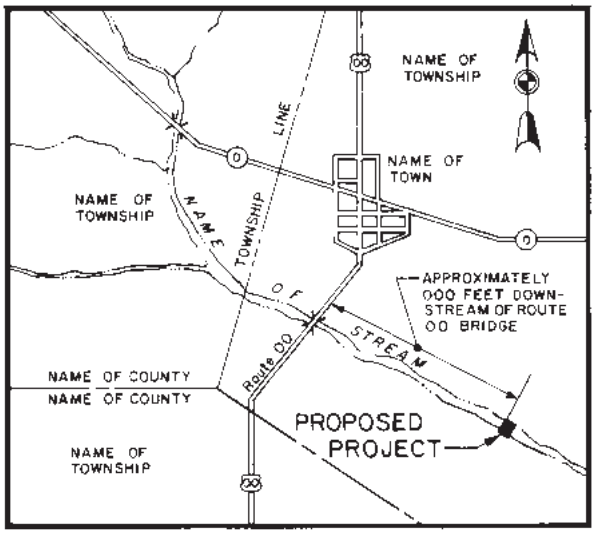
20. *Erosion and Sediment Pollution Controls*—Work must be done in compliance with Chapter 102 (relating to erosion and sediment control). Prior to construction an Erosion and Sediment Pollution Control Plan must be reviewed and determined adequate by the County Conservation District in which the activities are proposed and implemented prior to, during, and after construction. The County Conservation District shall be notified 10 days prior to the start of construction. The project site shall at all times be available for inspection by authorized employees of the County Conservation District. The Erosion and Sediment Pollution Control Plan shall be available at the site at all times.

21. *Utilization of General Permit BDWM-GP-8; Temporary Road Crossings*—Temporary road crossings of streams and causeways that are necessary for equipment to move back and forth across a stream and located adjacent to an agricultural crossing or ramp are authorized by and must be constructed in accordance with BDWM-GP-8. The owner shall indicate utilization of GP-8 on Exhibit C in the space provided. Owners constructing temporary road crossings in those areas where GP-8 is not authorized must apply for a Water Obstruction and Encroachment Permit for those road crossings.

2/91

Copyright © 2000 Commonwealth of Pennsylvania

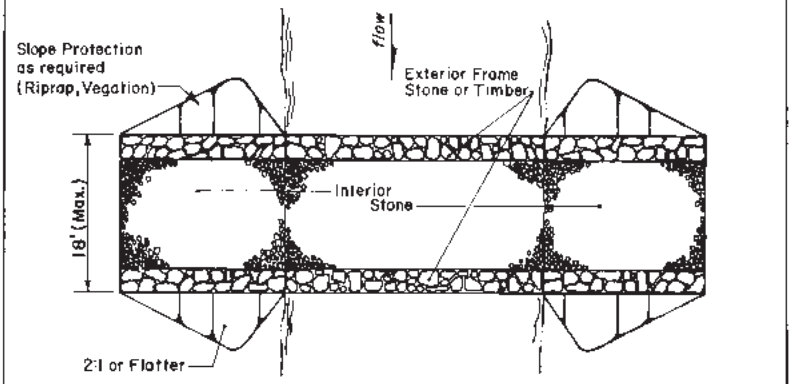
GENERAL PERMIT: B.D.W.M. GP-6
AGRICULTURAL CROSSINGS AND RAMPS
Dwg. No. 1 SAMPLE LOCATION MAP



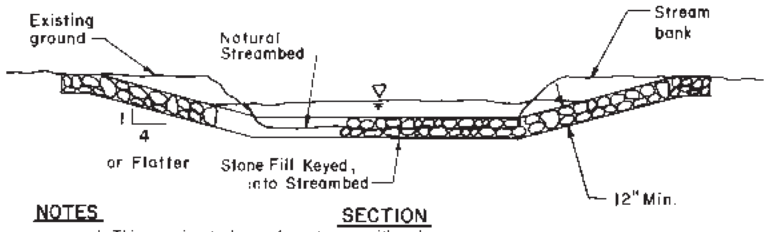
NOTE: Use of U.S.G.S. quadrangle map(s) is recommended.

(207857) No. 255 Feb. 96

GENERAL PERMIT: B.D.W.M. GP-6
AGRICULTURAL CROSSINGS AND RAMPS
Dwg. No. 2 LOW GRADIENT GRADE CROSSING



PLAN VIEW



SECTION

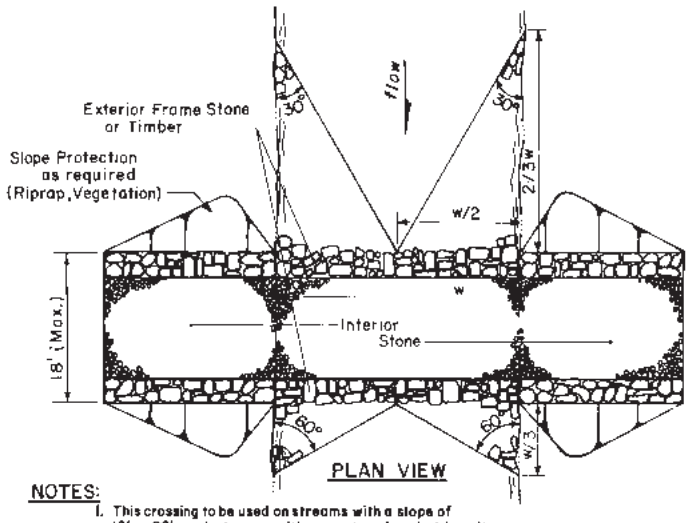
NOTES

1. This crossing to be used on streams with a slope of less than 1%.
2. All spoil shall be deposited outside of the floodway and wetlands. See Condition 13 (i).
3. Depth of stone fill above natural streambed shall not exceed 12-inches. See Condition 13 (Q).
4. No.4 or 5 stone to be used as interior stone.
5. No.2 stone to be used to fill any subsequent voids.
6. Stone shall be keyed into the streambank and bed. See Conditions 13 (i),(o) and (p).
7. Install fencing for livestock use. See Condition 13 (l).

(207858) No. 255 Feb. 96

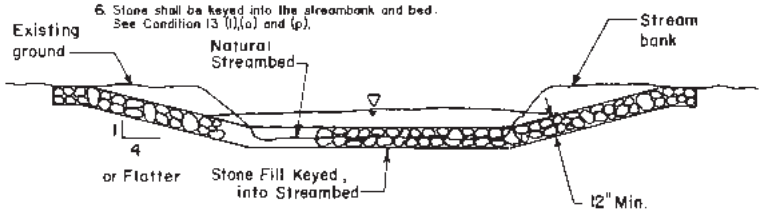
Copyright © 1996 Commonwealth of Pennsylvania

GENERAL PERMIT: B.D.W.M. GP-6
AGRICULTURAL CROSSINGS AND RAMPS
Dwg. No. 3 MODERATE STREAM GRADE CROSSING



NOTES:

1. This crossing to be used on streams with a slope of 1% - 2% and streams with a greater slope but less than 5 ft. wide.
2. All spoil shall be deposited outside of the floodway and wetlands. See Condition 13 (i).
3. Depth of stone fill above natural streambed shall not exceed 12-inches. See Condition 13 (Q).
4. No.4 or 5 stone to be used as interior stone.
5. No.2 stone to be used to fill any subsequent voids.
6. Stone shall be keyed into the streambank and bed. See Condition 13 (l),(o) and (p).

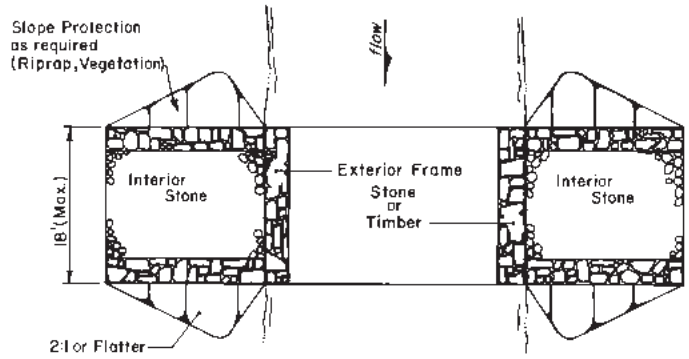


7. Install fencing for livestock use. See Condition 13 (t).

GENERAL PERMIT: B.D.W.M. GP-6
AGRICULTURAL CROSSINGS AND RAMPS

Dwg. No. 4

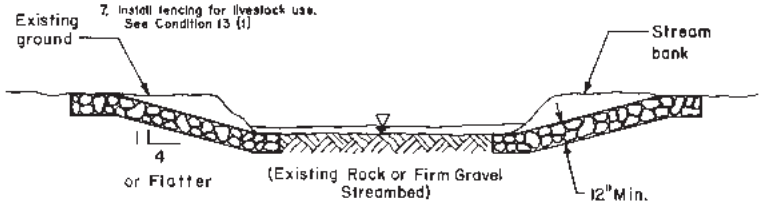
CROSSING UTILIZING
EXISTING STABLE STREAM BOTTOM



PLAN VIEW

NOTES:

1. All spoil shall be deposited outside of the floodway and wetlands. See Condition 13 (i).
2. Depth of stone fill above natural streambed shall not exceed 12-inches. See Condition 13 (Q).
3. No.4 or 5 stone to be used as interior stone.
4. No.2 stone to be used to fill any subsequent voids.
5. Stone shall be keyed into the streambank. See Conditions 13 (l),(o) and (p).
6. May substitute ramps as shown on Drawing Nos. 6 and 7.
7. Install fencing for livestock use. See Condition 13 (t)



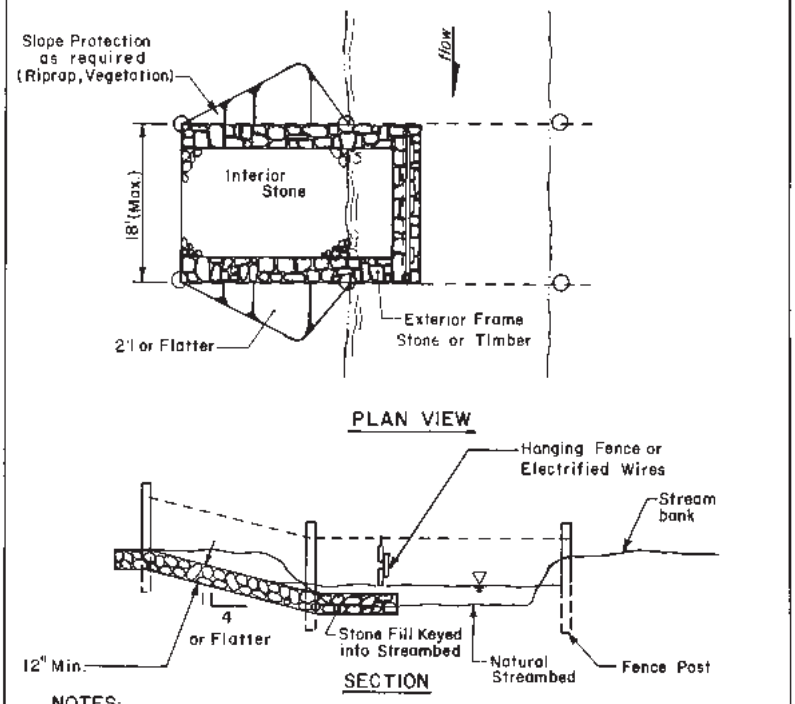
SECTION

Copyright © 1996 Commonwealth of Pennsylvania

GENERAL PERMIT: B.D.W.M. GP-6

AGRICULTURAL CROSSINGS AND RAMPS

Dwg. No. 5 ACCESS RAMPS



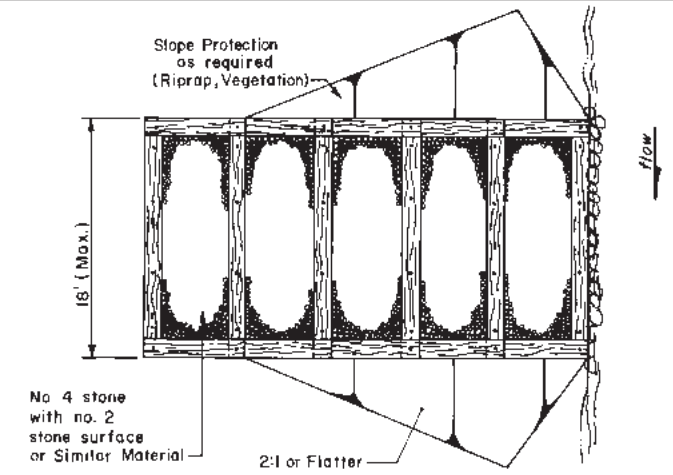
NOTES:

1. All spoil shall be deposited outside of the floodway and wetlands. See Condition 13 (j).
2. Depth of stone fill above natural streambed shall not exceed 12-inches. See Condition 13 (Q).
3. No.4 or 5 stone to be used as interior stone.
4. No.2 stone to be used to fill any subsequent voids.
5. Stone shall be keyed into the streambank. See Conditions 13 (l),(o) and (p).
6. May substitute ramps as shown on Drawing Nos. 6 and 7.
7. Install fencing for livestock use. See Condition 13 (l).

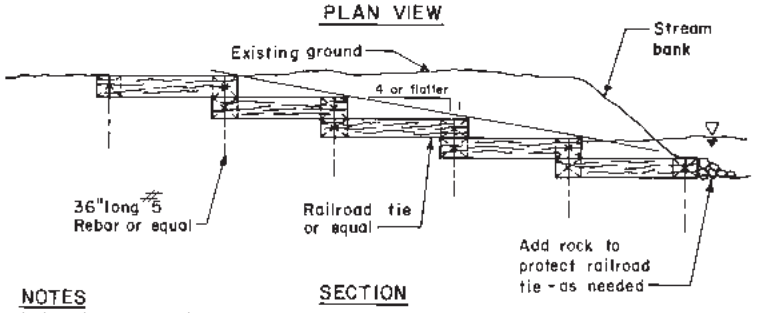
GENERAL PERMIT: B.D.W.M. GP-6

AGRICULTURAL CROSSINGS AND RAMPS

Dwg. No. 6 ACCESS RAMPS



PLAN VIEW



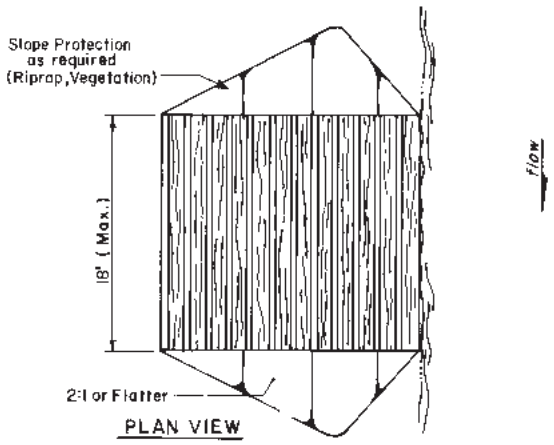
SECTION

NOTES

1. All spoil shall be deposited outside of the floodway and wetlands. See Condition 13 (i).
2. Depth of stone fill above natural streambed shall not exceed 12-inches. See Condition 13 (Q).
3. No.4 or 5 stone to be used as interior stone.
4. No.2 stone to be used to fill any subsequent voids.
5. Stone shall be keyed into the streambank and bed. See Condition 13 (l),(o) and (p).
6. This ramp may be used on Drawing Nos. 4 and 5.
7. Install fencing for livestock use. See Condition 13 (t).

Copyright © 1996 Commonwealth of Pennsylvania

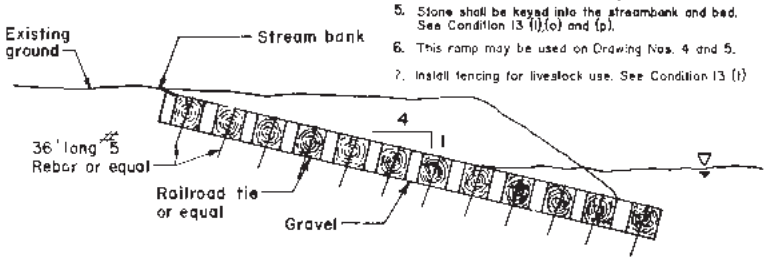
GENERAL PERMIT: B.D.W.M. GP- 6
AGRICULTURAL CROSSINGS AND RAMPS
Dwg. No. 7 ACCESS RAMPS



PLAN VIEW

NOTES:

1. All spoil shall be deposited outside of the floodway and wetlands. See Condition 13 (i).
2. Depth of stone fill above natural streambed shall not exceed 12-inches. See Condition 13 (Q).
3. No.4 or 5 stone to be used as interior stone.
4. No.2 stone to be used to fill any subsequent voids.
5. Stone shall be keyed into the streambank and bed. See Condition 13 (l),(o) and (p).
6. This ramp may be used on Drawing Nos. 4 and 5.
7. Install fencing for livestock use. See Condition 13 (t)



SECTION

EXHIBIT A
FISH COMMISSION'S OFFICES

Headquarters Address	*County Responsibility*
NORTHWEST REGION	
Regional Supervisor P. O. Box 349 1281 Otter Street Franklin, Pa. 16323 (814) 437-5774	Butler, Clarion, Crawford, Erie, Forest, Lawrence, Mercer, Venango and Warren
SOUTHWEST REGION	
Regional Supervisor R. D. 2, Box 39 Somerset, Pa. 15501-9311 (814) 445-8974	Allegheny, Armstrong, Beaver, Cambria, Fayette, Greene, Indiana, Somerset, Washington and Westmoreland
NORTHCENTRAL REGION	
Regional Supervisor Box 187 (Fishing Creek Road) Lamar, Pa. 16848 (717) 726-6056	Cameron, Centre, Clearfield, Clinton, Elk, Jefferson, Lycoming, McKean, Northumberland, Potter, Snyder, Tioga and Union
SOUTHCENTRAL REGION	
Regional Supervisor 1704 Pine Road Newville, Pa. 17241 (717) 486-7087	Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lebanon, Mifflin, Perry and York
SOUTHEAST REGION	
Regional Supervisor Box 8 Elm, Pa. 17521 (717) 626-0228	Berks, Bucks, Chester, Delaware, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia and Schuylkill
NORTHEAST REGION	
Regional Supervisor Box 88 Sweet Valley, Pa. 18656 (717) 477-5717	Bradford, Carbon, Columbia, Lackawanna, Luzerne, Monroe, Montour, Pike, Sullivan, Susquehanna, Wayne and Wyoming

Copyright © 1996 Commonwealth of Pennsylvania

DIVISION OF ENVIRONMENTAL SERVICES	*DIVISION OF PROPERTY SERVICES*
450 Robinson Lane Bellefonte, Pa. 16823-9616 (814) 359-5145	450 Robinson Lane Bellefonte, Pa. 16823-9616 (814) 359-5185

EXHIBIT B
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF DAMS AND WATERWAY MANAGEMENT

Area Office	*County Responsibility*
Southcentral Area Office Room 149, One Ararat Boulevard P. O. Box 8554 Harrisburg, Pa. 17105-8554 (717) 541-7901	Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Mifflin, Perry and York
Southeast Area Office Suite 6010, Lee Park 555 North Lane Conshohocken, Pa. 19428 (215) 832-6340	Berks, Bucks, Carbon, Chester, Delaware, Lehigh, Northampton, Montgomery, Philadelphia and Schuylkill
Southwest Area Office R. D. # 1, 482, Route 30 Clinton, Pa. 15026 (412) 899-2377	Allegheny, Armstrong, Beaver, Butler, Cambria, Fayette, Greene, Indiana, Lawrence, Somerset, Washington and Westmoreland
Northwest Area Office 190 Adams Road Jamestown, Pa. 16134 (412) 932-3162	Clarion, Clearfield, Crawford, Elk, Erie, Forest, Jefferson, McKean, Mercer, Venango and Warren
Northeast Area Office Suite 203, Cross Valley Centre 667 North River Street Plains, Pa. 18705-1099 (717) 826-5485	Bradford, Columbia, Lackawanna, Luzerne, Monroe, Pike, Sullivan, Susquehanna, Wayne and Wyoming Area Office

Area Office	*County Responsibility*
Northcentral Area Office 200 Pine Street Williamsport, Pa. 17701 (717) 327-3574	Cameron, Centre, Clinton, Lycoming, Montour, Northumberland, Potter, Snyder, Tioga and Union

CENTRAL OFFICE
P. O. Box 8554
Harrisburg, Pa. 17105-8554
(717) 541-7900

EXHIBIT C

Notification to Use
BDWM-GP-6
Agricultural Crossings and Ramps

I/We, _____
(owner name(s))

hereby notify the Bureau of Dams and Waterway Management of our intent to install

_____
(description of structure)

across/along _____
(name of stream or body of water)

at a point _____
(describe location)

_____

in _____ (municipality), _____ (county).

I/We have attached a LOCATION MAP similar to that shown on Drawing No. 1 indicating where the agricultural crossing or ramp will be installed.

I/We certify that a copy of this notification was sent this day _____ (date) to _____ (municipality), and _____ (county) where the work will be performed.

Signed: _____
(owner or authorized representative)

_____
(owner address)

_____

_____
(owner telephone number)

2/91

(207866) No. 255 Feb. 96

Copyright © 1996 Commonwealth of Pennsylvania

I/We hereby notify the Bureau that BDWM-GP-8, Temporary Road Crossings will also be utilized during the installation of the agricultural crossing or ramp.

Signed: _____

Send to one of the addresses on Exhibit B.

Source

The provisions of this Appendix F adopted February 8, 1991, effective February 9, 1991, 21 Pa.B. 547.

APPENDIX G
MINOR ROAD CROSSINGS; GENERAL PERMIT BDWM-GP-7

Editor's Note: The following permit was published in the *Pennsylvania Bulletin* as a Notice and is codified under 1 Pa. Code § 3.1(a)(9) (relating to contents of *Code*) as a document which the Legislative Reference Bureau finds to be general and permanent in nature. See §§ 105.441—105.449 (relating to general permits) for regulations governing this permit.

1. *General Description and Authority*—The Department of Environmental Resources hereby authorizes by General Permit, (1) the construction, operation and maintenance of a minor road crossing across wetlands which disturbs less than 0.1 acre of wetlands, (2) the construction, operation and maintenance of a minor road crossing across a stream where the watershed drainage area is 1.0 square mile or less and (3) the removal of an existing minor road crossing across a stream where the drainage area is 1.0 square mile or less. This authorization is pursuant to section 7(b) of the Dam Safety and Encroachments Act (32 P. S. § 693.7(b)) and the rules and regulations promulgated thereunder at 25 Pa. Code §§ 105.441—105.449 (relating to general permits). This General Permit is subject to the terms and conditions set forth below.

2. *Denial of Authorization*—The Department shall have the discretion, on a case-by-case basis, to deny, revoke or suspend the authorization to use this General Permit for any project which the Department determines to present a risk to life, property or the environment or otherwise would not be adequately regulated by the provisions of this General Permit.

3. *Definitions*—The following terms as used in this General Permit shall have the following meaning:

Body of water—Any natural or artificial lake, pond, reservoir, swamp, marsh or wetland.

Bridge—A structure and its appurtenant works erected over the regulated waters of this Commonwealth.

Causeway—A roadway embankment constructed in or across a wetland.

Construct—To erect, build, place or deposit including preliminary preparation of a site for construction.

Culvert—A structure with appurtenant works which carries a stream under or through an embankment or fill.

Dredge—To remove sand, gravel, mud or other materials from the beds of regulated waters of this Commonwealth.

Existing minor road crossing—A bridge or culvert and fill crossing of a stream where the watershed drainage area is 1.0 square mile or less.

FEMA—The Federal Emergency Management Agency.

Fill—Sand, gravel, earth or other material placed or deposited so as to form an embankment or raise the elevation of the land surface. The term includes material used to replace an area with aquatic life with dry land or to change the bottom elevation of a regulated water of this Commonwealth.

Flood—A general but temporary condition of partial or complete inundation of normally dry land areas from the overflow of streams, rivers or other waters of this Commonwealth.

Floodway—The channel of the water course and those portions of the adjoining floodplains which are reasonably required to carry and discharge the 100-year frequency flood. Unless otherwise specified, the boundary of the floodway is as indicated on maps and flood insurance studies provided by FEMA. In an area where no FEMA maps or studies have defined the boundary of the 100-year frequency floodway, it is assumed absent evidence to the contrary, that the floodway extends from the stream to 50 feet from the top of the bank of the stream.

Ford—A road crossing of a stream utilizing the existing streambed.

Maintenance dredging—Dredging conducted as part of the construction of a dam, water obstruction, or encroachment, and periodic dredging conducted in order to:

(i) maintain adequate depths for navigation;

(ii) assure proper passage of ice and flood flows; or

(iii) preserve the safety, stability and proper operation of the facility.

Minor road crossing—A road constructed across a wetland where the length of the crossing is less than 100 feet and the total wetland area disturbed is less than 0.1 acre, or a road constructed across a stream and an adjacent wetland utilizing a bridge, culvert, or ford crossing where the watershed drainage area is 1.0 square mile or less and the total wetland area disturbed is less than 0.1 acre.

Owner—A person who owns, controls, operates, maintains or manages a dam or reservoir, water obstruction or encroachment.

Person—A natural person, partnership, association, corporation, public utility, municipality, municipal authority, political subdivision of the Commonwealth, receiver or trustee and a department, board, commission or authority of the Commonwealth.

Regulated waters of the Commonwealth—Water courses, streams or bodies of water and their floodways wholly or partly within or forming part of the boundary of this Commonwealth.

Copyright © 1996 Commonwealth of Pennsylvania

Replacement wetlands—Artificially created wetlands to replace those wetlands destroyed by the construction of a minor road crossing.

Stocked trout streams—Streams classified as approved trout waters by the Pennsylvania Fish Commission. Classification shall be verified by contacting the Pennsylvania Fish Commission's Regional Office or Division of Environmental Services (see Exhibit A).

Stream—A watercourse.

Stream enclosure—Any bridge, culvert or other structure in excess of 100 feet in length upstream to downstream which encloses any regulated water of this Commonwealth.

Submerged lands of this Commonwealth—Waters and permanently or periodically inundated lands owned by the Commonwealth, including lands in the beds of navigable lakes and rivers and beds of streams declared public highways which are owned and held in trust by the Commonwealth.

Watercourse—A channel or conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

Watershed—A region or area contributing to the supply of a stream or lake; drainage area, drainage basin or catchment area.

Wetlands—Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas. The term includes but is not limited to wetland areas listed in the State Water Plan, United States Forest Service Wetlands Inventory of Pennsylvania, the Pennsylvania Coastal Zone Management Plan, and any wetland area designated by a river basin commission.

Wild trout streams—Streams classified as supporting reproducing trout populations by the Fish Commission. Classifications shall be verified by contacting the Fish Commission's Regional Office or the Division of Environmental Services (see Exhibit A).

4. *Submerged Lands of this Commonwealth*—This General Permit shall not be effective to authorize any project over, across or occupying submerged lands of this Commonwealth until the owner has obtained a license from the Department authorizing the occupation of such submerged lands issued under section 15 of the Dam Safety and Encroachments Act (32 P. S. § 693.15), section 514 of The Administrative Code of 1929 (71 P. S. § 194) or other applicable laws. Upon receipt of notification from the owner, the Department will review the project to determine if its location is over, across or occupies submerged lands of the Commonwealth.

5. *Specific Areas and Activities Where General Permit Does Not Apply*—This General Permit does not apply in and is not valid in the following situations:

a. Historic, cultural or archaeological sites as identified in the latest published version of the Pennsylvania Inventory of Historic Places or the National Register of Historic Places.

b. Local historical sites officially approved or recognized by a municipality.

c. Sites identified in the latest published version of the National Registry of Natural Landmarks.

d. Areas in or within 100 feet of a watercourse or body of water designated as a National or State Wild or Scenic river in accordance with the National Wild and Scenic Rivers Act of 1968 or the Pennsylvania Scenic Rivers Act (32 P. S. §§ 820.21—820.29).

e. Stocked trout streams from March 1 through June 15, wild trout streams from October 1 through December 31, and Lake Erie tributaries from September 1 through December 1 unless written approval is obtained from the Fish Commission's Division of Environmental Services. (See Exhibit A).

f. Stream enclosures.

g. Streams or water bodies designated as exceptional value waters as defined in Chapter 93 (relating to water quality standards).

h. Stream channel crossing(s) where the watershed drainage area upstream of the crossing is greater than 1 square mile.

i. A stream channel and the adjoining floodplain which is delineated as a floodway on Flood Insurance Maps that are part of a Flood Insurance Study prepared by FEMA. These maps are available from the local municipality.

j. Wetland crossings where the extent of wetland impact for an individual minor road crossing is greater than .1 acre and the cumulative wetland impact for all minor road crossings installed by an owner on an individual property or project including phased projects is greater than .25 acre. A project shall include the aggregate of all stages of development and all parcels within a subdivision plan, which are under the control of the registrant.

k. Wetland crossings where the wetlands serve as habitat for fauna or flora listed as ''threatened'' or ''endangered'' under the Endangered Species Act of 1973, the Wild Resource Conservation Act, the Fish and Boat Code or the Game and Wildlife Code. Sites for minor road crossings may be checked through the Pennsylvania Natural Diversity Inventory by contacting the Bureau of Forestry, Division of Advisory Services, Post Office Box 8552, Harrisburg, Pennsylvania 17105-8552 or any of the offices listed on Exhibit B.

6. *Other Permits*—Nothing in this General Permit relieves the owner(s) of the obligation of complying with all Federal, Interstate Compacts and State laws, regulations and standards for the construction, operation or maintenance of the minor road crossings.

7. *Registration of Proposed Use of General Permit*—Prior to construction, the owner(s) shall submit Exhibit C along with the wetland delineation data forms completed in accordance with current procedures, the required location map, and

Copyright © 1996 Commonwealth of Pennsylvania

a site plan showing the boundaries of the wetland delineation and the replacement wetlands to the Bureau of Dams and Waterway Management (See Exhibit B). A copy of Exhibit C shall also be sent to the municipality and county in which the work will be performed. The owner may *not* begin work until he has notified the Bureau of Dams and Waterway Management and received an acknowledgement of that notification. The Department's acknowledgement letter serves as registration to use this General Permit.

8. *Change of Ownership*—If there is a change in ownership of a minor road crossing installed in accordance with this General Permit, the new owner is required to register the crossing with the Department in accordance with Item 7.

9. *Fees*—There is no fee required for a project authorized under this General Permit.

10. *Effective Time Period*—This General Permit will remain in effect indefinitely, unless specifically modified, suspended or revised by the Department.

11. *Suspension, Modification or Revocation*—The Department may suspend, modify or revoke this General Permit at any time upon notice in the *Pennsylvania Bulletin*.

12. *Project Interference*—This General Permit does not authorize any interference with any existing or proposed Local, State, Federal or Federally Licensed Project, and permittee shall not be entitled to compensation for damage or injury to the work authorized herein which may be caused by or a result of existing or future operations undertaken by the United States, Commonwealth of Pennsylvania, and its Political Subdivisions in the public interest.

13. *Conditions.*

a. The construction of a minor road crossing shall be completed within 3 years of the date of the Department's acknowledgement letter. If all construction is not completed within this time frame, the owner(s) shall remove all of the minor road crossing and restore the watercourse and floodplain to their former conditions.

b. Minor road crossings shall not create or constitute a risk to life, property or the environment.

c. No fill shall be placed in any floodway, watercourse, or body of water, including approaches to the minor road crossing, except as specifically authorized in this General Permit.

d. Each minor road crossing shall be constructed in such a manner so that there is no interference with the migration of fish.

e. Plans, specifications and reports for bridges and culverts across a stream which are to be used by the general public such as an access to an industrial, commercial or residential development, etc., shall be prepared by a registered professional engineer and shall be affixed with his seal and his certification which shall read as follows:

''I (name) do hereby certify to the best of my knowledge, information and belief, that the information contained in the accompanying plans, specifi-

cations, and reports have been prepared in accordance with accepted engineering practice, is true and correct, and is in conformance with Chapter 105 of the Rules and Regulations of the Department of Environmental Resources.''

f. A project which disturbs wetlands requires (1) a wetland delineation performed in accordance with current procedures and (2) a mitigation plan prepared and affixed with a statement which shall read as follows:

''I (name) do hereby state to the best of my knowledge, information and belief that the information contained in the plans, specifications and reports have been prepared in accordance with accepted environmental practices, is true and correct, and is in conformance with Chapter 105 of the Rules and Regulations of the Department of Environmental Resources.''

g. Bridges and culverts shall be of sufficient width and size so as not to narrow the existing stream channel.

h. The crossing shall be designed to prevent the restriction of and to withstand expected high flows. Bridge and culvert crossings shall have a waterway opening sufficient to adequately discharge, at a minimum, the bank-full flow of the watercourse or stream. The waterway opening shall be large enough to minimize and confine any backwater to the owner's property.

i. Headwalls, wingwalls and riprap shall be installed for bridges and culverts as required to pass flood flows without loss of stability.

j. Bridges and culverts shall not increase velocity or direct flow so as to result in erosion of stream bed and banks.

k. Bridges and culverts shall be inspected by the owner on a regular basis to provide for continued operation and maintenance during the lifetime of the structure.

l. Bridges and culverts shall be kept open and functioning at all times by maintaining the waterway opening free of debris and other obstructions. Maintenance shall be performed in accordance with the ''Standards for Channel Cleaning at Bridges and Culverts''. Copies of this document are available from the offices noted in Exhibit B.

m. Approaches to bridges, culverts and fords should be constructed at original grades where possible. Where necessary, depth of fill in the approaches shall be minimized to allow overflow of the roadway during periods of high water.

n. Bridges shall have abutments set well into the stream banks in such a manner as to assure minimal increase in flood evaluations and no encroachment into the stream.

o. Bridges shall have abutments aligned with the flow of the stream. The use of wing walls at the upstream side of the bridge to assist in directing flood flows through the bridge opening is recommended.

Copyright © 1996 Commonwealth of Pennsylvania

p. Bridges having piers shall be designed and constructed to offer the least obstruction to the passage of water and ice, consistent with safety.

q. Culverts installed in stream channels shall be aligned with the stream flow.

r. Culverts shall be installed with the invert 6 inches below natural streambed and so that the gradient of the invert shall not deviate from that of the natural streambed.

s. The length of culverts installed shall be only that which is necessary to provide adequate road width with stable side slopes.

t. Spacing for multiple culvert installation in a stream channel shall be in accordance with the then current manufacturer's specifications.

u. Depth of fill covering culverts shall not exceed the minimum cover required by the then current manufacturer's specifications for the intended use of the crossing.

v. The removal of existing minor road crossings shall be completed in the following manner: (1) crossing is removed in its entirety, (2) the original stream gradient is restored and (3) the stream banks are stabilized.

w. Fords which are excavated or graded through stream banks must be properly stabilized.

x. Crossings of wetlands shall be avoided if an alternate location is possible. If the crossing of wetlands cannot be avoided, the crossing must be undertaken at the narrowest point of the wetland and shall not exceed 100 feet in length and .1 acre of disturbance.

y. The total wetland impact for all minor road crossings installed by an owner on an individual property or project including phased projects shall not exceed 0.25 acre. A project shall include the aggregate of all stages of development and all parcels within a subdivision plan, which are under the control of the registrant.

z. All wetlands impacted through the use of this General Permit must be replaced adjacent to or in the immediate proximity of the minor road crossing and at a ratio of 1:1 for function, value and areal extent (acreage).

aa. The use of this General Permit shall not prejudice any future Departmental decisions related to regulated activities on this property.

bb. Any archaeological artifacts discovered during the performance of work authorized under this General Permit must be adequately protected and their discovery promptly reported to the Director, Bureau of Historic Preservation, Pennsylvania Historic and Museum Commission, Post Office Box 1026, Harrisburg, Pennsylvania 17108-1026, telephone (717) 787-2891.

cc. Owner(s) shall investigate for drinking water intakes or reservoirs for public water supplies and permitted public bathing beaches within 5 miles downstream of the site of the minor road crossing. Written notice shall be given to operators of any such intakes or reservoirs or public bathing beaches at least 10 days prior to construction of the minor road crossing. Owner(s) must notify

operators immediately and no longer than 1 hour after an occurrence at the crossing site which results in a release of suspended solids and turbidity to the stream.

14. *Department Inspection*—As a condition of use of this General Permit and of the owner's authority to conduct the activities authorized by this General Permit, the owner hereby authorizes and consents to allow authorized employees or agents of the Department, without advance notice or a search warrant, at any reasonable time and upon presentation of appropriate credentials, and without delay, to have access to and to inspect all areas where the project is being constructed, operated or maintained. The authorization and consent shall include consent to conduct tests or sampling, to take photographs, to perform measurements, surveys and other tests, to inspect the methods of construction, operation or maintenance, to examine and copy books, papers and records pertinent to any matter under investigation, and to take any other action necessary to assure the project is constructed, operated or maintained in accordance with the terms and conditions of the General Permit. This General Permit condition is included under section 16 of the Dam Safety and Encroachments Act (32 P. S. § 693.16), and in no way limits any other powers granted under the Dam Safety and Encroachments Act.

15. *Activities not in Accordance with the Terms or Conditions*—If the Department determines, upon inspection, that the construction, operation or maintenance of a project has violated the terms or conditions of this General Permit or this chapter, the Department may take such actions, legal or administrative, that it may deem to be appropriate, including revocation of the General Permit with regard to the violation.

16. *Structure Removal*—The owner(s) shall remove all or any portion of the minor road crossing upon written notification to the owner by the Department in the event the project is causing an adverse impact on public health, safety or the environment or in any other manner violates the conditions of this General Permit or this chapter.

17. *Property Rights*—This General Permit does not convey any property rights, either in real estate or material, or any exclusive privileges; nor does it authorize any injury to property or invasion of rights or any infringement of Federal, State or local laws or regulations.

18. *Other Approvals*—The owner(s) shall secure all other approvals that may be necessary under Federal, State or local laws or regulations.

19. *Fish Commission Notification*—The owner(s) shall notify the Fish Commission's Regional Field Office Supervisor (see Exhibit A) responsible for the County where the activities are proposed 10 days prior to start of construction. Written notification is suggested. The project site shall at all times be available for inspection by authorized officers and employees of the Pennsylvania Fish Commission.

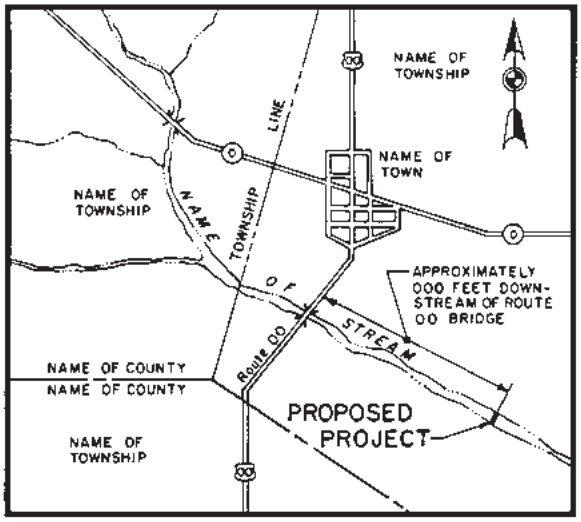
20. *Erosion and Sedimentation Pollution Controls*—Work must be done in compliance with Chapter 102 (relating to erosion and sediment control). Prior to

Copyright © 2000 Commonwealth of Pennsylvania

construction, an Erosion and Sediment Pollution Control Plan must be reviewed and determined to be adequate by the County Conservation District in which the activities are proposed and implemented prior to, during and after construction. The project site shall at all times be available for inspection by authorized employees of the County Conservation District. The Erosion and Sediment Pollution Control Plan shall be available at the site at all times.

EXHIBIT A

GENERAL PERMIT: B.D.W.M. GP-7
MINOR ROAD CROSSINGS
Dwg. No. 1 SAMPLE LOCATION MAP



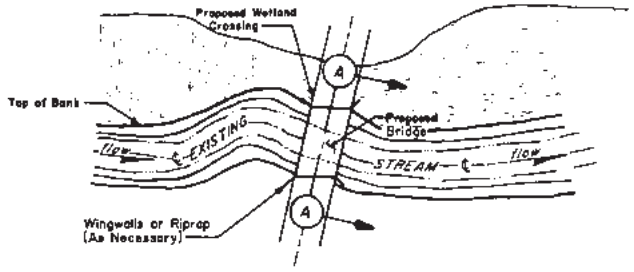
NOTE: Use of U.S.G.S. quadrangle map(s) is recommended.

(266278) No. 308 Jul. 00

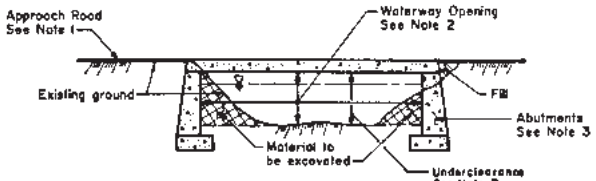
Copyright © 2000 Commonwealth of Pennsylvania

GENERAL PERMIT: B.D.W.M. GP-7
MINOR ROAD CROSSINGS
BRIDGE CROSSING

Dwg. No. 2



PLAN
No Scale



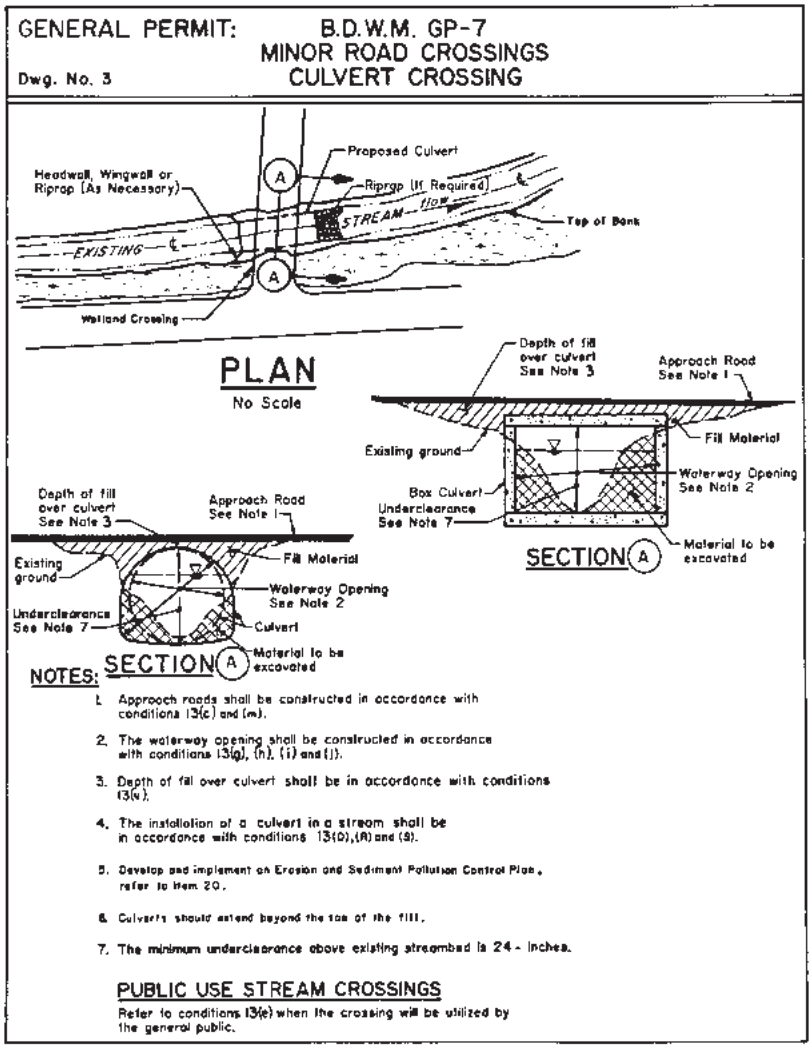
SECTION (A)
No Scale

NOTES:

1. Approach roads shall be constructed in accordance with conditions 13(c) and (m)
2. The waterways opening shall be constructed in accordance with conditions 13(g),(h),(i) and (j).
3. The minimum underclearance above existing streambed is 24-inches.
4. Abutments shall be constructed in accordance with conditions 13(n) and (o).
5. If a center pier is utilized refer to conditions 13(p).
6. Develop and implement an Erosion and Sediment Pollution Control Plan, refer to Item 20.

PUBLIC USE STREAM CROSSINGS

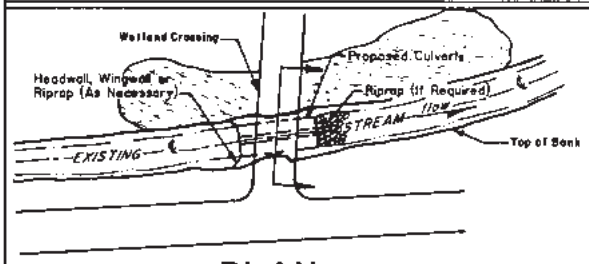
Refer to conditions 13(q) when the crossing will be utilized by the general public.



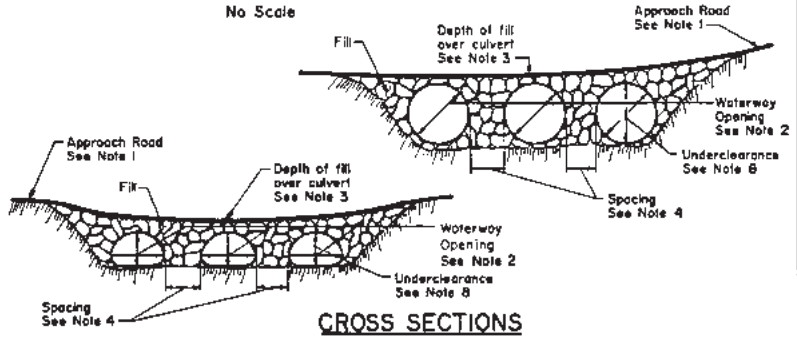
Copyright © 1996 Commonwealth of Pennsylvania

GENERAL PERMIT: B.D.W.M. GP-7
MINOR ROAD CROSSINGS
LOW FLOW CULVERTS

Dwg. No. 4



PLAN
No Scale



CROSS SECTIONS
No Scale

NOTES:

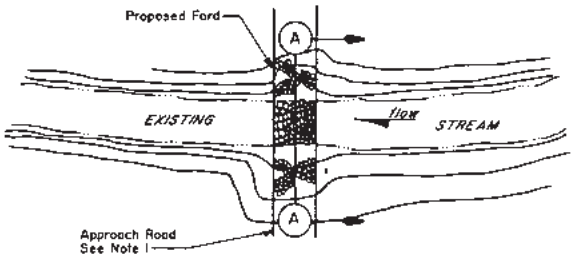
1. Approach roads shall be constructed in accordance with conditions 13(a) and (m).
2. The waterway opening shall be constructed in accordance with conditions 13(g), (h), (i) and (j).
3. Depth of fill over culvert shall be in accordance with conditions 13(e).
4. The installation of culverts in streams shall be in accordance with conditions 13(Q),(R),(S) and (t).
5. Develop and implement an Erosion and Sediment Pollution Control Plan, refer to Item 20.
6. Culverts should extend beyond the toe of the fill.
7. Roadway shall be depressed over culverts to allow for overflow.
8. The minimum underclearance above existing streambed is 24 - inches.

PUBLIC USE STREAM CROSSINGS

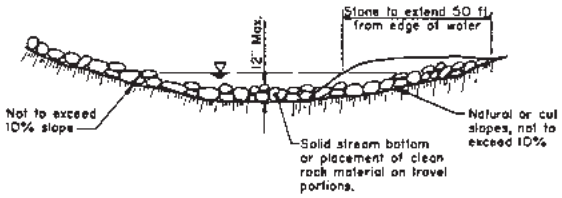
Refer to conditions 13(s) when the crossing will be utilized by the general public.

GENERAL PERMIT: B.D.W.M. GP-7
MINOR ROAD CROSSINGS
FORD CROSSINGS

Dwg. No. 5



PLAN
No Scale



SECTION (A)
No Scale

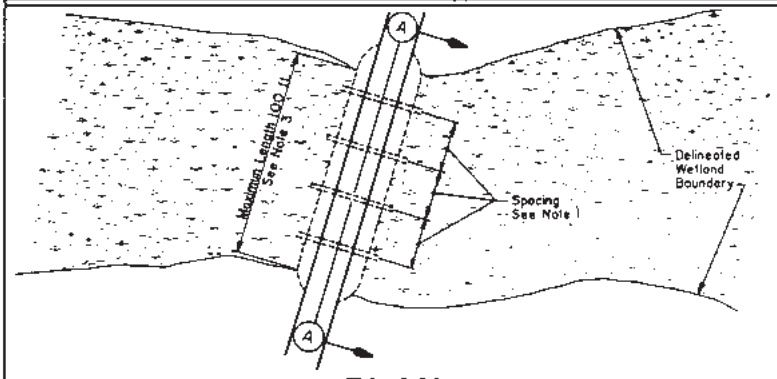
NOTES:

1. Approach roads shall be constructed in accordance with conditions 13(c) and (m).
2. Stream banks receiving approaches to fords and streambeds shall be properly stabilized.
3. Develop and implement an Erosion and Sediment Pollution Control Plan, refer to Item 20.

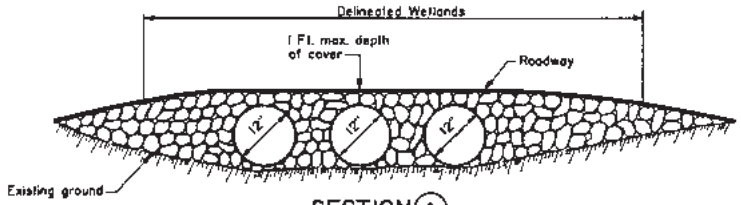
(207880) No. 255 Feb. 96

Copyright © 1996 Commonwealth of Pennsylvania

GENERAL PERMIT: B.D.W.M. GP-7
MINOR ROAD CROSSINGS
Dwg. No. 6 WETLAND CROSSING



PLAN
No Scale



SECTION (A)
No Scale

NOTES:

1. 12-inch culverts should be installed to maintain the hydrology of the wetland and shall be spaced on a minimum of 10' intervals.
2. Culverts should extend beyond the toe of the fill.
3. Placement of fill in a wetland shall be in accordance with conditions 13(x),(y) and (z).
4. Develop and implement an Erosion and Sediment Pollution Control Plan, refer to Item 20.

FISH COMMISSION'S OFFICES

Headquarters Address	*County Responsibility*
NORTHWEST REGION	
Regional Supervisor P. O. Box 349 1281 Otter Street Franklin, Pa. 16323 (814) 437-5774	Butler, Clarion, Crawford, Erie, Forest, Lawrence, Mercer, Venango and Warren
SOUTHWEST REGION	
Regional Supervisor R. D. 2, Box 39 Somerset, Pa. 15501-9311 (814) 445-8974	Allegheny, Armstrong, Beaver, Cambria, Fayette, Greene, Indiana, Somerset, Washington and Westmoreland
NORTHCENTRAL REGION	
Regional Supervisor Box 187 (Fishing Creek Road) Lamar, Pa. 16848 (717) 726-6056	Cameron, Centre, Clearfield, Clinton, Elk, Jefferson, Lycoming, McKean, Northumberland, Potter, Snyder, Tioga and Union
SOUTHCENTRAL REGION	
Regional Supervisor 1704 Pine Road Newville, Pa. 17241 (717) 486-7087	Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lebanon, Mifflin, Perry and York
SOUTHEAST REGION	
Regional Supervisor Box 8 Elm, Pa. 17521 (717) 626-0228	Berks, Bucks, Chester, Delaware, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia and Schuylkill
NORTHEAST REGION	
Regional Supervisor Box 88 Sweet Valley, Pa. 18656 (717) 477-5717	Bradford, Carbon, Columbia, Lackawanna, Luzerne, Monroe, Montour, Pike, Sullivan, Susquehanna, Wayne and Wyoming

Copyright © 1996 Commonwealth of Pennsylvania

DIVISION OF ENVIRONMENTAL SERVICES
450 Robinson Lane
Bellefonte, Pa. 16823-9616
(814) 359-5145

EXHIBIT B
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF DAMS AND WATERWAY MANAGEMENT

Area Office	*County Responsibility*
Southcentral Area Office One Ararat Boulevard P. O. Box 8554 Harrisburg, Pa. 17105-8554 (717) 541-7901	Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Mifflin, Perry and York
Southeast Area Office Suite 6010, Lee Park 555 North Lane Conshohocken, Pa. 19428 (215) 832-6340	Berks, Bucks, Carbon, Chester, Delaware, Lehigh, Northampton, Montgomery, Philadelphia and Schuylkill
Southwest Area Office 482 Route 30 R. D. 1 Clinton, Pa. 15026 (412) 899-2377	Allegheny, Armstrong, Beaver, Butler, Cambria, Fayette, Greene, Indiana, Lawrence, Somerset, Washington and Westmoreland
Northwest Area Office 190 Adams Road Jamestown, Pa. 16134 (412) 932-3162	Clarion, Clearfield, Crawford, Elk, Erie, Forest, Jefferson, McKean, Mercer, Venango and Warren
Northeast Area Office Cross Valley Centre, Suite 203 667 North River Street Plains, Pa. 18705-1099 (717) 826-5485	Bradford, Columbia, Lackawanna, Luzerne, Monroe, Pike, Sullivan, Susquehanna, Wayne and Wyoming
Northcentral Area Office 200 Pine Street Williamsport, Pa. 17701 (717) 327-3574	Cameron, Centre, Clinton, Lycoming, Montour, Northumberland, Potter, Snyder, Tioga and Union

BUREAU OF DAMS AND WATERWAY MANAGEMENT
CENTRAL OFFICE
P. O. Box 8554
Harrisburg, Pa. 17105-8554
(717) 541-7900

EXHIBIT C

Notification to Use
BDWM-GP-7
Minor Road Crossings

I/We, _____
(owner name(s))

hereby notify the Bureau of Dams and Waterway Management of our intent to install _____

_____
(description of crossing; bridge, culvert, etc.)

_____

in accordance with the drawings and conditions of this General Permit at a point _____

_____
(describe location)

along _____
(name of stream, body of water or wetland)

in _____ (municipality) , _____ (county) .

I/We have attached a LOCATION MAP similar to that shown on the Drawing No. 1 indicating where the minor road crossing will be installed. Also, I/we have attached the site plan and delineation data sheets as required by Item 7.

I/We certify that a copy of this notification was sent this day _____
(date)

_____ to _____ (municipality) and _____ (county)
where the work will be performed.

Signed: _____
(owner or authorized representative)

_____
(typed or printed signature)

_____
(owner address)

_____

(207884) No. 255 Feb. 96

Copyright © 1996 Commonwealth of Pennsylvania

(owner telephone number)

4/91
Send to one of the addresses on Exhibit B.

Source

The provisions of this Appendix G adopted April 12, 1991, effective April 13, 1991, 21 Pa.B. 1607.

APPENDIX H
TEMPORARY ROAD CROSSINGS; GENERAL PERMIT BDWM-GP-8

Editor's Note: The following permit was published in the *Pennsylvania Bulletin* as a Notice and is codified under 1 Pa. Code § 3.1(a)(9) (relating to contents of *Code*) as a document which the Legislative Reference Bureau finds to be general and permanent in nature. See §§ 105.441—105.449 (relating to general permits) for regulations governing this permit.

1. *General Description and Authority*—The Department of Environmental Resources hereby authorizes, by General Permit, subject to the terms and criteria set forth below, the construction, operation and maintenance of temporary road crossings across regulated waters of this Commonwealth, including wetlands, where no practicable alternatives exist. This authorization is under section 7(b) of the Dam Safety and Encroachments Act (32 P. S. § 693.7(b)), and the rules and regulations promulgated thereunder at §§ 105.441—105.449 (relating to general permits). This General Permit is subject to the terms and conditions set forth below.

2. *Denial of Authorization*—The Department has the discretion, on a case-by-case basis, to deny, revoke or suspend the authorization to use this General Permit for any project which the Department determines to have a significant effect on the safety and protection of life, health, property or the environment or otherwise would not be adequately regulated by the provisions of this General Permit.

3. *Definitions*—The following terms as used in this General Permit shall have the following meanings:

Body of Water—A natural or artificial lake, pond, reservoir, swamp, marsh or wetland.

Bridge—A single span structure erected from top of bank to top of bank carrying a temporary roadway over a stream.

Causeway—An embankment constructed partially across or along a stream.

Culvert—A structure with appurtenant works which carries a stream under or through an embankment or fill.

Exceptional Value Wetlands—Wetlands as defined at § 105.17(1) (relating to wetlands).

Ford—A road crossing of a stream utilizing the existing stream bed.

Install—To construct, place, lay or set in place.

Owner—A person who owns, controls, operates, maintains or manages a dam or reservoir, water obstruction or encroachment.

Person—Any natural person, partnership, association, corporation, public utility, municipality, municipal authority, political subdivisions of the Commonwealth, receiver or trustee and any department, board, commission or authority of the Commonwealth.

Regulated Waters of the Commonwealth—Watercourses, streams or bodies of water and their floodways wholly or partly within or forming part of the boundary of this Commonwealth.

Stocked Trout Stream—A Stream classified as approved trout waters by the Fish and Boat Commission. For a list of stocked trout streams, the Fish and Boat Commission can be contacted at: Fish and Boat Commission, Bureau of Fisheries, Division of Fisheries Management, 450 Robinson Lane, Bellefonte, Pennsylvania 16823-9616.

Stream—A watercourse.

Temporary Road Crossing—A road installed for a period of time not to exceed 1 year across a wetland or across or along a stream utilizing a pipe culvert or a series of culverts, a bridge, a causeway or a ford.

Watercourse—A channel or conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

Wetlands—Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas.

Wild Trout Streams—A stream classified as supporting naturally reproducing trout populations by the Fish and Boat Commission. For a list of wild trout streams, the Fish and Boat Commission can be contacted at: Fish and Boat Commission, Bureau of Fisheries, Division of Fisheries Management, 450 Robinson Lane, Bellefonte, Pennsylvania 16823-9616.

4. *Submerged Lands of this Commonwealth*—This General Permit shall not be effective to authorize any project over, across or occupying submerged lands of this Commonwealth until the owner has obtained a license from the Department authorizing the occupation of such submerged lands issued under section 15 of the Dam Safety and Encroachments Act (32 P. S. § 693.15), section 514 of The Administrative Code of 1929 (71 P. S. § 194), or other applicable laws. Upon receipt of notification from the owner, the Department will review the project to determine if its location is over, across or occupies submerged lands of the Commonwealth.

5. *Specific Areas Where General Permit Does Not Apply*—This General Permit does not apply and is not valid in the following areas:

a. Historic, cultural or archaeological sites as identified in the latest published version of the Pennsylvania Inventory of Historical Places or the National Register of Historical Places.

b. Sites identified in the latest published version of the National Registry of Natural Landmarks.

Copyright © 1996 Commonwealth of Pennsylvania

c. Stocked trout streams from March 1 through June 15, wild trout streams from October 1 through December 31 and Lake Erie tributaries from September 1 through December 1 unless written approval is obtained from the Fish and Boat Commission's Division of Environmental Services. See Exhibit A.

d. Sites which serve as habitat for fauna or flora listed as threatened or endangered under the Endangered Species Act of 1973, the Wild Resource Conservation Act, the Fish and Boat Code or the Game and Wildlife Code. Sites may be checked through the Pennsylvania Natural Diversity Inventory by contacting the Bureau of Forestry, Division of Advisory Services, Post Office Box 8552, Harrisburg, Pennsylvania 17105-8552 or any of the offices listed on Exhibit B.

6. *Other Permits*—Nothing in this General Permit relieves the owners of the obligation of complying with all Federal, Interstate Compact and State laws, regulations and standards for the construction, operation or maintenance of the temporary road crossings.

7. *Registration of Proposed Use of General Permit*—Prior to construction the owners shall submit Exhibit C along with the required location map to the Bureau of Dams and Waterway Management. See Exhibit B. A copy of Exhibit C shall also be sent to the municipality and county in which the work will be performed. The owner may not begin work until he has notified the Bureau of Dams and Waterway Management and received an acknowledgement of that notification.

8. *Change of Ownership*—If there is a change in ownership of a temporary road crossing installed in accordance with this General Permit, the new owner is required to register the crossing with the Department in accordance with Item 7.

9. *Fees*—There is no fee required for project authorized under this General Permit.

10. *Effective Time Period*—This General Permit will remain in effect indefinitely unless specifically modified, suspended or revised by the Department.

11. *Suspension, Modification or Revocation*—The Department may suspend, modify or revoke this General Permit at any time upon notice in the *Pennsylvania Bulletin*.

12. *Project Interference*—This General Permit does not authorize any interference with any existing or proposed Local, State, Federal or Federally Licensed Project, and permittee shall not be entitled to compensation for damage or injury to the work authorized herein which may be caused by or a result of existing or future operations undertaken by the United States, the Commonwealth of Pennsylvania and its political subdivision in the public interest.

13. *Conditions*.

a. Crossings may remain installed for a period of time not to exceed 1 year from the date of the Department's acknowledgement (Item 7) unless extended in writing by the Department.

b. The site of a temporary crossing, except fords, shall be restored to original topography and stabilized within 5 days after termination of its intended use or at the end of the 1 year period, whichever occurs first.

c. Fords used as temporary crossings shall have the approaches adequately blocked and stabilized to prevent future use within 5 days after termination of its intended use or at the end of the 1 year period, whichever occurs first.

d. Roads must cross all watercourses at a right angle to the stream, unless it is physically impossible to cross at a right angle to the stream.

e. Fords are prohibited on all streams within high quality (HQ) and exceptional value (EV) watersheds as specified in Chapter 93 (relating to water quality standards), and in watersheds tributary to drinking water intakes or reservoirs for public water supply users, where the ford is within 2,000 feet upstream of such intake or reservoir.

f. Skidding across fords is prohibited.

g. Whenever the streambed at the site of a ford does not have a rock bottom, a layer of clean rock must be provided. This layer of clean rock must not obstruct the stream flow. In addition, the approaches must: (1) be maintained in a firm and stable condition and (2) enter the stream on less than a 10% grade within 50 feet of the stream with the flow and (3) exit the stream against the flow on the same grade and distance limitation as specified for the entrance.

h. Culverts must provide a waterway area sufficient to adequately discharge the normal flow of the watercourse or stream, and shall be of sufficient length to extend beyond the toe of the clean rock fill.

i. Culverts must be installed in such manner that overtopping of the roadway will occur within the stream channel. This can be accomplished by providing a depressed roadway embankment as shown on attached Drawings No. 3 and No. 4.

j. A culvert having as large a diameter as possible must be provided to minimize placement of excessive fill and excavation of the stream banks. If the bank height prohibits a large diameter pipe culvert, the crossing could consist of a bridge or a series of culverts. The minimum size diameter culvert to be used is 12 inches.

k. Road crossings involving a series of pipe culverts shall be installed with a minimum spacing as specified on attached Drawing No. 4.

l. Road and causeway embankments shall consist of only clean rock material to prevent stream channel sedimentation doing placement, removal and periods of overtopping.

m. Bridges must be single span from top of bank to top of bank and structurally stable.

n. Approach roads to temporary road crossings shall utilize original grades. However, clean rock material or gravel to a depth of 6 inches above original grade shall be utilized for approaches as necessary.

Copyright © 1996 Commonwealth of Pennsylvania

o. Causeways may not extend streamward a distance greater than 1/2 the width of the stream channel.

p. Temporary road crossings shall be kept open and functioning at all times by maintaining the crossings free of debris and other obstructions.

q. The owner shall be responsible for any damages resulting from increased backwater caused by the temporary road crossing. The permittee shall remove the temporary road crossing in the event of high waters to prevent the increased backwater.

r. Wetlands shall be identified and delineated in accordance with the Federal Manual for Identifying and Delineating Jurisdictional Wetlands dated 1989.

s. Crossings of wetlands shall be avoided if an alternate location is possible. If the crossing of wetlands cannot be avoided, the crossing is permissible if it is located at the narrowest practicable point of the wetland and the length of the crossing within the wetland is less than 200 feet.

t. The site of a wetlands crossing shall be stabilized by any appropriate means, including but not limited to, using removable, temporary mats, pads or other similar devices to insure minimization of impact on the wetlands ecology.

u. Embankments for temporary roads across wetlands shall be installed to maintain the hydrology of the wetland.

v. Any archaeological artifacts discovered during the performance of work authorized under this General Permit must be adequately protected and their discovery promptly reported to the Director, Bureau for Historic Preservation, Historical and Museum Commission, Post Office Box 1026, Harrisburg, Pennsylvania 17120.

w. Pollution of the waterway with harmful chemicals, fuels, oils, greases, bituminous material, acid and/or other harmful or polluting materials, is prohibited.

x. Owners shall investigate for drinking water intakes or reservoirs for public water supplies within 5 miles downstream of the site of the temporary road crossing. Written notice shall be given to operators of any such intakes or reservoirs at least 10 days prior to construction of the temporary road crossing. Owners must notify public water supply operators immediately and no longer than 1 hour after an occurrence at the crossing site which results in the release of suspended solids and turbidity to the stream.

y. Access roads should not approach the stream channel directly downslope, but should traverse the slope obliquely to prevent high velocity road drainage flows from directly entering the stream channel. Road drainage shall include proper erosion and sedimentation control measures; as referred to in item 20.

14. *Department Inspection*—As a condition of use of this General Permit, and of the owner's authority to conduct the activities authorized by this General Permit, the owner hereby authorizes and consents to allow authorized employes

or agents of the Department, without advance notice or a search warrant, at any reasonable time and upon presentation of appropriate credentials, and without delay, to have access to and to inspect all areas where the project is being constructed, operated or maintained. The authorization and consent shall include consent to conduct tests or sampling, to take photographs, to perform measurements, surveys and other tests, to inspect the methods of construction, operation or maintenance, to examine and copy books, papers and records pertinent to any matter under investigation, and to take any other action necessary to assure that the projectd is constructed, operated or maintained in accordance with the terms and conditions of the General Permit. This General Permit condition is included under section 16 of the Dam Safety and Encroachments Act (32 P. S. § 693.16), and in no way limits any other powers granted under the Dam Safety and Encroachments Act.

15. *Activities Not in Accordance with the Terms or Conditions*—If the Department determines, upon inspection, that the construction, operation or maintenance of a project has violated the terms or conditions of this General Permit or this chapter, the Department may take such actions, legal or administrative, that it may deem to be appropriate, including revocation of the General Permit with regard to the violation.

16. *Structure Removal*—The owners shall remove all or any portion of the temporary road crossing upon written notification to the owners by the Department in the event the project is causing an adverse impact on public health, safety or the environment or in any other manner violates the conditions of this General Permit or this chapter.

17. *Property Rights*—This General Permit does not convey any property rights, either in real estate or material, or any exclusive privileges, nor does it authorize any injury to property or invasion of rights or any infringement of Federal, State or local laws or regulations.

18. *Other Approvals*—The owners shall secure all other approvals that may be necessary under Federal, State or local laws or regulations.

19. *Fish Commission Notification*—The owners shall notify the Fish and Boat Commission's Regional Field Office Supervisor, see Exhibit A, responsible for the County where the activities are proposed 10 days prior to start of construction. Written notification is suggested. The project site shall at all times be available for inspection by authorized officers and employes of the Fish and Boat Commission.

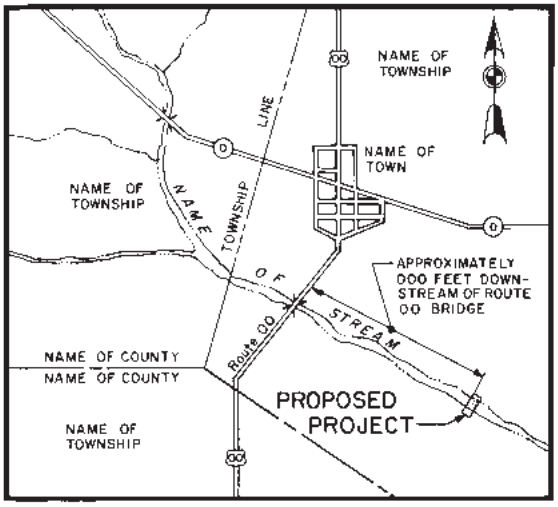
20. *Erosion and Sediment Pollution Controls*—Work must be done in compliance with Chapter 102 (relating to erosion and sediment control). Prior to construction an Erosion and Sediment Pollution Control Plan must be reviewed and determined to be adequate by the County Conservation District in which the activities are proposed and implemented prior to, during and after construction.

Copyright © 2000 Commonwealth of Pennsylvania

The Project site shall at all times be available for inspection by authorized employes of the County Conservation District. The Erosion and Sediment Pollution Control Plan shall be available at the site at all times.

EXHIBIT A

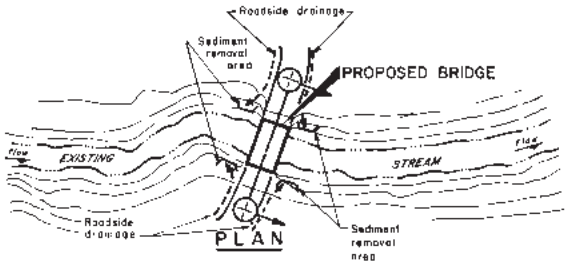
GENERAL PERMIT: B.D.W.M. GP-8
TEMPORARY ROAD CROSSINGS
Dwg. No. 1 SAMPLE LOCATION MAP



NOTE: Use of U.S.G.S. quadrangle map(s) is recommended.

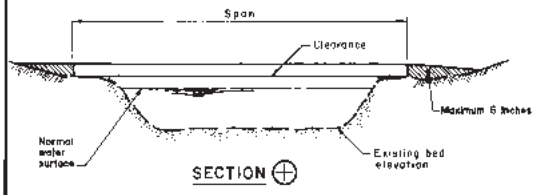
Copyright © 2000 Commonwealth of Pennsylvania

GENERAL PERMIT: B.D.W.M. GP-8
Dwg. No. 2 TEMPORARY ROAD CROSSINGS
BRIDGE

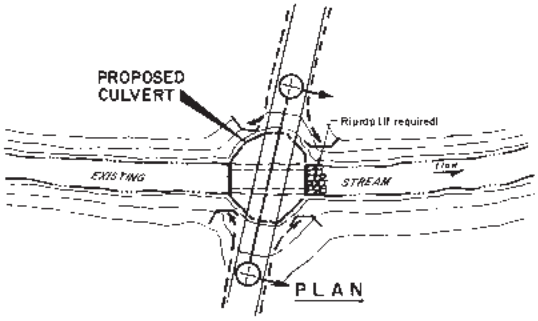


NOTES:

1. Approaches to crossings are not to exceed a depth of 6 inches above original grade.
2. Proper erosion and sedimentation control measures must be installed, refer to Item 20.
3. Provide satisfactory bearing for structure at top of banks.
4. Refer to Item 13, Conditions.

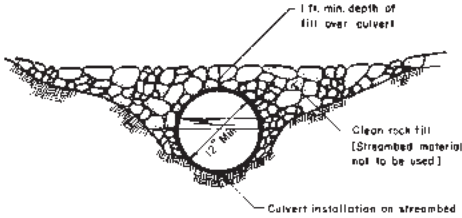


GENERAL PERMIT: B.D.W.M. GP-8
TEMPORARY ROAD CROSSINGS
Dwg. No. 3 SINGLE CULVERT



NOTES:

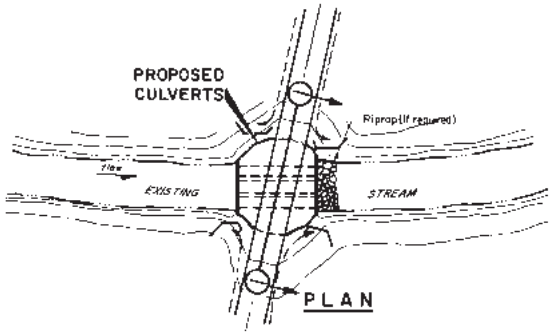
1. Pipe should extend beyond toe of roadway.
2. Roadway should be depressed over culvert to allow for overflow.
3. Clean rock fill shall be used to guard against erosion and sedimentation. Streambed material is not to be used.
4. Minimum size diameter culvert to be installed is 12 inches.
5. Approaches to crossings are not to exceed a depth of 6 inches above original grade.
6. Proper erosion and sedimentation control measures must be installed, refer to Item 20.
7. Refer to Item 13, Conditions.



SECTION ⊕

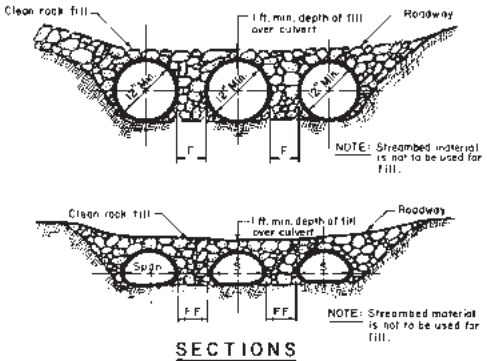
Copyright © 1996 Commonwealth of Pennsylvania

GENERAL PERMIT: B.D.W.M. GP-8
Dwg. No. 4
TEMPORARY ROAD CROSSINGS
SERIES OF CULVERTS



PIPE DIAMETER (D)	MIN. DISTANCE (F)
12 in. to 24 in.	12 in.
24 in. to 72 in.	1/2 Diam. (D) in.
72 in. to 120 in.	36 in.

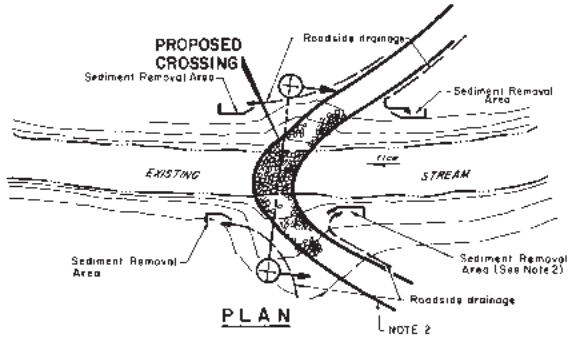
PIPE ARCH SIZE (IN.)	MIN. DISTANCE (FF)
18 x 11 to 25 x 16	12 in.
25 x 16 to 72 x 44	One - Third Span of Pipe Arch
Above 72 x 44	30 in.



NOTES:

1. Pipes should extend beyond toe of roadway.
2. Roadway should be depressed over culverts to allow for overflow.
3. Clean rock fill shall be used to guard against erosion and sedimentation. Streambed material is not to be used.
4. Minimum size diameter culvert to be installed is 12 inches.
5. Approaches to crossings are not to exceed a depth of 6 inches above original grade.
6. Proper erosion and sedimentation control measures must be installed, refer to Item 20.
7. Refer to Item 13, Conditions.

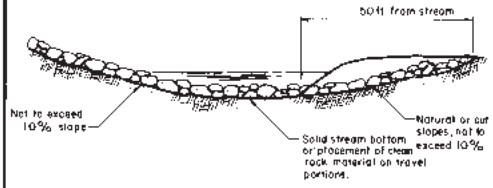
GENERAL PERMIT: B.D.W.M. GP-8
TEMPORARY ROAD CROSSINGS
Dwg. No. 5 FORD



PLAN

NOTES:

1. Approaches to crossings are not to exceed a depth of 6 inches above original grade.
2. Proper erosion and sedimentation control measures must be installed, refer to Item 20.
3. Refer to Item 13, Conditions.

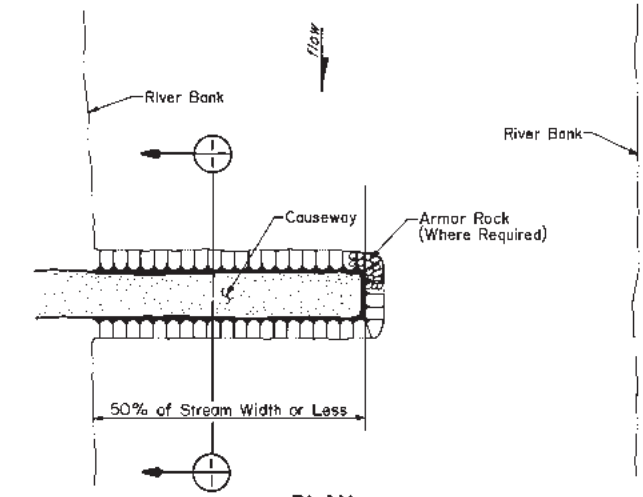


SECTION ⊕

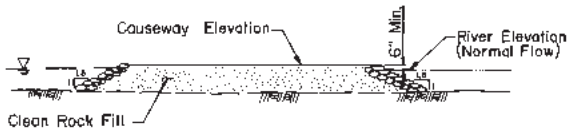
(207896) No. 255 Feb. 96

Copyright © 1996 Commonwealth of Pennsylvania

GENERAL PERMIT: B.D.W.M. GP-8
TEMPORARY ROAD CROSSINGS
Dwg. No. 6 CAUSEWAY



PLAN

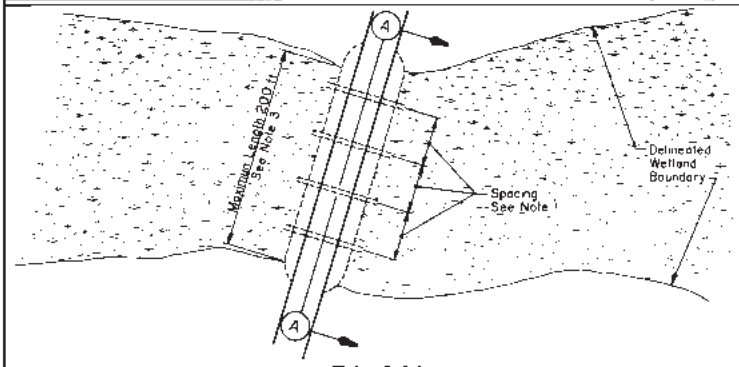


SECTION

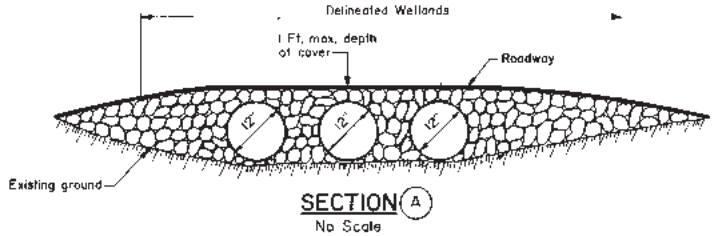
NOTES:

1. Approach to causeway is not to exceed a depth of 6 inches above original grade.
2. Proper erosion and sedimentation control measures must be installed, refer to Item 20.
3. Refer to Item 13, Conditions.

GENERAL PERMIT: B.D.W.M. GP-8
TEMPORARY ROAD CROSSINGS
Dwg. No. 7 WETLAND CROSSING



PLAN
No Scale



SECTION (A)
No Scale

NOTES:

1. 12-inch culverts should be installed to maintain the hydrology of the wetland and shall be spaced on a minimum of 10' intervals, refer to condition 13(t).
2. Culverts should extend beyond the toe of the fill.
3. The wetland crossing shall be in accordance with conditions 13(R) and (S).
4. Proper erosion and sedimentation control measures must be installed, refer to item 20.

Copyright © 1996 Commonwealth of Pennsylvania

FISH AND BOAT COMMISSION'S OFFICES

Headquarters Address	*County Responsibility*
NORTHWEST REGION	
Regional Supervisor P. O. Box 349 1281 Otter Street Franklin, Pa. 16323 (814) 437-5774	Butler, Clarion, Crawford, Erie, Forest, Lawrence, Mercer, Venango and Warren
SOUTHWEST REGION	
Regional Supervisor R. D. 2, Box 39 Somerset, Pa. 15501-9311 (814) 445-8974	Allegheny, Armstrong, Beaver, Cambria, Fayette, Greene, Indiana, Somerset, Washington and Westmoreland
NORTHCENTRAL REGION	
Regional Supervisor Box 187 (Fishing Creek Road) Lamar, Pa. 16848 (717) 726-6056	Cameron, Centre, Clearfield, Clinton, Elk, Jefferson, Lycoming, McKean, Northumberland, Potter, Snyder, Tioga and Union
SOUTHCENTRAL REGION	
Regional Supervisor 1704 Pine Road Newville, Pa. 17241 (717) 486-7087	Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lebanon, Mifflin, Perry and York
SOUTHEAST REGION	
Regional Supervisor Box 8 Elm, Pa. 17521 (717) 626-0228	Berks, Bucks, Chester, Delaware, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia and Schuylkill
NORTHEAST REGION	
Regional Supervisor Box 88 Sweet Valley, Pa. 18656 (717) 477-5717	Bradford, Carbon, Columbia, Lackawanna, Luzerne, Monroe, Montour, Pike, Sullivan, Susquehanna, Wayne and Wyoming

DIVISION OF ENVIRONMENTAL SERVICES
450 Robinson Lane
Bellefonte, Pa. 16823-9616
(814) 359-5145

EXHIBIT B
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF DAMS AND WATERWAY MANAGEMENT

Area Office	*County Responsibility*
Southcentral Area Office 49 One Ararat Blvd. P. O. Box 8554 Harrisburg, Pa. 17105-8554 (717) 541-7901	Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntington, Juniata, Lancaster, Lebanon, Mifflin, Perry and York
Southeast Area Office Suite 6010, Lee Park 555 North Lane Conshohocken, Pa. 19428 (215) 832-6340	Berks, Bucks, Carbon, Chester, Delaware, Lehigh, Northampton, Montgomery, Philadelphia and Schuylkill
Southwest Area Office 482 Route 30 R. D. 1 Clinton, Pa. 15026 (412) 899-2377	Allegheny, Armstrong, Beaver, Butler, Cambria, Fayette, Greene, Indiana, Lawrence, Somerset, Washington and Westmoreland
Northwest Area Office 190 Adams Road Jamestown, Pa. 16134 (412) 932-3162	Clarion, Clearfield, Crawford, Elk, Erie, Forest, Jefferson, McKean, Mercer, Venango and Warren
Northeast Area Office Cross Valley Centre, Suite 203 667 North River Street Plains, Pa. 18705-1099 (717) 826-5485	Bradford, Columbia, Lackawanna, Luzerne, Monroe, Pike, Sullivan, Susquehanna, Wayne and Wyoming
Northcentral Area Office 200 Pine Street Williamsport, Pa. 17701 (717) 327-3574	Cameron, Centre, Clinton, Lycoming, Montour, Northumberland, Potter, Snyder, Tioga and Union

Copyright © 1996 Commonwealth of Pennsylvania

BUREAU OF DAMS AND WATERWAY MANAGEMENT CENTRAL OFFICE
P. O. Box 8554
Harrisburg, Pa. 17105-8554
(717) 541-7900

EXHIBIT C
Notification to Use
BDWM-GP-8
Temporary Road Crossings

I/We, _____
(owner name(s))

hereby notify the Bureau of Dams and Waterway Management of our intent to install

_____
(description of temporary road crossing)

in accordance with the drawings and conditions of this General Permit at a point

_____
(describe location)

across _____
(name of stream, body of water or wetland)

in _____ , _____
(municipality) (county)

I/We have attached a LOCATION MAP similar to that shown on the Drawing No. 1 indicating where the temporary road crossing will be installed.

I/We certify that a copy of this notification was sent this day _____
(date)

to _____ and _____ where the work will be performed.
(municipality) (county)

Signed: _____
(owner or authorized representative)

_____
(typed or printed signature)

_____
(owner address)

_____

_____
(owner telephone number)

Send to one of the addresses on Exhibit B.

105-245

(266283) No. 308 Jul. 00

Source

The provisions of this Appendix H adopted October 5, 1984, effective October 6, 1984, 14 Pa.B. 3658; amended December 1, 1989, effective December 2, 1989, 19 Pa.B. 5165; amended December 27, 1991, effective December 28, 1991, 21 Pa.B. 5992. Immediately preceding text appears at serial pages (162494) to (162509).

APPENDIX I
AGRICULTURAL ACTIVITIES; GENERAL PERMIT
BDWM-GP-9

Editor's Note: The following permit was published in the *Pennsylvania Bulletin* as a Notice and is codified under 1 Pa. Code § 3.1(a)(9) (relating to contents of *Code*) as a document which the Legislative Reference Bureau finds to be general and permanent in nature. See §§ 105.441—105.449 (relating to general permits) for governing this permit.

1. *General Description and Authority*—The Department of Environmental Resources hereby authorizes by General Permit subject to the terms and criteria set forth below the installation, operation, modification and maintenance of certain agricultural activities that encroach into streams and their floodways or bodies of water wholly or partly within or forming part of the boundary of this Commonwealth. These agricultural activities are grassed or lined waterways, terraces, diversions, waste storage facilities, spring development and minor drainage that supports these activities and is necessary for contour strips when engaged in as a part of an existing agricultural operation and shall only be implemented as part of a conservation plan consistent with Chapter 102 (relating to erosion and sediment control) and approved by the County Conservation District. This authorization is under section 7(b) of the Dam Safety and Encroachments Act (32 P. S. § 693.7(b)) and the rules and regulations promulgated thereunder at §§ 105.441—105.449 (relating to general permits). This General Permit is subject to the terms and conditions set forth below.

2. *Denial of Authorization*—The Department has the discretion, on a case-by-case basis, to deny, revoke or suspend the authorization to use this General Permit for any project which the Department determines to present a risk to life, property or the environment or otherwise would not be adequately regulated by the provisions of this General Permit.

3. *Definitions*—The following terms as used in this General Permit shall have the following meanings:

Agricultural Operations—Activities, practices and procedures that farmers adopt, use or engage in for the production of crops and livestock. This does not include practices and procedures related to timber harvesting.

Body of Water—A natural or artificial lake, pond, reservoir, swamp, marsh or wetland.

Conservation Plan—A plan as required by Chapter 102 that includes a map and narrative that identifies conservation practices including an erosion and sedimentation control plan for the identified parcel of land.

Copyright © 2000 Commonwealth of Pennsylvania

Contour Strips—The practice of farming sloped land using alternating crops in such a way that plowing, preparing land, planting and cultivating are done on the contour as part of an agricultural operation. Contour strips without drainage are not regulated.

Diversions—A graded channel with a supporting ridge on the lower side which is constructed as part of an agricultural operation across the slope of a field to intercept surface water runoff and carry it slowly to surface or underground outlets.

Floodway—The channel of the watercourse and those portions of the adjoining floodplains which are reasonably required to carry and discharge the 100-year frequency flood. Unless otherwise specified, the boundary of the floodway is as indicated on maps and flood insurance studies provided by FEMA. In an area where no FEMA maps or studies have defined the boundary of the 100-year frequency floodway, it is assumed, absent evidence to the contrary, that the floodway extends from the stream to 50 feet from the top of the bank of the stream.

Grassed or Lined Waterway—A natural or constructed channel that is shaped or graded to required dimensions and established in suitable vegetation or protection for the stable conveyance of surface water runoff which is part of an agricultural operation.

Install—To construct, deposit, place, lay or set in place.

Minor Drainage—The installation of a water conveying device as necessary for the installation and operation of contour strips and other conservation practices authorized by this General Permit conducted as part of an agricultural operation.

Owner—A person who owns, controls, operates, maintains or manages a dam or reservoir, water obstruction or encroachment.

Person—A natural person, partnership, association, corporation, public utility, municipality, municipal authority, political subdivision of the Commonwealth, receiver or trustee and a department, board, commission or authority of the Commonwealth.

Regulated Waters of This Commonwealth—Watercourses, streams or bodies of water and their floodways wholly or partly within or forming part of the boundary of this Commonwealth.

Spring Development—The practice of intercepting and conveying water to a livestock watering facility that will not be used for a public water supply when conducted as part of an agricultural operation.

Stream—A watercourse.

Terrace—An earthen embankment or a ridge and channel constructed across a slope of a field to intercept surface runoff water and outlet it to a grassed or lined waterway or an underground tile as part of an agricultural operation.

Waste Storage Facility—A structure or basin for temporary storage of animal or other organic agricultural wastes constructed as part of an agricultural operation.

Watercourse—A channel or conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

Wetlands—Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas.

4. *Specific Areas Where the General Permit Does Not Apply*—This General Permit does not apply in and is not valid in the following situations:

a. Historic, cultural or archaeological sites as identified in the latest published version of the Pennsylvania Inventory of Historic Places or the National Register of Historic Places.

b. Sites identified in the latest published version of the National Registry of Natural Landmarks.

c. Wetlands which serve as habitat for fauna or flora listed as threatened or endangered under the Endangered Species Act of 1973, the Wild Resource Conservation Act, the Fish and Boat Code or the Game and Wildlife Code. Sites may be checked through the Pennsylvania Natural Diversity Inventory by contacting the Bureau of Forestry, Division of Advisory Services, Post Office Box 8552, Harrisburg, Pennsylvania 17105-8552 or any of the offices listed on Exhibit C.

d. Watercourses having a drainage area greater than 100 acres.

e. Submerged Lands of this Commonwealth.

f. A spring being developed for public drinking water.

5. *Other Permits*—Nothing in this General Permit relieves the owners of the obligation of complying with all Federal, Interstate Compacts and State laws, regulations and standards for the construction, operation or maintenance of the activities covered by this General Permit.

6. *Registration of Proposed Use of General Permit*—Prior to construction, the owners shall submit Exhibit D containing the required certification along with the required location map to the Bureau of Dams and Waterway Management. A copy of Exhibit D shall also be sent to the municipalities and county in which the work will be performed. The owners may not begin work until he has notified the Bureau of Dams and Waterway Management (Exhibit D) and received an acknowledgement of that notification. The Department's acknowledgement letter serves as registration to use this General Permit.

7. *Change of Ownership*—If there is a change in ownership of the agricultural activities installed in accordance with this General Permit, the new owners are required to register the activities with the Department in accordance with Item 6.

Copyright © 1996 Commonwealth of Pennsylvania

8. *Fees*—There is no fee required for a project authorized under this General Permit.

9. *Effective Time Period*—This General Permit will remain in effect indefinitely, unless specifically modified, suspended or revised by the Department.

10. *Suspension, Modification or Revocation*—The Department may suspend, modify or revoke this General Permit at any time upon notice in the *Pennsylvania Bulletin*.

11. *Project Interference*—This General Permit does not authorize any interference with any existing or proposed Local, State, Federal or Federally Licensed Project, and permittee may not be entitled to compensation for damage or injury to the work authorized herein which may be caused by or a result of existing or future operations undertaken by the United States, Commonwealth of Pennsylvania, or its Political Subdivisions in the public interest.

12. *Conditions*.

a. The use of this General Permit is only authorized as part of a conservation plan approved by the County Conservation District (Exhibit B).

b. Grassed waterways, terraces, diversions, waste storage facilities, spring development and minor drainage must be constructed and maintained according to § 101.8 (relating to pollution control and prevention from agricultural operations) and the design standards and specifications found in the technical guide for Pennsylvania available through the United States Department of Agriculture, Soil Conservation or the County Conservation District (Exhibit B).

c. All excess material from any activity must be deposited and stabilized outside the regulated waters of this Commonwealth.

d. Any archaeological artifacts discovered during the performance of work authorized under this General Permit must be adequately protected and their discovery promptly reported to the Director, Bureau of Historic Preservation, Historical and Museum Commission, Post Office Box 1026, Harrisburg, Pennsylvania 17108-1026, telephone (717) 787-2891.

e. Pollution of the waterway with harmful chemicals, fuels, oils, greases, bituminous material, acid, and/or other harmful or polluting materials, is prohibited.

f. Wetlands shall be avoided if an alternate location is possible. Where wetlands cannot be avoided and the activities are necessary to minimize erosion and sedimentation and improve water quality, the impact shall be minimized.

g. Waste storage facilities constructed within 250 feet of a source of water used as a public water supply source as defined under Pennsylvania Safe Drinking Water Act may need to be relocated due to the geology of the site. Contact the Regional Community Environmental Control Office in your area.

13. *Department Inspection*—As a condition of use of this General Permit and of the owner's authority to conduct the activities authorized by this General Permit, the owners hereby authorizes and consents to allow authorized employes or

agents of the Department, without advance notice or a search warrant, at any reasonable time and upon presentation of appropriate credentials, and without delay, to have access to and to inspect all areas where the project is being constructed, operated or maintained. The authorization and consent shall include consent to conduct tests or sampling, to take photographs, to perform measurements, surveys and other tests, to inspect the methods of construction, operation or maintenance, to examine and copy books, papers and records pertinent to any matter under investigation and to take other action necessary to assure the project is constructed, operated or maintained in accordance with the terms and conditions of this General Permit. This General Permit condition is included under section 16 of the Dam Safety and Encroachments Act (32 P. S. § 693.16) and in no way limits any other powers granted under the Dam Safety and Encroachments Act or The Clean Streams Law (35 P. S. §§ 691.1—691.1001).

14. *Activities Not in Accordance With the Terms or Conditions*—If the Department determines, upon inspection, that the construction, operation or maintenance of a project has violated the terms or conditions of this General Permit or the rules and regulations published in this chapter, Chapter 102 and § 101.8, the Department may take such actions, legal or administrative, that it may deem to be appropriate, including revocation of the General Permit with regard to the violation.

15. *Structural Removal*—The owners shall remove all or any portion of the activities covered by this General Permit upon written notification to the owners by the Department in the event the project is causing an adverse impact on public health, safety or the environment or in any other manner violates the conditions of this General Permit or this chapter.

16. *Property Rights*—This General Permit does not convey any property rights, either in real estate or material, or any exclusive privileges; nor does it authorize any injury to property or invasion of rights or any infringement of Federal, State or local laws or regulations.

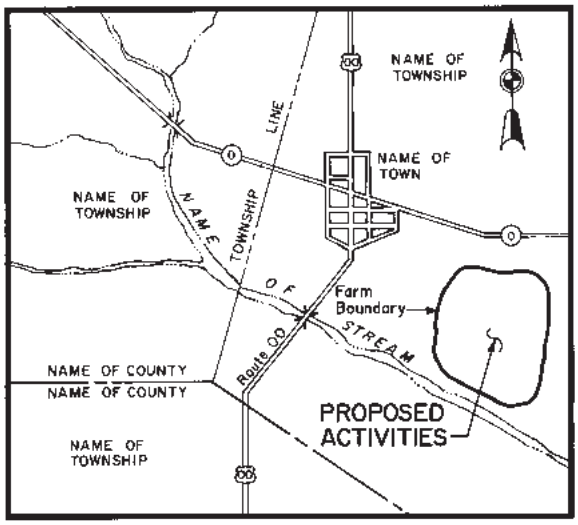
17. *Other Approvals*—The owners shall secure all other approvals that may be necessary under Federal, State or local laws or regulations.

18. *Fish and Boat Commission Notification*—The owners shall notify the Fish and Boat Commission's Regional Field Office Supervisor (see Exhibit A) responsible for the County where the activities are proposed 10 days prior to start of construction. Written notification is suggested. The project site shall at all times be available for inspection by authorized officers and employes of the Pennsylvania Fish Commission.

19. *Erosion and Sedimentation Controls*—Work must be done in compliance with a Conservation Plan which meets the requirements of Chapter 102, including erosion control measures for the construction of best management practices installed under that plan. The project shall at all times be available for inspection by authorized employes of the county conservation district. The Conservation Plan shall be available at the site at all times.

Copyright © 1996 Commonwealth of Pennsylvania

GENERAL PERMIT: B.D.W.M. GP-9
AGRICULTURE ACTIVITIES
Dwg. No. 1 SAMPLE LOCATION MAP



NOTE: Use of U.S.G.S. quadrangle map(s) is recommended.

EXHIBIT A
FISH AND BOAT COMMISSION'S OFFICES

Headquarters Address	*County Responsibility*
NORTHWEST REGION	
Regional Supervisor P. O. Box 349 1281 Otter Street Franklin, Pa. 16323 (814) 437-5774	Butler, Clarion, Crawford, Erie, Forest, Lawrence, Mercer, Venango and Warren
SOUTHWEST REGION	
Regional Supervisor R. D. 2, Box 39 Somerset, Pa. 15501-9311 (814) 455-8974	Allegheny, Armstrong, Beaver, Cambria, Fayette, Greene, Indiana, Somerset, Washington and Westmoreland
NORTHCENTRAL REGION	
Regional Supervisor Box 187 (Fishing Creek Road) Lamar, Pa. 16848 (717) 726-6056	Cameron, Centre, Clearfield, Clinton, Elk, Jefferson, Lycoming, McKean, Northumberland, Potter, Snyder, Tioga and Union
SOUTHCENTRAL REGION	
Regional Supervisor 1704 Pine Road Newville, Pa. 17241 (717) 486-7087	Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lebanon, Mifflin, Perry and York
SOUTHEAST REGION	
Regional Supervisor Box 8 Elm, Pa. 17521 (717) 626-0228	Berks, Bucks, Chester, Delaware, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia and Schuylkill
NORTHEAST REGION	
Regional Supervisor Box 88 Sweet Valley, Pa. 18656 (717) 477-5717	Bradford, Carbon, Columbia, Lackawanna, Luzerne, Monroe, Montour, Pike, Sullivan, Susquehanna, Wayne and Wyoming

Copyright © 1996 Commonwealth of Pennsylvania

DIVISION OF ENVIRONMENTAL SERVICES
450 Robinson Lane
Bellefonte, Pa. 16823-9616
(814) 359-5145

EXHIBIT B
COUNTY CONSERVATION DISTRICTS

Conservation District	*Phone Number*	*Conservation District*	*Phone Number*
Adams County	(717) 334-0636	Juniata County	(717) 436-6919
Allegheny County	(412) 921-1999	Lackawanna County	(717) 587-2607
Armstrong County	(412) 548-3425/3428	Lancaster County	(717) 299-5361
Beaver County	(412) 774-7090	Lawrence County	(412) 652-4512
Bedford County	(814) 623-6706/8099	Lebanon County	(717) 272-3377
Berks County	(215) 372-4655	Lehigh County	(215) 820-3398
Blair County	(814) 696-0877	Luzerne County	(717) 825-1844/5
Bradford County	(717) 265-5539	Lycoming County	(717) 326-5858
Bucks County	(215) 345-7577	McKean County	(814) 368-9960
Butler County	(412) 284-5270/5271	Mercer County	(412) 662-2242
Cambria County	(814) 472-5440 Ext 588	Mifflin County	(717) 248-4695
Cameron County	(814) 486-3350	Monroe County	(717) 629-3060
Carbon County	(215) 377-4894	Montgomery County	(215) 489-4506
Centre County	(814) 355-6817/6818	Montour County	(717) 271-1140
Chester County	(215) 696-5126	Northampton County	(215) 746-1971
Clarion County	(814) 226-4070	Northumberland County	(717) 988-4224
Clearfield County	(814) 765-2629	Perry County	(717) 582-4144
Clinton County	(717) 726-3798	Pike County	(717) 296-3429 Ext 309
Columbia County	(717) 784-1310	Potter County	(814) 274-8411
Crawford County	(814) 724-1793	Schuylkill County	(717) 429-1744
Cumberland County	(717) 249-8632 Ext 379	Snyder County	(717) 837-0085
Dauphin County	(717) 921-8100	Somerset County	(814) 445-4652
Delaware County	(215) 891-5962	Sullivan County	(717) 924-3983
Elk County	(814) 776-5373	Susquehanna County	(717) 278-4600 Ext 280
Erie County	(814) 796-4203	Tioga County	(717) 724-4812
Fayette County	(412) 438-4497	Union County	(717) 523-8782
Forest County	(814) 755-3450	Venango County	(814) 432-7456
Franklin County	(717) 264-8074	Warren County	(814) 723-7700
Fulton County	(717) 485-3547	Washington County	(412) 228-6774
Greene County	(412) 852-1171 Ext 319	Wayne County	(717) 253-1370

Huntingdon County	(814) 643-3536	Westmoreland County	(412) 837-5271
Indiana County	(412) 463-7702	Wyoming County	(717) 836-5111
Jefferson County	(814) 849-7463	York County	(717) 771-9430

EXHIBIT C

DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF DAMS AND WATERWAY MANAGEMENT

Area Office	*County Responsibility*
Southcentral Area Office 149 One Ararat Blvd. P. O. Box 8554 Harrisburg, Pa. 17105-8554 (717) 541-7901	Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntington, Juniata, Lancaster, Lebanon, Mifflin, Perry and York
Southeast Area Office Suite 6010, Lee Park 555 North Lane Conshohocken, Pa. 19428 (215) 832-6340	Berks, Bucks, Carbon, Chester, Delaware, Lehigh, Northampton, Montgomery, Philadelphia and Schuylkill
Southwest Area Office 482 Route 30 R. D. 1 Clinton, Pa. 15026 (412) 899-2377	Allegheny, Armstrong, Beaver, Butler, Cambria, Fayette, Greene, Indiana, Lawrence, Somerset, Washington and Westmoreland
Northwest Area Office 190 Adams Road Jamestown, Pa. 16134 (412) 932-3162	Clarion, Clearfield, Crawford, Elk, Erie, Forest, Jefferson, McKean, Mercer, Venango and Warren
Northeast Area Office Suite 203, Cross Valley Centre 667 North River Street Wilkes-Barre, Pa. 18705 (717) 826-5485	Bradford, Columbia, Lackawanna, Luzerne, Monroe, Pike, Sullivan, Susquehanna, Wayne and Wyoming
Northcentral Area Office 200 Pine Street Williamsport, Pa. 17701 (717) 327-3574	Cameron, Centre, Clinton, Lycoming, Montour, Northumberland, Potter, Snyder, Tioga and Union

Copyright © 1996 Commonwealth of Pennsylvania

BUREAU OF DAMS AND WATERWAY MANAGEMENT
CENTRAL OFFICE
P. O. Box 8554
Harrisburg, Pa. 17105-8554
(717) 541-7900

EXHIBIT D
Notification to Use
BDWM-GP-9
Agricultural Activities

I/We _____
(owner name(s))

hereby notify the Bureau of Dams and Waterway Management of our intent to install agricultural activities essential for the maintenance of existing agricultural operations in accordance with an approved conservation plan on property in

_____ (Municipality) , _____ (County) .

I/We have attached a LOCATION MAP similar to that shown on the Drawing No. 1 indicating where the activities will be installed.

I/We certify that a copy of this notification was sent this day _____ (date)

to _____ (municipality) and _____ (county) where the work will be performed.

Signed: _____
(owner or authorized representative)

_____
(type or printed signature)

_____
(owner address)

_____

_____
(owner telephone number)

I/We certify that the activities indicated above are an essential component of a conservation plan for this ongoing agricultural operation.

Signature:

_____ _____
County Conservation District date

Send to appropriate addresses on Exhibit C.

(207911) No. 255 Feb. 96

Source

The provisions of this Appendix I adopted January 24, 1992, effective January 25, 1992, 22 Pa.B. 392.

APPENDIX J
ABANDONED MINE RECLAMATION; GENERAL PERMIT BDWW-GP-10

1. *General Description and Authority*—The Department of Environmental Resources hereby authorizes, by general permit, subject to the terms and criteria set forth below, the construction, operation or maintenance of an encroachment or water obstruction for reclamation of an abandoned mining site, where the Department has issued a notice of intent to forfeit the bond for a mining activity permitted after August 1977, and before July 1982. This authorization is under section 7 of the Dam Safety and Encroachments Act (32 P. S. § 693.7) and the rules and regulations promulgated thereunder at 25 Pa. Code §§ 105.441—105.449 (relating to general permits).

2. *Denial of Authorization*—The Department shall have the discretion, on a case-by-case basis, to deny, revoke or suspend the authorization to use this general permit for any project which the Department determines to have a substantial risk to life, property or the environment or otherwise could not be adequately regulated by the provisions of this general permit.

3. *Sites and Conditions Where This General Permit Does Not Apply*—This General Permit does not apply and is not valid in the following situations:

a. Projects located where there would be an impact on species of special concern listed under the Endangered Species Act of 1973, the Wild Resources Conservation Act, the Fish and Boat Code or the Game and Wildlife Code. Records regarding species of special concern are maintained in a computer database called the ''Pennsylvania Natural Diversity Inventory'' (PNDI). To verify that there will be no such impacts for a specific project, the Department requires submission of the attached Supplement No. 1 prior to registration for use of the General Permit. The processed Supplement No. 1 is returned to the owner and must be attached to the General Permit notification as verification that the General Permit is applicable.

b. Construction activities in stocked trout streams from March 1 through June 15, wild trout streams from October 1 through December 31 and Lake Erie tributaries from September 1 through December 1, unless approval is obtained from the Fish and Boat Commission's Division of Environmental Services. Stocked and wild trout stream locations are compiled by the Commission's Division of Fisheries Management.

4. *Definitions*—The terms as used in this General Permit shall have the following meanings:

Body of Water—A natural or artificial lake, pond, reservoir, swamp, marsh or wetland.

Copyright © 1996 Commonwealth of Pennsylvania

Owner—Any person who owns, controls, operates, maintains or manages a dam or reservoir, water obstruction or encroachment.

Person—Any natural person, partnership, association, corporation, public utility, municipality, municipal authority, political subdivision of the Commonwealth, receiver or trustee and any department, board, commission or authority of the Commonwealth.

Reclamation—Those actions set forth in the forfeiting operators permit taken to restore the area affected by surface and underground mining activities as required by 25 Pa. Code Chapters 86—89 and for which State and/or Federal reclamation funding is used to perform the reclamation.

Regulated Waters of the Commonwealth—All watercourses, streams or bodies of water and their floodways wholly or partly within or forming part of the boundary of this Commonwealth.

Reservoir—Any basin, either natural or artificial, which contains or will contain the water or other fluid or semifluid impounded by a dam.

Stocked Trout Stream—A stream classified as approved trout waters by the Fish and Boat Commission. For current designations of stocked trout streams contact the Division of Fisheries Management.

Watercourse—Any channel of conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

Wetlands—Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adopted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas.

Wild Trout Streams—A stream classified as supporting reproducing trout populations by the Fish and Boat Commission. For current designations of wild trout streams, contact the Division of Fisheries Management.

5. *Other Permits*—Nothing in this General Permit relieves the owners of the obligation of complying with all Federal, Interstate Compact and State laws, regulations and standards for the construction, operation or maintenance of the activities covered by this General Permit.

6. *Registration for Use*—Prior to construction, the owners shall submit two copies of the completed Notification to Use (Exhibit D) along with two copies of the location map and processed Supplement No. 1 to the Soils and Waterways Section or the County Conservation District (Exhibits B and C). The notification must be sent to the County Conservation District only if there is a delegation agreement between the Department and the District. A copy of Exhibit D shall also be sent to the municipality and county in which the work will be performed. The owners may not begin work until they have received an acknowledgement from the Soils and Waterways Section of County Conservation District that the Exhibit D notification has been received and registered.

7. *Fees*—There is no fee required for a project authorized under this General Permit.

8. *Effective Time Period*—This General Permit will remain in effect indefinitely unless specifically modified, suspended or revised by the Department.

9. *Suspension, Modification or Revocation*—The Department may suspend, modify or revoke this General Permit at any time upon notice in the *Pennsylvania Bulletin.*

10. *Project Interference*—This General Permit does not authorize any interference with any existing or proposed local, State, Federal or Federally licensed project, and permittee shall not be entitled to compensation for damage or injury to the work authorized herein which may be caused by or a result of existing or future operations undertaken by the United States or the Commonwealth of Pennsylvania or its Political Subdivisions in the public interest.

11. *Conditions.*

a. Any archeological artifacts discovered during the performance of work authorized under this General Permit must be adequately protected and their discovery promptly reported to the Director, Bureau of Historic Preservation, Pennsylvania Historical and Museum Commission, P. O. Box 1026, Harrisburg, PA 17101-1026, telephone (717) 787-2891.

b. All excess fill or excavated and dredged material shall be deposited and immediately stabilized outside floodways, floodplains, wetlands and other regulated waters of this Commonwealth. Waste materials, scrap or excess construction materials shall be collected, stored and disposed of in accordance with the Solid Waste Management Act (35 P. S. §§ 6018.101—6018.1003) and the regulations promulgated thereunder.

c. Owners shall investigate for drinking water intakes or reservoirs to public and private water supplies within 5 miles downstream of the reclamation site and written notice shall be given at least 10 days prior to construction to operators of such intakes or reservoirs. Owners shall notify public and private water supply operators and the Department immediately and no longer than 1 hour after an occurrence at the reclamation site which results in the release of suspended solids and turbidity to the drinking water supply, including both surface and groundwater sources, that maintain the quality or quantity of the drinking water supply.

d. Reclamation projects shall not extend beyond the reclamation site.

e. During construction activities, all public and private property including existing vegetation, landscape features and monuments within, along and adjacent to the work area, shall be protected and preserved to the maximum degree possible. This shall include, but not be limited to, precautions taken to minimize damage, erosion, injury or destruction, prevent pollution, provide protection of all trees and other woody plants, special care being taken to protect the natural vegetation and surroundings to include all natural drainageways, ponds, lakes, swamps, woods and fields and storage of materials in such manner to

Copyright © 1999 Commonwealth of Pennsylvania

prevent leaching which would be injurious to soils and to plants. Precautions should be taken to prevent damage to pipes, conduits and other underground structures.

f. The owners shall notify the Fish and Boat Commission's Regional Field Office Supervisor responsible for the County where the activities are proposed 10 days prior to start of construction. Written notification is suggested. The project site shall at all times be available for inspection by authorized officers and employees of the Fish and Boat Commission.

g. Prior to the use of explosives in a watercourse or body of water, the permittee shall secure a written permit from the Fish and Boat Commission, under the Fish and Boat Code, Act 1980-175, 30 Pa.C.S. § 2906 (relating to permits for use of explosives). Requests should be directed to the Fish and Boat Commission, Division of Environmental Services.

h. Prior to construction, approval must be obtained from the Fish and Boat Commission's Division of Environmental Services for use of this project on reclamation sites bordering (1) stocked trout streams from March 1 through June 15 and (2) wild trout streams from October 1 through December 31.

i. All temporary road crossings of the regulated waters of the Commonwealth in areas unaffected by mining activities shall be constructed in accordance with the design standards and conditions of General Permit BDWW-8.

j. Prior to construction, the property owner of the abandoned mine site shall be sent, by certified mail, a questionnaire inquiring whether there are existing facilities on site such as ponds, wetlands or diversion ditches which the property owner wants left in place in their present condition. Construction may not be commenced until receipt of the complete questionnaire.

12. *Department Inspection*—As a condition of use of this General Permit, and of the owner's authority to conduct the activities authorized by this General Permit, the owner hereby authorizes and consents to allow authorized employees or agents of the Department or County Conservation District, without advance notice or a search warrant, at any reasonable time and upon presentation of appropriate credentials, and without delay, to have access to and to inspect all areas where the project is being constructed, operated or maintained. The authorization and consent shall include consent to conduct tests or sampling, to take photographs, to perform measurements, surveys and other tests, to inspect the methods of construction, operation or maintenance, to examine and copy books, papers and records pertinent to any matter under investigation, and to take any other action necessary to assure that the project is constructed, operated or maintained in accordance with the terms and criteria of the General Permit. This General Permit condition is referenced in accordance with section 16 of the Dam Safety and Encroachments Act (32 P. S. § 693.16) and in no way limits any other powers granted under the Dam Safety and Encroachments Act.

13. *Activities Not in Accordance With the Terms or Conditions*—If the Department or County Conservation District determines, upon inspection, that the

construction, operation or maintenance of a project has violated the terms or criteria of this General Permit, the Chapter 105 and 102 Rules and Regulations or the appropriate NPDES permit for discharge of stormwater from construction activities, the Department may take such actions, legal or administrative, that it may deem to be appropriate.

14. *Property Rights*—This General Permit does not convey any property rights, either in real estate or material or in any exclusive privileges; nor does it authorize any injury to property or invasion of rights or any infringement of Federal, State or local laws or regulations.

15. *Other Approvals*—The owners shall secure all other approvals that may be necessary under other Federal, State or local laws or regulations.

16. *Erosion and Sediment Pollution Controls*—Work must be done in compliance with Chapter 102 (relating to erosion and sediment control) and/or under the appropriate NPDES permit for discharge of stormwater from construction activities. Prior to construction, an Erosion and Sediment Pollution Control Plan must be reviewed and determined adequate by the County Conservation District in which the activities are proposed and implemented prior to, during and after construction. The County Conservation District shall be notified 10 days prior to the start of construction. The project site shall at all times be available for inspection by authorized employees of the County Conservation District. The Erosion and Sediment Pollution Control Plan shall be available at the site.

Source

The provisions of this Appendix J adopted July 8, 1994, effective August 8, 1994, 24 Pa.B. 3404.

APPENDIX O
GENERAL PERMIT BWQP-GP-15
PRIVATE RESIDENTIAL CONSTRUCTION IN WETLANDS

Editor's Note: The following permit was published in the *Pennsylvania Bulletin* as a Notice and is codified under 1 Pa. Code § 3.1(a)(9) (relating to contents of *Code*) as a document which the Legislative Reference Bureau finds to be general and permanent in nature. See §§ 105.441—105.449 (relating to general permits) for regulations governing this permit.

A. General Description. The Department of Environmental Protection hereby authorizes, by general permit, the placement and maintenance of fill in, or the excavation of, non-tidal wetlands for the construction or expansion of a single family home for the personal residence of the permittee, including reasonable and necessary features such as a driveway, storage shed and utilities on a residential lot purchased by the permitttee prior to November 22, 1991, within established subdivisions approved by the local governing authority where such activities do not impact greater than .50 acre of nontidal wetlands. The issuance of this General Permit also constitutes approval of a Water Quality Certification under section 401 of the Federal Clean Water Act (33 U.S.C.A. § 1341). The monetary

Copyright © 2000 Commonwealth of Pennsylvania

contribution associated with this General Permit is for participation in the Pennsylvania Wetland Replacement Project.

Neither the Department of Environmental Protection nor any County Conservation District which is delegated Chapter 105 permitting authority shall be liable for incidents resulting from subsidence, structure failure, water damage, vector problems or any other hardships that may occur as a result of building in wetlands.

B. Registration Procedure:

1. Complete the registration Form (Exhibit A).

The information requested in Item 2 on the registration form will be used to determine potential impacts to threatened and endangered species. If a potential impact is indicated, the Department will provide assistance to you to address threatened and endangered species concerns. The use of this general permit is not authorized until the potential impact is resolved.

If you desire, to avoid possible project delays, a search for potential impacts can be conducted prior to registration by completing the attached Supplement No. 1, Pennsylvania Natural Diversity Inventory Form (PNDI) and submitting it to the appropriate DEP Regional Office or delegated County Conservation District. The completed search information should be submitted when you register the permit.

2. Prepare a project location map utilizing a photocopy of a 7-1/2 minute U.S.G.S. Quadrangle Map showing the project site.

3. Delineate the wetlands in accordance with established Department procedures. Delineation services for the purpose of registering this general permit will be provided by the U. S. Army Corps of Engineers or the Department of Environmental Protection or its designee, upon request. If you choose to have delineation services provided by the Army Corps of Engineers or the Department, please request this service in writing early in the project planning stage to allow sufficient response and scheduling time to avoid project delays.

4. Prepare an Erosion and Sedimentation control plan. Permit users are encouraged to contact County Conservation Districts for erosion and sedimentation control planning assistance.

5. Prepare a sketch plan (Exhibit B) or attach a copy of a plot plan of the project showing the:

a. dimension of the entire property,
b. location of wetland,
c. location of erosion and sedimentation control measures,
d. dimension of the proposed wetland impact area,
e. location of house/driveways, and the like,
f. location of waterways, drainage ditches, and the like,
g. existing utilities,
h. proposed utilities, water, sewer, telephone, and the like.
i. building setbacks,

j. previously filled wetlands,

k. floodplains,

l. location of replacement wetlands.

6. To register use of the general permit send one copy of the:

a. Location Map,

b. Registration Form (Exhibit A),

c. Sketch Plan (Exhibit B),

d. Wetland delineation,

e. Erosion and Sedimentation Control Plan approval letter, for lots greater than 0.5 acre (see D.8. below),

f. A Wetland Replacement Plan or, a contribution to the Pennsylvania Wetland Replacement Project, as described in Part D.9 of this general permit;

g. Supplement Number 1, PNDI (see B.1); and

h. Corps authorization if the wetland impact is greater than .10 acre;

to the DEP Regional Soils and Waterways Section or the delegated County Conservation District.

7. You may not begin construction until you receive confirmation of registration and Federal authorization from the U. S. Army Corps of Engineers under Section 404 of The Clean Water Act. Please contact the appropriate Corps District for permit information.

Delaware River Basin	*Susquehanna River Basin*	*Ohio River Basin*
Philadelphia District Corps of Engineers Wanamaker Bldg. 100 Penn Square East Philadelphia, PA 19107 Phone: 215-656-6728	Baltimore District Corps of Engineers P. O. Box 1715 Baltimore, MD 21203-1715 Phone: 410-962-1846	Pittsburgh District Corps of Engineers Room 1834, Federal Bldg. 1000 Liberty Avenue Pittsburgh, PA 15222 Phone: 412-644-6872

C. Definitions Applicable to this General Permit:

Central Sewage—A sewerage system consisting of pipes, lateral lines, trunk lines or mains, which convey waste to a facility that provides treatment for final disposal. The term Central Sewage does not include onlot disposal, community onlot disposal, or any other system that requires a land surface or subsurface absorption area for treatment and disposal purposes.

FEMA—The Federal Emergency Management Agency

Floodplain—The lands adjoining a river or stream that have been or may be expected to be inundated by flood waters in a 100-year frequency flood. Unless otherwise specified, the boundary of the 100-year floodplain is as indicated on maps and flood insurance studies provided by FEMA. In an area where no FEMA maps or studies have defined the boundary of the 100-year floodplain it is assumed, absent evidence to the contrary, that the floodplain extends from the stream to 50 feet from the top of the bank of the stream. Other evidence of the

Copyright © 2000 Commonwealth of Pennsylvania

extent of the floodplain may include local stormwater management plans, local zoning ordinances, subdivision plans and similar land use mapping.

Impact—The loss of nontidal wetlands of the Commonwealth including any filled area previously permitted, the proposed filled area and any other nontidal wetlands of the Commonwealth that are adversely affected by flooding, excavation or drainage as a result of the project.

Individual—A natural person and/or couple but does not include a corporation, partnership or similar entity.

Parcel of Land—The entire contiguous quantity of land in possession of, recorded as property of, or owned (in any form of ownership, including land owned as a partner, corporation, joint tenant, and the like) by the same individual as of November 22, 1991 (and/or his or her spouse), and comprises not only the area of wetlands sought to be filled, but also all land contiguous to those wetlands, owned by the individual and/or his or her spouse in any form of ownership.

Pennsylvania Wetland Replacement Project—A fund managed by the National Fish and Wildlife Foundation from which money is dispersed at the direction of the Department of Environmental Protection, to which Chapter 105 permit applicants can make a monetary contribution, in lieu of creating wetlands.

Subdivision—The division or redivision of a lot, tract or parcel of land into two or more lots, tracts, parcels or other divisions of land including changes in existing lot lines.

Wetlands—Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas.

Emergent Wetland—Wetland areas dominated by nonwoody vegetation.

Forested Wetland—Wetland areas dominated by woody vegetation 20 feet or more in height.

Scrub/Shrub Wetland—Wetland areas dominated by woody vegetation less than 20 feet in height.

D. Conditions:

1. Impacts to wetlands must be avoided and minimized. Nonwetland areas onsite must be utilized whenever practical.

2. Fills or excavations in wetlands, including previously filled areas may not exceed more than 40% of the total lot area, except where lots are less than .25 acre in size where a maximum of .10 acre of fill in wetlands is authorized. In no circumstances may the total impact associated with the fill or excavation exceed 0.50 acre of wetlands.

The following conversion table provides an example of the amount of wetland fill authorized in accordance with the 40% maximum fill condition.

Lot Area in Acres	*x*	*40% of Lot Area*		*Maximum Area of Wetland Fill*
0.25	x	0.40	=	0.10 acre
0.33	x	0.40	=	0.13 acre
0.50	x	0.40	=	0.20 acre
0.75	x	0.40	=	0.30 acre
1.00	x	0.40	=	0.40 acre
1.25	x	0.40	=	0.50 acre

3. Fills, and/or excavations, in wetlands located on floodplains are not authorized by this General Permit. Information on floodplains may be available through local municipalities, home owner associations, county planning offices, FEMA and similar agencies.

4. This permit may only be used once by an individual.

5. This permit may only be used for a single-family home for a personal residence by an individual who purchased the lot prior to November 22, 1991.

6. This permit may only be used on residential lots with access to a central sewage system which is in place and operational at the time of registration, except in instances where the fill is for the expansion of an existing residence. Under no circumstances may fill be used to construct or expand an onlot sewage disposal system.

7. Fill material cannot contain wastes as defined in the Solid Waste Management Act.

8. Appropriate erosion control measures and facilities must be incorporated into all earthmoving activities associated with construction. Upon completion of construction the site shall be stabilized.

a. For lots greater than .50 acre an Erosion and Sedimentation Control Plan must be reviewed and approved by the County Conservation District in the county where your project is located prior to registration.

b. For all other lots equal to or less than .50 acre, an Erosion and Sedimentation Control Plan meeting the requirements of Chapter 102 (relating to erosion and sediment control) must be implemented and must be available at the site for review by the Department and/or the County Conservation District (see Exhibit B, Erosion and Sedimentation Control Notes). Permit users are encouraged to contact County Conservation Districts for erosion and sedimentation control planning assistance.

9. Individuals who wish to use this General Permit for impacts of up to .50 acre of wetlands must provide for the replacement of functions, values and areal extent of the wetlands impacted by:

a. creating a wetland in accordance with the Department's Design Criteria for Wetland Replacement on a 1:1 area ratio, replacement wetlands to filled wetlands. (Copies of the criteria are available at DEP Regional Offices.)

Copyright © 2000 Commonwealth of Pennsylvania

b. participating in the Pennsylvania Wetland Replacement Project by contributing to the National Fish and Wildlife Foundation Fund Project 95-096. The contribution rate is as follows:

Deminimus impact less than or equal to .05 acre	—	$ 0.00
Greater than .05 acre to .10 acre	—	$ 500.00
Greater than .10 acre to .20 acre	—	$ 1,000.00
Greater than .20 acre to .30 acre	—	$ 2,500.00
Greater than .30 acre to .40 acre	—	$ 5,000.00
Greater than .40 acre to .50 acre	—	$ 7,500.00

10. Fills and/or excavations should not increase flood levels or permanently restrict, impede, accelerate, increase or obstruct the passage of normal or expected stormwater flows in such a manner that adversely impacts the property or riparian rights of owners above, below, or adjacent to the project.

11. This permit is not valid for use within the corridor of a watercourse or body of water that has been designated as a National Wild or Scenic River in accordance with the Wild and Scenic Rivers Act of 1968 (16 U.S.C.A. §§ 1271—1287) or designated as wild or scenic under the Pennsylvania Scenic Rivers Act (32 P. S. §§ 820.21—820.29). Information may be obtained by contacting the Department of Conservation and Natural Resources (DCNR), Bureau of Recreation and Conservation, Scenic Rivers Program, P. O., Box 8475, Harrisburg, PA 17105 or calling (717) 787-2316.

E. Activities Not in Accordance with Terms or Conditions—If the Department determines, upon inspection, that the construction, operation or maintenance of a project has violated the terms or criteria of this General Permit or of the Chapter 105 Rules and Regulations, the Department may take such actions, legal or administrative, that it may deem to be appropriate.

F. Denial of Authorization—The Department shall have the discretion to deny, revoke or suspend the use of the General Permit for any project which the Department determines to have a substantial risk to life, health, property or the environment.

G. Authority—Authorization of this General Permit is under section 7 of the Dam Safety and Encroachment Act 32 P. S. § 693.7 et seq., and the rules and regulations promulgated thereunder at 25 Pa. Code §§ 105.441—105.449 (relating to general permits). This General Permit becomes effective April 7, 1997, and will remain in effect indefinitely unless specifically modified, suspended or revoked by the Department.

EXHIBIT A
REGISTRATION FORM

DEPARTMENT OF ENVIRONMENTAL PROTECTION
GENERAL PERMIT BWQP-GP-15
PRIVATE RESIDENTIAL CONSTRUCTION
IN WETLANDS

DEP BWQP-GP-15 Acknowledged
on _____(date).
GP Number(s): _____

Please check appropriate boxes

1. I/We _____
(owners name(s))

hereby notify the Department of Environmental Protection of the intent to fill or excavate a non-tidal wetland for the purpose of ☐ constructing or ☐ expanding a single-family home for a personal residence in accordance with the terms of and conditions of this General Permit.

Impact is to _____ of - ☐ (1) Forested ☐(2) Scrub/Shrub ☐(3) Emergent
(Actual Acreage)

wetland at a point _____
(describe location, subdivision name, street, lot no., etc.)

purchased on _____ in _____,
(date of purchase) (municipality)

_____.
(county)

2. I/We have enclosed the following: (check applicable items)

☐ a LOCATION MAP with the project site marked. This project is located on the _____ U.S.G.S. Quadrangle Map as follows:
North (up) _____ inches West (to the left) _____ inches

☐ a completed copy of SUPPLEMENT NO. 1 PNDI Search Form (only if this form was submitted prior to this registration process.)

☐ a SKETCH PLAN (Exhibit B) or plot plan.

☐ a formal wetland delineation conducted in accordance with established procedures.

☐ Corps authorization for wetland impacts greater than .10 acre.

If the lot is over .50 acre also submit

☐ an Erosion and Sedimentation Control Plan approval letter from the County Conservation District.

3. Choose A or B -

A. I/We have enclosed a wetland replacement plan in accordance with the Department's replacement criteria which provides _____ acre of wetlands.

B. I/We have enclosed a check, number _____ in the amount of $ _____ payable to the National Fish and Wildlife Foundation, Project 95-096 as compensatory mitigation for _____acre of impact in wetlands.

4. Owners signature -

_____ _____
(Signature) (Address)

_____ _____
(Telephone number) (City/state/zip code)

Copyright © 1997 Commonwealth of Pennsylvania

SAMPLE
EXHIBIT B

Lot Size = Width 120 ft. x Length 180 ft = 21,600 square feet

Wetland Impacts = Width 80 ft x Length 50 ft = 4,000 square feet

EROSION AND SEDIMENTATION CONTROL NOTES

1. Install rock construction entrance.
2. Install perimeter control measures, such as silt fence.
3. Maintain control measures at all times.
4. Inspect measures after each rain event & repair or replace as needed.
5. Stabilize disturbed areas promptly upon completion of construction or when earthmoving temporarily ceases for more than 20 days.

Conversion Chart

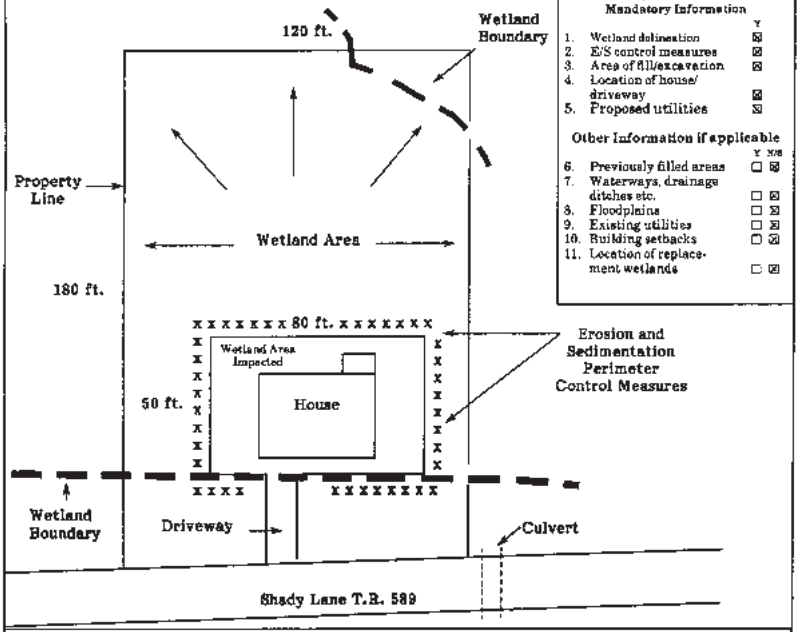
	square feet = acreage
	0 - 2,178 = 0 - .05
√	2,179 - 4,356 = .05 - .10
	4,357 - 8,712 = .10 - .20
	8,713 - 13,068 = .20 - .30
	13,069 - 17,424 = .30 - .40
	17,425 - 21,780 = .40 - .50

Check the box which includes your calculated wetland impact area

To ensure your sketch plan is complete check the following.
(Y = Yes, N/S = None on Site)

Mandatory Information	Y
1. Wetland delineation	☒
2. E/S control measures	☒
3. Area of fill/excavation	☒
4. Location of house/ driveway	☒
5. Proposed utilities	☒

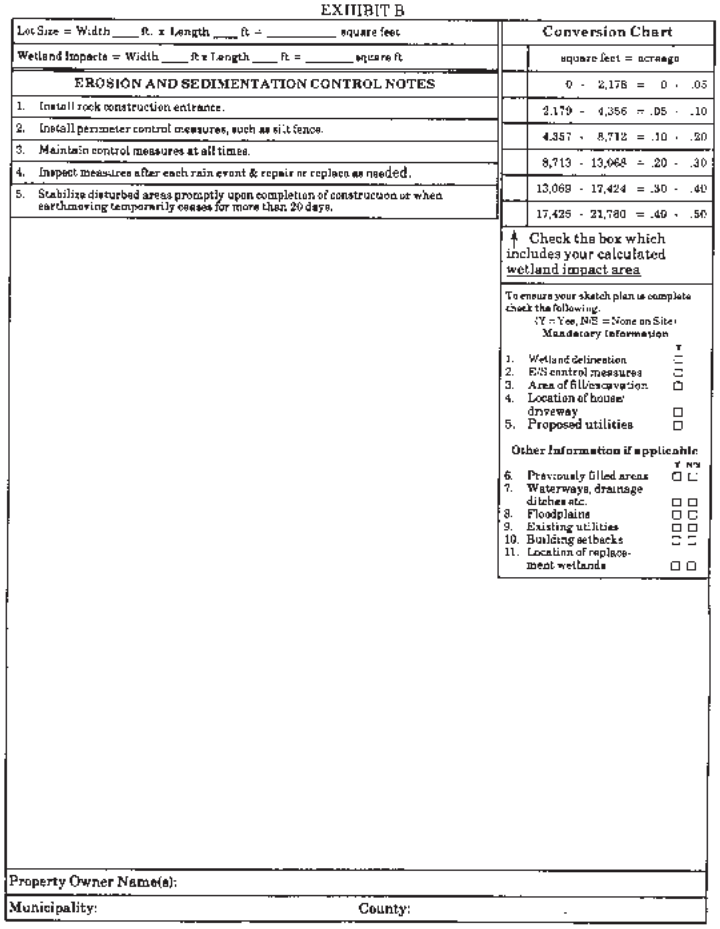
Other Information if applicable	Y	N/S
6. Previously filled areas	☐	☒
7. Waterways, drainage ditches etc.	☐	☒
8. Floodplains	☐	☒
9. Existing utilities	☐	☒
10. Building setbacks	☐	☒
11. Location of replacement wetlands	☐	☒



Property Owner Name(s): James & Janet Jones

Municipality: Fayette Township County: Juniata

EXHIBIT B



Lot Size = Width ____ ft. x Length ____ ft = _____ square feet

Wetland Impacts = Width ____ ft x Length ____ ft = _____ square ft

EROSION AND SEDIMENTATION CONTROL NOTES

1. Install rock construction entrance.
2. Install perimeter control measures, such as silt fence.
3. Maintain control measures at all times.
4. Inspect measures after each rain event & repair or replace as needed.
5. Stabilize disturbed areas promptly upon completion of construction or when earthmoving temporarily ceases for more than 20 days.

Conversion Chart

	square feet = acreage
	0 - 2,178 = 0 - .05
	2,179 - 4,356 = .05 - .10
	4,357 - 8,712 = .10 - .20
	8,713 - 13,068 = .20 - .30
	13,069 - 17,424 = .30 - .40
	17,425 - 21,780 = .40 - .50

Check the box which includes your calculated wetland impact area

To ensure your sketch plan is complete check the following.
(Y = Yes, N/S = None on Site)

Mandatory Information

		Y
1.	Wetland delineation	☐
2.	E/S control measures	☐
3.	Area of fill/excavation	☐
4.	Location of house/ driveway	☐
5.	Proposed utilities	☐

Other Information if applicable

		Y	N/S
6.	Previously filled areas	☐	☐
7.	Waterways, drainage ditches etc.	☐	☐
8.	Floodplains	☐	☐
9.	Existing utilities	☐	☐
10.	Building setbacks	☐	☐
11.	Location of replacement wetlands	☐	☐

Property Owner Name(s):

Municipality: County:

Source

The provisions of this Appendix O adopted February 2, 1996, effective March 4, 1996, and will remain in effect indefinitely unless specifically modified, suspended or revoked by the Department, 26 Pa.B. 526; amended March 7, 1997, effective April 7, 1997, 27 Pa.B. 1195. Immediately preceding text appears at serial pages (210128) to (210134) and (217395) to (217396).

[Next page is 106-1.]

Copyright © 1997 Commonwealth of Pennsylvania

E.38. Puerto Rico





LexJuris
Puerto Rico

Law Núm. 207 of year 2002

. of C. 2483), 2002, law 207

In order to amend Arts. 4 and 8 of the Law Núm. 133 of 1986: Committee of Supervision and Evaluation of the State Program of Inspection and Regulation of Prey and Dams
LAW NUM. 207 OF 28 OF AUGUST OF 2002

In order to amend Articles 4 and 8 of the Law Núm. 133 of 15 of 1986 July, in order to arrange that the Committee of Supervision and Evaluation of the State Program of Inspection and Regulation of Prey and Dams can be integrated by representatives of the respective agencies, to those who the faculty has been delegated him to act to name of the respective agencies, and to establish a new way to calculate the contribution that corresponds to pay to the Authority of Electrical Energy each organization or person to him owner of a dam or prey, and to other aims.

EXHIBITION OF REASONS

In Puerto Rico several prey and dams with multiple uses exist to give service to the citizenship. Some of these uses consist of the energy generation, irrigation of the agricultural fields, aqueducts, conservation, recreation, fishes and control of floods. The government of the Associated Free State of Puerto Rico, never has scrimped before his responsibility to adopt those measures that he considers necessary or pertinent to protect the life and the security of the citizens, especially, that one that is related to the storage of the water which we consumed.

The State Program of Inspection and Regulation of Prey and Dams was created by means of the Law Núm. 133 of 15 of 1986 July, in order to maintain, to conserve, to inspect and to guard by the security of the prey and dams in Puerto Rico. According to Article 2 of the Law Núm. 133, *supra*, the program before mentioned is administered by the Authority of Electrical Energy through the Unit of Inspection and Regulation for the Security of Prey and Dams.

Article 4 of the Law Núm. 133, *supra*, have the constitution a Committee to the supervision and evaluation of the mentioned Program, which is integrated by the President of the Meeting of Planning, the Executive Director of the Authority of Electrical Energy, the Director of Operations of the Authority of Aqueducts and Sewage systems, the Secretary of the Department of Natural and Environmental Resources and three citizens in representation of the public interest, named by the Governor. It is of general knowledge, that these officials government count on agendas of work extremely loaded. However, this Law nothing arranged to authorize these civil servants to delegate its responsibilities in representatives specifically designated by them to such effects. It brings, consequence, delay in the works of the Committee when, for some reason, three (3) of the civil servants to those who it was designated to them to comprise of the same, cannot attend the meetings properly summoned by the Committee.

In addition, according to Article 8 of the mentioned Law, the created unit is authorized to invoice

to name of the Authority, proportionally, to each agency, person or organization following the number of dams or dams that it owns, independent of the size, the capacity or the structural complexity and the maintenance that the wall requires that dams the water of the same.

The effect of the application of the established formula is unjust. Some prey and dams have needed very little effort and services of the Unit, whereas others have required that the Authority carries out extraordinary inspection and carries out expensive works, complex and continuous in relation to the same. The Legislative Assembly of Puerto Rico understands that it is not reasonable that those facilities that most of receive the services or whose walls of dam are in worse S-state are subsidized by the owners of prey and dams that require minor attention and effort or whose walls are in good state. For example, Represa de Carraízo, that has a capacity of dam of 23.500 acre-feet, has needed extraordinary and complex works, besides a continuous service. Their costs of inspection and maintenance as well as those of conservation of their walls exceed those all the other dams and dams in Puerto Rico, are public and private. He is not reasonable that the costs of operation of the Unit are divided in equal proportion between all the prey and dams, when we considered situations as the one of Represa Carraízo and we compared with Represa the Bronze, that inspects once every three years and has a dam of only 843 acre-feet.

Given the situation that we have indicated, the Government of the Free State Associated of Puerto Rico esteem that this Law, is necessary so that the distribution of expenses between the owners of the prey and dams, is more equitable and suitable, considering, among others factors, the size, material, the age and the conditions in which is the wall that dams the water. In addition, it turns out own to arrange that the civil servants appointed by law to form the Committee for the supervision and evaluation of the State Program of Inspection and Regulation of Prey and Dams, can delegate their responsibilities in representatives specifically designated to act to their name.

IT WOULD DECREE BY THE LEGISLATIVE ASSEMBLY OF PUERTO RICO:

Section 1. - Article 4 of the Law Núm reforms. 133 of 15 of 1986 July, so that it reads as it follows:

"Article 4. -

One forms a Committee for the supervision and evaluation of the Program, which will be integrated by the President of the Meeting of Planning, the Executive Director of the Authority of Electrical Energy, the Director of Operations of the Authority of Aqueducts and Sewage systems, the Secretary of the Department of Natural and Environmental Resources or his respective representatives in those who the faculty has been delegated to act to name of these, and three (3) citizens in representation of the public interest named by the Governor of the Associated Free State of Puerto Rico. The Executive Director of the Authority of Electrical Energy or his authorized representative to act in his name will be the President of the Committee. The first three (3) representing members of the public interest will be named one (1) by three (3) years and two (2) by four (4) years. When expiring the term of each, the subsequent appointments will become all by a term of four (4) years and until their successors are appointed and take possession from the position. In case of happening a vacancy between the members of the Committee in representation of the public interest, the Governor of the Associated Free State of Puerto Rico will send a new appointment by the term nonfulfilled del that caused the vacancy.

Five (5) members of the Committee will constitute quorum."

Section 2. - Article 6 of the Law Núm reforms. 133 of 15 of 1986 July, so that it reads as it follows:

"Article 6. -

When the Unit determines that a prey or dams of an agency or public instrumentality offers danger to the life and property of the citizens of the area in which it is, therefore it will notify the Executive Director of the Authority of Electrical Energy. The Director, as well, will notify the Committee, that in consultation with the Office of Management and Budget and the head or director of the agency or instrumentality owner of the prey or dam will adopt a plan of measures to take, with specification of the necessary bottoms, if some, to carry out them. The Unit will establish the term that will have the organization to correct the indicated deficiencies, of not correcting itself, within the ruled time, the Executive Director of the Authority of Electrical Energy will notify the Secretary of Justice of the breach, for its evaluation and later proceeding according to the Law. The Committee will notify in writing to the Governing one on the situation."

Section 3. - Article 8 of the Law Núm reforms. 133 of 15 of 1986 July, so that it reads as it follows:

"Article 8. -

Annually, the Unit, with the approval of the Committee, will invoice to each public agency, person or private organization that own a prey or a participant dam in the Program, the cost incurred across the Program during every year and the received thing will collect to him to the Authority of Electrical Energy.

The Committee will promulgate a regulation to establish the duties and the obligations of

the possessors of prey and dams that its conservation guarantees, and to determine the way in that the contribution will calculate that corresponds to each public agency, person or deprived organization, taking as it bases the costs incurred across the Program and the size, material, age and conditions in which is the wall of retention in each one of the prey and dams that receive the services that the Unit offers."

Section 4. - This Law will begin to prevail immediately after its approval.

Important note: This law is copy of the original law when it was approved, does not include later amendments to this.

It presses Here to return to the previous Menu and to select another law.

WARNING

This document constitutes a document of the laws of the Associated Free State of P.R that is subject to the changes and corrections of the process of compilation and official publication of the laws of Puerto Rico. Its electronic distribution becomes like a public service the community. It always looks for later laws for possible amendments this law.

LexJuris of Puerto Rico always is under construction.

| Home| Laws and Jurisprudence | Information | Agencies | Professionals | Biographies | History | Towns of Puerto Rico| Services |Publicity | Directories | Purchases | Events | The news | Entertainment |Publications CD| Decrees | Legal magazine |

© 1996-2002 LexJuris of Puerto Rico - Right Reserved

Programa de Reglamentación de Represas

Purpose - The Program's purpose is to provide for a safe design, construction, operation and maintenance of the dams to protect public safety.

Authority - The Puerto Rico Dam Safety **Act 207**. The Dam Safety and Security Act of 2002 (**Public Law 107-310**).

Puerto Rico Dam



¿Which dams are subject to the law? All dams in Puerto Rico are subject to the Dam Safety Act.

“Any artificial barrier, including appurtenant works, which impounds or diverts water, and which:

1) Is 25’ or more in height from the natural bed of the watercourse, measured at the downstream toe, or

2) Has an impounding capacity at the maximum water storage elevation of 50 acre-feet or more.”

National Inventory of Dams	Dams Under State Regulation
35	35

The height of a dam is defined as the vertical distance from the streambed at the downstream toe to the top of the dam.

The capacity of a dam is defined as the volume capable of being impounded at the top of the dam.

Hazard Classification of Dams - Dams are classified with a hazard potential depending upon the downstream losses anticipated in event of failure. Hazard potential is not related to the structural integrity of a dam but strictly to the potential for adverse downstream effects if the dam were to fail.

Hazard Classification	Property Damage	Potential Loss of Life
LOW	Minimal	None
SIGNIFICANT	Appreciable	Unlikely
HIGH	Excessive	Likely

Dams are classified by the hazard they represent to downstream life and property, if they were to fail. The classification does not indicate the state of disrepair or the likelihood of failure.

E.39. Rhode Island



STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OFFICE OF COMPLIANCE AND INSPECTION

Rules and Regulations for Dam Safety

December 2007

AUTHORITY: These regulations are adopted pursuant to Chapters 42-17.1, 42-17.6, 42-35, and 46-19 of the Rhode Island General Laws of 1956, as amended.

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

RULES AND REGULATIONS FOR DAM SAFETY

TABLE OF CONTENTS

RULE 1. PURPOSE....3

RULE 2. AUTHORITY....3

RULE 3. ADMINISTRATIVE FINDINGS....3

RULE 4. RESPONSIBILITY OF DAM OWNERS....4

RULE 5. APPLICATION....4

RULE 6. DEFINITIONS....4

RULE 7. PROHIBITIONS....7

RULE 8. REGISTRATION AND NOTIFICATION....7

RULE 9. HAZARD CLASSIFICATION....8

RULE 10. APPROVALS....8

(A) MAINTENANCE OF A HIGH OR SIGNIFICANT HAZARD DAM....8
(B) REPAIR OF A HIGH OR SIGNIFICANT HAZARD DAM....9
(C) EMERGENCY REPAIR OF A HIGH OR SIGNIFICANT HAZARD DAM....10
(D) PROCEDURES FOR REVIEW OF APPLICATIONS....11
(E) PUBLIC NOTICE....12
(F) EFFECT OF APPROVAL....12
(G) MODIFICATION, SUSPENSION OR REVOCATION OF APPROVAL....12

RULE 11. INSPECTIONS....13

(A) SCHEDULED INSPECTIONS....13
(B) UNSCHEDULED INSPECTIONS....14
(C) INSPECTIONS....14
(D) INSPECTION REPORTS....15

RULE 12. UNSAFE DAMS....15

RULE 13. ACCESS....16

RULE 14. ENFORCEMENT ACTIONS....16

RULE 15. APPEALS....16

RULE 16. SEVERABILITY....17

RULE 17. EFFECTIVE DATE....17

APPENDIX I: IMPACT AVOIDANCE AND MINIMIZATION....18

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

RULES AND REGULATIONS FOR DAM SAFETY

RULE 1. PURPOSE

The purpose of these Rules and Regulations is to implement the provisions of Chapter 46-19, “Inspection of Dams and Reservoirs” of Rhode Island General Laws (R.I. Gen. Laws) of 1956, as amended and to provide for the safety of dams to protect the public, real property and natural resources by establishing reasonable standards and to create a public record for reviewing the performance of dams.

RULE 2. AUTHORITY

These Rules and Regulations are promulgated pursuant to the requirements and provisions of Chapter 42-17.1, “Department of Environmental Management”, Chapter 42-17.6, "Administrative Penalties for Environmental Violations" and Chapter 46-19, “Inspection of Dams and Reservoirs” in accordance with the provisions of Chapter 42-35 “Administrative Procedures Act”, of the R.I. Gen. Laws of 1956, as amended.

RULE 3. ADMINISTRATIVE FINDINGS

The following administrative findings are made as a basis for these Rules and Regulations:

(A) Rhode Island has approximately 674 dams of varying age, size and state of repair;

(B) Failure or misoperation of high hazard dams or significant hazard dams (both of which represent approximately 30 percent of all dams in the state) will result in a probable loss of human life or cause major economic loss, disruption of lifeline facilities or impact other concerns;

(C) Investigations of dam failures have found that approximately 60 percent were caused by lack of maintenance, resulting in piping, surface erosion, slope protection damage or deterioration of outlet pipes;

(D) Many of these dams, both public and private, have not been properly maintained through the years and pose a significant threat to public safety, real property and natural resources;

(E) Since dam related laws were adopted, the threat to public safety, real property and natural resources has increased due to deterioration of dams and development in downstream areas over which dam owners do not necessarily have control.

(F) It is in the best interest of the state, the cities and towns of the state, and the citizen's thereof, to maintain a safe dam infrastructure; and

(G) In order to maintain a safe dam infrastructure, a collaborative effort is required by state and municipal officials, private dam owners and elected officials.

RULE 4. RESPONSIBILITY OF DAM OWNERS

(A) All owners of high hazard dams and significant hazard dams shall keep their dams and appurtenant works in a safe condition.

(B) All owners or precedent owners are responsible for liability for damage to property of others or injury to persons, including but not limited to loss of life, resulting by the following of the pond raised by the dam, by the stopping or raising of the water either above or below the dam, by the backing of water or by the flowing out of any fall of water by means of the dam.

(C) These regulations shall not be interpreted as relieving any owner or person maintaining or having control of a dam from responsibility, or lessening such responsibility, for any damages to persons or property caused by defects, inappropriate operation or inadequate maintenance or as creating liability on the part of the Department or the Director.

(D) Compliance with these Rules and Regulations does not relieve an owner or person maintaining or having control of a dam of any obligation to comply with any other applicable laws or regulations administered by, through or for the Department or any other government entity.

RULE 5. APPLICATION

(A) The terms and provisions of these Rules and Regulations shall be liberally construed to permit the Department to effectuate the purposes of state law, goals and policies.

(B) Nothing in these Rules and Regulations shall be deemed to prohibit a dam owner or person maintaining or having control of a dam, from seeking assistance from a municipality or prohibit a municipality from assisting a dam owner in complying with these Rules and Regulations.

RULE 6. DEFINITIONS

For the purposes of these Rules and Regulations, the following terms shall have the following meanings:

(A) "**Appurtenant works**" means any ancillary feature of a dam including such structures as dikes, training walls, spillways, either in the dam or separate there from, low level outlet works, and water conduits such as tunnels, channels, pipelines or penstocks, either through the dam or its abutments.

(B) "**Dam**" means any barrier made by humans, including appurtenant works, that impounds or diverts water.

(C) "**Department**" means the Department of Environmental Management and may be used interchangeably with Director.

(D) "**Department dam engineer**" means an individual employed by the Department who possesses a Bachelor of Science degree in engineering and has demonstrated, through a combination of education, experience, and/or training, that he/she is qualified to perform visual inspections.

(E) "**Detailed investigation**" means all studies, investigations and analyses appropriate to evaluate the structural safety and hydraulic capacity of a dam or reservoir and appurtenant works.

(F) "**Director**" means the Director of the Department of Environmental Management, or his or her designee and may be used interchangeably with Department.

(G) "**Embankment**" means the fill material, including but not limited to rock or earth, placed to provide a permanent barrier that impounds water.

(H) "**Freshwater wetlands**" means those areas as defined in Section 2-1-18, et. seq. of the R.I. Gen. Laws of 1956, as amended, and the Wetlands Regulations.

(I) "**Hazard classification**" means a rating for a dam that relates to the probable consequences of failure or misoperation of the dam, which is a determination made by the Director based on an assessment of loss of human life, damages to properties or structures located downstream of the reservoir, or loss of use as a drinking water supply. This rating has no relationship to the current condition of the dam. A higher hazard dam does not imply that it is more likely to fail or be misoperated than a lower hazard dam.

(J) "**Height**" means the vertical distance from the elevation of the uppermost surface of a dam to the lowest point of natural ground, including any stream channel, along the downstream toe of the dam.

(K) "**High hazard dam**" means a dam where failure or misoperation will result in a probable loss of human life.

(L) "**Hydraulic**" means the behavior of water relative to the dam. It is the manner in which water in the reservoir is passed over or through the dam, via an outlet such as a spillway or low level outlet.

(M) "**Hydrologic**" means the volume and speed at which precipitation flows along the earth, combines into streams and discharges into a reservoir.

(N) "**Lifeline facilities**" means essential facilities, the loss of which can result in indirect threats to life. Lifeline facilities may include hospitals, transportation links (highways, bridges, airports, rail lines, waterways, ports and harbor facilities and emergency evacuation routes), and utility systems (electric power plants, gas and liquid fuel pipelines, telecommunication systems, water supply and waste water treatment facilities).

(O) **"Low hazard dam**" means a dam where failure or misoperation results in no probable loss of human life and low economic losses.

(P) "**Maintenance**" means minor work on a dam necessary to maintain the dam in proper working order, including activities such as filling minor erosion areas, mowing or clearing vegetation provided that it does not affect the integrity of the dam, lubricating and exercising equipment and re-pointing masonry areas. Maintenance does not include repair of a dam or substantial alteration of a dam

(Q) "**Owner**" means the person or persons, including any individual, firm, partnership, association, syndicate, company, trust, corporation, municipality, agency, political or administrative subdivision of the state or any legal entity of any kind holding legal title to a dam.

(R) "**Person maintaining or having control of a dam**" means the person or persons, including any individual, firm, partnership, association, syndicate, company, trust, corporation, municipality, agency, political or administrative subdivision of the state or any legal entity of any kind having authority to operate or maintain a dam.

(S) "**Piping**" means the progressive development of internal erosion by seepage through the dam. Piping appears downstream as a hole or a discharging flow of water that includes soil particles from the dam embankment or foundation.

(T) "**Probable loss of human life**" means loss of human life that is likely to occur, or reasonably or realistically expected. This definition does not include persons who are only incidentally in the potential inundation area downstream of a dam. Examples include walking on the dam, driving on lightly traveled roads on or downstream of the dam and recreating downstream of the dam provided the area is not an established recreational area.

(U) "**Qualified engineer**" means a professional engineer fully registered in the State of Rhode Island, who is experienced with dam inspection, design, construction and repair.

(V) "**Registered owner**" means a dam owner who has been issued a certificate of registration by the Department.

(W) "**Regulated dam**" means a low hazard dam that is six (6) feet or more in height or has fifteen (15) acre-feet or more of storage capacity; or a high hazard dam; or a significant hazard dam. An acre-foot is a unit of volume equal to 43,560 cubic feet or 325,830 gallons (a measure that would cover one acre to a depth of one foot).

(X) "**Removal**" means the destruction or breaching of a dam to the extent that the dam no longer impounds or diverts water.

(Y) "**Repair** " means any work performed at a dam that may affect the integrity of the dam, including certain cutting or removal of trees where the resulting decomposition of the tree root system could jeopardize the integrity of the dam, work requiring excavation into the embankment fill or foundation of a dam, work requiring reinforcement of the embankment or work requiring removal or replacement of major structural components of a dam; or any related, new, temporary or permanent access way(s) that may be required within freshwater wetlands.

(Z) "**Reservoir**" means the body of water that is impounded or diverted by a dam.

(AA) "**Significant hazard dam**" means a dam where failure or misoperation results in no probable loss of human life but can cause major economic loss, disruption of lifeline facilities or impact other concerns detrimental to the public's health, safety or welfare. Examples of major economic loss include but are not limited to washout of a state or federal highway, washout of two or more municipal roads, loss of vehicular access to residences, (e.g. a dead end road whereby emergency personnel could no longer access residences beyond the washout area) or damage to a few structures.

(AB) "**Spillway**" means a structure, a low area in natural grade or any part of the dam which has been designed or relied upon to allow normal flow or major flood flow to pass over or through while being discharged from a reservoir.

(AC) "**Substantial alteration**" means any physical modification to a dam that results in a permanent change in the water elevation of the reservoir or in water flow downstream of the dam.

(AD) "**Unsafe dam**" means the condition of a regulated dam, as determined by the Director, is such that an unreasonable risk of failure exists that will result in a probable loss of human life or major economic loss. Among the conditions that would result in this determination are: excessive vegetation that does not allow the Director to perform a complete visual inspection of a dam, excessive seepage or piping, significant erosion problems, inadequate spillway capacity, inadequate capacity and/or condition of control structure(s) or serious structural deficiencies, including movement of the structure or major cracking.

(AE) "**Visual inspection**" means a visual, technical evaluation of the physical conditions of a dam that affect performance of the structure.

(AF) "**Wetlands Regulations**" means the "Rules and Regulations Governing the Administration and Enforcement of the Freshwater Wetlands Act".

RULE 7. PROHIBITIONS

(A) No repair of a high hazard dam or significant hazard dam shall occur until plans and specifications of the proposed work have been filed with and approved by the Director in accordance with these Rules and Regulations.

(B) No repair of a low hazard dam shall occur without approval of the Director in accordance with the Wetlands Regulations unless specifically exempted under the Wetlands Regulations.

(C) No maintenance of a high hazard dam or significant hazard dam shall occur without approval of the Director unless specifically exempted under these Rules and Regulations.

(D) No maintenance of a low hazard dam shall occur without approval of the Director in accordance with the Wetlands Regulations unless specifically exempted under the Wetlands Regulations.

(E) No new construction, substantial alteration, or removal of a dam shall occur without approval of the Director.

RULE 8. REGISTRATION AND NOTIFICATION

(A) The owner of a regulated dam shall file with the Department, within sixty (60) days of promulgation of these Rules and Regulations, a fully completed registration form to be provided by the Director.

(B) The owner of a regulated dam shall notify the Director and the local municipality's emergency management authority having jurisdiction, of the transfer of legal title of such dam or a change in the mailing address, telephone number or emergency contact person not later than thirty (30) days after the date of such transfer or change and provide to the Director the new owner, mailing address, telephone number, or emergency contact person.

(C) The Director, following receipt of a fully completed registration form, shall issue a certificate of registration to the owner of a regulated dam identifying the proper name, registration number and current hazard classification of the dam.

(D) The owner of a regulated dam, upon written request from the Department, shall make available to the Director, all the existing surveys, plans, drawings and reports related to the dam, in possession of or available to the owner, that may be required by the Director for the purposes of dam safety.

(E) The owner of a regulated dam, upon written request from the Department, shall prepare all the necessary surveys, plans, drawings and reports related to the dam that may be required by the Director for the purposes of dam safety.

RULE 9. HAZARD CLASSIFICATION

(A) The Department shall classify each regulated dam in the State as a high hazard dam, significant hazard dam or low hazard dam. The Director shall send a notice of the proposed classification to the registered owner of a dam. The dam owner may contest the proposed classification pursuant to Rule 15 of these Rules and Regulations. The Director shall maintain a list of all classified dams and shall make the list available to the public.

(B) The Director shall examine each regulated dam as often as he or she shall deem necessary to assess whether the dam warrants reclassification.

(C) Any person may petition the Director for reclassification of a dam. The petition must be in writing and must include a written report prepared by a qualified engineer that details the findings and analyses that support the engineer's opinion that the dam should be reclassified.

RULE 10. APPROVALS

(A) MAINTENANCE OF A HIGH OR SIGNIFICANT HAZARD DAM

(1) Maintenance of a high hazard dam or significant hazard dam, except for certain cutting or removal of trees, does not require an approval from the Department. To be exempt from Department approval, the cutting or removal of trees must be limited to those trees with a diameter less than 6 inches (measured 2 feet above the ground level) or that do not affect the integrity of the dam. If trees have a diameter greater than 6 inches (measured 2 feet above the ground level) then the dam owner shall first consult with a qualified engineer who will determine if the cutting or removal could jeopardize the integrity of the dam. The owner shall obtain a written report from the qualified engineer, if the qualified engineer determines that the cutting or removal is not a threat to the integrity of the dam, and keep a copy of the report on file. The report does not have to be filed with the Department. The owner shall file an application for repair of the dam in accordance with these Rules and Regulations if the qualified engineer determines that the cutting or removal is a threat to the integrity of the dam.

Mowing or cutting of vegetation may be performed without an approval from the Department provided it is limited to areas on the dam and adjacent to the dam such that an area does not exceed fifteen (15) feet from the embankment, spillway or low level control structure. All other mowing or cutting of vegetation within freshwater wetlands will require a permit from the Director unless specifically exempted under the Wetlands Regulations. Areas exceeding fifteen (15) feet from the embankment, spillway or low level control structure that have been historically mowed and maintained are specifically exempted under the Wetlands Regulations. These areas can continue to be mowed without a permit from the Director.

(2) All maintenance activities shall comply with the following:

(a) Best management practices for erosion and sediment controls must be used. All controls must be maintained in effective operating condition during the activity, and all exposed soil and other fills must be permanently stabilized at the earliest possible date. (For guidance see *Rhode Island Soil Erosion and Sediment Control Handbook* and *Rhode Island Stormwater Design and Installation Standards Manual.*);

(b) All equipment used for maintenance activities shall be removed from any freshwater wetland upon completion of the maintenance project; and

(c) All maintenance activities shall be protective of water quality and freshwater wetland functions and values so as to prevent pollutants, sediment, direct discharge of stormwater runoff, or any material foreign to waters of the State including freshwater wetlands, or hazardous to life, from entering any waters of the State including freshwater wetlands.

(B) REPAIR OF A HIGH OR SIGNIFICANT HAZARD DAM

The dam owner must submit an application for repair of a high hazard dam or significant hazard dam directly to the Department's Dam Safety Program. Applications shall be in writing and on a form prescribed by the Director and shall contain such documentation and information as the Director may require, which may include but not be limited to the following:

(1) A locus map indicating the location of the dam in relation to other fixed infrastructure in the community such as roads, etc.;

(2) Written justification explaining the need for the work;

(3) Three (3) sets of plans and specifications for the proposed work, prepared and stamped by a qualified engineer. The Department reserves the right to request additional copies for coordination with other State or federal permitting agencies;

(4) Plans drawn in sufficient detail to clearly indicate the extent and complexity of the work, including plan, profile and cross section views, along with any new, temporary or permanent access ways;

(5) Written description of the method of construction;

(6) Supporting computations and field measurements for all assumptions and design work (hydrologic, hydraulic, structural, geotechnical);

(7) Criteria and basis for selection of the design;

(8) Specifications of all material to be used in the repair;

(9) Estimated construction schedule including commencement and completion of the repairs;

(10) Amount (estimated vertical, horizontal and areal) and schedule of reservoir drawdown and schedule of reservoir recovery;

(11) If a temporary water by-pass or diversion is proposed, the dam owner shall provide plans, details and calculations for such by-pass or diversion. The design of the by-pass or diversion shall be capable of accommodating peak flows from a minimum of 95% of all storm events that may be expected to occur within the proposed construction period and contain a contingency provision to safely accommodate a 100-year, 24 hour duration Type III storm event. The design of the by-pass or diversion shall be capable of accommodating, at a minimum, peak flows in accordance with the following table.

Construction Duration	**Required Design Storm**
up to 3 months	5 year
3 months to 6 months	10 year
6 months to 1 year	20 year
1 year to 2 years	50 year

(12) Supporting documentation to demonstrate that there is no practicable alternative to the proposed repair that would have less adverse impact on freshwater wetlands, that addresses the impact avoidance and minimization criteria specified in Appendix I. A practicable alternative is defined as one that is "available and capable of being done after taking into consideration cost, existing technology and logistics in light of the overall project purposes";

(13) Contact name and telephone number of person(s) responsible for repair; and

(14) Statement that a record drawing, certified by the qualified engineer responsible for design that the dam was repaired in conformance with the plan approved by the Director, will be provided to the Director upon completion of the work.

The Director shall provide dam owners with written notice for any additional information the Director requires.

(C) EMERGENCY REPAIR OF A HIGH OR SIGNIFICANT HAZARD DAM

The Director may grant verbal approval of an emergency repair consistent with the following requirements:

(1) Verbal or written request for permission to proceed with an emergency repair must be made by the owner or person maintaining or having control of a dam;

(2) The request must inform the Department of at least the following:

(a) An explanation of the problem necessitating an emergency repair;

(b) The reason why the problem represents an imminent threat to public safety or real property;

(c) The location of the dam on which the repair is required;

(d) The proposed actions necessary to correct the problem and complete the repair;

(e) The person responsible for overseeing the repair, including means of contact; and

(f) The means proposed to restore any wetland areas following the emergency repair that may be required by the Director.

(3) Any emergency repair undertaken shall not result in a significant alteration of any wetland unless authorized by a permit issued by the Director.

(4) Alteration of wetlands shall not exceed work beyond that necessary to abate the emergency;

(5) Unless otherwise informed by the Director, the dam owner must submit a report, a record drawing and a permit application to the Department no later than thirty (30) days following the emergency repair. The report must explain the emergency repair undertaken, and the short-term and long-term effects that the emergency repair had on abating the emergency, any wetlands affected, any permanent, significant alteration which resulted from the activity, and all restoration activities undertaken, or which may still be required;

(6) The time limitation for performance of an emergency repair shall not exceed ten (10) days following initial approval by the Department unless written approval for an extension is obtained from the Department; and

(7) Following submission of the record drawing required above, the applicant is required to comply with any additional activities necessary to prevent significant wetland alterations or to obtain a permit as detailed in writing by the Department.

An emergency repair may be taken by the owner or person maintaining or having control of a dam without prior Department approval in accordance with Rule 12 of these Rules and Regulations. The Department will evaluate the emergency repair to determine if it is consistent with Rule 10(C) of these Rules and Regulations. The Department will consider good faith efforts made by the owner or person maintaining or having control of the dam to obtain prior approval from the Department for the emergency repair.

(D) PROCEDURES FOR REVIEW OF APPLICATIONS

(1) In consideration of the application, the Department may use, but is not limited to, the criteria, manuals and procedures used by the following agencies:

The United States Army Corps of Engineers;
The United States Department of Agriculture, Natural Resources Conservation Services;
The United States Department of Energy, Federal Energy Regulatory Commission;
The United States Department of Homeland Security, Federal Emergency Management Agency; and
The United States Department of the Interior, Bureau of Reclamation.

(2) At any time during the review, the Director may:

(a) Require that the dam owner provide such information as the Director deems necessary for the review of the application;

(b) Issue an approval requiring such terms, conditions, management practices and operation and maintenance requirements as deemed necessary to comply with the requirements of applicable state laws; or

(c) Deny the application for failure to satisfy the requirements of applicable laws and advise the dam owner of the right to appeal under Rule 15 of these Rules and Regulations. A denial may be based on, but is not limited to, any of the following:

(i) Failure to submit any information required by the department; or

(ii) Failure to provide clear and convincing documentation demonstrating, to the satisfaction of the Director, that the project will not violate these Rules and Regulations.

(E) PUBLIC NOTICE

The Director may require the applicant to provide written notice of the planned repair to abutters of the dam and reservoir and to the municipality(s) in which the dam and reservoir are located. In general, an abutter will be limited to a property owner with frontage on the reservoir. The Director may prescribe a form or a format for such notice.

(F) EFFECT OF APPROVAL

(1) The issuance of an approval mandates compliance with all terms, conditions, management practices and operation and maintenance requirements set forth in the approval.

(2) The issuance of an approval does not relieve any person of the continuing responsibility to comply with any other applicable federal, state or local law or regulation.

(3) The issuance of an approval does not relieve any person of the responsibility for obtaining any other necessary permits or approvals from any federal, state, regional, or local agency.

(4) The issuance of an approval does not authorize any injury to persons or property or invasion of other private rights, or any infringement of federal, state or local law or regulations.

(G) MODIFICATION, SUSPENSION OR REVOCATION OF APPROVAL

(1) The Director may modify, suspend, or revoke, in whole or in part, an approval for cause, including, but not limited to, the following:

(a) Information indicating that the project will result in an unsafe condition of the dam;

(b) The existence of a factor or factors which, if properly and timely brought to the attention of the Director, would have justified the application of more or less stringent conditions than required by these regulations, but only if such factor(s) arose after the approval was issued;

(c) Where circumstances on which the approval was based have materially and substantially changed since the approval was issued, including but not limited to pertinent amendment of these rules and regulations;

(d) The information or data submitted by the dam owner either on the form required or in any other material in support of the application is found to be false, misleading or erroneous; or

(e) The project is not undertaken in strict compliance with the conditions or provisions of any approval issued by the Department.

(2) A notice of revocation/suspension of an approval will be in the form of a certified letter notifying the dam owner of the revocation or suspension and the reasons why the approval is being revoked or suspended. Such notice shall be in conformance with the Administrative Procedures Act, R.I. Gen. Laws Sections 42-35-9(b) and 42-35-14, as amended.

(3) The dam owner issued a notice of revocation/suspension of an approval may request an adjudicatory hearing to contest the revocation as set forth in the provisions of Rule 15 of these Rules and Regulations. A notice of revocation/suspension of an approval automatically becomes a final order of the Director enforceable in Superior Court upon failure to request said adjudicatory hearing.

(4) Modification of an approval shall be in accordance with Rule 10(B) of these Rules and Regulations.

RULE 11. INSPECTIONS

(A) SCHEDULED INSPECTIONS

(1) Regulated dams shall be inspected in accordance with the following schedule. These time periods are the maximum time between inspections and more frequent inspections may be performed at the discretion of the Director.

Hazard Classification	Minimum Inspection Frequency	Type of Inspection
High	2 years	Visual
Significant	5 years	Visual
Low	5 years	Hazard Classification Assessment

(2) The Director shall periodically perform or require the owner to perform a visual inspection of all high hazard dams and significant hazard dams. The Director will notify the owner by certified letter in the event that the Department will require the owner to perform a visual inspection of the dam. The owner must then retain a qualified engineer to perform a visual inspection of the dam. Visual inspection by a qualified engineer must be completed within sixty (60) days following receipt of notification from the Director.

(3) At any time, the owner may elect to employ the services of a qualified engineer to perform a visual inspection of his or her dam.

(4) Whenever the findings of the visual inspection reveal, in the opinion of the Director, that the dam may be unsafe, the owner shall be required to retain a qualified engineer to perform a detailed investigation of the dam and to provide a schedule by which any work needed shall be accomplished. The owner shall be responsible for completing all work required by the Director and in a reasonable time frame required by the Director.

(5) Evaluations of regulated, low hazard dams shall be conducted by the Director at least every five (5) years to determine whether conditions have changed over time that warrant raising the hazard classification to significant or high. If the Director determines the classification of a low hazard dam should be raised to significant or high, the owner shall be informed of the classification change in accordance with Rule 9(A) of these Rules and Regulations.

(B) UNSCHEDULED INSPECTIONS

(1) Any person who has cause to believe that an unsafe dam exists may make a request to the Director to inspect the dam. If in the opinion of the Director, the failure of the dam will result in a probable loss of human life or cause major economic loss, disruption of lifeline facilities or impact other concerns detrimental to the public's health, safety or welfare, then the Director shall perform a visual inspection, or cause a visual inspection to be performed, of the dam to determine if the dam is unsafe.

(2) The Director shall, whenever he or she has cause to believe that an unsafe dam exists, perform a visual inspection, or cause a visual inspection to be performed, of the dam to determine if the dam is unsafe.

(C) INSPECTIONS

(1) Visual Inspections
A qualified engineer or a Department dam engineer must perform a visual inspection. The visual inspection shall include an assessment of the condition of the major components of the dam subjectively rated as *good*, *fair* or *poor*. The major components of a dam are the embankment(s), the spillway(s) and the low level control structure(s). *Good* is defined as meeting minimum guidelines, where no irregularities are observed and the component appears to be maintained properly. *Fair* is defined as a component that requires maintenance. *Poor* is defined as a component that has deteriorated beyond a maintenance issue and requires repair; the component no longer functions as it was originally intended.

(2) Detailed Investigations

A qualified engineer must perform a detailed investigation. A detailed investigation may include soil analysis, concrete or earth stability analysis, materials testing, foundation explorations, hydraulic and hydrologic analysis, including basin studies, flood potential, and an analysis of the dam's ability to pass flood waters.

(D) INSPECTION REPORTS

A report must be prepared for each visual inspection or detailed investigation. If deficiencies are found, the report must identify the specific deficiencies and, when warranted, specify further investigation or corrective measures. The report, completed by a qualified engineer retained by a dam owner, must provide a recommended schedule to complete any work identified as necessary to correct the deficiencies noted in the report. Such reports must be provided to the dam owner and the Director within thirty (30) days of the date of the visual inspection or within sixty (60) days of the date of the detailed investigation.

RULE 12. UNSAFE DAMS

(A) Whenever the Director determines that a dam is unsafe the Director shall determine whether the water in the reservoir shall be drawn off in whole or in part, and the actions necessary to make the dam safe.

(B) The Director shall notify the owner or person maintaining or having control of the dam, by certified mail, that the dam is unsafe, the actions necessary to make the dam safe and a schedule to complete the actions.

(C) The Director may notify the owner or person maintaining or having control of the dam, by certified mail, that the dam is unsafe after completing his/her own inspection or after receiving an inspection report completed by a qualified engineer.

(D) The Director may, pursuant to R.I. Gen. Laws Section 42-17.1-2(u), issue an immediate compliance order stating the existence of the unsafe condition and the action deemed necessary to correct the unsafe condition. The Director may order the water in the reservoir to be drawn off, in whole or in part. The immediate compliance order shall become effective immediately upon service or within such time as is specified by the Director in such order.

(E) Any emergency action taken by the owner or person maintaining or having control of a dam shall immediately be reported by the dam owner to the Director and the municipality(s) in which the dam and reservoir lies. The owner or person maintaining or having control of a dam shall also report, by telephone within twenty-four (24) hours and in writing within three (3) days, the emergency action taken.

(F) If water has been drawn off or the dam has been altered pursuant to an order by the Director, the reservoir shall not be refilled without approval of the Director.

(G) If the owner or person maintaining or having control of a dam fails to comply with an order of the Director, the Director may also, by summons and complaint, seek to enforce the order in a court of competent jurisdiction.

RULE 13. ACCESS

The Director shall conduct all inspections in accordance with the "Administrative Inspection Guidelines", adopted on January 23, 2003, and any amendments thereto.

RULE 14. ENFORCEMENT ACTIONS

As set forth in R.I. Gen. Laws Chapter 42-17.1, et seq. and Section 42-17.6-1 et seq., the Director shall have the power to issue enforcement notices, orders, administrative penalties or other requirements to ensure compliance with these Rules and Regulations. The Director may also provide written or verbal warning of his/her intent to undertake enforcement action, but is not required to do so. Nothing in these Rules and Regulations shall limit the authority of the attorney general to prosecute offenders as required by law. The Department shall forward a copy of the enforcement notices and/or orders to recognized watershed councils in accordance with the *Rules and Regulations of the Rhode Island Rivers Council for Watershed Council Grants and Notification of Proposed Actions to Watershed Councils* and the municipality wherein the dam is located.

RULE 15. APPEALS

(A) The procedures for appeal of Departmental decisions pursuant to the provisions of Chapter 42-35 of the R.I. Gen. Laws are contained in the "Administrative Rules of Practice and Procedure for the Department of Environmental Management Administrative Adjudication Division for Environmental Matters".

(B) Within thirty (30) days of the receipt of a decision from the Department regarding an application for repair of a dam or hazard classification of a dam, the owner may request an adjudicatory hearing to appeal the decision, or portions thereof. The request for an adjudicatory hearing must be in writing, must comply in form and content for such requests as required by the "Administrative Rules of Practice and Procedure for the Administrative Adjudication Division for Environmental Matters", and must be filed directly with the Administrative Adjudication Division (AAD) of the Department. A copy of such request must also be forwarded to the Dam Safety Program. A request for an adjudicatory hearing automatically stays any contested approval issued for repair of a dam. It shall be the dam owner's burden to demonstrate by a preponderance of the evidence that the application as proposed or hazard classification is consistent with the purposes of the law, complies with these Rules and Regulations and protects the public, real property and natural resources.

(C) Any person who has received a Notice of Violation (NOV) alleging violation of these Rules and Regulations, or whose approval has been suspended or revoked, may appeal to the Director for review of the decision on which the NOV, suspension or revocation is based by filing an appeal with AAD.

(1) Filing of Appeal - All appeals shall be in writing and shall be filed with and received by AAD within twenty (20) days after the date of receipt of the subject NOV, or within thirty (30) days after receipt of the revocation or suspension.

(2) Contents of Appeal - Every appeal shall contain a detailed basis upon which the appeal is taken.

RULE 16. SEVERABILITY

If any provision of these Rules and Regulations, or the application thereof to any person or circumstance, is held invalid by a court of competent jurisdiction, the validity of the remainder of the Rules and Regulations shall not be affected thereby.

RULE 17. EFFECTIVE DATE

The foregoing Rules and Regulations for Dam Safety, after due notice, are hereby adopted and filed with the Secretary of State this _____ day of _____, 2007 to become effective twenty (20) days thereafter, in accordance with the provisions of Chapters 46-19, 42-35, 42-17.1, and 42-17.6 of the General Laws of Rhode Island of 1956, as amended.

_____

W. Michael Sullivan, Director
Department of Environmental Management

Notice Given on: July 23, 2007

Public Hearing held: August 23, 2007

Filing Date:

Effective Date:

APPENDIX I: IMPACT AVOIDANCE AND MINIMIZATION

Rhode Island's Freshwater Wetlands Act (R.I. Gen. Laws Section 2-1-18 et seq.) and Water Pollution Act (R.I. Gen. Laws Section 46-12-1 et seq.) require the Director to protect freshwater wetland values and water quality, respectively. It is important for the dam owner to recognize the Director's responsibilities under these laws and to plan his/her repair projects to minimize any negative impacts to freshwater wetlands and water quality values. In particular, the dam owner must:

(A) Minimize the impacts from lowering the water elevation in a reservoir during a repair project, such as by installing a temporary cofferdam. This is necessary to reduce detrimental impacts to fish and wildlife associated with the wetland environment and to reduce loss of aquatic vegetation that serves as wildlife habitat. In the event that a dam owner is unable to install controls to maintain water in the reservoir to assist in protecting fish and wildlife habitat, the dam owner must specifically inform the Director of this situation and document in writing why water is not proposed to be maintained upstream of the dam during the repair activity. Efforts must be made to avoid drawdowns between April 15 to July 1, and to avoid significant drawdowns between October 15 and March 15.

(B) Use best management practices regarding the installation of sediment and erosion controls to prevent sediment from entering adjacent waters of the state.

(C) Minimize construction disturbance so as to keep disturbed soils and areas subject to erosion to a minimum.

(D) Prevent any hazardous substances injurious to aquatic life used during the repair activity from entering any adjacent water and freshwater wetlands.

(E) Stabilize all disturbed soils following construction activities to ensure erosion will not take place.

(F) Minimize clearing of vegetation to that necessary to conduct the project and remove the slash material from adjacent freshwater wetlands and water bodies.

(G) Use only the amount of fill of other material necessary to complete the project and minimize the placement of material in any flood plain.

(H) Replace, restore or mitigate alterations to freshwater wetlands as deemed necessary in the opinion of the Department.

E.40. South Carolina



South Carolina Department of Health and Environmental Control - www.scdhec.gov

Water

Dams and Reservoir - Summary of Laws and Regulations

Summary of the SC Dams and Reservoirs Safety Act

The SC Dams and Reservoirs Safety Act is the basis of South Carolina's dams and reservoirs safety programs. The purpose of the act is protect citizens health, safety, and welfare by creating a regulatory program to reduce the risk of failure of dams. The law confers upon the Department the regulatory authority to accomplish the purposes of the act. This includes the power to promulgate regulations, require permits, conduct inspections and take enforcement actions among other things.

Section 49-11-190 of the act allows the Department to issue emergency orders as may be necessary from time to time to protect life and property. This section also allows the Department to enter on private property to take immediate actions necessary to protect life and property when the owner of a dam does not comply with an emergency order.

Section 49-11-200 of the act requires a permit from the Department before a new dam may be constructed or before the alteration, repair, or removal of an existing dam.

Section 49-11-230 grants authority to the Department to conduct inspections while Section 49-11-240 allows the Department entry on property to carry out the general provisions of the program.

In summary, this act empowers the Department to conduct the dams and reservoirs safety program through a wide range of activities such as permitting, inspections, compliance, monitoring, enforcement and public education. To meet the requirements of the act, the Department regulates a large number of dams.

Summary of Regulation 72-1: Dams and Reservoirs Safety Act Regulations

The regulations were initially approved in 1977 and they were most recently amended in July of 1997. The regulations for the most part mirror the requirements of the SC Dams and Reservoirs Safety Act. The regulations create a tiered permitting program based on a classification system of dams. Dams regulated by the Department are classified based on size and hazards. The size classifications are large, intermediate, small, and very small. Hazard classifications are high hazard, significant hazard, and low hazard.

These regulations specify the administrative process for obtaining a permit for either a new dam or the alteration, repair, or removal of an existing dam. The items required to be submitted to the Department as part of the permit application package are also given in the regulations as well as some general design criteria a dam must meet.

Bureau of Water . Phone: (803) 898-4300 . Fax: (803) 898-3795 . Contact Us

Welcome to the South Carolina Legislature Online

South Carolina Code of Laws
(Unannotated)
Current through the end of the 2009 Session

DISCLAIMER

The South Carolina Legislative Council is offering access to the unannotated South Carolina Code of Laws on the Internet as a service to the public. The unannotated South Carolina Code on the General Assembly's website is now current through the 2009 session. The unannotated South Carolina Code, consisting only of Code text and numbering, may be copied from this website at the reader's expense and effort without need for permission.

The Legislative Council is unable to assist users of this service with legal questions. Also, legislative staff cannot respond to requests for legal advice or the application of the law to specific facts. Therefore, to understand and protect your legal rights, you should consult your own private lawyer regarding all legal questions.

While every effort was made to ensure the accuracy and completeness of the unannotated South Carolina Code available on the South Carolina General Assembly's website, the unannotated South Carolina Code is not official, and the state agencies preparing this website and the General Assembly are not responsible for any errors or omissions which may occur in these files. Only the current published volumes of the South Carolina Code of Laws Annotated and any pertinent acts and joint resolutions contain the official version.

Please note that the Legislative Council is not able to respond to individual inquiries regarding research or the features, format, or use of this website. However, you may notify Legislative Printing, Information and Technology Systems at LPITS@scstatehouse.gov regarding any apparent errors or omissions in content of Code sections on this website, in which case LPITS will relay the information to appropriate staff members of the South Carolina Legislative Council for investigation.

Title 49 - Waters, Water Resources and Drainage

CHAPTER 11.

DAMS

ARTICLE 1.

GENERAL PROVISIONS

SECTION 49-11-10. Prohibition on dams or banks erected or water let off to injury of others.

No person shall be permitted or allowed to make or keep up any dam or bank to stop the course of any waters so as to overflow the lands of another person without the consent of such person first had and obtained nor shall any person be permitted or allowed to let off any reserved water to injure the crops upon the grounds of other persons.

SECTION 49-11-20. Persons may not keep water on other's lands.

Nothing contained herein shall be construed to authorize any person to keep water at any time on any lands other than his own.

ARTICLE 3.

DAMS AND RESERVOIRS SAFETY ACT

SECTION 49-11-110. Short title.

This article shall be cited as the "Dams and Reservoirs Safety Act."

SECTION 49-11-120. Definitions.

Unless the context otherwise requires, as used in this article:

(1) "Alterations" and "repairs" mean only the alterations or repairs which may affect the safety of a dam or reservoir.

(2) "Appurtenant works" include, but are not limited to, structures such as spillways, either in the dam or separate from it, low-level outlet works, and water conduits.

(3) "Department" means the South Carolina Department of Health and Environmental Control or its staff or agents.

(4) "Dam" means an artificial barrier with appurtenant works, including, but not limited to, dams, levees, dikes, or floodwalls for the impoundment or diversion of waters or other fluids where failure may cause danger to life or property. However, this does not include a dam:

(a) less than twenty-five feet in height from the natural bed of the stream or watercourse measured at the downstream toe of the dam, or less than twenty-five feet from the lowest elevation of the outside limit of the dam, if it is not across a stream channel or watercourse, to the maximum water storage elevation and has an impounding capacity at maximum water storage elevation of less than fifty-acre feet unless a situation exists where the hazard potential as determined by the department is such that dam failure or improper reservoir operation may cause loss of human life;

(b) owned or operated by a department or an agency of the federal government;

(c) owned or licensed by the Federal Energy Regulatory Commission, the South Carolina Public Service Authority, the Nuclear Regulatory Commission, the United States Corps of Engineers, or other responsible federal licensing agencies considered appropriate by the department;

(d) upon which the Department of Transportation or county or municipal governments have accepted maintenance responsibility for a road or highway where that road or highway is the only danger to life or property with respect to failure of the dam.

(5) "Districts" means the soil and water conservation districts of this State. For the purposes of this article the districts may serve as agents and advisors to the department.

(6) "Danger to life or property" means a situation exists where the hazard potential as determined by the department is such that dam failure or improper reservoir operation may cause injury to persons, loss of human life, or damage to property.

(7) "Detailed inspection" means all studies, investigations, and analyses necessary to evaluate conclusively the structural safety and hydraulic capacity of a dam or reservoir and appurtenant works. This inspection includes, but is not limited to, soil analyses, concrete or earth stability analyses, materials testing, foundation explorations, and hydrologic analyses, including basin studies and flood potential. This inspection must be performed by a qualified registered professional engineer.

(8) "Enlargement" means a change in or an addition to an existing dam or reservoir which raises or may raise the water storage elevation of the water impounded by the dam or reservoir.

(9) "Owner" means those who own, control, operate, maintain, manage, or propose to construct a dam or reservoir.

(10) "Removal" means destruction or breaching of an existing dam or drainage of water impoundment or reservoir.

(11) "Reservoir" means a reservoir which contains the impoundment of water by a dam or reservoir.

(12) "Order" means a written document prepared and issued by the department which mandates specific actions to be accomplished by a dam owner within a specified time frame. Failure to comply makes the owner subject to penalties outlined in Section 49-11-260.

(13) "Unsafe" means the condition of the dam is such that repairs or alterations are necessary to reduce the risk of dam failure.

SECTION 49-11-130. Declaration of purpose.

It is the purpose of this article to provide for the certification and inspection of certain dams in South Carolina in the interest of public health, safety, and welfare in order to reduce the risk of failure of the dams, prevent injuries to persons and damage to property, and confer upon the department the regulatory authority to accomplish the purposes.

SECTION 49-11-140. General duties of department.

The authority for the safe maintenance of the dams and reservoirs of this State and the powers of inspection and certification provided in this article are the responsibility of the department. The department may employ engineers and technicians it considers necessary to implement this article for which appropriations are available.

SECTION 49-11-150. Owner responsible for safe maintenance of dam or reservoir; notice of change of ownership; emergency action plan requirement.

The owner of a dam or reservoir constructed in this State solely is responsible for maintaining the dam or reservoir in a safe condition throughout the life of the structure. The owner of a dam or reservoir shall inform the department in writing within thirty days after title to the dam or reservoir legally has been transferred from his ownership. The notice must include the name and address of the new owner. The owner of a dam or reservoir whose failure likely would cause loss of life or substantial property damage, a dam or reservoir classified as a high or significant hazard under existing regulations, shall provide the department a current emergency action plan in the format the department by regulation requires.

SECTION 49-11-160. Order to maintain, alter, repair, or remove dam or reservoir; findings supporting order.

The department may issue an order directing the owner of a dam or reservoir to make at his expense the necessary maintenance, alteration, repair, or removal upon a finding that the dam or reservoir:

(a) is or has become unsafe and is dangerous to life or property;

(b) is not maintained in good repair or operating condition; or

(c) is not maintained or operated in accordance with the terms and conditions of the certificate of completion and operation issued by the department.

SECTION 49-11-170. Bringing unsafe dams to attention of department; preliminary inspections;

detailed inspection at owner's expense; notice to owner; hearings.

(A) The existence of a dam which is not maintained in good repair or operating condition or may be unsafe and a danger to life or property may be brought to the attention of the department by complaint, staff, or authorized investigation or by other means.

(B) Upon staff or other authorized investigations or upon receipt of a written private complaint alleging that the person or property of the complainant is endangered by the construction, maintenance, operation, or condition of a dam or reservoir, the department shall cause a preliminary inspection of the structure and downstream development to be made by field observations to determine if the complaint is meritorious. The department may require the owner of the dam or reservoir to provide data, records, and design plans of the structure specified by regulations.

(C) If upon the preliminary inspection it is determined that the dam or reservoir is unsafe and is dangerous to life or property, the department may order the owner at his expense to make a detailed inspection of the dam and reservoir and surrounding area and to provide to the department within a time frame specified by the department plans prepared by a qualified registered professional engineer for correction of all deficiencies of the dam or to provide to the department plans and specifications for removal of the dam. In either instance the plans must be approved by the department before implementation and implemented within a time frame specified by the department. If upon inspection it is determined that the dam or reservoir has not been maintained in good repair or operating condition, the department may order the owner at his expense to accomplish the necessary maintenance or to obtain a permit for removal and to remove the dam within a time frame specified by the department.

(D) The department shall give the owner notice of its action when:

(1) a complaint has been filed alleging that the owners' dam or reservoir is unsafe and a danger to life or property stating the nature of the complaint;

(2) a preliminary inspection has been made with findings.

(E) The owner of a dam or reservoir determined through a preliminary inspection not to be maintained in good repair or operating condition or to be unsafe and a danger to life or property may request a hearing before the board of the department within thirty days after notice of the findings are delivered. The owner may submit written or present oral evidence which must be considered by the board of the department in the issuance of the order.

SECTION 49-11-180. Voluntary compliance; time extensions.

(A) The department may solicit voluntary compliance by the owner of a dam or reservoir found to be unsafe and a danger to life or property to take remedial steps necessary to render the dam safe.

(B) Extension of time to complete work specified in an order may be granted by the department. No extension may be granted when there appears substantial and immediate danger of dam failure.

SECTION 49-11-190. Emergency orders; owner to notify department of emergency; action when owner is unknown or fails to comply with order.

(A) The department immediately shall order remedial measures necessary to protect life or property if the condition of a dam or reservoir is so dangerous to the safety of life or property as not to permit time for the issuance and enforcement of a repair order or passing or imminent floods threaten overtopping erosion or destruction of a dam or reservoir capable of danger to life or property.

(B) In applying emergency measures the department has the following limited powers to order the owner to:

(1) lower the water level by releasing water from the reservoir;

(2) empty the reservoir completely;

(3) take other steps essential to safeguard life and property.

(C) For an emergency where the owner finds repairs are necessary to safeguard life or property, he may start the repairs immediately but shall notify the department at once of the proposed repair and work underway.

(D) When the owner fails to comply with the emergency order or cannot be ascertained or found, the department or its authorized agents may enter and immediately take actions necessary to provide protection to life or property, including removal of the dam. The department may recover from the owner, in the name of the State, the expenses incurred in taking the action in the same manner debts are recoverable by law.

SECTION 49-11-200. Department approval required for construction or alteration; exceptions.

(A) The construction of a new dam or reservoir or enlargement, removal, or repair may not begin until the owner has applied for and obtained from the department written approval of plans and specifications.

(B) Where the location and size of the dam or reservoir renders the requirements of subsection (A) and Section 49-11-210 unnecessary, the department may grant approval and waive certain nonessential requirements in instances, including, but not limited to, small dams and reservoirs for agricultural, fish or wildlife, or recreational uses on private lands and of no danger to other life or property downstream.

SECTION 49-11-210. Separate application required for each alteration; information to accompany application.

A separate application for each dam or reservoir and all enlargements, removals, or repairs to existing dams or reservoirs must be filed with the department upon forms to be provided by it, except only one application need be filed for a dam and the reservoir which will contain the water impounded by the dam. The application must be accompanied by maps and plans and specifications of a character and size and setting forth pertinent details and dimensions required by regulation. The application for construction of a new dam or reservoir whose failure likely would cause loss of life or substantial property damage, a dam or reservoir classified as high or significant hazard under existing regulations, must include a fully-developed emergency action plan in a format the department by regulation requires. After the dam or reservoir is constructed, this emergency action plan must be updated by the owner of the dam or reservoir each time it becomes noncurrent.

SECTION 49-11-220. Filing of certification of approved design; designs by federal agencies excepted.

An applicant for approval of a dam or reservoir subject to Section 49-11-200 also shall file with the department a design approved by a registered professional engineer legally qualified in the State. Dams designed by the USDA-Soil Conservation Service or other federal agencies do not require certification by a registered professional engineer.

SECTION 49-11-230. Inspections during construction; maximum rate of discharge for water released during construction.

(A) The department may make necessary inspections during construction of new dams and reservoirs, enlargements, removal, and repairs of dams and reservoirs and during work done pursuant to repair orders to assure compliance with the approved plans and specifications or provisions of the order.

(B) If water is to be released during the construction, repair, or removal, the department shall specify the maximum discharge rate allowable to avoid endangering or causing injury to downstream owners.

SECTION 49-11-240. Authority of department to inspect and enter on lands and waterways; regulations.

(A) The department or its authorized agents may inspect the dam or reservoir and surrounding area to determine the safety of the structure.

(B) An authorized member, agency, or representative of the department may enter state or private lands and natural or artificial waterways in the State to discharge the duties set forth in this article.

(C) The department shall formulate reasonable regulations, including, but not limited to, minimum safety design standards for impoundments, safety inspection standards, water discharge, or drawdown rates and levels in unsafe impoundments and for other purposes necessary to administer this article.

(D) The department shall issue all orders, permits, or licenses set forth in this article.

SECTION 49-11-250. Liability for actions or failure to act.

Nothing in this article and no action or failure to act under this article:

(1) imposes liability on the State, the department, districts, or an agency or its officers or employees for the recovery of damages caused by the action or failure to act; or

(2) relieves the owner or operator of a dam or reservoir of the duties, obligations, responsibilities, or liabilities arising from or incident to the ownership or operation of a dam or reservoir.

SECTION 49-11-260. Penalties; injunction; appeals; disposition of fines.

(A) A person violating this article is guilty of a misdemeanor and, upon conviction, must be fined not less than one hundred nor more than five hundred dollars. Each day the violation continues after notice to take corrective action is a separate offense.

(B) The department may assess an administrative fine of not less than one hundred nor more than one thousand dollars against a person who violates this article or an order issued or regulation promulgated pursuant to it. In determining the amount of the fine the department shall consider the degree and extent of harm caused by the violation and the cost of rectifying the damage. Fines assessed under this subsection may be appealed to the department who may reduce them based on information presented at the appeal hearing.

(C) Upon a violation of this article or related regulations the department may institute legal action to obtain injunctive relief in the name of the department.

(D) A person against whom a final order or decision has been made, except for emergencies specified in Section 49-11-190, may appeal to the board under the Administrative Procedures Act. The burden of proof is on the party attacking an order or a decision of the department to show that the order is unlawful or unreasonable.

(E) Civil fines collected under this article must be deposited in a special account of the department to fund educational activities relating to dams and reservoirs safety, including, but not limited to, workshops, seminars, manuals, and brochures.

E.41. South Dakota



CHAPTER 74:02:08

SAFETY OF DAMS

Section
74:02:08:01 Definitions.
74:02:08:02 Scope.
74:02:08:03 Intent.
74:02:08:04 Actions required to be performed by engineers.
74:02:08:05 Classification of dams -- Hazard potential.
74:02:08:05.01 Preliminary risk assessment.
74:02:08:06 Classification of dams -- Size.
74:02:08:07 Minimum spillway design flood requirements -- Exception.
74:02:08:07.01 Category 3 spillway design flood exception.
74:02:08:07.02 Category 2 spillway design flood exemption.
74:02:08:07.03 Design requirements for category 1 tailings dams.
74:02:08:07.04 Design requirements for dams constructed without spillways.
74:02:08:08 Additional design requirements.
74:02:08:09 Contents of plans and specifications.
74:02:08:10 Emergency preparedness plan.
74:02:08:11 Periodic inspection program.

74:02:08:01. Definitions. Terms defined by SDCL 46-1 to 46-7, inclusive, have the same meaning when used in this chapter. In addition, terms used in this chapter mean:

(1) "Area capacity curves," graphic curves which show the relationship between reservoir surface area and the storage capacity of the reservoir at given elevations;

(2) "Breach analysis," a simulated dam failure performed to determine the outflow hydrograph and to route the resulting flood wave;

(3) "Category 1 dam," a high hazard dam whose failure may cause loss of life;

(4) "Category 2 dam," a significant hazard dam whose failure may cause damage to buildings, highways, railroads, bridges, or public utilities; loss of a water supply reservoir for a water distribution system; other extensive economic loss; or the reservoir is the only source of water for a water distribution system;

(5) "Category 3 dam," a low hazard dam whose failure may cause limited damage to agricultural lands or county and township roads or minimum economic loss;

(6) "Conservation storage capacity," the volume in acre-feet in the reservoir at the crest of the primary spillway;

(7) "Dam," for the purpose of this chapter an artificial barrier, including appurtenant works, which impounds or diverts water and which is 25 feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum water storage elevation or has an impounding capacity at maximum water storage elevation of 50 acre-feet or more. A barrier is not considered a dam for the purpose of this chapter if the height does not exceed 6 feet regardless of storage capacity or if the storage capacity at maximum water storage elevation does not exceed 15 acre-feet regardless of height;

(8) "Effective height," the difference in elevation in feet between the lowest point in the cross section taken along the centerline of the dam and the crest of the emergency spillway. If there is no emergency spillway, the top of the dam is the upper limit;

(9) "Emergency preparedness plan," "EPP," a predetermined plan of action to be taken to reduce the potential for property damage and loss of lives in an area that may be affected by a dam break;

(10) "Engineer," a person who is registered as a professional engineer pursuant to SDCL 36-18, or a person who is employed by a federal or state agency and who designs or inspects dams as part of the person's employment, acting under the supervision of a professional engineer registered pursuant to SDCL 36-18;

(11) "Freeboard," the vertical distance between the top of the dam and the estimated maximum water level;

(12) "Height," the difference in the elevation of either the natural bed of the stream or watercourse or the lowest point on the toe of the dam, whichever is lower, and the crest elevation of the dam;

(13) "Inspection," a visual or mechanical check by measuring, boring, or any method necessary to determine the adequacy of construction techniques and the safety and operating performance of a dam;

(14) "Intermediate storage capacity," the volume in acre-feet in the reservoir at the crest of the emergency spillway;

(15) "Maximum storage capacity," the volume in acre-feet in the reservoir at the crest of the dam;

(16) "Owner," "dam owner," a person as defined by SDCL 46-1-6(1) who owns, controls, operates, maintains, manages, or proposes to construct a dam or reservoir;

(17) "Preliminary risk assessment," as applied to dam safety, the process of identifying the downstream hazard potential for the purpose of classifying a dam;

(18) "Probable maximum flood," "PMF," the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are possible in the region;

(19) "Probable maximum precipitation," "PMP," the precipitation that may be expected from the most severe combination of critical meteorologic conditions that are reasonably possible in an area as found in the National Weather Service Hydrometeorological Report No. 51, "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian"; or Hydrometeorological Report No. 55, "Probable Maximum Precipitation Estimates, United States Between the Continental Divide and the 103rd Meridian";

(20) "Process water," water that may have chemicals, sewage, metals, or any other material added to it during the use of the water in an operation;

(21) "Risk assessment," as applied to dam safety, the process of identifying the likelihood and consequences of dam failure to provide the basis for informed decisions on a course of action;

(22) "Spillway," an open or closed channel, conduit, or drop structure used to convey water from a reservoir.

(23) "Spillway design flood," the flood that the spillway of a given project is designated to pass safely without overtopping the structure;

(24) "25-year, 24-hour duration flood," the flood magnitude expected to be equaled or exceeded on the average of once in 25 years, with a four percent chance of being exceeded in any given year, determined by using the 25-year, 24-hour storm unless gauging data is available and proved to be accurate;

(25) "50-year, 24-hour duration flood," the flood magnitude expected to be equaled or exceeded on the average of once in 50 years, with a two percent chance of being exceeded in any given year, determined by using the 50-year, 24-hour storm unless gauging data is available and proved to be accurate;

(26) "100-year flood," the flood magnitude expected to be equaled or exceeded on the average of once in 100 years, with a one percent chance of being exceeded in any given year, determined by using the 100-year, 24-hour storm unless gauging data is available and proved to be accurate.

Source: 13 SDR 49, effective October 27, 1986; 13 SDR 129, 13 SDR 141, effective July 1, 1987; 13 SDR 197, effective July 2, 1987; 14 SDR 67, effective November 8, 1987; 15 SDR 158, effective April 23, 1989.

General Authority: SDCL 46-2-5, 46-7-3.

Law Implemented: SDCL 46-1-6, 46-1-15, 46-5-10, 46-5-11, 46-5-47, 46-7-3, 46-7-5.

References: Hydrometeorological Report No. 51, "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian," June 1978, Reprinted August 1986; Hydrometeorological Report No. 55, "Probable Maximum Precipitation Estimates, United States Between the Continental Divide and the 103rd Meridian," March 1984, prepared by the Office of Hydrology, National Weather Service, National Oceanic and Atmospheric Administration, U. S. Department of Commerce. Copies may be obtained from the Division of Water Rights, Joe Foss Building, 523 East Capitol Avenue, at no cost.

74:02:08:02. Scope. This chapter applies to all new dams and all existing Category 1 dams and Category 2 dams. Category 2 dams constructed before October 27, 1986, that have highways across the crest or that have highways, railroads, or bridges below the dams are exempt from spillway requirements unless a dam fails and is to be rebuilt and provided that an emergency plan is established by the owner to monitor the dam and procedures are established to close the crest highways or downstream highways, railroads, and bridges during flood conditions. Other category 2 dams constructed before October 27, 1986, are exempt from spillway requirements, except for dams that serve as the sole source of water for a water distribution system or whose failure may cause extensive downstream damage, unless a dam fails and is to be rebuilt and provided that the spillway capacities comply with spillway requirements for category 3 dams. Category 3 dams constructed before October 27, 1986, are exempt from spillway requirements unless a dam fails and is to be rebuilt. Reconstruction of category 2 and 3 dams that fail must comply with the requirements of § 74:02:08:07. New dams are dams constructed after October 26, 1986.

If the classification of a category 3 dam changes to a category 2 or 1 dam or if a category 2 dam changes to a category 1 dam, the spillway capacity must comply with the spillway requirements for the new category classification.

Source: 13 SDR 49, effective October 27, 1986; 13 SDR 129, 13 SDR 141, effective July 1, 1987; 13 SDR 197, effective July 2, 1987; 14 SDR 67, effective November 8, 1987.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-5-8, 46-5-30, 46-7-3, 46-7-5.

Note: The owner of a dam may be responsible for resultant damage if a dam fails. Although § 74:02:08:02 exempts category 3 and certain category 2 dams constructed before October 27, 1986, from the spillway requirements of § 74:02:08:07, the owner should make an assessment of the risks and potential for damage in the event of dam failure.

74:02:08:03. Intent. The intent of this chapter is to provide minimum standards for design, construction, alteration, maintenance, and repair of dams and to prevent loss of life. These standards are not intended to apply to ordinary maintenance and repair of dams if the work is performed in accordance with an original design prepared by an engineer and no change in safety hazard or purpose is involved.

When conflicts develop in the interpretation of the rules in this chapter, this section will be the basis for settlement of the conflicts.

Source: 13 SDR 49, effective October 27, 1986; 13 SDR 129, 13 SDR 141, effective July 1, 1987; 13 SDR 197, effective July 2, 1987.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-1-15, 46-5-10, 46-5-11, 46-5-30, 46-5-47, 46-7-3, 46-7-5.

74:02:08:04. Actions required to be performed by engineers. The following shall be completed by engineers:

(1) Prepare plans and specifications for the construction of new dams or alteration of existing dams;
(2) Inspect the construction or alteration of dams; and
(3) Perform periodic inspections, detailed investigations, and analyses of existing dams.

Source: 13 SDR 49, effective October 27, 1986; 13 SDR 129, 13 SDR 141, effective July 1, 1987.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-1-15, 46-5-10, 46-5-11, 46-5-47, 46-7-3, 46-7-5.

74:02:08:05. Classification of dams -- Hazard potential. The classification of dams based on potential hazards is as follows:

CATEGORY	LOSS OF LIFE POTENTIAL	ECONOMIC LOSS POTENTIAL
3	None expected	Minimal (undeveloped to
		occasional structures)
2	None expected	Extensive (community
		or industry)
1	Potential loss	

Source: 13 SDR 49, effective October 27, 1986; 13 SDR 129, 13 SDR 141, effective July 1, 1987; 13 SDR 197, effective July 2, 1987.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-1-15, 46-5-8, 46-5-10, 46-5-11, 46-5-30, 46-7-3, 46-7-5.

74:02:08:05.01. Preliminary risk assessment. The chief engineer may request a preliminary risk assessment. The preliminary risk assessment shall consist of an on-site inspection of the downstream area with a description of any structures and an elevation in reference to the stream channel bottom. The hazard classification is subject to approval of the preliminary risk assessment by the chief engineer. The preliminary risk assessment must be performed by an engineer as defined in this chapter.

Source: 15 SDR 158, effective April 23, 1989.
General Authority: SDCL 46-2-5, 46-7-3.

Law Implemented: SDCL 46-1-15, 46-5-8, 46-5-10, 46-5-11, 46-5-30, 46-7-3, 46-7-5.

74:02:08:06. Classification of dams -- Size. The classification of dams by size is as follows: The size classification is determined by either the maximum storage capacity or the height, whichever gives the larger size category.

SIZE	STORAGE CAPACITY	HEIGHT
	(acre-feet)	(feet)
Small	50 to 1000	25 to 40
Intermediate	1001 to 50,000	41 to 100
Large	greater than 50,000	greater than 100

Source: 13 SDR 49, effective October 27, 1986; 13 SDR 129, 13 SDR 141, effective July 1, 1987; 13 SDR 197, effective July 2, 1987.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-5-8, 46-5-30, 46-7-3, 46-7-5.

74:02:08:07. Minimum spillway design flood requirements -- Exception. The hydraulic capacity of a dam must, by category and size, be such that the following minimum spillway design floods can be passed through the spillways without overtopping the structure:

CATEGORY	SIZE	SPILLWAY DESIGN FLOOD
3	Small	50-year frequency unless dam
		qualifies for § 74:02:08:07.01
		exception
	Intermediate	100-year frequency
	Large	0.5 PMF
2	Small	100-year frequency
	Intermediate	0.5 PMF, unless dam qualifies
		for § 74:02:08:07.02 exception
	Large	PMF
1	Small	0.5 PMF
	Intermediate	0.5 PMF
	Large	PMF

A spillway system for a dam must meet the requirements in this section unless the owner can provide information and justification to show the chief engineer that the proposed design

flow can be stored, passed through, or passed over the dam without failure of the dam or if a variance is granted pursuant to SDCL 46-7-5.3.

Source: 13 SDR 49, effective October 27, 1986; 13 SDR 129, 13 SDR 141, effective July 1, 1987; 13 SDR 197, effective July 2, 1987; 14 SDR 67, effective November 8, 1987.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-5-8, 46-5-30, 46-7-3, 46-7-5, 46-7-5.3.

74:02:08:07.01. Category 3 spillway design flood exception. For small size category 3 dams with an emergency spillway, the minimum spillway design flood is a 25-year frequency if the product of the intermediate storage capacity times the effective height is less than 3000. For small size category 3 dams without an emergency spillway, the spillway design flood is a 25-year frequency if the product of the maximum storage capacity times the effective height is less than 3000.

Source: 13 SDR 197, effective July 2, 1987.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-5-8, 46-5-30, 46-7-3, 46-7-5.

74:02:08:07.02. Category 2 spillway design flood exemption. Unless the reservoir of a category 2 dam serves as the sole water supply source for a water distribution system, the spillway design flood for a new or rebuilt intermediate size category 2 dam may be lowered to a design flood between the 0.5 PMF and 100-year spillway design flood based upon a risk assessment. The risk assessment must be submitted to and approved by the chief engineer.

Source: 14 SDR 67, effective November 8, 1987.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-5-8, 46-5-30, 46-7-3, 46-7-5.

74:02:08:07.03. Design requirements for category 1 tailings dams. Dams constructed to store, without discharge, tailings as defined by 45-6B-3 (14) shall be sized to retain the PMF plus at least a 100-year flood.

Source: 14 SDR 67, effective November 8, 1987.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-5-8, 46-5-30.

74:02:08:07.04. Design requirements for dams constructed without spillways. Dams which are designed and constructed without spillways and constructed so that there is no external drainage into the facility, and constructed for the purpose of containing process water shall be sized to contain design operating volumes from the operation plus enough freeboard to contain the PMP falling on the facility.

Source: 15 SDR 158, effective April 23, 1989.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-5-8, 46-5-30.

74:02:08:08. Additional design requirements. In addition to the minimum spillway design flood requirements of § 74:02:08:07, all new category 1 and 2 dams must have low-level drawdown facilities. If an existing category 1 or 2 dam undergoes extensive repairs which require complete drawing down of the reservoir or is being repaired after the dam has failed, a low-level drawdown facility must be installed. A low-level drawdown facility may be either a gated pipe through the embankment that would allow the release of water below the primary spillway or sufficient available pumping capacity to draw down the reservoir. A breach analysis report must be completed by the owner for the proposed dam if a preliminary risk assessment indicates that the dam is a category 1 or 2 dam and must be submitted to the chief engineer with the plans and specifications required by § 74:02:08:09. A breach analysis, if required, must be performed with a simulated water surface at or above the top of the dam.

Source: 13 SDR 49, effective October 27, 1986; 13 SDR 129, 13 SDR 141, effective July 1, 1987; 13 SDR 197, effective July 2, 1987; 15 SDR 158, effective April 23, 1989.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-5-8 to 46-5-11, 46-5-47, 46-7-3, 46-7-5.

74:02:08:09. Contents of plans and specifications. Minimum plans and specifications submitted to the chief engineer for review must include the following:

(1) A topographic map of the dam site specifying the legal description of the proposed dam and the location of the spillway and outlet works, and all test borings, test pits, and borrow pits. The map shall also show all property contiguous to the dam site and contiguous to the flood zone behind the dam and the owners of the contiguous property;

(2) A profile along the dam axis showing the location, elevations, and depth of borings or test pits, including logs of bore holes or test pits;

(3) A maximum cross-section of the dam showing the elevation and width of the crest; slopes of upstream and downstream faces; thickness of riprap; zoning of earth embankment; location of cutoff and bonding trenches; and elevations, size, and type of outlet conduit, valves, and operating mechanism;

(4) Area-capacity curves of the proposed reservoir;

(5) Detailed drawings showing plans, cross and longitudinal sections of the outlet conduits, valves and controls for operating the outlet, and trash racks;

(6) The discharge capacity in cubic feet per second of the spillway for each foot in water depth above the spillway crest up to the maximum high-water level and the formula used in making the calculations;

(7) Detailed plans of spillway structures, cross-section of the channel heading to and from the spillway, spillway profile, and procedures for operation of the spillway structure;

(8) Specifications including provisions during the period of construction for supervision by an engineer; and

(9) An EPP for a proposed category 1 dam.

Reconstruction, alteration, or repair that requires plans and specifications, or breaching of an existing dam may not begin until plans and specifications have been approved by the chief engineer. Construction of a new dam pursuant to this chapter may not begin until plans and specifications have been approved by the chief engineer and a water permit to construct the dam has been approved by the water management board pursuant to SDCL 46-2A-7 or 46-2A-11.

Source: 13 SDR 49, effective October 27, 1986; 13 SDR 129, 13 SDR 141, effective July 1, 1987; 13 SDR 197, effective July 2, 1987; 14 SDR 67, effective November 8, 1987.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-1-15, 46-5-8 to 46-5-11, 46-5-47, 46-7-3, 46-7-5.

74:02:08:10. Emergency preparedness plan. An EPP shall be prepared by the owner for all existing category 1 dams and submitted to the chief engineer for approval prior to January 1, 1988.

Source: 13 SDR 49, effective October 27, 1986; 13 SDR 129, 13 SDR 141, effective July 1, 1987.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-5-8, 46-7-3, 46-7-5.

74:02:08:11. Periodic inspection program. The chief engineer may inspect all category 1 dams at least once every five years or as often as necessary in order to ensure the continued safety of a dam.

Source: 13 SDR 49, effective October 27, 1986; 13 SDR 129, 13 SDR 141, effective July 1, 1987.
General Authority: SDCL 46-2-5, 46-7-3.
Law Implemented: SDCL 46-2-19, 46-5-8, 46-5-30, 46-7-3, 46-7-5.

SOUTH DAKOTA DAM SAFETY LAWS AND REGULATIONS

Citation

South Dakota dam safety statutes are contained in the South Dakota Codified Laws (SDCL) Chapter 46-7, enacted in 1955 and last amended in 1996. Dam safety regulations are in Administrative Rules of South Dakota (ARSD) Chapter 74:02:08, which became effective in 1986 and were last amended in 1992.

History

South Dakota participated in the U.S. Army Corps of Engineers National Dam Safety inspection program of 1978-1981. South Dakota Safety of Dams Rules, Chapter 74:02:08 were adopted in 1986 after the 1984 failure of Menno Dam, a state-owned high-hazard-potential dam.

Definitions/Dam Classifications

The term *dam* is defined in ARSD 74:02:08:01 (7) as "an artificial or manmade barrier that is 25 feet or more in height or that may store more than 50 acre-feet of water". A barrier is not considered a dam if the height does not exceed 6 feet regardless of storage capacity, or if the storage capacity at maximum storage elevation does not exceed 15 acre-feet regardless of height. The term *height* is defined in the same section as "the difference in the elevation of either the natural bed of the stream or watercourse or the lowest point on the toe of the dam, whichever is lower, and the crest elevation of the dam.

Dams are classified according to hazard potential and size:

Hazard Potential

Category	Loss of Life Potential	Economic Loss Potential
3	none expected	minimal
2	none expected	appreciable
1	potential loss	extensive

Size Classification

Size	Storage Capacity (acre-feet)	Height (feet)
Small	50 - 1000	25 - 40
Intermediate	1001 - 50,000	41 - 100
Large	greater than 50,000	greater than 100

Design Criteria

Hydrologic:

74:02:08:07. Minimum spillway design flood requirements -- Exception. The hydraulic capacity of a dam must, by category and size, be such that the

following minimum spillway design floods can be passed through the spillways without overtopping the structure:

Category	*Size*	*Spillway Design Flood*
3	Small	50-year frequency unless dam qualifies for exception
	Intermediate	100-year frequency
	Large	0.5 PMF
2	Small	100-year frequency
	Intermediate	0.5 PMF, unless dam qualifies
	Large	PMF
1	Small	0.5 PMF
	Intermediate	0.5 PMF
	Large	PMF

A spillway system for a dam must meet these requirements unless the owner can provide information and justification to show the chief engineer that the proposed design flow can be stored, passed through, or passed over the dam without failure of the dam or if a variance is granted pursuant to SDCL 46-7-5.3.

Seismic: South Dakota has no specific Seismic Criteria.

Jurisdiction/Powers of Department

The Chief Engineer of the SD Water Rights Program has the statutory authority to review and approve or disapprove plans to construct, alter, maintain or repair dams.

(See ARSD 74:02:08:03 and :09) The Chief Engineer, according to the provisions of SDCL 46-7-5, may also inspect dams, and if a dam is found to be in an unsafe condition, issue orders for remedial work to be done at the owner's expense. The statutes (Section 46-7-5.1) also grant to the Chief Engineer the authority to enter upon the property of a dam owner who has failed or refused to comply with an order to repair, for the purpose of making the necessary changes. Powers in an emergency situation are addressed in SDCL Section 46-7-5.2

Section 78:02:08:09 of the Rules states that the Chief Engineer must review and approve plans and specifications prior to the new construction, reconstruction, alteration, repair or breaching of a dam. In addition, the Water Management Board has the power to issue permits for construction and impoundment, and a permit must be obtained prior to the construction of a new dam. The Water Management Board is also responsible for the promulgation of rules to establish minimum safety standards for the design, construction, alteration, maintenance and repair of works. (See SDCL 46-7-3)

Permit/Approval Process

ARSD 74:02:08:09 requires that minimum plans and specifications for the design, construction, or alteration of dams be submitted to the Chief Engineer for review, and sets forth the types of information which must be included. Plans and specifications must be prepared, and construction or alteration inspections must be performed by a

registered professional engineer in accordance with the provisions of ARSD 74:02:08:01. Plans and specifications must be approved, and a water permit to construct must be acquired from the Water Management Board before new construction can begin.

Minimum spillway design flood requirements are listed for each hazard category and size of dam in the rules, section 74:02:08:07. Exceptions to these standards, standards for tailings dams, and additional design requirements are addressed in ARSD 74:02:08:07.01 through :07.04. Water permit application fees are addressed in SDCL Section 46-2-13.

Fees: Fees are based on storage capacity, the 1st 120 acre-feet = $150.00, the 2nd 120 acre-feet = $75.00 and then each additional 120 acre-feet = $25.00 plus a $50.00 inspection fee.

Inspection Process

ARSD 74:02:08:11 authorizes the Chief Engineer to inspect all category 1 dams at least once every 5 years or as often as necessary in order to ensure the continued safety of a dam. If the works are found to be unsafe, the Chief Engineer is authorized by law (SDCL 46-7-5) to issue an order for necessary changes within a specified time, and if the owner fails to make the repairs, the Chief Engineer may enter the property and put the works in a safe condition. Costs incurred are borne by the owner. Inspection fees are not assessed by the state.

Section 46-7-3 of the statutes charges the owner of a dam with the responsibility of keeping the works "in good repair at all times" to ensure safety of the works. Additionally, the rules (section 74:02:08:04) require that periodic inspections, detailed investigations, and analysis of existing dams be performed by registered professional engineer. No requirements regarding the scheduling or frequency of such inspections are found in the statutes or rules.

Frequency of Inspections

Hazard Classification	*Inspection Cycle*
High	Every 3 years.
Significant	Every 3 years.
Low	Every 3 years if state-owned

Owner Non-Compliance/Violations/Penalties

SDCL Sections 46-7-5 and 5.1 state that if upon inspection, the Chief Engineer finds that a dam is in an unsafe condition, he may issue an order for remedial work or repairs within a specified time limit. If the owner fails or refuses to make the required repairs, the Chief Engineer is authorized to enter the property and make them. Costs of such repairs are the responsibility of the owner, and may be recorded as a lien against the owner's property until paid. It is also noted in the statutes that the authorization of these activities does not limit any other remedy against the owner of the works, although additional penalties may include fines, and are referenced in SDCL 46-1-11.

Emergencies

Emergency procedures are addressed in SDCL 46-7-5.2. The Chief Engineer may immediately breach or repair any works if, in his judgment, it is necessary to protect human life from imminent danger. Emergency Preparedness Plans (Rules 74:02:08:09 & :10) are required to be prepared and submitted by the owners of all existing category 1 dams, and as part of the plans and specifications for proposed category 1 dams.

Liability

SDCL 46-7-5 provides that "The Chief Engineer, the state or its employees shall not incur any liability, either sovereign or personal, as a result of the duties imposed by this section or other provisions related to the inspection and repair, maintenance or alteration of works or the notification to owners of unsafe conditions".

Oversight

A hearing process by which owners may contest an order of the Chief Engineer is described in SDCL 46-7-5. Owners may file a written protest, which suspends the operation of the order until a hearing has been scheduled and action taken by the Water Management Board. In addition, Section 46-7-5.3 allows owners to petition the Chief Engineer for a variance to board rules relating to minimum spillway design requirements. The Chief Engineer then investigates the works and conducts the necessary analysis to determine the potential for damage to downstream residents or property in the case of failure due to inadequate spillway capacity. After the investigation and analysis, the Chief Engineer may recommend to the Water Management Board that the variance request be granted or denied.

SDCL 46-7-5.4 through 5.11 provides that owners of privately owned high hazard dams who refuse to correct an unsafe condition identified by order of the Chief Engineer may execute an affidavit assuming liability for the dam and holding the state harmless from all such liability and damages to the dam's failure. The affidavit must certify, among other things, that the owner's family is the only family inhabiting the floodplain.

Miscellaneous

1. SDCL 46-7-1 provides that the owners of a storage or diversion works may be required to make excess capacity of the works (over and above that needed by the owner for lawful application of water to beneficial use) available at reasonable rates, to any person entitled to use water for beneficial purposes. The Water Management Board is responsible for determining the amount of excess capacity, establishing reasonable rates, and setting the amount of compensation to be paid the owner for damage to the works.

2. The Water Management Board is authorized in SDCL 46-7-2 to require any appropriator to construct head gates and measuring devices before allowing the diversion of water.

3. Section 46-7-14 of the statutes makes it unlawful in the state for any person to interfere with, damage or destroy any dam or embankment, or to interfere with or damage any pier, boom, gate or piles used in securing a dam.

State Citations

	STATUTE	REGULATIONS
Original	1955	1986
Last Amended	1990	1992

State Web Site: http://www.state.sd.us/denr/denr.html

E.42. Tennessee



RULES
OF
TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER SUPPLY

CHAPTER 1200-5-7
RULES AND REGULATIONS APPLIED TO THE SAFE DAMS ACT OF 1973

TABLE OF CONTENTS

1200-5-7-.01	General	1200-5-7-.06	Standards for Existing Dams
1200-5-7-.02	Definitions	1200-5-7-.07	Design Standards for New Dams
1200-5-7-.03	Duties and Authority	1200-5-7-.08	Engineering Requirements
1200-5-7-.04	Certificates of Construction, Operation and Alteration	1200-5-7-.09	Fees
		1200-5-7-.10	Emergency Action by Owner
1200-5-7-.05	Classification of Dams	1200-5-7-.11	Repealed

1200-5-7-.01 GENERAL.

(1) Passed on May 1, 1973, "The Safe Dams Act of 1973", *T.C.A. §69-11-101 et seq.,* provides that on or after July 1, 1973, no person shall construct, enlarge, repair, alter, remove, maintain, or operate a non-federal dam in the State of Tennessee without first obtaining a certificate. The Act further requires every owner of a dam file with the Commissioner of Environment and Conservation an application for a certificate.

(2) Under the Act, certain provisions and conditions are established for the issuance and continuance of said certificates, and authority is granted the Commissioner for the adoption of general rules and regulations which he deems necessary to accomplish the purpose of the Act. To safeguard the public by reducing the risk of failure of such dams, the following rules and regulations are made to (1) effect the orderly inventory and inspection of existing dams in Tennessee; (2) provide for pre-construction review and approval of all future dam construction and alteration of dams; and (3) allow for a program of regular inspection of dams within the State.

Authority: *T.C.A. §§4-5-202, 69-11-101 et seq., and 69-11-104.* ***Administrative History:*** *Original rule filed August 19, 1987; effective October 3, 1987. Amendment filed August 2, 1995; effective October 15, 1995.*

1200-5-7-.02 DEFINITIONS. For the purpose of these rules and regulations, the term:

(1) Abutment means the bordering area of the dam site which functions as a support for the ends of the dam structure.

(2) Act means "The Safe Dams Act of 1973", *T.C.A. §69-11-101 et seq.*, as amended.

(3) Alterations means any repair, change to the structure, removal or change in use of a dam that may affect the safety of that dam.

(4) Applicant means any owner of an existing or new dam who applies to the Division for a "Certificate" under the provisions of the Act.

(5) Appurtenant Works means such structures as spillways, either in the dam or separate therefrom; the reservoir and its rims; water level outlet works; access bridges; and water conduits such as tunnels, pipelines or penstocks, either through the dam or its abutments.

(6) Certificate means a "Certificate" as required by the Act for the construction, alteration, or operation of a dam.

(Rule 1200-5-7-.02, continued)

(7) Commence Construction means the actual start of on-site building but does not include preliminary surveying work or engineering plans preparation.

(8) Commissioner means the Commissioner of the Department of Environment and Conservation, his duly authorized representatives and in the event of his absence or a vacancy in the office of Commissioner, the Deputy Commissioner .

(9) Conduit means any closed waterway including but not limited to, a cast-in-place cut-and-cover culvert, a precast or prefabricated pipe embedded in the dam or foundation or a tunnel bored through the dam.

(10) Dam means any artificial barrier, together with appurtenant works, which does or may impound or divert water, and which either (1) is or will be twenty (20) feet or more in height from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the Commissioner, or (2) has or will have an impounding capacity at maximum water storage elevation of thirty (30) acre-feet or more. Provided, however, that any such barrier which is or will be less than six (6) feet in height, regardless of storage capacity, or which has or will have a maximum storage capacity not in excess of fifteen (15) acre-feet, regardless of height, shall not be considered a dam, nor shall any barrier, regardless of size, be considered a dam, if, in the judgment of the Commissioner, such barrier creates an impoundment used only as a farm pond. Diversion weirs, roadbeds, water tanks, and wastewater impoundment barriers as defined in this section are not dams.

(11) Days means calendar days, including Sundays and holidays.

(12) Division means the Division of Water Supply of the Tennessee Department of Environment and Conservation.

(13) Director means the Director of the Division of Water Supply of the Department of Environment and Conservation of the State of Tennessee.

(14) Diversion Weir means a structure substantially within the bed of a stream, designed to impound water only during low flow conditions, that would not cause substantial overflow of water onto the downstream floodplain in the event of failure, and meets the definition of a Category 3 dam in Rule 1200-5-7-.05(2)(b)(3).

(15) Easily Erodible means any soil with a plasticity index of less than ten (10) or greater than forty (40).

(16) Emergency Spillway means the spillway which conveys out of the reservoir any runoff in excess of that conveyed by the principal spillway.

(17) Engineer means a professional engineer registered by the State of Tennessee.

(18) Erosion Resistant means any soil not easily erodible.

(19) Existing Dam means any dam complete and capable of impounding water prior to October 3, 1987.

(20) Enlargement means any change in, or addition to, an existing dam or reservoir, which does or may raise the water storage elevation of the dam.

(Rule 1200-5-7-.02, continued)

(21) Factor of Safety means the ratio of the forces or moments resisting mass movement to the forces or moments tending to produce mass movement.

(22) Farm Pond means any impoundment used only for providing water for agricultural and domestic purposes such as livestock and poultry watering, irrigation of crops, recreation, and conservation, for the owner or occupant of the farm, his family, and invited guests, but does not include any impoundment for which the water, or privileges or products of the water, are available to the general public.

General Public as used above means patrons, members, and customers of institutions and/or clubs such as but not limited to summer camps, schools, retirement facilities, churches, private clubs, communes, hunting clubs, and health care facilities.

The following are some examples of impoundments which are not farm ponds:

Lakes owned or operated by a city, county, or the state, lakes that lie on three or more property parcels, residential subdivision lakes, industrial waste impoundments, industrial water supply impoundments, impoundments owned or used by hunting clubs, public water supply impoundments, commercial land development impoundments, and watershed district impoundments.

The following are some examples of impoundments which are farm ponds:

1. Impoundments directly used in support of farming operations.

2. Impoundments used for agriculture, livestock watering, recreation or conservation solely by the owner and not available to the general public.

(23) Foundation means the earth or rock on which the dam rests.

(24) Freeboard means the difference in elevation between the top of the dam and the maximum reservoir water surface that would result should the inflow design flood occur and should the outlet works function as planned.

(25) Impoundment means the water or liquid substance that is or will be stored by a dam.

(26) Maximum Water Storage Elevation means the elevation of the lowest point on the top of the dam, excluding any spillway structures.

(27) Maximum Storage Capacity means the volume of water stored at the maximum water storage elevation.

(28) New Dam means any dam that is not an existing dam.

(29) Normal Water Storage Elevation means the normal elevation of water surface which is obtained by the reservoir when the intake and outlet works are operating as planned during periods of normal precipitation and runoff and not during periods of drought or flood.

(30) Owner means any person who owns an interest in, controls, or operates a dam.

(31) Person means any individual, firm, association, organization, partnership, business trust, corporation, company, county, municipal or quasi-municipal corporation, public utility, utility or other district, the State of Tennessee and its departments, divisions, institutions, and agencies, and the duly authorized officers, agents, and representatives thereof, or any

(Rule 1200-5-7-.02, continued)

combination of any of the above. Person does not include the United States government nor any agency owned by the United States or any agency thereof, nor those who own a dam or reservoir leased to or operated by the United States or any agency thereof, nor those dams licensed by the Federal Energy Regulatory Commission (previously the Federal Power Commission).

(32) Principal Spillway means the spillway which conveys normal runoff out of the reservoir.

(33) Probable Maximum Precipitation (PMP) means the greatest amount of rainfall of a six-hour duration which would be expected for a given drainage basin as determined by National Weather Service meteorological estimates. The PMP for 10 square miles shall be used for watersheds smaller than 10 square miles.

(34) Probable Maximum Flood (PMF) means the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is derived from the probable maximum precipitation (PMP).

(35) Removal means altering a dam such that it is no longer a dam as defined in these rules.

(36) Reservoir means any basin which contains or will contain the water impounded by a dam.

(37) Roadbed means the earth support work of a road prepared for surfacing which is not intended to impound water and which does not impound water continuously.

(38) Spillway means the feature of a storage or detention dam which is designed to release surplus water, and at diversion dams is a means to bypass flows exceeding those which are turned into the diversion system.

(39) Structural Height means the height of the dam measured from the natural bed of the stream or watercourse at the downstream toe of the barrier to the low point in the top of the dam.

(40) Wastewater Impoundment Barrier means an artificial barrier impounding a body of wastewater for the purpose of treatment and designed so that no surface runoff from areas adjacent to the barrier is introduced into the impoundment.

(41) Water Tank means a vessel designed and used to hold water.

Authority: *T.C.A. §§4-5-202, 69-11-101 et seq., and 69-11-104.* ***Administrative History:*** *Original rule filed August 19, 1987; effective October 3, 1987. Amendment filed August 2, 1995; effective October 15, 1995. Amendment filed December 6, 2000; effective February 19, 2001. Amendment filed April 18, 2008; effective July 2, 2008.*

1200-5-7-.03 DUTIES AND AUTHORITY. The general responsibility to administer and enforce the provisions of this Act and all rules and regulations thereunder shall be carried out by the Division of Water Supply of the Department of Environment and Conservation.

Authority: *T.C.A. §§4-5-202, 69-11-101 et seq., and 69-11-104.* ***Administrative History:*** *Original rule filed August 19, 1987; effective October 3, 1987. Amendment filed August 2, 1995; effective October 15, 1995.*

1200-5-7-.04 CERTIFICATES OF CONSTRUCTION, OPERATION, AND ALTERATION.

(1) General Provisions for Certificates.

(Rule 1200-5-7-.04, continued)

(a) Certificate applications shall be made on forms available from the Commissioner. Where there are multiple owners of a dam, each owner shall not be required to file an application if all owners are listed in the application filed by any one of them.

(b) Application for a Certificate shall be made on forms available from the Commissioner and shall include the following information:

1. The name of the dam.

2. The name of the owner.

3. The legal address of the owner and/or lessee.

4. The location of the dam.

5. The type, size and height of the dam.

6. The storage capacity and reservoir surface area for normal and maximum water surface elevation.

7. The purpose or purposes for which the dam or reservoir is to be used.

8. In the case of an application by an owner or lessee of a dam, the names and addresses of all persons having a real property interest in the dam.

9. Such other plans and detailed information as the Commissioner may deem reasonable and necessary to fulfill his responsibilities hereunder.

(c) An owner making application for an Alteration or Construction Certificate shall engage a qualified professional engineer, practicing in accordance with the registration laws of Tennessee, to plan, to prepare designs and specifications, and to supervise construction. This engineer must be qualified and experienced in the design and construction of dams of the type proposed and may be required to present evidence of his qualifications to undertake the project.

(d) The Commissioner shall examine the application for a certificate of approval and cause an on-the-ground inspection to be made of the existing or proposed dam or reservoir and downstream floodplain. He shall then, within sixty (60) days of the receipt of the completed application for a certificate of approval, either grant the certificate or disapprove it in writing, stating the reasons for disapproval. In the case of applications for construction certificates, applicants who fail to submit, within 18 months from the date of the original application submittal, plans or other detailed information required by the Commissioner must refile an application and plans review fee to obtain a construction certificate.

(e) Certificates are not transferable from one person to another or from one dam to another.

(f) The Commissioner shall be notified of any proposed change in the operation of a dam.

(g) Certificates shall not be granted until all fees required by the provisions of the Act and these rules have been paid.

(Rule 1200-5-7-.04, continued)

(h) It shall be a violation of the Safe Dams Act for any person to knowingly submit a false or inaccurate report, data, or information.

(2) Operating Certificate.

(a) No person shall operate a dam without an Operating Certificate.

(b) Application for an Operating Certificate for a new dam already having a Construction Certificate shall be made on forms available from the Commissioner within thirty (30) days of the completion of the dam. The application shall be accompanied by a history of the construction of the dam as maintained by the responsible engineer and by a statement signed by the responsible engineer certifying that the project was constructed in conformity with approved plans and specifications. The history of construction shall include but not be limited to:

1. A record of all geological and foundation data.

2. Date, location, and results of all material tests made.

3. Narrative of problems encountered during construction and changes in design. (Necessity for such changes shall be reported to the Division for approval before proceeding with construction.)

4. Photographs of completed foundations, critical features (such as construction and backfilling around conduits and low level outlet structures) and periodic stages of construction are desirable. These may be required for selected projects.

5. A record of permanent location points, benchmarks, and any instruments embedded in the structure.

6. Plans which show the actual construction of the dam after changes in the original design.

(c) Application for an Operating Certificate for a dam already having an Alteration Certificate shall be made within thirty (30) days from the completion of the alteration on forms available from the Commissioner. The application shall be accompanied by a statement signed by the responsible engineer certifying that the project was constructed in conformity with the approved plans and specifications. Additional information about the construction, such as that listed in 1200-5-7-.04(2)(b), must be included if the Commissioner determines that such information is needed to insure that the alteration is constructed properly.

(d) Any new dam or dam alteration must be constructed in accordance with the approved plans and specifications in order to receive an Operating Certificate.

(e) A new dam must not be allowed to impound water other than transient storage due to storm runoff until an Operating Certificate has been issued.

(f) Application for an Operating Certificate shall be made on forms available from the Commissioner. Any dam owner who is notified by the Commissioner of the need to apply for an Operating Certificate shall submit such application within thirty (30) days.

(Rule 1200-5-7-.04, continued)

(g) Whenever legal title to a dam, for which a certificate of approval has been issued, is modified to create real property interests, including leasehold interests, in persons not listed on the application for such certificate, the owner of such dam shall make application for a new certificate within ninety (90) days of the date such interests are created, other provisions of this chapter notwithstanding.

(h) An Operating Certificate shall be issued only on evidence satisfactory to the Commissioner that the requirements of Rule 1200-5-7-.06 are being met for an existing dam and the requirements of Rule 1200-5-7-.07 are being met for a new dam.

(3) Construction Certificate.

(a) No person shall commence construction on a new dam without first obtaining a Construction Certificate from the Commissioner.

(b) Application for a Construction Certificate shall be made at least 60 days prior to the commencement of construction on forms available from the Commissioner.

(c) The Commissioner shall issue a Construction Certificate for construction of a new dam only if the requirements of Rule 1200-5-7-.07 Design Standards for New Dams, Rule 1200-5-7-.08 Engineering Requirements, and Rule 1200-5-7-.09 Fees, are met.

(d) The owner or his agent shall provide written notice to the Commissioner within five days of the date that construction commences and shall include the name of the engineer's inspector. For dams which are to be greater than 30 feet high or which will impound more than 100 acre-feet at the maximum storage capacity, the engineer in charge of construction or his inspector shall be on site whenever construction is occurring. The Commissioner may require such full time inspectors on smaller dams as he deems necessary. During construction the Commissioner may make such inspections as are needed to ensure conformity with approved plans and specifications. The inspection by the Commissioner does not relieve the owner or the responsible engineer from providing adequate inspection of the construction in progress.

(e) If at any time during the progress of the work the Commissioner finds that the work is not being done in accordance with the approved plans and specifications or approved revisions, he shall serve written notice to that effect to the owner. Such notice shall state the particulars in which the approved plans and specifications have not been complied with and may request the suspension of work until such compliance has been effected. If, after due notice, the owner, or his duly authorized agents, fails to comply with the requirements of the above notice, the Certificate by which construction is authorized shall be subject to revocation by the Commissioner.

(f) The owner or his agent shall give written notice of the completion of the dam to the Commissioner within five (5) days of the completion or in time for the Commissioner's representative to be present at the final inspection with the engineer and the contractor, whichever occurs sooner.

(4) Alteration Certificate.

(a) No person shall make an alteration to a dam without first obtaining an Alteration Certificate.

(Rule 1200-5-7-.04, continued)

(b) Application for an Alteration Certificate shall be made on forms available from the Commissioner at least 60 days prior to a planned alteration. The application shall identify the dam, state reasons why alteration, repair, or removal is necessary, give details of the proposed work, and provide an evaluation of the effects of the contemplated action. Plans and specifications will accompany the application along with a schedule for accomplishing the proposed project. The plans and specifications shall be submitted in conformance with Rule 1200-5-7-.08. The Commissioner may require full time inspection of any alteration construction by the responsible engineer or his inspector as he determines is necessary to ensure that the construction is performed properly.

(c) The owner or his agent shall provide written notice to the Commissioner within five days of the date that construction commences and shall include the name of the engineer's inspector if an inspector is required. The owner or his agent shall give written notice of the completion of the alteration to the Commissioner within five (5) days of the completion or in time for the Commissioner's representative to be present at the final inspection with the engineer and the contractor, whichever occurs sooner.

(d) In the event of an emergency where immediate repairs are necessary to safeguard life and property, such repairs shall be made immediately by the owner, or his duly authorized agents, and in accordance with Rule 1200-5-7-.10. In such events, the Commissioner shall be notified of the necessary emergency repairs and of work under way. The owner shall give written notice to the Commissioner within two days of learning of the emergency.

(5) Duration of Certificates.

(a) Construction and Alteration Certificates shall be for a single construction event. Construction Certificates shall be valid only for construction that begins within one year of issuance of the certificate.

(b) Alteration and Operating Certificates shall be valid for a definite period of time, not to exceed five (5) years, as determined by the Commissioner and stated on the certificate. In determining the period of approval, the Commissioner may take account of any circumstances pertinent to the situation, including, but not limited to, the size and type of dam, topography, geology, soil conditions, hydrology, climate, use of reservoir and the lands lying in the floodplain downstream from the dam, and the hazard category of the dam.

(6) Imposition of Additional Conditions - Hazard Categories.

(a) In granting a Certificate, the Commissioner may impose such conditions relating to the inspection, operation, maintenance, alteration, repair, use, or control of a dam or reservoir as he determines are necessary for the protection of public health, safety, or welfare.

(b) The Commissioner shall establish hazard categories for dams in accordance with Rule 1200-5-7-.05(2).

(7) Modification of certificates. The Commissioner may modify a Certificate or the conditions attached to it. Such modifications shall become effective ninety (90) days following issuance by the Commissioner of a revised Certificate, except when the Commissioner finds that a state of emergency exists, and that life or property would be endangered by delay. In case of

an emergency declared by the Commissioner, the new conditions shall be effective immediately.

(8) Suspension, Revocation, or Modification. The Commissioner may revoke, suspend, or modify any Certificate issued pursuant to the Act or deny the issuance of a Certificate for cause including, but not limited to the following:

(a) Violation of any condition of said Certificate.

(b) Obtaining a Certificate by misrepresentation, or failure to disclose fully all relevant facts.

(c) Violation of any provision of the Act or any rule promulgated thereunder.

(9) Rights of Appeal. Any applicant aggrieved by the denial of a Certificate or any term or condition in a Certificate may appeal to the Commissioner for a hearing within sixty (60) days of the date of issuance of the Certificate or the denial of a Certificate. After sixty (60) days no such appeal may be filed. All appeals shall be conducted in accordance with *T.C.A. §69-11-118* of the Act and Uniform Administrative Procedures Act, *T.C.A. §§4-5-301 et seq.*

Authority: *T.C.A. §§4-5-202, 69-11-101 et seq., and 69-11-104.* ***Administrative History:*** *Original rule filed August 19, 1987; effective October 3, 1987. Amendment filed August 2, 1995; effective October 15, 1995. Amendment filed December 6, 2000; effective February 19, 2001. Amendment filed April 18, 2008; effective July 2, 2008.*

1200-5-7-.05 CLASSIFICATION OF DAMS. Dams will be classified in accordance to size, hazard potential, and design characteristics in order to formulate a priority basis for selecting dams to be scheduled in the inspection program and also to provide compatibility between guideline requirements and involved risks. When conditions at the dam or the hazard potential changes, the dam may be reclassified, and, if necessary, the dam must be upgraded to meet the standards of the new classification. The downstream conditions will be evaluated for hazard potential reclassification at least every 5 years.

(1) Size. The classification for size is based on the height of the dam and storage capacity in accordance with the table below. The height of the dam is established with respect to the maximum water storage elevation measured from the natural bed of the stream or watercourse at the downstream toe of the barrier, or if it is not across a stream or watercourse, the height from the lowest elevation of the outside limit of the barrier, to the maximum water storage elevation. For the purpose of determining project size, the maximum storage elevation will be considered equal to the top of dam elevation as defined in Rule 1200-5-7-.02(26). Size classification will be determined by either storage or height, whichever gives the larger size category. For size classification purposes, fractions of heights and storages shall be rounded down to the nearest whole number, e.g., 49.9 feet would be classified in the 20 to 49 feet category.

Size Classification

Category	Storage (Ac-Ft)	Height (Ft)
Small	30 to 999	20 to 49
Intermediate	1,000 to 49,999	50 to 99
Large	50,000 or greater	100 or greater

(2) Hazard Potential Category.

(Rule 1200-5-7-.05, continued)

(a) Every dam will be assigned a hazard potential category to reflect the damage which might occur in the event of a dam failure, either structurally or operationally. The hazard potential will take into account a number of factors which will include, but not be limited to: the physical characteristics and degree of development of the site and valley downstream; the relationship of the site to industrial and residential areas; use of downstream properties throughout the danger reach; geological considerations; public and private uses of the impoundment or reservoir; and probable future downstream development.

(b) The hazard potential category of a dam may impose different standards at different sites for design and conditions for issuance of a Certificate and will have a bearing upon the frequency of inspections by the Commissioner. The following categories are established to permit the association of criteria with the damage that might result from such a failure.

1. Category 1 dams are located where failure would probably result in any of the following: loss of human life; excessive economic loss due to damage of downstream properties; excessive economic loss, public hazard, or public inconvenience due to loss of impoundment and/or damage to roads or any public or private utilities.

2. Category 2 dams are located where failure may damage downstream private or public property, but such damage would be relatively minor and within the general financial capabilities of the dam owner. Public hazard or inconvenience due to loss of roads or any public or private utilities would be minor and of short duration. Chances of loss of human life would be possible but remote.

3. Category 3 dams are located where failure may damage uninhabitable structures or land but such damage would probably be confined to the dam owner's property. No loss of human life would be expected.

(3) Removal of Dams. A dam shall be considered removed if it meets one of the following criteria.

(a) A portion of the dam is removed such that at the invert of the removed portion the dam is less than six feet high or has less than 15 acre-feet of storage capacity.

(b) A portion of the dam is removed or an open-channel spillway is built such that the invert of the removed portion is at the approximate elevation of the top of the tailings or sediment in the impoundment and the dam can no longer permanently impound water. In the case of embankment dams that receive surface runoff from areas adjacent to the impoundment, the open channel must be sufficiently large to preclude overtopping during the Freeboard Design Storm specified in Rule 1200-5-7-.06(3)(b) or Rule 1200-5-7-.07(4)(d), respectively.

Authority: *T.C.A. §§4-5-202, 69-11-101 et seq., and 69-11-104.* ***Administrative History:*** *Original rule filed August 19, 1987; effective October 3, 1987. Amendment filed August 2, 1995; effective October 15, 1995. Amendment filed December 6, 2000; effective February 19, 2001. Amendment filed April 18, 2008; effective July 2, 2008.*

1200-5-7-.06 STANDARDS FOR EXISTING DAMS.

(1) Stability. All dams shall be stable. There shall not be excessive cracks, sloughing, seepage or other signs of instability or deterioration. In cases where the stability of the dam is questionable, it shall be the responsibility of the owner to either demonstrate to the

(Rule 1200-5-7-.06, continued)

Commissioner that the dam is stable or drain the reservoir and remedy the unstable condition prior to refilling the reservoir.

(2) Slope Protection

(a) Earth embankments shall be protected from surface erosion by appropriate vegetation or some other type protective surface such as riprap or paving and shall be maintained. Examples of appropriate vegetation include, but are not limited to, Bermuda grass and fescue. All inappropriate vegetation such as honeysuckle, briers, bushes, and trees shall be removed from the dam. Some trees may be allowed to remain on a dam if the Commissioner concurs with a justification from a qualified engineer for doing so. Such justification must satisfy the Commissioner that the number, size, location, root characteristics, etc., of such trees will not adversely affect the dam's structural integrity and safety nor impede inspection.

(b) The root mass of all trees larger than four (4) inches in diameter as measured at two feet above ground level shall be grubbed out and the hole backfilled with suitable fill material properly compacted. Smaller trees may either be cut at ground level or be removed as specified above. The Commissioner may require an engineer to oversee the tree removal.

(3) Emergency Spillway.

(a) All dams shall have an emergency spillway system with capacity to pass a flow resulting from a 6 hour design storm indicated in (b) below for a hazard classification appropriate for the dam. However, if the applicant's engineer provides calculations, designs, and plans to show that the design flow can be stored, passed through, or passed over the dam without failure occurring, or if he can successfully demonstrate to the Commissioner by engineering analysis that the dam is a safe structure and can certify that the dam is sufficient to protect against probable loss of human life downstream, said dam design may be approved by the Commissioner.

(b) Minimum Freeboard Design Storms.

Hazard Potential Category	Size	Freeboard Design Storm (6 Hours)
Category 3 (Low)	Small	100 year
	Intermediate	1/3 PMP
	Large	1/2 PMP
Category 2 (Significant)	Small	1/3 PMP
	Intermediate	1/2 PMP
	Large	PMP
Category 1 (High)	Small	1/2 PMP
	Intermediate	PMP
	Large	PMP

(c) No dam which is modified after original construction to increase its design storm to a 1/2 PMP or greater shall be required to pass a larger design storm unless the dam itself is enlarged or its normal or maximum storage volume is increased.

(4) Concrete and Masonry Dams. Concrete and/or masonry dams shall be structurally sound and shall have joints free of trees and other vegetation and shall show no signs of significant

(Rule 1200-5-7-.06, continued)

structural deterioration such as excessive cracks, spallation, efflorescence and exposed reinforcing steel.

Authority: *T.C.A. §§4-5-202, 69-11-101 et seq., and 69-11-104.* ***Administrative History:*** *Original rule filed August 19, 1987; effective October 3, 1987. Amendment filed August 2, 1995; effective October 15, 1995. Amendment filed December 6, 2000; effective February 19, 2001.*

1200-5-7-.07 DESIGN STANDARDS FOR NEW DAMS.

(1) Design of Dams. Designs of dams shall conform to accepted practices and procedures of the engineering profession. Design references developed by the U.S. Army Corps of Engineers, Soil Conservation Service, and the Bureau of Reclamation may be used although the limiting criteria must be in accordance with these rules.

(a) All dams will be considered on an individual basis and reviewed in accordance with prevailing practices that are currently accepted by the engineering profession.

(b) All structures other than Category 3 dams constructed before 2008 shall be designed to withstand seismic accelerations of the following intensities: Zone 1 = 0.025g, Zone 2 = 0.05g, Zone 3 = 0.15g. Zones refer to "Geologic Hazards Map of Tennessee" by Robert A. Miller, 1978. All dams constructed during or after 2008 shall be designed to withstand the peak ground acceleration for an earthquake with a 10% probability of exceedance in 50 years as determined by the United States Geological Survey at the time the construction permit is issued. A different peak ground acceleration may be used if site specific studies using accepted engineering practices determine that a different value is appropriate.

(c) A complete engineering report, plans, and specifications shall be submitted for each dam.

(d) A complete geotechnical report shall be submitted as an integral part of the engineering report for all Hazard Potential Category (HPC) 1 and 2 dams (defined in Rule 1200-5-7-.05). For HPC 3 dams, sufficient investigation will have to be made to determine if the site and the fill material to be used are suitable, and this information will have to be included in the engineering report.

(e) A hydrologic/hydraulic analysis shall be submitted as an integral part of the engineering report for all dams. A breach analysis shall be submitted for all HPC 1 and HPC 2 dams and, for the former, shall be included in the Emergency Action Plan. The breach analysis must use surveyed cross sections at all stations where homes or other structures may be flooded. A sunny-day breach shall be modeled with the impoundment at the elevation of the emergency spillway invert when the failure begins, or, if there is no emergency spillway, at the elevation of the inlet of the principal spillway. Breach modeling under sunny-day, overtopping, or any other conditions, is site specific.

(f) All Category 1 dams shall submit to the Commissioner an Emergency Action Plan. This plan shall include, but not be limited to, the following:

1. Inundation information and an inundation map based on the breach analysis.

2. Procedures for notification of people downstream and law enforcement and other government agencies.

(Rule 1200-5-7-.07, continued)

3. Resources for emergency actions such as contractors, equipment supply businesses, etc.

(g) Design calculations for all major components of the structure, i.e., spillways, pipes, etc., shall be included in the engineering report.

(2) Principal Spillways.

(a) All component parts of the principal spillway except attached gates and trash racks will be of equal durability. The structural design criteria and detailing of such spillways will conform to recognized standards and codes of practice.

(b) In requiring the capacity of the principal spillway, the Commissioner may consider: (1) the benefits that accrue to the reduction of the discharge rate, (2) damages that may result from prolonged storage in the reservoir, (3) damages that may result from prolonged outflow, (4) the possibility of occurrence of significant runoff from two or more consecutive storm events within the time required to empty the reservoir, and (5) limitations in water rights or other legal requirements.

1. All conduits under a dam shall support the external loads imposed with an adequate factor of safety. They must withstand the internal hydraulic pressures without leakage under full external load and settlement. They must convey water at the design velocity without damage to the interior surface of the conduit.

2. Principal spillway conduits under earth dams shall be designed to support fill heights greater than the original constructed height where there is a reasonable possibility that it may become desirable to raise the embankment height at a later date to incorporate additional storage.

3. Principal spillway conduits shall be of reinforced concrete pipe, cast-in-place reinforced concrete, ductile iron pipe, or plastic pipe. Fill height and foundation conditions require special considerations for ductile iron pipe and plastic pipe so that each use will be checked on an individual basis; cradling or encasement in concrete may be required. Welded steel pipe is not acceptable for Category 1 and Category 2 dams, and corrugated metal pipe is not acceptable for any class of dam.

4. Principal spillway conduits shall be field tested for watertightness before backfilling. This requirement as well as the method of testing shall appear on the plans or in the specifications.

5. Rigid principal spillway conduits shall be designed as positive projecting conduits.

6. All reinforced concrete water pipe - steel cylinder type - prestressed, all reinforced concrete water pipe - steel cylinder type - not prestressed, and all reinforced concrete water pipe - noncylinder type - not prestressed, shall meet the AWWA specifications effective at the time of application.

7. Elliptical or other systems of reinforcement requiring special orientation of pipe sections are not permitted in pipe drop inlet barrels.

8. Reinforced concrete pipe, with or without cradles, shall be designed to support at least 12 feet of earth fill above the pipe at all points along the conduit.

(c) The minimum inside diameters of pipes shall be as follows:

1. Category 3 dams: The minimum diameter of the principal spillway barrel will be 18 inches for fill heights up to 50 feet and 24 inches for greater heights; or

   Where the drop inlet is designed hydraulically in such a way that the flow in the barrel under all possible conditions of discharge and foundation consolidation is positively known to be open channel flow with the water surface in the conduit subject to atmospheric pressure only, the minimum diameter shall be 18 inches; or

   Where welded steel pipe is used, the principal spillway shall be designed in accordance with conditions presented in Rule 1200-5-7-.07(2)(e).

2. Category 2 dams: The minimum diameter of the principal spillway barrel shall be 24 inches.

3. Category 1 dams: The minimum diameter of the principal spillway barrel shall be 30 inches.

4. Smaller conduits may be used if detailed calculations show them to be hydraulically and structurally adequate and all other requirements of Rule 1200-5-7-.07 are met.

(d) Where the barrel and cradle or bedding are to rest directly on firm bedrock thick enough so that there is essentially no foundation consolidation under the barrel, the cradle under the pipe need not be articulated.

(e) Principal spillways of welded steel pipe may be used for Category 3 dams under the following conditions, all of which must be met:

1. The minimum diameter of the barrel will be 18 inches.

2. The height of fill over the pipe will be less than 35 feet.

3. Welded steel pipe conduits are to conform to American Society of Testing Materials (ASTM) specifications A53, A120, A135, A139, or A134 and are to be structurally designed as rigid pipe. A joint extension safety margin of 1.5 inches is to be provided for conduits on yielding foundations. Welded pipe is to be protected by an approved exterior coating.

(f) Conduit joints will be designed and constructed to remain water tight under maximum anticipated hydrostatic head and maximum probable conditions of joint opening, including the effects of joint rotation, and must have a margin of safety where required.

(g) Trash racks will be designed and built to provide positive protection against clogging of the spillway at any point. The average velocity of flow through a clean trash rack will not exceed 2.5 feet per second with the water elevation in the reservoir five feet above the top of the trash rack or at the crest of the emergency spillway, whichever is lower. Velocity will be computed on the basis of the net area of opening through the rack.
For dry dams, a trash rack may be used in lieu of a ported concrete riser. The principal spillway trash rack will extend sufficiently above the anticipated sediment elevation at the inlet to provide full design flow through the spillway with velocities through the net

area of the trash rack above the sediment elevation not in excess of two feet per second when the water surface in the reservoir is five feet above the top of the trash rack.

(h) All closed conduit principal spillways designed for pressure flow will have an anti-vortex device.

(3) Drawdown Facilities.

(a) All new dams shall have a drawdown facility. This facility shall be capable of draining the reservoir in ten (10) days or less. It may be assumed that this requirement has been met if seventy-five (75) percent of the liquid volume from the normal water storage elevation has been evacuated in the ten (10) day period. The use of a longer period must be justified.

(b) The necessary drawdown facility for any dam shall be made an integral part of the principal spillway structure if the principal spillway configuration warrants it, but in no case will the drawdown facility be valved on the downstream side of the embankment. Siphon facilities will be accepted after proper engineering justification.

(c) The above stated requirement does not apply in the case of a water supply line through the dam, but in such cases provision must be made for a positive shutoff on the upstream side of the structure.

(d) Drawdown systems shall be maintained in an operable condition. Drawdown valves shall be opened and closed at least annually to ensure operability.

(4) Emergency Spillways.

(a) An emergency spillway shall be provided for each structure, unless the principal spillway is large enough to pass the routed freeboard hydrograph discharge and the debris that comes to it. A conduit type principal spillway having a barrel with a cross-sectional area of 20 square feet or more, an inlet which will not clog, and an elbow designed to facilitate the passage of debris, is the minimum size and design that may be utilized without an emergency spillway. If a principal spillway of this type and size is not provided, danger from clogging requires the use of an emergency spillway regardless of the volume of storage provided.

(b) A single uncontrolled open channel spillway may be used for all purposes provided it is designed to accommodate all discharges, including the freeboard storm, without damage to the structure. However, a positive means to drain the reservoir must also be provided.

(c) Emergency spillways shall be proportioned so that they will pass the freeboard hydrograph at the safe velocity determined for the site. They shall have sufficient capacity to pass the freeboard hydrograph with the water surface in the reservoir at or below the maximum storage elevation.

(d) Minimum Freeboard Design Storms

Size	Freeboard Design Storm (6 Hour)
Small	½ PMP
Intermediate	PMP

Large PMP

(e) All dams shall have an emergency spillway system with capacity to pass a flow resulting from a 6 hour design storm indicated in (d) above for the size corresponding to the dam. Any new dam constructed between October 3, 1987, and February 19, 2001, shall be required to pass the Freeboard Design Storm specified in subparagraph 1200-5-7-.06(3)(b). However, if the applicant's engineer provides calculations, designs, and plans to show that the design flow can be stored, passed through, or passed over the dam without failure occurring, or if he can successfully demonstrate to the Commissioner that the dam is a safe structure and can certify that the dam is sufficient to protect against probable loss of human life downstream, said dam design may be approved by the Commissioner. The establishment of the criteria in (d) above does not eliminate the need for sound engineering judgment but only establishes the lowest limit of design considered acceptable.

(f) The relationship between the water surface elevation in the reservoir and the discharge through the emergency spillway shall be evaluated by computing the head losses in the inlet channel upstream of the control section, or if a control section is not used, by computing the water surface profile through the full length of the spillway. Manning's formula will be used to evaluate friction losses and determine velocities.

(g) The freeboard hydrograph shall be routed through the reservoir starting with the water surface at the elevation of the principal spillway inlet.

(h) A vegetated earth or unlined emergency spillway shall be approved when computations indicate that it will pass the design storm without jeopardizing the safety of the structure. The risk of recurring storms, excessive erosion, and inadequate vegetative cover will be considered acceptable in such a spillway when its average frequency of use is predicted to be not more frequent than once in 25 years for Category 3 dams, once in 50 years for Category 2 dams, and once in 100 years for Category 1 dams.

1. Vegetated and earth emergency spillways may be open channels and may consist of an inlet channel, a control section and an exit channel. Subcritical flow exists in the inlet channel and the flow may be supercritical in the exit channel.

2. Vegetated emergency spillways may be trapezoidal in cross-section and shall be protected from damaging erosion by a grass cover. They shall be used at sites where a vigorous grass growth can be sustained by normal maintenance without irrigation.

3. Earth spillways may be used in those areas where vegetative growth cannot be maintained. They are similar to vegetated spillways but are designed for lower permissible velocities and less frequent use. The needed maintenance after a flow occurs is the responsibility of the certificate holder.

4. Earth and vegetated emergency spillways are designed on the basis that some erosion or scour is permissible if its occurrence is infrequent, if maintenance facilities are provided, and if damage from a severe storm, as represented by the freeboard inflow hydrograph, will not endanger the structure.

5. A Manning's "n" of 0.040 may be used for determining the velocity and capacity in vegetated spillways. Permissible velocities in earth spillways may be based on an "n" value of 0.020 but the capacity of earth spillways will be based on an appraisal of the roughness condition at the site.

6. When the anticipated average use of a vegetated emergency spillway is more frequent than once in 50 years, the maximum permissible velocity will be in accordance with the values given below. The values may be increased 10 percent when the anticipated average use is not more frequent than once in 50 years or 25 percent when the anticipated average use is not more than once in 100 years. The maximum velocity limitations given below for vegetated or earth emergency spillways apply to the exit channel.

7. The values given will be the upper limit for all grasses. Values for grasses or grass mixtures will be determined by comparison with the values shown, with due consideration given to the growth characteristics and density attained in the local area by the species under consideration.

8. Where bona fide studies or investigations have been made to determine the permissible velocity for a specific soil and site, these values may be used in lieu of those shown below.

9. Maximum Permissible Velocities for Vegetated Earth Spillways.

Grasses or Grass Mixtures

Soil Type	Slope	Maximum Permissible Velocity
Erosion Resistant	0-5 %	8.0 fps
	5-10%	7.0 fps
Easily Erodible	0-5 %	6.0 fps
	5-10%	5.0 fps

(5) Earth Embankments.

(a) Sufficient freeboard shall be provided to prevent overtopping with the passage of the freeboard hydrograph plus the additional freeboard required by the site for wave action.

(b) The top width of earth embankments will not be less than the value given by the following equation:

$$W = \frac{H + 35}{5}$$

where H = height of embankment in feet.

W = minimum top width of embankment in feet.

(c) The earth embankment will be riprapped or have other wave erosion protection provided over the full range in stage between three feet above and below the normal pool elevation.

(d) All dams shall be designed and constructed to prevent the development of instability due to excessive seepage forces, uplift forces, or loss of materials in the embankment, abutments, spillway areas, or foundation. Seepage analysis for design and inspection during construction shall be in sufficient detail to prevent the occurrence of critical

(Rule 1200-5-7-.07, continued)

seepage gradients. All dams permanently impounding water shall be constructed with an embankment toe drain with drain pipes installed to discharge the seepage.

(e) All dams shall have a permanent bench mark monument located near the embankment in undisturbed soil or in bedrock. This bench mark shall be detailed in the plans and specifications.

(f) All dams shall be protected from surface erosion by appropriate vegetation or some other type of protective surface such as rip-rap or paving and shall be maintained. Examples of appropriate vegetation include, but are not limited to, Bermuda grass and fescue. All inappropriate vegetation such as honeysuckle, briers, bushes and trees shall be kept off the dam by routine mowing.

Authority: *T.C.A. §§4-5-202, 69-11-101 et seq., and 69-11-104.* ***Administrative History:*** *Original rule filed August 19, 1987; effective October 3, 1987. Amendment filed August 2, 1995; effective October 15, 1995. Amendment filed December 6, 2000; effective February 19, 2001. Amendments filed April 18, 2008; effective July 2, 2008.*

1200-5-7-.08 ENGINEERING REQUIREMENTS.

(1) Engineering Standards. The design engineer shall take into consideration the standards and recommendations made in accepted publications concerning dams, and also the current practices of the various agencies that may be concerned with the design and construction of dams.

(2) Engineering Drawings. All drawings shall be submitted in the form of permanent type drawings of a standard and uniform size. Drawings that do not conform to standard practices and drawings that are not easily legible will not be reviewed.

(3) Engineering Plans. At least four (4) complete sets of construction plans and specifications shall be submitted to the Commissioner. Upon approval, each submitted copy shall be stamped accordingly, two copies retained for the Division's file, and the remaining copies returned to the applicant. An approved copy bearing the stamp of approval must be kept at the construction site during all times of construction.

(4) Engineering Report. The engineering report shall be submitted for review prior to or along with the submittal of the plans and specifications. The engineering report is the basis of the design and shall include, but not be limited to, the data and analyses required by Rule 1200-5-7-.07 for new dam construction or by Rule 1200-5-7-.06 for alterations to existing dams.

(5) Plans and Specifications. The plans and specifications shall provide the details of the structure designed in the engineering report, the construction materials, the construction methods, and shall include, but not be limited to, the following:

(a) Standard and uniform paper. Preferably 24" x 36".

(b) Cover sheet.

(c) Site plan.

(d) Embankment plan and profile views.

(e) Spillways plan and profile views.

(Rule 1200-5-7-.08, continued)

(f) Seepage control detail including collection system.

(g) Wave protection detail.

(h) Service spillway outfall structure and energy dissipator details.

(i) Location of permanent bench mark.

(j) Location sketch.

(k) Actual mean sea level (MSL) elevations of the dam and its appurtenant works.

Authority: *T.C.A. §§4-5-202, 69-11-101 et seq., and 69-11-104.* ***Administrative History:*** *Original rule filed August 19, 1987; effective October 3, 1987. Amendment filed August 2, 1995; effective October 15, 1995. Amendment filed December 6, 2000; effective February 19, 2001.*

1200-5-7-.09 FEES.

(1) Project Review Fee. A project review fee will be charged by the Commissioner for all new dam and reservoir construction. The fee is to accompany the application for a Construction Certificate. New dams will not be charged for the inspection fee for the initial Operating Certificate. The fee will be based upon the size categories shown below, but in no case shall the total project review fee exceed one percent (1%) of the total estimated cost of the dam.

Schedule of Charges

Height of Dam	Charge for Project Review
6 - 40 feet	$1000
41 - 60 feet	$1500
greater than 60 feet	$2000

If a construction certificate expires without construction having begun, the certificate holder may re-apply for a new construction certificate within one year of the expiration date of the original certificate and pay a project review fee of only $500, provided that no substantial changes have been made to the plans and specifications.

(2) Safety Inspection Fee. Fees will be charged for Safety Inspections by the Division. The fee is to accompany the application for an Operating Certificate. The fee will be $500 per inspection. All fees and charges shall be payable only by check or money order to the State of Tennessee.

(3) No fees shall be imposed for inspections of dams which are constructed, operated, or maintained by a watershed district pursuant to *T.C.A. §69-7-101 et seq.*

Authority: *T.C.A. §§4-5-202, 69-11-101 et seq., and 69-11-104.* ***Administrative History:*** *Original rule filed August 19, 1987; effective October 3, 1987. Amendment filed August 2, 1995; effective October 15, 1995. Amendment filed December 6, 2000; effective February 19, 2001. Amendment filed April 18, 2008; effective July 2, 2008.*

1200-5-7-.10 EMERGENCY ACTION BY OWNER. Nothing in *T.C.A. §69-11-117* of the Act, whereby the Commissioner has the authority to act under a state of emergency requested of and declared by the Governor, nor any provisions or requirements for Certificates, shall be construed to relieve or prevent an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or

operation of the dam. In the event of an emergency where immediate repairs are necessary to safeguard life and property, such repairs shall be made immediately by the owner or his duly authorized agents. In such events, the Commissioner shall be promptly notified of the necessary emergency repairs and of work under way, if any, and such work shall conform to such requirements as specified by the Commissioner.

Authority: *T.C.A. §§4-5-202, 69-11-101 et seq., and 69-11-104.* ***Administrative History:*** *Original rule filed August 19, 1987; effective October 3, 1987. Amendment filed August 2, 1995; effective October 15, 1995.*

1200-5-7-.11 REPEALED.

Authority: *T.C.A. §§4-5-202, 69-11-101 et seq. and 69-11-104.* ***Administrative History:*** *Original rule filed August 19, 1987; effective October 3, 1987. Repeal filed August 2, 1995; effective October 15, 1995.*

E.43. Texas





Hydrologic and Hydraulic Guidelines for Dams in Texas

Dam Safety Program
Texas Commission on Environmental Quality

GI-364
January 2007

TCEQ

Contents

Chapter One. Introduction to Guidelines 4
1.0 Introduction 4
1.1 Regulatory Authority 4
1.2 Professional Responsibility and Duty 4
1.3 Copies 4
1.4 Feedback 4
1.5 Applicability 4
1.6 Definitions 4
1.7 Acknowledgments 4

Chapter Two. Submitting Reports 6
2.0 Introduction 6
2.1 Minimum Requirements for Submission 6

Chapter Three. Dam Classification 7
3.0 Introduction 7
3.1 Dam Size Classification 7
3.2 Design-Flood Criteria 7
3.3 Minimum Freeboard 7

Chapter Four. Determining the Design Flood—Precipitation 9
4.0 Introduction 9
4.1 Watershed Delineation 9
4.2 Minimum PMP Duration 9
4.3 Temporal Distribution of Design-Storm Precipitation 10
4.4 Storm Location and Spatial Distribution of PMP 11

Chapter Five. Determining the Design Flood—Runoff Calculations 12
5.0 Introduction 12
5.1 Antecedent Moisture Conditions 12
5.2 Infiltration Losses—Excess Precipitation 12
5.3 Land-Use Assumptions 13
5.4 Unit Hydrograph Method 13
5.5 Calibration 14

Chapter Six. Determining the Design Flood—Routing Methodologies 16
6.0 Introduction 16
6.1 Methods for Hydrologic and Hydraulic Streamflow Routing 16
6.2 Base Flow 16
6.3 Hydraulic Input Parameters 16
6.4 Calibration 17
6.5 Modeling Through Reservoirs 18
6.6 Design-Flood Hydrographs 19
6.7 Computer Models 19

Chapter Seven. Hydraulic Design Criteria 20
7.0 Introduction 20
7.1 Elevation-Area-Capacity 20
7.2 Spillway Rating Curves 20

Chapter Eight. Dam-Breach Analyses 22
8.0 Introduction 22
8.1 Hydrologic Conditions 22
8.2 Downstream Conditions 22
8.3 Breach Parameters 23
8.4 Dam-Breach Models 24
8.5 Breach Inundation Lengths 24
8.6 Dams in Sequence 24
8.7 Inundation Mapping 24
8.8 Simplified Breach Method 24

Chapter Nine. Risk Assessment and Classification of Hazard Potential 26
9.0 Introduction 26
9.1 Multiple Dams 26
9.2 Individual Components of a Dam 26
9.3 Hazard Potential Classification 26
9.4 Alternative Means of Assessing Risk and Hazard 26

Appendix. Submittal Forms 28
Information Sheet: Existing Dam (Form TCEQ-20344) 29
Information Sheet: Proposed New Construction Modification, Repair, Alteration, or Removal of a Dam (Form TCEQ-20345) 31
Hydrologic and Hydraulic (H&H) Evaluation Summary (Form TCEQ-20346) 33
Engineer's Notification of Completion (Form TCEQ-20347) 35

Glossary 37

References 38

Tables
4.1 Minimum PMP Duration 9
4.2 Breakpoints for PMP Temporal Distributions 11
5.1 NRCS Hydrologic Soil Groups and Uniform Infiltration (Loss) Rates 13
5.2 Infiltration-Loss Methods Compared 13
5.3 Unit Hydrograph Methods Compared 15
6.1 Streamflow Routing Methods Compared 18

Figure
4.1 Temporal Distribution of Total Depth of PMP for All Durations of PMPs 10

CHAPTER 1

Introduction to Guidelines

1.0 Introduction

These guidelines present instructions, standards, and accepted procedures for the hydrologic and hydraulic analysis of existing and proposed dams in Texas. They also clarify the expectations of the TCEQ with respect to submitted analyses, and simplify review by standardizing processes and elements so they will be acceptable to the reviewer. Though the guidelines are relatively specific, the engineer may always submit alternate procedures that either are more conservative or are sufficiently explained and justified.

Dams and spillways designed to comply with TCEQ rules, using hydrologic and hydraulic procedures of the Natural Resources Conservation Service, are acceptable, provided that they are shown to be equally conservative as, or more conservative than, designs developed using the criteria contained in this set of guidelines. The breach-analysis procedures described in Chapter 8 do not depend on which design method is used, and more exact full breach-analysis procedures can always be used in lieu of the conservative simplified procedures.

1.1 Regulatory Authority

These guidelines supplement the Texas Administrative Code, Title 30, Part 1, Chapter 299.

1.2 Professional Responsibility and Duty

These guidelines assume that anyone using or referencing them is a licensed professional engineer or is working under the guidance of a professional engineer. Users should also have appropriate knowledge of the processes and methodologies referenced, and be able to use standard software common in the engineering profession that is appropriate to the analysis.

The hydrologic and hydraulic analyses associated with the design or evaluation of dams, or their rehabilitation, in Texas is considered the practice of Engineering and, as such, subject to the Texas Engineering Practice Act, as amended.

1.3 Copies

Copies of the guidelines may be viewed online at <www.tceq.state.tx.us/goto/damhhguidelines>.

1.4 Feedback

Direct any questions or comments on the content of these guidelines to the coordinator of the Dam Safety Program, Texas Commission on Environmental Quality.

1.5 Applicability

The guidelines described in this document apply to all dams and all design floods determined for dams under the jurisdiction of the TCEQ Dam Safety Program. Some dams may also need to meet the requirements of other agencies such as the NRCS or the U.S. Army Corps of Engineers. Design floods developed to meet requirements of these agencies will be accepted by TCEQ as long as their results are shown to be at least as conservative as would be required by this document.

1.6 Definitions

Many of the words and terms used throughout these guidelines are defined in the Glossary.

1.7 Acknowledgments

These guidelines were prepared by Freese and Nichols, Inc., Austin, under the direction of Warren D. Samuelson, P.E., coordinator of the Dam Safety Program, Texas Commission on Environmental Quality, and Jack Kayser, Ph.D., P.E., senior water resources engineer, Dam Safety Program, TCEQ.

These guidelines have drawn liberally upon the work of many agencies and individuals who have greatly contributed to the state of the art in hydrologic and hydraulic designs of dams in the United States. Acknowledgments of the contributions of these agencies and individuals appear throughout the text of these guidelines.

Appreciation is expressed to the following organizations and firms that supplied data and gave input or reviewed these guidelines:

Federal Agencies

U.S. Army Corps of Engineers
Natural Resources Conservation Service
U.S. Bureau of Reclamation
Interagency Committee on Dam Safety
Federal Energy Regulatory Commission
National Weather Service
U.S. Geologic Survey

State Agencies

Texas Department of Transportation
North Central Texas Council of Governments

Professional Associations

Association of State Dam Safety Officials
American Society of Civil Engineers

Project Consultants

Freese and Nichols, Inc., Austin
Raymond Chan and Associates, Austin

CHAPTER 2

Submitting Reports

2.0 Introduction

All hydrologic and hydraulic analysis reports investigating one or more dams in Texas are to be prepared by, or under the direct supervision of, a professional engineer with direct responsibility for the analysis of the dam. Reports submitted to the TCEQ must document the technical basis for the analysis sufficiently for a thorough review by TCEQ personnel, including methods used, key assumptions, the results and conclusions of the analysis, and any recommendations. Such reports must also include all pertinent and significant data utilized in the analysis and necessary for the TCEQ to perform their desired review of the analysis. The engineer should supply the required information regardless of whether the analysis is a standalone review of an existing dam or supports the design of a new dam or the rehabilitation of an existing one.

The TCEQ's requirements as to detailed preparation of plans, specifications, and designs are not part of these guidelines.

2.1 Minimum Requirements for Submission

For hydrologic and hydraulic studies that are either individual or part of a design project, include their bases and results in a report. Fill in all appropriate Dam Information Forms (Appendix B) and submit them with the report. Tabulate the following data in the report, if applicable:

Rainfall and Runoff Information

- characteristics for the entire watershed and all subbasins, as applicable to calculation methods
- data used to develop parameters describing the watershed characteristics, including any available calibration data
- design-flood inflow and discharge hydrographs
- reservoir routing data and parameters
- discharge-frequency relationships
- determinations of hydraulic roughness
- water-surface profiles

Dam and Spillway Information

- spillway stage–discharge relationships
- maximum height and reservoir storage values
- elevation-area-storage relationship
- key operational elevations for the dam and spillway
- pertinent spillway dimensions
- energy-dissipating facility features
- results of hydraulic model tests when the hydraulic design is based on a model study
- details of low-flow release structures

Breach-Analysis information

- breach parameters
- profile of peak flood levels
- profile of warning time versus distance downstream
- delineation on the best available mapping base of the extent of inundation for the normal pool and design-flood breach events for the project
- identification of any potential loss of public services and of critical facilities
- assessment of hazard-potential classification

CHAPTER 3

Dam Classification

3.0 Introduction

Dams more than 6 ft high fall under TCEQ jurisdiction and are to comply with TCEQ regulations on dam safety regardless of whether the TCEQ requires a water right for the impoundment.

The TCEQ regulations and these guidelines do not apply to:

- dams designed by, constructed under the supervision of, and owned and maintained by federal agencies such as the Corps of Engineers and the Bureau of Reclamation;
- embankments used for roads, highways, and railroads, including low-water crossings, that may temporarily impound floodwater;
- dikes or levees designed to prevent inundation by floodwater; and
- off-channel impoundments authorized by the TCEQ under Texas Water Code Chapter 26.

3.1 Dam Size Classification

The classification for size based on the maximum height of the dam or maximum reservoir storage capacity shall be in accordance with Chapter 299 of the Texas Administrative Code (TAC).

3.2 Design-Flood Criteria

Existing and proposed dams must safely pass the design-flood hydrograph, expressed as a percentage of the probable maximum flood. The design flood is determined based upon the size (previous section) and hazard-potential classification (Chapter 9) of the dam. TAC Chapter 299 describes the required design flood for the various combinations of size and hazard classification. Safely passing a flood for an existing dam means discharging the flood without a failure of the dam or one of its critical elements. A failure would be considered an unintended release of impounded water due to the loss of all or a portion of the dam or affiliated structure. For dams without a structural design that allows for safe overtopping, any overtopping of an earthen embankment would be considered not safely passing the flood.

Design-flood criteria established by other public agencies, if shown to be more conservative, will generally be acceptable. Those that may produce a less conservative result, such as the FEMA Inflow design-flood methodology, if based on a properly prepared incremental risk analysis, may be acceptable, but will require a thorough review of the risk analysis as well as the hydrologic and hydraulic analyses.

3.3 Minimum Freeboard

No freeboard for wave action is required for existing dams above the peak design-flood level, either for determination of existing conditions or for the design of an upgrade or modification.

New dams should have appropriate freeboard. As part of the freeboard calculations for a proposed new dam, consider an appropriate wave run-up. Overtopping from wave action due to design wind loads, as described below, is generally not allowable. It may, however, be acceptable if the design engineer can show reasonable cause—as in the case of a new concrete dam or a dam with other appropriate slope protection on the downstream side. Freeboard between the effective crest of the dam and the various water surface elevations that may be associated with the reservoir is to be based on suitable assumed wind speeds and related wave heights.

The longer that a reservoir is shown to be at or above a certain level, the higher the potential wind speeds that should be considered. In addition, the timing of the peak lake level with respect to the storm event that generated it is also a factor. For example, the freeboard above the maximum normal operating level should be greater than or equal to the maximum wave height, including run-up, caused by the maximum wind potential along the maximum fetch of the reservoir.

Freeboard above higher flood levels in the reservoir, such as the top of any dedicated flood pool, should consider wave height and run-up for lesser winds consistent with the potential risks associated with wind-driven waves overtopping or eroding the embankment and potential flood durations at those levels. Freeboard above the maximum reservoir level resulting from the design flood does not need to reflect significant wave height from unusual wind conditions, if it can be shown that the peak

reservoir level occurs after the intense portions of the storm that generated the design flood. Multiple storm events do not need to be considered.

The freeboard should include the expected wind effects that could occur during the design-flood event if the peak reservoir level occurs within the critical portion of the storm event itself. This critical portion would generally be considered the portion of the critical duration prior to the break point, if the temporal distribution described in Chapter 4 is employed. An acceptable rule of thumb would be to use 50 percent of the maximum wind speed if the peak occurs before the break point, 33 percent of the maximum if the peak is after the break point but before the onset of the critical storm, and 20 percent of the maximum wind speed if the peak occurs after the end of the assumed rainfall event.

These are general guidelines and the engineer should provide reasonable explanation of assumed winds for freeboard determination. Appropriate determinations will be needed if a different temporal distribution is used.

All freeboard calculations should include the expected future settlement and consolidation of the embankment after construction in addition to wave run-up.

Determining the Design Flood—Precipitation

CHAPTER 4

4.0 Introduction

The design flood hydrograph for existing and proposed dams shall be derived from the appropriate percentage of the probable maximum flood (PMF), which is, in turn, derived from the estimated runoff resulting from the probable maximum precipitation (PMP). The PMP varies depending on the size and shape of the dam's contributing drainage area. The intent of the precipitation analysis is to find the critical storm size, location, orientation, and duration that would produce the most critical loading on the dam. PMP values in Texas are generally derived from HMR-51 (Schreiner and Riedel 1978) and HMR-52 (Hansen, Schreiner, and Miller 1982) for most of the state and HMR-55A (Hansen et al.1988) for parts of extreme west Texas. (*HMR* = 'hydrometeorological report.') These would apply unless an approved site-specific PMP study is performed. All references to "PMP" are to one of these sources of derivation.

4.1 Watershed Delineation

Many of the dams in Texas can be modeled appropriately with a single basin. However, many will need to be divided into multiple subbasins. The size and delineation of the subbasins is dependent on the rainfall-runoff method used and various hydrologic factors. Subdivision should also be considered if there are portions of the drainage basin that:

- possess hydrologic characteristics obviously different from the average characteristics of the total basin,
- may contribute to delays in flood passage, such as upstream lakes,
- are controlled by large constrictions that can act as hydraulic control structure by restricting, cross-sectional areas and attenuating water flow, as may occur at some bridges,
- have a total drainage area that is too large for averaging a single storm distribution, or
- have stream gauges or observed data that may be used for calibration.

Watersheds should be delineated and their characteristics determined in accordance with the standards of the following references:

- *National Engineering Handbook,* Part 630 (Hydrology) (NRCS 1997)
- EM 1110-2-1417 (U.S. Army Corps of Engineers, 1994)
- Federal Energy Regulatory Commission (2001)

4.2 Minimum PMP Duration

The PMP depths for a particular storm size and range of storm durations are used to determine the critical storm duration for a dam. The intent is to review multiple potential durations of storm events in order to determine a critical event, namely, that which produces the maximum reservoir level. Possible durations would include 1, 2, 3, 6, 12, 24, 48, and 72 hours. The minimum design-storm duration is based on the total contributing drainage area for the dam, as shown in Table 4.1.

Table 4.1. Minimum PMP Duration

Contributing Drainage Area (DA) (sq mi)	Minimum Storm Duration (hr)
DA < 25	1
25 ≤ DA < 100	3
100 ≤ DA < 1,000	6
1,000 ≤ DA < 10,000	24
DA ≥ 10,000	72

The PMP depths should first be determined for the minimum storm duration listed in Table 4.1. Then each possible duration up to 72 hours should be reviewed in order to determine the critical duration. For example, for a reservoir with a drainage area of 80 sq mi, the minimum duration is 3 hr. First, the peak reservoir level from a 3-hour PMP is determined, then that of a 6-hour and a 12-hour PMP event. This continues until the peak reservoir level from a longer duration event is lower than the previous one, thus bounding

the critical duration. The duration that produces the maximum reservoir level then becomes the critical duration and that duration event is used for the PMF. If the 72-hour PMP produces the maximum reservoir level, then a 72-hour PMF is utilized. No durations longer than 72 hours need to be reviewed.

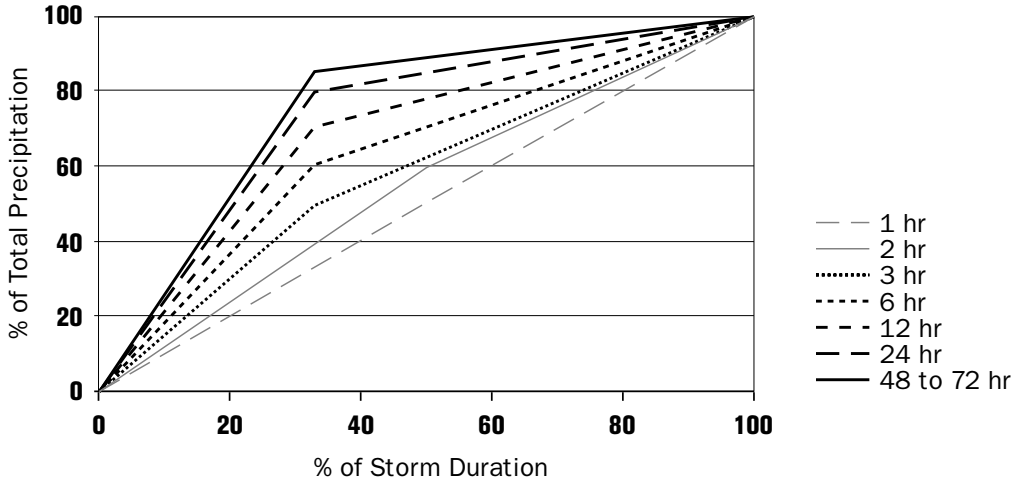
4.3 Temporal Distribution of Design-Storm Precipitation

Distribute the total depth of the PMP, for both the entire basin as well as for each subbasin, as appropriate, temporally in accordance with the dimensionless parameters of Figure 4.1 and Equation 4.1. **Since the new temporal distributions are different for each duration, a dam needs to be evaluated for all of the durations required by Section 4.2 and the peak elevation for each duration must be estimated in order to determine the critical duration for that structure.** This critical peak lake level may then be compared, if desired, to the peak lake level determined by other methods in order to determine which method is more conservative.

The new temporal distributions will tend to reduce the conservatism of the PMP on the flood routings by reducing the intensity of the peak portion of the rainfall event. The result will be tend to include flatter inflow hydrographs, significantly lower peak inflow rates, and slightly lower peak lake levels.

The development of the guideline's temporal distributions is based on observed evidence that near-PMP values for significantly different durations have not occurred in the same event. In other words, though previous methods assumed the PMP value for the peak one-hour event occurred within the same event as the peak PMP value for 24 hours and also for 72 hours, such storms have never actually been observed. Historical data has also shown that the most extreme near-PMP events tend to be front loaded, with most of the rainfall occurring early in the event. The guidelines attempt to provide a reasonably conservative temporal distribution for the given set of durations. It is important to note that only the distribution of the rainfall has changed; the total rainfall amounts for any given duration are unchanged from previous methods. More

Figure 4.1. Temporal Distribution of Total Depth of PMP for All Durations of PMPs



This distribution can be estimated within calculations and spreadsheets as:

Eq. 4.1 For $T \le x$: $P = (T / x) \cdot y$

For $T > x$: $P = y + ((100–y) / (100–x)) \cdot (T–x)$

Where:
P = percentage of total precipitation
T = percentage of storm duration
x, y = coordinates of breakpoint

The breakpoint will vary depending on the duration storm being analyzed (Table 4.2). For a one-hour event, a breakpoint with coordinates at 50 percent, 50 percent is listed for consistency, though that represents a linear distribution of rainfall over the hour.

conservative distributions can be used, such as the HMR-51 or the NRCS distributions.

Table 4.2. Breakpoints for PMP Temporal Distributions

Duration (hr)	x (%)	y (%)
1	50	50
2	50	60
3	33	50
6	33	60
12	33	70
24	33	80
48 to 72	33	85

4.4 Storm Location and Spatial Distribution of PMP

Drainage Areas ≤ 10 Square Miles: Apply the total depth of the PMP, estimated as the point values delineated in HMR-51 and HMR-52, over the entire drainage area for all storm durations.

Drainage Areas > 10 Square Miles: Distribute the total depth of the PMP for all storm durations spatially over the drainage area using the single-centered concentric ellipse pattern and methodology specified in HMR-52. For single basins, the center of the storm should generally be at the centroid of the basin and a basin-average total depth of design storm precipitation calculated for the specified duration. For larger basins, when the watershed is divided into multiple subbasins, the center of the PMP storm isohyets must be moved to multiple locations away from the geometric centroid of the overall drainage area to verify the critical design storm location and orientation that produces the maximum corresponding PMF level in the reservoir. This will generally be the same storm center that produces the maximum basin-average total PMP depth. However, in very large basins (greater than 10,000 sq mi), the location of the storm center producing the maximum rainfall depth and the storm center producing the maximum basin discharge may not be the same, depending on the size and orientation of the various tributaries, so the full flood routing through the reservoir should include iterative trials to determine the critical storm location.

CHAPTER 5

Determining the Design Flood—Runoff Calculations

5.0 Introduction

Precipitation hyetographs, developed as described in Chapter 4, that are calculated for the watershed above a reservoir are used to develop estimates of runoff hydrographs in two basic steps. First, the excess precipitation is generated by deducting estimated losses from the total precipitation. This excess precipitation will generate the full volume of runoff from the storm event. In the second step, the excess rainfall is applied to a suitable unit hydrograph for the basin or subbasins to produce a runoff hydrograph.

5.1 Antecedent Moisture Conditions

Superimpose the PMP upon watershed soils assumed to be saturated. This will equate to losses at the beginning of the design storm equal to zero or Natural Resources Conservation Service Antecedent Runoff Conditions III (ARC III), or some other equivalent and approved assumptions. In Texas, there is no need to analyze snowmelt contributions to runoff or frozen ground conditions for infiltration for design-flood calculations.

5.2 Infiltration Losses—Excess Precipitation

Determination of excess rates of precipitation and infiltration losses can be determined by one of several precipitation loss methods. The two most common are:

- Initial and Constant-Rate Loss Method
- NRCS Curve Number Loss Method

Other usable methods include:

- Green and Ampt Loss Method
- Holton Loss Rate
- Exponential Loss Rate

These methods are described in most hydrology textbooks and in user manuals for modeling software.

For certain areas—paved areas, buildings, and open water—it may be appropriate to assume a certain percentage of the basin or subbasin has no infiltration at all. Such areas are typically designated by an impervious-area percentage in the description of the basin characteristics. A large area—such as the reservoir area itself, if it is a significant portion of the drainage area—can be modeled as a unique subbasin with zero infiltration losses.

The methodologies for the first two methods and their associated input parameters are described below.

Initial and Uniform

This simple method is widely used and consists of establishing an initial loss amount and a uniform loss rate. The initial assumption is that all rainfall is lost to infiltration up to the initial loss amount. After that, the uniform rate is adjusted to the calculation time step and then subtracted from each rainfall amount for that time step. The remaining precipitation is the excess rainfall.

For all design-flood calculations, the initial loss amount should be zero, equivalent to saturated conditions. The uniform rate is estimated based on soil types. The values will typically range from 0.05 in/hr for clays to as high as 0.4 in/hr for sandy soils.

NRCS Curve Number Loss Method

The NRCS has standardized detailed procedures for developing estimates of infiltration rates based on soil types and land use characteristics. The process is summed up in the derivation of the curve number (CN), from which estimates for soil moisture deficit, initial abstraction, and the resulting excess rainfall are derived. Multiple NRCS publications are available that provide guidelines for estimating the CN based on soil classifications and land use parameters. Soil classifications are most readily obtained from NRCS County soil maps. Many of these were published when the agency was known as the Soil Conservation Service (SCS). All of the soil classifications listed in the County Survey reports are classified in one of the four hydrologic soil groups, A, B, C, and D. These four groups range from the most pervious, A, to the most impervious, D. Generally, multiple groups will

be represented within a basin or subbasin and the representative values can be averaged over the basin, weighted by representative area. Either calculate the average to develop a basin average hydrologic group and then assign the entire basin a CN, or assign each of the various soil types within the basin a hydrologic group and then a CN, and average all the CNs, weighted by area.

Most of the available tables indicating CN assume an ARC (formerly referred to as *antecedent moisture condition*, or *AMC*) II antecedent condition. This needs to be adjusted to reflect ARC III conditions.

Infiltration Loss Methods

For comparison, Table 5.1 shows a general relationship between the NRCS soil classification (described in the next section) and uniform loss rates.

5.3 Land-Use Assummptions

For developing the design storm runoff hydrograph for design and risk assessment of proposed dams or modifications to existing dams, assume land uses expected to exist at the completion of the modification or construction project. Dam owners will be held responsible for the safety of the dam throughout its entire life; therefore, they should attend to the build-out conditions that are reasonably expected to occur within the entire drainage area during the operational life of the dam.

5.4 Unit Hydrograph Method

The PMP needs to be transformed into the PMF runoff hydrograph for each basin or subbasin using an acceptable unit hydrograph method. The two most commonly used methods for hydrologic and hydraulic studies associated with dams are:

- Snyder Unit Hydrograph Method
- NRCS Dimensionless Unit Hydrograph Method

Other possible methods that are used include:

- Clark Unit Hydrograph Method
- Kinematic Wave Method

Table 5.1. NRCS Hydrologic Soil Groups and Uniform Infiltration (Loss) Rates

Soil Group	Description	Range of Uniform Loss Rates (in/hr)
A	Deep sand, deep loess, aggregated silts	0.30–0.40
B	Shallow loess, sandy loam	0.15–0.30
C	Clay loams, shallow sandy loam, soils low in organic content, soils usually high in clay	0.05–0.15
D	Soils that swell significantly when wet, heavy plastic clays, certain saline solutions	0.00–0.05

References: NRCS 1997, Skaggs and Khaleel 1982

These two most widely used methods, the Initial and Constant Rate method and the NRCS Curve Number method, are contrasted in Table 5.2.

Table 5.2. Infiltration-Loss Methods Compared

Method	Pros	Cons	References
Initial and Constant Rate	■ Simple and easy to use. ■ Easy to calibrate. ■ Apply to all storm durations.	Since it does not reflect varying loss rates, it can misestimate losses within the event, particularly those of very short duration.	■ EM 1110-2-1417 (U.S. Army Corps of Engineers 1994) ■ *Hydrology Handbook* (ASCE 1996)
NRCS Curve Number	■ Simple and easy to use. ■ Easy to calibrate. ■ Good availability of material to estimate parameters for ungauged areas.	Infiltration rate will be asymptotic to zero and losses tend to be understated for storms longer than 24 hours in duration.	■ EM 1110-2-1417 ■ *Hydrology Handbook* (ASCE 1996) ■ Win TR-55 (NRCS 1998) ■ *National Engineering Handbook* (NRCS 1997)

These methods are described in most hydrology textbooks and in user manuals for modeling software.

Procedures for the first two methods and their associated input parameters are described below.

Snyder Unit Hydrograph

The Snyder method estimates a peak discharge and a time to the peak of the unit hydrograph. It also estimates shape parameters. Rainfall runoff models, such as HEC-1, will typically complete the unit hydrograph based on assumed parameters and relationships. Typically, two parameters are needed to develop a Snyder Unit Hydrograph:

- T_L, lag time
- C_p, shape factor, also commonly expressed as C_p640.

The lag time has historically been calculated in multiple ways. The following equation is best suited to regional parameters:

$$T_L = C_T(L \cdot L_{CA}/S^{0.5})^{0.38}$$

T_L = Lag Time (hr)
C_T = coefficient
L = hydraulic length of watershed along the longest flow path (mi)
L_{CA} = hydraulic length along the longest water course from the point under consideration to a point opposite the centroid of the drainage basin (mi)
S = weighted slope of the basin (ft/mi), measured from the 85% to the 10% points along the longest stream path in the basin (EM 1110-2-1405)

The value C_T is a dimensionless parameter that is typically assumed to be consistent for various areas of the state. For instance, it could be estimated from neighboring areas or calibrated for the whole or portions of the basin, and then applied to multiple subbasins within the watershed.

Note that there are multiple forms of the Snyder equation for T_L. Some use ft/ft for the slope and some do not include the slope at all. If a regional value for C_T is used, verify that the same equation was used in the study within which it was developed. Values generally range from about 0.7 up to about 3.0, though values outside that range have been calibrated.

The shape factor, C_p640, reflects the sharpness of the hydrograph. High values, up to about 500, reflect a rapidly responding basin with a sharp peaked hydrograph. Low values, such as 250, generally reflect a flatter, slow responding basin with a longer, flatter hydrograph. These values are generally divided by 640 and entered into HEC-1, if that model is used, as the C_p value, ranging from about 0.4 to 0.8. Generally, smaller C_T times are associated with higher C_p640 values, though many exceptions exist.

NRCS Dimensionless Unit Hydrograph

Only one parameter is used in the models that use the NRCS Unit Hydrograph method—the lag time, T_L, typically estimated as 0.6 times the time of concentration, T_C, which is estimated through a procedure of several steps based on parameters reflecting the basin. The factor 0.6 for conversion from T_C to T_L has been shown to vary with certain urban characteristics, but, without detailed information, 0.6 is generally considered acceptable for most situations. The time of concentration, T_C, is the time it takes for water to flow from the most hydraulically remote point of the drainage area to the outlet of the drainage basin. There are multiple methods to determine the time of concentration, each generally associated with a particular unit hydrograph estimation procedure.

One of the more common methods for estimating T_C is to sum three runoff time components: overland sheet flow, shallow concentrated flow, and open channel. *Sheet flow* reflects the uppermost end of the basin and consists of flow traveling over the open planar surfaces and not in formed channels. Its length is generally estimated from maps, but should be no greater than 100 ft. The primary factors for estimating the time for sheet flow are length, slope, and roughness. *Shallow concentrated flow* reflects the flow as more concentrated, but still not in a fully formed channel. It may be in minor ditches and swales and is also affected primarily by the length, slope, and roughness. *Open channel flow* is the flow in distinct, well formed channels, within which flow can be readily depicted using Manning's equation. More than one channel type, with separate time calculations for each, may be added to obtain the overall time of concentration. However, there cannot be more than one component for sheet flow or shallow concentrated flow.

The intention of these estimates is to sum the estimated travel time of flow across each component. The factors listed above are estimated in order to determine a flow velocity which is assumed constant over the defined length. Times for each of the three components are estimated, totaled, and the sum used as the time of concentration for the basin, which is then adjusted to estimate the lag time, T_L. These two widely used unit hydrograph methods, Snyder's and the NRCS method, are contrasted in Table 5.3.

5.5 Calibration

The calibration of hydraulic and hydrologic runoff parameters is strongly preferable in most cases. For breach analyses, a recently prepared PMF analysis usually suffices. If the previously prepared

Table 5.3. Unit Hydrograph Methods Compared

Method	Pros	Cons	References
Snyder's Unit Hydrograph	■ Simple and easy to use. ■ Easy to calibrate. ■ Applies to wide range of area.	Parameters cannot be estimated from field observations. Values must be calibrated or estimated from similar areas.	■ EM 1110-2-1417 (U.S. Army Corps of Engineers 1994) ■ *Hydrology Handbook* (ASCE 1996)
NRCS Dimensionless Unit Hydrograph	■ Simple and easy to use. ■ Easy to calibrate. ■ Good availability of material to estimate parameters for ungauged areas.	Not well-suited to large drainage areas. Should not be used for subbasins larger than about 20 sq mi.	■ EM 1110-2-1417 ■ *Hydrology Handbook* ■ TR-55 (NRCS 1998) ■ *National Engineering Handbook* (NRCS 1997)

PMF was not based on calibrated runoff values, a new calibration is not needed, except for large, high-hazard dams. For PMF determinations associated with new dams or the upgrade of existing dams, use calibrated values for all intermediate and large high-hazard dams and large significant-hazard dams. Exceptions may be allowed if the values chosen can be demonstrated to be conservative or if insufficient data are available.

The following suggestions should be considered during calibration:

- The process compares calculated runoff hydrographs to observed hydrographs from gauges or calculated from lake levels. Inflow rates estimated from reservoir levels will generally need some smoothing, as small errors in lake-level measurements typically represent a large error in inflow. However, these will tend to be self-correcting in subsequent time steps.
- There is error in all observed data, so multiple storms should be used for calibration. Three or four events are preferable. If an event suggests values that are inconsistent with others, consider not using that event.
- Most rain gauges use daily values and their temporal distribution will need to be estimated based on adjacent hourly gauges. Some lag time between the gauges is often appropriate.
- The Theissen Polygon method is a simple and suitable way to distribute rainfall values across basins. However, multiple tools that make use of GIS technology are also available and well-suited to the task.
- Distributing observed rainfall values across large areas will tend to exacerbate the errors inherent in the rainfall. Inevitably, the calibration of infiltration rates tends to be more of a correction of rainfall errors than a determination of true infiltration. Unless a strong, repetitive pattern is noted, determine loss rates from analysis of the soil types with little emphasis on the calibrated infiltration rates.
- When calibrating a model, first adjust infiltration losses to obtain a matching runoff volume. Then, adjust the parameters that reflect the timing to match the time of the peak flow. Finally, adjust the hydrograph shape, including the magnitude of the peak flow. Some iterations will typically be necessary.
- Minimize the number of variables to be calculated. For example, rather than attempting to adjust the lag time for each subbasin within the Snyder methodology, assume one C_T and one C_p640 value for the entire group of subbasins above the observed hydrograph, with each basin's lag time calculated based on the dimensions of its own basin. If variations in the C_p640 values are deemed appropriate, then it helps to keep the ratios between them constant so that all are effectively calibrated together.

CHAPTER 6

Determining the Design Flood—Routing Methodologies

6.0 Introduction

The last of the three primary steps in determining the design flood is the routing of hydrographs through the reservoir. Watersheds modeled as a single basin need no streamflow routing, and the design-flood runoff hydrograph is the reservoir-inflow hydrograph. Watersheds modeled with multiple subbasins need streamflow routing unless all subbasins drain directly into the reservoir.

6.1 Methods for Hydrologic and Hydraulic Streamflow Routing

In models that require routing of the design-storm runoff hydrographs through a stream channel, either a hydrologic or hydraulic routing method may be used. The hydrologic methods are either empirical or semi-empirical. Approved hydrologic routing methods include:

- Muskingum
- Muskingum-Cunge
- Average-Lag
- Successive Average-Lag (Tatum)
- Modified Puls
- Working R and D

Hydraulic routing methods are more complicated and difficult to use as they are based on theoretical hydraulic equations, but they more accurately reflect flood-routing conditions. Hydraulic methods are typically used under the following conditions:

- Very flat channel slopes, less than 5 ft/mi
- Wide floodplains with significant storage effects on the hydrograph
- High flows from a tributary
- Unusual backwater effects from structures

Acceptable hydraulic modeling methods include:

- Kinematic Wave
- Dynamic Wave
- Diffusion Wave

6.2 Base Flow

Estimates of base flow conditions to which calculated runoff hydrographs are added are sometimes appropriate on larger rivers, particularly for frequency flood–level events, such as 10-year or 100-year floods. However, in Texas, they are rarely a significant component of the design-storm peak flows, generally much less than 1 percent. For any river with a dependable flow that could be counted as a base flow, the drainage area is usually quite large and the resulting design-flood runoff will still dwarf the base flow. For these reasons, base flow is not required within design-flood calculations but may be employed if the analyst deems appropriate; it will typically be of the same order of magnitude as median flows or estimated as the receding limb of an antecedent event.

6.3 Hydraulic Input Parameters

All of the streamflow routing methods use various input parameters, generally measured or estimated from the physical characteristics of the channel. All will include a parameter that measures the length of the channel directly or reflects it in an estimate of travel time. For these, use the full length of the channel without assuming shortening due to overbank flooding. Even in very high flows, the predominant conveyance is usually within the channel itself. If the overbank flows are thought to be a dominant factor in the flood conveyance, then employ a routing method that takes differing floodplain flow characteristics into account, possibly including hydraulic models.

The Muskingum routing method, instead of physically measured values, incorporates an estimate of storage effects though the storage coefficient, x. This value ranges from 0.0 to 0.5, where 0.0 reflects a straight translation of a hydrograph and 0.5 reflects a storage-controlled routing process. The former would indicate of a steep narrow channel with little attenuation of the peak expected. The latter would reflect a broader, flatter channel with significant attenuation of the peak from overbank storage effects. This parameter cannot be measured from physical characteristics of the channel, but can be calibrated or estimated with experience.

Most methods will also typically use some description of a typical cross-section or multiple cross-sections. These should simply be measured from available mapping and should represent average conditions. For hydraulic models, where the entire length of the channel is modeled with cross-sections, reasonable mapping will be necessary, though rarely are surveyed cross-sections justified. For unsteady-flow hydraulic models, such as the NWS models and HEC-RAS, it is important that the cross-sections reflect with reasonable accuracy the existing floodplain storage. In steady-state models, there is a tendency to place cross-sections at constrictions and other features that control the flow rate. However, in unsteady models, the full flood storage of the floodplain tends to control the downstream movement of the hydrograph. Therefore, cross-sections should reflect both the constricted sections and the wider sections, as well as the storage that occurs in tributaries and adjacent draws. Off-channel storage, or ineffective flow area—often ignored in steady-state models—can be significant in unsteady models.

Manning's Roughness Coefficients

Except for the purely empirical hydrologic equations, each of the streamflow routing models will use the most widely recognized flow relationship, Manning's equation. Input parameters to Manning's equation consist simply of descriptions of the topography through the use of cross-sections, either in detail or simplified, and the roughness coefficient.

Numerous sources exist that describe the use of the equation and provide means to estimate Manning's coefficient (*n*), both for channel flow and overbank flow. The primary criterion is the size of the roughness particle, usually vegetation or the exposed channel surface, relative to the overall flow area. For example, the same grass-lined channel will have a smaller value for *n* if the channel area is large than if it is small. For that reason, roughness values will decrease with increasing flow for a consistent channel. However, this trend is often countered by the fact that roughness in the form of vegetation tends to increase quickly when significant portions of the flow are in the overbank areas. Single *n* values for a channel regardless of flow apply only in simplified estimates or in a narrow range of flows.

For design-flood calculations, where there is likely to be a large component of flow area in the floodplain, some variation in the value of *n* will need to taken into account. The simplest way to do this is to use three *n* values, one for the channel and one for each overbank. This is a very common technique, used in some routing methods in HEC-1 and often in the hydraulic model, HEC-RAS. The NWS models require input roughness values that are related to each top-width elevation or to flow, so weighted values need to be determined. These are typically best weighted by conveyance rather than by area as that will proportion the effective roughness relative to the portion of the flow it affects.

Table 6.1 compares some of the more common hydrologic and hydraulic streamflow routing methods and gives some of the pros and cons of each.

6.4 Calibration

The calibration of hydraulic and hydrologic streamflow routing parameters, similar to runoff parameters, is strongly preferable in most cases when sufficient data is available. For breach analyses, a recently prepared PMF analysis can usually be employed. If the previously prepared PMF was not based on calibrated runoff values, a new calibration is not needed, except for large high-hazard dams when sufficient data are available. For PMF determinations associated with new dams or the upgrade of existing dams, use calibrated values for all intermediate and large high-hazard dams and large significant-hazard dams. Exceptions may be allowable if the values used can be demonstrated to be conservative or insufficient data are available. During calibration, consider the following:

- The process compares calculated routed hydrographs to observed hydrographs from gauges or calculated from lake levels. Inflow rates estimated from reservoir levels will generally need some smoothing, as small errors in lake-level measurements typically represent a large error in inflow. However, these will tend to be self-correcting in subsequent time steps.
- There is error in all observed data, so multiple storms should be used for calibration. Three or four events are preferable. If an event suggests values that are inconsistent with others, consider not using that event.
- When calibrating a model, first calibrate runoff components, if they can be isolated, in order to match the flow volume. Then, adjust the streamflow parameters to match the translation time of the peak flow. Finally, adjust the hydrograph shape, including the magnitude of the peak flow. Some iterations will typically be necessary.
- Isolate the variables to be calculated and minimize their number as much as possible. For example, if two stream gauges exist, use the observed upstream hydrograph with lateral inflows estimated and calibrated separately, if possible, and estimate the resulting downstream hydrograph. This will isolate the routing parameters of that reach. As another example, rather than attempting to calibrate a wide range of roughness coefficients, relating all the appropriate values of *n* to standard channel and overbank values will allow the calibration of only two or three values. This can be carried out with overbank roughness values representing clear and

wooded areas, for instance, that are averaged for different reaches based on field conditions.

6.5 Modeling Through Reservoirs

Hydrologic Routing

For hydrologic routing, the peak design-flood reservoir elevation is determined by routing the estimated inflow hydrograph through the reservoir using one of the various hydrologic models. The methods most typically used for routing a hydrograph through a reservoir in hydrologic models are:

- Level Pool Routing
- Modified Puls

Take the following into consideration:

- Assume that reservoir losses equal zero.
- For gated dams, route the design-flood inflow hydrograph through the reservoir and through the dam's hydraulic control structures using the planned flood operational rules for the spillway or in a manner that takes into consideration downstream flood risks.
- The antecedent reservoir elevation in the reservoir should be the maximum normal operating pool (MNOP) level, which is the highest water surface elevation within the range of planned operating levels for the reservoir, above which floodwaters would be released. No antecedent storm is required. This applies to all upstream reservoirs in the drainage area.
  - ▼ For detention ponds that are dry or do not have significant permanent storage, consider the MNOP to be at the level of the primary outlet, above which water is always released.

Table 6.1. Streamflow Routing Methods Compared

Method	Pros	Cons	References
Muskingum	■ Simple and easy to use. ■ Easy to calibrate. ■ Applies to wide range of channel types.	■ Parameters cannot be estimated from field observations. Values must be calibrated or estimated from similar areas. ■ Does not account for backwater effects of structures or tributaries.	■ EM 1110-2-1417 (U.S. Army Corps of Engineers 1994) ■ HEC-1 user's manual ■ *Hydrology Handbook* (ASCE 1996)
Muskingum-Cunge	■ Simple and easy to use. ■ Parameters can be estimated from field observations.	■ Does not account for overbank or other storage effects well in broad, flat channels.	■ EM 1110-2-1417 ■ HEC-1 user's manual ■ *Hydrology Handbook* (ASCE 1996)
Kinematic Wave	■ Simple and easy to use. ■ Parameters can be estimated from field observations.	■ Does not account for overbank or other storage effects well in broad, flat channels.	■ EM 1110-2-1417 ■ HEC-1 user's manual ■ *Hydrology Handbook* (ASCE, 1996)
Modified Puls Storage	■ Simple and easy to use. ■ Applies to storage routing for reservoirs.Well suited to flat, broad channels with significant overbank storage.	■ Can be difficult to apply to streams if no relationship between flow and storage is available.	■ EM 1110-2-1417 ■ HEC-1 user's manual ■ *Hydrology Handbook* (ASCE 1996)
Dynamic Wave	■ Most accurate, particularly in broad, flat channels, with slopes less than about 5 ft/mi. ■ Best method for translating values calibrated from actual events up to design flood–level event. ■ Good availability of material to estimate parameters for ungauged streams. ■ Only method that can accurately describe the impact of major tributary flow that creates backwater or even reverse flow on the main stem.	■ Difficult to use, requires a large quantity of data.	■ HEC-RAS user's manual ■ NWS user's manuals (DWOPER, NETWORK, DAMBRK)

- For recharge reservoirs that are normally dry but have no release capabilities, the MNOP would be an empty reservoir provided that it can be shown that the lake has historically been, or will typically be, dry within a week of a major storm event. If not, the design engineer should show a statistically based justification for an appropriate starting water level.
- For existing storage reservoirs that have not filled up to their MNOP within the last 10 years, use starting levels at both the MNOP and the maximum level of the lake within the last decade. If the dam can safely pass its appropriate design flood at the lower historical level, but not at the MNOP, then modifications to enable the dam to pass the design flood will still be required. However, these modifications do not need to be initiated until such time as the reservoir reaches a water level starting at which it cannot safely pass the design flood. Determine this "trigger starting elevation"—at which the dam is overtopped by the design flood—and report it along with the rest of the analysis.

- Do not assume the reservoir to be drawn down below the maximum normal operating level in advance of the design storm.
- For new structures, no long-term effects of sedimentation on flood storage capacity need to be assessed for flood routing. For modification or rehabilitation of existing structures, a revised state-storage curve, accounting for sedimentation, should be developed from a field survey.

Hydraulic Routing

For hydraulic routing of hydrographs through reservoirs, there is no distinction between streamflow and reservoir routing. The reservoir is simply modeled with cross-sections as part of the stream with the spillway modeled either directly in the computer model or as an internal boundary based on the spillway rating curve. Though the modeling methodology is the same, certain issues should be considered.

- Through all but the shallowest portions of the reservoir, water levels are not sensitive to roughness coefficients.
- Adjust cross-sections and the intervening lengths to match the overall reservoir elevation-storage relationship.
- For gated dams, route the design-storm inflow hydrograph through the reservoir and through the dam's hydraulic control structures using the planned flood-operation rules for the spillway or in a manner that takes into consideration downstream flood risks.
- Do not assume the reservoir to be drawn down below the maximum normal operating level in advance of the design storm.

Each method will require hydraulic data about the reservoir and spillway, as described in Chapter 7.

6.6 Design-Flood Hydrographs

After estimating the full PMF hydrograph, determine the design-flood level, based on the size and hazard classification as described in Section 3.2. For hydrologic models that produce a full reservoir-inflow hydrograph, determine the design flood by multiplying each ordinate of the PMF inflow hydrograph by the required percentage. For example, if the design flood is 75 percent of the PMF, then multiply the 100 percent PMF-inflow hydrograph ordinates by 0.75. Make no adjustments to the precipitation data. This design flood–inflow hydrograph is then routed through the reservoir appropriately to determine the peak design-flood level.

For models using hydraulic flood routing methods for the streamflow components and the reservoir, similarly adjust each runoff hydrograph that represents a boundary or lateral inflow hydrograph, multiplying each ordinate of the hydrograph by the specified percentage. Then route these adjusted hydrographs would through the hydraulic model to determine the design-flood level.

6.7 Computer Models

Acceptable computer models for hydrologic and some hydraulic modeling methods include:

- HEC-HMS (U.S. Army Corps of Engineers)
- HEC-1 (U.S. Army Corps of Engineers)
- SITES (National Resource Conservation Service)
- WIN TR20 (National Resource Conservation Service)
- WIN TR55 (National Resource Conservation Service)

Acceptable computer models for hydraulic modeling include:

- HEC-RAS, unsteady flow (U.S. Army Corps of Engineers)
- NWS Dynamic Wave Models (DAMBRK, DWOPER, FLDWAV) (National Weather Service)

Other models may be acceptable upon written approval of the coordinator of the Dam Safety Program.

CHAPTER 7

Hydraulic Design Criteria

7.0 Introduction

Important components of any design flood determination are the accurate representation of the elevation-area-capacity (EAC) relationship for the reservoir and the dam's spillway rating curve. Each is an essential component of the process of routing hydrographs through the reservoir.

7.1 Elevation-Area-Capacity

Determine the EAC from the best mapping available, commonly by simply measuring the area within the reservoir at all available contours. GIS techniques often suffice, giving due importance to properly accounting for islands within the overall area. In many areas of Texas, U.S. Geological Survey 1:24,000 mapping is the best available with 10-foot contour intervals. If no other updated information is available, these are generally sufficiently accurate for flood routing. In such situations, measure and plot the areas at each contour interval from the bottom of the reservoir to the first contour above the top of the dam. Then use the curve generated through these points to pull off areas at individual one-foot increments and tabulate a summation of the average area for each one-foot increment. This process will generate appropriate volumes of storage at each elevation needed for flood routing.

For existing reservoirs for which no mapping below the water surface is available, this process can be performed starting with an assumed storage at the maximum normal operating level, which will be used as the starting water surface elevation for the flood routing. Incremental storage amounts below the starting water surface do not impact hydrologic flood routing procedures.

For hydraulic routing procedures, do not use an EAC directly, as the reservoir is to be modeled using cross-sections. As described in the previous chapter, adjust the cross-sections or the distances between them so that the volumes calculated within the model are reasonably close to the actual EAC.

7.2 Spillway Rating Curves

The spillway rating curve needs to be determined for both existing and proposed reservoirs and for each component of the dam that will be used to pass flood flows during the design flood event. For many dams, this will be a combination of a principal spillway that is used for all flood events and an emergency spillway that is only used in larger, rarer events. Numerous sources describe appropriate methodologies for determining rating curves. Widely used references—for both existing and proposed spillways—include *Design of Small Dams* (U.S. Department of the Interior, Bureau of Reclamation, 1987) and NRCS methodologies.

Principal Spillways

Rating-curve development needs to reflect the unique characteristics of the individual spillway. Ungated spillways will generally be shaped as a weir—either ogee, sharp crested, or broad crested—or as a drop-inlet, or morning-glory, spillway. The weirs would utilize the simple weir equation, $Q = CLH^{3/2}$, with C set by the shape and dimensions of the structure. In planning stages, C can be assumed to be constant, but in design-level analyses C will also vary with the height of water over the crest. Gated spillways will typically require the same procedure for determining total capacity, assuming the gates are opened sufficiently so as to not affect the flow. For discharges through partial gate openings, use orifice-flow assumptions. Standard drawdown profiles are necessary, assuming unimpeded flows, in order to determine the size of the gate opening needed to switch back to weir control for the rating curve.

Rating curves for drop-inlet, or morning-glory, spillways are generally calculated assuming two different types of hydraulic control. For low flows, the circumference of the inlet operates as a weir, with discharge estimated using the weir equation. For higher flows, the inlet will work as an orifice at the narrowest portion, or throat, of the vertical column. If the spillway conduit through the dam is designed for pressure flow, then the hydraulic control may rest with the sum of energy losses acting through the closed system as a whole. In these cases, sum entrance, bend, friction, and exit loss coefficients, along with other losses that may apply, and determine the rating curve

determined for a closed, pressure-flow system. For these spillways of these types, make calculations assuming each type of flow patterns and use the lowest discharge as the controlling situation.

Points on the final rating curve developed for reservoir routing reflect the total discharge, typically more points at the lower end of the curve where the rates change more rapidly, with points plotted for key break points such as the crest of the emergency spillway or where changes in the gate operating procedures occur.

For proposed dams and new spillways, keep in mind the following concepts in order to determine the most appropriate principal spillway type:

- Generally use drop-inlet, or morning-glory, spillways when there is plenty of available flood-storage volume. The flow capacity of the spillway does not significantly increase once the reservoir reaches a level at which the spillway "plugs" or operates under pressure or orifice control. Morning-glory spillways are well suited to flood control.
- In morning-glory spillways, it is preferable that the conduit through the dam be designed to have open channel flow with depths no more than 75 percent of the height of the conduit. This will generally require a hydraulically steep slope carrying supercritical flow and a diameter greater than that of the throat of the spillway riser. If that is not practical, then a conduit significantly smaller than the riser that forces pressure flow through the conduit quickly will be preferable. Both of these concepts attempt to minimize the large pressure fluctuations that typically occur with flow transitioning from open channel to pressure flow.
- Larger morning-glory inlets will need anti-vortex devices to break up naturally occurring vortices in the entering flow.
- Gated spillways require considerable additional cost for the operating system, operating personnel, and maintenance. In addition, it is generally perceived that an owner takes on significant additional potential liability with a gated spillway.

Emergency Spillways

Emergency spillways are generally cut into an abutment and have little or no erosion protection from flows discharging through them. For this reason, only for the largest and rarest of floods are they an economical way to pass large quantities of flow. It is often accepted that erosion damage will occur should the emergency spillway operate, but that the effective cost of the very infrequent repairs is much lower than the upfront capital costs of the means to prevent the erosion. Most emergency spillways are built to prevent passage of flows for less than about the 50- or 100-year flood.

Generally, determine rating curves for emergency spillways using a backwater analysis with a steady-state water- surface profile model, such as HEC-RAS. Perform several runs with varying discharges, relating each to a reservoir water-surface elevation. Enough sections are needed such that the most upstream section has minimal approach velocity; ignore any energy losses upstream from that point. Then find the rating curve by assuming that the energy level, not the water surface elevation, at the most upstream section equates to the reservoir level for the specified discharge. Then plot these values and determine the discharges for set elevations from the curve. A standard equation for broad-crested weirs should be used only for rough planning. For such an equation to be accurate, the slope downstream from the crest would need to be steep enough to create supercritical flow down the slope, which has the consequence of causing much more damage than would occur under critical flow.

For proposed dams and new emergency spillways, consider the following in order to determine the most appropriate configuration and location:

- Locate emergency spillways such that any flows that discharge through them will not strike or flow against the dam embankment.
- Configure the channel such that critical flow will occur as far downstream as reasonably possible so as to maximize the length of any erosion path back to the reservoir. The crest can be centered, but the slope downstream from the crest should be set to effect subcritical flow—generally be a slope of about 0.25 percent or less, depending on the vegetation. An alternative would be to address the potential erosion from supercritical flow, either with the provision of an erosion-resistant surface or a determination that the final configuration will not erode sufficiently to cause a significant release of water from the reservoir.
- The crest of the spillway should be set above the 50- or 100-year flood level to minimize its frequency of operation. In general, the less frequently an emergency spillway operates, the more erosion will be acceptable.
- The roughness coefficients used in the analysis should reflect ultimate vegetative conditions of the emergency spillway, not newly constructed conditions.

CHAPTER 8

Dam-Breach Analyses

8.0 Introduction

Breach analyses for existing dams can be performed in one of two manners, *simplified* and *full*.

The simplified method is for proposed and existing small dams, and existing intermediate dams. The method is empirical and conservatively approximates the assumptions for downstream flow and extent of flooding. It will significantly reduce the preparation time and cost of inundation mapping. A full breach analysis may be used for a dam of any size if the owner wishes either to demonstrate a lower hazard classification than that determined using the simplified method or simply to estimate inundation more accurately.

For large dams, use the full breach analysis, whether evaluating a proposed or an existing dam. Also use a full breach analysis for proposed intermediate-sized dams.

8.1 Hydrologic Conditions

Perform full breach analyses for the following hydrologic conditions at a minimum:

- *Sunny-day breach:* Reservoir at its maximum normal operating pool level.
- *Barely overtopping breach:* Inflow design flood set to the percentage of the PMF or design flood that equals the top of the dam. If the dam passes 100 percent of the design flood without overtopping, this scenario does not need to be run.
- *Design-flood breach:* Inflow hydrograph equal to the full design flood.

Compare barely overtopping and design-flood breach runs to runs for the same event assuming that the dam does not fail. The simplified breach method for existing dams only reviews the impacts from a breach occurring with the reservoir at the effective crest of the dam.

If the design-flood breach overtops the dam, the analysis will need to either assume flow over the top of the dam or not. The former adds complexity to the model as the length of the dam that is overtopped is reduced by the breach width, but it also provides a more exact and less conservative determination of breach discharge for existing conditions. For dams for which upgrades to the dam are being considered, assume no flow over the crest, as if the dam were raised to contain the design flood. This is simpler and more conservative.

Initiate the breach at the peak reservoir level under each scenario.

8.2 Downstream Conditions

Under the barely overtopping and design-flood conditions, estimate inflows from downstream tributaries by extending the design-flood ellipses under the HMR-52 methodology over the associated areas. Use the size, location, and orientation of the ellipses used for determining the critical design flood without adjustment. Adjust downstream-runoff hydrographs to the same degree that the barely overtopping flood is upstream of the reservoir. Assume that runoff parameters from the dam's watershed apply, or extrapolate them appropriately to the adjacent basins. No additional calibration downstream is warranted. If the stream on which the breach hydrograph is being routed opens into a much larger river, then multiple considerations are necessary:

- DAMBRK cannot model a dendritic system and can only be used iteratively, with the initial and receiving stream each modeled separately. The stage hydrograph on the receiving stream will serve as a downstream boundary of the initial stream and the discharge hydrograph of the upstream river will serve as a lateral inflow hydrograph to the downstream river. Iterations continue until agreement is reached. HEC-RAS and FLDWAV can model a dendritic system and are usually more appropriate.
- A large volume of water discharging into the receiving stream will tend to distribute flows in both the upstream and downstream directions. Depending on the initial flow on the receiving stream, this can be seen as a reduction in flow rate or even in negative

flows traveling upstream. Therefore, sufficient cross-sections on the receiving stream need to be included upstream of the junction to allow for this phenomenon, if appropriate.

- If the drainage area of the receiving stream is too large for it to be effectively covered by the ellipses representing the design flood, an assumption on initial flows is needed. It can be assumed that significant flows will occur coincidental to the design flood on the tributary; however, their timing and magnitude will be virtually unrelated and indeterminate. Therefore a constant flow hydrograph can be assumed. As an example, this could be equal to the 10-, 50-, or 100-year flood, depending on the relative sizes of the two streams. The larger the ratio of the drainage areas (the receiving stream drainage area divided by the dam watershed area), the smaller the assumed flow level should be in the receiving stream. A reasonable level that puts the receiving stream at or slightly above flood stage before the breach flows arrive will usually produce the critical incremental impact due to the breach. This should be considered in the decision.

8.3 Breach Parameters

Breach Location

Perform the breach analysis on the component of the dam for which failure would create the worst impact downstream, regardless of the relative likelihood of failure. Analyze this component of the structure for the hydrologic conditions listed above. Review each major component of the dam to determine the maximum discharge. This review will not take into account the likelihood of failure of any component, but should look at the most likely configuration of a breach, should one occur. For each structure component, the breach section should be at the maximum portion of the structure that can contain the full bottom width of the breach. For example, if the breach width for an embankment is 200 feet wide, the location should be planned for the lowest 200 ft section of the dam above natural ground at the toe. If the channel downstream is only 50 feet wide, then it would not be in the original channel or at the maximum height of the dam. However, the 200-foot-wide breach at a higher level should be compared to a 50-foot-wide breach at the maximum section over the river channel. Use whichever has the higher peak discharge.

Breach Configuration (Embankments)

Assume breach configurations in an embankment, regardless of the failure mechanism to have, at a minimum, a width of three times the depth of water impounded under each hydrologic condition described above, with vertical side slopes. Any configuration that will produce a larger peak breach discharge will be acceptable. This configuration represents a minimum; larger values may be more appropriate in certain situations, based on the engineer's judgment.

Breach Configuration (Structural Components)

Determine breach configurations in a structural component of the dam, such as the spillway or gravity section, case by case. The minimum breach width will generally match individual elements of the structure, such as one buttress in a slab and buttress dam or one monolith in a gravity non-overflow section. Review multiple adjacent components with varying failure times in order to determine the critical configuration.

Time of Failure (Embankments)

Assume that breach configurations in an embankment—regardless of the failure mechanism—form at a minimum rate of three feet of depth of water impounded per minute under each hydrologic condition described above. Any time of failure that will produce a larger peak breach discharge is acceptable. This failure time represents a maximum. Smaller values may be more appropriate in certain situations, based on the engineer's judgment. Longer times to failure may be used in the modeling process if needed for computational stability and if it can be shown that the peak breach discharge is not sensitive to the time to failure. This is often the case for dams with large storage volumes for which the lake level does not change significantly during the elapsed time of the breach formation.

Time of Failure (Structural Components)

Determine time of failure for a breach configuration in a structural component of the dam case by case. When assuming an individual element of the structure, such as one buttress in a slab and buttress dam or one monolith in a gravity non-overflow section, the time should be instantaneous. Also review more than one adjacent component with varying failure times in order to determine the critical configuration. Base the incremental failure time of adjacent structures on the estimated time for the component to fail due to erosion of the foundation. Present justification in all cases. However, the amount of failure time per adjacent component needs not exceed 30 minutes per component in an alluvial foundation and one hour in a rock foundation. The analyst should also consider the likelihood that this failure mechanism of adjacent structural components will occur in both directions outward from the original component.

8.4 Dam-Breach Models

When using a full breach analysis method, choose appropriate models that can properly determine and route full breach flood waves. For large high-hazard dams, choose an unsteady, dynamic wave model—such as HEC-RAS, DAMBRK, or FLDWAV—to determine the downstream impacts and inundation limits of a breach. For existing small or intermediate-size dams, regardless of hazard rating, a simpler (but less accurate) hydrologic model, such as HEC 1 (HMS), is acceptable for modeling the breach flood wave and to determine inundation limits. However, a dam owner who is performing the breach analysis in order to justify a reduction from a high hazard classification should use one of the dynamic wave models.

8.5 Breach Inundation Lengths

Extend models of breach flood waves far enough downstream to allow analysis of the area that is likely to be significantly affected by a breach of the dam and to provide sufficient information for proper development and execution of an EAP. Though judgment is needed on the part of the engineer performing the analysis, the following guidelines will generally be suitable:

- *Sunny-day breach*—The floodwave should be modeled for a length downstream, beyond which approximately 75% of the flow is within the channel and no structures are threatened.
- Barely overtopping and design-flood breaches—These floodwaves should be modeled for a length downstream, beyond which the increase, due to the breach, in the peak flood level over the non-breach condition is insignificant and with no adverse effects—generally 1 ft in developed areas. In undeveloped areas, a higher differential may be acceptable.

8.6 Dams in Sequence

For design-flood PMF analyses, generally assume that upstream reservoirs remain intact, unless the design flood for the dam under consideration would overtop the upstream dam. If so, further analysis of the upstream dam may be warranted. For an upstream dam assumed to breach, assume it to breach in both the breach and non-breach runs for the downstream dam under consideration. Multiple combinations of breach and non-breach conditions for multiple dams are not necessary.

Assume that downstream dams breach if overtopped by either the breach or non-breach condition and that they do not breach if not overtopped. Assumptions possibly could differ if specific information indicates otherwise. However, as with upstream dams, multiple combinations of breach and non-breach conditions for multiple dams are not necessary. It is possible that the design flood for the upstream dam does not overtop the downstream dam, but does so with a failure of the upstream dam. In that case, assume that the downstream dam fails in the breach scenario and does not in the non-breach scenario. The failure of the upstream dams will contribute to the inflow hydrograph, and have an impact on whether the downstream dam overtops and breaches.

8.7 Inundation Mapping

As described above, perform full breach analyses for a sunny-day breach, a barely overtopping breach (if needed), and a design-flood breach. In a breach study, the barely overtopping breach flood is compared to a barely overtopping flood which does not have a breach. A similar comparison would be done using the design-flood breach, and the design flood with no breach. However, inundation mapping, which is to be used in an Emergency Action Plan, should only include the outline of the water levels reached in the sunny-day and the design-flood breach runs. Do not show non-breach runs in EAP inundation maps. The report should compare breach and non-breach runs in tabular form. As described in the following section, for studies using the simplified breach method, only one inundation condition, equivalent to a flood level at the top of the dam, is to be shown.

Base inundation maps on the best available mapping and present them as sequenced 11" × 17" maps for ease in inclusion in EAPs. Choose scales that allow for clear depiction of structures and major infrastructure, yet that do not generate a large number of sequenced maps that would be difficult to interpret during an emergency by non-technical personnel. USGS 1:24,000 maps are generally suitable, though often outdated with respect to showing structures and major infrastructure. Aerial photos, if available with reasonable clarity and scale, can also be used as a background for inundation maps.

Inundation maps should also indicate times to flood, or the time from the breach to the time that critical structures are flooded. Label these times directly on the map at occasional intervals or at critical structures.

8.8 Simplified Breach Method

For small and intermediate-size dams, the following approximation of peak discharge and inundation limits can be applied. The peak discharge from a breach, using the assumed breach criteria for the dam as described above, can be estimated by the following equation:

Eq. 8.1 $Q_B = 3.1 \cdot B \cdot H^{3/2}$, where

Q_B = peak total discharge from the breach, in cfs
B = bottom width of breach, assumed to be $3 \cdot H$ for embankments or $^1/_2$ the width of a structural spillway or concrete structure, in ft
H = maximum height of the dam, in ft

The total release discharge (Q_T) would then be:

Eq. 8.2 $Q_T = Q_B + Qs$, where

Q_S = peak discharge capacity from the spillway(s) with the reservoir at the top of the dam, in cfs

Estimate the inundation at selected locations downstream using normal flow calculations and an appropriate representation of the cross-section from available mapping. Manning's equation should be used for the normal flow calculations. Within this equation, roughness coefficients estimates should be increased by 25% to account for increased turbulence and energy losses typically associated with breach floodwaves. The peak discharge should be assumed to attenuate at a linear rate from its peak at the downstream toe of the dam, Q_T, down to Q_S over the "inundation length" of the stream downstream. This inundation length, L_U, is to be determined by the following equation:

Eq. 8.3 $L_U = 0.012 \cdot K_S \cdot \sqrt{2 \cdot C \cdot H}$, where

L_U = inundation length in miles.
K_S = Correction factor for spillway size
$K_S = Q_B/Qs$; Maximum value = 2.0
Minimum value = 0.5
C = Total capacity of the reservoir at the top of the dam, in acre-feet
H = Maximum height of the dam, in ft

If the inundation length extends past the point where the stream on which the dam is located flows into a larger stream, continue the length on the larger stream either for the full inundation length or to a point where the normal flow estimates show approximately 75 percent of the flow within the channel and no structures threatened.

For each location of interest, estimate the inundation limits by normal flow calculations, as described above, for sufficient points within the inundation length to map an approximate inundation boundary. Also estimate the limits at all identified structures—residences and infrastructure elements alike. At locations where the stream on which the dam is located flows into a larger stream, the first elevation determined on the larger receiving stream shall be used as the elevation of all backwater inundation on that larger stream upstream of where the tributary joined. The downstream surface calculations can also be performed, if desired, using a standard water-surface-profile model, such as HEC-RAS in steady-state mode, using the interpolated discharges along the inundation length.

Then use this entire approximate inundation limit for impact evaluation, hazard classification, and EAP development. Since time is not considered in this simplified method, consider all structures that may be affected as having no warning time for evaluations of hazard classifications. No times to flood need be estimated or shown on inundation maps developed using the simplified method.

CHAPTER 9

Risk Assessment and Classification of Hazard Potential

9.0 Introduction

Based upon its hazard potential, a dam is classified into one of three risk categories: low, significant, and high. Determine each hazard-potential classification, as described in the following sections, based on the consequences and losses caused by a dam breach under the most critical assumptions for the three hydrologic scenarios described in Chapter 8: sunny-day, barely overtopping (if applicable), and design-flood breaches. In hazard-potential classification, give consideration to potential adverse consequences including deaths and the loss of major infrastructure elements—infrastructure whose loss may indirectly place such a burden on a community that lives would be at risk as a result. Examples include major roads and highways, hospitals, water supply reservoirs, cooling reservoirs, and the like. Hazard assessment is also based on the potential economic risk associated with the flooding of industry, businesses, and infrastructure. This risk and the related regulatory issues are also handled within the confines of local flood protection regulations, such as those enforcing FEMA's 100-year-floodplain regulations. A hazard-potential classification does not reflect any estimate of the likelihood that a dam may fail, but only reviews the consequences of the assumed failure.

In many cases, the hazard potential classification of a dam is visually apparent from field reconnaissance and, with TCEQ approval, a description of the observations will be sufficient to support a determination. These will typically be for dams that are clearly either low or high hazard. In other cases, classifications must be based on the recommendations—in which conservatism is expected—of a licensed professional engineer knowledgeable in the field. To determine the potential of lowering the hazard classification from a conservative field evaluation, detailed studies including dam-breach analyses are to be performed for various hydrologic conditions to evaluate the effects of a failure of a dam, as described below. For this study, use either the full breach analysis or the conservative, simplified breach-inundation estimation method, as described in Chapter 8, to identify the areas at risk.

9.1 Multiple Dams

If failure of an upstream dam will not cause failure of another dam downstream, then the hazard-potential classification of the upstream dam must be determined independently from that of the downstream dam. If the failure of an upstream dam will likely cause the failure of a downstream dam, then the hazard-potential classification of the upstream dam needs to take into account the potential failure of the downstream dam.

9.2 Individual Components of a Dam

Separate components of a dam may not be assigned separate hazard classifications. Determine a single hazard classification for the entire dam. If the harmless failure of an isolated dike or levee reduces the likely failure of the dam, then the failure of the isolated component should be properly incorporated into the design and operation of the dam, as in the example of a fuse-plug spillway. However, a breach analysis to demonstrate the different incremental impacts of various components may be a useful means of allocating limited resources for repair and maintenance.

9.3 Hazard-Potential Classification

Upon completing the mapping of a breach inundation area and the identification of the population and infrastructure at risk, determine the hazard-potential classification. These guidelines do not provide any set numerical markers or definitive equations for defining the hazard classification. The evaluation is to be a conservative judgment based on the available information. General guidelines and descriptions appear in the Texas Administrative Code, Title 30, Part 1, Chapter 299.

9.4 Alternative Means of Assessing Risk and Hazard

Hazard classifications are subjective, but conservative, evaluations reflecting the quantity of structures that exist within the

breach inundation area, based on the assumption that structures reflect lives at risk. Though purposefully simple and adaptable to many situations, the procedure may not prove capable of discerning clear distinctions in marginal cases. More precise assessments of risk can be made through a variety of procedures. These alternative methods can be used to determine the population at risk within the inundation zone or the incremental value at risk from a breach relative to the costs of implementing modifications to reduce that risk. Such alternative methods are typically based on evaluating the probability of people being home when the flood passes by, or on a more exact analysis of the flood depth and velocity effects on the population exposed to the flood. Statistical economic methods can also be applied. Submission of alternative analyses such as these must include documentation of a theoretical explanation for the method, verifiable calculations, and adequate references for justifying the assumptions and parameters used. The TCEQ must approve all alternative methods.

Appendix
Submittal Forms

Information Sheet: Existing Dam
Form TCEQ-20344

Information Sheet: Proposed New Construction Modification, Repair, Alteration, or Removal of a Dam
Form TCEQ-20345

Hydrologic and Hydraulic (H&H) Evaluation Summary
Form TCEQ-20346

Engineer's Notification of Completion
Form TCEQ-20347

Texas Dam Safety Program, MC 174
Field Operations Support Division, Office of Compliance and Enforcement
Texas Commission on Environmental Quality
P.O. Box 13087
Austin, TX 78711

INFORMATION SHEET: EXISTING DAM

(PLEASE PRINT OR TYPE)

Reference 30 Texas Administrative Code, Chapter 299, Dams and Reservoirs

SECTION 1: OWNER INFORMATION

Owner's Name _____ Title _____

Organization _____

_____ _____

(Signature of Owner) *(Date)*

Owner's Address _____

City _____ State _____ Zip Code _____

Phone Number ( ) _____ Emergency Contact Phone ( ) _____

Fax Number ( ) _____ E-mail _____

Owner Code *(Please check one)*: ❑ Federal (F) ❑ Local Government (L) ❑ Utility (U) ❑ Private (P) ❑ State (S)
❑ Other (O) please specify: _____

Year Built _____ Year Modified _____

Dam and Reservoir Use *(Please check one)*:

❑ Augmentation	❑ Diversion	❑ Domestic	❑ Erosion Control		
❑ Evaporation	❑ Flood Control	❑ Fire Control	❑ Fish	❑ Hydroelectric	❑ Industrial
❑ Irrigation	❑ Mining	❑ Municipal	❑ Pollution Control	❑ Recreation	❑ Stock Water
❑ Settling Ponds	❑ Tailings	❑ Waste Disposal	❑ Other, please specify: _____		

Engineering Firm _____

Project Engineer _____ Texas P.E. License Number _____

Engineering Firm Address _____

City _____ State _____ Zip Code _____

Phone ( ) _____ Fax ( ) _____

E-mail _____

SECTION 2: GENERAL INFORMATION

Name of Dam _____

Other Name(s) of Dam _____

Reservoir Name _____

Location _____ Latitude _____ Longitude _____

County _____ Stream Name _____

River Basin _____ Topographic Map No. _____

Distance & Direction from Nearest City or Town _____

Last Inspection Date _____ Inspected by (name of company or agency) _____

TX Number _____ Water Rights Number _____

Date of Emergency Action Plan (EAP), if one exists _____

Describe the current operating condition of dam _____

_____

If you have questions on how to fill out this form or about the Dam Safety Program, please contact us at 512-239-5195. *Individuals are entitled to request and review their personal information that the agency gathers on its forms. They may also have any errors in their information corrected. To review such information, contact us at 512-239-3282.*

SECTION 3: INFORMATION ON DAM

Classification

Size Classification: ❑ Large ❑ Medium ❑ Small

Hazard Classification: ❑ High ❑ Significant ❑ Low

Number of People at Risk _____ Study Year _____

Type of Dam: ❑ Concrete ❑ Gravity ❑ Earthfill ❑ Rockfill ❑ Masonry ❑ Other (specify) _____

Dam Structure **(dimensions to nearest tenth of foot, volume to nearest acre-foot or cubic yard, areas to nearest acre):**

Spillway Height _____ ft *(natural surface of ground to bottom of emergency spillway at longitudinal centerline)*

Embankment Height _____ ft *(natural surface of ground to crest of dam at centerline)*

Structural Height _____ ft *(bottom of cutoff trench to crest of dam at centerline)*

Length of Dam _____ ft Crest Width _____ ft

Normal Pool Elevation _____ ft-MSL Principal Spillway Elevation _____ ft-MSL

Emergency Spillway Elevation _____ ft-MSL Top of Dam Elevation _____ ft-MSL

Embankment Volume _____ cu yd

Maximum Impoundment Capacity _____ ac-ft *(at top of dam)*

Normal Reservoir Capacity _____ ac-ft *(at normal or conservation pool)*

Reservoir Surface Area _____ acres *(at normal or conservation pool)*

Outlet

Outlet Diameter: _____ ❑ in ❑ ft *(check one)*

Type: _____

Principal Spillway

Type: ❑ Natural ❑ Riprap ❑ Concrete ❑ CMP ❑ RCP ❑ Other

Width (Diam.): _____ ft Capacity: _____ cfs

Emergency Spillway

Type: ❑ Natural ❑ Riprap ❑ Concrete ❑ CMP ❑ RCP ❑ Other

Width (Diam.): _____ ft Capacity: _____ cfs

Total Spillway Capacity: _____ cfs (crest of the dam)

SECTION 4: HYDROLOGIC INFORMATION

Required Hydrologic Criteria (% PMF) _____ % PMF Passing _____

PMF Study Year _____

Drainage Area: _____ acres, or _____ sq mi

Curve Number (AMC III condition) _____

Time of Concentration _____ hr

Peak Discharge _____ cfs

Peak Stage _____ ft-MSL

Storm Duration Causing Peak Stage _____ hr

Texas Dam Safety Program, MC 174
Field Operations Support Division, Office of Compliance and Enforcement
Texas Commission on Environmental Quality
P.O. Box 13087
Austin, TX 78711

INFORMATION SHEET: PROPOSED NEW CONSTRUCTION, MODIFICATION, REPAIR, ALTERATION, OR REMOVAL OF A DAM

(PLEASE PRINT OR TYPE)

Reference 30 Texas Administrative Code, Chapter 299, Dams and Reservoirs

PLEASE CHECK ONE: ❑ New ❑ Modification ❑ Repair ❑ Removal ❑ Alteration

SECTION 1: OWNER INFORMATION

Owner's Name _____ Title _____

Organization _____

I have authorized the submittal of the final construction plans and specifications to the TCEQ Dam Safety Program according to 30 TAC Chapter 299.

_____ _____

(Signature of Owner) *(Date)*

Owner's Address _____

City _____ State _____ Zip Code _____

Phone Number ( ) _____ Emergency Contact Phone ( ) _____

Fax Number ( ) _____ E-mail _____

Owner Code *(Please check one)*: ❑ Federal (F) ❑ Local Government (L) ❑ Utility (U) ❑ Private (P) ❑ State (S)
❑ Other (O) please specify: _____

Dam and Reservoir Use *(Please check one)*: ❑ Augmentation ❑ Diversion ❑ Domestic ❑ Erosion Control
❑ Evaporation ❑ Flood Control ❑ Fire Control ❑ Fish ❑ Hydroelectric ❑ Industrial
❑ Irrigation ❑ Mining ❑ Municipal ❑ Pollution Control ❑ Recreation ❑ Stock Water
❑ Settling Ponds ❑ Tailings ❑ Waste Disposal ❑ Other, please specify: _____

Engineering Firm _____

Project Engineer _____ Texas P.E. License Number _____

Engineering Firm Address _____

City _____ State _____ Zip Code _____

Phone ( ) _____ Fax ( ) _____

E-mail _____

SECTION 2: GENERAL INFORMATION

Name of Dam _____

Other Name(s) of Dam _____

Reservoir Name _____

Location _____ Latitude _____ Longitude _____

County _____ Stream Name _____

River Basin _____ Topographic Map No. _____

Distance and Direction from Nearest City or Town _____

TX Number _____ Water Rights Number _____

If you have questions on how to fill out this form or about the Dam Safety Program, please contact us at 512-239-5195. *Individuals are entitled to request and review their personal information that the agency gathers on its forms. They may also have any errors in their information corrected. To review such information, contact us at 512-239-3282.*

SECTION 3: INFORMATION ON DAM

Classification

Size Classification: ❑ Large ❑ Medium ❑ Small

Hazard Classification: ❑ High ❑ Significant ❑ Low

Number of People at Risk _____ Study Year _____

Type of Dam: ❑ Concrete ❑ Gravity ❑ Earthfill ❑ Rockfill ❑ Masonry ❑ Other (specify) _____

Dam Structure **(dimensions to nearest tenth of foot, volume to nearest acre-foot or cubic yard, areas to nearest acre):**

Spillway Height _____ ft *(natural surface of ground to bottom of emergency spillway at longitudinal centerline)*

Embankment Height _____ ft *(natural surface of ground to crest of dam at centerline)*

Structural Height _____ ft *(bottom of cutoff trench to crest of dam at centerline)*

Length of Dam _____ ft Crest Width _____ ft

Normal Pool Elevation _____ ft-MSL Principal Spillway Elevation _____ ft-MSL

Emergency Spillway Elevation _____ ft-MSL Top of Dam Elevation _____ ft-MSL

Embankment Volume _____ cu yd

Maximum Impoundment Capacity _____ ac-ft *(at top of dam)*

Normal Reservoir Capacity _____ ac-ft *(at normal or conservation pool)*

Reservoir Surface Area _____ acres *(at normal or conservation pool)*

Outlet

Outlet Diameter: _____ ❑ in ❑ ft *(check one)*

Type: _____

Principal Spillway

Type: ❑ Natural ❑ Riprap ❑ Concrete ❑ CMP ❑ RCP ❑ Other

Width (Diam.): _____ ft Capacity: _____ cfs

Emergency Spillway

Type: ❑ Natural ❑ Riprap ❑ Concrete ❑ CMP ❑ RCP ❑ Other

Width (Diam.): _____ ft Capacity: _____ cfs

Total Spillway Capacity: _____ cfs (crest of the dam)

SECTION 4: HYDROLOGIC INFORMATION

Required Hydrologic Criteria (% PMF) _____ % PMF Passing _____

PMF Study Year _____

Drainage Area: _____ acres, or _____ sq mi

Curve Number (AMC III condition) _____

Time of Concentration _____ hr

Peak Discharge _____ cfs

Peak Stage _____ ft-MSL

Storm Duration Causing Peak Stage _____ hr

Texas Dam Safety Program, MC 174
Field Operations Support Division, Office of Compliance and Enforcement
Texas Commission on Environmental Quality
P.O. Box 13087
Austin, TX 78711

HYDROLOGIC AND HYDRAULIC (H&H) EVALUATION SUMMARY

(Please complete **all** sections, unless otherwise specified)

Name of Dam: _____

TCEQ Dam Safety Project No.: _____

County: _____

Year to Build: _____

Maximum Record Precipitation (in): _____

Record Area (county or city): _____

Duration (hr): _____

Date of Record (MM/DD/YY): _____

Source Ref. (FEMA, National Weather Service, etc.): _____

Downstream Dam Toe _____ (ft-MSL)

Normal Pool _____ (ft-MSL)

Principal Spillway _____ (ft-MSL)

Emergency Spillway _____ (ft-MSL)

Top of Dam _____ (ft-MSL)

Normal Reservoir Capacity _____ (ac-ft)

Maximum Reservoir Capacity _____ (ac-ft)

Reservoir Surface Area _____ (ac)

Drainage Area _____ (ac)

Outlet Diameter or Cross-Section _____ (in)

Storm Duration	**Peak Inflow (cfs)**	**Peak Outflow (cfs)**	**Peak Stage (ft-MSL)**	**% PMF Passing**	**Comments (if needed)**
1 hr					
2 hr					
3 hr					
6 hr					
12 hr					
24 hr					
48 hr					
72 hr					

To the best of my knowledge, I certify the above data are correct. I will supply the hydrologic and hydraulic reports to the Texas Commission on Environmental Quality upon request.

_____
(Signature)

(P. E. Seal)

_____
(Date)

Texas Dam Safety Program, MC 174
Field Operations Support Division, Office of Compliance and Enforcement
Texas Commission on Environmental Quality
P.O. Box 13087
Austin, TX 78711

ENGINEER'S NOTIFICATION OF COMPLETION

(PLEASE PRINT OR TYPE)

PLEASE CHECK ONE: ❑ New ❑ Modification ❑ Repair ❑ Removal ❑ Alteration

TX Number _____ County _____

Adjudication Number _____ Permit Number _____

Name of Dam/Project _____

Owner:

Name _____

Address _____

City _____ State _____ Zip Code _____

Phone ( ) _____ Emergency Contact Phone ( ) _____

Fax ( ) _____ E-mail _____

Engineering Firm:

Firm Name _____

Project Engineer _____ TX P.E. License No _____

Firm Address _____

City _____ State _____ Zip Code _____

Phone ( ) _____ Fax ( ) _____

E-mail _____

The project was completed on _____, 20_____. To the best of my knowledge, the project was constructed in substantial conformance with plans, specifications, and change orders filed with and approved by the Texas Commission on Environmental Quality.

_____
(Signature)

(P. E. Seal)

_____
(Date)

If you have questions on how to fill out this form or about the Dam Safety Program, please contact us at 512-239-5195. *Individuals are entitled to request and review their personal information that the agency gathers on its forms. They may also have any errors in their information corrected. To review such information, contact us at 512-239-3282.*

Glossary

breach—An excavation through a dam or spillway that is capable of draining the entire reservoir so the structure—no longer considered a dam—will no longer impound water.

breach analysis—The determination of the most likely uncontrolled release of water from a dam (magnitude, duration, and location), using accepted engineering practice, to evaluate the inundation downstream.

breach area—An area that would be flooded as a result of a dam failure.

dam—Any barrier or barriers, with any appurtenant structures, constructed for the purpose of impounding water.

design flood—The flood used in the design and evaluation of a dam and appurtenant structures, particularly for determining the size of spillways, outlet works, and the effective crest of the dam.

effective crest—The elevation of the lowest point on the crest (top) of the dam, excluding spillways.

emergency action plan (EAP)—A written document prepared by the owner or the owner's professional engineer describing a detailed plan to prevent or lessen the effects of a potential failure of the dam or appurtenant structures.

emergency spillway—A secondary spillway designed to pass a large, but infrequent, volume of flood flows.

fetch—The straight-line distance across a reservoir subject to wind forces.

fuse-plug spillway—An auxiliary spillway that is intentionally blocked by an erodible berm. A higher discharge elevation is maintained during normal floods, while during extreme flooding the discharge elevation is lowered by erosion.

hazard classification—A categorization of the potential for loss of life or property damage in the area downstream of the dam in the event of a failure or malfunction of the dam or appurtenant structures. Does not represent the condition of the dam.

height of dam—The difference in elevation between the natural bed of the watercourse or the lowest point on the toe of the dam, whichever is lower, and the effective crest of the dam.

isohyet—An elliptical area representing the size, shape, and rainfall intensity of a PMP event.

inundation map—Map delineating the area that would be newly covered by water in a particular flood event.

maximum normal operating level—The highest water-surface elevation within the range of planned operating levels for the reservoir, above which floodwaters would be released.

maximum storage capacity—The volume, in acre-feet, of the impoundment created by the dam at its effective crest. Only water that can be stored above natural ground level or that could be released by a failure of the dam is considered in assessing the storage volume.

minimum freeboard—The difference in elevation between the effective crest of the dam and the maximum water surface elevation resulting from routing the design flood appropriate for the dam.

normal storage capacity—The volume, in acre-feet, of the impoundment created by the dam at the lowest uncontrolled spillway crest elevation, or at the maximum elevation of the reservoir under normal operating conditions.

population at risk—The number of people present in an area that would be flooded by a particular flood event.

principal spillway—The primary or initial spillway, designed to pass normal flows, that is engaged during a rainfall-runoff event.

probable maximum flood (PMF)—The flood magnitude that may be expected from the most critical combination of meteorological and hydrologic conditions that are reasonably possible for a given watershed.

probable maximum precipitation (PMP)—The theoretically greatest depth of precipitation for a given duration that is physically possible over a given storm area at a particular geographic location at a certain time of the year.

professional engineer—An individual licensed by the Texas Board of Professional Engineers to practice engineering in Texas, with expertise in the investigation, design, construction, repair, and maintenance of dams.

proposed dam—Any dam not yet under construction.

spillway—An appurtenant structure that conducts overflow from a reservoir.

top width elevation—The elevation of the water surface of a flood, associated with the top width of the flood cross-section.

References

American Society of Civil Engineers. 1996. *Hydrology Handbook*. 2nd ed. New York: McGraw-Hill.

Hansen, E. M., et al. 1988. *Hydrometeorological Report No. 55A: Probable Maximum Precipitation Estimates—United States Between the Continental Divide and the 103rd Meridian*. Washington: National Weather Service, Office of Hydrology.

Hansen, E. M., L. C. Schreiner, and J. F. Miller. 1982. *Hydrometeorological Report No. 52: Application of Probable Maximum Precipitation Estimates—United States East of the 105th Meridian.* Washington: National Weather Service, Office of Hydrology.

Federal Energy Regulatory Commission. 2001. *Engineering Guidelines for the Evaluation of Hydropower Projects.* Chapter 8, Determination of the Probable Maximum Flood. Washington. Available online at: <www.ferc.gov/industries/hydropower/safety/guidelines/eng-guide/chap8.pdf>.

Natural Resources Conservation Service. 1997. *National Engineering Handbook.* Part 630: Hydrology. Washington: U.S. Department of Agriculture.

———. 2005. *TR-60—Earth Dams and Reservoirs*. Washington: U.S. Department of Agriculture.

———. 1986. *TR-55—Urban Hydrology for Small Watersheds*. Washington: U.S. Department of Agriculture.

Reynolds, Dale. 1983. *Regional Relationships for Unit Hydrograph Coefficients—Natural and Urbanized Streams*. Tulsa, OK: U.S. Army Corps of Engineers, Tulsa District.

Rutledge, John. 2006, *Simplified Dam Breach Method—Technical Memorandum*. Austin: Freese and Nichols.

——— and Michelle Evans. 2006. *PMF Temporal Distribution—Technical Memorandum*. Austin: Freese and Nichols.

Schreiner, Louis C., and Riedel, John T. 1978. *Hydrometeorological Report No. 51, Probable Maximum Precipitation Estimates, Unites States East of the 105th Meridian.* Washington: National Weather Service, Office of Hydrology.

Skaggs, R. W., and R. Khaleel. 1982, *Infiltration in Hydrologic Modeling of Small Watersheds, American Society of Agricultural Engineers.* Monograph No. 5. American Society of Agricultural and Biological Engineers. St. Joseph, MI.

U.S. Army Corps of Engineers. 1982. *Hydrograph Analysis and Computation*. EM 1110-2-1405. Washington.

———. 1994. *Engineering and Design—Flood Runoff Analysis*. EM 1110-2-1417. Washington.

U.S. Department of the Interior, Bureau of Reclamation. 1987. *Design of Small Dams.* 3rd ed. Denver.



Texas Commission on Environmental Quality

The TCEQ is an equal opportunity/affirmative action employer. The agency does not allow discrimination on the basis of race, color, religion, national origin, sex, disability, age, sexual orientation or veteran status. In compliance with the Americans with Disabilities Act, this document may be requested in alternate formats by contacting the TCEQ at 512-239-0028, Fax 239-4488, or 1-800-RELAY-TX (TDD), or by writing P.O. Box 13087, Austin, TX 78711-3087.

printed on recycled paper

E.44. Utah



Utah Administrative Code

The Utah Administrative Code is the body of all effective administrative rules as compiled and organized by the Division of Administrative Rules (Subsection 63G-3-102 (5); see also Sections 63G-3-701 and 702).

NOTE: For a list of rules that have been made effective since October 1, 2010, please see the codification segue page.

NOTE TO RULEFILING AGENCIES: Use the RTF version for submitting rule changes.

Download the RTF file

Rule R655-10. Dam Safety Classifications, Approval Procedures and Independent Reviews.

As in effect on October 1, 2010

Table of Contents

- R655-10-1. Authority.
- R655-10-2. Purpose.
- R655-10-3. Applicability.
- R655-10-4. Definitions.
- R655-10-5. Hazard Classification.
- R655-10-5A. Hazard Classification--Criteria.
- R655-10-5B. Hazard Classification--Exceptions.
- R655-10-6. Approval Processes.
- R655-10-6A. Application Procedure.
- R655-10-6B. Submission of Plans.
- R655-10-7. Independent Consultant Review.
- R655-10-7A. Review of Design.
- R655-10-7B. Review of Construction.
- R655-10-7C. Operation.
- R655-10-7D. Selection of Independent Consultants.
- R655-10-7E. Qualifications of Independent Consultants.
- R655-10-7F. Scope of Work.
- R655-10-7G. Purpose of Independent Consultants Investigations.
- KEY
- Date of Enactment or Last Substantive Amendment
- Notice of Continuation
- Authorizing, Implemented, or Interpreted Law

R655-10-1. Authority.

The following rule is established under the authority of Title 73, Chapter 5a. The procedures constitute minimum requirements for dams. Additional procedures may

be required to comply with any other governing statute, federal law, federal regulation, or local ordinance.

R655-10-2. Purpose.

The purpose of this rule is to outline the procedures necessary to obtain approval to design, construct, operate, and remove a dam. This rule in no way waives the right of the State Engineer to evaluate the merits of different procedures or to require additional information before approval of any project.

R655-10-3. Applicability.

These rules apply to any dam constructed in the state with the exception of those specifically exempted by Section 73-5a-102. Some dams may have an abbreviated approval process as outlined in Section 73-5a-202.

R655-10-4. Definitions.

ABUTMENT is the part of the valley side against which the dam is constructed. Right and left abutments are those on respective sides of an observer when viewed looking downstream.

ACRE-FOOT (AC-FT) of water is the volume of water required to cover one acre, one foot deep. This is the term commonly associated with reservoir storage. It is equal to 43,560 cubic feet.

ACTIVE FAULT is a fault that has exhibited one or more of the following characteristics:

(a) movement at or near the ground surface at least once in the last 35,000 years;

(b) instrumentally determined seismicity that demonstrates a causal relationship with the fault;

(c) structural relationship to an active fault such that movement on one fault could be expected to cause movement on the other.

ACTIVE STORAGE CAPACITY is the amount of storage that can be released and utilized.

ANISOTROPY means having physical characteristics which vary in different directions.

APPURTENANT STRUCTURE means the outlet works, spillways, access structures, bridges, and other related structure to a dam.

AXIS OF DAM is the plane or curved surface, arbitrarily chosen by a designer, appearing as a line, in plan or in cross section, to which the horizontal dimensions of the dam can be referred.

BENCHMARK is a permanent physical mark of known horizontal coordinates and elevation.

BREACH is an opening or a breakthrough in a dam.

CALIBRATED WATERSHEDS are watersheds with sufficient precipitation and streamflow measuring devices and records to allow for computations of the relationships between precipitation and streamflow.

CAMBER is additional material placed on the dam crest to protect design freeboard from anticipated settlement.

CAPACITY is the maximum volume that can be stored in a reservoir below the

primary spillway level.

CAVITATION is wear on a hydraulic structure where a high hydraulic gradient is present.

CHANGE ORDER is a document used to modify approved plans or make adjustments in pay quantities.

COLLECTION PIPE is a conduit used to collect seepage waters from drainage blankets and drains and convey the water to a point downstream of the dam.

CONDUIT is a closed channel to convey water through, under, or around a dam.

CONDUIT FILTER DRAIN is a pervious filter drain around a conduit for the purpose of seepage control.

CONTROL SECTION is the section where flow passes through critical depth.

CONTOUR LINE is a line of constant elevation on a map or drawing.

CREST LENGTH is the developed length of the top of a dam.

CREST WIDTH is the developed width of the top of a dam.

CUBIC FEET PER SECOND (CFS) is a unit expressing rates of discharge. One cubic foot per second is equal to the discharge through a rectangular cross-section, one foot wide and one foot deep, flowing at an average velocity of one foot per second.

CUTOFF COLLAR is a projecting collar, usually of concrete, built around the outside of a pipe, tunnel, or conduit, to lengthen the seepage path along the outer surface of the conduit.

DAM is any artificial barrier or obstruction, together with appurtenant works, if any, which impounds or diverts water.

DEAD STORAGE is the storage that lies below the invert of the lowest outlet and that cannot be withdrawn from the reservoir without pumping.

DEFORMATION ANALYSIS is a study of how a dam will permanently deform as a result of strains caused by seismic loads.

DENTAL CONCRETE is concrete used to level discontinuities in dam foundations and abutments.

DESICCATION is the process of cracking of soils due to shrinkage during drying.

DIFFERENTIAL SETTLEMENT is unequal settlement of a structure or soil mass, often leading to excessive stresses or unacceptable strains.

DISPERSIVE CLAYS are clays whose particles detach in the presence of water and may be transported by the water, leading to a piping failure.

DRAINAGE AREA or watershed is the area that drains naturally to a particular point on a river, stream or creek.

DRAINAGE BLANKET is a drainage layer placed directly over the foundation material.

DRAINAGE WELLS or pressure relief wells are wells or boreholes usually downstream of impervious cores, grout curtains, or cutoffs, designed to collect and control seepage through or under a dam, so as to reduce uplift pressures under or within a dam. A line of wells forms a drainage curtain.

DRAWDOWN is the lowering of a reservoir's water surface level due to releases.

DRAWINGS are graphical details of proposed construction.

DROP STRUCTURES are permanent structures used to facilitate the vertical downward movement of water without causing erosion.

DYNAMIC ANALYSIS is an analysis which predicts the stability and/or deformation of a dam due to seismic loads.

EARLY WARNING SYSTEM is an automatic device used to alert downstream interests of existing or impending high flows caused by storms or dam failures.

EMERGENCY ACTION PLAN is a predetermined plan of action to be taken to reduce the potential for loss of life and property damage in an area affected by a dam break.

EMERGENCY SPILLWAY, or secondary spillway, is the spillway designed to convey excess water generated by unusual hydrological events through, over or around a dam.

ENLARGEMENT is any change or addition to an existing dam or its appurtenant works which increases, or may increase, the maximum quantity of water which can be stored therein.

EPICENTER is the point on the earth's surface directly above the site of initial movement on the fault.

EXIT CHANNEL is an open channel, located downstream from any conduit or spillway, which conducts the flow to a point where it may be released without jeopardizing the dam.

FACE, in reference to a structure, is the external surface that limits the structure.

FILTER or filter zone is a band or zone that is incorporated in a dam and is graded, either naturally or by selection, so as to allow seepage to flow across or down the filter without allowing the migration of material from zones adjacent to the filter.

FLASHBOARDS are lengths of timber, concrete, or steel placed on the crest of a spillway to raise the water level but that may be quickly removed in the event of a flood, either by a tripping device or by a deliberately designed failure of the flashboards or their supports.

FLOOD ROUTING is a computation of the changes in the rise and fall in stream flow or reservoir levels as a flood moves downstream. The results provide hydrographs of flow or elevation versus time at given points on the stream or in a reservoir.

FLOOD STAGE is the stage or elevation in which overflow of the natural banks of a stream or body of water begins.

FLOWLINE or invert is the lowest point in a water conveyance structure where water can flow.

FOUNDATION OF DAM is the natural material on which the dam structure is placed.

GALLERY is a permanent accessible structure within the interior of a dam used for seepage collection, monitoring, and remedial work.

GEOLOGIST is a person with a degree in geology or a related field from an accredited college or university with at least three years of experience in engineering geology.

GEOMEMBRANE is a term for a geosynthetic which is designed to be an

impermeable barrier.

GEOSYNTHETICS is a broad term used to describe manmade fabrics used in geotechnical applications.

GEOTEXTILE is a term for a geosynthetic which is designed to be a filter, a drain, act as reinforcement, or for separation.

GROIN is that area along the contact or intersection of the face of a dam with the abutments.

GROUT CURTAIN is a barrier to reduce seepage under a dam, produced by injecting grout into a vertical zone in the foundation.

HYDRAULIC FRACTURING is the fracturing of soil materials due to excessive fluid pressures.

HYDRAULIC HEIGHT is the vertical dimension of a dam as measured from the natural streambed at the downstream toe to the elevation of the water surface at the crest of the primary spillway.

HYDRAULICS is the science of the static and dynamic behavior of fluids.

HYDROGRAPH is a graphical representation of discharge, stage, volume, or other hydraulic property, with respect to time, for a particular point.

HYDROLOGY is the study of the properties, distribution and movement of water on the earth's surface, in the soil and underlying rocks.

INCREMENTAL DAMAGE ASSESSMENT (IDA) is an analysis showing the influence of a dam failure when superimposed upon an extreme hydrologic event.

INDEPENDENT CONSULTANT is a consultant used, in addition to the owner's engineer, to assess the design, construction, investigation or operation of a dam.

INFILTRATION RATE is the rate at which a given soil can accept surface water.

INFLOW DESIGN FLOOD (IDF) means the flood hydrograph which is used to size a dam's spillway.

INITIAL FILLING PLAN is a written procedure used during the first filling of a reservoir.

INLET CHANNEL is an open channel upstream from a spillway or conduit.

INTERNAL EROSION is piping.

INUNDATION MAPS show areas that would be subject to flooding due to storm conditions or failure of a dam.

LIQUEFACTION is the sudden loss of strength or stiffness of a soil resulting from dynamic loading as from earthquakes.

LOG BOOM is a floating device intended to prevent large floating debris from being carried into a spillway.

LOW-LEVEL OUTLET is a conduit from a reservoir, generally used for lowering the reservoir or for providing downstream releases.

MAGNITUDE of an earthquake is a quantity characteristic of the total energy released by an earthquake.

MAXIMUM CAPACITY is the maximum volume of water that can be stored in a reservoir when filled to the crest of the dam.

MAXIMUM CREDIBLE EARTHQUAKE (MCE) -- All active sources of seismicity with the potential to impact the stability of a dam should be assigned a maximum credible seismic event. The event which has the greatest potential to cause damage at the site will be defined as the Maximum Credible Earthquake.

NAPPE is the free-falling stream from a weir.

NORMAL FREEBOARD is the vertical distance between the primary spillway overflow crest and the top of the dam.

ONE HUNDRED YEAR FLOOD means the flood having a one percent probability of being equalled or exceeded in any given year.

ONE HUNDRED YEAR PRECIPITATION means the precipitation having a one percent probability of being equalled or exceeded in any given year.

OPERATING BASIS EARTHQUAKE (OBE) -- All active sources of seismicity with the potential to impact the stability of a dam should be assigned an operating basis seismic event. This event is considered to have a return interval of at least 200 years. The event which has the greatest potential to cause damage at the site will be defined as the Operating Basis Earthquake.

OWNER includes all who own, control, operate, maintain, manage, or propose to construct a dam; also, their agents, lessees, trustees, and receivers.

OWNER'S ENGINEER is a professional engineer, licensed in Utah, retained to design, construct, monitor, operate, or evaluate a dam.

PEAK FLOW is the maximum instantaneous discharge that occurs during a flood. It is coincident with the peak of a flood hydrograph.

PERVIOUS ZONE is a part of the cross section of an embankment dam comprising material of high permeability.

PHREATIC SURFACE is the free surface of ground water at atmospheric pressure.

PIEZOMETER is an instrument for measuring pore water pressure within soil, rock, or concrete.

PIPING is the progressive development of internal erosion by seepage, appearing downstream as a hole or seam, discharging water that contains soil particles.

PLANS are engineering drawings, specifications, and design reports supporting the design of a dam and detailing the construction of the dam.

POROUS INTERVAL is the portion of a piezometer where infiltrating water is allowed to act on the device.

PRINCIPAL SPILLWAY is the main spillway for normal operating conditions.

PROBABLE MAXIMUM FLOOD (PMF) is the flood that may be reasonably expected from the most severe combination of critical meteorologic and hydrologic conditions that are possible in the region.

PROBABLE MAXIMUM PRECIPITATION (PMP) is the maximum amount of precipitation that could be expected to fall on a drainage under the most severe meteorologic condition.

PSEUDO STATIC ANALYSIS is an approximate method for predicting the dynamic stability of a structure using static loads.

RESERVOIR AREA is the surface area of a reservoir when filled to a given water

elevation.

RESERVOIR RIM is a term used to describe the land forms around the perimeter of a reservoir which could have an adverse impact on the dam or reservoir due to movement.

RESERVOIR STAGE is the measure of the depth or elevation of water in a reservoir relative to an established datum.

RESIDUAL FREEBOARD means the vertical distance between the maximum water surface during a given hydrologic event and the top of the dam.

RESPONSE SPECTRUM is a graphical representation of actual motions, including displacement, velocity, and acceleration, caused by seismic events.

RIPRAP is a layer of large stones, broken rock, or precast blocks placed on the upstream slope of an embankment dam, on a reservoir shore, or on the sides of a channel, as a protection against waves, ice, and scour.

SEDIMENT POOL is the portion of the reservoir allotted to the accumulation of submerged sediment during the design life of the dam.

SEISMIC means pertaining to an earthquake or earth vibration.

SLOPE PROTECTION is the protection of an embankment slope against wave action or erosion.

SPECIFICATIONS are written descriptions of the proposed construction.

SPILLWAY is an open or closed channel, conduit or drop structure used to convey excess water through a reservoir. It may contain gates, either manually or automatically controlled, to regulate the discharge of the water.

SPILLWAY EVALUATION FLOOD (SEF) is the flood that may be expected at the dam from applying the SEP to a given watershed.

SPILLWAY EVALUATION PRECIPITATION (SEP) is the lowest, site specific, precipitation estimate allowed by the State Engineer, used in the analysis of new, existing, high or moderate hazard dams.

STAFF GAGE is a permanent instrument or device used to read reservoir stage.

STANDARD OPERATING PLAN is a written procedure outlining the operation and maintenance of a dam and its appurtenant structures and equipment.

STATE ENGINEER is the Director of the Utah Division of Water Rights.

STILLING BASIN is a basin constructed to dissipate excess energy of waters emerging from a spillway or outlet.

STOPLOGS are beams placed on top of each other with their ends held in guides on each side of a channel or conduit.

STORAGE CAPACITY is the volume of water which can be stored at the elevation of the primary spillway, including both active and dead storage.

STRUCTURAL HEIGHT means the vertical dimension of a dam as measured from the natural streambed at the downstream toe of a dam to the top of a dam.

SURVEY MARKER is a permanent physical mark on a dam or appurtenant structure used to measure changes in horizontal and vertical movement.

TECTONICS is a study of the broader features of the earth's crust and the causes of its deformation.

TEST BORINGS are holes drilled to determine the type and physical properties of subsurface materials.

TEST PIT is an excavation used to evaluate and observe subsurface materials.

TOE OF DAM is the junction of a dam face with the foundation. For an embankment dam, the junction of the upstream face with ground surface is called the upstream toe, and the junction of the downstream face with the ground surface is referred to as the downstream toe.

TRANSITION ZONE is a zone of material used to provide filter requirements between two zones of material which do not meet filter requirements.

TRASH RACK is a screen located at an intake to prevent the entry of floating or submerged debris.

UNGATED OUTLET is an outlet that allows uncontrolled flow through or around a dam.

UNIT HYDROGRAPH is a hydrograph which shows the rates at which runoff occurs for one inch of storm runoff from a drainage area.

UPLIFT is the upward water pressure in the pores of a material or on the base of a structure.

WATER STOPS are strips of material used to prevent leakage through joints between adjacent sections of concrete.

WEIR is a device used to measure or control water.

R655-10-5. Hazard Classification.

Hazard classification of a dam places the dam into a category based upon the consequences of failure of the dam. The State Engineer is the ultimate authority on the hazard classification designation for a given dam.

R655-10-5A. Hazard Classification--Criteria.

The hazard classification analysis should include a determination of the threat to human life and property damage in the event of the failure of a dam. In some cases the classification can be assigned by observance of the downstream development in relationship to the location of the dam. In other cases it will be necessary to prepare inundation maps to determine the downstream consequences of failure. In preparing the inundation maps, the following criteria relative to the dam should be used.

1. No concurrent flooding conditions exist.

2. The reservoir level is at the emergency spillway crest.

3. The low level outlet is discharging at capacity.

4. The breach times and geometric parameters used to simulate the dam failure should be acceptable to the State Engineer and consistent with accepted practices.

5. The inundation study should be carried downstream to a point that the breach flows are contained within the banks of the natural channel or a downstream reservoir.

R655-10-5B. Hazard Classification--Exceptions.

It should be noted that the hazard classification as outlined in R655-10-5A may not be an absolute indicator of the hazard of the dam, since a dam failure superimposed on natural flooding conditions may cause incremental risk to life and

property. Although this scenario is not normally used in the hazard classification process, it is a factor the owner should consider in determining their overall liability. Under special circumstances, as determined by the State Engineer, a hazard classification may be determined giving consideration to concurrent flooding events.

R655-10-6. Approval Processes.

There are two procedures for obtaining approval from the State Engineer to construct or modify a dam. The first procedure requires the filing of an application, while the second procedure requires the submission of plans. No approval will be given for any dam unless the water rights are in order.

R655-10-6A. Application Procedure.

For dams not requiring submission of plans as outlined in Section 73-5a-202, an application must be submitted and approved by the State Engineer. Blank applications are available upon request. Upon reviewing the application the State Engineer may approve it, reject it, return it for correction, or approve it with conditions.

R655-10-6B. Submission of Plans.

A. All projects requiring submission of plans should include a package including the drawings, specifications, design reports, and any other information which will assist in reviewing the project. The amount of information generated becomes more involved as the size and hazard rating of the structure increases. The following guidelines are included to alert the designer to the basic information required.

B. All drawings submitted should comply with the following:

1. The size of all drawings submitted for review, shall be 24 inches by 36 inches. Following approval of the project by the State Engineer, two sets of 11 inch by 17 inch drawings shall be submitted.

2. All drawings should include a bar scale to allow for accurate scaling of reductions.

3. All drawings shall have a title block in the lower right corner showing the project name, the owner's name, the sheet number, and the date of preparation of the plans.

4. All drawings shall have provisions for noting the dates of any modifications.

5. Each drawing shall include the signature and seal of the responsible engineer. Geological drawings should also be signed by the responsible geologist.

C. Drawings to be included in plans are:

1. Title sheet, including:

a. General location map including access roads.

b. Signature block for owner's acceptance.

c. Index of drawings.

d. Reference to the water rights for the reservoir.

e. Reservoir stage/storage curve.

f. Rating curves for outlets and spillways.

2. Plan view of reservoir, including:

a. Existing topography.

b. Borrow areas.

c. Supply canals and pipelines.

d. Suitable contour lines.

e. Clearing limits.

f. Waste areas.

3. Plan view of dam, including:

a. Location of all pertinent features.

b. A survey tie, to an outside section corner, where the longitudinal axis of the dam intersects the axis of the original stream channel or the low level outlet.

c. Clearing limits.

4. Longitudinal profile, showing:

a. Original ground line.

b. Location of core trench or other cutoff features.

c. Location of outlets and spillways.

d. Camber and anticipated settlement.

5. Typical cross-sections of dam, showing:

a. Embankment geometrics including internal zones.

b. Slope protection.

c. Cutoff.

d. Delineation of embankment on natural ground surface.

e. Freeboard.

f. Internal drainage.

g. Limits of foundation excavation.

6. Plan, profile, cross sections and details of all outlets, spillways, and other structures.

7. Structural details for reinforcing steel, metal fabrication, or waterstops.

8. Site geology map of the damsite and reservoir basin including locations of all borings and test pits.

9. Longitudinal geologic profile of both the dam and reservoir, showing:

a. Original ground line.

b. Location and orientation of borings.

c. Geological profile showing pertinent lithologic, hydrologic, and structural information.

10. Logs of borings with classifications of soil and rock, results of water pressure tests and other downhole material property tests, soil classification, standard penetration tests, core recovery, rock quality designations, and strength tests.

11. Any additional drawings such as instrumentation details necessary to construct the project.

D. Specification Requirements.

The State Engineer must review and approve all technical specifications for a proposed project. A partial list of specifications directly related to dam safety follows:

1. Site Preparation.

a. Clearing and Grubbing.

b. Soil Stripping.

c. Structure Removal.

d. Diversion and Care of Stream.

2. Foundation Preparation.

a. Foundation Dewatering.

b. Relief Wells.

c. Grouting.

d. Cutoffs.

e. Abutment Contacts.

f. Exploration.

g. Dental Concrete.

3. Earthwork.

a. Excavation.

b. Earth Fill.

c. Drain Fill.

d. Rock Fill.

e. Material Handling.

f. Testing Procedures.

4. Concrete and Reinforcement.

a. Concrete Mixing and Placement.

b. Steel Reinforcement.

c. Admixtures.

d. Curing and Curing Compounds.

e. Joint Fillers and Waterstops.

5. Outlets.

a. Water Control Gates and Valves.

b. Air Vent.

c. Operating Equipment.

d. Bedding Requirements.

6. Aggregates and Rock.

a. Drain Fill and Filters.

b. Concrete Aggregates.

c. Riprap.

7. Erosion Control.

8. Miscellaneous Structural Work.

a. Metal Fabrication and Installation.

b. Instrumentation.

9. All technical specifications should also include testing intervals to assure compliance with the specifications.

E. Design Report Requirements. The design report should include all information used to design the dam, including assumptions made and methodology used with sufficient documentation. Any building codes or design manuals used in the design should be referenced, including the year of publication of the source. If the design report is a product of a team effort, the names of all persons producing the report should be included along with the sections they prepared. Examples of items to be included in the design report are as follows:

1. Hydrology calculations for determining the spillway requirements.

2. Hydraulic characteristics of the outlets and spillways.

3. Subsurface investigation including logs of test borings and geologic cross-sections.

4. Material testing results and the location and logs of test pits.

5. Foundation treatment and abutment contact design.

6. Calculations for the reinforced concrete design and the loading conditions utilized.

7. Stability analysis of the dam, abutments, and reservoir rim, including appropriate seismic loading, safety factors and embankment zone characteristics.

8. Geological investigations including:

a. Regional perspective of the site's geologic and seismic setting at a scale appropriate to the geologic complexity of the area.

b. Seismic evaluation establishing the relationship of the site to all seismic features of concern and the potential for reservoir induced seismicity.

c. Site geology of areas affected by construction activities and appropriate adjacent areas.

d. Plans to compensate for any geological weakness in the dam foundation, abutment areas, and reservoir rim.

9. Seepage considerations including the cutoff trench design and internal drainage design.

10. Post-construction monitoring or alarm systems.

R655-10-7. Independent Consultant Review.

The State Engineer may require an independent consultant review to assess the adequacy of the design, construction, or operation of a dam. For purposes of these rules, an independent consultant review is a review of the owner's engineers' work in addition to the review provided by the State Engineer.

R655-10-7A. Review of Design.

The following situations will require an independent consultant review of the design of a new dam or significant enlargement of an existing dam.

1. All high hazard dams, which have a structural height over 50 feet and an active storage over 1,000 acre-feet, will require an independent review unless exempted in writing by the State Engineer.

2. Any high or moderate hazard dam which, in the opinion of the State Engineer, has a unique problem requiring additional review.

3. Any high or moderate hazard dam whose design is not typical of dams normally built in the state and is thus beyond the technical abilities of the State Engineer's dam safety staff.

4. If the owner's engineer and the State Engineer cannot reach an agreement on the design of a dam.

5. If the owner specifically requests an independent consultant review.

R655-10-7B. Review of Construction.

The State Engineer may require an independent consultant review when peculiar problems are noted during construction of a dam or the dam is not being constructed as per approved plans and specifications.

R655-10-7C. Operation.

The State Engineer may require an independent consultant review of the operation of a dam including initial filling plans, standard operating plans, emergency action plans, and performance of the dam if, in his opinion, conditions require a review.

R655-10-7D. Selection of Independent Consultants.

Upon notification to the owner, the owner will select independent consultants to conduct the required review. Prior to contracting with the proposed consultants, they must be approved by the State Engineer.

R655-10-7E. Qualifications of Independent Consultants.

All independent consultants must have a minimum of ten years' experience related to dams. In the case of engineers, they need to be licensed in the state where they reside, unless exempted by the State Engineer. All proposed consultants must demonstrate that they have the expertise to investigate problems identified and that they have insignificant past association with the dam in question.

R655-10-7F. Scope of Work.

In requiring the owner to obtain the services of an independent consultant, the State Engineer will include specific items needing investigation, the format for the reports submitted by the independent consultant, and a timetable for completion of the investigations.

R655-10-7G. Purpose of Independent Consultants Investigations.

The purpose of an independent consultant is to provide additional technical expertise and to insure safety issues are addressed. Conclusions generated by the independent consultants are not binding on the State Engineer.

KEY

dam safety, dams, reservoirs

Date of Enactment or Last Substantive Amendment

December 10, 2003

Notice of Continuation

May 3, 2006

Authorizing, Implemented, or Interpreted Law

73-5a

Rule converted into HTML by the Division of Administrative Rules.

For questions regarding the *content* or *application* of rules under Title R655, please contact the promulgating agency (Natural Resources, Water Rights). A list of agencies with links to their homepages is available at http://www.utah.gov/government/agencylist.html or from http://www.rules.utah.gov/contact/agencycontacts.htm.

The HTML version of this rule is a convenience copy made available on the Internet as a public service. **Please see the State of Utah Terms of Use**.

2010 © Division of Administrative Rules
4120 State Office Building / Capitol Hill Complex / 450 North State Street / Salt Lake City, UT 84114
Phone: 801-538-3764 / Fax: 801-359-0759

Utah Administrative Code

The Utah Administrative Code is the body of all effective administrative rules as compiled and organized by the Division of Administrative Rules (Subsection 63G-3-102 (5); see also Sections 63G-3-701 and 702).

NOTE: For a list of rules that have been made effective since October 1, 2010, please see the codification segue page.

NOTE TO RULEFILING AGENCIES: Use the RTF version for submitting rule changes.

Download the RTF file

Rule R655-11. Requirements for the Design, Construction and Abandonment of Dams.

As in effect on October 1, 2010

Table of Contents

- R655-11-1. Authority and Applicability.
- R655-11-2. Purpose and Scope.
- R655-11-3. Definitions.
- R655-11-4. Hydrologic Design.
- R655-11-4A. Inflow Design Hydrograph Determination.
- R655-11-4B. Freeboard Requirements.
- R655-11-4C. Spillways.
- R655-11-4D. Infiltration Rates.
- R655-11-4E. Flood Routing.
- R655-11-4F. Incremental Damage Assessment for High and Moderate Hazard Dams.
- R655-11-4G. Historical Records.
- R655-11-5. Seismic Design.
- R655-11-5A. Geological and Seismic Study.
- R655-11-5B. Determination of Dam and Foundation Material Properties.
- R655-11-5C. Method of Analysis.
- R655-11-5D. Design Measures.
- R655-11-5E. Appurtenant Structures.
- R655-11-6. Embankment Requirements.
- R655-11-6A. Factors of Safety.
- R655-11-6B. Dam Crest Requirements.
- R655-11-6C. External Erosion Control.
- R655-11-6D. Internal Erosion Control.
- R655-11-6E. Internal Drainage.
- R655-11-7. Outlet Requirements.

- R655-11-7A. Outlet Sizing.
- R655-11-7B. Outlet Materials.
- R655-11-7C. Outlet Details.
- R655-11-8. Spillway Requirements.
- R655-11-9. Other Design Requirements.
- R655-11-10. Instrumentation.
- R655-11-10A. Reservoir Staff Gages.
- R655-11-10B. Survey Markers and Bench Marks.
- R655-11-10C. Piezometers.
- R655-11-10D. Seepage Measurements.
- R655-11-10E. Strong Motion Instruments.
- R655-11-11. Abandonment of Dams.
- R655-11-11A. Removal of Dam.
- R655-11-11B. Breaching of Dam.
- R655-11-12. Construction.
- R655-11-12A. Informal Construction Inspections.
- R655-11-12B. Formal Construction Inspections.
- R655-11-12C. Construction Reporting Requirements.
- R655-11-12D. Change Order Approvals.
- R655-11-12E. Final Inspection.
- KEY
- Date of Enactment or Last Substantive Amendment
- Notice of Continuation
- Authorizing, Implemented, or Interpreted Law

R655-11-1. Authority and Applicability.

The following rule is established under the authority of Title 73, Chapter 5a. The procedures constitute minimum design requirements for dams. Additional procedures may be required to comply with any other governing statute, federal law, federal regulation, or local ordinance. These rules apply to any dam constructed in the state with the exception of those specifically exempted by Section 73-5a-102 and those dams not requiring plans as outlined in Section 73-5a-202.

R655-11-2. Purpose and Scope.

A. The following minimum design requirements will serve as a guide to the owner's engineer. It should be noted that these are minimum requirements for general conditions and may be changed when dealing with a specific structure. Designs below the minimum requirements must be approved in writing by the State Engineer prior to final design submittal of the project. The design requirements are quite rigid, allowing little latitude in the utilization of new materials and unproven construction methods. The burden to show adequate protection of public interests with the use of new materials or unproven methods rests with the owner's engineer.

B. The following minimum design requirements apply to all proposed dams where applicable. Since the vast majority of dams in the state are earthfill or rockfill dams, the focus of the design criteria is on these dams. Specific structural design

criteria for concrete dams is not given. The State Engineer, upon approval in writing, will accept structural design criteria for concrete dams developed by other dam regulatory or dam design agencies, providing it reflects state-of-the-art criteria for the design of concrete dams and does not conflict with the following rules.

R655-11-3. Definitions.

Definitions are as outlined in R655-10-4.

R655-11-4. Hydrologic Design.

In order to arrive at an Inflow Design Hydrograph or Inflow Design Flood (IDF) more representative of actual conditions in Utah, the State Engineer has commissioned, or has been involved in, numerous studies to supplement the National Oceanic and Atmospheric Administration's (NOAA) Report entitled "Hydrometeorological Report No. 49 (HMR49) - "Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages". The results of most of these studies are used to better identify soil conditions, discharge coefficients, and unit hydrograph parameters. The results of two of the studies are used directly to refine the calculation of the design rainfall values. Both studies were completed by Donald Jensen of the Utah Climate Center and are entitled, "2002 Update for Probable Maximum Precipitation, Utah 72 Hour Estimates to 5,000 sq. mi. - March 2003" (USUL) and "Probable Maximum Precipitation Estimates for Short Duration, Small Area Storms in Utah - October 1995 "(USUS). All of HMR49, Table 1, page 4 of USUL, and Table 15, pages 74-75 of USUS are hereby incorporated by reference. All High Hazard and Moderate Hazard dams in Utah must use the precipitation values obtained from the use of all three publications. To avoid confusion, precipitation values obtained from HMR49 exclusively will be referred to as the Probable Maximum Precipitation (PMP), while those obtained from using HMR49 in conjunction with USUL or USUS, will be referred to as the Spillway Evaluation Precipitation (SEP). The resulting hydrographs generated will be referred to as the Probable Maximum Flood (PMF) and the Spillway Evaluation Flood (SEF) respectively.

R655-11-4A. Inflow Design Hydrograph Determination.

A) In Utah, the IDF for all High and Moderate Hazard Dams will be the SEF. It will be necessary to calculate both the 72 hour SEF using HMR49/ USUL as well as the 6 hour SEF using HMR49/ USUS. Both of these hydrographs must be routed through the reservoir to determine which one represents the most extreme event.

B) Once the critical SEF has been determined, it must be compared to a flood generated by the 100 year, 6 hour (for local storms), or 100 yr, 24 hour (for general storms) precipitation applied on a saturated watershed. If the routed 100 year event, including appropriate allowances for freeboard, is more critical than the SEF it must be used as the minimum IDF. This 100 year flood should also be used as the IDF for all Low Hazard Dams.

R655-11-4B. Freeboard Requirements.

All dams must have a normal freeboard above the crest of the principal spillway capable of containing the maximum wave action considering site wind-duration and fetch control characteristics. Wave action includes wave height and maximum runup, as well as reservoir setup against the embankment slope. Unless otherwise justified by specific data acceptable to the State Engineer, an extreme wind velocity (fastest mile) over land of 100 miles per hour should be considered. In addition, while routing the 100 year precipitation event through the spillway, sufficient residual freeboard must be available to control wave action from a fetch controlled 50 miles per hour wind. In no case will the normal freeboard be less than three feet for high

and moderate hazard dams. The State Engineer may reduce the three feet minimum freeboard requirement for low hazard dams based upon a review of the relative increase in risk associated with this reduction.

R655-11-4C. Spillways.

In designing the spillway for a dam to pass the IDF, the State Engineer will consider the use of a principal spillway in conjunction with emergency spillways. The principal spillway must be designed so that no structural damage will occur during passage of the IDF. Emergency spillways, including Fuse Plug Spillways, may be designed so that some damage may be expected during use provided the anticipated damage does not represent a threat to the dam. Sunny day failure modeling of Fuse Plug Spillways may be required to determine if they are creating an additional unacceptable risk. Overtopping of the dam will not be considered as an emergency spillway on earthfill dams, unless it can be demonstrated that the dam is protected from erosion, and the duration of overtopping will not saturate the dam and reduce its stability.

R655-11-4D. Infiltration Rates.

The State Engineer will accept an IDF using SEP values in conjunction with soil moisture conditions representative of historical maximums. If the design engineer is using infiltration rates which represent something less than saturated conditions, information should be submitted to justify the lower soil moisture selection.

R655-11-4E. Flood Routing.

A. In routing the IDF through the reservoir, the initial water surface should reflect conservative estimates which would exist at the time of the flood event. Unless documentation can be provided to the contrary, it should be assumed that all low level outlets are closed during routing of the IDF. For dams receiving inflow from pipelines and supply canals, it should be assumed these additional sources are operating at capacity during the flood event. In the event the spillway is gated or has "stop logs", which are only allowed on existing dams, documentation must be provided to show the gates are automated or operational procedures are in place to insure that the gates can be opened or the stop logs removed in a timely manner.

B. The SEF can be routed so the maximum water surface is at an elevation equal to the lowest point on the crest of the dam with no residual freeboard.

C. In generating the IDF, the basin characteristics used and the parameters used to generate the unit hydrograph should be based on the best information available. Unit hydrographs generated from historical records or calibrated watersheds should be used, where data is available, rather than using synthetic procedures.

R655-11-4F. Incremental Damage Assessment for High and Moderate Hazard Dams.

The State Engineer may, at his discretion, accept an IDF less than the SEF based on the results of an Incremental Damage Assessment (IDA) which shows that failure of the dam would cause insignificant incremental damage to property and no additional threat to human life. The State Engineer may consider the use of early warning systems in evaluating the threat to human life. In requesting the acceptance of an IDF determined from an IDA, documentation must be furnished that the owner of the dam is aware that the design reflects something less than the SEF and they are willing to accept the additional liability. In no case will the State Engineer approve an IDF generated by something less than the applicable 100 year flood event. The resulting selected IDF, based on the IDA, should be reported as a percent of the SEF.

R655-11-4G. Historical Records.

In some cases it may be appropriate to use historical streamflow records to generate a 100 year flood. If these records are used as a basis for the IDF, they should be accompanied by the Synthetic IDF established by using the 100 year precipitation. Following a review of the data, the State Engineer will make a determination of which flood will be used as the IDF.

R655-11-5. Seismic Design.

A. Because each dam site has a unique seismic and geological setting, detailed direction cannot be provided for seismic design which is applicable to all dams. Rather, an order of evaluation is presented beginning with more simplified methods and progressing, as required, to more rigorous procedures. In determining the sophistication of analysis required, the State Engineer may consider factors including consequences of failure, available freeboard, duration of reservoir pool, and site geometry. Regardless of the method of analysis, the final determination of seismic adequacy of a dam will be based on all pertinent factors involved and not strictly on the numerical analysis. The order of progression of the seismic analysis follows:

1. Undertake geological and seismological investigations to determine the potential for earthquakes and associated ground motions at the site, including the source and magnitude of the earthquakes to be considered and the selected motions, including potential fault rupture.

2. Undertake field and laboratory investigations of the dam and foundation materials to determine their properties and liquefaction potential.

3. Undertake an appropriate analysis for seismic events to predict factors of safety against slope failures, structural deformations, and liquefaction resulting from earthquake shaking or fault rupture.

4. Incorporate defensive design measures based on the analysis and proven practices.

B. In many instances, an adequate seismic analysis can be determined from the geological study and determination of the general properties of the dam and foundation. Other projects may require more detailed investigations and analyses. Decisions as to seismic safety and risk should be made as the analysis progresses and the extent of further investigations required after each step should be determined following consultation with the State Engineer as necessary.

R655-11-5A. Geological and Seismic Study.

A review of the seismic or earthquake history of the region will be performed to establish the relationship of the site to known faults and epicenters. This will be based primarily on review of existing maps and technical literature and should include major earthquakes during historic time, epicenter locations and magnitudes, and the location of any major or regional fault traces. Geologic conditions at or near the dam site that might indicate recent fault or seismic activity should be included. Resulting design earthquakes and associated site ground motion parameters will be selected considering all available evidence including tectonic and seismological history. The ground motion parameters to be selected for the site will consist of those that are needed by the analyses that are appropriately selected for design and may include peak accelerations, velocities, displacements, response spectra, and acceleration time histories. Both the Maximum Credible Earthquake (MCE) and the Operating Basis Earthquake (OBE) will need to be investigated for all projects. The MCE should be evaluated from the following analyses:

1. A deterministic analysis from active faults in the region surrounding the dam.

2. Unless otherwise required by the State Engineer, the random or background event will consist of a minimum magnitude 6.5 event having a peak horizontal site acceleration obtained from a map, herein incorporated by reference, produced by the USGS and entitled "Peak Accelerations (%g) with 5,000 Year Return Time; no fault-specific sources." Alternatively, site specific evaluations may be performed to define ground motions for this event if the methods used and assumptions made are acceptable to the State Engineer. At the discretion of the State Engineer, the OBE requirement may be waived.

3. The OBE will be determined by probabilistic methods acceptable to the State Engineer.

R655-11-5B. Determination of Dam and Foundation Material Properties.

Results of the geological and seismological studies may be sufficient to evaluate seismic safety. However, if it appears the dam cannot safely withstand the earthquake motions or if sufficient information is not available to make an adequate determination, the next step of a phased evaluation program would be a field investigation and laboratory testing program. Field investigation should include a sufficient number of borings and test pits to accurately define the embankment, foundation, and abutment materials types, properties, and extent. Particular care and sufficient field data should be obtained where potentially liquefiable soils are present. In place and laboratory testing should be performed to adequately assess the material properties under the anticipated dynamic conditions.

R655-11-5C. Method of Analysis.

A. Procedures are available for selecting design earthquakes and associated site-specific motions and for assessing the resistance of dams to these earthquake motions. Procedures and techniques for evaluating the effects on dams from estimated earthquake ground motions range from simplified concepts to comprehensive dynamic analyses. When the degree of sophistication of analytical procedures is far advanced, however, uncertainty is produced in the results by imperfect knowledge of input parameters obtained through field exploration and laboratory testing programs.

B. The extent or scope of studies, investigations, tests and analyses which may be required to adequately determine the seismic safety of a dam will vary from site to site. In general, the following physical factors will indicate a high priority and a greater degree of investigations and analysis:

1. Proximity to known active faults.

2. Indications of low-density materials in the dam or foundation.

3. Zones of high pore pressures or potential liquefaction.

4. Indications of marginal static stability.

5. Lack of adequate construction records for existing dams.

C. Regardless of these factors, however, one of the major considerations will be the "consequences of a failure". High and moderate hazard structures with permanent pools which could result in loss of life or extensive property damage from a failure will, in general, require a greater scope of investigation and analyses.

D. Following are the general analysis requirements for MCE design earthquakes:

1. Embankments, foundations, and abutments not subject to liquefaction:

a. For a maximum acceleration of 0.2g or less, or a maximum acceleration of .35g

or less if the embankment consists of clay on a clay or bedrock foundation, a pseudo-static coefficient which is at least 50 percent of the maximum peak bedrock acceleration at the site should be used in the stability analysis. The minimum factor of safety in an analysis should be 1.0.

b. For a maximum peak acceleration greater than indicated above, a deformation and settlement analysis should be performed to estimate anticipated total crest movement. The evaluation should be performed for both the upstream and downstream slopes of the dam. Total crest movement should consider potential accumulation of movement from both sides. The minimum factor of safety against overtopping should be 2.5.

2. Embankment, foundation, or abutment soils subject to liquefaction:

a. A liquefaction analysis should be completed with enough detail to establish the boundaries of the liquefiable soils and the physical characteristics of the soil following liquefaction.

b. A post earthquake stability analysis should be performed to show that the embankment is stable after liquefaction occurs with a minimum factor of safety of 1.2.

c. Calculated deformation and settlement of the embankment total crest movement should result in a minimum factor of safety, against overtopping, of 3.0.

3. Other more sophisticated analytical procedures may be required at the discretion of the State Engineer, where conditions warrant greater detailed studies.

E. In addition to analysis of deformation and liquefaction, it will be necessary to assess the potential for internal erosion and cracking. Judgment must be used to decide whether or not erosion would tend to be self- healing as a result of filtering.

F. Construction of dams on active faults will not be allowed unless evidence is presented to, and approved by, the State Engineer that the dam can safely withstand the anticipated offset.

G. Evaluation of a dam under OBE conditions should be completed by similar methods to those described for the MCE. Under the OBE loading conditions the dam should experience no significant damage.

R655-11-5D. Design Measures.

Design of new dams should include measures, which provide multiple lines of defense, that enhance their performance under seismic loading. Measures may include:

1. Significantly wide transition and drainage zones in the embankment of material not vulnerable to cracking.

2. Controlled compaction of embankment zones to enhance dynamic performance.

3. Removal or treatment of foundation materials of low strength or density.

4. Enhanced ability to drain reservoir.

5. Flare the embankment core at abutment contacts.

6. Locate the core to minimize saturation of materials.

7. Stabilize slopes around the reservoir rim.

R655-11-5E. Appurtenant Structures.

The effects of seismic loading should also be considered during the design of all appurtenant structures.

R655-11-6. Embankment Requirements.

All embankment designs should meet the following criteria.

R655-11-6A. Factors of Safety.

A. All dams should meet the following criteria for factors of safety under normal loading conditions.

TABLE

Condition	Minimum Factor of Safety
End of Construction Case--upstream and downstream slopes	1.3
Steady State Seepage--upstream and downstream slopes (full pool)	1.5
Instantaneous Drawdown--upstream slope	1.2
OR	
Actual Drawdown--upstream slope	1.5

B. All factors of safety should be generated by methodology acceptable to the State Engineer. In undertaking the analysis, the effects of anisotropy should be considered and a ratio of horizontal to vertical permeability of at least nine should be used in the seepage analysis. Ratios of up to 100 should be considered if the material types and construction techniques will cause excessive stratification.

C. The strengths used in the stability analysis should be obtained from tests which best model the situation being analyzed.

D. The analysis of the upstream slope stability for actual drawdown should consider drawdown rates which the low level outlets are capable of generating. Actual residual pore pressures should be used.

E. For low hazard dams the State Engineer may waive the requirements of a stability analysis, including a seismic analysis, if it can be demonstrated that conservative slopes and competent materials are used in the dam, and seismic problems (i.e., liquefiable materials, active faults close to the dam) are not present.

F. Stability evaluations where residual strengths are used must have a minimum factor of safety of 1.3.

R655-11-6B. Dam Crest Requirements.

A. The crest width of all dams should be, at a minimum, equal to the structural height of the dam divided by five plus five feet. The absolute minimum required shall be 12 feet and the absolute maximum required shall be 25 feet. Wider crest widths may be used at the designer's discretion.

B. All dams shall have a cross slope on the crest of 2% to 3% towards the reservoir.

C. All crests shall be protected with a wearing surface of granular material to prevent vehicular rutting.

D. Dam crests should be cambered to allow for anticipated settlement. The side slopes of the dam may be steepened to accommodate the camber.

E. For dams over 500 feet long which have a crest that dead ends, a turn-around should be provided at the abutment.

F. The impervious portion of the dam under the crest may need to be terminated at the anticipated frost line to prevent desiccation cracking and damage from frost; however, it needs to be carried high enough to prevent seepage over the core by capillary rise.

R655-11-6C. External Erosion Control.

A. All downstream slopes of dams should be protected from erosion by placing armor or seeding with grasses. No planting of any shrubs, trees, or other woody vegetation will be allowed unless it is approved in writing by the State Engineer.

B. All downstream groins of dams receiving runoff from adjacent abutments shall be protected from erosion.

C. All upstream slopes on dams which impound water for significant lengths of time shall be armored. If rock riprap is used it shall be well graded, durable, and sized to withstand wave action. If the material underlying the riprap is fine grained and subject to erosion, a properly designed filter blanket must be installed. Geotextiles may be used in lieu of the filter blanket at the discretion of the State Engineer.

R655-11-6D. Internal Erosion Control.

A. All dams should have design provisions for controlling internal erosion. In zoned dams all adjacent zones must meet filter criteria with the abutting zones and foundation soils. If filter criteria cannot be met, a transition zone must be provided.

B. All filter zones in a dam must meet criteria acceptable to the State Engineer.

C. In designing filter zones where dispersive clays or broadly-graded materials exist, special considerations may be imposed by the State Engineer.

D. All internal filter zones will have a minimum width of three feet to facilitate construction. Wider zones are encouraged especially in active seismic areas.

E. Proper filtering is essential in all dams where cracking from differential settlement, hydraulic fracturing, or earthquake shaking is possible.

R655-11-6E. Internal Drainage.

A. All underdrains and collection pipes shall be constructed using non-corrodible materials capable of withstanding the anticipated loads.

B. Underdrains and collection pipes should be designed to conduct flows several times larger than anticipated. All pipes within the dam which are not easily accessible shall have a minimum diameter of six inches.

C. All internal drain pipes should be enveloped with free draining material, meeting filter requirements with adjacent zones.

D. Where multiple pipes are used to conduct drainage from internal portions of the dam, they should be carried to the downstream toe or gallery separately without intervening connections or manifold systems. If the drain pipes are connected at their termination points, manholes should be provided to facilitate observation and measurement of the separate drain lines.

E. All underdrains and collection pipes should have provisions for measuring discharges in manholes or at their discharge points. If the anticipated discharge is in excess of 10 gallons per minute (gpm), a weir or other suitable measuring device

should be provided. If the anticipated flows are less than 10 gpm, provisions should be made so the water can be discharged freely into a vessel 1.5 feet high and one foot in diameter.

F. All exposed underdrain and collection pipes shall have an appropriate rodent screen attached.

G. All underdrains and collection pipes should be cleaned out prior to the first filling of the reservoir.

H. All seepage collection systems must include a collection pipe to discharge flows.

I. All internal drains must have a minimum cover of 3 feet of impermeable material to eliminate the collection of surface waters.

R655-11-7. Outlet Requirements.

All outlet designs should meet the following criteria.

R655-11-7A. Outlet Sizing.

A. All dams shall have a low level outlet capable of draining the reservoir to the sediment pool. The outlet should be sized to meet the project demands as well as the following criteria.

1. All outlets shall be 24 inches in diameter or larger unless exempted in writing by the State Engineer. Outlets should have valves or capped flanges which can facilitate entry into the pipe by personnel or video equipment.

2. All outlets shall have the capacity to evacuate 90% of the active storage capacity of the reservoir within 30 days neglecting reservoir inflows. The State Engineer may adjust this requirement on large reservoirs if it can be demonstrated that compliance would result in an unreasonably sized outlet or potential releases would exceed the downstream channel carrying capacity.

3. All outlets shall have the capacity to satisfy prior downstream water rights and the owners' release requirements.

R655-11-7B. Outlet Materials.

All outlets will be made of appropriate materials with due regard for loading condition, seismic forces, thermal expansion, resistance to corrosion, and potential abrasion. The use of corrugated metal pipes and other thin-walled steel pipes will not be accepted unless they serve only to provide a form for a poured-in-place concrete conduit or they are specifically accepted in writing by the State Engineer.

R655-11-7C. Outlet Details.

A. All outlets shall have a trash rack to prevent clogging.

B. All outlets connected directly to a downstream pipeline shall have an emergency bypass valve.

C. All outlets shall have a suitable energy dissipator at the discharge end to prevent erosion of the downstream channel.

D. All outlets will be placed on a concrete cradle or encased in concrete unless specifically exempted by the State Engineer in writing.

E. All outlets, with the exception of ungated outlets, shall have an operating gate or a guard gate on the upstream end.

F. All outlets shall have seepage control measures to reduce the potential for piping along the conduit. Common methods may include locating the outlet conduit in bedrock and installing a conduit filter drain to intercept seepage.

G. Outlets encased in concrete should have battered sides to facilitate compaction against the encasement.

H. Every attempt should be made to locate the outlet on bedrock or consolidated materials. In the event this is not possible, consideration should be given to articulating the outlet to allow for settlement.

I. Outlet gates and valves can be either mechanically or hydraulically operated. In either case the hydraulic lines or mechanical stems must be adequately protected from debris, wave action, settlement, and ice damage. Buried stems should be encased in an oil-filled pipe supported on pedestals. No catwalks or similar access structures will be allowed on reservoirs where freezing occurs or significant floating debris is present. All outlets which are operated with electrical equipment must have back-up generating capability or a manual bypass system capable of being operated in a reasonable amount of time.

J. All outlets shall be properly vented to avoid cavitation, surging, and reservoir vortexes. On low head dams adequate ventilation may naturally occur through the conduit if a free water surface is maintained. In most cases a vent pipe and air manifold around the perimeter of the conduit immediately downstream of the gate will be required. The air supply lines should be conservatively sized for the anticipated flows and protected in the same manner as the outlet control lines or stems.

K. All operators and supporting equipment for outlet controls should be properly protected and secured. Particular attention needs to be given to protection from vandals and unauthorized operation. All outlet controls should be clearly marked as to which way the gates and valves operate so that overloading of a closed gate or valve should not occur.

L. Outlet controls should be accessible when the spillways are in use.

R655-11-8. Spillway Requirements.

A. On all spillway control structures, provisions should be made for aeration of the nappe.

B. All spillways excavated in soils or soft rock should include a check structure to avoid headcutting and lowering of the spillway flowline.

C. All spillway channels should have suitable armor to prevent erosion.

D. If the spillway has concrete sidewalls, adequate weepholes should be provided or the walls should be designed with full hydrostatic loads in conjunction with the soil loads.

E. For spillways in remote areas where significant snowfall occurs, efforts should be made to maximize the southern exposure of the spillway to prevent ice blockage. In many cases elimination of tall trees will be required.

F. All construction joints should be provided with adequate water stops.

G. Design provisions should be made so that downstream spillway channel flows cannot encroach on the dam.

H. All spillways draining reservoirs with large amounts of floating debris should include a log boom to avoid plugging the spillway.

I. Spillway designs should provide for energy dissipation so that waters returned to the natural channel will not cause erosion.

J. For spillways with concrete floors, provisions should be made to control uplift pressures.

K. Stop logs or flashboards which restrict the design spillway capacity will not be allowed.

R655-11-9. Other Design Requirements.

A. To facilitate inspection, all dams shall have a zone 25 feet beyond all contacts at the downstream groins and toe of the dam in which all woody vegetation is to be removed.

B. If the dam is located in an area where grazing occurs, then livestock must be restricted from the dam by suitable fencing.

C. Unless the dam crest serves as a public road, a suitable gate or other barrier should be installed to prohibit traffic.

D. Geosynthetics may not be used in a dam as the primary design feature unless specifically approved, in writing, by the State Engineer.

E. The foundation downstream of a dam should be graded to convey seepage waters and runoff away from the dam.

F. All control houses and other structures housing instrumentation and operating devices should be designed to discourage unauthorized entry and damage from vandalism.

G. If burrowing animal activity is anticipated to be excessive, design consideration should be made to prohibit their entry, or place materials as a shell which are not capable of sustaining a rodent hole.

R655-11-10. Instrumentation.

Instrumentation on a dam serves the purposes of comparing actual performance with predicted performance and to observe the long term performance for unexpected changes, indicating a safety problem. Since each dam site and design varies, considerable judgment is needed in developing an instrumentation plan. The State Engineer may require any instrumentation necessary to adequately monitor a dam to insure its safety. Where instrumentation is required threshold values should be established for field personnel. Readings which exceed threshold values will indicate that the design criteria has been exceeded and the stability analysis should be reevaluated. Some minimal instrumentation will be required on dams as outlined in the following paragraphs.

R655-11-10A. Reservoir Staff Gages.

All dams shall have a suitable staff gage to monitor reservoir levels. Staff gages should be designed to be durable and capable of resisting movement, water forces and ice. All gages shall have permanent markings at a minimum of one foot intervals with actual elevations recorded at five foot intervals. The State Engineer may allow the use of other measuring devices if it can be demonstrated that they are reliable and accurate.

R655-11-10B. Survey Markers and Bench Marks.

All moderate and high hazard dams shall have permanent survey markers on the crest of the dam to monitor vertical and horizontal movement. The survey markers should be located to prevent damage from traffic. In conjunction with the survey

markers a permanent bench mark shall be installed on each abutment, sufficiently removed from the dam so any effects of the dam movement will not be felt at the bench mark. Reference markers should be established so the bench mark can be reset in the event of damage. Spacing of survey markers should not exceed 200 feet and spacing should be decreased as the height of the dam increases.

R655-11-10C. Piezometers.

A. All high hazard dams as well as moderate hazard dams, at the State Engineer's discretion, shall include piezometers. As a minimum, piezometers should be installed along two cross sections of the dam, one of which should be at or near the maximum section. Each cross section should include piezometers at critical locations in the embankment and foundation. It is preferable to have only one piezometer in each hole; however, more than one piezometer may be installed in each hole if the intervening zone between the piezometer tips can be adequately sealed.

B. All piezometers should have a surface casing projecting beyond the ground with the surface casing adequately sealed. The surface casing should include a locking cap to prevent unauthorized access.

C. All piezometer holes should be logged during drilling and any pertinent information included on the as-constructed plans. As-built locations, designations and elevations of the top, bottom, and porous interval of the piezometers should be shown on the as-constructed plans.

R655-11-10D. Seepage Measurements.

Seepage measurements for all drains and collection pipes should be provided, as outlined in R655-11- 6E, for all high and moderate hazard dams. Any significant seepage areas which develop following the initial filling should also be provided with measuring devices.

R655-11-10E. Strong Motion Instruments.

The State Engineer may require strong-motion instrumentation in seismic zones 2 and 3.

R655-11-11. Abandonment of Dams.

Abandonment of all dams requires approval by the State Engineer.

R655-11-11A. Removal of Dam.

If it is proposed to totally remove a dam, the main concern is to return the stream and reservoir basin to their pre-dam condition. Plans should be submitted showing how the original channel is to be reclaimed, how deposited silts are to be controlled, and what methods will be used to revegetate the reservoir basin and riparian areas.

R655-11-11B. Breaching of Dam.

If a dam is to be breached the following minimum criteria should be met:

1. The flowline of the breach should be excavated down to natural ground or stabilized at the top of the silt level. In most cases grade control and drop structures will be required to avoid mobilization of reservoir silts and debris.

2. The breach should be designed to pass a flood with a return interval of 100 years without backing water up in the historic reservoir more than five feet.

3. Regardless of hydraulic requirements the bottom width of the breach will be one half the structural height of the dam with an absolute minimum of 10 feet. Additional width may be required by the State Engineer in areas where beaver

activity occurs.

4. Breach side slopes must be flat enough to hold the slope when saturated, with an absolute minimum of one vertical on one horizontal. In areas where there is significant human travel, the minimum side slopes should be one vertical on two horizontal.

5. The exposed banks and bottom of the breach should be protected with riprap, vegetation, or other suitable means to prevent downcutting and lateral slope erosion.

6. Barriers should be placed on the original dam crest to warn any possible traffic on the crest of the breach.

R655-11-12. Construction.

The State Engineer will monitor construction of approved projects as outlined in the following paragraphs.

R655-11-12A. Informal Construction Inspections.

During the course of constructing, enlarging, repairing, or removing a dam, the State Engineer may make periodic inspections to determine compliance with plans and specifications, as well as to observe field conditions to see if actual conditions are consistent with those used during design. Any problems observed will be pointed out to the resident inspector or engineer for correction or change. All significant problems noted will be outlined in a letter to the owner and the owner's engineer. The engineer must respond in writing to the State Engineer as to what steps were undertaken to correct the problems.

R655-11-12B. Formal Construction Inspections.

In approving plans the State Engineer may require his approval of certain construction operations before the next phase of construction can commence. The owner's engineer or inspector must notify the State Engineer and determine a mutually acceptable time to observe and approve the work prior to continuation of the construction. Written acceptance of work inspected during formal inspections will be sent to the owner and his engineer.

R655-11-12C. Construction Reporting Requirements.

Written documentation of all construction activities should be maintained by the owner's engineer. The documentation must be submitted weekly to the State Engineer by the owner's engineer when any work is underway. At a minimum the documentation should include:

1. All materials certifications submitted by suppliers to insure compliance with specifications.

2. Results of all material tests or any other testing undertaken during construction. Any tests not meeting the requirements of the plans must include notations indicating what was done to correct the sub-standard work.

3. All engineers' and inspectors' diaries, field notes, or other written documentation.

4. Photographs to clarify work completed or problems noted.

5. All geological logs of foundation excavations.

R655-11-12D. Change Order Approvals.

All change orders revising the plans that involve technical changes must be

approved by the State Engineer. Since the State Engineer is not a party to the construction contract, change orders involving strictly payment to the contractor do not need to be approved by the State Engineer.

R655-11-12E. Final Inspection.

Before any dam can be placed in operation a final inspection of the project must be undertaken by the State Engineer and his written acceptance of the project received. The Emergency Action Plan, Standard Operating Plan, and Initial Filling Plan, if required, must be completed and approved before final acceptance and authorization for filling can be given. As-constructed plans of the project must be submitted within 60 days of the date of the final inspection. All as-constructed plans submitted must be on a high quality reproducible medium. As-constructed plans should reflect design changes made during construction, geological logs of the foundation excavation, and piezometer borings.

KEY

dams, earthquakes, floods, reservoirs

Date of Enactment or Last Substantive Amendment

December 10, 2003

Notice of Continuation

May 3, 2006

Authorizing, Implemented, or Interpreted Law

73-5a

Rule converted into HTML by the Division of Administrative Rules.

For questions regarding the *content* or *application* of rules under Title R655, please contact the promulgating agency (Natural Resources, Water Rights). A list of agencies with links to their homepages is available at http://www.utah.gov/government/agencylist.html or from http://www.rules.utah.gov/contact/agencycontacts.htm.

The HTML version of this rule is a convenience copy made available on the Internet as a public service. **Please see the State of Utah Terms of Use**.

2010 © Division of Administrative Rules
4120 State Office Building / Capitol Hill Complex / 450 North State Street / Salt Lake City, UT 84114
Phone: 801-538-3764 / Fax: 801-359-0759

R655. Natural Resources, Water Rights.
R655-11. Requirements for the Design, Construction and Abandonment of Dams.
R655-11-4. Hydrologic Design.

In order to arrive at an Inflow Design Hydrograph or Inflow Design Flood (IDF) more representative of actual conditions in Utah, the State Engineer has commissioned, or has been involved in, numerous studies to supplement the National Oceanic and Atmospheric Administration's (NOAA) Report entitled "Hydrometeorological Report No. 49 (HMR49) - " Probable Maximum Precipitation Estimates, Colorado River & Great Basin Drainages". The results of most of these studies are used to better identify soil conditions, discharge coefficients, and unit hydrograph parameters. The results of two of the studies are used directly to refine the calculation of the design rainfall values. Both studies were completed by Donald Jensen of the Utah Climate Center and are entitled, "2002 Update for Probable Maximum Precipitation, Utah 72 Hour Estimates to 5,000 sq. mi. - March 2003" (USUL) and " Probable Maximum Precipitation Estimates for Short Duration, Small Area Storms in Utah - October 1995 "(USUS). All of HMR49, Table 1, page 4 of USUL, and Table 15, pages 74-75 of USUS are hereby incorporated by reference. All High Hazard and Moderate Hazard dams in Utah must use the precipitation values obtained from the use of all three publications. To avoid confusion, precipitation values obtained from HMR49 exclusively will be referred to as the Probable Maximum Precipitation (PMP), while those obtained from using HMR49 in conjunction with USUL or USUS, will be referred to as the Spillway Evaluation Precipitation (SEP). The resulting hydrographs generated will be referred to as the Probable Maximum Flood (PMF) and the Spillway Evaluation Flood (SEF) respectively.

R655-11-4A. Inflow Design Hydrograph Determination.

A) In Utah, the IDF for all High and Moderate Hazard Dams will be the SEF. It will be necessary to calculate both the 72 hour SEF using HMR49/ USUL as well as the 6 hour SEF using HMR49/ USUS. Both of these hydrographs must be routed through the reservoir to determine which one represents the most extreme event.

B) Once the critical SEF has been determined, it must be compared to a flood generated by the 100 year, 6 hour (for local storms), or 100 yr, 24 hour (for general storms) precipitation applied on a saturated watershed. If the routed 100 year event, including appropriate allowances for freeboard, is more critical than the SEF it must be used as the minimum IDF. This 100 year flood should also be used as the IDF for all Low Hazard Dams.

R655-11-4B. Freeboard Requirements.

All dams must have a normal freeboard above the crest of the principal spillway capable of containing the maximum wave action considering site wind-duration and fetch control characteristics. Wave action includes wave height and maximum runup, as well as reservoir setup against the embankment slope. Unless otherwise

justified by specific data acceptable to the State Engineer, an extreme wind velocity (fastest mile) over land of 100 miles per hour should be considered. In addition, while routing the 100 year precipitation event through the spillway, sufficient residual freeboard must be available to control wave action from a fetch controlled 50 miles per hour wind. In no case will the normal freeboard be less than three feet for high and moderate hazard dams. The State Engineer may reduce the three feet minimum freeboard requirement for low hazard dams based upon a review of the relative increase in risk associated with this reduction.

R655-11-4C. Spillways.

In designing the spillway for a dam to pass the IDF, the State Engineer will consider the use of a principal spillway in conjunction with emergency spillways. The principal spillway must be designed so that no structural damage will occur during passage of the IDF. Emergency spillways, including Fuse Plug Spillways, may be designed so that some damage may be expected during use provided the anticipated damage does not represent a threat to the dam. Sunny day failure modeling of Fuse Plug Spillways may be required to determine if they are creating an additional unacceptable risk. Overtopping of the dam will not be considered as an emergency spillway on earthfill dams, unless it can be demonstrated that the dam is protected from erosion, and the duration of overtopping will not saturate the dam and reduce its stability.

R655-11-4D. Infiltration Rates.

The State Engineer will accept an IDF using SEP values in conjunction with soil moisture conditions representative of historical maximums. If the design engineer is using infiltration rates which represent something less than saturated conditions, information should be submitted to justify the lower soil moisture selection.

R655-11-4E. Flood Routing.

A. In routing the IDF through the reservoir, the initial water surface should reflect conservative estimates which would exist at the time of the flood event. Unless documentation can be provided to the contrary, it should be assumed that all low level outlets are closed during routing of the IDF. For dams receiving inflow from pipelines and supply canals, it should be assumed these additional sources are operating at capacity during the flood event. In the event the spillway is gated or has "stop logs", which are only allowed on existing dams, documentation must be provided to show the gates are automated or operational procedures are in place to insure that the gates can be opened or the stop logs removed in a timely manner.

B. The SEF can be routed so the maximum water surface is at an elevation equal to the lowest point on the crest of the dam with no residual freeboard.

C. In generating the IDF, the basin characteristics used and the parameters used to generate the unit hydrograph should be based on the best information available. Unit hydrographs generated from historical records or calibrated watersheds should be used, where data is available, rather than using synthetic procedures.

R655-11-4F. Incremental Damage Assessment for High and Moderate Hazard Dams.

The State Engineer may, at his discretion, accept an IDF less than the SEF based on the results of an Incremental Damage Assessment (IDA) which shows that failure of the dam would cause insignificant incremental damage to property and no additional threat to human life. The State Engineer may consider the use of early warning systems in evaluating the threat to human life. In requesting the acceptance of an IDF determined from an IDA, documentation must be furnished that the owner of the dam is aware that the design reflects something less than the SEF and they are willing to accept the additional liability. In no case will the State Engineer approve an IDF generated by something less than the applicable 100 year flood event. The resulting selected IDF, based on the IDA, should be reported as a percent of the SEF.

R655-11-4G. Historical Records.

In some cases it may be appropriate to use historical streamflow records to generate a 100 year flood. If these records are used as a basis for the IDF, they should be accompanied by the Synthetic IDF established by using the 100 year precipitation. Following a review of the data, the State Engineer will make a determination of which flood will be used as the IDF.

KEY: dams, earthquakes, floods, reservoirs
November 29, 2001
Notice of Continuation July 12, 2001
73-5a
Effective Date: 12/10/2003

Utah Code
Title 73 Water and Irrigation
Chapter 5a Dam Safety
Section 101 Power of state engineer to regulate dams.

73-5a-101. Power of state engineer to regulate dams.

(1) The state engineer has the authority to regulate dams for the purpose of protecting public safety.

(2) To protect life and property, the state engineer may make rules controlling the construction and operation of dams, including rules controlling:

(a) design;

(b) maintenance;

(c) repair;

(d) removal; and

(e) abandonment.

(3) The state engineer may by rule exempt from this chapter any dam that:

(a) impounds less than 20 acre-feet of water and does not constitute a threat to human life if it fails; or

(b) does not constitute a threat to human life and would result in only minor damage to property of the owner if it fails.

73-5a-102. Chapter does not apply to certain federal dams and reservoirs.

This chapter does not apply to works owned by the United States Bureau of Reclamation. However, the Bureau of Reclamation shall file plans, drawings, and specifications of its works with the state engineer.

73-5a-103. Liability of owner or operator.

(1) Nothing in this chapter shall be construed to relieve an owner or operator of a dam or reservoir of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam or reservoir.

(2) The owner or operator of a dam or reservoir may not be held to be strictly liable for any act or omission incident to the construction, ownership, or operation of the dam or reservoir.

73-5a-104. Qualifications of persons designing dams.

Each plan for the construction, enlargement, repair, alteration, or removal of any dam in this state shall be prepared by a qualified engineer who is:

(1) licensed in Utah; and

(2) experienced in dam design and construction.

73-5a-105. Independent consultants -- Owner to pay costs.

(1) The state engineer may require the owner of a dam or proposed dam to obtain the services of an independent consultant or team of consultants approved by the state engineer to consult regarding the adequacy of the design, construction, or operation of the dam if safety considerations pertaining to the

design, construction, or operation of the dam warrant an independent review.

(2) The state engineer shall make rules specifying:

(a) the safety considerations that will be considered in determining if an independent review is required;

(b) the requisite qualifications and experience of the independent consultants; and

(c) the timing of the consultants' review so that their recommendations are made in a timely manner.

(3) (a) The independent consultants shall be considered to be the agents of the owner of the dam.

(b) The costs of the independent consultants' services shall be paid by the owner of the dam.

(c) The owner of the dam may require the independent consultants to consider other issues, in addition to safety considerations, such as:

(i) design selections or alternatives;

(ii) site selection;

(iii) cost effectiveness; or

(iv) other tasks as defined by the contract.

73-5a-106. Dams classified according to hazard and use.

(1) Dams shall be classified according to hazard and use.

(2) Hazard classifications are as follows:

(a) high hazard - those dams which, if they fail, have a high probability of causing loss of human life or extensive economic loss, including damage to critical public utilities;

(b) moderate hazard - those dams which, if they fail, have a low probability of causing loss of human life, but would cause appreciable property damage, including damage to public utilities; and

(c) low hazard - those dams which, if they fail, would cause minimal threat to human life, and economic losses would be minor or limited to damage sustained by the owner of the structure.

(3) Use classifications are as follows:

(a) water storage - dams which impound water for prolonged periods, including those built for irrigation, power generation, water supply, aquatic culture, and recreation;

(b) flood control - dams constructed to operate only during significant runoff events and which impound water for a small percentage of time, including those built for flood control or sediment control and debris basins;

(c) tailings - dams in which a large component of the material impounded consists of saturated solids; and

(d) other - dams which impound a minimal amount of water or where the head behind the dam is minimal, including stock ponds, wash water ponds, recirculated process water ponds, regulating reservoirs, and diversion dams.

E.45. Vermont



State of Vermont
Department of Environmental Conservation

Instructions for Completing
Application for Authorization to Construct or Alter a Dam

10 V.S.A. Chapter 43

Item 1: **Applicant.** Ordinarily, the applicant(s) should be the owner(s) of the dam and land upon which the dam is or will be located. If there is more than one owner, all owners must be listed and become joint applicants. If the dam is on leased land, both the lessor and lessee become co-applicants.

Item 2: **Legal Entity.** Complete only if applicant is not applying as an individual, e.g., corporation, partnership, municipality, etc.

Item 3: **Contact.** Person to contact regarding this application if other than applicant.

Item 4: **Land Ownership and Flowage Rights.** Complete *Schedule A* and provide any required documentation.

Item 5: **Project Description**

a. Check appropriate box.

b. Name of existing dam, if any, or name of applicant or pond as appropriate.

c. Name of town(s) in which the **dam** is located.

d. Name of water course (river, stream, lake or pond) on which the dam is or will be located. If the dam is an offstream structure or on an unnamed watercourse, indicate that it is on an unnamed tributary of the nearest named watercourse.

e. Drainage area in acres at the dam.

f. Indicate type of dam, e.g., earthfill, concrete gravity, earthfill-stonewall, stone masonry, timber A-frame, etc.

g. Surface area of impoundment in acres (A), at Normal Water Level (NWL) and with water level at Top of Dam.

h. Storage in acre-fee (AF). NOTE: One acre-foot is equal to 43,560 cubic feet; 500,000 cubic feet is approximately 11.48 AF. Provide storage values for both NWL and **top of dam**, i.e., top of non-overflow part of dam or top of freeboard, conditions. Storage will be based on one of the following cases.

Case I. Totally artificial (man-made) lakes, ponds, reservoirs, lagoons or other impoundments. Includes man-made dams constructed on beaver ponds. Storage, including accumulated sediments, controlled by the dam **and** any storage created by excavating below the lowest elevation of the dam foundation. If there is no dam above original ground elevation, e.g., a “dug pond,” lagoon,

etc., it is the total storage created by excavation below the lowest ground elevation along the periphery of the pond.

Case II. Dams at the outlets of natural lakes or ponds. Storage is total storage, including any accumulated sediments, controlled by the dam but does not include existing **natural** storage below the lowest foundation elevation of the dam. However, it does include any additional **man-made** storage created by dredging or enlarging a natural pond with a dam on it.

i. The maximum height is the vertical distance from the lowest point along the downstream toe of the dam (usually the original bed of the stream or watercourse) to the top of the non-overflow part of the structure. For impoundments without dams indicate N/A (not applicable).

j. Indicate, for existing lakes, ponds or dams if the existing normal water level will be raised or lowered and by how much. If there is no existing lake or pond or dam, indicate N/A.

k. Provide a brief narrative description of the project and its purpose.

l. Describe the method of operation. Include such things as any proposed manipulation of water levels and any diversions of water into or out of the pond.

Item 6: **Engineer.** List name, address, telephone, and Vermont P.E. license number for engineer providing design and construction supervision services. Sections 1080(4), 1083(b) and 1090 of the statute require that the dam owner retain the services of a professional engineer, registered in Vermont, who has experience in the design and investigation of dams to design and supervise construction or alteration of any dam requiring approval from the department under 1082.

It is desirable, but not necessary, that the design engineer also provide the required construction supervision. **Full time construction supervision and submittal of daily construction status reports is ordinarily required.**

Item 7: **Estimated Construction Cost.** Estimated construction cost – exclusive of cost of land.

Item 8: **Estimated Start and Completion Dates.** Indicate when you would like to begin the project and when it would be completed.

NOTE: For most projects the work should be scheduled to be completed during one construction season (generally April 15 – November 15). For projects that require more than one construction season, a longer construction period may be approved provided there are adequate provisions to safely “winter over” the uncompleted project. If project is to be phased, provide detailed schedule.

Item 9: **Financial Information.** Complete *Schedule B.*

Item 10: **Right of Entry.** Complete *Schedule C.*

Item 11: **Public Good.** Complete *Schedule D.*

Item 12: Documents and Schedules Attached.

A. The following items are required for all applications:

1. Location map. Show location of dam on section from U.S. Geological Survey topographic map.

2. Schedules A, B, C, and D.

3. Plans and Specifications. Complete and detailed engineering plans and specifications must accompany the application. Submit two (2) complete sets of 24 inch by 36 inch engineering plans and one (1) complete set of 11 inch by 17 inch engineering plans.

   NOTE: Prior to submitting the application, the department encourages the applicant's engineer to discuss preliminary design concepts and parameters before completing the detailed plans and specifications. Contact with state fish and wildlife, water quality and wetlands personnel is strongly recommended prior to preliminary design.

B. The following items are generally required for all new construction and most reconstruction and alterations.

1. Soils Information. Provide boring and test pit logs, laboratory analyses of soils for foundation, embankment, filters, spillways, etc. Provide filter design and stability analyses as appropriate. Filter gradation requirements should be designed in accordance with NRCS (formerly SCS), *Part 633, National Engineering Handbook, Chapter 26, Gradation Design of Sand and Gravel Filters* (May 1994 or later revisions), or other appropriate standard nationally recognized by the engineering profession as suitable for dams.

2. Hydrology and Hydraulics. Provide detailed H&H study of site and basin hydrology and project hydraulics showing adequate freeboard, spillway capacity and drain capacity to support downstream hazard classification using appropriate and generally accepted methodologies.

3. Storage and Surface Area Data. Provide area-capacity curves or tables for full range of storage controlled by the dam.

4. Breach Analysis. Provide breach analysis and inundation mapping for determination of downstream hazard classification, for sizing spillways and outlet works, and, where appropriate, for use in preparation of Engineering Action Plans (EAP).

   The downstream hazard classification used by the department is the same as that used by the U.S. Army Corps of Engineers in *Recommended Guidelines for Safety Inspections of Dams* (ER 1110-2-106: 24 Mar 80, Chg. 1, page D-8). The classification used by the Soil Conservation Service (SCS) as given on page 1-1 of *Technical Release 60* (Revised October 1985) is acceptable, but the classifications should be corrected with the Corps designations.

The breach analysis may be done by generally accepted method such as the National Weather Service (NWS) DAMBRK and FLDWAV models or Corps of Engineers HEC-1 Dam Break computer models. For further guidance, see the Federal Energy Regulatory Commission (FERC), *Engineering Guidelines for the Evaluation of Hydropower Projects, Appendix II-A, Dambreak Studies* October 1993. The NWS models are the preferred methodologies.

5. Spillway Design Flood (SDF)

   SDF and outlet works capacities should be consistent with guidelines or service criteria established by Federal agencies such as the Corps of Engineers, Soil Conservation Service and the Bureau of Reclamation for a given size and hazard classification, with the following additional requirements:

   - SDF, **as appropriate**, but in no case less than a routed Q100 (one hundred-year frequency) inflow (Ref: FERC *Engineering Guidelines . . .* , October 1993, Paragraph 2-3.3.).

   - Freeboard, as appropriate, but not less than 1.5 feet with a routed Q100 inflows, and not less than 3.0 feet from principal spillway crest (usually NWL). Applies to all embankment dams and other dams where appropriate.

6. **Operation and Maintenance (O&M) Manual.** Prepare O&M manual for dam owner/operator. Include, as appropriate, project description, records, photos; operating practices for gates, spillways, etc.; maintenance practices; inspections, frequency for owner/operator and owner's engineer; inspection check lists; recordkeeping, etc.

7. **First Filling Plan.** Provide a plan to be followed by the dam owner and his engineer to monitor dam during first filling following construction or modification.

8. **Emergency Action Plan (EAP).** An EAP is recommended for all dams, particularly Class I (high hazard) structures. An EAP is required for all new Class I and Class II dams. The EAP should be developed in coordination with the affected municipalities and be acceptable to them. Coordination with Vermont Emergency Management is also recommended.

Item 13: **Application Fee Enclosed.** Compute from fee Schedule and submit a check payable to *State of Vermont*.

Item 14: **Certification.** Sign, date and provide typed name and title. If more than one applicant, **all** must sign.

Dam Design

The department expects all dams will be designed in accordance with generally accepted, modern engineering practices by qualified and experienced professional engineers **registered in the State of Vermont**. Although, the department has not formally adopted specific design criteria, the following general standards are used by the department:

1. **Low level outlets.** All new and reconstructed dams must have an adequate low level (bottom) outlet that is operable from the surface and is of sufficient size to drain the reservoir. Slide gates or gate valves are preferred. ”Flap valves” are unacceptable.

2. **Corrugated Galvanized Metal Pipe (CGMP).** CGMP is not acceptable for spillways, low level outlets or drains in new or reconstructed dams.

3. **Seepage Control.** The department places strong emphasis on adequate seepage control to prevent piping (internal erosion) and instability of embankments, structures, foundations and abutments of dams.

   All conduits and structures passing through earth dams must be protected by properly designed mineral filters. In accordance with modern practice, rigid anti-seep collars or diaphragms are no longer to be used on conduits.

   Mineral filter design should be in accordance with NRCS (SCS) Chapter 26, NEH (See Item 12, B-1) or other appropriate standard nationally recognized by the engineering profession as sustainable for dams.

   Filter fabrics should not be used to wrap piezometer screws or as filter material within or on the upstream face of dams, or within any portion of the embankment. (Ref: Corps of Engineers, EM 1110-2-1901, 9/30/86, *Seepage Analysis and Control for Dams*.

Mail completed application to:

Department of Environmental Conservation
Facilities Engineering Division
Dam Safety Section
103 South Main Street
Waterbury, VT 05671-0511

Notes:

(1) The department may request other information from the applicant it considers necessary to properly review the application.

(2) The department will have a notice of the completed application published in an area newspaper, request posting in the town clerk's Office and will seek comments from state, municipal or regional agencies and other individuals or organizations who have requested a notice.

(3) The applicant is requested to provide the department with the names and addresses of any persons the applicant knows to have an interest in the application and would like to receive a notice.

(4) Under 10 V.S.A. Section 1083(a) notice of the application must be given **by the applicant** to governing body of the municipality or municipalities in which the dam or any part of the dam is to be located.

July 2009

STATE OF VERMONT
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

INSPECTION OF DAMS

The Department of Environmental Conservation has for many years made routine safety inspections of non-federal, non-hydroelectric dams. Since 1982, the Department has been required to carry out periodic inspections of dams subject to its jurisdiction under provisions of 10 V.S.A. § 1105. This section reads as follows:

§ 1105. Inspection of dams

> The state agency having jurisdiction shall employ an engineer to make periodic inspections of non-federal dams in the state to determine their condition and the extent, if any, to which they pose a potential or actual threat to life and property, or shall promulgate rules pursuant to chapter 25 of Title 3 to require an adequate level of inspection by an independent registered engineer experienced in the design and investigation of dams. The agency shall provide the owner with the findings of the inspection and any recommendations. - Added 1981, No. 242 (Adj. Sess.), § 13, amended 1985, No. 60

The Department classifies dams according to a dam's potential for causing loss of life and property damage in the area downstream of the dam if it were to fail. The following Downstream Hazard Classification system is used by the Department. It is same as the U.S. Army Corps of Engineers system given in *Recommended Guidelines for Safety Inspection of Dams* (ER 1110-2-106, 25 Sept. 79, 24 Mar 80 Chg 1).

DOWNSTREAM HAZARD CLASSIFICATION OF DAMS

Class	Hazard Category	Potential Loss of Life	Potential Economic Loss
3	Low	None expected (No permanent structures for human habitation)	Minimal (Undeveloped to occasional structures or agriculture)
2	Significant	Few (No urban developments and no more than a small number of inhabitable structures)	Appreciable (Notable agriculture, industry or structures)
1	High	More than few	Excessive (Extensive community, industry or agriculture)

Under the Corps system, the classifications are further described as follows:

(a) *LOW Hazard (Class 3)*

Dams conforming to criteria for the low hazard potential category generally will be located in rural or agricultural areas where failure may damage farm buildings, limited agricultural land, or township and country roads.

(b) *SIGNIFICANT Hazard (Class 2)*

Significant hazard potential category structures will be those located in predominantly rural or agricultural areas where failure may damage isolated homes, secondary highways or minor railroads or cause interruption of use or service of relatively important public utilities.

(c) *HIGH Hazard (Class 1)*

Dams in the high hazard potential category will be those located where failure may cause serious damage to homes, extensive agricultural, industrial and commercial facilities, important public utilities, main highways or railroads.

Additional information:

1. The terminology HIGH, SIGNIFICANT, AND LOW hazard refers to the potential for damage or loss of life and does **not** refer to the condition of the dam. For example, a HIGH hazard (Class 1) dam may be in excellent condition and a LOW hazard (Class 3) dam may be in poor condition.

2. A dam's classification may change from what it was when it was built or at the last inspection because of changes in downstream conditions. For example, a Class 3 (low hazard) dam may become a Class 2 (significant hazard) or Class 1 (high hazard) dam if some houses are built downstream that could be impacted by a failure. The classification could also change (either up or down) if a more detailed breach analysis is carried out that more accurately determines downstream damage potential.

3. It should not be assumed that the failure of a Class 3 (low hazard) dam would never be a threat to lives. Although direct loss of life (such as by flooding a house) is not expected, the failure could, for example, wash out a road and result in a fatal accident.

The Department bases its minimum periodic inspection frequency on the downstream hazard classification. The Department's goal is to inspect dams as follows:

Class	Downstream Hazard Classification Category	Inspection Frequency
1	High	1
2	Significant	1-5
3	Low	7-10

The Department may increase the inspection frequency when in its opinion more frequent or non-routine inspections are warranted. Reasons to increase the frequency or undertake non-routine inspections may include: (1) problems or concerns with the condition or safety of the dam; (2) following significant flood events, and (3) during and subsequent to impounding water following construction or reconstruction of the dam.

The inspections by the Department do not and are not intended to relieve the owner of the dam of the owner's legal duties, obligations or liabilities incidental to the ownership, operation, maintenance, emergency preparedness or inspection of the dam. The owner should inspect or have the dam inspected on a frequent basis so that routine maintenance may be undertaken as needed and to monitor and/or identify any changes or conditions that could indicate problems with the dam. Should any such conditions or changes occur the owner should contact an engineer experienced with the design and investigation of dams. The engineer should evaluate the significance of the change or condition so that the engineer can advise the owner accordingly. Even if no changes are observed, the owner should have an experienced and qualified engineer inspect and evaluate the dam on an appropriate periodic basis, e.g., annually, biannually, etc. The inspections by the owner or owner's engineer are independent of any inspections that may be carried out by the Department.

The Department's current policy is to inspect only those dams that are capable of impounding more than 500,000 cubic feet. Although the statute does not limit size when considering "unsafe" dams (10 V.S.A. § 1095), only those dams impounding more than 500,000 cubic feet require prior authorization to construct, alter or remove (10 V.S.A. § 1082).

The inspection program relies on the voluntary assistance of dam owners. Before an inspection is made, a diligent effort will be made to contact the landowner for access permission. The landowner may deny permission for inspection. Consult your attorney.

The purpose of the inspection is to investigate and determine the condition of the dam and the extent, if any, to which it may pose a potential or actual threat to life and property. A report on the findings of the inspection and any recommendations are provided the dam owner. The report provides an assessment of the general condition of the dam which is based upon available data and a visual inspection. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations or detailed hydrologic and hydraulic analyses are beyond the scope of the inspection, however, the inspection may identify a need for further studies.

The reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the Department. In cases where the reservoir was lowered or drained prior to inspection, such action, while usually improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

The safety of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions are detected.

No dam can ever be considered to be completely "safe" (i.e., it can't fail) even if it has been well designed, constructed, operated and maintained. Even if it is considered that the chance of a failure is remote, it is still a possibility and should not be ignored. All dams to some degree, but old dams in particular, are unpredictable and can fail under conditions as or less severe than they have survived in the past.

The scope of an inspection report does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is beyond the scope of the inspection program.

For further information contact:

Department of Environmental Conservation
Facilities Engineering Division, Dam Safety and Hydrology Section
103 South Main Street, Laundry Building
Waterbury, Vermont 05671-0511

Telephone: 802.241.3454
Facsimile: 802.244.4516

Revised August 2007

The Vermont Statutes Online

Title 10: Conservation and Development

Chapter 43: DAMS

§ 1080. Definitions

As used in this chapter:

(1) "Department" means the department of environmental conservation.

(2) "Person" means any individual; partnership; company; corporation; association; joint venture; trust; municipality; the state of Vermont or any agency, department, or subdivision of the state, any federal agency, or any other legal or commercial entity.

(3) "Person in interest" means, in relation to any dam, a person who has riparian rights affected by that dam, a substantial interest in economic or recreational activity affected by the dam, or whose safety would be endangered by a failure of the dam.

(4) "Engineer" means a professional engineer registered under Title 26 who has experience in the design and investigation of dams.

(5) "Time" shall be reckoned in the manner prescribed by 1 V.S.A. § 138. (Added 1981, No. 242 (Adj. Sess.), § 1; amended 1987, No. 76, § 18; 2003, No. 115 (Adj. Sess.), § 22.)

§ 1081. Jurisdiction of department and public service board

(a) Unless otherwise provided, the powers and duties authorized by this chapter shall be exercised by the department, except that the public service board shall exercise those powers and duties over dams and projects that relate to or are incident to the generation of electric energy for public use or as a part of a public utility system.

(b) Transfer of jurisdiction. Jurisdiction over a dam is transferred from the department to the public service board whenever the Federal Energy Regulatory Commission grants a license to generate electricity at the dam or whenever the public service board receives an application for a certificate of public good for electricity generation at that dam. Jurisdiction is transferred from the public service board to the department whenever such a federal license expires or is otherwise lost, whenever such a certificate of public good is revoked or otherwise lost, or whenever the public service board denies an application for a certificate of public good.

(c) Upon transfer of jurisdiction as set forth above and upon written request, the state agency having former jurisdiction shall transfer copies of all records pertaining to the dam to the agency acquiring jurisdiction. (Amended 1959, No. 203; 1959, No. 329 (Adj. Sess.), § 39, eff. March 1, 1961; 1961, No. 100, § 2; 1981, No. 242 (Adj. Sess.), § 2.)

§ 1082. Authorization

(a) No person shall construct, enlarge, raise, lower, remodel, reconstruct, or otherwise alter any dam, pond or impoundment or other structure which is or will be capable of impounding more than 500,000 cubic feet of water or other liquid after construction or alteration, or remove, breach or otherwise lessen the capacity of an existing dam that is or was capable of impounding more than 500,000 cubic feet within or along the borders of this state where land in this state is proposed to be overflowed, or at the outlet of any body of water within this state, unless authorized by the state agency having jurisdiction so to do. However, in the matter of flood control projects where cooperation with the federal government is provided for by the provisions of section 1100 of this title that section shall control.

(b) For the purposes of this chapter, the volume a dam or other structure is capable of impounding is the volume of water or other liquid, including any accumulated sediments, controlled by the structure with the water or liquid level at the top of the nonoverflow part of the structure. (Amended 1975, No. 179 (Adj. Sess.), § 1; 1981, No. 242 (Adj. Sess.), § 3.)

§ 1083. Application

(a) Any person who proposes to undertake an action subject to regulation pursuant to section 1082 of this title shall apply in writing to the state agency having jurisdiction, and shall give notice thereof to the governing body of the municipality or municipalities in which the dam or any part of the dam is to be located. The application shall set forth:

(1) the location, the height, length and other dimensions and any proposed changes to any existing dam;

(2) the approximate area to be overflowed and the approximate number of, or any change in the number of cubic feet of water to be impounded;

(3) the plans and specifications to be followed in the construction, remodeling, reconstruction, altering, lowering, raising, removal, breaching, or adding to;

(4) any change in operation and maintenance procedures; and

(5) other information that the state agency having jurisdiction considers necessary to properly review the application.

(b) The plans and specifications shall be prepared under the supervision of an engineer. (Amended 1959, No. 329 (Adj. Sess.), § 23(d), eff. March 1, 1961; 1975, No. 179 (Adj. Sess.), § 2; 1981, No. 242 (Adj. Sess.), § 4.)

§ 1083a. Agricultural dams

(a) Notwithstanding the provisions of sections 1082, 1083, 1084 and 1086 of this title, the owners of an agricultural enterprise who propose, as an integral and exclusive part of the enterprise, to construct or alter any dam, pond or impoundment or other structure requiring a permit under section 1083 shall apply to the natural resources conservation district in which his land is located. The natural resources conservation districts created under the

provisions of chapter 31 of this title shall be the state agency having jurisdiction and shall review and approve the applications in the same manner as would the department. The districts may request the assistance of the department for any investigatory work necessary for a determination of public good and for any review of plans and specifications as provided in section 1086.

(b) As used in this section, "agricultural enterprise" means any farm, including stock, dairy, poultry, forage crop and truck farms, plantations, ranches and orchards, which does not fall within the definition of "activities not engaged in for a profit" as defined in section 183 of the Internal Revenue Code and regulations relating thereto. The growing of timber does not in itself constitute farming.

(c) Notwithstanding the provisions of this section, jurisdiction shall revert to the department when there is a change in use or when there is a change in ownership which affects use. In those cases the department may, on its own motion, hold meetings in order to determine the effect on the public good and public safety. The department may issue an order modifying the terms and conditions of approval.

(d) The natural resources conservation districts may adopt any rules necessary to administer this chapter. The districts shall adhere to the requirements of chapter 25 of Title 3 in the adoption of those rules.

(e) Notwithstanding the provisions of chapter 7 of Title 3, the attorney general shall counsel the districts in any case where a suit has been instituted against the districts for any decision made under the provisions of this chapter. (Added 1975, No. 179 (Adj. Sess.), § 5; amended 1981, No. 242 (Adj. Sess.), § 5.)

§ 1084. Department of fish and wildlife; investigation

The commissioner of fish and wildlife shall investigate the potential effects on fish and wildlife habitats of any proposal subject to section 1082 of this title and shall certify the results to the state agency having jurisdiction prior to any hearing or meeting relating to the determination of public good and public safety. (Amended 1975, No. 179 (Adj. Sess.), § 3; 1981, No. 242 (Adj. Sess.), § 6; 1983, No. 158 (Adj. Sess.), eff. April 13, 1984.)

§ 1085. Notice of application

Upon receipt of the application required by section 1082 of this title, the state agency having jurisdiction shall give notice to all persons interested.

(1) For any project subject to its jurisdiction under this chapter, on the petition of 25 or more persons the department shall, or on its own motion it may, hold a public information meeting in a municipality in the vicinity of the proposed project to hear comments on whether the proposed project serves the public good and provides adequately for the public safety. Public notice shall be given by posting in the municipal offices of the towns in which the project will be completed and by publishing in a local newspaper at least 10 days before the meeting.

(2) For any project subject to its jurisdiction under this chapter, the public service board shall hold a hearing on the application. The purpose of the hearing shall be to determine

whether the project serves the public good as defined in section 1086 of this title and provides adequately for the public safety. The hearing shall be held in a municipality in the vicinity of the proposed project and may be consolidated with other hearings, including hearings under 30 V.S.A. § 248 concerning the same project. Notice shall be given at least 10 days before the hearing to interested persons by posting in the municipal offices of the towns in which the project will be completed and by publishing in a local newspaper. (Amended 1981, No. 242 (Adj. Sess.), § 7.)

§ 1086. Determination of public good; certificates

(a) "Public good" means the greatest benefit of the people of the state. In determining whether the public good is served, the state agency having jurisdiction shall give due consideration, among other things, to the effect the proposed project will have on:

(1) the quantity, kind, and extent of cultivated agricultural land that may be rendered unfit for use by or enhanced by the project, including both the immediate and long range agricultural land use impacts;

(2) scenic and recreational values;

(3) fish and wildlife;

(4) forests and forest programs;

(5) the need for a minimum water discharge flow rate schedule to protect the natural rate of flow and the water quality of the affected waters;

(6) the existing uses of the waters by the public for boating, fishing, swimming, and other recreational uses;

(7) the creation of any hazard to navigation, fishing, swimming, or other public uses;

(8) the need for cutting clean and removal of all timber or tree growth from all or part of the flowage area;

(9) the creation of any public benefits;

(10) the classification, if any, of the affected waters under chapter 47 of this title;

(11) any applicable state, regional or municipal plans;

(12) municipal grand lists and revenues;

(13) public safety; and

(14) in the case of proposed removal of a dam that formerly related to or was incident to the generation of electric energy, but which was not subject to a memorandum of understanding dated prior to January 1, 2006 relating to its removal, the potential for and value of future power production.

(b) If the state agency having jurisdiction finds that the proposed project will serve the public good, and, in case of any waters designated by the board as outstanding resource waters, will preserve or enhance the values and activities sought to be protected by designation, the agency shall issue its order approving the application. The order shall include conditions for minimum stream flow to protect fish and instream aquatic life, as determined by the agency of natural resources, and such other conditions as the agency having jurisdiction considers necessary to protect any element of the public good listed above. Otherwise it shall issue its order disapproving the application.

(c) The agency shall provide the applicant and interested parties with copies of its order.

(d) In the case of a proposed removal of a dam that is under the jurisdiction of the department and that formerly related to or was incident to the generation of electric energy but that was not subject to a memorandum of understanding dated before January 1, 2006 relating to its removal, the department shall consult with the department of public service regarding the potential for and value of future power production at the site. (Amended 1969, No. 281 (Adj. Sess.), § 10; 1975, No. 179 (Adj. Sess.), § 4; 1981, No. 242 (Adj. Sess.), § 8; 1987, No. 67, § 13; No. 76, § 18; 2005, No. 208 (Adj. Sess.), § 4.)

§ 1087. Review of plans and specifications

Upon receipt of an application, the state agency having jurisdiction shall employ a registered engineer experienced in the design and investigation of dams to investigate the property, review the plans and specifications, and make additional investigations as it considers necessary to ensure that the project adequately provides for the public safety. The engineer shall report his findings to the agency. (Amended 1981, No. 242 (Adj. Sess.), § 9.)

1088. Repealed. 1975, No. 179 (Adj. Sess.), § 6.

§ 1089. Employment of hydraulic engineer

With the approval of the governor, the state agency having jurisdiction may employ a competent hydraulic engineer to investigate the property, review the plans and specifications, and make such additional investigation as such agency shall deem necessary, and such engineer shall report to the agency his findings in respect thereto.

§ 1090. Construction supervision

The construction, alteration or other action authorized in section 1086 of this title shall be supervised by a registered engineer employed by the applicant. Upon completion of the authorized project, the engineer shall certify to the agency having jurisdiction that the project has been completed in conformance with the approved plans and specifications. (Amended 1981, No. 242 (Adj. Sess.), § 10.)

§ 1091-1094. Repealed. 1981, No. 242 (Adj. Sess.), § 18.

§ 1095. Unsafe dam; petition; hearing; emergency

(a) On receipt of a petition signed by not less than ten persons in interest or the legislative body of a municipality, the agency having jurisdiction shall, or upon its own motion it may,

institute investigations by an engineer as described in section 1087 of this title regarding the safety of any existing dam or portion of a dam, of any size. The agency may fix a time and place for hearing and shall give notice in the manner it directs to all parties interested. The engineer shall present his findings and recommendations at the hearing. After the hearing, if the agency finds that the dam or portion of the dam as maintained or operated is unsafe or is a menace to people or property above or below the dam, it shall issue an order directing reconstruction, repair, removal, breaching, draining or other action it considers necessary to make the dam safe.

(b) If, upon the expiration of such date as may be ordered, the owner of such dam has not complied with the order directing the reconstruction, repair, breaching, removal, draining or other action of such unsafe dam, the state agency having jurisdiction may petition the superior court in the county in which the dam is located to enforce its order or exercise the right of eminent domain to acquire such rights as may be necessary to effectuate a remedy as the public safety or public good may require. If the order has been appealed, the court may prohibit the exercise pending disposition of the appeal.

(c) If, upon completion of the investigation described in subsection (a), the state agency having jurisdiction considers the dam to present an imminent threat to human life or property it shall take whatever action it considers necessary to protect life and property and subsequently conduct the hearing described in subsection (a). (Amended 1959, No. 329 (Adj. Sess.), § 39, eff. March 1, 1961; 1961, No. 100, § 2; 1969, No. 281 (Adj. Sess.), § 12; 1981, No. 242 (Adj. Sess.), § 11.)

1096. Repealed. 1981, No. 242 (Adj. Sess.), § 18.

§ 1097. Survey of existing dams; orders for protection of salmon

The fish and wildlife board shall forthwith make a survey of all dams within the state which impound more than three hundred thousand cubic feet of water and determine if the operation of such dams adversely affects the propagation and preservation of salmon, or materially diminishes the amount of flow in portions of a stream likely to be used for such preservation and propagation of salmon. If the board determines that the operation of an existing dam does adversely affect the propagation and preservation of salmon or materially diminishes the flow of water over portions of stream likely to be used therefor, it shall order such changes in operation for such length of time or times as are reasonably necessary in its judgment to fully protect such preservation and propagation of salmon. Any order of the board made under this section shall be based upon facts found and stated. Appeal from an order of the board may be taken in the manner prescribed for appeals from the public service b

oard as provided in chapter 1 of Title 30. (Amended 1959, No. 329 (Adj. Sess.), §§ 23(d), 39, eff. March 1, 1961; 1983, No. 158 (Adj. Sess.), eff. April 13, 1984.)

§ 1098. Removal of obstructions; appropriation

The department may contract for the removal of sandbars, debris or other obstructions from streams which the department finds that while so obstructed may be a menace in time of flood, or endanger property or life below, or the property of riparian owners. The expense of investigation and removal of the obstruction shall be paid by the state from funds provided

for that purpose. (Amended 1981, No. 242 (Adj. Sess.), § 14.)

§ 1099. Appeals

(a) Appeals of any act or decision of the department under this chapter shall be made in accordance with chapter 220 of this title.

(b) Appeals from actions or orders of the public service board may be taken in the supreme court in accord with 30 V.S.A. § 12. (Amended 1981, No. 242 (Adj. Sess.), § 15; 2001, No. 94 (Adj. Sess.), § 3; 2003, No. 115 (Adj. Sess.), § 23, eff. Jan. 31, 2005.)

§ 1100. Federal cooperation

As a basis for cooperation with the federal government and its duly established agencies in the matter of flood control, the state defines its policy with reference to flood control developments as follows:

(1) A flood control project, which shall contemplate as an incident thereof, the generation of electric energy, shall not be built on any waters within the state without the certificate of the public service board provided for in this chapter having first been obtained in the manner herein provided by the proper federal agency or authority, having in charge the building of such flood control project. Any modifications of flood control dams erected by authority of the federal government in this state shall not be made with a view to their utilization for the generation of electric energy, except by like authority first being obtained;

(2) Where such flood control project is strictly for flood control purposes, no village or city in this state shall be inundated, flooded, or destroyed thereby;

(3) Adequate compensation shall be made to any town whose grand list shall be substantially adversely affected by such strictly flood control project for the loss of its tax revenue;

(4) Where cultivated agricultural lands in excess of one hundred acres are to be taken for the purposes of a flood control project, or the recreational development of the state or the economy of the river basin involved may be affected thereby, the department, of its own motion, may, and upon petition to it by interested parties, shall, appoint a time and place for hearing in the vicinity of the flood control project, hold a public information meeting after giving notice to interested parties as it directs. Upon hearing, the department shall determine the effect the flood control project will have upon agricultural land uses or recreational values in this state, or upon the economy of the river basin involved, and report its findings and recommendations to the proper federal agency or authority having the flood control project in charge for its consideration and recognition. (Amended 1959, No. 329 (Adj. Sess.), § 39, eff. March 1, 1961; 1961, No. 100, § 2; 1981, No. 242 (Adj.

Sess.), § 16.)

1101. Repealed. 1959, No. 35, § 2, eff. March 12, 1959.

§ 1102. Federal receipts, distribution

All sums of money which the state receives from the United States under the provisions of section 701c-3 of Title 33 of the United States Code, as the same may be amended, being a portion of the rentals of property acquired and owned by the United States for purposes of flood control dams and reservoirs, shall be distributed to the municipality or political subdivision in which the dams and reservoirs are located. The department shall administer payment of money so received and the commissioner of finance and management shall issue his warrants on orders of the department. (1959, No. 35, § 1, eff. March 12, 1959; amended 1959, No. 328 (Adj. Sess.), § 8; 1961, No. 100, § 2; 1981, No. 242 (Adj. Sess.), § 17; 1983, No. 195 (Adj. Sess.), § 5(b).)

§ 1103. Approval for flood control dams

(a) No department or agency of the federal government shall construct any flood control dam which is within the state of Vermont, either in whole or in part, or cause any land within the state of Vermont to be overflowed through the operation of a flood control dam located outside the state, except with the approval of the governor and the general assembly.

(b) For purposes of this section "flood control dam" means any dam which has among its principal purposes the prevention or control of floods either within or without the state, or which is financed in whole or in part with funds appropriated, allocated or made available under a federal flood control program, excepting programs under Public Law 83-566, known as the Watershed Protection and Flood Prevention Act. (Added 1971, No. 167 (Adj. Sess.), § 3.)

1104. Repealed. 1989, No. 98, § 4(b)

§ 1105. Inspection of dams

The state agency having jurisdiction shall employ an engineer to make periodic inspections of nonfederal dams in the state to determine their condition and the extent, if any, to which they pose a potential or actual threat to life and property, or shall promulgate rules pursuant to chapter 25 of Title 3 to require an adequate level of inspection by an independent registered engineer experienced in the design and investigation of dams. The agency shall provide the owner with the findings of the inspection and any recommendations. (Added 1981, No. 242 (Adj. Sess.), § 13; amended 1985, No. 60.)

§ 1106. Unsafe dam revolving loan fund

(a) There is hereby established a special fund to be known as the Vermont unsafe dam revolving loan fund which shall be used to provide grants and loans to municipalities, nonprofit entities, and private individuals, pursuant to rules proposed by the agency of natural resources and enacted by the general assembly, for the reconstruction, repair, removal, breaching, draining, or other action necessary to reduce the threat of a dam or portion of a dam determined to be unsafe pursuant to section 1095 of this chapter.

(b) The fund created by this section shall be established and held separate and apart from any other funds or moneys of state and shall be used and administered exclusively for the purposes set forth in this section. The funds shall be invested in the same manner as permitted for investment of funds belonging to the state or held in the treasury. The fund shall consist of the following:

(1) Such sums as may be appropriated or transferred thereto from time to time by the general assembly, the emergency board, or the joint fiscal committee during such times as the general assembly is not in session.

(2) Principal and interest received from the repayment of loans made from the fund.

(3) Capitalization grants and awards made to the state by the United States of America for the purposes for which the fund has been established.

(4) Interest earned from the investment of fund balances.

(5) Private gifts, bequests, and donations made to the state for the purposes for which the fund has been established.

(6) Other funds from any public or private source intended for use for any of the purposes for which the fund has been established.

(c) The secretary may bring an action under this subsection or other available state and federal laws against the owner of the dam to seek reimbursement to the fund for all loans made from the fund pursuant to this section. (Added 2003, No. 121 (Adj. Sess.), § 66, eff. June 8, 2004.)

E.46. Virginia



VIRGINIA SOIL AND WATER CONSERVATION BOARD GUIDANCE DOCUMENT ON DAM BREAK INUNDATION ZONE AND INCREMENTAL DAMAGE ANALYSIS AND MAPPING PROCEDURES

(Approved XXXXX, 2010)
Working Draft Version January 14, 2010

Summary:
This guidance document specifies the procedures to be utilized by the Virginia Soil and Water Conservation Board in determining the adequacy of a dam break inundation zone analysis and map prepared in accordance with 4VAC50-20-54 and the adequacy of an incremental damage analysis conducted in accordance with 4VAC50-20-52.

Electronic Copy:
An electronic copy of this guidance in PDF format is available on the Regulatory TownHall under the Virginia Soil and Water Conservation Board at http://townhall.virginia.gov/L/GDocs.cfm.

Contact Information:
Please contact the Department of Conservation and Recreation's Division of Dam Safety and Floodplain Management at dam@dcr.virgina.gov or by calling 804-371-6095 with any questions regarding the application of this guidance.

Disclaimer:
This document is provided as guidance and, as such, sets forth standard operating procedures for the Virginia Soil and Water Conservation Board and the Department of Conservation and Recreation that administers the program on behalf of the Board. This guidance provides a general interpretation of the applicable Code and Regulations but is not meant to be exhaustive in nature. Each situation may differ and may require additional interpretation of the Dam Safety Act and attendant regulations.

Dam Break Inundation Zone and Incremental Damage Analysis and Mapping Procedures

I. Background:
The Impounding Structure Regulations require an owner of a regulated dam to conduct a dam break analysis to support the appropriate hazard classification of the impounding structure in accordance with 4VAC50-20-40 (Hazard Potential Classification of Impounding Structures). Additionally, in accordance with Section 4VAC50-20-54 of the Impounding Structure Regulations, a dam break inundation zone map shall be developed that meets the requirements of the Dam Safety Act and the Impounding Structure Regulations for regulated dams with a High, Significant or Low Hazard Potential. The spillway design flood requirement of dams may also be reduced if it can be demonstrated through an incremental damage analysis in accordance with

4VAC50-20-52 that such a determination will not reduce the protection of public safety that would be afforded by using the spillway design flood that would otherwise by specified by Table 1. This guidance outlines the procedures that dam owners and their engineers should utilize to conduct dam break and incremental damage assessment analyses as well as to produce the associated maps.

II. Definitions (pursuant to § 10.1-604 and 4VAC50-20-30):
"Dam break inundation zone" means the area downstream of a dam that would be inundated or otherwise directly affected by the failure of a dam.

III. Authority:
The Dam Safety Act in the Code of Virginia contains the following authorities applicable to this guidance:

> **§ 10.1-605. Promulgation of regulations by the Board.**
> The Board shall promulgate regulations to ensure that impounding structures in the Commonwealth are properly and safely constructed, maintained and operated.

The Impounding Structure Regulations contain the following authorities applicable to this guidance:

> **4VAC50-20-54. Dam break inundation zone mapping.**
> A. Dam break inundation zone maps shall be provided to the department to meet the requirements set out in Hazard Potential Classifications of Impounding Structures (4VAC50-20-40), Emergency Action Plan for High and Significant Potential Hazard Impounding Structures (4VAC50-20-175), and Emergency Preparedness for Low Hazard Potential Impounding Structures (4VAC50-20-177), as applicable.
> B. The location of the end of the inundation mapping should be indicated where the water surface elevation of the dam break inundation zone and the water surface elevation of the spillway design flood during an impounding structure nonfailure event converge to within one foot of each other. The inundation maps shall be supplemented with water surface profiles showing the peak water surface elevation prior to failure and the peak water surface elevation after failure.
> C. All inundation zone map(s), except those utilized in meeting the requirements of Emergency Preparedness for Low Hazard Potential Impounding Structures (4VAC50-20-177), shall be signed and sealed by a licensed professional engineer.
> D. For determining the hazard potential classification, a minimum of the following shall be provided to the department:
> 1. A sunny day dam break analysis utilizing the volume retained at the normal or typical water surface elevation of the impounding structure;
> 2. A dam break analysis utilizing the spillway design flood with a dam failure;
> 3. An analysis utilizing the spillway design flood without a dam failure; and
> 4. For the purposes of future growth planning, a dam break analysis utilizing the probable maximum flood with a dam failure.
> E. To meet the requirements of Emergency Preparedness set out in 4VAC50-20-177, all Low Hazard Potential impounding structures shall provide a simple map, acceptable to the department, demonstrating the general inundation that would result

from a dam failure. Such maps do not require preparation by a professional licensed engineer, however, it is preferred that the maps be prepared by a licensed professional engineer.

F. To meet the Emergency Action Plan requirements set out in 4VAC50-20-175, all owners of High and Significant Hazard Potential impounding structures shall provide dam break inundation map(s) representing the impacts that would occur with both a sunny day dam failure and a spillway design flood dam failure.

1. The map(s) shall be developed at a scale sufficient to graphically display downstream inhabited areas and structures, roads, public utilities that may be affected, and other pertinent structures within the identified inundation area. In coordination with the local organization for emergency management, a list of downstream inundation zone property owners and occupants, including telephone numbers may be plotted on the map or may be provided with the map for reference during an emergency.

2. Each map shall include the following statement: "The information contained in this map is prepared for use in notification of downstream property owners by emergency management personnel."

4VAC50-20-40. Hazard potential classifications of impounding structures.

A. Impounding structures shall be classified in one of three hazard classifications as defined in subsection B of this section and Table 1.

B. For the purpose of this chapter, hazards pertain to potential loss of human life or damage to the property of others downstream from the impounding structure in event of failure or faulty operation of the impounding structure or appurtenant facilities. Hazard potential classifications of impounding structures are as follows:

1. High Hazard Potential is defined where an impounding structure failure will cause probable loss of life or serious economic damage. "Probable loss of life" means that impacts will occur that are likely to cause a loss of human life, including but not limited to impacts to residences, businesses, other occupied structures, or major roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, major roadways, railroads, personal property, and agricultural interests. "Major roadways" include, but are not limited to, interstates, primary highways, high-volume urban streets, or other high-volume roadways.

2. Significant Hazard Potential is defined where an impounding structure failure may cause the loss of life or appreciable economic damage. "May cause loss of life" means that impacts will occur that could cause a loss of human life, including but not limited to impacts to facilities that are frequently utilized by humans other than residences, businesses, or other occupied structures, or to secondary roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, secondary roadways, railroads, personal property, and agricultural interests. "Secondary roadways" include, but are not limited to, secondary highways, low-volume urban streets, service roads, or other low-volume roadways.

3. Low Hazard Potential is defined where an impounding structure failure would result in no expected loss of life and would cause no more than minimal economic damage. "No expected loss of life" means no loss of human life is anticipated.

C. The hazard potential classification shall be proposed by the owner and shall be subject to approval by the board. To support the appropriate hazard classification, dam break analysis shall be conducted by the owner's engineer. Present and planned land-use for which a development plan has been officially approved by the locality in the dam break inundation zones downstream from the impounding structure shall be considered in determining the classification.

D. Impounding structures shall be subject to reclassification by the board as necessary.

4VAC50-20-52. Incremental damage analysis.

A. When appropriate, the spillway design flood requirement may be reduced by the board in accordance with this section.

B. The owner's engineer may proceed with an incremental damage an alysis. Once the owner's engineer has determined the required spillway design flood through application of Table 1, further analysis may be performed to evaluate the limiting flood condition for incremental damages Site-specific conditions should be recognized and considered. This analysis may be used to lower the spillway design flood. In no situation shall the allowable reduced level be less than the level at which the incremental increase in water surface elevation downstream due to failure of an impounding structure is no longer considered to present an additional downstream threat. This engineering analysis will need to present water surface elevations at each structure that may be impacted downstream of the dam. An additional downstream threat to persons or property is presumed to exist when water depths exceed two feet or when the product of water depth (in feet) and flow velocity (in feet per second) is greater than seven.

C. The spillway design flood shall not be reduced below the minimum threshold values as determined by Table 1.

D. The required spillway design flood shall be subject to reclassification by the board as necessary to reflect changed conditions at the impounding structure and in the dam break inundation zone.

IV. Discussion and Interpretation:

Dam Break Analysis and Inundation Zone Mapping

The Impounding Structure Regulations require an owner of a regulated dam to conduct a dam break analysis to support the appropriate hazard classification of the impounding structure in accordance with 4VAC50-20-40 (Hazard Potential Classification of Impounding Structures). Additionally, in accordance with Section 4VAC50-20-54 of the Impounding Structure Regulations, a dam break inundation zone map shall be developed that meets the requirements of the Dam Safety Act and the Impounding Structure Regulations for regulated dams with a High, Significant or Low Hazard Potential. This section requires that dam break inundation zone maps shall be provided to the department to meet the requirements set out in Hazard Potential Classifications of Impounding Structures (4VAC50-20-40), Emergency Action Plan for High and Significant Potential Hazard Impounding Structures (4VAC50-20-175), and Emergency Preparedness for Low Hazard Potential Impounding Structures (4VAC50-20-177), as applicable. All dam break inundation zone maps shall be signed and sealed by a professional engineer licensed in the Commonwealth of Virginia (unless solely developed to satisfy the requirements

of 4VAC50-20-177 which allows the owner to develop a simple dam break inundation map acceptable to the director, demonstrating the general inundation that would result from an impounding structure failure. Such maps required pursuant to this section do not require preparation by a professional licensed engineer; however, maps prepared by a licensed professional engineer are preferred and are additionally required to satisfy §§ 4VAC50-20-40 and 4VAC50-20-54.)

A dam break analysis using an approved hydrologic/hydraulic computer model shall be conducted by the dam owner's professional engineer. The modeling effort must conform to the intended use of the chosen computer model. Mixing the criteria of one procedure, listed in 4VAC50-20-320 (Acceptable design procedures and references) with criteria from another procedure, unless otherwise mentioned, is prohibited. Compute modeling must generate appropriate inflow hydrographs which are routed through the dam and downstream of the dam. Some computer models that are acceptable include HEC-1, HEC-HMS, HEC-RAS and the NRCS computer models TR-60 with TR-66. Other computer models may be used if approved by the DCR Regional Engineer prior to submitting the results to the Division of Dam Safety and Floodplain Management. Present and planned land-use for which a development plan has been officially approved by the locality in the dam break inundation zones downstream from the impounding structure shall be considered when conducting the dam break analysis.

For the validation of the hazard potential of a dam and the development of an Emergency Action Plan, at a minimum, the following shall be reflected on each map using an approved hydrologic/hydraulic computer model and shown on one map (numerous sheets are allowed to accommodate scale):

1. Sunny day dam break with the starting water surface elevation at the normal or typical water surface elevation of the impounding structure. If the impounding structure was designed and built for flood control, the starting water surface elevation shall be at the crest of the auxiliary or emergency spillway.
2. Dam failure during the required spillway design flood. An overtopping failure shall be modeled if the emergency spillway is unable to pass the spillway design flood without overtopping the crest of the dam. A piping failure shall be modeled if the emergency spillway has enough capacity to pass the required spillway design flood without overtopping the crest of the dam.
3. Routing the spillway design flood through the dam without any failure.
4. Dam failure during the Probable Maximum Flood.

Topographic information, including TINS, that show at a minimum ten-foot contour elevations shall be used to develop the hydrologic/hydraulic computer model downstream of the dam, including cross sections at potential damage locations (homes, businesses, roads, utilities, etc.) downstream of the dam. The dam owner's engineer must develop reliable cross sections to input into the computer model. If adequate topographic information is not available, the dam owner must provide an alternative method for identifying potential damage locations that must be approved by the DCR Regional Engineer, prior to initiating the evaluation. Topography may be a component of the submitted inundation map; however, map clutter must be avoided. If the topography is not submitted on the inundation map, a copy of the topographical information or

TINS used shall be submitted with the engineering analysis. Paper copies of all hydrologic and hydraulic computer model runs shall be provided to the Regional Engineer.

The owner's engineer shall use sanctioned engineering criteria and sound professional judgment for the worst case storm conditions in the selection of:

a. Dam failure parameters
b. Rainfall distributions
c. Flood routing procedures and coefficients
d. Use of available topography and supporting field surveys
e. Development of SCS Curve Numbers
f. Development of spillway rating curves and area-capacity curves
g. Determination of the Time of Concentration and/or lag time
h. Other steps used during the modeling and analysis of flood conditions in the watershed and downstream of the impounding structure.

The judgments and the engineering criteria used by the dam owner's engineer shall be reviewed and approved by the DCR Regional Engineer for appropriateness. The DCR Regional Engineer will provide specific guidance via written correspondence to the dam owner should the judgments or the use of the engineering criteria be determined to be inappropriate. If the map is acceptable, a statement of confirmation that the map appears to be in conformance with the regulations will also be provided to the owner.

The computer model shall be extended to a point downstream of the impounding structure where the water surface elevations of the spillway design flood with and without dam failure converge to within one foot of each other or to the last impacted structure caused by a sunny-day dam failure, whichever is farthest downstream.

The following shall be clearly marked at each potential damage location on each map:

a. Cross Section number and distance downstream from the dam to the nearest tenth of a mile
b. Relative time of travel, in minutes, of the first flood waters associated with a dam failure to reach the impact location
c. Relative time of travel, in minutes, of the peak flood level associated with a dam failure to reach the impact location
d. Maximum depth of water with a dam failure at each impact location in feet (depth of water on the structure)

The map lines delineating the inundation areas shall be drawn in such thickness (solid, dashed or dotted lines in black) to identify the inundation limits as the main feature of the map. The lines shall not obliterate the location of structures, or features which are shown as being inundated. The map shall also identify the scale and show the north arrow on each map sheet.

Inundation maps may have color in the background and shall be at a scale where impacted structures downstream may be clearly seen. The maps should not utilize color-coding of the inundation lines since the maps will often be copied on black and white reproduction equipment. If the inundation area is too large to be shown on one map, an index map shall be included which

shows the full extent of the inundation area and the outline of the detailed maps with an identifier for each map sheet. Impacted structures (homes, businesses, roads, utilities, etc) shall be clearly shown and if cross-hatching is used it must not obscure the structures. The physical addresses and contact persons may be located on a separate attachment to avoid clutter. This information will be used to aid emergency responders in quickly locating impacted structures and conducting evacuations. Inundation maps shall not be produced in a size larger than 11'' by 17" and the final size must be folded to a size of 8 1/2" by 11". The inundation maps shall be submitted to the DCR Regional Engineer electronically in a Windows compatible image format and as a set of paper maps. Acceptable digital image formats consist of JPEG, TIF, BMP, GIF, PNG, or EMF files. Adobe software constructed PDFs are also acceptable. Image resolution should be sufficient to view and read the necessary information noted above.

A narrative describing the accuracy and limitation of the information supplied on the inundation maps, including reference to the datum used, shall be provided to the DCR Regional Engineer. Since local officials are likely to use the maps for evacuation purposes, the following note shall be attached to each map: "Mapping of flooded areas and flood wave travel times are approximate. Timing and extent of actual inundation may differ from the information presented on this map."

The hazard potential classification shall be proposed by the dam owner and shall be subject to reclassification by the Virginia Soil and Water Conservation Board, upon review of the information submitted by the dam owner and the owner's engineer and any pertinent information regarding potential impacts downstream of the dam caused by a failure of the dam.

Incremental Damage Assessment

Once a dam owner has had the consulting engineer complete the Dam Break Inundation Zone Analysis and Map (Map) and concluded a determination of the hazard classification and, once the hazard classification has been reviewed and accepted by the appropriate Regional Engineer; the Spillway Design Flood (SDF) would then be identified in Table 1 of the Impounding Structure Regulations (4VAC50-20-50). Should the dam owner wish to consider lowering the SDF through an Incremental Damage Analysis (IDA), the consulting engineer must then perform the following procedures. However, as noted in Table 1 of the Impounding Structure Regulations an SDF less than the Minimum Threshold will not be accepted.

1. Identify the Required SDF
Once the hazard classification is determined, Table 1 will identify the required SDF. If the dam owner decides to have the consulting engineer perform an incremental damage analysis, the computer models previously used to determine the inundation and subsequent hazard classification must be used to identify the flood event at which no significant increase in damage will occur due to a dam failure. This process may start with the required SDF or with the Minimum Threshold for IDA (Minimum Threshold), see Table 1.

2. Have Models Showing all Requirements with Backup Calculations
The consulting engineer must have at a minimum, hydrologic computer models for the Sunny-Day Dam Failure, Spillway Design Flood With a Dam Failure, Spillway Design Flood Without a

Dam Failure and the Probable Maximum Flood With a Dam Failure. These models must be routed downstream of the dam to a point in which the maximum water surface elevations during the SDF with a Dam Failure and the SDF without a Dam Failure converge to within one foot of each other or to the last impacted structure cause by a sunny-day dam failure, whichever is farthest downstream.

3. Prepare the Map
The results of the models are plotted onto the Map to demonstrate inundation expected by each event. All homes, buildings, roads and other impacted facilities shall be shown on the map.

4. Use IDA to Determine if the SDF can be Reduced
If it can be shown that the aforementioned list of potentially impacted facilities would, at some lesser flood compared to the SDF, be severely damaged due to floods associated storm flows without a dam failure then the owner can have the consulting engineer adjust the input storm in the computer models in an attempt to identify at what storm event that a dam failure would not significantly add to damaged facilities or threats to life downstream.

When structures, such as homes, businesses, and utilities buildings are identified in the inundation zone, the consulting engineer can determine significant impact to that structure if, during a dam failure, the water depth will equal or exceed two feet above the ground/building connection. If the product of the depth of water on a structure in feet and the velocity of water flowing at that location in feet per second equals seven (7) or more, then the structure is considered significantly impacted and projects the probable loss of life. If the depth of water is less than two feet on the structure and the product of the total water depth and the velocity of water at the structure is less than seven (7) during any dam failure, the structure would not be considered threatened nor would result in probable loss of life.

5. Determination of the Adjusted SDF
An IDA should always result in the same answer no matter whether you start at the SDF or at the Minimum Threshold working toward the Adjusted SDF. The Adjusted SDF should represent the maximum flood at which the dam will provide maximum flood protection downstream and no further damages would be expected with larger flood events with a dam failure.

The dam owner may choose to have the engineer design the emergency spillway to the Adjusted SDF or some flood event larger than the adjusted SDF that would consider potential increases in hazard classification due to future development downstream of the dam.

The dam owner's consulting engineer will need to provide one set of paper copies of the computer model results and an electronic copy on diskette. Profiles, calculations and other supporting information used to determine an adjusted SDF shall be submitted to the Dam Safety Regional Engineer for review and acceptance.

Dam Safety's acceptance of an adjusted SDF does not guarantee that any future development will not place new increased spillway capacity requirements on the dam owner.

For a Secondary roadway (secondary highway, low-volume urban street, service road and other low-volume roadway) located below a dam the hazard classification may be significant requiring a SDF of ½ PMF (see roadways guidance for additional information on how roadways may impact hazard classification). If the dam owner desires, an IDA may be performed that would identify at what flood event (between the ½ PMF and the 100-Year Flood) the computed water surface elevation for the flood event without a dam failure would result in a water level at or just below the roadway surface edge without a dam failure. With this storm event, if a dam failure would overtop the roadway by four (4) inches or more, it could lead to possible loss of life of persons in vehicles on the roadway or loss of the roadway itself. If the dam failure does not overtop the roadway for the Sunny-Day Failure and storm events up to the PMF with a dam failure, then the dam should be classified as Low Hazard, if there are no other impacted structures or facilities, should the dam fail. If the roadway is a major roadway (interstate, primary highway, high-volume urban street or other high-volume roadway) then the incremental damage analysis would start at PMF and could result in a SDF no less than the ½ PMF.

If there are several roadways below a dam, then the roadway that results in the largest spillway design flood applies.

If a secondary or low volume roadway crosses the dam then the SDF would usually be at a minimum the ½ PMF (see roadways guidance for additional information on how roadways may impact hazard classification) and no IDA would be permitted for a dam with a significant hazard classification. If a major roadway crosses the dam then the SDF would be the PMF and no IDA would be permitted.

In cases where there are other facilities below the dam along with roadways, the impact that creates the highest hazard classification shall dictate. If permitted, the owner may choose to have the consulting engineer perform an IDA in the hopes of lowering the SDF.

V Adoption, Amendments, and Repeal:

This document was adopted by the Board on XXXX, 2010 and may be amended or repealed as necessary by the Board.

VIRGINIA ACTS OF ASSEMBLY -- 2010 SESSION

CHAPTER 249

An Act to amend and reenact § 10.1-605 of the Code of Virginia, relating to dam safety.

[S 276]

Approved April 8, 2010

Be it enacted by the General Assembly of Virginia:

1. That § 10.1-605 of the Code of Virginia is amended and reenacted as follows:

§ 10.1-605. Promulgation of regulations by the Board.

A. The Board shall promulgate regulations to ensure that impounding structures in the Commonwealth are properly and safely constructed, maintained and operated. Dam safety regulations promulgated by the State Water Control Board shall remain in full force until amended in accordance with applicable procedures.

B. The Board's Impounding Structure Regulations shall not require any impounding structure in existence or under a construction permit prior to July 1, 2010, that is currently classified as high hazard, or is subsequently found to be high hazard through reclassification, to upgrade its spillway to pass a rainfall event greater than the maximum recorded within the Commonwealth, which shall be deemed to be 90 percent of the probable maximum precipitation.

Additionally, such an impounding structure shall be determined to be in compliance with the spillway requirements of the regulations provided that (i) the impounding structure will pass two-thirds of the reduced probable maximum precipitation requirement described in this subsection and (ii) the dam owner certifies annually that such impounding structure meets each of the following conditions:

1. The owner has a current emergency action plan that is approved by the Board and that is developed and updated in accordance with the regulations;

2. The owner has exercised the emergency action plan in accordance with the regulations and conducts a table-top exercise at least once every two years;

3. The Department has verification that both the local organization for emergency management and the Virginia Department of Emergency Management have on file current emergency action plans and updates for the impounding structure;

4. That conditions at the impounding structure are monitored on a daily basis and as dictated by the emergency action plan;

5. The impounding structure is inspected at least annually by a professional engineer and all observed deficiencies are addressed within 120 days of such inspection;

6. The owner has a dam break inundation zone map developed in accordance with the regulations that is acceptable to the Department;

7. The owner is insured in an amount that will substantially cover the costs of downstream property losses to others that may result from a dam failure; and

8. The owner shall post the dam's emergency action plan on his website, or upon the request of the owner, the Department or another state agency responsible for providing emergency management services to citizens agrees to post the plan on its website. If the Department or another state agency agrees to post the plan on its website, the owner shall provide the plan in a format suitable for posting.

A dam owner who meets the conditions of subdivisions 1 through 8, but has not provided record drawings to the Department for his impounding structure, shall submit a complete record report developed in accordance with the construction permit requirements of the Impounding Structure Regulations, excluding the required submittal of the record drawings.

2. That the Virginia Soil and Water Conservation Board may amend its Impounding Structure Regulations to conform with the provisions of this act through a regulatory process that is exempt from the requirements of the Administrative Process Act (§ 2.2-4000 et seq.) of the Code of Virginia.

3. That an emergency exists and this act is in force from its passage.

VIRGINIA ACTS OF ASSEMBLY -- 2010 SESSION

CHAPTER 270

An Act to amend and reenact §§ 10.1-605, 10.1-607.1, and 10.1-609 of the Code of Virginia, relating to dam safety.

[H 438]

Approved April 8, 2010

Be it enacted by the General Assembly of Virginia:

1. That §§ 10.1-605, 10.1-607.1, and 10.1-609 of the Code of Virginia are amended and reenacted as follows:

§ 10.1-605. Promulgation of regulations by the Board; guidance document.

A. The Board shall ~~promulgate~~ *adopt* regulations to ensure that impounding structures in the Commonwealth are properly and safely constructed, maintained and operated. Dam safety regulations promulgated by the State Water Control Board shall remain in full force until amended in accordance with applicable procedures.

B. The Board's regulations shall establish an incremental damage analysis procedure that permits the spillway design flood requirement for an impounding structure to be reduced to the level at which dam failure shall not significantly increase downstream hazard to life or property, provided that the spillway design flood requirement shall not be reduced to below the 100-year flood event for high or significant hazard impounding structures, or to below the 50-year flood event for low hazard potential impounding structures.

C. The Board shall consider the impact of limited-use or private roadways with low traffic volume and low public safety risk that are downstream from or across an impounding structure in the determination of the hazard potential classification of an impounding structure.

§ 10.1-607.1. Criteria for designating a dam as unsafe.

A. Designation of a dam as unsafe shall be based on one or more of the following findings:

1. The dam has serious deficiencies in its design or construction or has a physical condition that if left unaddressed could result in a failure that may result in loss of life or *significant* damage to downstream property.

2. The design, construction, operation, or maintenance of the dam is such that its expected performance during flooding conditions threatens the structural integrity of the dam.

B. After completion of the safety inspections pursuant to § 10.1-607, or as otherwise informed of an unsafe condition, the Department shall take actions in accordance with § 10.1-608 or 10.1-609 depending on the degree of hazard and imminence of failure caused by the unsafe condition.

§ 10.1-609. Unsafe dams presenting nonimminent danger.

A. Within a reasonable time after completion of a safety inspection of an impounding structure authorized by § 10.1-607, the Board shall issue a report to the owner of the impounding structure containing its findings and recommendations for correction of any deficiencies which could threaten life or property if not corrected. Owners who have been issued a report containing recommendations for correction of deficiencies shall undertake to implement the recommendations contained in the report according to the schedule of implementation contained in the report. If an owner fails or refuses to commence or diligently implement the recommendations for correction of deficiencies according to the schedule contained in an issued report, the Director shall have the authority to issue an administrative order directing the owner to commence implementation and completion of such recommendations according to the schedule contained in the report with modifications as appropriate. Within thirty days after being served by personal service or by mail with a copy of an order issued pursuant to this section, any owner shall have the right to petition the Board for a hearing. *As part of his petition, a dam owner may submit to the Board his own plan, consistent with regulations adopted pursuant to § 10.1-605, to address the recommendations for correction of deficiencies and the schedule of implementation contained in the report. The Board shall determine if the submitted plan and schedule are sufficient to address deficiencies.* A timely filed petition shall stay the effect of the administrative order.

The hearing shall be conducted before the Board or a designated member thereof pursuant to § 2.2-4019. The Board shall have the authority to affirm, modify, amend or cancel the administrative order. Any owner aggrieved by a decision of the Board after a hearing shall have the right to judicial review of the final Board decision pursuant to the provisions of the Administrative Process Act (§ 2.2-4000 et seq.).

B. The provisions of subsection A of this section notwithstanding, if the Director determines, after the report is issued, that changed circumstances justify reclassifying the deficiencies of an impounding structure as an imminent danger to life or property, the Director may proceed directly under § 10.1-613 for enforcement of his order, and the owner shall have the opportunity to contest the fact based upon

which the administrative order was issued.

C. The Director, upon a determination that there is an unsafe condition at an impounding structure, is authorized to cause the lowering or complete draining of such impoundment until the unsafe condition has been corrected at the owner's expense and prior to any authorization to refill.

An owner who fails to comply with the provisions contained in an administrative order of the Department shall be subject to procedures set out in § 10.1-613 and the penalties authorized under §§ 10.1-613.1 and 10.1-613.2.

D. No persons, other than those authorized to maintain an impounding structure, shall interfere with the operation of an impounding structure.

Virginia Administrative Code

Database updated through November 15, 2010

Part I

General

4VAC50-20-10. Authority.

This chapter is promulgated by the Virginia Soil and Water Conservation Board in accordance with the provisions of the Dam Safety Act, Article 2, Chapter 6, Title 10.1 (§ 10.1-604 et seq.), of the Code of Virginia.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 1.1, eff. February 1, 1989.

4VAC50-20-20. General provisions.

A. This chapter provides for the proper and safe design, construction, operation and maintenance of impounding structures to protect public safety. This chapter shall not be construed or interpreted to relieve the owner or operator of any impoundment or impounding structure of any legal duties, obligations or liabilities incident to ownership, design, construction, operation or maintenance.

B. Approval by the board of proposals for an impounding structure shall in no manner be construed or interpreted as approval to capture or store waters. For information concerning approval to capture or store waters, see Chapter 8 (§ 62.1-107) of Title 62.1 of the Code of Virginia, and other provisions of law as may be applicable.

C. In promulgating this chapter, the board recognizes that no impounding structure can ever be completely "fail-safe," because of incomplete understanding of or uncertainties associated with natural (earthquakes and floods) and manmade (sabotage) destructive forces; with material behavior and response to those forces; and with quality control during construction.

D. All engineering analyses required by this chapter, including but not limited to, plans, specifications, hydrology, hydraulics and inspections shall be conducted or overseen by and bear the seal of a professional engineer licensed to practice in Virginia.

E. Design, inspection and maintenance of impounding structures shall be conducted utilizing

competent, experienced, engineering judgment that takes into consideration factors including but not limited to local topography and meteorological conditions.

F. The forms noted in this chapter are available from the department at the department's website.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 1.2, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-30. Definitions.

The following words and terms when used in this chapter shall have the following meanings unless the context clearly indicates otherwise:

"Acre-foot" means a unit of volume equal to 43,560 cubic feet or 325,853 gallons (equivalent to one foot of depth over one acre of area).

"Agricultural purpose" means the production of an agricultural commodity as defined in § 3.1-249.27 of the Code of Virginia that requires the use of impounded waters.

"Agricultural purpose dams" means impounding structures which are less than 25 feet in height or which create a maximum impoundment smaller than 100 acre-feet, and operated primarily for agricultural purposes.

"Alteration" means changes to an impounding structure that could alter or affect its structural integrity. Alterations include, but are not limited to, changing the height or otherwise enlarging the dam, increasing normal pool or principal spillway elevation or physical dimensions, changing the elevation or physical dimensions of the emergency spillway, conducting necessary structural repairs or structural maintenance, or removing the impounding structure. Structural maintenance does not include routine maintenance.

"Alteration permit" means a permit required for any alteration to an impounding structure.

"Board" means the Virginia Soil and Water Conservation Board.

"Conditional Operation and Maintenance Certificate" means a certificate required for impounding structures with deficiencies.

"Construction" means the construction of a new impounding structure.

"Construction permit" means a permit required for the construction of a new impounding structure.

"Dam break inundation zone" means the area downstream of a dam that would be inundated or otherwise directly affected by the failure of a dam.

"Department" means the Virginia Department of Conservation and Recreation.

"Design flood" means the calculated volume of runoff and the resulting peak discharge utilized in the evaluation, design, construction, operation and maintenance of the impounding structure.

"Director" means the Director of the Department of Conservation and Recreation or his designee.

"Drill" means a type of emergency action plan exercise that tests, develops, or maintains skills in an emergency response procedure. During a drill, participants perform an in-house exercise to verify telephone numbers and other means of communication along with the owner's response. A drill is considered a necessary part of ongoing training.

"Emergency Action Plan or EAP" means a formal document that recognizes potential impounding structure emergency conditions and specifies preplanned actions to be followed to minimize loss of life and property damage. The EAP specifies actions the owner must take to minimize or alleviate emergency conditions at the impounding structure. It contains procedures and information to assist the owner in issuing early warning and notification messages to responsible emergency management authorities. It shall also contain dam break inundation zone maps as required to show emergency management authorities the critical areas for action in case of emergency.

"Emergency Action Plan Exercise" means an activity designed to promote emergency preparedness; test or evaluate EAPs, procedures, or facilities; train personnel in emergency management duties; and demonstrate operational capability. In response to a simulated event, exercises should consist of the performance of duties, tasks, or operations very similar to the way they would be performed in a real emergency. An exercise may include but not be limited to drills and tabletop exercises.

"Emergency Preparedness Plan" means a formal document prepared for Low Hazard impounding structures that provides maps and procedures for notifying owners of downstream property that may be impacted by an emergency situation at an impounding structure.

"Freeboard" means the vertical distance between the maximum water surface elevation associated with the spillway design flood and the top of the impounding structure.

"Height" means the hydraulic height of an impounding structure. If the impounding structure spans a stream or watercourse, height means the vertical distance from the natural bed of the stream or watercourse measured at the downstream toe of the impounding structure to the top of the impounding

structure. If the impounding structure does not span a stream or watercourse, height means the vertical distance from the lowest elevation of the downstream limit of the barrier to the top of the impounding structure.

"Impounding structure" or "dam" means a man-made structure, whether a dam across a watercourse or structure outside a watercourse, used or to be used to retain or store waters or other materials. The term includes: (i) all dams that are 25 feet or greater in height and that create an impoundment capacity of 15 acre-feet or greater, and (ii) all dams that are six feet or greater in height and that create an impoundment capacity of 50 acre-feet or greater. The term "impounding structure" shall not include: (a) dams licensed by the State Corporation Commission that are subject to a safety inspection program; (b) dams owned or licensed by the United States government; (c) dams operated primarily for agricultural purposes which are less than 25 feet in height or which create a maximum impoundment capacity smaller than 100 acre-feet; (d) water or silt retaining dams approved pursuant to § 45.1-222 or § 45.1-225.1 of the Code of Virginia; or (e) obstructions in a canal used to raise or lower water.

"Impoundment" means a body of water or other materials the storage of which is caused by any impounding structure.

"Life of the impounding structure" and "life of the project" mean that period of time for which the impounding structure is designed and planned to perform effectively, including the time required to remove the structure when it is no longer capable of functioning as planned and designed.

"Maximum impounding capacity" means the volume of water or other materials in acre-feet that is capable of being impounded at the top of the impounding structure.

"Normal or typical water surface elevation" means the water surface elevation at the crest of the lowest ungated outlet from the impoundment or the elevation of the normal pool of the impoundment if different than the water surface elevation at the crest of the lowest ungated outlet. For calculating sunny day failures for flood control impounding structures, stormwater detention impounding structures, and related facilities designed to hold back volumes of water for slow release, the normal or typical water surface elevation shall be measured at the crest of the auxiliary or emergency spillway.

"Operation and Maintenance Certificate" means a certificate required for the operation and maintenance of all impounding structures.

"Owner" means the owner of the land on which an impounding structure is situated, the holder of an easement permitting the construction of an impounding structure and any person or entity agreeing to

maintain an impounding structure. The term "owner" may include the Commonwealth or any of its political subdivisions, including but not limited to sanitation district commissions and authorities, any public or private institutions, corporations, associations, firms or companies organized or existing under the laws of this Commonwealth or any other state or country, as well as any person or group of persons acting individually or as a group.

"Planned land use" means land use that has been approved by a locality or included in a master land use plan by a locality, such as in a locality's comprehensive land use plan.

"Spillway" means a structure to provide for the controlled release of flows from the impounding structure into a downstream area.

"Stage I Condition" means a flood watch or heavy continuous rain or excessive flow of water from ice or snow melt.

"Stage II Condition" means a flood watch or emergency spillway activation or impounding structure overtopping where a failure may be possible.

"Stage III Condition" means an emergency spillway activation or impounding structure overtopping where imminent failure is probable.

"Sunny day dam failure" means the failure of an impounding structure with the initial water level at the normal reservoir level, usually at the lowest ungated principal spillway elevation or the typical operating water level.

"Tabletop Exercise" means a type of emergency action plan exercise that involves a meeting of the impounding structure owner and the state and local emergency management officials in a conference room environment. The format is usually informal with minimum stress involved. The exercise begins with the description of a simulated event and proceeds with discussions by the participants to evaluate the EAP and response procedures and to resolve concerns regarding coordination and responsibilities.

"Top of the impounding structure" means the lowest point of the nonoverflow section of the impounding structure.

"Watercourse" means a natural channel having a well-defined bed and banks and in which water normally flows.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 1.3, eff. February 1, 1989; amended, Virginia Register Volume 18, Issue 14, eff. July 1, 2002; Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-40. Hazard potential classifications of impounding structures.

A. Impounding structures shall be classified in one of three hazard classifications as defined in subsection B of this section and Table 1.

B. For the purpose of this chapter, hazards pertain to potential loss of human life or damage to the property of others downstream from the impounding structure in event of failure or faulty operation of the impounding structure or appurtenant facilities. Hazard potential classifications of impounding structures are as follows:

1. High Hazard Potential is defined where an impounding structure failure will cause probable loss of life or serious economic damage. "Probable loss of life" means that impacts will occur that are likely to cause a loss of human life, including but not limited to impacts to residences, businesses, other occupied structures, or major roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, major roadways, railroads, personal property, and agricultural interests. "Major roadways" include, but are not limited to, interstates, primary highways, high-volume urban streets, or other high-volume roadways.

2. Significant Hazard Potential is defined where an impounding structure failure may cause the loss of life or appreciable economic damage. "May cause loss of life" means that impacts will occur that could cause a loss of human life, including but not limited to impacts to facilities that are frequently utilized by humans other than residences, businesses, or other occupied structures, or to secondary roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, secondary roadways, railroads, personal property, and agricultural interests. "Secondary roadways" include, but are not limited to, secondary highways, low-volume urban streets, service roads, or other low-volume roadways.

3. Low Hazard Potential is defined where an impounding structure failure would result in no expected loss of life and would cause no more than minimal economic damage. "No expected loss of life" means no loss of human life is anticipated.

C. The hazard potential classification shall be proposed by the owner and shall be subject to approval by the board. To support the appropriate hazard classification, dam break analysis shall be conducted by the owner's engineer. Present and planned land-use for which a development plan has been officially

approved by the locality in the dam break inundation zones downstream from the impounding structure shall be considered in determining the classification.

D. Impounding structures shall be subject to reclassification by the board as necessary.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 1.4, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-50. Performance standards required for impounding structures.

A. In accordance with the definitions provided by § 10.1-604 of the Code of Virginia and 4VAC50-20-30, an impounding structure shall be regulated if the impounding structure is 25 feet or greater in height and creates a maximum impounding capacity of 15 acre-feet or greater, or the impounding structure is six feet or greater in height and creates a maximum impounding capacity of 50 acre-feet or greater and is not otherwise exempt from regulation by the Code of Virginia. Impounding structures exempted from this chapter are those that are:

1. Licensed by the State Corporation Commission that are subject to a safety inspection program;

2. Owned or licensed by the United States government;

3. Operated primarily for agricultural purposes that are less than 25 feet in height or that create a maximum impoundment capacity smaller than 100 acre-feet;

4. Water or silt-retaining dams approved pursuant to § 45.1-222 or 45.1-225.1 of the Code of Virginia; or

5. Obstructions in a canal used to raise or lower water.

Impounding structures of regulated size and not exempted shall be constructed, operated and maintained such that they perform in accordance with their design and purpose throughout the life of the project. For impounding structures, the spillway(s) capacity shall perform at a minimum to safely pass the appropriate spillway design flood as determined in Table 1. For the purposes of utilizing Table 1, Hazard Potential Classification shall be determined in accordance with 4VAC50-20-40.

TABLE 1

Impounding Structure Regulations

Applicable to all impounding structures that are 25 feet or greater in height and that create a maximum impounding capacity of 15 acre-feet or greater, and to all impounding structures that are six feet or greater in height and that create a maximum impounding capacity of 50 acre-feet or greater and is not otherwise exempt from regulation by the Code of Virginia.

Hazard Potential Class of Dam	Spillway Design Flood (SDF)[B]	Minimum Threshold for Incremental Damage Analysis
High	PMF[C]	.50 PMF
Significant	.50 PMF	100-YR[D]
Low	100-YR[D]	50-YR[E]

B. The spillway design flood (SDF) represents the largest flood that need be considered in the evaluation of the performance for a given project. The impounding structure shall perform so as to safely pass the appropriate SDF. Reductions in the established SDF may be evaluated through the use of incremental damage analysis pursuant to 4VAC50-20-52. The SDF established for an impounding structure shall not be less than those standards established elsewhere by state law or regulations, including but not limited to the Virginia Stormwater Management Program (VSMP) Permit Regulations (4VAC50-60). Due to potential for future development in the dam break inundation zone that would necessitate higher spillway design flood standards or other considerations, owners may find it advisable to consider a higher spillway design flood standard than is required.

C. PMF: Probable Maximum Flood is the flood that might be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is derived from the current probable maximum precipitation (PMP) available from the National Weather Service, NOAA. In some cases, a modified PMF may be calculated utilizing local topography, meteorological conditions, hydrological conditions, or PMP values supplied by NOAA. Any deviation in the application of established developmental procedures must be explained and justified by the owner's engineer. The owner's engineer must develop PMF hydrographs for 6-, 12-, and 24-hour durations. The hydrograph that creates the largest peak outflow is to be used to determine capacity for nonfailure and failure analysis. Present and planned land-use conditions shall be considered in determining the runoff characteristics of the drainage area.

D. 100-Yr: 100-year flood represents the flood magnitude expected to be equaled or exceeded on the average of once in 100 years. It may also be expressed as an exceedence probability with a 1.0% chance of being equaled or exceeded in any given year. Present and planned land-use conditions shall be

considered in determining the runoff characteristics of the drainage area.

E. 50-Yr: 50-year flood represents the flood magnitude expected to be equaled or exceeded on the average of once in 50 years. It may also be expressed as an exceedence probability with a 2.0% chance of being equaled or exceeded in any given year. Present and planned land-use conditions shall be considered in determining the runoff characteristics of the drainage area.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 1.5, eff. February 1, 1989; amended, Virginia Register Volume 18, Issue 14, eff. July 1, 2002; Volume 24, Issue 25, eff. September 26, 2008; Errata, 25:3 VA.R. 542 October 13, 2008.

4VAC50-20-51. Special criteria for certain low hazard impounding structures.

A. Notwithstanding the requirements of this chapter, should the failure of a low hazard potential impounding structure cause no expected loss of human life and no economic damage to any property except property owned by the impounding structure owner, then the owner may follow the below requirements instead of the requirements specified in this chapter:

1. No map required pursuant to 4VAC50-20-54 shall be required to be developed for the impounding structure should a licensed professional engineer certify that the impounding structure is a low hazard potential impounding structure and eligible to utilize the provisions of this section;

2. The spillway design flood for the impounding structure is recommended as a minimum 50-year flood; however, no specific spillway design flood shall be mandatory for an impounding structure found to qualify under the requirements of this section;

3. No emergency preparedness plan prepared pursuant to 4VAC50-20-177 shall be required. However, the impounding structure owner shall notify the local emergency services coordinator in the event of a failure or emergency condition at the impounding structure;

4. An owner shall perform inspections of the impounding structure annually in accordance with the requirements of 4VAC50-20-105. No inspection of the impounding structure by a licensed professional engineer shall be required, however, so long as the owner certifies at the time of operation and maintenance certificate renewal that conditions at the impounding structure and downstream are unchanged since the last inspection conducted by a licensed professional

engineer; and

5. No certificate or permit fee established in this chapter shall be applicable to the impounding structure.

B. Any owner of an impounding structure electing to utilize the requirements of subsection A of this section shall otherwise comply with all other requirements of this chapter applicable to low hazard impounding structures.

C. The owner shall notify the department immediately of any change in circumstances that would cause the impounding structure to no longer qualify to utilize the provisions of this section.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-52. Incremental damage analysis.

A. When appropriate, the spillway design flood requirement may be reduced by the board in accordance with this section.

B. The owner's engineer may proceed with an incremental damage analysis. Once the owner's engineer has determined the required spillway design flood through application of Table 1, further analysis may be performed to evaluate the limiting flood condition for incremental damages Site-specific conditions should be recognized and considered. This analysis may be used to lower the spillway design flood. In no situation shall the allowable reduced level be less than the level at which the incremental increase in water surface elevation downstream due to failure of an impounding structure is no longer considered to present an additional downstream threat. This engineering analysis will need to present water surface elevations at each structure that may be impacted downstream of the dam. An additional downstream threat to persons or property is presumed to exist when water depths exceed two feet or when the product of water depth (in feet) and flow velocity (in feet per second) is greater than seven.

C. The spillway design flood shall not be reduced below the minimum threshold values as determined by Table 1.

D. The required spillway design flood shall be subject to reclassification by the board as necessary to reflect changed conditions at the impounding structure and in the dam break inundation zone.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-54. Dam break inundation zone mapping.

A. Dam break inundation zone maps shall be provided to the department to meet the requirements set out in Hazard Potential Classifications of Impounding Structures (4VAC50-20-40), Emergency Action Plan for High and Significant Potential Hazard Impounding Structures (4VAC50-20-175), and Emergency Preparedness for Low Hazard Potential Impounding Structures (4VAC50-20-177), as applicable.

B. The location of the end of the inundation mapping should be indicated where the water surface elevation of the dam break inundation zone and the water surface elevation of the spillway design flood during an impounding structure nonfailure event converge to within one foot of each other. The inundation maps shall be supplemented with water surface profiles showing the peak water surface elevation prior to failure and the peak water surface elevation after failure.

C. All inundation zone map(s), except those utilized in meeting the requirements of Emergency Preparedness for Low Hazard Potential Impounding Structures (4VAC50-20-177), shall be signed and sealed by a licensed professional engineer.

D. For determining the hazard potential classification, a minimum of the following shall be provided to the department:

1. A sunny day dam break analysis utilizing the volume retained at the normal or typical water surface elevation of the impounding structure;

2. A dam break analysis utilizing the spillway design flood with a dam failure;

3. An analysis utilizing the spillway design flood without a dam failure; and

4. For the purposes of future growth planning, a dam break analysis utilizing the probable maximum flood with a dam failure.

E. To meet the requirements of Emergency Preparedness set out in 4VAC50-20-177, all Low Hazard Potential impounding structures shall provide a simple map, acceptable to the department, demonstrating the general inundation that would result from a dam failure. Such maps do not require preparation by a professional licensed engineer, however, it is preferred that the maps be prepared by a licensed professional engineer.

F. To meet the Emergency Action Plan requirements set out in 4VAC50-20-175, all owners of High

and Significant Hazard Potential impounding structures shall provide dam break inundation map(s) representing the impacts that would occur with both a sunny day dam failure and a spillway design flood dam failure.

1. The map(s) shall be developed at a scale sufficient to graphically display downstream inhabited areas and structures, roads, public utilities that may be affected, and other pertinent structures within the identified inundation area. In coordination with the local organization for emergency management, a list of downstream inundation zone property owners and occupants, including telephone numbers may be plotted on the map or may be provided with the map for reference during an emergency.

2. Each map shall include the following statement: "The information contained in this map is prepared for use in notification of downstream property owners by emergency management personnel."

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-58. Local government notifications.

For each certificate issued, the impounding structure owner shall send a copy of the certificate to the appropriate local government(s) with planning and zoning responsibilities. A project description and the map(s) required under 4VAC50-20-54 showing the area that could be affected by the impounding structure failure shall be submitted with the certificate. The department will provide a standard form cover letter for forwarding the certificate copy and accompanying materials.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-59. Reporting.

For the purposes of categorizing and reporting information to national and other dam safety databases, impounding structure size shall be classified as noted in Table 2.

Table 2

Impounding Structure Regulations

Maximum Impounding Capacity (Ac-Ft)	Height (Ft)
Large ≥ 50,000	≥ 100
Medium ≥ 1,000 & < 50,000	≥ 40 & < 100
Small ≥ 15 & < 1,000	≥ 6 & < 40

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

Part II

Permit Requirements

4VAC50-20-60. Required permits.

A. No person or entity shall construct or begin to construct a new impounding structure until the board has issued a construction permit.

B. No person or entity shall alter or begin to alter an existing impounding structure until the board has issued an alteration permit. If an owner or the owner's engineer has determined that circumstances are impacting the integrity of the impounding structure that could result in the imminent failure of the impounding structure, temporary repairs may be initiated prior to approval from the board. The owner shall notify the department within 24 hours of identifying the circumstances impacting the integrity of the impounding structure. Such emergency notification shall not relieve the owner of the need to obtain an alteration permit as soon as may be practicable, nor shall the owner take action beyond that necessary to address the emergency situation.

C. When the owner submits an application to the board for any permit to construct or alter an impounding structure, the owner shall also inform the local government jurisdiction or jurisdictions that might be affected by the permit application.

D. In evaluating construction and alteration permit applications the director shall use the design criteria and standards referenced in 4VAC50-20-320.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 2.1, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25,

eff. September 26, 2008.

4VAC50-20-70. Construction permits.

A. Prior to preparing the complete design report for a Construction Permit, applicants may submit a preliminary design report to the department to determine if the project concept is acceptable to the department. The preliminary design report should contain, at a minimum, a general description of subdivisions 1 through 12 of subsection B of this section and subdivisions 1 and 2 of this subsection:

1. Proposed design criteria and a description of the size of the impounding structure, ground cover conditions, extent of current upstream development within the watershed and the hydraulic, hydrological and structural features, geologic conditions and the geotechnical engineering assumptions used to determine the foundation, impoundment rim stability and materials to be used.

2. Preliminary drawings of a general nature, including cross sections, plans and profiles of the impounding structure, proposed pool levels and types of spillway(s).

B. An applicant for a Construction Permit shall submit a design report. A form for the design report is available from the department (Design Report for the Construction or Alteration of Virginia Regulated Impounding Structures). The design report shall be prepared in accordance with 4VAC50-20-240. The design report is a required element of a complete application for a Construction Permit and shall include the following information:

1. Project information including a description of the proposed construction, name of the impounding structure, inventory number if available, name of the reservoir, and the purpose of the reservoir.

2. The proposed hazard potential classification in conformance with Table 1 of 4VAC50-20-50.

3. Location of the impounding structure including the city or county, number of feet or miles upstream or downstream of a highway and the highway number, name of the river or the stream, and the latitude and longitude.

4. Owner's name or representative if corporation, mailing address, residential and business telephone numbers, and other means of communication.

5. Owner's engineer's name, firm, professional engineer Virginia number, mailing address, and business telephone number.

6. Impounding structure data including type of material (earth, concrete, masonry or other) and the

following design configurations:

a. Top of impounding structure (elevation);

b. Downstream toe – lowest (elevation);

c. Height of impounding structure (feet);

d. Crest length – exclusive of spillway (feet);

e. Crest width (feet);

f. Upstream slope (horizontal to vertical); and

g. Downstream slope (horizontal to vertical).

7. Reservoir data including the following:

a. Maximum capacity (acre-feet);

b. Maximum pool (elevation);

c. Maximum pool surface area (acres);

d. Normal capacity (acre-feet);

e. Normal pool (elevation);

f. Normal pool surface area (acres); and

g. Freeboard (feet).

8. Spillway data including the type, construction material, design configuration, and invert elevation for the low level drain, the principal spillway, and the emergency spillway.

9. Watershed data including drainage area (square miles); type and extent of watershed development; time of concentration (hours); routing procedure; spillway design flood used and state source; design inflow hydrograph volume (acre-feet), peak inflow (cfs), and rainfall duration (hours); and freeboard during passage of the spillway design flood (feet).

10. A description of properties located in the dam break inundation zone downstream from the site of the proposed impounding structure, including the location and number of structures, buildings, roads, utilities and other property that would be endangered should the impounding structure fail.

11. Evidence that the local government or governments have been notified of the proposal by the owner to build an impounding structure.

12. Maps showing the location of the proposed impounding structure that include: the county or city in which the proposed impounding structure would be located, the location of roads and

access to the site, and the outline of the impoundment. Existing aerial photographs or existing topographic maps may be used for this purpose.

13. A report of the geotechnical investigations of the foundation soils, bedrock, or both and of the materials to be used to construct the impounding structure.

14. Design assumptions and analyses sufficient to indicate that the impounding structure will be stable during its construction and during the life of the impounding structure under all conditions of impoundment operations, including rapid filling, flood surcharge, seismic loadings, and rapid drawdown of the impoundment.

15. Evaluation of the stability of the impoundment rim area to safeguard against impoundment rim slides of such magnitude as to create waves capable of overtopping the impounding structure and evaluation of rim stability during seismic activity.

16. Design assumptions and analyses sufficient to indicate that seepage in, around, through or under the impounding structure, foundation and abutments will be reasonably and practically controlled so that internal or external forces or results thereof will not endanger the stability and integrity of the impounding structure. The design report shall also include information on graded filter design.

17. Calculations and assumptions relative to hydraulic and structural design of the spillway or spillways and energy dissipater or dissipaters. Spillway capacity shall conform to the criteria of Table 1 and 4VAC50-20-52.

18. Provisions to ensure that the impounding structure and appurtenances will be protected against unacceptable deterioration or erosion due to freezing and thawing, wind, wave action, and rain or any combination thereof.

19. Other pertinent design data, assumptions and analyses commensurate with the nature of the particular impounding structure and specific site conditions, including when required by this chapter, a plan and water surface profile of the dam break inundation zone.

20. A description of the techniques to be used to divert stream flow during construction so as to prevent hazard to life, health and property, including a detailed plan and procedures to maintain a stable impounding structure during storm events, a drawing showing temporary diversion devices, and a description of the potential impoundment during construction. Such diversion plans shall also be in accordance with applicable environmental laws.

21. A plan for project construction monitoring and quality control testing to confirm that construction materials and performance standards meet the design requirements set forth in the specifications.

22. Plans and specifications as required by 4VAC50-20-310.

23. Certification by the owner's engineer that the information provided pursuant to this subsection is true and correct in their professional judgment. Such certification shall include the engineer's signature, printed name, Virginia number, date, and the engineer's Virginia seal.

24. Owner's signature certifying receipt of the information provided pursuant to this subsection.

C. A plan of construction is a required element of a complete permit application for a Construction Permit and shall include:

1. A construction sequence with milestones.

2. Elements of the work plan that should be considered include, but are not limited to, foundation and abutment treatment, stream or river diversion, excavation and material fill processes, phased fill and compaction, testing and control procedures, construction of permanent spillway and drainage devices.

3. The erosion and sediment control plan, as approved by the local government, which minimizes soil erosion and sedimentation during all phases of construction.

4. The stormwater management plan or stormwater management facility plan, as approved by the local government, if the impounding structure is a stormwater management best management practice.

D. A Temporary Emergency Action Plan is a required element of a complete application for a Construction Permit and shall include:

1. A notification list of state and local emergency response agencies;

2. Provisions for notification of potentially affected residences and structures;

3. Construction site evacuation routes; and

4. Any other special notes particular to the project.

E. Within 120 days of receipt of a complete Construction Permit Application the board shall act on the application. If the application is not acceptable, the director shall inform the applicant within 60 days of receipt and shall explain what changes are required for an acceptable application. A complete Construction Permit Application consists of the following:

1. A final design report, submitted on the department form (Design Report for the Construction or Alteration of Virginia Regulated Impounding Structures), with attachments as needed, and certified by the owner and the owner's engineer;

2. A plan of construction that meets the requirements of subsection C of this section; and

3. A Temporary Emergency Action Plan that meets the requirements of subsection D of this section.

F. Prior to and during construction the owner shall provide the director with any proposed changes from the approved design, plans, specifications, or plan of construction. Approval shall be obtained from the director prior to the construction or installation of any changes that will affect the integrity or impounding capacity of the impounding structure.

G. The Construction Permit shall be valid for the plan of construction specified in the Construction Permit Application.

H. Construction must commence within two years after the permit is issued. If construction does not commence within two years after the permit is issued, the permit shall expire, except that the applicant may petition the board for extension of the two-year period and the board may extend such period for good cause with an appropriately updated plan of construction and Temporary Emergency Action Plan.

I. The board, the director, or both may take any necessary action consistent with the Dam Safety Act (§ 10.1-604 et seq. of the Code of Virginia) if any terms of this section or of the permit are violated, if the activities of the owner are not in accordance with the approved plans and specifications, if construction is conducted in a manner hazardous to downstream life or property, or for other cause as described in the Act.

J. Within 90 days after completion of the construction of an impounding structure, the owner shall submit:

1. A complete set of record drawings signed and sealed by a licensed professional engineer and signed by the owner:

2. A complete Record Report (Record Report for Virginia Regulated Impounding Structures) signed and sealed by a licensed professional engineer and signed by the owner that includes:

a. Project information including the name and inventory number of the structure, name of the reservoir, and whether the report is associated with a new or old structure;

b. Location of the impounding structure including the city or county, number of feet or miles

upstream or downstream of a highway and the highway number, name of the river or the stream, and the latitude and longitude;

c. Owner's name or representative if corporation, mailing address, residential and business telephone numbers, and other means of communication;

d. Information on the design report, including who it was prepared by, the date of design report preparation, whether it was for new construction or for an alteration, and the permit issuance date;

e. Owner's engineer's name, firm, professional engineer Virginia number, mailing address, and business telephone number;

f. Impounding structure data including type of material (earth, concrete, masonry or other) and the following configurations:

(1) Top of impounding structure (elevation);

(2) Downstream toe – lowest (elevation);

(3) Height of impounding structure (feet);

(4) Crest length – exclusive of spillway (feet);

(5) Crest width (feet);

(6) Upstream slope (horizontal to vertical); and

(7) Downstream slope (horizontal to vertical).

g. Reservoir data including the following:

(1) Maximum capacity (acre-feet);

(2) Maximum pool (elevation);

(3) Maximum pool surface area (acres);

(4) Normal capacity (acre-feet);

(5) Normal pool (elevation);

(6) Normal pool surface area (acres); and

(7) Freeboard (feet).

h. Spillway data including the type, construction material, design configuration, and invert elevation for the low level drain, the principal spillway, and the emergency spillway; a description of the low level drain and principal spillway including dimensions, trash guard

information, and orientation of intake and discharge to impounding structure if looking downstream; and a description of the emergency spillway including dimensions and orientation to impounding structure if looking downstream;

i. Watershed data including drainage area (square miles); type and extent of watershed development; time of concentration (hours); routing procedure; spillway design flood used and state source; design inflow hydrograph volume (acre-feet), peak inflow (cfs), and rainfall duration (hours); and freeboard during passage of the spillway design flood (feet);

j. Impounding structure history including the date construction was completed, who it was designed by and the date, who it was built by and the date, who performed inspections and dates, description of repairs, and confirmation as to whether the impounding structure has ever been overtopped;

k. A narrative describing the impounding structure procedures for operation, maintenance, filling, emergency action plan implementation, and structure evaluation;

l. A narrative describing the hydraulic and hydrologic data on the spillway design flood, hydrologic records, flood experience, flood potential, reservoir regulation, and comments or recommendations regarding these attributes;

m. A narrative describing stability of the foundation and abutments, embankment materials, and a written evaluation of each;

n. A complete set of record drawings signed and sealed by a licensed professional engineer and signed by the owner;

o. Certification by the owner's engineer that the information provided pursuant to subdivision J 2 of this section is true and correct in their professional judgment. Such certification shall include the engineer's signature, printed name, Virginia number, date, and the engineer's Virginia seal; and

p. Owner's signature certifying receipt of the information provided pursuant to subdivision J 2 of this section.

3. Certification from the licensed professional engineer who has monitored construction of the impounding structure during construction that, to the best of the engineer's judgment, knowledge and belief, the impounding structure and its appurtenances were constructed in conformance with the plans, specifications, drawings and other requirements approved by the board;

4. Operation and Maintenance Certificate Application (Operation and Maintenance Certificate Application for Virginia Regulated Impounding Structures) in accordance with 4VAC50-20-105; and

5. Emergency Action Plan or Emergency Preparedness Plan in accordance with 4VAC50-20-175 or 4VAC50-20-177.

K. Upon completion of construction, the impoundment may be filled upon board issuance of an Operation and Maintenance Certificate.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 2.2, eff. February 1, 1989; amended, Virginia Register Volume 18, Issue 14, eff. July 1, 2002; Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-80. Alterations permits.

A. Alterations which would potentially affect the structural integrity of an impounding structure include, but are not limited to, changing the height or otherwise enlarging the dam, increasing normal pool or principal spillway elevation or physical dimensions, changing the elevation or physical dimensions of the emergency spillway, conducting necessary repairs or structural maintenance, or removing the impounding structure. Structural maintenance does not include routine maintenance.

B. An applicant for an Alteration Permit shall submit a design report. A form for the design report is available from the department (Design Report for the Construction or Alteration of Virginia Regulated Impounding Structures). The design report shall be prepared in accordance with 4VAC50-20-240. The design report shall include, but not be limited to, the following information:

1. Project information including a description and benefits of the proposed alteration, name of the impounding structure, inventory number if available, name of the reservoir, and the purpose of the reservoir.

2. The hazard potential classification in conformance with Table 1 in 4VAC50-20-50.

3. Location of the impounding structure including the city or county, number of feet or miles upstream or downstream of a highway and the highway number, name of the river or the stream, and the latitude and longitude.

4. Owner's name or representative if corporation, mailing address, residential and business telephone numbers, and other means of communication.

5. Owner's engineer's name, firm, professional engineer Virginia number, mailing address, and business telephone number.

6. Impounding structure data including type of material (earth, concrete, masonry or other) and the following configurations (note both existing and design configurations for each):

a. Top of impounding structure (elevation);

b. Downstream toe – lowest (elevation);

c. Height of impounding structure (feet);

d. Crest length – exclusive of spillway (feet);

e. Crest width (feet);

f. Upstream slope (horizontal to vertical); and

g. Downstream slope (horizontal to vertical).

7. Reservoir data including the following (note both existing and design configurations for each):

a. Maximum capacity (acre-feet);

b. Maximum pool (elevation);

c. Maximum pool surface area (acres);

d. Normal capacity (acre-feet);

e. Normal pool (elevation);

f. Normal pool surface area (acres); and

g. Freeboard (feet).

8. Spillway data including the type, construction material, design configuration, and invert elevation for the low level drain, the principal spillway, and the emergency spillway.

9. Watershed data including drainage area (square miles); type and extent of watershed development; time of concentration (hours); routing procedure; spillway design flood used and state source; design inflow hydrograph volume (acre-feet), peak inflow (cfs), and rainfall duration (hours); and freeboard during passage of the spillway design flood (feet).

10. Evidence that the local government has been notified of the alteration and repair plan.

11. Plans and specifications as required by 4VAC50-20-310. The plan view of the impounding structure site should represent all significant structures and improvements that illustrate the location of all proposed work.

12. A report of the geotechnical investigations of the foundation soils, bedrock, or both in the areas affected by the proposed alterations and of the materials to be used to alter the impounding structure.

13. Design assumptions and analyses sufficient to indicate that the impounding structure will be stable during the alteration of the impounding structure under all conditions of reservoir operations.

14. Calculations and assumptions relative to design of the improved spillway or spillways, if applicable.

15. Provisions to ensure that the impounding structure and appurtenances during the alteration will be protected against unacceptable deterioration or erosion due to freezing and thawing, wind, wave action and rain or any combination thereof.

16. Other pertinent design data, assumptions and analyses commensurate with the nature of the particular impounding structure and specific site conditions, including when required by this chapter, a plan and water surface profile of the dam break inundation zone.

17. If applicable, a description of the techniques to be used to divert stream flow during alteration work so as to prevent hazard to life, health and property, including a detailed plan and procedures to maintain a stable impounding structure during storm events, a drawing showing temporary diversion devices, and a description of the potential impoundment during the alteration. Such diversion plans shall be in accordance with the applicable environmental laws.

18. A plan for project construction monitoring and quality control testing to confirm that materials used in the alteration work and that performance standards meet the design requirements set forth in the specifications.

19. Certification by the owner's engineer that the information provided pursuant to this subsection is true and correct in their professional judgment. Such certification shall include the engineer's signature, printed name, Virginia number, date, and the engineer's Virginia seal.

20. Owner's signature certifying receipt of the information provided pursuant to this subsection.

C. A plan of construction is a required element of complete permit application and shall include:

1. A construction sequence with milestones.

2. Elements of the work plan that should be considered include, but are not limited to, foundation and abutment treatment, excavation and material fill processes, phased fill and compaction, testing and control procedures, construction of permanent spillway and drainage devices, if applicable.

3. The erosion and sediment control plan, as approved by the local government, which minimizes soil erosion and sedimentation during all phases of construction.

D. Within 120 days of receipt of a complete Alteration Permit Application, the board shall act on the application. If the application is not acceptable, the director shall inform the applicant within 60 days of receipt and shall explain what changes are required for an acceptable application. A complete Alteration Permit Application consists of the following:

1. A final design report with attachments as needed, and certified by the owner;

2. A plan of construction that meets the requirements of subsection C of this section;

3. Any necessary interim provisions to the current Emergency Action Plan or Emergency Preparedness Plan. Interim provisions shall be submitted to the local organization for emergency management, the Virginia Department of Emergency Management, and the department; and

4. If the owner is requesting the deregulation of an impounding structure, the application shall specify whether the impounding structure is to be removed so that the impounding structure is incapable of storing water, either temporarily or permanently; or whether the impounding structure is to be altered in such a manner that either the height or storage capacity of the impounding structure causes the impounding structure to be of less than regulated size.

E. During the alteration work, the owner shall provide the director with any proposed changes from the approved design, plans, specifications, or a plan of construction. Approval shall be obtained from the director prior to the alteration or installation of any changes that will affect the integrity or impounding capacity of the impounding structure.

F. The Alteration Permit shall be valid for the construction sequence with milestones specified in the approved Alteration Permit Application.

G. Work identified in the Alteration Permit must commence within the time frame identified in the Alteration Permit. If work does not commence within the prescribed time frame, the permit shall expire, except that the applicant may petition the board for extension of the prescribed time frame and the board may extend such period for good cause with an updated construction sequence with milestones.

H. The board, the director, or both may take any necessary action consistent with the Dam Safety Act (§ 10.1-604 et seq. of the Code of Virginia) if any terms of this section or of the permit are violated, if the activities of the owner are not in accordance with the approved plans and specifications, if the alteration is conducted in a manner hazardous to downstream life or property, or for other cause as described in the

Act.

I. Within 90 days after completion of the alteration of an impounding structure, the owner shall submit a complete Record Report. A form for the Record Report is available from the department (Record Report for Virginia Regulated Impounding Structures). The Record Report shall be signed and sealed by a licensed professional engineer and signed by the owner and shall be sent to the department indicating that the modifications made to the structural features of the impounding structure have been completed. This report is not required when the Alteration Permit has been issued for the removal of an impounding structure. The Record Report shall include the following:

1. Project information including the name and inventory number of the structure, name of the reservoir, and whether the report is associated with a new or old structure;

2. Location of the impounding structure including the city or county, number of feet or miles upstream or downstream of a highway and the highway number, name of the river or the stream, and the latitude and longitude;

3. Owner's name or representative if corporation, mailing address, residential and business telephone numbers, and other means of communication;

4. Information on the design report, including who it was prepared by, the date of design report preparation, whether it was for new construction or for an alteration, and the permit issuance date;

5. Owner's engineer's name, firm, professional engineer Virginia number, mailing address, and business telephone number;

6. Impounding structure data including type of material (earth, concrete, masonry or other) and the following configurations:

a. Top of impounding structure (elevation);

b. Downstream toe – lowest (elevation);

c. Height of impounding structure (feet);

d. Crest length – exclusive of spillway (feet);

e. Crest width (feet);

f. Upstream slope (horizontal to vertical); and

g. Downstream slope (horizontal to vertical).

7. Reservoir data including the following:

a. Maximum capacity (acre-feet);

b. Maximum pool (elevation);

c. Maximum pool surface area (acres);

d. Normal capacity (acre-feet);

e. Normal pool (elevation);

f. Normal pool surface area (acres); and

g. Freeboard (feet).

8. Spillway data including the type, construction material, design configuration, and invert elevation for the low level drain, the principal spillway, and the emergency spillway; a description of the low level drain and principal spillway including dimensions, trash guard information, and orientation of intake and discharge to impounding structure if looking downstream; and a description of the emergency spillway including dimensions and orientation to impounding structure if looking downstream;

9. Watershed data including drainage area (square miles); type and extent of watershed development; time of concentration (hours); routing procedure; spillway design flood used and state source; design inflow hydrograph volume (acre-feet), peak inflow (cfs), and rainfall duration (hours); and freeboard during passage of the spillway design flood (feet);

10. Impounding structure history including the date construction was completed, who it was designed by and the date, who it was built by and the date, who performed inspections and dates, description of repairs, and confirmation as to whether the impounding structure has ever been overtopped;

11. A narrative describing the impounding structure procedures for operation, maintenance, emergency action plan implementation, and structure evaluation;

12. A narrative describing the hydraulic and hydrologic data on the spillway design flood, hydrologic records, flood experience, flood potential, reservoir regulation, and comments or recommendations regarding these attributes;

13. A narrative describing stability of the foundation and abutments, embankment materials, and a written evaluation of each;

14. A complete set of record drawings signed and sealed by a licensed professional engineer and signed by the owner;

15. Certification by the owner's engineer that the information provided pursuant to this subsection is true and correct in their professional judgment. Such certification shall include the engineer's signature, printed name, Virginia number, date, and the engineer's Virginia seal; and

16. Owner's signature certifying receipt of the information provided pursuant to this subsection.

J. For altered impounding structures, a certification from a licensed professional engineer who has monitored the alteration of the impounding structure that, to the best of the engineer's judgment, knowledge, and belief, the impounding structure and its appurtenances were altered in conformance with the plans, specifications, drawings and other requirements approved by the board.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 2.3, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-90. Transfer of permits.

A. Prior to the transfer of ownership of a permitted impounding structure the permittee shall notify the director in writing and the new owner shall file a transfer notification with the department. A form for the transfer notification is available from the department (Transfer of Impounding Structure Notification form Past Owner to New Owner). The new owner shall amend the existing permit application as necessary and shall certify to the director that he is aware of and will comply with all of the requirements and conditions of the permit.

B. The transfer notification shall include the following required information:

1. Project information including the name and inventory number of the structure, name of the reservoir, and impoundment hazard classification;

2. Location of the impounding structure including the city or county, number of feet or miles upstream or downstream of a highway and the highway number, name of the river or the stream, and the latitude and longitude;

3. Type of certificates and permits to be transferred including effective date and expiration date of all certificates and permits;

4. Past owner's name, mailing address, and residential and business telephone numbers;

5. New owner's name, mailing address, and residential and business telephone numbers;

6. Request to transfer certification statement signed and dated by the past owner;

7. Certification of compliance with permit or certificate with all said terms and conditions signed and dated by the new owner; and

8. Contact information updates for Emergency Action Plan or Emergency Preparedness Plan provided by the new owner. Such updates shall include the name, mailing address, and residential and business telephone numbers for the impounding structure owner, impounding structure operator, rainfall and staff gage observer, and alternate observer.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 2.4, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-100. (Repealed.)

Historical Notes

Derived from VR625-01-00 § 3.1, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

Part III

Certificate Requirements

4VAC50-20-105. Regular Operation and Maintenance Certificates.

A. A Regular Operation and Maintenance Certificate is required for an impounding structure. Such six-year certificates shall include the following based on hazard classification:

1. High Hazard Potential Regular Operation and Maintenance Certificate;

2. Significant Hazard Potential Regular Operation and Maintenance Certificate; or

3. Low Hazard Potential Regular Operation and Maintenance Certificate.

B. The owner of an impounding structure shall apply for the renewal of the six-year Regular Operation and Maintenance Certificate 90 days prior to its expiration. If a Regular Operation and Maintenance Certificate is not renewed as required, the board shall take appropriate enforcement action.

C. Any owner of an impounding structure that does not have a Regular Operation and Maintenance

Certificate or any owner renewing a Regular Operation and Maintenance Certificate shall file an Operation and Maintenance Certificate Application. A form for the application is available from the department (Operation and Maintenance Certificate Application for Virginia Regulated Impounding Structures). Such application shall be signed by the owner and signed and sealed by a licensed professional engineer. The following information shall be submitted on or with the application:

1. The application shall include the following required information:

a. The name of structure and inventory number;

b. The proposed hazard potential classification;

c. Owner's name or representative if corporation, mailing address, residential and business telephone numbers, and other means of communication;

d. An operating plan and schedule including a narrative on the operation of control gates and spillways and the impoundment drain;

e. For earthen embankment impounding structures, a maintenance plan and schedule for the embankment, principal spillway, emergency spillway, low-level outlet, impoundment area, downstream channel, and staff gages;

f. For concrete impounding structures, a maintenance plan and schedule for the upstream face, downstream face, crest of dam, galleries, tunnels, abutments, spillways, gates and outlets, and staff gages;

g. An inspection schedule for operator inspection, maintenance inspection, technical safety inspection, and overtopping situations;

h. A schedule including the rainfall amounts, emergency spillway flow levels or storm event that initiates the Emergency Action or Preparedness Plan and the frequency of observations;

i. A statement as to whether or not the current hazard potential classification for the impounding structure is appropriate and whether or not additional work is needed to make an appropriate hazard potential designation;

j. For newly constructed or recently altered impounding structures, a certification from a licensed professional engineer who has monitored the construction or alteration of the impounding structure that, to the best of the engineer's judgment, knowledge, and belief, the impounding structure and its appurtenances were constructed or altered in conformance with the plans, specifications, drawings and other requirements approved by the board;

k. Certification by the owner's engineer that the Operation and Maintenance Certificate Application information provided pursuant to subdivision 1 of this subsection is true and correct in their professional judgment. Such certification shall include the engineer's signature, printed name, Virginia number, date, and the engineer's Virginia seal; and

l. Owner's signature certifying the Operation and Maintenance Certificate Application information provided pursuant to subdivision 1 of this subsection and that the operation and maintenance plan and schedule shall be conducted in accordance with this chapter.

2. An Inspection Report (Annual Inspection Report for Virginia Regulated Impounding Structures) in accordance with subsection E of this section;

3. An Emergency Action Plan in accordance with 4VAC50-20-175 or an Emergency Preparedness Plan in accordance with 4VAC50-20-177 and evidence that the required copies of such plan have been submitted to the local organization for emergency management and the Virginia Department of Emergency Management; and

4. Any additional analysis determined necessary by the director, the board or the owner's engineer to address public safety concerns. Such additional analysis may include, but not be limited to, seismic stability, earthen spillway integrity, adequate freeboard allowance, stability assessment of the impoundment's foundation, potential liquefaction of the embankment, overturning or sliding of a concrete structure and other structural stress issues.

D. If the Operation and Maintenance Certificate Application submittal is found to be not complete, the director shall inform the applicant within 30 days and shall explain what changes are required for an acceptable submission. Within 60 days of receipt of a complete application the board shall act upon the application. Upon finding that the impounding structure as currently operating is in compliance with this chapter, the board shall issue a Regular Operation and Maintenance Certificate. Should the board find that the impounding structure as currently operating is not in compliance with this chapter, the board may deny the permit application or issue a Conditional Operation and Maintenance Certificate in accordance with 4VAC50-20-150.

E. Inspections shall be performed on an impounding structure annually.

1. Inspection Reports (Annual Inspection Report for Virginia Regulated Impounding Structures) signed and sealed by a licensed professional engineer shall be submitted to the department in accordance with the following schedule:

a. For a High Hazard Potential impounding structure, every two years,

b. For a Significant Hazard Potential impounding structure, every three years,

c. For a Low Hazard Potential impounding structure, every six years.

In years when an Inspection Report signed and sealed by a licensed professional engineer is not required, an owner shall submit the Annual Inspection Report for Virginia Regulated Impounding Structures.

2. The Inspection Report shall include the following required information:

a. Project information including the name and inventory number of structure, name of the reservoir, and purpose of the reservoir;

b. City or county where the impounding structure is located;

c. Owner's name or representative if corporation, mailing address, residential and business telephone numbers, and other means of communication;

d. Owner's engineer's name, firm, professional engineer Virginia number, mailing address, and business telephone number;

e. Inspection observation of the impounding structure including the following:

(1) Earthen embankment information including any embankment alterations; erosion; settlement, misalignments or cracks; seepage and seepage flow rate and location;

(2) Upstream slope information including notes on woody vegetation removed, rodent burrows discovered, and remedial work performed;

(3) Intake structure information including notes on deterioration of concrete structures, exposure of rebar reinforcement, need to repair or replace trash rack, any problems with debris in the reservoir, and whether the drawdown valve operated;

(4) Abutment contacts including notes on seepage and seepage flow rate and location;

(5) Earthen emergency spillway including notes on obstructions to flow and plans to correct, rodent burrows discovered, and deterioration in the approach or discharge channel;

(6) Concrete emergency spillway including notes on the deterioration of the concrete, exposure of rebar reinforcement, any leakage below concrete spillway, and obstructions to flow and plans to correct;

(7) Downstream slope information including notes on woody vegetation removed, rodent

burrows discovered, whether seepage drains are working, and any seepage or wet areas;

(8) Outlet pipe information including notes on any water flowing outside of discharge pipe through the impounding structure and a description of any reflection or damage to the pipe;

(9) Stilling basin information including notes on the deterioration of the concrete, exposure of rebar reinforcement, deterioration of the earthen basin slopes, repairs made, and any obstruction to flow;

(10) Gates information including notes on gate malfunctions or repairs, corrosion or damage, and whether any gates were operated and if so how often and to what extreme;

(11) Reservoir information including notes on new developments upstream of the dam, slides or erosion of lake banks, and general comments to include silt, algae, or other influence factors;

(12) Instruments information including any reading of instruments and any installation of new instruments; and

(13) General information including notes on new development in the downstream dam break inundation zone that would impact hazard classification or spillway design flood requirements, the maximum stormwater discharge or peak elevation during the previous year, whether general maintenance was performed and when, and actions that need to be completed before the next inspection.

f. Evaluation rating of the impounding structure and appurtenances (excellent, good, or poor), general comments, and recommendations;

g. Certification by the owner and date of inspection; and

h. Certification and seal by the owner's engineer and date of inspection, as applicable.

F. The owner of an impounding structure shall notify the department immediately of any change in the use of the area downstream that would impose hazard to life or property in the event of failure.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-110. (Repealed.)

Historical Notes

Derived from VR625-01-00 § 3.2, eff. February 1, 1989; repealed, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-120. (Repealed.)

Historical Notes

Derived from VR625-01-00 § 3.3, eff. February 1, 1989; repealed, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-125. Delayed effective date for Spillway Design Flood requirements for impounding structures.

A. If an impounding structure has been determined to have an adequate spillway capacity prior to September 26, 2008, and is currently operating under a Regular Operation and Maintenance Certificate, but will now require spillway modifications due to changes in these regulations, the owner shall submit to the board an Alteration Permit Application in accordance with 4VAC50-20-80 to address spillway capacity at the time of the expiration of their Regular Operation and Maintenance Certificate or by September 26, 2011, whichever is later. The Alteration Permit Application shall contain a construction sequence with milestones for completing the necessary improvements within five years of Alteration Permit issuance. The board may approve an extension of the prescribed time frame for good cause. Should the owner be able to demonstrate that no spillway capacity change is necessary, the impounding structure may be found to be in compliance with this chapter.

B. In accordance with 4VAC50-20-105, the owner shall submit the Operation and Maintenance Certificate Application (Operation and Maintenance Certificate Application for Virginia Regulated Impounding Structures), the Emergency Action Plan or Emergency Preparedness Plan, and the Inspection Report (Annual Inspection Report for Virginia Regulated Impounding Structures) 90 days prior to the expiration of the Regular Operation and Maintenance Certificate.

C. If circumstances warrant more immediate repairs to the impounding structure, the board may direct alterations to the spillway to be completed sooner.

D. During this delay period, owners are required to address other deficiencies that may exist that are not related to the spillway design flood.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-130. (Repealed.)

Historical Notes

Derived from VR625-01-00 § 3.4, eff. February 1, 1989; repealed, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-140. (Repealed.)

Historical Notes

Derived from VR625-01-00 § 3.5, eff. February 1, 1989; repealed, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-150. Conditional operation and maintenance certificate.

A. During the review of any Operation and Maintenance Certificate Application (Operation and Maintenance Certificate Application for Virginia Regulated Impounding Structures) completed in accordance with 4VAC50-20-105 should the director determine that the impounding structure has nonimminent deficiencies, the director may recommend that the board issue a Conditional Operation and Maintenance Certificate.

B. The Conditional Operation and Maintenance Certificate for High, Significant, and Low Hazard Potential impounding structures shall be for a maximum term of two years. This certificate will allow the owner to continue normal operation and maintenance of the impounding structure, and shall require that the owner correct the deficiencies on a schedule approved by the board.

C. A Conditional Certificate may be extended in accordance with the procedures of 4VAC50-20-155 provided that Inspection Reports (Annual Inspection Report for Virginia Regulated Impounding Structures) are on file, and the board determines that the owner is proceeding with the necessary corrective actions.

D. Once the deficiencies are corrected, the board shall issue a Regular Operation and Maintenance Certificate based upon the impounding structure's meeting the requirements of 4VAC50-20-105.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 3.6, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25,

eff. September 26, 2008.

4VAC50-20-155. Extension of Operation and Maintenance Certificates.

The board may extend an Operation and Maintenance Certificate for impounding structures provided that the owner submits a written request justifying an extension, the amount of time needed to comply with the requirements set out in the current Operation and Maintenance Certificate, and any required fees. The owner must have demonstrated substantial and continual progress towards meeting the requirements of the certificate in order to receive an extension.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-160. Additional operation and maintenance requirements.

A. The owner of an impounding structure shall not, through action or inaction, cause or allow such structure to impound water following receipt of a written report from the owner's engineer that the impounding structure will not safely impound water.

B. In accordance with § 10.1-609.2 of the Code of Virginia, impounding structure owners shall not permit the growth of trees and other woody vegetation and shall remove any such vegetation from the slopes and crest of embankments and the emergency spillway area, and within a distance of 25 feet from the toe of the embankment and abutments of the dam.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 3.7, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-165. Agricultural exemption.

A. Impounding structures operated primarily for agricultural purposes that are less than 25 feet in height or that create a maximum impoundment capacity smaller than 100 acre-feet are exempt from the Impounding Structure Regulations.

B. An owner covered by an agricultural exemption pursuant to § 10.1-604 of the Code of Virginia and

4VAC50-20-30 may validate such exemption by submitting an Agricultural Exemption Report (Agricultural Exemption Report for Impounding Structures). The Agricultural Exemption Report shall include the following information:

1. Project information including the name and inventory number of the structure and name of the reservoir;

2. Location of the impounding structure including the city or county, number of feet or miles upstream or downstream of a highway and the highway number, name of the river or the stream, and the latitude and longitude;

3. Owner's name or representative if corporation, mailing address, residential and business telephone numbers, and other means of communication;

4. The impounding structure height in feet and the maximum impounding capacity in acre-feet;

5. A list of the agricultural functions for which the impoundment supplies water;

6. The date of validation; and

7. The owner's signature validating that the impoundment is operated primarily for agricultural purposes and is exempt from the regulations.

C. The Agricultural Exemption Report may be verified by the department through a site visit.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-170. Transfer of certificates.

A. Prior to the transfer of ownership of an impounding structure the certificate holder shall notify the director in writing and the new owner shall file a transfer notification with the department. A form for the transfer notification is available from the department (Transfer of Impounding Structure Notification from Past Owner to New Owner). The new owner may elect to continue the existing operation and maintenance certificate for the remaining term or he may apply for a new certificate in accordance with 4VAC50-20-105. If the owner elects to continue the existing certificate, he shall certify to the director that he is aware of and will comply with all of the requirements and conditions of the certificate.

B. The transfer notification shall include the following required information:

1. Project information including the name and inventory number of the structure, name of the reservoir, and impoundment hazard classification;

2. Location of the impounding structure including the city or county, number of feet or miles upstream or downstream of a highway and the highway number, name of the river or the stream, and the latitude and longitude;

3. Type of certificates and permits to be transferred including effective date and expiration date of all certificates and permits;

4. Past owner's name, mailing address, and residential and business telephone numbers;

5. New owner's name, mailing address, and residential and business telephone numbers;

6. Request to transfer certification statement signed and dated by the past owner;

7. Certification of compliance with permit or certificate with all said terms and conditions signed and dated by the new owner; and

8. Contact information updates for Emergency Action Plan or Emergency Preparedness Plan provided by the new owner. Such updates shall include the name, mailing address, and residential and business telephone numbers for the impounding structure owner, impounding structure operator, rainfall and staff gage observer, and alternate observer.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 3.8, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-175. Emergency Action Plan (EAP) for High and Significant Hazard Potential impounding structures.

A. In order to protect life during potential emergency conditions at an impounding structure, and to ensure effective, timely action is taken should an impounding structure emergency occur, an EAP shall be required for each High and Significant Hazard Potential impounding structure. The EAP shall be coordinated with the Department of Emergency Management in accordance with § 44-146.18 of the Code of Virginia. The EAP required by these regulations shall be incorporated into local and interjurisdictional emergency plans pursuant to § 44-146.19 of the Code of Virginia.

B. It is the impounding structure owner's responsibility to develop, maintain, exercise, and implement a site-specific EAP.

C. An EAP shall be submitted every six years. The EAP shall be submitted with the owner's submittal of their Regular Operation and Maintenance Certificate application (Operation and Maintenance Certificate Application for Virginia Regulated Impounding Structures).

D. The owner shall update and resubmit the EAP immediately upon becoming aware of necessary changes to keep the EAP workable. Should an impounding structure be reclassified, an EAP in accordance with this section shall be submitted.

E. A drill shall be conducted annually for each high or significant hazard impounding structure. To the extent practicable, the drill should include a face-to-face meeting with the local emergency management agencies responsible for any necessary evacuations to review the EAP and ensure the local emergency management agencies understand the actions required during an emergency. A table-top exercise shall be conducted once every six years,although more frequent table-top exercises are encouraged. Drills and table-top exercises for multiple impounding structures may be performed in combination if the involved parties are the same. Owners shall certify to the department annually that a drill, a table-top exercise, or both has been completed and provide any revisions or updates to the EAP or a statement that no revisions or updates are needed.

F. Impounding structure owners shall test existing monitoring, sensing, and warning equipment at remote or unattended impounding structures at least twice per year or as performed by the Virginia Department of Emergency Management pursuant to § 10.1-609.1 of the Code of Virginia and maintain a record of such tests.

G. An EAP shall contain the following seven basic elements unless otherwise specified in this subsection.

1. Notification chart. A notification chart shall be included for all classes of impounding structures that shows who is to be notified, by whom, and in what priority. The notification chart shall include contact information providing 24-hour telephone coverage for all responsible parties including, but not limited to, the impounding structure operator or manager, state and local emergency management officials, local police or sheriffs' departments, and the owner's engineer. The notification chart shall also identify the process by which downstream property owners will be notified, and what party or parties will be responsible for making such notifications.

2. Emergency Detection, Evaluation, and Classification. The EAP shall include a discussion of the procedures for timely and reliable detection, evaluation, and classification of emergency situations considered to be relevant to the project setting and impounding features. Each relevant emergency situation is to be documented to provide an appropriate course of action based on the urgency of the situation. Where appropriate, situations should address impounding structure failures that are imminent or in progress, a situation where the potential for impounding structure failure is rapidly developing, and a situation where the threat is slowly developing.

3. Responsibilities. The EAP shall specify responsibilities for EAP-related tasks. The EAP shall also clearly designate the responsible party for making the decision that an emergency condition no longer exists at the impounding structure. The EAP shall include procedures and the responsible parties for notifying to the extent possible any known local occupants, owners, or lessees of downstream properties potentially impacted by the impounding structure's failure.

4. Preparedness. The EAP shall include a section that describes preparedness actions to be taken both before and following development of emergency conditions.

5. Dam Break Inundation Maps. The EAP shall include dam break inundation maps developed in accordance with 4VAC50-20-54.

6. Appendices. The appendices shall contain information that supports and supplements the material used in the development and maintenance of the EAP such as analyses of impounding structure failure floods; plans for training, exercising, updating, and posting the EAP; and other site-specific concerns.

7. Certification. The EAP shall include a section that identifies all parties with assigned responsibilities in the EAP pursuant to subdivision 3 of this subsection. This will include certification that the EAP has been received by these parties. The preparer's name, title, and contact information shall be printed in this section. The preparer's signature shall also be included in the certification section. The local organization for emergency management shall provide the owner and the department with any deficiencies they may note.

H. The development of the EAP shall be coordinated with all entities, jurisdictions, and agencies that would be affected by an impounding structure failure or that have statutory responsibilities for warning, evacuation, and postflood actions. Consultation with state and local emergency management officials at appropriate levels of management responsible for warning and evacuation of the public shall occur to

ensure that there is awareness of their individual and group responsibilities. The owner shall also coordinate with the local organization for emergency management to identify properties that upon failure of the impounding structure would result in economic impacts.

I. The EAP, or any updates to an existing EAP, shall be submitted to the department, the local organization for emergency management, and the Virginia Department of Emergency Management. Two copies shall be provided to the department.

J. The following format shall be used as necessary to address the requirements of this section.

Title Page/Cover Sheet

Table of Contents

I. Certifications

II. Notification Flowchart

III. Statement of Purpose

IV. Project Description

V. Emergency Detection, Evaluation, and Classification

VI. General Responsibilities Under the EAP

A. Impounding Structure Owner Responsibilities

B. Responsibility for Notification

C. Responsibility for Evacuation

D. Responsibility for Termination and Follow-Up

E. EAP Coordinator Responsibility

VII. Preparedness

VIII. Inundation Maps

IX. Appendices

A. Investigation and Analyses of Impounding Structure Failure Floods

B. Plans for Training, Exercising, Updating, and Posting the EAP

C. Site-Specific Concerns

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-177. Emergency Preparedness Plan for Low Hazard impounding structures.

Low Hazard impounding structures shall provide information for emergency preparedness to the department, the local organization for emergency management and the Virginia Department of Emergency Management. A form for the submission is available from the department (Emergency Preparedness Plan for Low Hazard Virginia Regulated Impounding Structures). The information shall include, but not be limited, to the following:

1. Name of the impounding structure, inventory number, city or county, latitude, and longitude;

2. Owner's name, mailing address, residential and business telephone numbers, and other means of communication. Contact information shall provide for 24-hour telephone contact capability;

3. Impounding structure operator's name, mailing address, residential and business telephone numbers, and other means of communication. Contact information shall provide for 24-hour telephone contact capability;

4. Rainfall and staff gage observer's name, mailing address, residential and business telephone numbers, and other means of communication. Contact information shall provide for 24-hour telephone contact capability;

5. Contact information for alternate operator and alternate rainfall and staff gage observer, if applicable;

6. Contact information for the local dispatch center nearest impounding structure including address and 24-hour telephone number;

7. City or county emergency services coordinator's name, mailing address, residential and business telephone numbers, and other means of communication;

8. A procedure and the responsible parties for notifying to the extent possible any known local occupants, owners, or lessees of downstream properties potentially impacted by the impounding structure's failure;

9. A discussion of the procedures for timely and reliable detection, evaluation, and classification of emergency situations considered to be relevant to the project setting and impounding features. Each relevant emergency situation is to be documented to provide an appropriate course of action based on the urgency of the situation;

10. A simple dam break inundation map acceptable to the director, demonstrating the general inundation that would result from an impounding structure failure. Such maps required pursuant to this section do not require preparation by a professional licensed engineer; however, maps prepared by a licensed professional engineer are preferred;

11. Identification of public roads downstream noting the highway number and distance below the impounding structure. If roads exist, contact information for the resident Virginia Department of Transportation engineer or city or county engineer including address and 24-hour telephone numbers;

12. Amount of rainfall that will initiate a Stage II Condition in inches per six hours, inches per 12 hours, and inches per 24 hours and a Stage III Condition in inches per six hours, inches per 12 hours, and inches per 24 hours;

13. Amount of flow in the emergency spillway that will initiate a Stage II Condition in feet (depth of flow) and a Stage III Condition in feet (depth of flow);

14. Staff gage location and description; the frequency of observations by the rainfall or staff gage observer under a Stage I Condition, and Stage II Condition, and a Stage III Condition; and a clear description of an access route and means of travel during flood conditions to the impounding structure;

15. Evacuation procedures including notification, monitoring, evacuation, and reporting processes and responsibilities;

16. Evidence that the required copies of such plan have been submitted to the local organization for emergency management and the Virginia Department of Emergency Management; and

17. Certification of the plan by the owner.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

Part IV

Procedures

4VAC50-20-180. Inspections.

A. The director may make inspections during construction, alteration or operation and maintenance as deemed necessary to ensure that the impounding structure is being constructed, altered or operated and maintained in compliance with the permit or certificate issued by the board. The director shall provide the owner a copy of the findings of these inspections. The department's inspection does not relieve the owner from the responsibility of providing adequate inspection during construction, alteration, or operation and maintenance. During the maintenance, construction, or alteration of any impounding structure or reservoir, the director shall require the owner to perform, at the owner's expense, such work or tests as necessary to obtain information sufficient to enable the director to determine whether conformity with the plans and specifications approved by the certificate is being secured.

B. Periodic inspections during construction or alteration shall be conducted under the direction of a licensed professional engineer who shall provide for monitoring, review of contractor submittals, and appropriate confirmatory testing of all facets of construction affecting the safety of the impounding structure in accordance with the construction or alteration permit issued by the board.

C. Required inspections during operation and maintenance shall be conducted under the supervision of a licensed professional engineer at intervals designated under 4VAC50-20-105.

D. Every owner shall provide for an inspection by a licensed professional engineer after overtopping of the impounding structure or after flows cause damage to the emergency spillway. A copy of the findings of each inspection with the engineer's recommendations shall be filed with the board within a reasonable period of time not to exceed 30 days subsequent to completion of the inspection.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 4.1, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-190. Right to informal fact-finding proceeding or hearing.

Any owner aggrieved by an action taken by the director or by the board without hearing, or by inaction of the director or the board, under the provisions of this chapter, may demand in writing an informal fact-finding proceeding pursuant to § 2.2-4019 of the Code of Virginia or a formal hearing pursuant to § 2.2-4020 of the Code of Virginia. A formal hearing may be granted only with the consent of the board.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 4.2, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-200. Enforcement.

The provisions of this chapter may be enforced by the board, the director, or both in any manner consistent with the provisions of the Dam Safety Act (§ 10.1-604 et seq. of the Code of Virginia).

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 4.3, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-210. Consulting committee.

A. When the board needs to satisfy questions of safety regarding plans and specifications, construction, alteration, or operation and maintenance, or when requested by the owner, the board may appoint a consulting committee to report to it with respect to those questions of the impounding structure's safety. Such a committee shall consist of two or more consultants, none of whom have been associated with the impounding structure.

B. The costs and expenses incurred by the consulting committee, if appointed at the request of an owner, shall be paid by the owner.

C. The costs and expenses incurred by the consulting committee, if initiated by the board, shall be paid by the board.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 4.4, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-220. Unsafe conditions.

A. No owner shall maintain an unsafe impounding structure. Designation of an impounding structure

as unsafe shall be made in accordance with § 10.1-607.1 of the Code of Virginia.

B. Imminent danger.

1. If an owner or the owner's engineer has determined that circumstances are impacting the integrity of the impounding structure that could result in the imminent failure of the impounding structure, temporary repairs may be initiated prior to approval from the board. The owner shall notify the department within 24 hours of identifying the circumstances impacting the integrity of the impounding structure. Such emergency notification shall not relieve the owner of the need to obtain an alteration permit as soon as may be practicable, nor shall the owner take action beyond that necessary to address the emergency situation.

2. When the director finds that an impounding structure is unsafe and constitutes an imminent danger to life or property, he shall immediately notify the Virginia Department of Emergency Management and confer with the owner who shall activate the Emergency Action Plan or Emergency Preparedness Plan if appropriate to do so. The owner of an impounding structure found to constitute an imminent danger to life or property shall take immediate corrective action to remove the imminent danger as required by § 10.1-608 of the Code of Virginia.

C. Nonimminent danger. The owner of an impounding structure who has been issued findings and recommendations, by the board, for the correction of deficiencies that may threaten life or property if not corrected, shall undertake to implement the recommendations for correction of deficiencies according to a schedule of implementation contained in that report as required by § 10.1-609 of the Code of Virginia.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 4.5, eff. February 1, 1989; amended, Virginia Register Volume 18, Issue 14, eff. July 1, 2002; Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-230. Complaints.

A. Upon receipt of a complaint alleging that the person or property of the complainant is endangered by the construction, alteration, maintenance or operation of an impounding structure, the director shall cause an inspection of the structure, unless the data, records and inspection reports on file with the board are found adequate to determine if the complaint is valid.

B. If the director finds that an unsafe condition exists, the director shall proceed under the provisions

of §§ 10.1-608 and 10.1-609 of the Code of Virginia to render the extant condition safe.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 4.6, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

Part V

Design Requirements

4VAC50-20-240. Design of structures.

A. The owner shall complete all necessary investigations prior to submitting the design report (Design Report for the Construction or Alteration of Virginia Regulated Impounding Structures). The design report shall contain those components outlined in 4VAC50-20-70 for construction activities or those outlined in 4VAC50-20-80 for alteration activities. The scope and degree of precision required is a matter of engineering judgment based on the complexities of the site and the hazard potential classification of the proposed structure.

B. Surveys shall be made with sufficient accuracy to locate the proposed construction site and to define the total volume of storage in the impoundment. Locations of center lines and other horizontal and vertical controls shall be shown on a map of the site. The area downstream and upstream from the proposed impounding structure shall be investigated in order to delineate the areas and extent of potential damage in case of failure or backwater due to flooding.

C. The drainage area shall be determined. Present and planned land-use conditions shall be considered in determining the runoff characteristics of the drainage area. The most severe of these conditions shall be included in the design calculations which shall be submitted as part of the design report.

D. The geotechnical engineering investigation shall consist of borings, test pits and other subsurface explorations necessary to adequately define the existing conditions. The investigations shall be performed so as to appropriately define the soil, rock and ground water conditions.

E. All construction materials shall be adequately researched and selected so as to ensure that their as constructed behavior will reasonably conform to design criteria. If on-site materials are to be utilized, they shall be located and determined to be adequate in quantity and quality.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 5.1, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-250. (Repealed.)

Historical Notes

Derived from VR625-01-00 § 5.2, eff. February 1, 1989; repealed, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-260. Spillway design.

A. Every impounding structure shall have a spillway system with adequate capacity to discharge the design flood without endangering the safety of the impounding structure.

B. Vegetated earth or an unlined emergency spillway may be approved when the applicant demonstrates that it will pass the spillway design flood without jeopardizing the safety of the impounding structure (such as by allowance of overtopping of a structure not designed to permit overtopping). In no case shall impounding structure owners permit the growth of trees and other woody vegetation in the emergency spillway area.

C. Lined emergency spillways shall include design criteria calculations, plans and specifications for suitable energy dissipators and for spillways that include crest control structures, chutes, walls, panel lining, sills, blocks, and miscellaneous details. All joints shall be reasonably water-tight and placed on a foundation capable of sustaining applied loads without undue deformation. Provision shall be made for handling under seepage and uplift pressures from the foundation which might adversely affect the structural integrity and structural stability of the impounding structure.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 5.3, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-270. Principal spillways and outlet works.

A. It will be assumed that principal spillways and regulating outlets provided for special functions will operate to normal design discharge capabilities during the spillway design flood, provided appropriate analyses show:

1. That control gates and structures are suitably designed to operate reliably under maximum heads for durations likely to be involved and risks of blockage by debris are minimal;

2. That access roads and passages to gate regulating controls would be safely passable by operating personnel under spillway design flood conditions; and

3. That there are no substantial reasons for concluding that outlets would not operate safely to full design capacity during the spillway design flood.

B. If there are reasons to doubt that any of the above basic requirements might not be adequately met under spillway design flood conditions, the "dependable" discharge capabilities of regulating outlets shall be assumed to be less than 100% of design capacities, generally as outlined in the following subsections C through G of this section.

C. Any limitations in safe operating heads, maximum velocities to be permitted through structures or approach channels, or other design limitations shall be observed in establishing "dependable" discharge rating curves to be used in routing the spillway design flood hydrograph through the reservoir.

D. If intakes to regulating outlets are likely to be exposed to significant quantities of floating debris, sediment depositions or ice hazards prior to or during major floods, the dependable discharge capability during the spillway design flood shall be assumed to be zero.

E. If access roads or structural passages to operating towers or controls are likely to be flooded or otherwise unusable during the spillway design flood, the dependable discharge capability of regulating outlets will be assumed to be zero for the periods of time during which such conditions might exist.

F. Any deficiencies in discharge performance likely to result from delays in the operation of gates before attendants could be reasonably expected to reach the control must be taken into account when estimating "dependable" discharge capabilities assumptions in routing the spillway design flood through the impoundment. Reports on design studies shall indicate the allowances made for possible delays in initiating gate operations. Normally, for projects located in small basins, where critical spillway design flood inflows may occur within several hours after intense precipitation, outflows through any regulating outlets that must be opened after the flood begins shall be assumed to be zero for an appropriate period of time subsequent to the beginning of intense rainfall.

G. All gates, valves, conduits and concrete channel outlets shall be designed and constructed to prevent significant erosion or damage to the impounding structure or to the downstream outlet or channel.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 5.4, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-280. Drain requirements.

All new impounding structures regardless of their hazard potential classification, shall include a device to permit draining of the impoundment within a reasonable period of time as determined by the owner's licensed professional engineer. Existing drains on impounding structures shall be kept operational. When practicable, existing impounding structures shall be retrofitted with devices to permit draining.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 5.5, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-290. Life of the impounding structure.

Components of the impounding structure, the outlet works, drain system and appurtenances shall be durable and maintained or replaced in keeping with the design and planned life of the impounding structure.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 5.6, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-300. Additional design requirements.

A. Flood routings shall start at or above the elevation of the crest of the lowest ungated outlet. Freeboard determination and justification must be addressed by the owner's engineer.

B. All elements of the impounding structure shall conform to sound engineering practice. Safety factors, design standards and design references that are used shall be included with the design report.

C. Inspection devices may be required by the director for use by inspectors, owners or the director in conducting inspections in the interest of structural integrity during and after completion of construction and during the life of the impounding structure.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 5.7, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-310. Plans and specifications.

The plans and specifications for a proposed impounding structure required in 4VAC50-20-70 for construction activities and in 4VAC50-20-80 for alteration activities shall consist of a detailed engineering design report (Design Report for the Construction or Alteration of Virginia Regulated Impounding Structures) and engineering drawings and specifications, with the following as a minimum:

1. The name of the project; the name of the owner; classification of the impounding structure as set forth in this chapter; designated access to the project and the location with respect to highways, roads, streams and existing impounding structures and impoundments that would affect or be affected by the proposed impounding structure.

2. Cross-sections, plans, profiles, logs of test borings, laboratory and in situ test data, drawings of principal and emergency spillways, impounding structures, outlet works, drain system and appurtenances, and other project components in sufficient detail to indicate clearly the extent and complexity of the work to be performed.

3. Contract drawings should include, but not be limited to, foundation and abutment treatment, stream or river diversion, excavation and material fill processes, phased fill and compaction and drainage devices.

4. The erosion and sediment control plan, as approved by the local government, which minimizes soil erosion and sedimentation during all phases of construction or alteration.

5. Technical specifications, as may be required to describe the materials, performance, and methods of the construction and construction quality control for the project.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 5.8, eff. February 1, 1989; amended, Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-320. Acceptable design procedures and references.

To ensure consistency of approach, within the major engineering disciplines of hydrology, hydraulics, soils and foundations, structures, and general civil design, criteria and approaches from multiple sources shall not be mixed for developing the design of a given feature or facility without approval of the director. In all cases the owner's engineer shall identify the source of the criteria.

The following are acceptable as design procedures and references:

1. The design procedures, manuals and criteria used by the United States Army Corps of Engineers.

2. The design procedures, manuals and criteria used by the United States Department of Agriculture, Natural Resources Conservation Service.

3. The design procedures, manuals and criteria used by the United States Department of the Interior, Bureau of Reclamation.

4. The design procedures, manuals and criteria used by the United States Department of Commerce, National Weather Service.

5. The design procedures, manuals and criteria used by the United States Federal Energy Regulatory Commission.

6. Other design procedures, manuals and criteria that are accepted as current, sound engineering practices, as approved by the director prior to the design of the impounding structure.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from VR625-01-00 § 5.9, eff. February 1, 1989; amended, Virginia Register Volume 18, Issue 14, eff. July 1, 2002; Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-330. Other applicable dam safety references.

A. Manuals, guidance, and criteria used by the Federal Emergency Management Agency, including the following:

1. Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners, U.S. Department of Homeland Security, Federal Emergency Management Agency, October 1998, Reprinted January 2004; FEMA 64 or as revised.

2. Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams, U.S. Department of Homeland Security, Federal Emergency Management Agency, October 1998, Reprinted April 2004; FEMA 94 or as revised.

B. Manuals, guidance, and forms provided by the department. Such materials may be located on the department's website at: http://www.dcr.virginia.gov.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

Part VI

Fees

4VAC50-20-340. Authority to establish fees.

Under § 10.1-613.5 of the Code of Virginia, the board is authorized to establish and collect application fees for the administration of the dam safety program, administrative review, certifications, and the repair and maintenance of impounding structures. The fees will be deposited into the Dam Safety, Flood Prevention and Protection Assistance Fund.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-350. Fee submittal procedures.

A. Effective September 26, 2008, fees for all application submittals required pursuant to 4VAC50-20-370 through 4VAC50-20-390 are due prior to issuance of a certificate or permit. No application for an Operation and Maintenance Certificate or a Construction Permit will be acted upon by the board without

full payment of the required fee per § 10.1-613.5 of the Code of Virginia.

B. Fees shall be paid by check, draft or postal money order payable to the Treasurer of Virginia, or submitted electronically (if available), and must be in U.S. currency, except that agencies and institutions of the Commonwealth of Virginia may submit Interagency Transfers for the amount of the fee. All fees shall be sent to the following address (or submitted electronically, if available): Virginia Department of Conservation and Recreation, Division of Finance, Accounts Payable, 203 Governor Street, 4th Floor, Richmond, Virginia 23219.

C. All fee payments shall be accompanied by the following information:

1. Applicant name, address and daytime phone number.

2. The name of the impounding structure, and the impounding structure location.

3. The type of application or report submitted.

4. Whether the submittal is for a new permit or certificate issuance or permit or certificate reissuance.

5. The amount of fee submitted.

6. Impounding structure identification number, if applicable.

D. No permit fees remitted to the department shall be subject to refund except as credits provided for in 4VAC50-20-390 C.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-360. Fee exemptions.

Impounding structures owned by Virginia Soil and Water Conservation Districts shall be exempt from all fees associated with this part in accordance with § 10.1-613.5 of the Code of Virginia. There will be no fee assessed for a low hazard impounding structure exempted from fees pursuant to 4VAC50-20-51 or for the decommissioning of an impounding structure.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-370. Construction Permit application fees.

A. Any application form submitted pursuant to 4VAC50-20-70 for permitting a proposed impounding structure construction after September 26, 2008, shall be accompanied by a payment as determined in subsection B of this section.

B. Fees shall be as follows:

1. $2,500 for High or Significant Hazard Potential impounding structures.

2. $1,000 for Low Hazard Potential impounding structures.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-380. Regular Operation and Maintenance Certificate application fees.

A. Any application for a six-year Regular Operation and Maintenance Certificate after September 26, 2008, except as otherwise exempted, shall be accompanied by a payment as determined in subsection B of this section.

B. Fees for High, Significant, or Low Hazard Potential impounding structures shall be as follows:

1. $600 for High Hazard Potential.

2. $600 for Significant Hazard Potential.

3. $300 for Low Hazard Potential.

C. Fees for extension of Regular Operation and Maintenance Certificates shall be $250 per year or portion thereof.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-390. Conditional Operation and Maintenance Certificate application fee.

A. Fees for issuance of a Conditional Operation and Maintenance Certificate shall be as follows:

1. For a certificate for more than one year but no more than two years: $300.

2. For a certificate for one year or less: $150.

B. The fee for an extension of a Conditional Operation and Maintenance Certificate shall be $250 per year or portion thereof.

C. The board may allow a partial credit towards the Regular Operation and Maintenance Certificate fee if the owner of the impounding structure has completed, to the director's satisfaction, the conditions of the Conditional Certificate prior to its expiration.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

4VAC50-20-400. Incremental Damage Analysis review fees.

Should the department determine that outside expertise to assist with the review of an incremental damage analysis is necessary, the applicant shall be responsible for the cost of such outside expertise. Such costs shall be agreed upon in advance by the department and the applicant.

Statutory Authority

§ 10.1-605 of the Code of Virginia.

Historical Notes

Derived from Virginia Register Volume 24, Issue 25, eff. September 26, 2008.

NAVIGATING DAM SAFETY RULES IN VIRGINIA

Greg Zamensky, P.E., Black & Veatch Corporation

Introduction

For decades, the probable maximum flood (PMF) and fractions thereof have been the dominant spillway design criterion used by state dam safety agencies for high and significant hazard potential dams throughout the United States. The methodologies used to compute the PMF vary with topography and climate and were last updated in the late 1980s. Regardless, the PMF has always been a theoretical event. As such, the PMF does not have a definable recurrence interval (i.e., 100-year event, 500-year event, etc.), however, some estimates put the recurrence interval of the PMF at between a 100,000 and 1,000,000-year event. The immense size of the PMF and the lack of an understandable return period lead most dam owners and many engineers to question the reasonableness of the criterion.

In Virginia, the use of the PMF led one politically connected dam owner to nearly undermine the entire state dam safety program. Along the way, the dam safety legislation and regulations underwent several iterations of extensive revisions; some laws were clearly positive while others left the dam safety community perplexed. Since then, dam owners as well as engineering consultants have scrambled to stay abreast of the regulatory changes to understand how the regulations affect their dams.

Virginia has maintained a strong dam safety program for over 20 years, beginning with the inception of dam safety legislation in 1989. The Department of Conservation and Recreation, Dam Safety Division (DCR) oversees dam safety in the Commonwealth and administers the applicable regulations. In September 2008, the Virginia Impounding Structure Regulations were revised from top to bottom after several years of debate between regulators, legislators, engineers, and the public. Between September 2008 and April 2009, before the ink was even dry on these revised regulations, several pieces of new legislation were drafted that once again changed the dam safety landscape in Virginia. As of June 2010, the dam safety community in Virginia continues to monitor the situation as regulators struggle to provide updated regulations and guidance documents to clarify the application of these new laws.

In the meantime, dam owners and consultants cautiously try to navigate the obscure regulations and hope that future guidance includes insightful discussion across the industry—discussion that focuses on setting reasonable standards for selection of appropriate spillway design floods.

Regulatory and Legislative Changes

The Virginia Dam Safety Act was originally passed in to law under Article 2, Chapter 6, Title 10.1 of the Code of Virginia. The Virginia Impounding Structure Regulations (§4VAC50-20) became effective February 1, 1989. These regulations were recodified in 1997 and reprinted 2004.

Until the September 2008 revisions, no changes to the impounding structure regulations had occurred since the late 1980s except to update the definition of "regulated dams" to conform to the 2001 legislative change in definition (Chapter 92 (SB1166) of the 2001 Virginia Acts of Assembly). Over the decades, the management of dams evolved to include factors that were not considered in the 1980 legislation. For example, the residential and commercial populations near existing dams have increased, which in turn increased public safety concerns. Similarly, engineering and technology and methodologies have advanced over the decades, creating a host of approaches that were unavailable at the time the current law was drafted. Given the evolution of the dams practice and the community issues surrounding existing dams, it was determined that a substantive review of these regulations would be prudent, and that amendments may be necessary.

The significant revisions to the Virginia Dam Safety Act during the 2006 legislative session (Chapter 30 (HB597) of the 2006 Virginia Acts of Assembly) necessitated updates to the regulations to reflect the revised and enhanced powers and authorities. It has also been determined that the administration and implementation of the Dam Safety Program could be improved through regulatory updates and that the intent and procedures embodied within the regulations could be clarified to benefit the regulated community and the public.

A Technical Advisory Committee (TAC) composed of public and private dam owners, regulators, consultants, and contractors was impaneled in 2006 to develop the revised Impounding Structure Regulations. Formation of the TAC was influenced by a politically connected, private dam owner who was faced with costly spillway upgrades necessitated by building downstream that resulted in a change to the hazard potential classification. Although the dam was well maintained, construction of homes downstream, resulted in a high hazard potential classification, requiring that the spillway pass the full PMF versus the previous requirement of about 50 percent of the PMF.

While the TAC and DCR considered changes to the Impounding Structure Regulations, the Virginia legislature focused on protecting dam owners whose dams are located upstream from large, newly constructed communities. Developers' actions downstream affect dams upstream, often requiring dam owners to undergo costly upgrades to protect newly established downstream populations. In March 2008, the Governor signed House Bill 837 that provided

this protection, to a point. The bill requires dam owners to submit dam break inundation maps to their local jurisdiction's planning and zoning group. The bill provides localities with the authority to address development in dam break inundation zones. The bill directs developers to assist dam owners with dam upgrades (100 percent of the design cost and 50 percent of the construction cost) that are required as a direct result of the developer's proposed building in the dam break inundation zone.

After nearly three years, numerous public input periods, and several draft documents, the TAC and DCR produced revised regulations. Released in September 2008, the changes were substantial and affected nearly every regulated dam in the Commonwealth. Some of the more substantial issues affecting dam owners include:

1. Revising the dam hazard potential classification system;
2. Specifying that spillway design requirements are applicable to all state regulated dams;
3. Modifying the spillway design requirements to enhance public safety and reduce subjectivity (eliminate Section 130 exception from previous regulations);
4. Allowing for the potential reduction of the spillway design flood requirement through an incremental damage assessment (IDA) for all qualified dams;
5. Establishing dam break inundation zone mapping requirements;
6. Expanding emergency action plan requirements for High and Significant Hazard Potential dams and emergency preparedness plan requirements for Low Hazard Potential dams;
7. Establishing permit application fees for the administration of the Dam Safety Program that will create a stream of revenue sufficient to support an additional dam safety engineer;
8. Removing the forms that are incorporated by reference and move reporting standards into the regulations;
9. Creating new definitions or modifying current definitions;
10. Reorganizing, clarifying, and expanding sections related to permitting procedures; and
11. Updating sections related to inspections, enforcement, and unsafe conditions.

Most thought these changes were wholly appropriate; however, they did not relieve the aforementioned private dam owner of his responsibility to upgrade their spillway. Under the revised regulations, the private dam owner remained obligated to safely pass the full PMF. Further, the prospect of an IDA resulting in a lowered spillway design flood was negligible given the location of the homes downstream. So, once again, changes to the dam safety laws were sought.

Not surprisingly, the dam safety landscape in Virginia changed again in January 2010 when two new dam safety bills were introduced to the Virginia legislature: Senate Bill 276 and House Bill 438. The original version of Senate Bill 276 would have allowed dam owners to ignore safety concerns issued by DCR until the Commonwealth was able to fund any and all repairs needed to satisfy the dam safety regulations. Inexplicably, Senate Bill 276 passed both the Virginia House and Senate and was sent to the Governor's office for his signature. The original text was as follows:

> *"Until such time as adequate funding is available through the Dam Safety….Fund…., the [Board] shall continue to issue conditional operation and maintenance certificates for any existing impoundment that does not comply with dam safety regulations so long as the owner of the impoundment has adopted a dam safety emergency action plan…."*, Senate Bill 276, January 27, 2010

As written, the law would have completely undermined dam safety in Virginia. Justifiably, the Governor's office received intense pressure to reject the bill, including pleas from the American Society of Civil Engineers and the Association for State Dam Safety Officials. The Governor elected to send the bill back to the House for revision based on these and other comments. The amended Senate Bill 276 and House Bill 438, as signed by the Governor, provide potentially significant relief from the 2008 regulations for some dam owners. In summary, these bills provide the following major elements:

Senate Bill 276 – The maximum rainfall event to be used for evaluating all impounding structures and spillways built or permitted prior to July 1, 2010, shall be 90 percent of the probable maximum precipitation (PMP), reduced from 100 percent of the PMP. The maximum precipitation can be further reduced (to 60 percent of the PMP) for some qualified structures, if the owner can satisfy eight provisions including having a DCR-accepted EAP that is tested; daily inspections of the impounding structure; and insurance in an amount that will substantially cover property losses due to a dam failure. It is the insurance provision of the bill that the vast majority of dam owners can not satisfy.

The last line of the one page bill indicates "that this act is in force from its passage". As a result, DCR did not have the opportunity to interpret the legislation and modify the Impounding Structure Regulations accordingly. Therefore, interested dam owners must approach not just their Regional Dam Safety Engineer from DCR, but others including the Dam Safety Manager and the DCR Director to discuss their opportunity to apply the bill. As fate would have it, the aforementioned private dam owner can satisfy these provisions and, therefore, can take advantage of the relief provided.

House Bill 438 – The minimum spillway design flood for high hazard potential dams as identified through an IDA is reduced from 0.50PMF to the 100-year storm event. Limited-use or private roadways with low traffic volume shall be considered when determining the hazard potential classification of an impounding structure.

In January 2010, DCR issued a series of guidance documents to help owners and engineers interpret the rule changes including Dam Break Inundation Zone and Incremental Damage Analysis and Mapping Procedure; Roadways on or Below Impounding Structures; Special Low Hazard Impounding Structure Requirements; and Impounding Structure Hazard Potential Classifications. Given a date of January 14, 2010, these documents do not yet consider the implications of Senate Bill 276 or House Bill 438. Although these "Working Drafts" are available on DCR's website, they are not yet approved by the Virginia Soil and Water Conservation Board. Revised guidance documents are currently being reviewed by DCR. Release of the guidance documents is expected to occur sometime in the summer of 2010.

Dam Owner's Perspectives

Every owner in Virginia with a regulated impounding structure is affected by the aforementioned legislative and regulatory changes. The following section describes three cases studies of owners and their situation relative to the changing dam safety landscape. Considering none of these owners have fully navigated the process, the owner and dam names will be kept anonymous.

DAM A

Dam A and the impoundment are owned and operated by a city's utilities department as a surface water supply source. DCR classified Dam A as Class II structure, or having a significant hazard potential classification. Dam A, built in 1960, is a mass concrete structure with a central spillway capable of passing about 25 percent of the PMF before overtopping the remainder of the dam. The dam is well maintained and, as a result of the Section 130 Exception in the older dam safety regulations, the city held a Regular Operation & Maintenance (O&M) Certificate that expired in 2009. In late 2008, the city began planning for renewal of their O&M Certificate and contracted Black & Veatch to provide a comprehensive safety evaluation of the impounding structure that included hydrologic modeling, hydraulic modeling, stability evaluation, hazard classification, and foundation scour analysis.

The city was provided a Regular Certificate in 2003 through the Section 130 Exception of the dam safety regulations even though the spillway capacity was considerably less than the allowed range for a Class II structure (e.g., 0.50PMF to PMF). The revised regulations promulgated in 2008 removed the Section 130 Exception. Therefore, the city recognized that their next certificate renewal submission would not only require documentation demonstrating

a Significant Hazard Potential classification, but would also require justification for a lesser spillway capacity than required (e.g., an IDA).

Black & Veatch studies revealed that Dam A should be classified as a high hazard potential structure with more than 20 homes within the dam break inundation limits. Stability analyses indicated the mass concrete dam was stable even under the PMF loading condition. However, foundation scour evaluations revealed an erodible zone at the dam foundation if the dam were overtopped. Based on hydrologic modeling, precipitation in excess of the 500-year storm event is necessary to create sufficient overtopping to cause potential foundation scour. Nonetheless, relatively minor upgrades were needed to protect the foundation materials from potential scour to satisfy dam safety requirements.

The city accepted the study's conclusions and submitted a certificate renewal package in accordance with the 2008 dam safety regulations with provisions for installing the upgrades in the near future. Considering the new regulations and legislative changes, the city's choices to navigate the dam safety rules included:

Table 1: Dam A - City Regulatory Decisions

Choice Presented to the City	Source	City's Decision
Hazard potential classification determination. Hazard classification process not clearly defined in regulations.	Draft guidance for hazard potential classification, January 14, 2010 (not available at the time). Dam owners partially protected from downstream construction changing the SDF (House Bill 837, 2008)	Due to the potential for additional building downstream, the city chose to rehabilitate the dam as a High Hazard structure to avoid any future changes.
Perform IDA to potentially reduce the SDF from the PMF to as low as the 0.50PMF	IDA permitted by the 2008 regulations (4VAC50-20-52)	Based on review of the PMF dam break inundation maps, the city elected to not pursue an IDA.
Perform IDA to potentially reduce the SDF from the PMF to as low as the 100-year storm	SDF as low as the 100-year storm for high hazard structure by House Bill 438	Based on review of the PMF dam break inundation maps, the city elected to not pursue an IDA.
Reduce the extent of the upgrade at the dam from the PMF to 90 percent of the PMP	Reduced maximum storm for structures permitted before July 1, 2010 by Senate Bill 276	The city is considering, but the reduction is small
Reduce the extent of the upgrade at the dam from the PMF to 60 percent of the PMP	Reduced SDF allowed if other provisions are met by Senate Bill 276	The city is not willing to insure downstream property owners

DAM B

Dam B and the impoundment are owned and operated by a private home owners association as a recreational facility. DCR classified Dam B as a Class I impounding structure, or having a high hazard potential based on the 2008 regulations. Built in 1971, Dam B is a 100-foot-high zoned embankment dam with an off-channel spillway. The spillway is capable of passing about 20 percent of the PMF before dam overtopping begins. Considering the default SDF is the PMF (as defined in the 2004 regulations and the 2008 regulations), DCR issued the owner a Conditional O&M Certificate based on an inadequate spillway.

Due to very limited funding and continuous attrition of their board members, the owner struggled to develop or execute a definitive plan to address the spillway inadequacy. Consulting engineering firms had been working with the owner regarding the dam and spillway since 2006. Cognizant of the owner's financial situation, DCR provided several extensions to the Conditional Certificate and the 2008 regulation changes provided the owner even more time to develop a way forward.

In 2009, the owner engaged Black & Veatch to evaluate spillway upgrade alternatives to manage the PMF and satisfy dam safety regulations. In November 2009, the owner selected their preferred option; in January 2010, with a wary eye to the proposed legislative changes, Black & Veatch began final design. In April 2010, Senate Bill 276 was signed by the Governor causing the owner and Black & Veatch to mutually stop work to assess the applicability of the bill's provisions. After several discussions, DCR told the owner that they could apply for the large reduction in SDF described in Senate Bill 276. Although the owner has received no official paperwork from DCR, all correspondence with DCR indicate acceptance of the application. Based on these correspondences, in May 2010, the owner directed Black & Veatch to redesign the preferred alternative to meet the provisions of Senate Bill 276.

Table 2: Dam B - Owner Regulatory Decisions

Choice Presented to the Owner	Source	Owner's Decision
Perform IDA to potentially reduce the SDF from the PMF to as low as the 0.50PMF	IDA permitted by the 2008 regulations (4VAC50-20-52)	The owner elected to fund a preliminary IDA that revealed reduction of the SDF was not likely due to location of downstream occupied structures.
Perform IDA to potentially reduce the SDF from the PMF to as low as the 100-year storm	SDF as low as the 100-year storm for high hazard structure by House Bill 438	Preliminary IDA (above) revealed SDF reduction not likely.
Reduce the extent of the upgrade at the dam from the PMF to 90 percent of the PMP	Reduced maximum storm for structures permitted before July 1, 2010 by Senate Bill 276	The owner is automatically granted this reduction and accepts it.
Reduce the extent of the upgrade at the dam from the PMF to 60 percent of the PMP	Reduced SDF allowed if other provisions are met by Senate Bill 276	The owner elected to take the opportunity to potentially reduce the size (i.e., cost) of the spillway upgrades.

DAM C

Dam C is owned and operated by a city's public works department because a major roadway passes across the dam's crest. The reservoir is owned by a private institution. DCR classified Dam C as Class II structure, or having a significant hazard potential classification. Dam C, built in 1934, is a zoned embankment, about 35 feet high, with an off-channel spillway capable of passing about 10 percent of the PMF before overtopping of the dam. Even with an inadequate spillway according to the regulations, the city held a Regular O&M Certificate that expired in 2010 as a result of the Section 130 Exception from the 2004 dam safety regulations. An O&M Certificate renewal application is due to DCR by the end of 2010.

The city recognized that the 2008 regulations require a certificate renewal submission to include background data and computations supporting a reduced SDF that they did not have. In addition, the submission requires verification of the hazard potential classification. Due to downstream construction over the past 20 years, the city suspected that Dam C should be classified as a high hazard potential structure rather than a significant hazard structure. In 2009, the city began planning for renewal of their O&M Certificate by contracting Black &

Veatch to provide a safety evaluation of the impounding structure that included hydrologic modeling, hydraulic modeling, hazard classification, and rehabilitation alternatives development, if needed.

Black & Veatch completed the studies confirming Dam C as a high hazard potential structure with a spillway capacity significantly less than that required—10 percent of the PMF versus 50 to 100 percent of the PMF. An IDA requested by the city re-established the SDF to be the PMF; no reduction in the SDF was possible. Therefore, Black & Veatch prepared dam and spillway upgrade alternatives including embankment armoring, spillway expansion, and decommissioning.

By the end of 2010, the city will submit an O&M Certificate renewal package that describes the dam's issues, most notably an inadequate spillway, and their planned way forward in addressing the issues.

Table 3: Dam C - City Regulatory Decisions

Choice Presented to the City	Source	City's Decision
Perform IDA to potentially reduce the SDF from the PMF to as low as the 0.50PMF	IDA permitted by the 2008 regulations (4VAC50-20-52)	The city elected to fund a preliminary IDA that revealed reduction of the SDF was not likely due to location of downstream occupied structures.
Perform IDA to potentially reduce the SDF from the PMF to as low as the 100-year storm	SDF as low as the 100-year storm for high hazard structure by House Bill 438	Preliminary IDA (above) revealed SDF reduction not likely.
Reduce the extent of the upgrade at the dam from the PMF to 90 percent of the PMP	Reduced maximum storm for structures permitted before July 1, 2010 by Senate Bill 276	The city is automatically granted this reduction and accepts it, although the reduction provides only minor relief.
Reduce the extent of the upgrade at the dam from the PMF to 60 percent of the PMP	Reduced SDF allowed if other provisions are met by Senate Bill 276	The city is not willing to insure downstream property owners.

Conclusions

Through the influence of one local, politically connected, private dam owner, the dam safety rules in Virginia changed significantly in September 2008 and have continued to evolve since that point. In fact, the landscape is changing so rapidly that DCR representatives have been unable to compose guidance documents that provide their interpretation of the new rules.

Dam owners are left to wander through the collection of regulations, legislation, and draft guidance documents to find the optimal way forward considering their specific situation. Some dam owners are waiting for the dust to settle regarding DCR's interpretation of the new rules. Others are forging ahead with decisions trusting that the rules won't change again.

When you step back through the legislative changes and regulatory changes over the past five years and the reasonable or unreasonable justifications of the single dam owner, you find the core issue – the PMF. The PMF is a standard long used by the dam safety industry, but rarely brought to the forefront of political discourse.

Faced with shrinking budgets, many dam owners need to make difficult decisions and prioritize their expenditures based on public safety considerations. Some dam owners are questioning the reasonableness of regulations that require protection against the 100,000-year storm event (PMF) and only a 2,500-year earthquake event. The debate will continue and amplify in the upcoming years as states are faced with dam owners unable to pay for large spillway expansions. Public policy meets public safety.

References

Virginia Soil and Water Conservation Board. 2008. Chapter 20 of the Code of Virginia, Impounding Structure Regulations.

Chapter 491 of the Code of Virginia as amended by House Bill 837, March 2008

Chapter 249 of the Code of Virginia as amended by Senate Bill 276, April 2010

Chapter 270 of the Code of Virginia as amended by House Bill 438, April 2010

Virginia Dam Safety. Floodplain Management website Accessed June 30, 2010 http://www.dcr.virginia.gov/dam_safety_and_floodplains/index.shtml

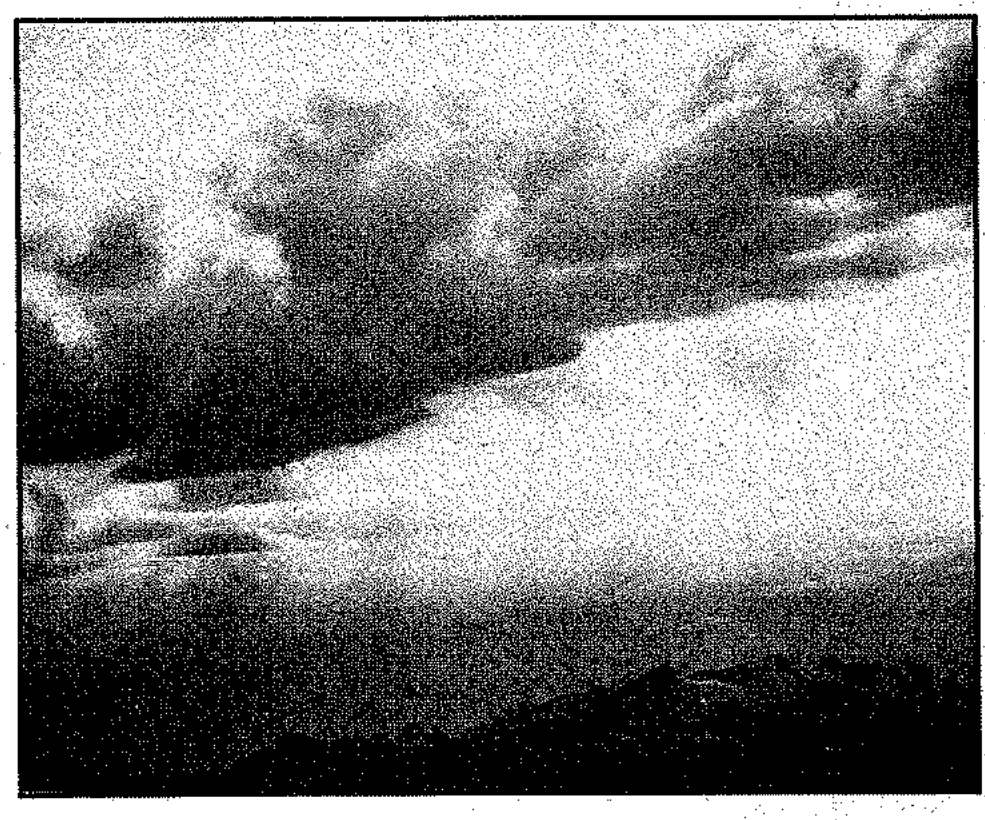
Virginia Dam Safety. 2004. Impounding Structures Regulations.

E.47. Washington



F-912
WDOE
89-51
C. 2

90101366



Characteristics of Extreme Precipitation Events in Washington State

Water Resources Program

WASHINGTON STATE DEPARTMENT OF ECOLOGY

October, 1989
89-51

90101366

PROPERTY OF STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY LIBRARY

Washington State
Department of Ecology
Water Resources Program

Characteristics of Extreme Precipitation Events in Washington State

By Melvin G. Schaefer
Dam Safety Section

DSS-01

October 1989
89-51

90101366

TABLE OF CONTENTS

	PAGE
INTRODUCTION	1
OVERVIEW	2
METHOD OF ANALYSIS	2
OBJECTIVES AND STUDY CONTENTS	2
HOMOGENEITY AND REGION DEFINITION	4
EXTREME STORM CATALOG	9
PROCESS FOR SELECTION OF EXTREME STORMS	9
SEASONALITY OF EXTREME STORMS	12
TEMPORAL DISTRIBUTION OF STORMS	15
DEFINITIONS - GLOSSARY OF TERMS	15
MACRO STORM PATTERNS	19
ANALYSIS OF DEPTH-DURATION CURVES	25
Methods of Analysis	26
Stage 1 of Analysis	27
Stage 2 of Analysis	35
CONSTRUCTION OF PROBABILISTIC DEPTH-DURATION CURVES	40
Curves Conditioned on the Total Storm Depth	49
VERIFICATION OF VALIDITY OF USING DIMENSIONLESS ORDINATES IN DEPTH-DURATION CURVES	54
TIMING CHARACTERISTICS OF HIGH INTENSITY SEGMENTS	56
SEQUENCING OF INCREMENTAL PRECIPITATION SEGMENTS	58
Sequencing of High Intensity Segments Within Storms	58
Sequencing of 6 Hour Segments Within 24 Hour ID Storms	59

ANTECEDENT STORMS 62

SPATIAL CHARACTERISTICS 65

THUNDERSTORM CHARACTERISTICS - EASTERN WASHINGTON 66

Thunderstorm Areal Coverage 66

Thunderstorms - Direction of Movement 67

Thunderstorm - Storm Shape 68

DEPTH-AREA RELATIONSHIPS 69

ASSEMBLY OF SYNTHETIC STORMS 72

METHODOLOGY FOR ASSEMBLY OF SYNTHETIC STORMS 73

SUMMARY AND CONCLUSIONS 87

ACKNOWLEDGMENTS 91

REFERENCES 92

APPENDICES 1A to 1E - EXTREME STORM CATALOG 94

APPENDIX 2 - CONSTRUCTION OF DEPTH-DURATION CURVES 102

APPENDIX 3 - WORKSHEETS FOR ASSEMBLY OF SYNTHETIC STORMS 105

ABSTRACT

Regional analyses were conducted on data from extreme storms for each of three storm durations and five climatologically homogeneous regions within Washington State. The primary objective of the study was to obtain probabilistic information about the temporal and spatial characteristics of extreme precipitation events for use in constructing synthetic storms for rainfall-runoff modeling.

Probabilistic analyses were conducted on those storm characteristics which are needed either to construct synthetic storms or to provide initial conditions for rainfall-runoff modeling. Those characteristics which were investigated included: seasonality of occurrence, macro storm patterns, precipitation depth-duration relationships, time of occurrence and temporal distribution of high intensity storm segments and the magnitude and frequency of occurrence of antecedent storms. Particular emphasis was placed on the analysis of the cross-correlation structure of the incremental precipitation amounts within storms. These analyses allowed the development of dimensionless probabilistic depth-duration curves which exhibited the statistical characteristics of observed extreme storms.

Methodologies were developed for assembly of synthetic storms using the probabilistic depth-duration data and associated storm characteristics for each of the five regions and three storm durations.

LIST OF FIGURES

		PAGE
Figure 1a.	Washington State Precipitation Gaging Network	7
Figure 1b.	Mean Annual Precipitation in Washington State and Delineation of Climatic Regions	8
Figure 2a-2f.	Frequency Histograms for Seasonality of Extreme Storms in Washington State	13
Figure 3.	Frequency Histogram for Occurrence of 2 Hour Extreme Storms Versus Time of Day	14
Figure 4.	Example of Relationships Between Independent Duration, Total Duration and Trisectors	19
Figure 5.	Generalized Macro Storm Patterns for Categorization of Extreme Storms	21
Figure 6a-6f.	Frequency Histograms for Macro Patterns of Extreme Storms in Washington State	22
Figure 7.	Depth-Duration Curve for 2 Hour ID Extreme Storm Depicting Typical Characteristics and Physical Boundaries	28
Figure 8a-8f.	Magnitude-Frequency Characteristics of Ordinate Values of Dimensionless Depth-Duration Curves	29
Figure 9.	Smoothing Functions for Improved Regression Parameters Example - 24 Hour ID Storms for Puget Sound Lowlands	39
Figure 10.	Typical Shape Characteristics of Depth-Duration Curves Example - 2 Hour ID Storms for Eastern Washington	41
Figure 11.	Comparison of Depth-Duration Curves for 24 Hour ID Storms Example - Western Washington Mountains	50

Figure 12a.	Variation of Kernel Ordinates with Storm Annual Exceedance Probability Example - 6 Hour ID Events in Western Washington	55
Figure 12b.	Relationship of Kernel Duration Precipitation Amounts to Independent Duration Precipitation Amounts Example - 6 Hour ID Events in Western Washington	55
Figure 13.	Relationship of Antecedent 24 Hour Duration Storms to 24 Hour ID Extreme Storms	63
Figure 14.	Variation of Areal Coverage with Maximum Point Rainfall for 2 Hour ID Pacific Northwest Thunderstorms	68
Figure 15.	Depth-Area Curves for 6 Hour and 24 Hour ID Storms	69
Figure 16.	Depth-Area Curves for 2 Hour ID storms	70
Figure 17.	Synthetic Mass Hyetograph for 2 Hour ID Extreme Storm for a 1 Square Mile Watershed near Olympia, WA.	78
Figure 18.	Synthetic Mass Hyetograph for 6 Hour ID Extreme Storm for a 5 Square Mile Watershed near Olympia, WA.	80
Figure 19.	Synthetic Mass Hyetograph for 24 Hour ID Extreme Storm for a 100 Square Mile Watershed near Olympia, WA.	85
Figure 20.	Comparison of Depth-Duration and Observed Mass Curves for Extreme Storm of October 14, 1945 near Snoqualmie Pass, WA.	104

LIST OF TABLES

		PAGE
Table 1.	Formulation for Region Definition	5
Table 2.	General Guideline for Selection of the Duration Most Representative of a Given Storm Event	11
Table 3.	Percentage of Extreme Storms which had Continuous or Intermittent Precipitation	20
Table 4.	Typical Macro Pattern Characteristics for Extreme Storms	23
Table 5.	Corrections Applied to Dimensionless Ordinates in Depth-Duration Curves	27
Table 6a-6c.	Cross-Correlation Matrices for Dependent Duration Ordinates	36
Table 7.	Time Increments used in Various Elements of the Study of the Temporal Distribution of Extreme Storms	38
Table 8a-81.	Dimensionless Depth-Duration Curves	42
Table 9a-9e.	Dimensionless Depth-Duration Curves with 48 Hour Kernel Ordinate for 24 Hour Extreme Storms	51
Table 10.	Frequency Characteristics for Time of Occurrence of High Intensity Segment of Extreme Storms	57
Table 11.	Sequencing Characteristics of High Intensity Segments	59
Table 12.	Frequency that the First and Second Largest 6 Hour Precipitation Segments Occur Adjacent to Each Other Within 24 Hour ID Extreme Storms	60

Table 13.	Sequencing Characteristics of the Largest 6 Hour Precipitation Segment Within 24 Hour ID Extreme Storms	61
Table 14.	Commonly Occurring Sequences for 6 Hour Precipitation Segments Within 24 Hour ID Extreme Storms	61
Table 15.	Characteristics of Storms Antecedent to Extreme Storms	63
Table 16.	Database of Selected Pacific Northwest Thunderstorms	67
Table 17.	Assembly of Synthetic Mass Hyetograph for 2 Hour ID Extreme Storm for 1 Square Mile Watershed near Olympia, WA.	77
Table 18.	Assembly of Synthetic Mass Hyetograph for 6 Hour ID Extreme Storm for 5 Square Mile Watershed near Olympia, WA.	81
Table 19.	Assembly of Synthetic Mass Hyetograph for 24 Hour ID Extreme Storm for 100 Square Mile Watershed near Olympia, WA.	84
Table 20.	Development of Depth-Duration Curve for Observed 6 Hour ID Extreme Storm of October 14, 1945 at Snoqualmie Pass, WA.	104

INTRODUCTION

The occurrence of an extreme precipitation event and the resultant flood are critical considerations in the design of many types of hydraulic structures. Dams for water resource projects, large stormwater conveyance and/or detention facilities, bridges for important transportation links and flood barriers such as major dikes and levees are examples of structures which must accommodate extreme floods to function properly.

Estimation of the flood peak discharge or the entire flood hydrograph for the design of these facilities is commonly accomplished using rainfall-runoff models. While numerous factors can affect the magnitude of an extreme flood, the magnitude of the precipitation event and its associated temporal and spatial characteristics are often dominant factors. Successful rainfall-runoff modeling of extreme floods is, therefore, highly dependent upon the use of realistic storm characteristics in the modeling process.

Given these considerations, a program of study was developed to analyze the characteristics of extreme storms. One study element was the development of methodologies to provide at-site precipitation magnitude-frequency information. Particular emphasis was placed on obtaining reasonable estimates of extreme events with annual exceedance probabilities in the range of 10^{-2} to 10^{-4}. Regional analyses techniques were selected to meet that objective and they are the subject of a separate paper titled "Regional Analyses of Precipitation Annual Maxima in Washington State" [Schaefer, 1990].

Another study element was the probabilistic examination of the temporal and spatial characteristics of extreme storms and that is the subject of this paper.

In the Pacific Northwest, minimal information previously existed on many aspects of extreme storms which are needed to properly model extreme floods. It is intended that the findings from these studies will further the understanding of extreme storms and will allow improved modeling of extreme floods.

O V E R V I E W

METHOD OF ANALYSIS

When an extreme storm occurs, it is the result of the interaction of a number of complex meteorological processes. The magnitude and/or intensity of any given meteorological process, which produces precipitation, is ultimately governed by atmospheric conditions having both random and deterministic components. This results in the measurable physical characteristics of a storm, such as the temporal and spatial distribution of the precipitation amounts, being highly variable and complex. It is, therefore, important that methods of analysis be used which recognize the stochastic nature of storms. For this reason, probabilistic methods of analysis have been used throughout this study.

OBJECTIVES AND STUDY CONTENTS

The primary objective of the study was to develop probabilistic information about the characteristics of extreme storms for use in the computer modeling of extreme floods. Specifically, information was needed for the construction of synthetic storm hyetographs which have the statistical properties of observed extreme storms. This required that information be obtained and probabilistic analyses be conducted on numerous aspects of observed storms. In addition, many of the meteorological characteristics associated with extreme storms have hydrologic implications in the modeling process. For example, knowledge about the season of occurrence of extreme storms allows inferences to be made about likely antecedent soil moisture conditions, initial streamflow magnitudes and, if appropriate, concurrent snowpack conditions. Thus meteorological characteristics, such as season of occurrence and the magnitude of antecedent storms, were also included in the study.

It was anticipated that the majority of applications of the information produced by this study would be on small watersheds.

Small watersheds are taken to be those having less than 50 square miles in drainage area, with most applications on watersheds having less than 10 square miles in drainage area. Because of the small size of the watersheds of interest, relative to the typical areal coverage of extreme storms, the emphasis of the study was directed towards at-site storm characteristics. Precipitation depth-area information has been excerpted from other sources to allow application of the results of this study on larger watersheds.

Given the aforementioned considerations, the following storm characteristics were selected for investigation:

Temporal Characteristics

- season of occurrence
- macro storm patterns
- time of occurrence and temporal distribution of high intensity segments within the storm
- correlation structure between incremental precipitation amounts within the storm and resultant depth-duration relationships
- magnitude and frequency of occurrence of storms antecedent to the extreme storm

Spatial Characteristics

- precipitation depth-area relationships
- areal coverage of thunderstorms in eastern Washington
- direction of storm movement and storm shape for thunderstorms in eastern Washington

HOMOGENEITY AND REGION DEFINITION

Inherent in the use of statistical methods is the desirability of obtaining representative samples of the data. Extreme storms, are, as the name implies, rare events. As such, insufficient data exists at any given station to produce a representative sample. To obtain sufficient data for a representative sample, data from numerous stations must be pooled for use in a "regional" analysis.

The validity of any regional analysis is dependent upon the actual homogeneity of the regional data. Herein, homogeneity refers to the condition that the particular data under analysis, either as directly observed or after some transformation, have common statistical properties. The statistical properties of interest in a particular analysis may refer to any or all of the following: mean; variance; coefficient of skew; probability distribution - and for data observed in pairs, the covariance and correlation coefficient could also be of interest.

The issues of region delineation and climatic homogeneity were a topic of much discussion and analyses in the companion paper on Regional Analyses of Precipitation Annual Maxima [Schaefer, 1990]. In that study, Washington State was subdivided into 13 climatically homogenous regions, where each region was comprised of recording stations within a small range of Mean Annual Precipitation (MAP). That produced a continuum from arid to rainforest climates where MAP ranged from 7 to 200 inches/yr, respectively. Extreme storms are a subset of the annual maxima and, thus, the aforementioned region formulation posed a logical starting point for defining homogeneous regions. However, a database of extreme storms is much smaller than a database of annual maxima. Thus, if regions were to be defined in terms of MAP it would be necessary to pool the extreme storm data over larger ranges of MAP which would result in a smaller number of regions.

A competing scheme for region definition was the formulation used by the National Weather Service (NWS) in their precipitation magnitude-frequency study, NOAA Atlas 2 [Miller et al, 1973].

In that scheme, four geographic regions were defined; comprised of the mountainous areas and central basin of eastern Washington and the lowlands and mountainous areas of western Washington (Figure 1a).

Comparison of the two schemes indicated compatibility in several areas. Regions defined geographically by the NWS were found to occupy reasonably distinct, although somewhat broad, ranges of MAP. In addition, preliminary analyses indicated homogeneity of seasonality and depth-duration characteristics from stations having either similar MAP or representing a specific geographic area.

Given the limitations of the database size, a formulation of 5 regions was proposed (Table 1) which had characteristics of both geographic delineation and definition by ranges of MAP (Figure 1b).

Table 1. Formulation for Region Definition

REGION	RANGE OF MEAN ANNUAL PRECIPITATION FOR REGION (inches)	AVERAGE VALUE OF MEAN ANNUAL PRECIPITATION OF RECORDING STATIONS (inches)	CORRESPONDS TO NWS REGION DESIGNATION	GEOGRAPHIC DESCRIPTION AND METEOROLOGIC COMPONENTS *
2	7 - 20	9.5	2	EASTERN WASHINGTON - CENTRAL BASIN Convergence
1	15 - 70	23.5	1	EASTERN WASHINGTON - MOUNTAINS Convergence and Orographic
3	20 - 70	42.0	3 partial region	WESTERN WASHINGTON - PUGET SOUND LOWLANDS Convergence
4	50 - 200	86.5	4	WESTERN WASHINGTON - MOUNTAINS Convergence and Orographic
5	70 - 120	89.0	3 partial region	WESTERN WASHINGTON - COASTAL LOWLANDS Convergence and Onshore Stimulation

* Convergence, Orographic, and Onshore Stimulation are Described in Definitions Section

Review of Table 1 reveals that the proposed regions occupy reasonably distinct ranges of MAP. Each region represents a different geographic area and is generally associated with a different mix of meteorologic components which produce precipitation.

Verification of the suitability of this formulation was accomplished by examining data homogeneity during the various analyses. In some cases, data from several regions were found to be homogeneous and were pooled for analyses. In other cases, separate analyses were conducted for each of the five regions.

In summary, the five region formulation, as described in Table 1 and delineated in Figure 1b, was found to yield reasonably homogeneous data and was accepted for use in the study.

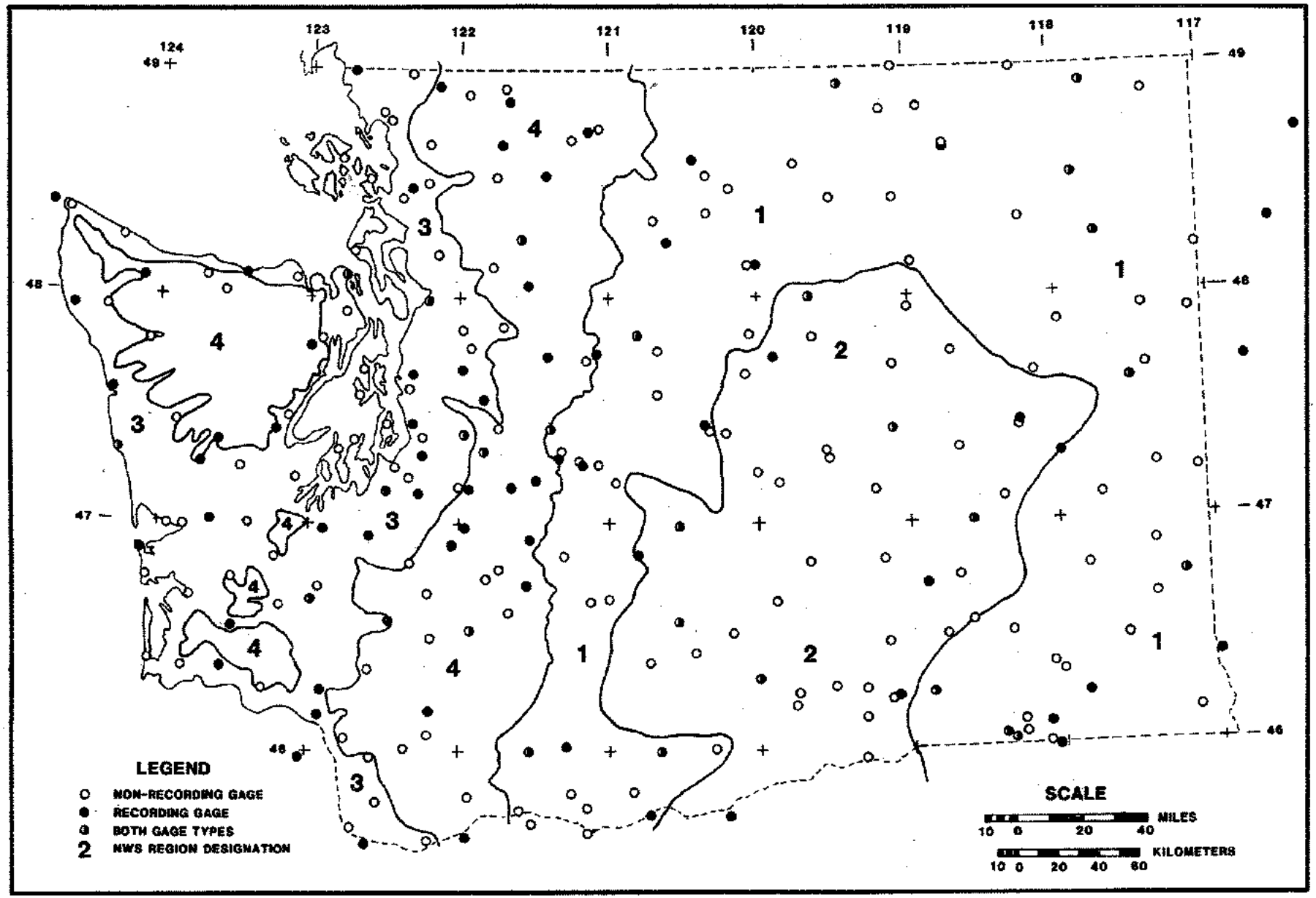


Figure 1a. Washington State Precipitation Gaging Network

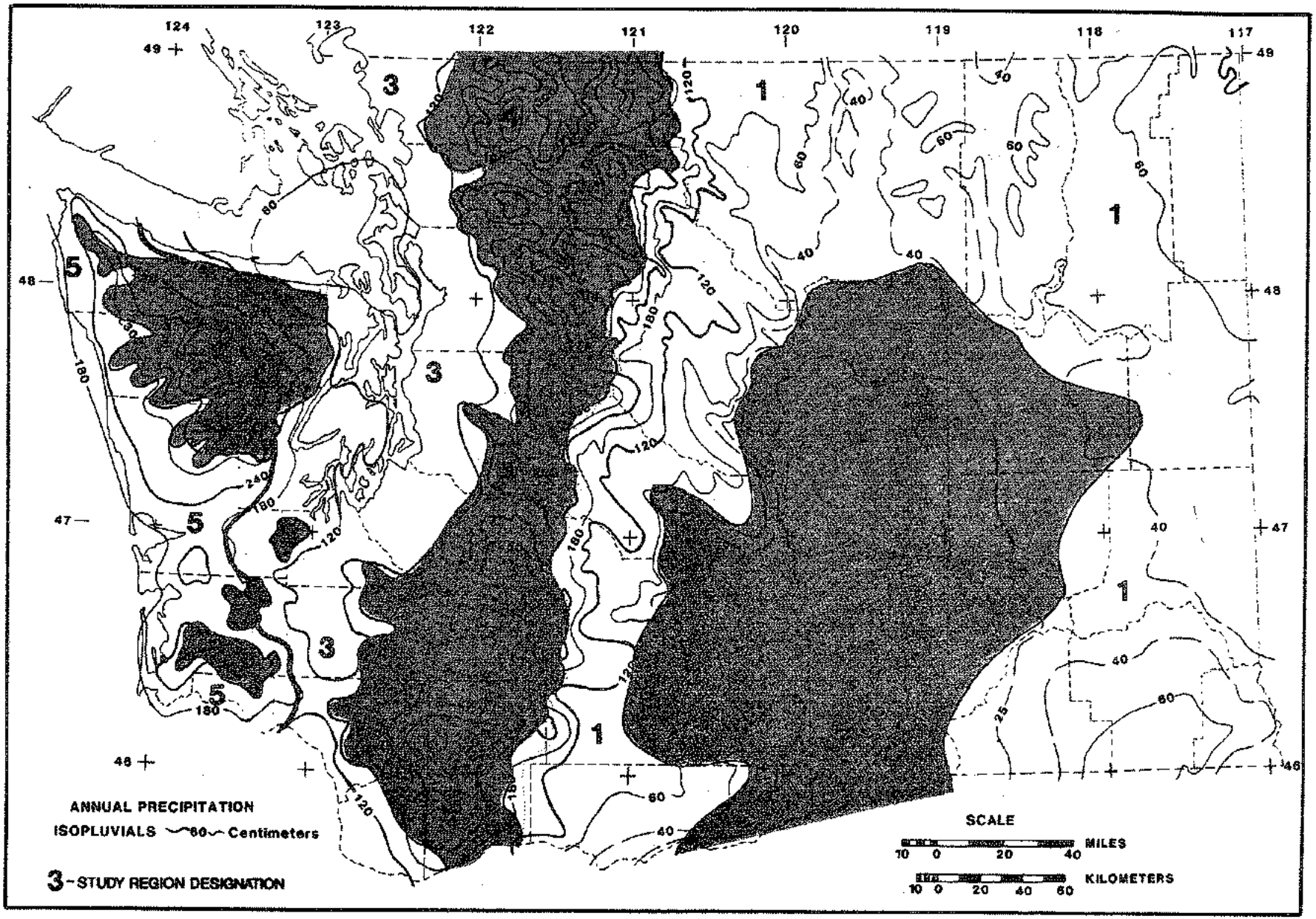


Figure 1b. Mean Annual Precipitation in Washington State and Delineation of Climatic Regions

EXTREME STORM CATALOG

To investigate the various storm characteristics, it was necessary to assemble a database of extreme storms for each of the five regions. The list of these databases is contained in Appendices 1A through 1E and is labeled the Extreme Storm Catalog.

PROCESS FOR SELECTION OF EXTREME STORMS

The term "extreme" as applied to precipitation events does not have a generally accepted meaning among the engineers and scientists who analyze and/or use the data. The selection of a threshold for defining extreme storms was made based on the needs of this study. There were three primary considerations. First, similitude considerations suggest that storms chosen for analyses should be of a similar magnitude/intensity to those which are desired for modeling of extreme floods. Second, prior studies by the NWS [Frederick et al, 1981] have shown that there are statistical differences between the characteristics of extreme events and common events. Based on these two considerations, the chosen threshold should certainly preclude the use of common events and should be set as high as practicable. Third, the threshold should be set at a level which yields databases of sufficient size to provide representative samples and thus allow valid statistical analyses.

These considerations resulted in setting the threshold for defining an extreme storm at an annual exceedance probability of 5%. Thus, any storm which contained precipitation amounts representing an at-site return period of 20 years or greater would be a candidate for inclusion in the catalog.

The following procedures were used to screen the storm data from each region and to assemble the extreme storm catalog:

- Three specific durations were selected for analyses; 2 hrs, 6 hrs, and 24 hrs.

- An annual maxima series was assembled for the precipitation data at each recording station (Figure 1a) for each of the three durations.

- Exceedance probabilities were computed for the annual maxima at each station for each duration using the Generalized Extreme Value distribution and regional analysis procedures as described by Schaefer [1990].

- The annual maxima and associated annual exceedance probabilities at each duration were then examined to identify the "extreme" storms and corresponding dates of occurrence.

- When an event, having extensive areal coverage, produced precipitation amounts which exceeded the extreme storm threshold at two or more stations within a region, only the station representing the rarest amount was retained in the catalog.

A review of the selected storm data disclosed that, occasionally, an individual event exceeded the extreme storm threshold at two or more durations. To avoid duplicity, it was decided that a storm event should only be contained in the database for a region at one of the three specified durations. Further, it was important for homogeneity considerations that storms of similar duration be grouped together in the analyses of storm characteristics. This necessitated that the databases be further screened to meet these two additional considerations.

Additional screening was accomplished wherein an extreme storm (storm date) could only appear in the catalog at one of the three durations. The selection of the duration which best represented the observed storm event was made using the following criteria:

- When a storm event was identified as extreme at two or more durations, it was placed in the database for the duration at which the corresponding precipitation amount was markedly the most rare (smallest annual exceedance probability).

- If a storm event was not markedly more rare at any specific duration, then the storm was examined to determine the effective duration [NWS, 1984]. The effective duration was defined as being the time period during which the bulk of the precipitation occurred; i.e., 90% of the total precipitation. The effective duration was then compared to the three durations under study and the criteria shown in Table 2 were used as a general guideline in selecting the representative duration.

Table 2 General Guideline for Selection of the Duration Most Representative of a Given Storm Event

REPRESENTATIVE STORM DURATION	SELECTION GUIDELINE
2 hours	effective duration < 3 hrs
6 hours	4 hrs < effective duration < 12 hrs
24 hours	15 hrs < effective duration

These procedures resulted in the selection of 252 extreme storms from 11,200 annual maxima. The 252 storms are listed in the storm catalog in Appendices 1A through 1E. These storms provided the databases which were used for all analyses on storm characteristics.

SEASONALITY OF EXTREME STORMS

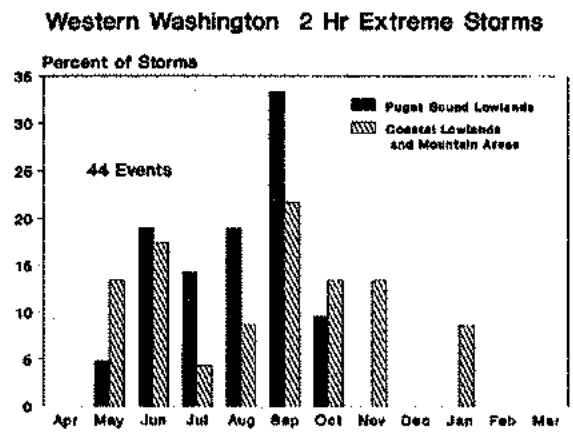
It is common knowledge that the majority of the precipitation that falls annually in the Pacific Northwest occurs in the winter months. However, only limited study [Frederick et al, 1981] has been conducted on the season of occurrence (seasonality) of extreme storms.

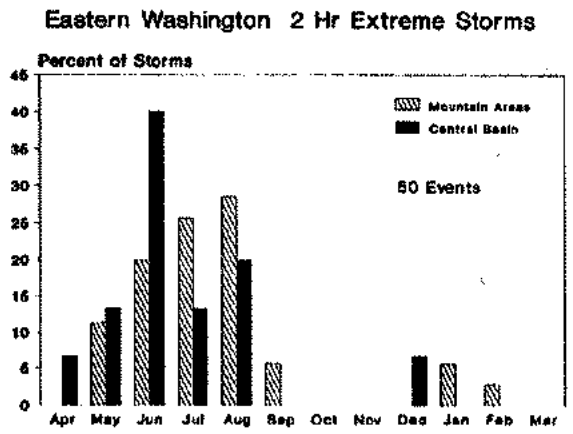
The principal application of seasonality information is in selecting the likely climatological and hydrologic conditions which will accompany an extreme storm event at a specific geographic location. Use of published climatological data [NCDC] and streamflow data [USGS] in combination with seasonality information can aid in the selection of antecedent soil moisture conditions, runoff characteristics, initial streamflow magnitudes, initial reservoir levels, etc. Where flood events produced by rain on snow are a consideration, selection of snowpack conditions can be made based on the historical record of snowfall in combination with seasonality information.

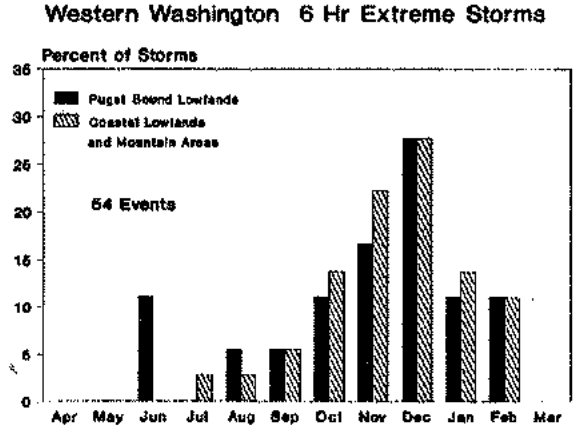
The seasonality of extreme storms was investigated in each region by constructing frequency histograms of the storm dates. In eastern Washington, there was insufficient data for the central basin at the 6 hour and 24 hour durations to provide representative samples. It was necessary to combine the central basin data (Region 2) with the data from the mountain areas (Region 1) for the seasonality analyses.

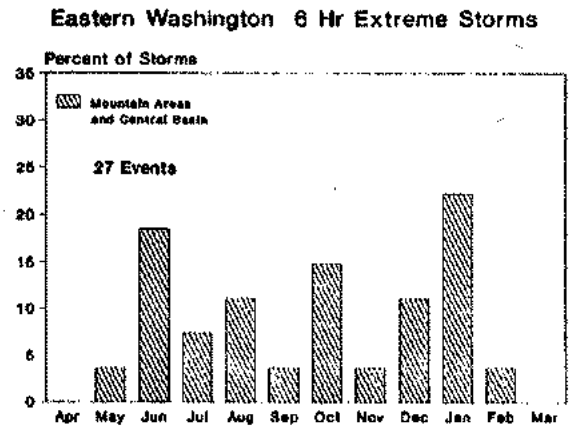
In western Washington, the amount of coastal data was marginally adequate to provide representative samples. Analyses of the coastal data (Region 5) indicated similarity to the data from the mountain areas (Region 4) at all three durations. Thus, the data from the two regions were combined in the seasonality analyses.

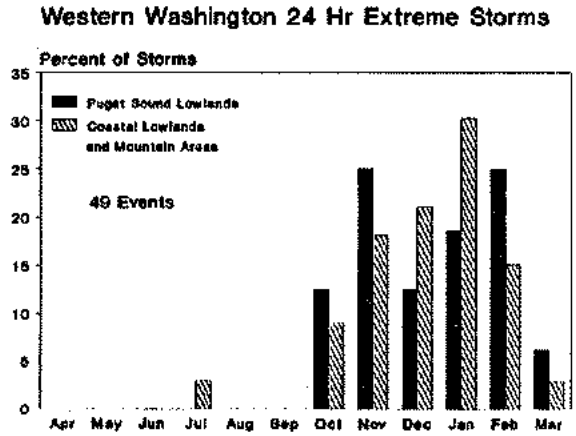
It can be seen in Figures 2a through 2f that, for each region and each duration, extreme storms occur in reasonably well-defined periods of the year. The short duration, 2 hour events, occur predominately in the warm season while the long duration, 24 hour events, occur in the late fall and winter months.

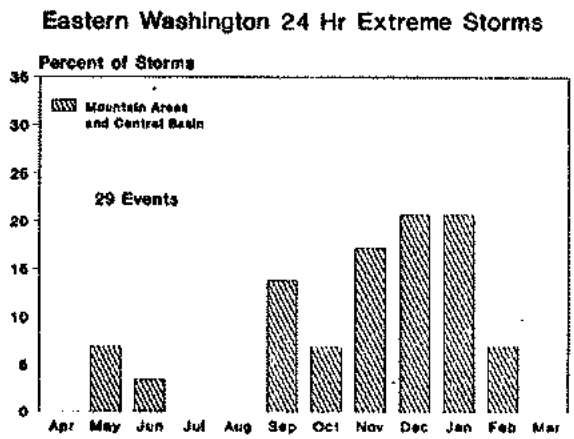












Figures 2a,2d
2b,2e
2c,2f

Frequency Histograms for Seasonality of Extreme Storms in Washington State

In general, the long duration extreme storms are produced by synoptic scale cyclonic weather systems and associated fronts. These storms are characterized by large precipitation amounts and contain moderate and relatively uniform rainfall intensities.

The short duration extreme storms are commonly produced by strong convective activity which may or may not be associated with a precipitation producing weather feature identifiable at the synoptic scale. The short duration events are characterized by high intensity, but short lived rainfall. They are a warm weather phenomenon, deriving much of the needed energy from the sun. The importance of insolation in the development of convective cells can be seen in Figure 3 where the short duration storms are seen to occur predominately in the late afternoon and early evening during the warm season.

The intermediate duration extreme storms have seasonality characteristics reflecting the causative storm types. In eastern Washington, some 6 hour events are hybrids of the 2 hour storms occurring in the warm season. Other 6 hour storms occur in the cool season and have similarities to the 24 hour storms. In western Washington, the 6 hour storms are almost always associated with cyclonic weather systems and the cool season.

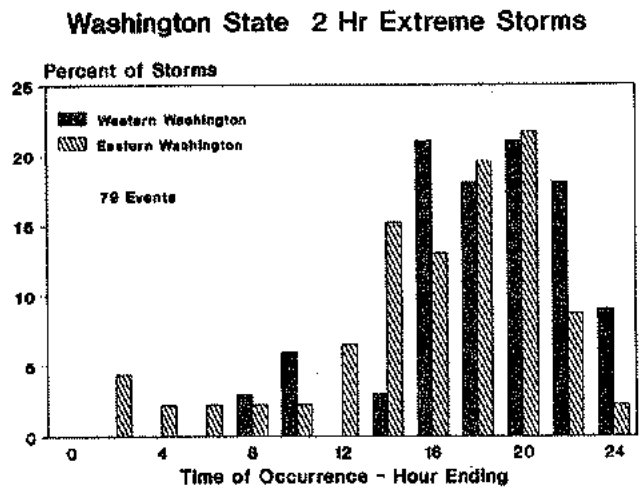


Figure 3. Frequency Histogram for Occurrence of 2 Hour Extreme Storms versus Time of Day

TEMPORAL DISTRIBUTION OF STORMS

The purpose of this component of the study was to develop probabilistic information about the temporal distribution of precipitation amounts during extreme storms. Elements of this component include probabilistic assessments of: macro storm patterns, depth-duration relationships and the time of occurrence and arrangement of high intensity storm segments.

DEFINITIONS - GLOSSARY OF TERMS

Storms are inherently complex. A discussion of the characteristics of extreme storms and the methods of analysis requires that a comprehensive nomenclature be utilized. Many of the terms used in this study are common to either meteorology or to statistical analyses. Other terms were created specific for use in this study. Most of the important terms are listed below. Those terms which are used in the study but not listed below should be found in most reference books on meteorology or statistics.

The reader may choose to review these terms now or may find it advantageous to wait until the terms are referenced in the paper.

At-site:

The term at-site is used in various ways. It may be used to distinguish analyses/data at a specific station (site) from regional analyses/data. It may be used in reference to a recording station and/or a specific geographic location. Observed at-site precipitation may be used synonymous with observed point rainfall.

Convergence Precipitation:

Convergence is intended to encompass all precipitation producing processes associated with the circulation of a cyclonic weather system.

Dependent Duration (DD):
Any specified period of time, internal to or exterior to the independent duration. The term dependent is used in the statistical sense of dependency. Precipitation during this period is dependent upon (correlated with) precipitation for the independent duration.

Depth-Duration Curve:
A precipitation mass curve created by rearrangement of observed incremental precipitation amounts in a manner which contains the largest incremental amounts at the start of the mass curve. See Appendix 2.

Effective Duration:
The period of time during which 90% of the total precipitation accumulated. This term assists in identifying the elapsed time during which the bulk of the precipitation occurred and eliminates periods of trace or small amounts which may precede or follow the period of heavy storm activity.

Extreme Storm:
An at-site precipitation amount, for a specified independent duration, which has an annual exceedance probability of 0.05 or less.

Hyetograph:
The hyetograph is a graphical representation of precipitation as it occurred with time. The graph may be discretized or continuous, displaying either incremental or accumulated (mass) precipitation or precipitation intensities.

Independent Duration (ID):
A continuous period of time during which extreme storm precipitation has occurred. Precipitation may have been continuous or intermittent during this period and precipitation may have also occurred prior to or following this period. Independent durations in these analyses are for the specific durations of 2 hrs, 6 hrs and 24 hrs.

Kernel Duration:
The dependent duration associated with the kernel ordinate.

Kernel Ordinate:
The initial dimensionless ordinate value selected in the development of probabilistic depth-duration curves. All other ordinates of the depth-duration curve are obtained by way of correlation relationships with the kernel value.

Local Storm:
A storm comprised of an isolated convective cell or group of cells, commonly referred to as a thunderstorm. Its occurrence is unrelated to any precipitation producing synoptic weather feature such as a cyclone or associated front.

Macro Storm Pattern:
A histogram describing the general shape of the incremental precipitation amounts during the total duration of the storm event.

Onshore Stimulation:
Precipitation which occurs from vertical instability and resultant lifting of atmospheric moisture in response to increased surface friction which accompanies the onshore movement of marine air.

Orographic Precipitation:
Precipitation which occurs from lifting of atmospheric moisture over mountain barriers.

Regional Analyses:
Analyses which are conducted on data collected from, and representative of, various sites within a specified region. Distinguished from at-site analyses which are conducted on data from a specific site.

Seasonality of Storms:
Frequency characteristics for the time of year (month) during which storms have been observed to occur.

Sequence:
Refers to the ordered arrangement of data. A sequence of 1342 indicates the largest data value occurred first, followed by the third, fourth and second largest values respectively.

Storm:
The term storm may be used in several ways. It may be used synonymous with the definition of "extreme storm" or it may be used generically in reference to the amount, total duration, temporal distribution or the areal coverage of precipitation.

Storm Segment:
Any selected time period and associated precipitation amount or dimensionless value.

Total Duration (TD):
A dependent duration representing a time period three times larger than the independent duration. The total duration would include the period of time containing the independent duration. The total duration must begin with precipitation, although precipitation need not be occurring at the end of the total duration.

Trisector:
Trisectors are used to subdivide the total duration into three equal periods of time. Each trisector has a duration equal in magnitude to the independent duration. Trisectors aid in categorizing and describing macro storm patterns.

MACRO STORM PATTERNS

This first element of the study investigated the temporal distribution of storms by examining the general arrangement (macro pattern) of the incremental precipitation amounts for each storm. The goal was to describe probabilistically the observed macro patterns for a given independent duration (ID) and region of occurrence.

In order to investigate the temporal characteristics of extreme storms, it was necessary to first establish a uniform approach for describing and categorizing the storms. The period of interest for investigation of storm activity was expanded to a total duration (TD) equal to three times the independent duration to include precipitation which may have preceded or followed the extreme event. The starting and ending times of the TD were selected such that precipitation was occurring at the start of the TD and the precipitation amount for the TD was the greatest for any window of time containing the ID. To facilitate the categorization of macro patterns, the total duration was subdivided into three equal time segments, called trisectors (Figure 4).

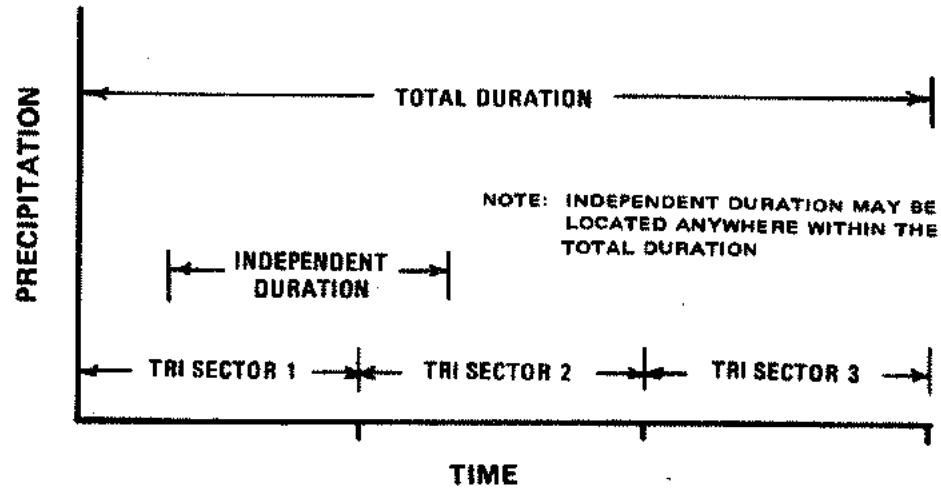


Figure 4 Example of Relationships between Independent Duration, Total Duration and Trisectors

The use of the trisector system allowed for 6 permutations in the storm pattern sequences. Consideration of both continuous and intermittent patterns produced the twelve generalized macro patterns which were used for categorizing storms (Figure 5).

To apply this categorization system, the precipitation amounts from a given storm were computed for each trisector and the amounts were compared and ordered in relative magnitude to form a sequence; i.e.: 312, 123, 213 etc. The effective duration and time of occurrence of the highest intensity were recorded and the precipitation was identified as either continuous or intermittent. Using the above information, the storm was categorized as one of the twelve macro patterns shown in Figure 5. Frequency histograms were then constructed (Figures 6a-6f) of the observed macro patterns for the various regions and independent durations.

Statistics were then compiled on the aforementioned storm characteristics. The percentage of storms which were continuous or intermittent are shown in Table 3. The typical values of the effective duration, time of highest intensity and macro storm patterns are shown in Table 4.

Table 3. Percentage of Extreme Storms which had Continuous or Intermittent Precipitation

REGIONS	INDEPENDENT DURATION (hours)	MACRO PATTERNS	
		CONTINUOUS %	INTERMITTENT %
1 & 2	2	100	0
3 & 4 & 5	2	93	7
1 & 2	6	90	10
3 & 4 & 5	6	93	7
1 & 2	24	75	25
3 & 4 & 5	24	67	33

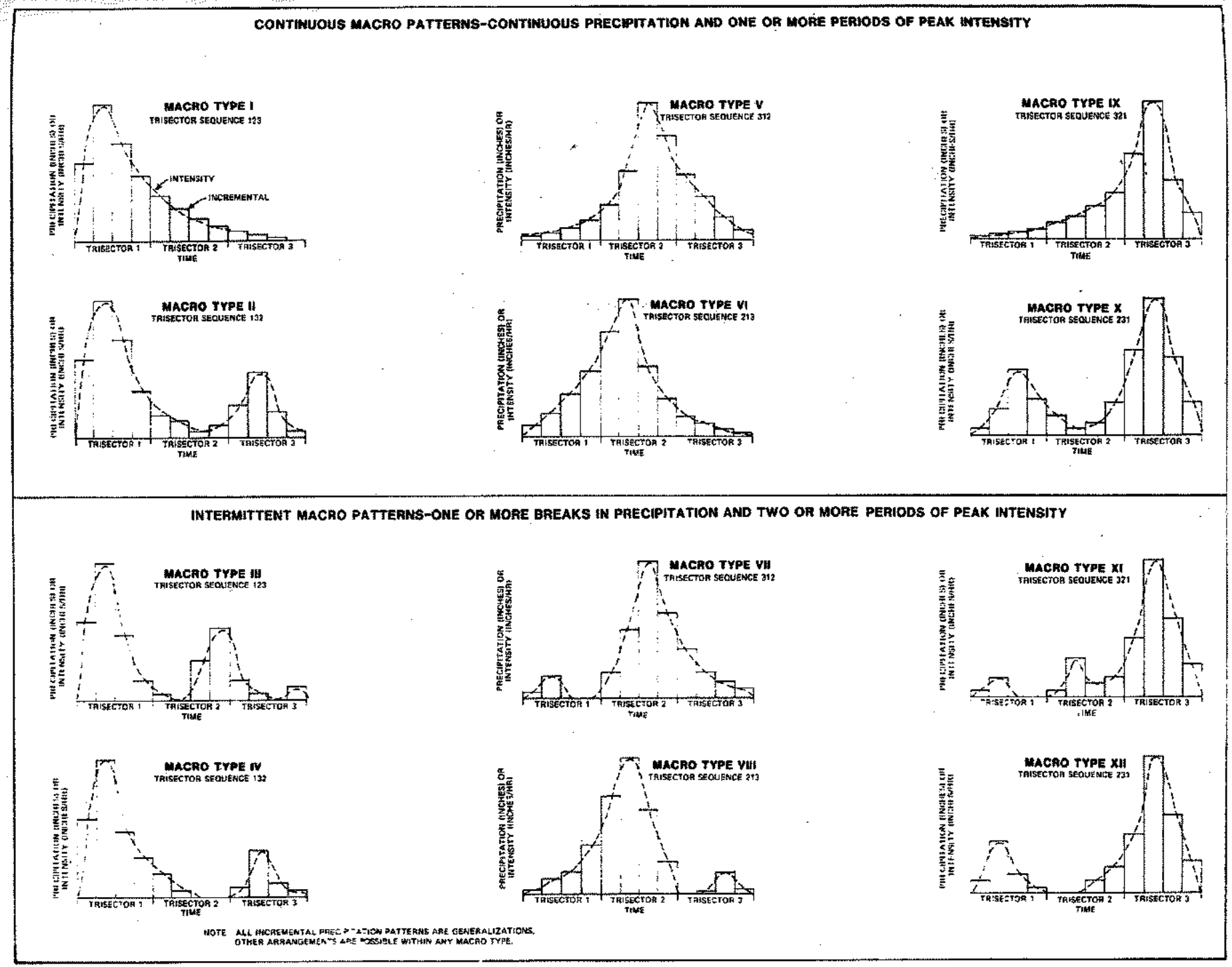
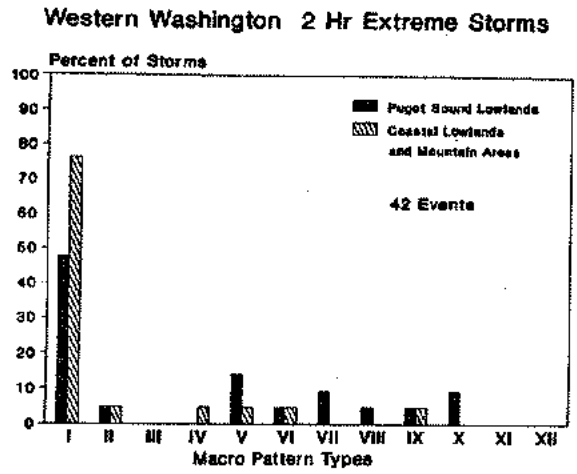
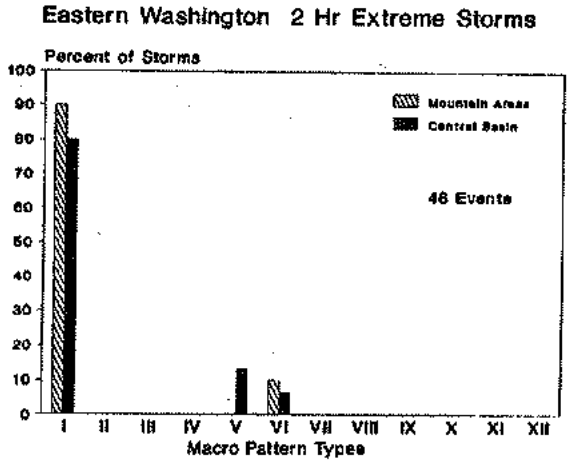
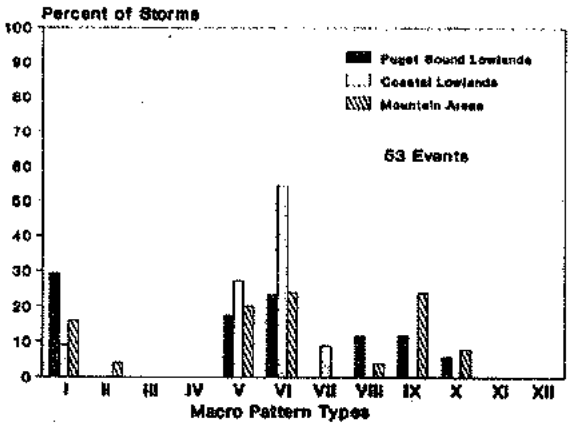
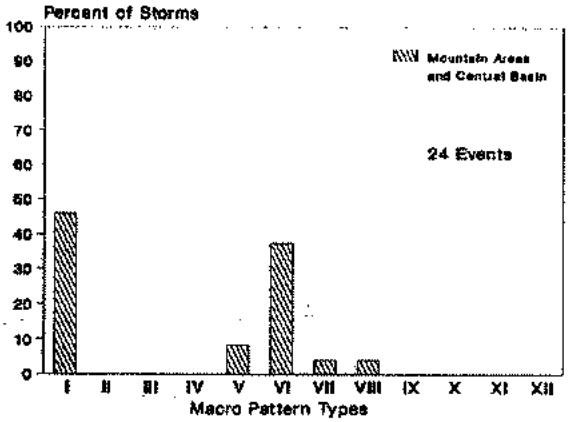


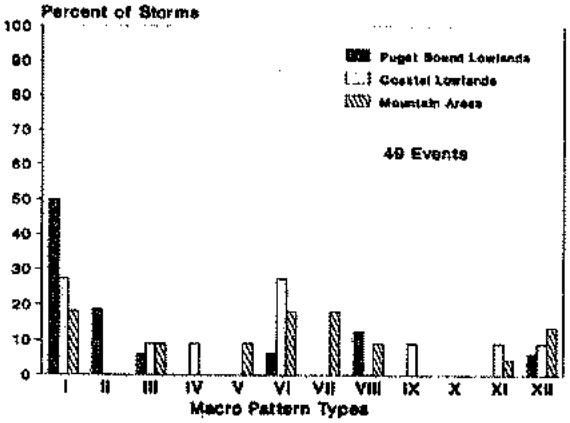
FIGURE 5. GENERALIZED MACRO STORM PATTERNS FOR CATEGORIZATION OF EXTREME STORMS.

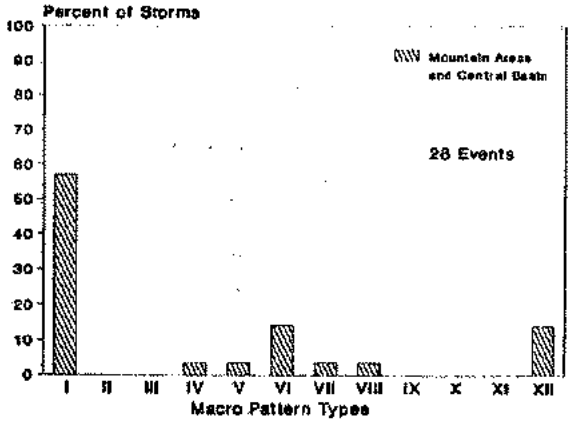












Figures 6a,6d
6b,6e
6c,6f
Frequency Histograms for Macro Patterns of Extreme Storms in Washington State

Table 4. Typical Macro Storm Characteristics For Extreme Storms

REGION	INDEPENDENT DURATION (hours)	TOTAL DURATION (hours)	MACRO STORM CHARACTERISTICS			
			TIME OF HIGHEST INTENSITY (hours)		EFFECTIVE DURATION (hours)	TYPICAL MACRO PATTERN
			MEAN	STND. DEVIATION	MEAN	
1 & 2	2	6	0.7	0.7	1.3	I
3 & 4 & 5	2	6	0.9	0.6	2.6	I
1	6	18	6.3	3.7	10.5	VI
2	6	18	6.3	3.7	9.0	VI
3	6	18	9.2	4.3	10.1	VI
4	6	18	9.2	4.3	12.5	VI
5	6	18	9.2	4.3	12.1	VI
1	24	72	23.7	16.7	40.8	I
2	24	72	15.6	13.5	30.4	I
3	24	72	25.5	14.2	38.1	I
4	24	72	33.6	14.5	45.3	VI
5	24	72	30.6	17.2	49.5	VI

A review of the results displayed in the frequency histograms and contained in Tables 3,4 reveals several trends. The 2 hour ID events, in all regions, had predominately Type I macro patterns with the high intensity segment near the beginning of the storm. Frequently, these storms were quite localized, convective events which dissipated rapidly after the occurrence of the high intensity segment. Storms of this type would carry the generic label of "thunderstorm".

Comparison of characteristics for mountain areas versus lowlands for the 6 hour and 24 hour ID storms, in either eastern or western Washington, revealed the mountain areas to always have larger effective durations. This results from persistence of the storm in mountain areas due to the orographic lifting of atmospheric moisture which is not present in lowland areas. The persistence of precipitation due to orographic effects will be quantified in the section on depth-duration relationships.

The short duration storms occurred almost exclusively as continuous events. As the duration of the storm increased, there was an increase in the percentage of intermittent macro patterns. Likewise, there was a tendency for greater variability in observed macro patterns as the storm duration became longer. While, the short duration events occured primarily as Type I macro patterns, the longer duration events exhibited a number of macro patterns which were nearly equally likely.

It will be seen later that a macro pattern for use in developing a synthetic storm will not be selected directly. Instead, the determination of an appropriate macro pattern will be governed by the selection of the time of occurrence and sequence of incremental precipitation amounts surrounding the high intensity segment. This issue will be discussed in the section on Assembly of Synthetic Storms.

ANALYSIS OF DEPTH-DURATION CURVES

The depth-duration curve [Chow, 1964], [WMO, 1974] is an analytical tool originally developed by meteorologists to allow precipitation depth and duration comparisons to be made between observed storms. In simple terms, the depth-duration curve is a precipitation mass curve created by rearrangement of observed storm precipitation in a manner which contains the largest incremental precipitation amounts at the start of the new mass curve. The primary application of depth-duration data is in the construction of synthetic storms for use in rainfall-runoff modeling.

Historically, depth-duration data have been used in a deterministic manner which does not incorporate the stochastic nature of storms. Depth-duration curves have usually been obtained from only a small number of "representative" storms and then scaled to the magnitude necessary for a specific application. An alternative procedure has been to prepare an "envelope" curve which envelopes all observed storms and which is intended to represent the most severe manner in which the storm might occur. Neither of these two procedures exploit the full amount of information contained in the observed storm data.

In this element of the study, regional analyses techniques will be utilized to statistically examine a large number of extreme storms. This procedure will allow the development of a family of probabilistic depth-duration curves which have the statistical characteristics of depth-duration data exhibited by observed extreme storms. The probabilistic framework employed herein will provide a methodology to predetermine the likelihood of the depth-duration characteristics which are used to assemble a given synthetic storm. Thus, a synthetic storm can be constructed which both suits the needs of a particular application and for which the likelihood of occurrence is reasonably known.

In the following sections, it is assumed that the reader is familiar with precipitation mass curves and with the construction of depth-duration curves. If needed, the reader may refer to Appendix 2 for a detailed discussion of depth-duration curves.

Methods of Analysis

Analyses of depth-duration curves/data were accomplished on a regional basis. Separate analyses were conducted on the collection of extreme storms at each of the three Independent Durations (IDs) for each region. A significant amount of data preparation was required prior to analysis and for sake of clarity, the progression of data preparation is listed below.

- For each storm, precipitation amounts were recorded at the time intervals shown in Table 7. A depth-duration curve was then assembled by accumulation of the incremental precipitation amounts using procedures contained in Appendix 2. Each duration for which mass precipitation was tabulated, except the ID, was labeled a Dependent Duration (DD).

Basic data needed to compute the curves were obtained either from weighing bucket charts from the National Climatic Data Center (NCDC), [NOAA, 1940-1986] or from incremental precipitation data contained in the Hourly Precipitation Data periodicals published by NCDC [NOAA, 1951-1986].

- The tabulated mass precipitation amounts at each dependent duration were made dimensionless by division by the precipitation amount for the independent duration.

- For curves which were based on incremental precipitation amounts obtained from NCDC periodicals, corrections were applied (Table 5) to the dimensionless tabulated amounts (ordinates) to account for systematic errors produced by recording precipitation at fixed intervals (Weiss, 1964).

These procedures transformed all mass precipitation amounts from the collection of extreme storms to a common scale. The dimensionless ordinates at each dependent duration could then be grouped together for analysis.

Table 5. Corrections Applied to Dimensionless Ordinates in Depth-Duration Curves

INDEPENDENT DURATION (hours)	DATA SOURCE	CORRECTIONS APPLIED TO DIMENSIONLESS DEPTH-DURATION ORDINATES TABULATION TIMES - - DEPENDENT DURATIONS MINUTES						HOURS				
		15	30	45	60	75	90	2	3	4	5	6
2	FP	1.12	1.03	1.02	1.01	1.01	1.00	1.00	1.00	0.99	0.99	0.99
2	HR	--	--	--	1.09	--	--	1.00	0.99	0.98	0.97	0.97

INDEPENDENT DURATION (hours)	DATA SOURCE	CORRECTIONS APPLIED TO DIMENSIONLESS DEPTH-DURATION ORDINATES TABULATION TIMES - - DEPENDENT DURATIONS MINUTES			HOURS										
		15	30	60	2	3	6	9	12	15	18	24	36	48	60	72
6	FP	1.13	1.04	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00					
6	HR	--	--	1.12	1.03	1.02	1.00	1.00	0.99	0.99	0.99					
24	FP	1.13	1.04	1.02	1.01	1.01	1.00	1.00	1.00	--	1.00	1.00	1.00	1.00	1.00	1.00
24	HR	--	--	1.13	1.04	1.03	1.01	1.00	1.00	--	1.00	1.00	1.00	1.00	1.00	1.00

FP -- Fisher Porter recording gage .. reporting at 15 minute intervals
HR -- Hourly recording gage .. reporting at clock-hour intervals

Stage 1 of Analyses

Probabilistic analyses were accomplished in two stages for the depth-duration data for each ID within each region. The first stage was patterned after techniques used by the NWS [Frederick et al, 1981] wherein frequency analyses were conducted on the dimensionless ordinates at each of the dependent durations. In the NWS study, the Extreme Value Type I distribution [Fisher and Tippett, 1929] was used to model the magnitude-frequency characteristics of the ordinate data. Upon review of the ordinate data it was determined that the Beta Distribution [Benjamin and Cornell, 1970] would be a better choice. The four parameter Beta distribution was selected because it is extremely flexible, being capable of modeling data with either a positive or negative skew as exhibited by the ordinate data at various dependent durations.

The Beta distribution also incorporates both an upper and lower bound which is consistent with the physical constraints inherent in the construction of depth-duration curves (Figure 7).

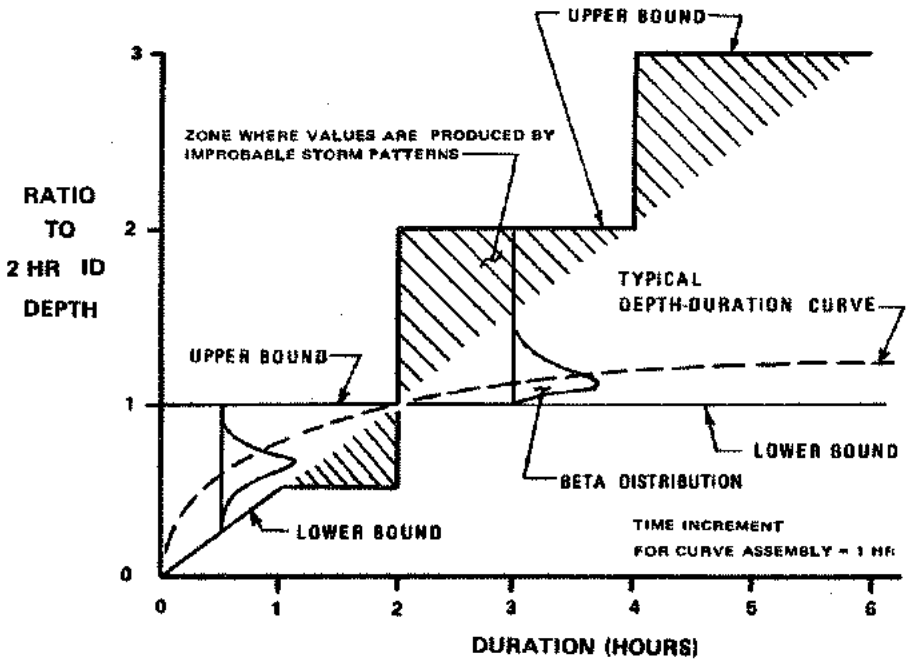


Figure 7. Depth-Duration Curve for 2 Hour ID Extreme Storm Depicting Typical Characteristics and Physical Boundaries

The probability density function for the Beta distribution is:

$$f(x) = \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\ \Gamma(\beta)} \left[(\delta_2-\delta_1)^{1-\alpha-\beta} \right] (x-\delta_1)^{\alpha-1} (\delta_2-x)^{\beta-1} \qquad (1)$$

where:

δ_1 and δ_2 are the lower and upper bounds respectively
α and β are distribution parameters
$\Gamma(\ )$ is the Gamma function

The conventional moments for the Beta distribution are:

$$\mu_x = \delta_1 + (\delta_2 - \delta_1) \left[\frac{\alpha}{(\alpha+\beta)} \right] \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\sigma_x^2 = (\delta_2 - \delta_1)^2 \left[\frac{\alpha\beta}{(\alpha+\beta)^2 (\alpha+\beta+1)} \right] \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\gamma_x = \frac{\alpha}{\sigma_x^3 (\alpha+\beta)} \left[\frac{(\alpha+2)(\alpha+1)}{(\alpha+\beta+2)(\alpha+\beta+1)} - \frac{3\alpha(\alpha+1)}{(\alpha+\beta)(\alpha+\beta+1)} + \frac{2\alpha^2}{(\alpha+\beta)^2} \right] \quad (4)$$

where:

μ_x, σ_x^2 and γ_x are the mean, variance and skew coefficient respectively

The method of moments was used to estimate the distribution parameters and quantile estimates where obtained for the ordinate values by numerical integration of the density function.

The results of the magnitude-frequency analyses are displayed in Figures 8a,b,c,d,e,f. It should be noted that the analysis of the ordinate data at each of the dependent durations is accomplished separately and without consideration of the ordinate data at other DDs. Thus, while this type of analysis provides valid magnitude-frequency information at a given DD, this information, alone, is insufficient to assemble synthetic depth-duration curves. For there are innumerable combinations in which the ordinate values, and a resultant depth-duration curve, can be assembled.

Further information is needed on the interrelationships between the ordinate values to determine the statistical dependencies. This type of analysis will be conducted in Stage 2 and will ultimately allow decisions to be made regarding which combinations are "best" and reflect observed storm characteristics.

This Page Intentionally Left Blank

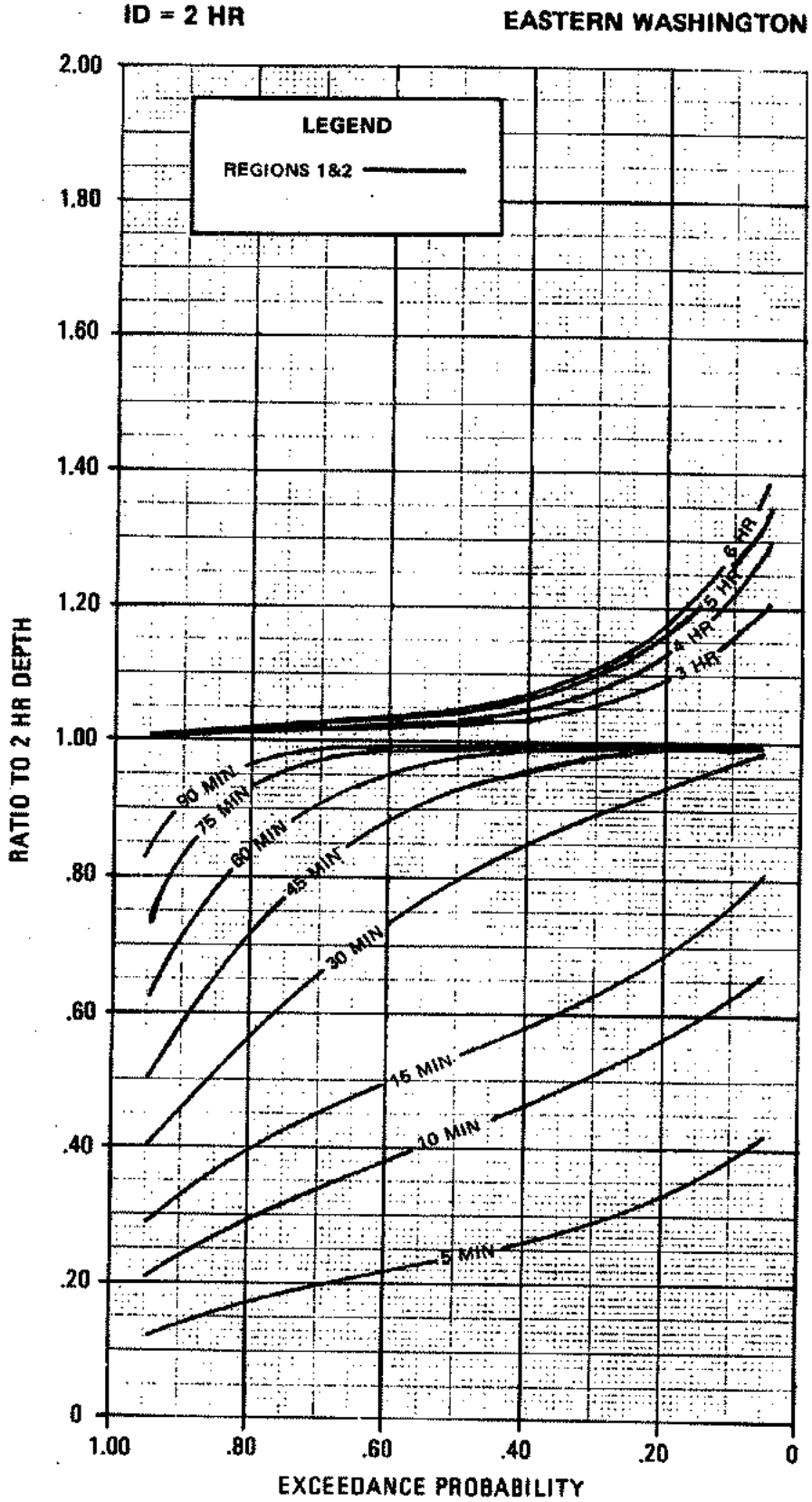


Figure 8a. Magnitude-Frequency Characteristics of Ordinate Values of Dimensionless Depth-Duration Curves for Dependent Durations of 2 Hour Extreme Storms in Eastern Washington

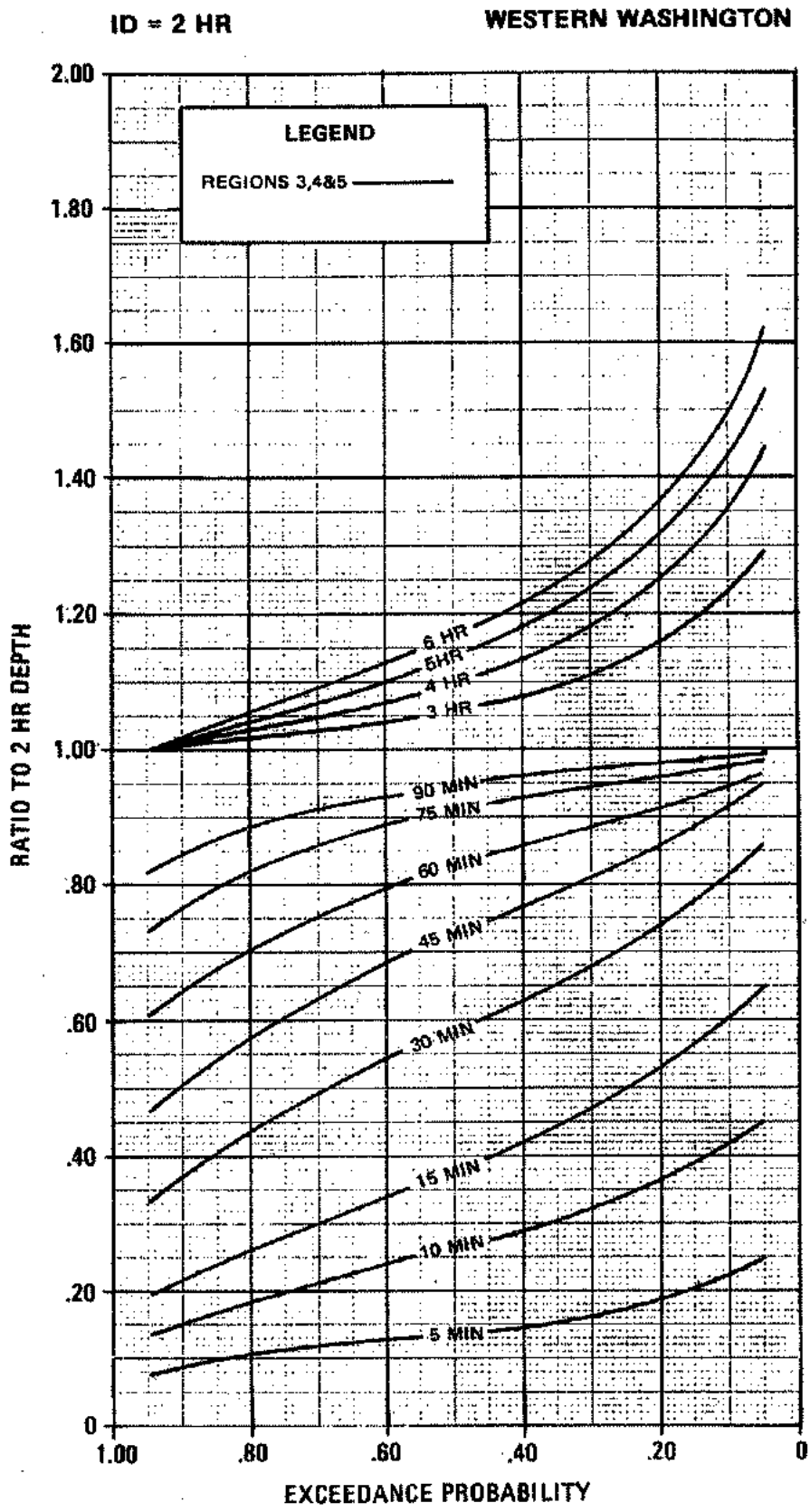


Figure 8b. Magnitude-Frequency Characteristics of Ordinate Values of Dimensionless Depth-Duration Curves for Dependent Durations of 2 Hour Extreme Storms in Western Washington

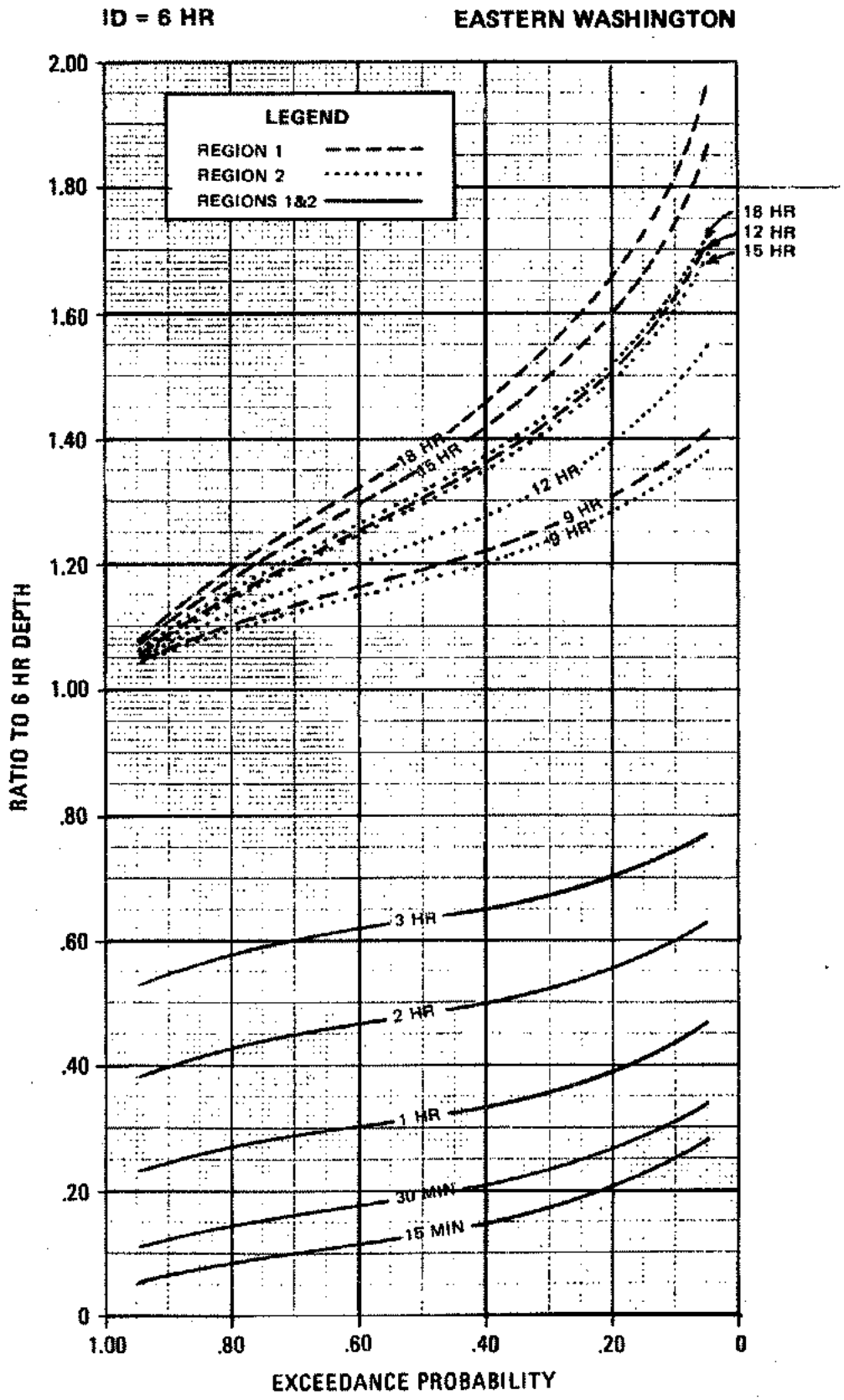


Figure 8c. Magnitude-Frequency Characteristics of Ordinate Values of Dimensionless Depth-Duration Curves for Dependent Durations of 6 Hour Extreme Storms in Eastern Washington

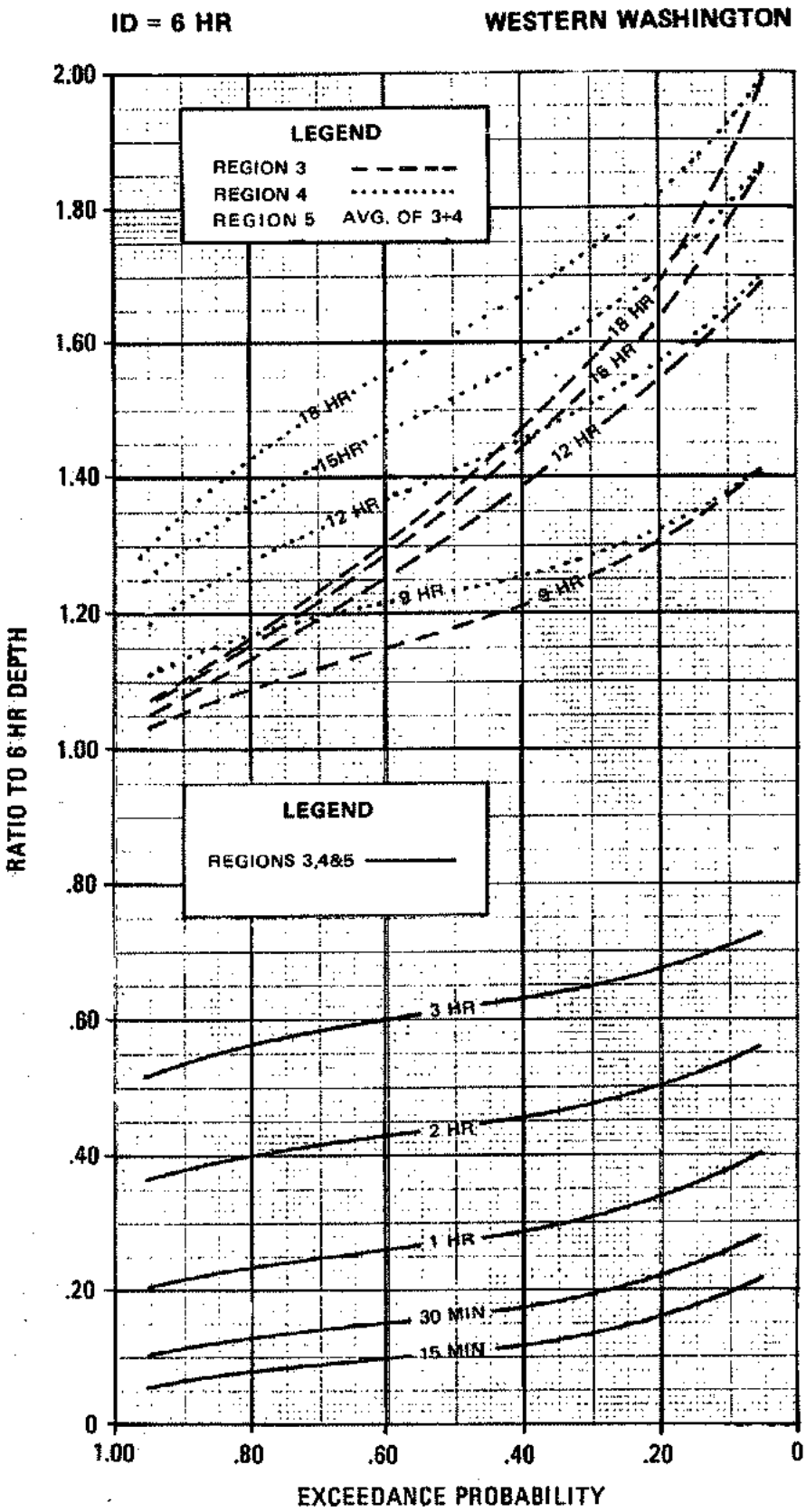


Figure 8d. Magnitude-Frequency Characteristics of Ordinate Values of Dimensionless Depth-Duration Curves for Dependent Durations of 6 Hour Extreme Storms in Western Washington

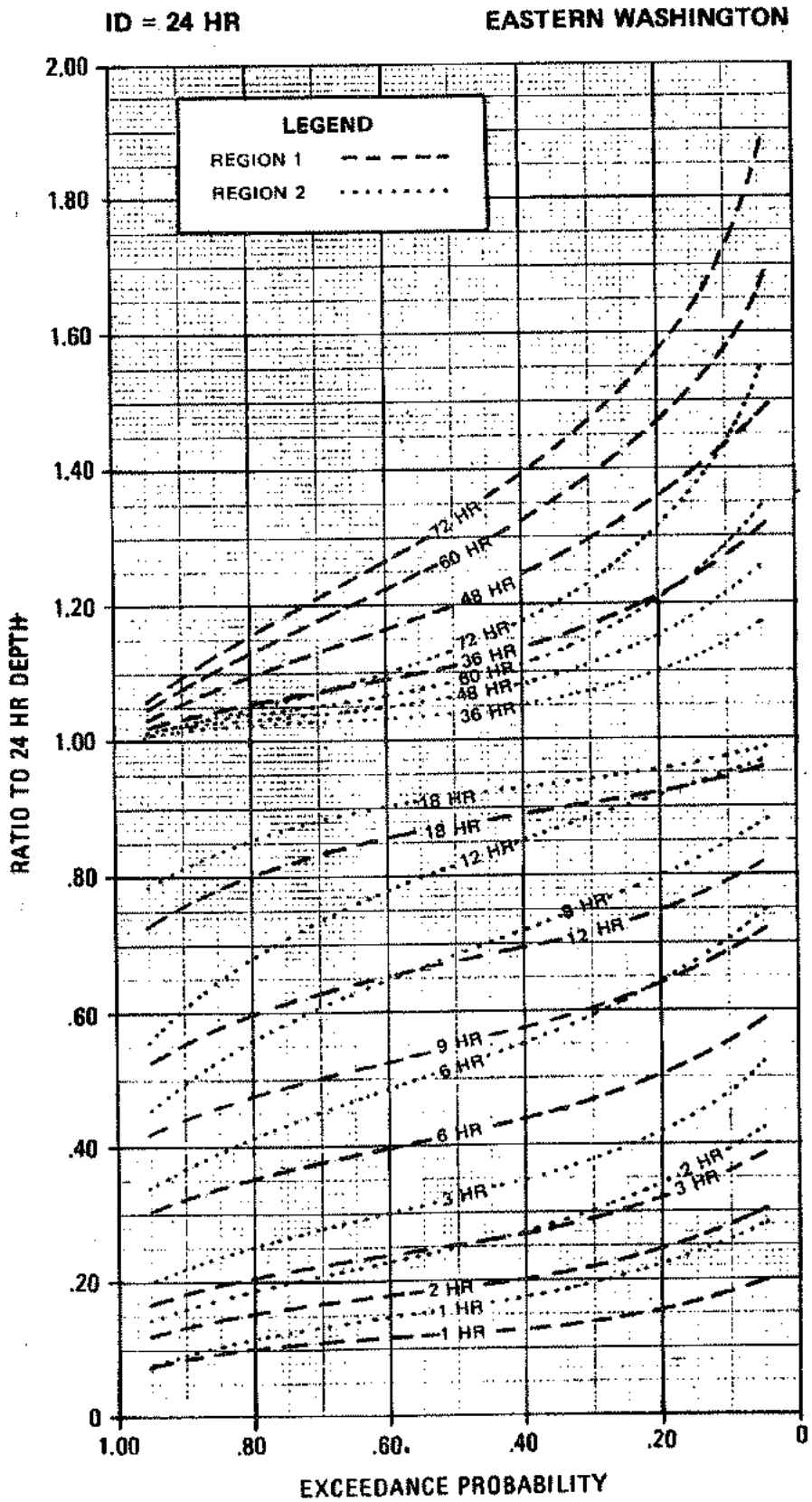


Figure 8e. Magnitude-Frequency Characteristics of Ordinate Values of Dimensionless Depth-Duration Curves for Dependent Durations of 24 Hour Extreme Storms in Eastern Washington

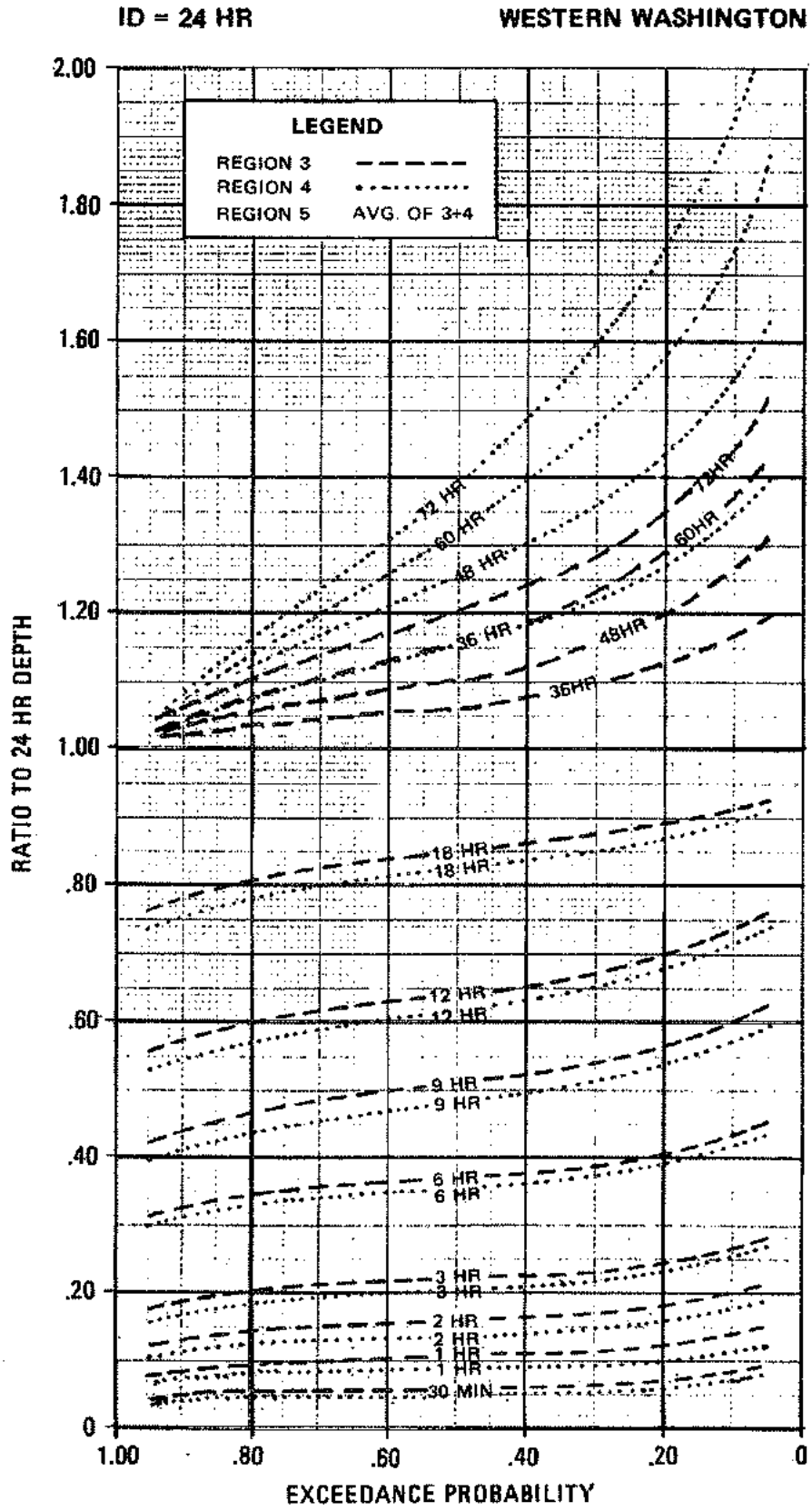


Figure 8f. Magnitude-Frequency Characteristics of Ordinate Values of Dimensionless Depth-Duration Curves for Dependent Durations of 24 Hour Extreme Storms in Western Washington

Stage 2 of Analyses

The second stage of analysis was employed to determine the interrelationships between the ordinates at the various Dependent Durations (DDs). This required an investigation of the correlation structure of the DD ordinate values. Use of the correlation structure provided information by which selection of the ordinate value for a specific DD would allow realistic selection of the ordinate values at other DDs.

The analysis was initiated by computing correlation coefficients for all DD ordinate pairs at each of the three IDs in each of the five regions. Cross-correlation matrices were then assembled for inspection. A review of the magnitude of the correlation coefficients for some typical cross-correlation matrices (Tables 6a,b,c) reveals that the DD ordinates are highly correlated. In addition, given any specific DD, the correlation coefficients are seen to decay in absolute magnitude with DDs progressively further from the starting DD. Strong correlation interrelationships exist for the short duration 2 hour ID events and there is a movement towards weaker correlation structure for the longer duration 24 hour ID events where the time increment between DDs becomes greater.

To properly utilize this information, a methodology was needed to allow the correlation structure to be incorporated into the selection of DD ordinates values for the development of the depth-duration curves. One approach available was to develop a stochastic model for generating synthetic storms. The correlation decay characteristics of the depth-duration data were indicative that models such as the Auto Regressive (AR) or Auto Regressive Moving Average (ARMA) models [Box and Jenkins, 1976] might be applicable. Variations of models of precipitation point processes such as those discussed by Woolhiser and Osborn [1985] or Istok and Boersma [1989] could also provide suitable alternatives.

After due consideration, it was determined that nothing as sophisticated as these models was needed. The primary objective of this element of the analyses was to develop a finite number of depth-duration curves which would span the range exhibited in observed storms. Therefore, a simple way to include the correlation structure would be to use disaggregation techniques

Table 6a. Cross-Correlation Matrix for Dependent Duration Ordinates for 2 Hour Extreme Storms in Eastern Washington

DEPENDENT DURATION (hours)	CROSS-CORRELATION MATRIX 2 HOUR EXTREME STORMS - - EASTERN WASHINGTON REGIONS 1 & 2 DEPENDENT DURATION (hours)											
	.08	.17	.25	.50	.75	1.00	1.25	1.50	3.00	4.00	5.00	6.00
.08	1.00	.89	.77	.74	.71	.74	.72	.70	-.74	-.66	-.47	-.42
.17	.89	1.00	.93	.78	.75	.75	.70	.67	-.67	-.63	-.43	-.33
.25	.77	.93	1.00	.86	.81	.81	.71	.68	-.71	-.66	-.57	-.49
.50	.74	.78	.86	1.00	.93	.90	.82	.77	-.79	-.73	-.63	-.58
.75	.71	.75	.81	.93	1.00	.97	.94	.88	-.79	-.72	-.64	-.60
1.00	.74	.75	.81	.90	.97	1.00	.99	.95	-.71	-.73	-.72	-.68
1.25	.72	.70	.71	.82	.94	.99	1.00	.98	-.89	-.84	-.70	-.65
1.50	.70	.67	.68	.77	.88	.95	.98	1.00	-.93	-.89	-.77	-.72
3.00	-.74	-.67	-.71	-.79	-.79	-.71	-.89	-.93	1.00	.94	.89	.88
4.00	-.66	-.63	-.66	-.73	-.72	-.73	-.84	-.89	.94	1.00	.95	.93
5.00	-.47	-.43	-.57	-.63	-.64	-.72	-.70	-.77	.89	.95	1.00	.99
6.00	-.42	-.33	-.49	-.58	-.60	-.68	-.65	-.72	.88	.93	.99	1.00

Table 6b. Cross-Correlation Matrix for Dependent Duration Ordinates for 6 Hour Extreme Storms in Western Washington Mountains

DEPENDENT DURATION (hours)	CROSS-CORRELATION MATRIX 6 HOUR EXTREME STORMS - - WESTERN WASHINGTON REGION 4 DEPENDENT DURATION (hours)								
	.25	.50	1.00	2.00	3.00	9.00	12.00	15.00	18.00
.25	1.00	.98	.91	.90	.91	-.34	-.70	-.75	-.74
.50	.98	1.00	.85	.77	.46	-.25	-.39	-.47	-.63
1.00	.91	.85	1.00	.93	.75	-.31	-.36	-.33	-.36
2.00	.90	.77	.93	1.00	.84	-.47	-.55	-.46	-.44
3.00	.91	.46	.75	.84	1.00	-.35	-.51	-.51	-.47
9.00	-.34	-.25	-.31	-.47	-.35	1.00	.87	.73	.66
12.00	-.70	-.40	-.36	-.55	-.51	.87	1.00	.91	.85
15.00	-.75	-.47	-.33	-.46	-.51	.73	.91	1.00	.97
18.00	-.74	-.63	-.36	-.44	-.47	.66	.85	.97	1.00

Table 6c. Cross-Correlation Matrix for Dependent Duration Ordinates for 24 Hour Extreme Storms in Puget Sound Lowlands

DEPENDENT DURATION (hours)	CROSS-CORRELATION MATRIX 24 HOUR EXTREME STORMS - - WESTERN WASHINGTON REGION 3 DEPENDENT DURATION (hours)										
	1.00	2.00	3.00	6.00	9.00	12.00	18.00	36.00	48.00	60.00	72.00
1.00	1.00	.92	.82	.67	.44	.74	.62	-.45	-.43	-.31	-.33
2.00	.92	1.00	.91	.74	.51	.69	.69	-.36	-.27	-.18	-.24
3.00	.82	.91	1.00	.78	.56	.70	.72	-.34	-.24	-.20	-.24
6.00	.67	.74	.78	1.00	.86	.82	.62	-.35	-.24	-.17	-.27
9.00	.44	.51	.56	.86	1.00	.85	.59	-.39	-.22	-.13	-.20
12.00	.74	.69	.70	.82	.85	1.00	.74	-.42	-.31	-.21	-.30
18.00	.62	.69	.72	.62	.59	.74	1.00	-.22	-.02	.07	.06
36.00	-.45	-.36	-.34	-.35	-.39	-.42	-.22	1.00	.90	.87	.80
48.00	-.43	-.27	-.24	-.24	-.22	-.31	-.02	.90	1.00	.89	.78
60.00	-.31	-.18	-.20	-.17	-.13	-.21	.07	.87	.89	1.00	.94
72.00	-.33	-.24	-.24	-.27	-.20	-.30	.06	.80	.78	.97	1.00

[Valencia and Schaake, 1973] and standard correlation methods to preserve the correlation structure. Specifically, this could be accomplished by selecting a representative DD and using the appropriate regression parameters of slope and intercept from the cross-correlation analyses to estimate the "expected values" of the ordinates at all other DDs.

The selection of a representative DD for each of the IDs was made with consideration of several factors. First, estimation of the flood peak discharge is often the item of primary interest in rainfall-runoff modeling. And, the occurrence of the high intensity segment of a storm normally produces the flood peak discharge. Therefore, the representative DD should be a relatively short duration DD within the ID. Second, a review of the cross-correlation matrices revealed the short duration DDs to be highly correlated. Thus, the selection of a specific DD among the shorter duration DDs was not critical. Based on these considerations, the

representative DD for use in developing probabilistic depth-duration curves for each ID was chosen such that it was from 1/4 to 1/3 the duration of the IDs. These representative durations were labeled as "Kernels" (Table 7) because they defined the initial ordinate from which all other DD ordinates would be obtained.

Table 7. Time Increments Used in Various Elements of the Study of the Temporal Distribution of Extreme Storms

INDEPENDENT DURATION (hours)	ASSEMBLY OF DEPTH DURATION CURVES (minutes)	KERNEL DEPENDENT DURATION (minutes)	HIGH INTENSITY STORM SEGMENTS (minutes)
2	60	30	15
6	180	120	60
24	360	360	60

After selection of the kernel DDs, the next step was to refine the estimates of the regression parameters obtained from the cross-correlation analyses. Improved estimates of the regression parameters were made based on a smoothing of either the correlation coefficients or the slope parameters. In either instance, the parameters to be smoothed were obtained from the cross-correlation analyses for the case where the kernel duration was the independent variable (see for example, graytone blocks in Tables 6a,b,c).

Three separate smoothing functions were employed (Figure 9). A first order polynomial was fit to the correlation coefficient data for DDs less than the kernel DD and a second order polynomial was fit to the data for DDs greater than the kernel DD but less than the ID. In both cases, the solution polynomials were constrained to a value of unity at the kernel DD. Improved estimates of the regression parameters were then made based on the new estimates of the cross-correlation coefficients and the observed sample statistics for the kernel and DD ordinate data.

Thus, for linear correlation where: $Y = a + bX$ . . . . (5)
Improved estimates of the regression parameters a and b are:

$$\bar{Y} = \hat{a} + \hat{b}\bar{X} \qquad \text{or} \qquad \bar{Y} = \hat{a} + \hat{\rho}(S_y/S_x)\,\bar{X} \quad . \ . \ . \ . \ (6)$$

where:

$\hat{\rho}$ is the improved estimate of the correlation coefficient
$\hat{a}$ and $\hat{b}$ are the improved estimates of the intercept and slope
$\bar{X}$ and S_x are the mean, standard deviation of the Kernel ordinate data
$\bar{Y}$ and S_y are the mean, standard deviation of some specified DD data

For DDs greater than the ID, the slope parameters from the regression analyses were plotted against the DDs and a second order polynomial was fit to the coefficients (Figure 9). The slope parameters were used in lieu of the correlation coefficients because they generally allowed a simpler function description. The solution for this case was constrained to a value of zero slope at the ID. Improved estimates of the intercept parameters were then made based on the new estimates of the slope parameters and the observed sample statistics for the kernel and DD ordinate data (equation 6).

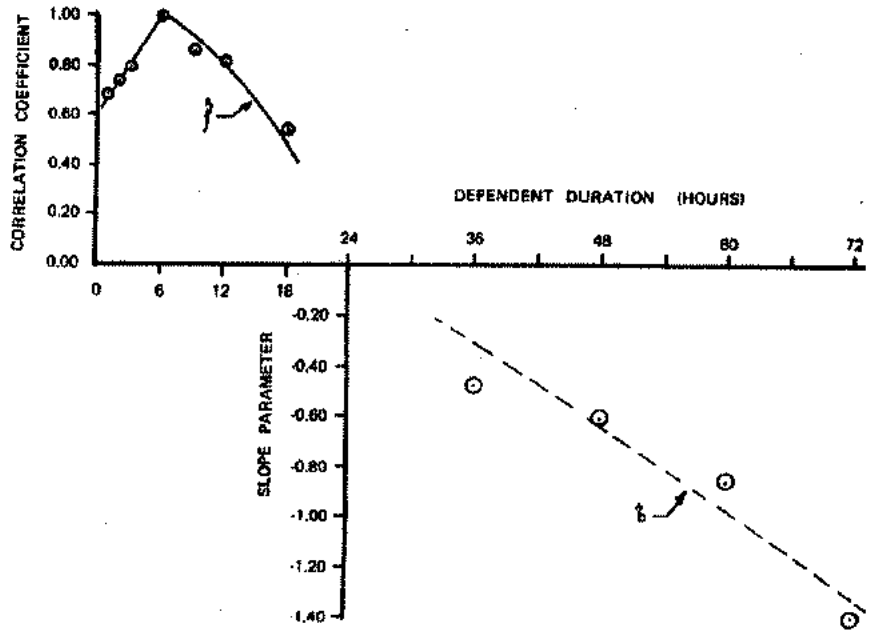


Figure 9. Smoothing Functions for Improving Regression Parameters
Example - 24 Hour ID Storms for Puget Sound Lowlands

CONSTRUCTION OF PROBABILISTIC DEPTH-DURATION CURVES

The stage 1 and 2 solutions provided the framework for the construction of the probabilistic depth-duration curves. Curves were generated for each ID and region as follows:

- Nine levels of exceedance probability were selected for use in developing probabilistic depth-duration curves.

- The kernel ordinate was computed for each of the nine exceedance probabilities based on the results of fitting the Beta distribution to the ordinate data for the kernel DD. (Stage 1 solution).

- The ordinate values of each probabilistic depth-duration curve were then computed using the previously computed kernel ordinate and the improved estimates of the regression parameters from the cross-correlation analyses. (Stage 2 solutions).

The resultant depth-duration curves were then examined to verify the existence of a reasonably smooth monotonically increasing function with the the first derivative, the slope of the curve, exhibiting a continuously decreasing positive magnitude over the initial period of time equal to the ID. Both of these characteristics are desirable properties of synthetic depth-duration curves. For some curves, minor adjustments of the ordinate values were made to produce the characteristics described above.

Probabilistic depth-duration curves generated by these procedures are shown in Tables 8a,b,c,d,e,f,g,h,i,j,k,l. After developing these curves, it is appropriate to examine their characteristics. A review of typical correlation matrices (Tables 6a,b,c) in combination with the curves in Tables 8a to 8l, reveals several common characteristics. For DDs which are shorter than the ID, there is positive correlation between DDs: i.e. above average ordinates are associated with above average ordinates; below

average ordinates are associated with below average ordinates. For DDs which are longer than the ID, there is negative correlation with ordinates for DDs which are less than the ID. This produces synthetic depth-duration curves having certain characteristic shapes regardless of the ID. Curves with sharp rising limbs have predominately flat tails. Conversely, curves with more flattened rising limbs have heavier (steeper) tails (Figure 10). These characteristic shapes simply reflect the observed correlation structure of observed storms - it is quite rare to have the dimensionless depth-duration curve from an observed storm with an unusually steep rising limb and an unusually heavy tail.

With those thoughts in mind, an interpretation can be made of the probabilistic labels attached to the curves. In general, for a curve with a 0.20 exceedance probability, there would be a 20% chance that any given extreme storm would have a steeper rising limb, reflecting more severe rainfall intensities, than that for the 20% curve. In addition, these curves are comprised of expected values for all DD ordinates conditioned on the magnitude of the kernel ordinate. Thus, the depth-duration curve with a 20% label represents the most likely manner in which the curve will occur, given that the 20% kernel ordinate has occurred.

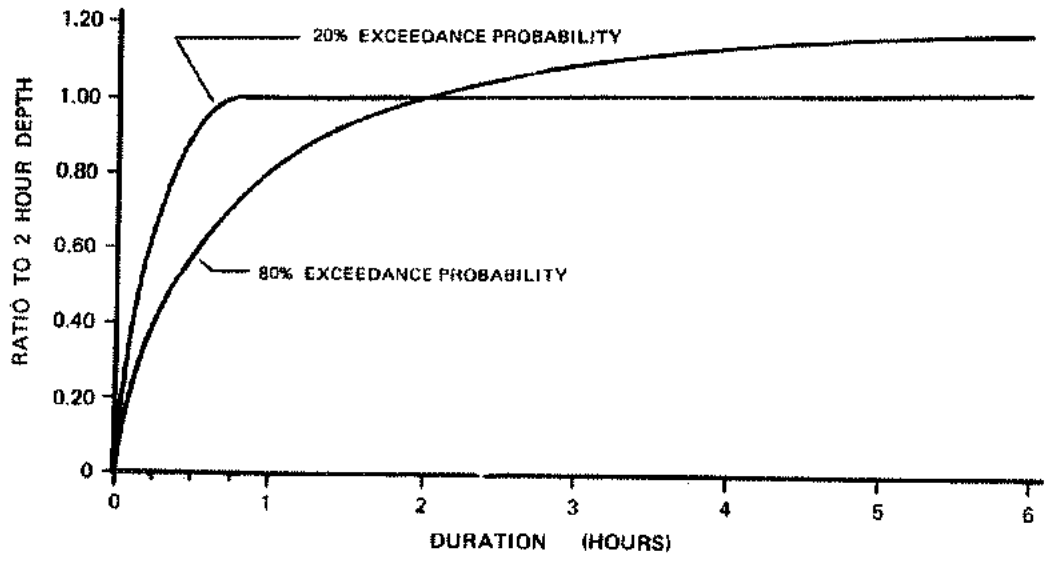


Figure 10. Typical Shape Characteristics of Depth-Duration Curves Example - 2 Hour ID Storms for Eastern Washington

Tables 8a,b Dimensionless Depth-Duration Curves for 2 Hour Extreme Storms in Washington State

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES DIMENSIONLESS DEPTH-DURATION CURVES 2 HOUR EXTREME STORMS - EASTERN WASHINGTON - ALL AREAS - REGIONS 1 & 2 KERNEL VALUES AT 0.50 HOURS DURATION (hours)												
	.08	.17	.25	.50	.75	1.00	1.25	1.50	2.00	3.00	4.00	5.00	6.00
.95	.123	.223	.277	.422	.560	.686	.797	.900	1.000	1.160	1.208	1.242	1.246
.90	.149	.264	.331	.483	.621	.733	.829	.915	1.000	1.139	1.180	1.210	1.216
.80	.188	.325	.411	.574	.712	.803	.877	.937	1.000	1.106	1.138	1.162	1.171
.67	.227	.387	.492	.685	.804	.875	.925	.960	1.000	1.074	1.095	1.114	1.126
.50	.266	.449	.572	.794	.896	.945	.973	.982	1.000	1.041	1.057	1.070	1.082
.33	.297	.499	.636	.882	.969	1.000	1.000	1.000	1.000	1.015	1.027	1.037	1.044
.20	.318	.531	.679	.940	1.000	1.000	1.000	1.000	1.000	1.008	1.014	1.018	1.021
.10	.330	.551	.704	.975	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
.05	.335	.559	.714	.989	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES DIMENSIONLESS DEPTH-DURATION CURVES 2 HOUR EXTREME STORMS - WESTERN WASHINGTON - ALL AREAS - REGIONS 3, 4 & 5 KERNEL VALUES AT 0.50 HOURS DURATION (hours)												
	.08	.17	.25	.50	.75	1.00	1.25	1.50	2.00	3.00	4.00	5.00	6.00
.95	.091	.158	.211	.355	.498	.639	.776	.888	1.000	1.166	1.265	1.328	1.356
.90	.098	.176	.240	.387	.529	.668	.792	.895	1.000	1.155	1.246	1.306	1.335
.80	.110	.202	.283	.440	.582	.711	.830	.905	1.000	1.138	1.218	1.273	1.303
.67	.123	.232	.332	.504	.641	.761	.857	.917	1.000	1.119	1.187	1.236	1.268
.50	.139	.267	.386	.586	.712	.814	.888	.931	1.000	1.097	1.149	1.193	1.226
.33	.155	.304	.442	.671	.783	.867	.920	.945	1.000	1.074	1.111	1.148	1.183
.20	.172	.337	.493	.747	.849	.916	.949	.969	1.000	1.053	1.089	1.120	1.144
.10	.188	.368	.542	.821	.911	.962	.977	.990	1.000	1.037	1.074	1.099	1.106
.05	.197	.390	.575	.871	.955	.980	.989	.996	1.000	1.021	1.047	1.060	1.078

Tables 8c,d Dimensionless Depth-Duration Curves for 6 Hour Extreme Storms in Eastern Washington

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES DIMENSIONLESS DEPTH-DURATION CURVES 6 HOUR EXTREME STORMS - EASTERN WASHINGTON - MOUNTAINS - REGION 1 KERNEL VALUES AT 2.00 HOURS DURATION (hours)									
	.25	.50	1.00	2.00	3.00	6.00	9.00	12.00	15.00	18.00
.95	.079	.134	.235	.405	.575	1.000	1.314	1.475	1.587	1.621
.90	.087	.144	.247	.420	.588	1.000	1.299	1.453	1.560	1.595
.80	.099	.158	.266	.440	.606	1.000	1.276	1.421	1.522	1.558
.67	.111	.173	.286	.464	.626	1.000	1.251	1.386	1.481	1.519
.50	.126	.191	.309	.498	.650	1.000	1.222	1.345	1.432	1.472
.33	.143	.210	.335	.534	.676	1.000	1.190	1.300	1.379	1.420
.20	.159	.230	.361	.571	.703	1.000	1.158	1.254	1.324	1.368
.10	.178	.252	.391	.613	.733	1.000	1.121	1.203	1.263	1.309
.05	.194	.271	.416	.648	.758	1.000	1.090	1.159	1.211	1.259

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES DIMENSIONLESS DEPTH-DURATION CURVES 6 HOUR EXTREME STORMS - EASTERN WASHINGTON - CENTRAL BASIN - REGION 2 KERNEL VALUES AT 2.00 HOURS DURATION (hours)									
	.25	.50	1.00	2.00	3.00	6.00	9.00	12.00	15.00	18.00
.95	.079	.134	.235	.405	.575	1.000	1.289	1.410	1.487	1.511
.90	.087	.144	.247	.420	.588	1.000	1.274	1.388	1.460	1.485
.80	.099	.158	.266	.440	.606	1.000	1.251	1.356	1.422	1.448
.67	.111	.173	.286	.464	.626	1.000	1.226	1.321	1.381	1.409
.50	.126	.191	.309	.498	.650	1.000	1.197	1.280	1.332	1.362
.33	.143	.210	.335	.534	.676	1.000	1.165	1.235	1.279	1.310
.20	.159	.230	.361	.571	.703	1.000	1.133	1.189	1.224	1.258
.10	.178	.252	.391	.613	.733	1.000	1.096	1.138	1.169	1.199
.05	.194	.271	.416	.648	.758	1.000	1.065	1.094	1.122	1.149

Tables 8e,f Dimensionless Depth-Duration Curves for 6 Hour Extreme Storms in Western Washington

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES DIMENSIONLESS DEPTH-DURATION CURVES 6 HOUR EXTREME STORMS - WESTERN WASHINGTON - PUGET SOUND LOWLANDS - REGION 3 KERNEL VALUES AT 2.00 HOURS DURATION (hours)									
	.25	.50	1.00	2.00	3.00	6.00	9.00	12.00	15.00	18.00
.95	.075	.121	.210	.384	.557	1.000	1.248	1.401	1.495	1.533
.90	.080	.128	.219	.394	.566	1.000	1.241	1.389	1.481	1.520
.80	.089	.139	.233	.410	.581	1.000	1.231	1.372	1.461	1.500
.67	.099	.151	.249	.428	.597	1.000	1.220	1.353	1.438	1.478
.50	.111	.166	.268	.450	.617	1.000	1.205	1.329	1.410	1.450
.33	.124	.184	.290	.482	.640	1.000	1.189	1.301	1.378	1.418
.20	.139	.202	.314	.515	.664	1.000	1.171	1.272	1.344	1.385
.10	.156	.224	.341	.554	.692	1.000	1.151	1.239	1.304	1.346
.05	.170	.242	.364	.587	.716	1.000	1.134	1.210	1.270	1.312

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES DIMENSIONLESS DEPTH-DURATION CURVES 6 HOUR EXTREME STORMS - WESTERN WASHINGTON - MOUNTAINS - REGION 4 KERNEL VALUES AT 2.00 HOURS DURATION (hours)									
	.25	.50	1.00	2.00	3.00	6.00	9.00	12.00	15.00	18.00
.95	.075	.121	.210	.384	.557	1.000	1.296	1.486	1.611	1.689
.90	.080	.128	.219	.394	.566	1.000	1.291	1.478	1.601	1.679
.80	.089	.139	.233	.410	.581	1.000	1.283	1.466	1.586	1.665
.67	.099	.151	.249	.428	.597	1.000	1.274	1.453	1.569	1.648
.50	.111	.166	.268	.450	.617	1.000	1.264	1.436	1.548	1.627
.33	.124	.184	.290	.482	.640	1.000	1.252	1.417	1.523	1.604
.20	.139	.202	.314	.515	.664	1.000	1.239	1.397	1.498	1.579
.10	.156	.224	.341	.554	.692	1.000	1.224	1.374	1.468	1.550
.05	.170	.242	.364	.587	.716	1.000	1.211	1.354	1.443	1.525

Table 8g Dimensionless Depth-Duration Curves for 6 Hour Extreme Storms in Western Washington

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES DIMENSIONLESS DEPTH-DURATION CURVES 6 HOUR EXTREME STORMS - WESTERN WASHINGTON - COASTAL LOWLANDS - REGION 5 KERNEL VALUES AT 2.00 HOURS DURATION (hours)									
	.25	.50	1.00	2.00	3.00	6.00	9.00	12.00	15.00	18.00
.95	.075	.121	.210	.384	.557	1.000	1.272	1.444	1.554	1.612
.90	.080	.128	.219	.394	.566	1.000	1.266	1.434	1.542	1.601
.80	.089	.139	.233	.410	.581	1.000	1.257	1.420	1.524	1.583
.67	.099	.151	.249	.428	.597	1.000	1.247	1.403	1.504	1.563
.50	.111	.166	.268	.450	.617	1.000	1.235	1.382	1.479	1.539
.33	.124	.184	.290	.482	.640	1.000	1.220	1.359	1.450	1.511
.20	.139	.202	.314	.515	.664	1.000	1.205	1.334	1.420	1.481
.10	.156	.224	.341	.554	.692	1.000	1.188	1.305	1.385	1.447
.05	.170	.242	.364	.587	.716	1.000	1.173	1.281	1.355	1.418

Tables 8h,i Dimensionless Depth-Duration Curves for 24 Hour Extreme Storms in Eastern Washington

ORDINATE VALUES

DIMENSIONLESS DEPTH-DURATION CURVES

24 HOUR EXTREME STORMS - EASTERN WASHINGTON - MOUNTAINS - REGION 1

KERNEL VALUES AT 6.00 HOURS

EXCEEDANCE PROBABILITY FOR KERNEL	DURATION (hours) .50	1.00	2.00	3.00	6.00	9.00	12.00	18.00	24.00	36.00	48.00	60.00	72.00
.95	.038	.072	.130	.177	.308	.439	.570	.826	1.000	1.180	1.303	1.393	1.458
.90	.041	.079	.140	.190	.323	.455	.586	.832	1.000	1.173	1.292	1.380	1.445
.80	.049	.090	.156	.209	.351	.481	.608	.841	1.000	1.162	1.275	1.361	1.425
.67	.059	.102	.173	.230	.382	.509	.634	.850	1.000	1.151	1.257	1.339	1.403
.50	.070	.117	.194	.256	.420	.544	.665	.862	1.000	1.136	1.235	1.314	1.377
.33	.084	.133	.217	.285	.462	.586	.699	.874	1.000	1.120	1.210	1.285	1.347
.20	.097	.150	.241	.315	.506	.630	.735	.888	1.000	1.104	1.184	1.255	1.317
.10	.113	.169	.269	.349	.555	.679	.775	.903	1.000	1.085	1.155	1.222	1.282
.05	.126	.185	.292	.378	.597	.721	.809	.915	1.000	1.069	1.133	1.193	1.253

ORDINATE VALUES

DIMENSIONLESS DEPTH-DURATION CURVES

24 HOUR EXTREME STORMS - EASTERN WASHINGTON - CENTRAL BASIN - REGION 2

KERNEL VALUES AT 6.00 HOURS

EXCEEDANCE PROBABILITY FOR KERNEL	DURATION (hours) .50	1.00	2.00	3.00	6.00	9.00	12.00	18.00	24.00	36.00	48.00	60.00	72.00
.95	.054	.107	.164	.219	.360	.501	.641	.848	1.000	1.087	1.150	1.189	1.262
.90	.062	.116	.177	.236	.380	.522	.661	.855	1.000	1.082	1.141	1.178	1.250
.80	.072	.128	.195	.258	.413	.553	.688	.865	1.000	1.074	1.129	1.162	1.233
.67	.083	.142	.214	.282	.447	.584	.716	.875	1.000	1.067	1.116	1.146	1.216
.50	.095	.157	.238	.309	.487	.624	.748	.887	1.000	1.058	1.101	1.127	1.196
.33	.108	.173	.261	.337	.528	.665	.782	.900	1.000	1.049	1.086	1.107	1.175
.20	.124	.188	.284	.366	.570	.707	.816	.912	1.000	1.040	1.071	1.087	1.155
.10	.135	.206	.310	.396	.615	.752	.852	.928	1.000	1.030	1.054	1.066	1.132
.05	.147	.220	.332	.422	.652	.789	.883	.943	1.000	1.022	1.040	1.048	1.114

Tables 8j,k Dimensionless Depth-Duration Curves for 24 Hour Extreme Storms in Western Washington

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES — DIMENSIONLESS DEPTH-DURATION CURVES — 24 HOUR EXTREME STORMS - WESTERN WASHINGTON - PUGET SOUND LOWLANDS - REGION 3 — KERNEL VALUES AT 6.00 HOURS — DURATION (hours)												
	.50	1.00	2.00	3.00	6.00	9.00	12.00	18.00	24.00	36.00	48.00	60.00	72.00
.95	.043	.076	.133	.179	.311	.441	.569	.806	1.000	1.095	1.157	1.214	1.255
.90	.046	.080	.139	.187	.320	.452	.584	.812	1.000	1.092	1.152	1.208	1.249
.80	.050	.086	.147	.197	.335	.472	.604	.820	1.000	1.088	1.146	1.200	1.240
.67	.055	.091	.155	.208	.354	.493	.624	.829	1.000	1.083	1.139	1.192	1.232
.50	.060	.098	.165	.221	.376	.517	.648	.840	1.000	1.078	1.132	1.182	1.221
.33	.065	.106	.175	.235	.400	.544	.675	.851	1.000	1.073	1.123	1.172	1.210
.20	.071	.114	.186	.249	.424	.571	.702	.862	1.000	1.067	1.115	1.161	1.199
.10	.078	.122	.198	.265	.452	.602	.732	.875	1.000	1.061	1.105	1.149	1.186
.05	.083	.130	.209	.279	.475	.629	.758	.886	1.000	1.055	1.097	1.139	1.175

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES — DIMENSIONLESS DEPTH-DURATION CURVES — 24 HOUR EXTREME STORMS - WESTERN WASHINGTON - MOUNTAINS - REGION 4 — KERNEL VALUES AT 6.00 HOURS — DURATION (hours)												
	.50	1.00	2.00	3.00	6.00	9.00	12.00	18.00	24.00	36.00	48.00	60.00	72.00
.95	.033	.059	.111	.159	.287	.411	.534	.779	1.000	1.211	1.329	1.436	1.537
.90	.036	.063	.116	.165	.294	.421	.545	.790	1.000	1.206	1.321	1.427	1.526
.80	.039	.068	.123	.174	.310	.437	.562	.803	1.000	1.199	1.311	1.414	1.511
.67	.043	.073	.130	.184	.327	.455	.581	.811	1.000	1.192	1.300	1.400	1.494
.50	.048	.080	.140	.197	.348	.478	.604	.821	1.000	1.182	1.287	1.382	1.472
.33	.054	.087	.150	.211	.371	.503	.630	.832	1.000	1.172	1.271	1.362	1.449
.20	.060	.095	.162	.225	.397	.532	.658	.844	1.000	1.160	1.255	1.341	1.423
.10	.067	.105	.175	.243	.426	.565	.691	.858	1.000	1.147	1.236	1.316	1.393
.05	.073	.113	.186	.258	.453	.595	.720	.870	1.000	1.135	1.219	1.294	1.367

Table 81 Dimensionless Depth-Duration Curves for 24 Hour Extreme Storms in Western Washington

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES DIMENSIONLESS DEPTH-DURATION CURVES 24 HOUR EXTREME STORMS - WESTERN WASHINGTON - COASTAL LOWLANDS - REGION 5 KERNEL VALUES AT 6.00 HOURS DURATION (hours)												
	.50	1.00	2.00	3.00	6.00	9.00	12.00	18.00	24.00	36.00	48.00	60.00	72.00
.95	.038	.067	.122	.167	.297	.425	.553	.798	1.000	1.158	1.255	1.343	1.412
.90	.040	.071	.127	.174	.308	.437	.566	.804	1.000	1.154	1.249	1.335	1.403
.80	.044	.077	.135	.184	.324	.456	.585	.811	1.000	1.148	1.241	1.324	1.391
.67	.049	.082	.143	.195	.342	.476	.605	.820	1.000	1.142	1.232	1.313	1.377
.50	.054	.089	.152	.207	.364	.500	.628	.830	1.000	1.135	1.221	1.299	1.362
.33	.059	.097	.163	.221	.388	.527	.654	.841	1.000	1.127	1.209	1.284	1.344
.20	.065	.104	.174	.236	.412	.555	.682	.853	1.000	1.119	1.197	1.268	1.326
.10	.072	.113	.187	.253	.441	.587	.713	.866	1.000	1.109	1.183	1.250	1.305
.05	.077	.121	.198	.267	.466	.615	.741	.878	1.000	1.101	1.170	1.234	1.287

In actual application, these procedures will preserve the three most important statistical characteristics of depth-duration curves, namely: the marginal distribution at the kernel duration (Stage 1); the correlation relationships between ordinate values, through the use of expected values of the ordinates at the various dependent durations (Stage 2); and the desired storm magnitude, through its use to directly scale the dimensionless ordinates.

In summary, the probabilistic depth-duration curves produced by these procedures, and displayed in the previous Tables, are descriptive of a wide range of observed depth-duration curves. These curves should be useful in rainfall-runoff modeling for examining the flood response of a watershed for a wide range of storm characteristics.

Depth-Duration Curves Conditioned on the Total Storm Depth

The depth-duration curves discussed up to this point have all been constructed conditioned on the magnitude of a high intensity storm segment. This was done because the high intensity segment of the storm is primarily responsible for producing the flood peak discharge. However, there are design cases where the volume of the flood is more important than the flood peak discharge. If the design of a facility is dependent on flood volume, then the 24 hour ID event (largest precipitation depth) would be the extreme storm of interest. A depth-duration curve for use in flood volume critical cases should, therefore, be conditioned on the magnitude of an ordinate for a long duration DD from the 24 ID storm.

The procedures for generating depth-duration curves conditioned on a long duration DD were essentially the same as those discussed previously. The following procedures were employed:

- The 48 hour duration was selected as the kernel DD.

- Nine levels of exceedance probability were selected to describe characteristic depth-duration curves.

- The 48 hour kernel ordinate was computed for each of the nine exceedance probabilities based on the results of fitting the Beta distribution to the ordinate data for the kernel DD (Stage 1 solution, Figures 8e,f).

- Improved estimates of the regression parameters from the cross-correlation analyses at the 48 hour DD were obtained using smoothing functions in a manner similar to that used in the Stage 2 solutions. A first order polynomial was fit to the correlation coefficients for DDs longer than the 48 hour kernel DD. The correlation coefficient at the 36 hour DD was retained as originally computed. A second order polynomial was fit to the slope parameters for DDs between 6 hours and 24 hours. For DDs less than 6 hours, the 6 hour ordinate amount was disaggregated in the same manner as was accomplished in Stage 2.

- The ordinate values of each probabilistic depth-duration curve were then computed using the previously computed 48 hour kernel ordinate and the improved estimates of the regression parameters from the cross-correlation analyses.

The depth-duration curves generated by these procedures are contained in Tables 9a,b,c,d,e. Differences between these curves and those curves containing ordinates conditioned on a high intensity segment (Tables 8h,i,j,k,l) are readily apparent (Figure 11). For curves at the same exceedance probability: a curve which was conditioned on the magnitude of a high intensity segment has a steeper rising limb (contains larger rainfall intensities) and a flatter tail. Conversely, if the depth-duration curve is conditioned on the magnitude of an ordinate for a DD longer than the ID, then it has a steeper tail (contains larger total depth) and a flatter rising limb.

Curves contained in Tables 8a to 8l and 9a to 9e obviously do not contain all ordinate combinations which could comprise depth-duration curves. They do, however, represent the most likely curves conditioned on the magnitude of high intensities or total storm depth, whichever is of primary interest.

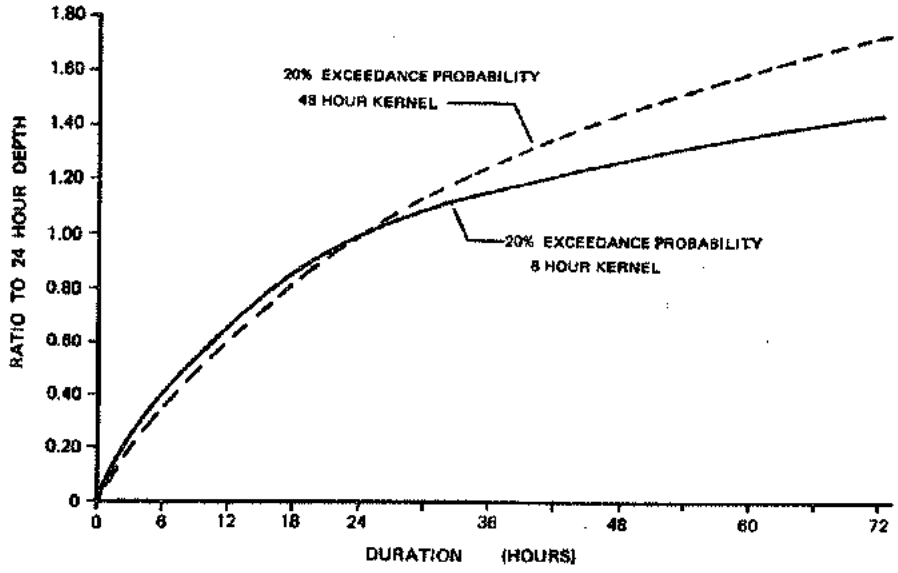


Figure 11. Comparison of Depth-Duration Curves for 24 Hour ID Storms Example - Western Washington Mountains

Table 9a,b Dimensionless Depth-Duration Curves with 48 Hour Kernel Ordinate for 24 Hour Extreme Storms in Eastern Washington

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES DIMENSIONLESS DEPTH-DURATION CURVES 24 HOUR EXTREME STORMS - EASTERN WASHINGTON - MOUNTAINS - REGION 1 KERNEL VALUES AT 48.00 HOURS DURATION (hours)												
	.50	1.00	2.00	3.00	6.00	9.00	12.00	18.00	24.00	36.00	48.00	60.00	72.00
.95	.081	.129	.212	.279	.453	.586	.709	.892	1.000	1.014	1.022	1.085	1.165
.90	.080	.129	.211	.278	.451	.583	.706	.889	1.000	1.022	1.041	1.105	1.183
.80	.079	.127	.209	.275	.447	.578	.700	.885	1.000	1.040	1.076	1.143	1.219
.67	.077	.125	.206	.272	.442	.570	.692	.878	1.000	1.070	1.125	1.195	1.267
.50	.075	.122	.202	.267	.435	.560	.680	.870	1.000	1.115	1.193	1.268	1.334
.33	.072	.119	.197	.260	.426	.548	.666	.859	1.000	1.155	1.276	1.358	1.417
.20	.069	.115	.192	.254	.416	.534	.650	.847	1.000	1.197	1.367	1.455	1.507
.10	.066	.111	.186	.246	.405	.519	.633	.834	1.000	1.245	1.470	1.566	1.609
.05	.063	.107	.181	.240	.396	.508	.618	.823	1.000	1.285	1.555	1.657	1.693

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES DIMENSIONLESS DEPTH-DURATION CURVES 24 HOUR EXTREME STORMS - EASTERN WASHINGTON - CENTRAL BASIN - REGION 2 KERNEL VALUES AT 48.00 HOURS DURATION (hours)												
	.50	1.00	2.00	3.00	6.00	9.00	12.00	18.00	24.00	36.00	48.00	60.00	72.00
.95	.102	.165	.251	.325	.510	.653	.779	.909	1.000	1.002	1.004	1.010	1.086
.90	.102	.165	.250	.324	.509	.652	.778	.908	1.000	1.004	1.008	1.015	1.090
.80	.101	.164	.249	.323	.507	.650	.775	.906	1.000	1.008	1.016	1.025	1.100
.67	.101	.163	.247	.321	.504	.646	.771	.903	1.000	1.019	1.033	1.045	1.118
.50	.099	.161	.244	.317	.499	.638	.763	.896	1.000	1.042	1.064	1.082	1.153
.33	.096	.158	.240	.312	.491	.627	.750	.887	1.000	1.062	1.110	1.138	1.206
.20	.093	.154	.234	.305	.481	.613	.734	.875	1.000	1.087	1.169	1.208	1.272
.10	.089	.149	.228	.296	.468	.595	.713	.859	1.000	1.126	1.246	1.301	1.359
.05	.085	.145	.221	.287	.456	.578	.694	.850	1.000	1.166	1.318	1.387	1.440

Table 9c,d Dimensionless Depth-Duration Curves with 48 Hour Kernel Ordinate for 24 Hour Extreme Storms in Western Washington

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES DIMENSIONLESS DEPTH-DURATION CURVES 24 HOUR EXTREME STORMS - WESTERN WASHINGTON - PUGET SOUND LOWLANDS - REGION 3 KERNEL VALUES AT 48.00 HOURS DURATION (hours)												
	.50	1.00	2.00	3.00	6.00	9.00	12.00	18.00	24.00	36.00	48.00	60.00	72.00
.95	.062	.102	.170	.228	.387	.534	.671	.857	1.000	1.007	1.014	1.038	1.071
.90	.062	.102	.169	.227	.387	.533	.669	.856	1.000	1.013	1.026	1.052	1.086
.80	.062	.101	.169	.227	.385	.531	.666	.853	1.000	1.023	1.045	1.076	1.111
.67	.062	.101	.168	.226	.384	.529	.663	.850	1.000	1.036	1.072	1.108	1.144
.50	.061	.100	.168	.225	.382	.525	.657	.845	1.000	1.063	1.107	1.152	1.190
.33	.061	.100	.166	.223	.380	.521	.651	.839	1.000	1.089	1.153	1.208	1.248
.20	.060	.099	.165	.222	.377	.516	.643	.832	1.000	1.117	1.204	1.271	1.314
.10	.059	.098	.164	.220	.374	.510	.634	.824	1.000	1.151	1.267	1.348	1.394
.05	.059	.097	.162	.218	.371	.504	.626	.816	1.000	1.181	1.324	1.417	1.465

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES DIMENSIONLESS DEPTH-DURATION CURVES 24 HOUR EXTREME STORMS - WESTERN WASHINGTON - MOUNTAINS - REGION 4 KERNEL VALUES AT 48.00 HOURS DURATION (hours)												
	.50	1.00	2.00	3.00	6.00	9.00	12.00	18.00	24.00	36.00	48.00	60.00	72.00
.95	.052	.084	.146	.205	.362	.501	.631	.841	1.000	1.021	1.040	1.071	1.108
.90	.051	.084	.146	.205	.361	.499	.629	.839	1.000	1.035	1.069	1.103	1.147
.80	.051	.084	.145	.204	.360	.497	.625	.836	1.000	1.060	1.113	1.163	1.217
.67	.051	.083	.144	.203	.358	.494	.621	.832	1.000	1.100	1.173	1.239	1.305
.50	.050	.082	.143	.201	.356	.490	.614	.826	1.000	1.162	1.252	1.338	1.421
.33	.050	.081	.142	.200	.353	.485	.607	.820	1.000	1.214	1.344	1.455	1.557
.20	.049	.081	.141	.198	.350	.480	.600	.813	1.000	1.267	1.440	1.575	1.697
.10	.048	.080	.140	.197	.348	.474	.591	.805	1.000	1.326	1.544	1.706	1.851
.05	.048	.079	.139	.195	.345	.470	.585	.799	1.000	1.372	1.627	1.811	1.974

Table 9e Dimensionless Depth-Duration Curves with 48 Hour Kernel Ordinate for 24 Hour Extreme Storms in Western Washington

EXCEEDANCE PROBABILITY FOR KERNEL	ORDINATE VALUES DIMENSIONLESS DEPTH-DURATION CURVES 24 HOUR EXTREME STORMS - WESTERN WASHINGTON - COASTAL LOWLANDS - REGION 5 KERNEL VALUES AT 48.00 HOURS DURATION (hours)												
	.50	1.00	2.00	3.00	6.00	9.00	12.00	18.00	24.00	36.00	48.00	60.00	72.00
.95	.057	.093	.158	.215	.377	.519	.654	.850	1.000	1.019	1.036	1.066	1.103
.90	.056	.093	.158	.215	.376	.518	.652	.848	1.000	1.029	1.057	1.093	1.132
.80	.056	.092	.157	.214	.375	.516	.648	.845	1.000	1.046	1.092	1.137	1.181
.67	.056	.092	.156	.213	.373	.513	.643	.841	1.000	1.078	1.136	1.192	1.242
.50	.055	.091	.155	.212	.371	.509	.638	.835	1.000	1.119	1.193	1.264	1.322
.33	.055	.090	.154	.210	.368	.504	.631	.829	1.000	1.157	1.261	1.349	1.417
.20	.054	.090	.153	.208	.366	.499	.623	.822	1.000	1.197	1.333	1.440	1.518
.10	.053	.089	.152	.207	.363	.493	.615	.815	1.000	1.242	1.416	1.544	1.633
.05	.053	.088	.151	.205	.360	.489	.607	.808	1.000	1.281	1.486	1.632	1.731

VERIFICATION OF VALIDITY OF USING DIMENSIONLESS ORDINATES IN DEPTH-DURATION CURVES

The use of dimensionless depth-duration curves for analysis and design has been a standard technique for decades. An underlying assumption in the use of dimensionless depth-duration curves is that the curve ordinates are independent of scale. This infers that the probabilistic characteristics of the ordinate values are independent of the magnitude of the ID storm. Although dimensionless depth-duration and dimensionless precipitation mass curves are "well accepted", the author is unaware of any detailed theoretical discussion or an investigation of historical data to demonstrate the validity of the scale independence assumption.

An investigation of this assumption can be made by examination of the ordinate values for the kernel DDs relative to the ID storm magnitude. If the independence assumption is valid, then the sample correlation coefficient for the two variables would approach zero and there would be no trend for the ordinate values to increase or decrease with storm magnitude.

The 6 hour ID storm data set for western Washington is one case where there is both a sufficient number of storms and range of storm magnitude to examine the assumption of scale independence. Referring to Figure 12a, it is seen that for the range of 6 hour ID extreme storm data available, the kernel ordinates do not appear to vary with storm magnitude (correlation coefficient = 0.06). Additional analyses were conducted for the 2 hour ID data in eastern and western Washington and the results were similar. In both cases, correlation coefficients had absolute values less than 0.12.

An alternative way to examine the linear scaling assumption is to perform correlation analyses using a logarithmic transform of the original precipitation amounts at various DDs. The logarithm of the precipitation amounts for the ID would be used as the independent variable. In this type of procedure, the scaling is assumed to be a power function (equation 7) and if, in fact the scaling is linear, then the scaling equation simplifies to a linear form. A graphical depiction of this approach is shown in Figure 12b for the 6 hour extreme storm data in western Washington.

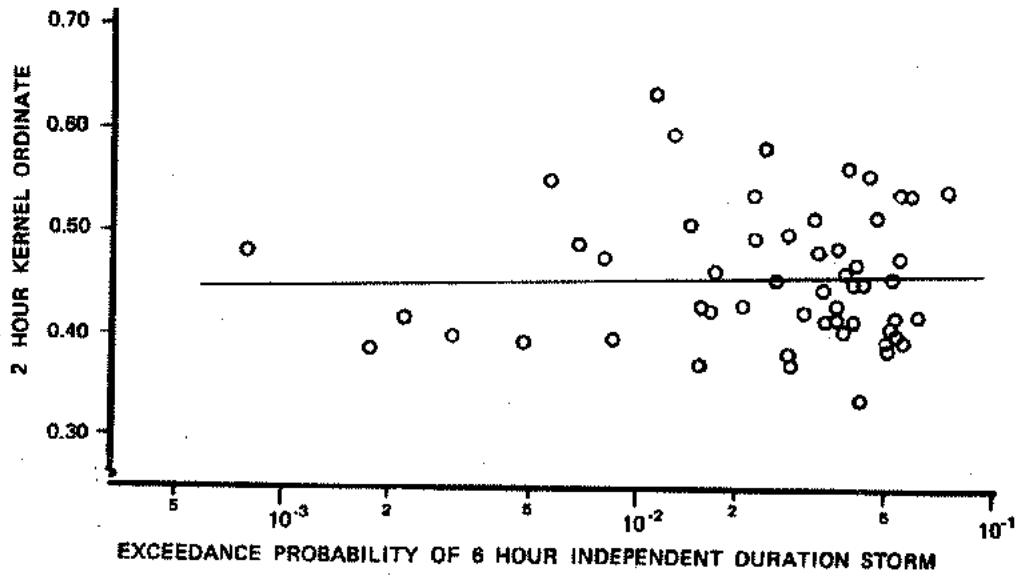


Figure 12a. Variation of Kernel Ordinates with Storm Annual Exceedance Probability
Example - 6 Hour ID Events Western Washington

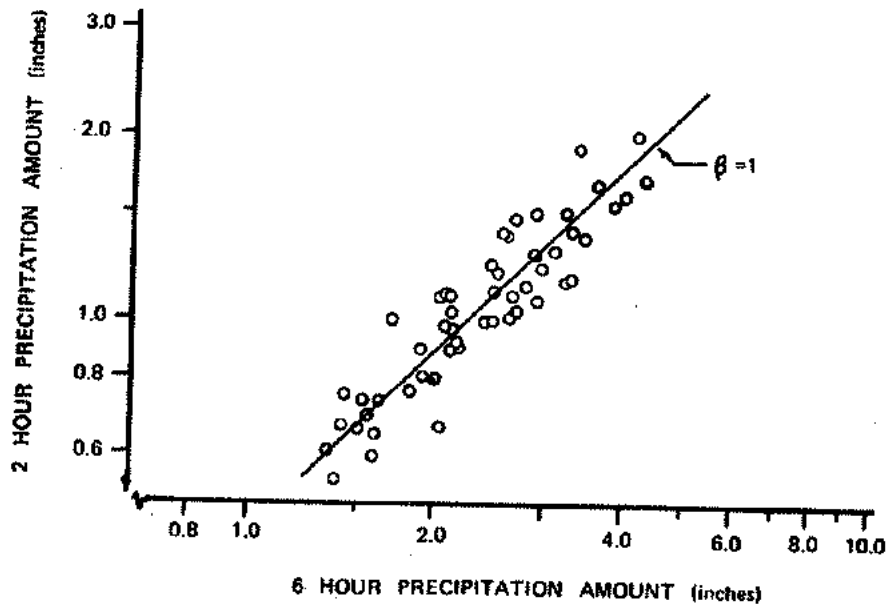


Figure 12b. Relationship of Kernel Duration Precipitation Amounts to Independent Duration Precipitation Amounts
Example - 6 Hour ID Events Western Washington

The scaling relationship for this approach is a simple power function. The solution equation follows directly from the use of log-log correlation and takes the form:

$$P_{dd} = \alpha P_{id}^{\beta} \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

where:

P_{dd} is the precipitation amount for a specified DD
P_{id} is the precipitation amount for the ID
α and β are intercept and slope parameters, respectively

If the linear scaling assumption is applicable, then the slope should have a value of near unity. Rearrangement of equation 7 for a slope of unity results in the equation simplifying to a linear scaling equation. Wherein, the ordinate value (P_{dd}/P_{id}) is equal to the constant α and is not scale (storm magnitude) dependent. If the slope takes on a value other than unity, then the scaling is non-linear and a function of storm magnitude as shown below:

$$\frac{P_{dd}}{P_{id}} = \alpha P_{id}^{\beta-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Log-log correlation analyses for the western Washington 6 hour extreme storms resulted in slope parameters near unity and ranging from 1.08 to 0.92 for DDs between 1 hour and 18 hours, respectively. Analyses for the short duration 2 hour extreme storm events in both eastern and western Washington produced similar results. Slope values ranged between 1.12 and 0.92 with the larger values generally associated with DDs within the ID and smaller values associated with DDs exterior to the ID.

Thus, based on the information available, it appears that the use of the ID precipitation depth to scale up or down a storm of interest, is a reasonable approximation of the meteorologic process.

This Page Intentionally Left Blank

TIMING CHARACTERISTICS OF HIGH INTENSITY SEGMENT

The time of occurrence of the high intensity segment within a storm is an important element in the analysis of observed storms and in the development of synthetic storms. The time of occurrence of the high intensity segment within a storm often affects the magnitude of the flood peak which will be generated by the storm. Storms with the high intensity segment near the end of the storm will generally produce larger flood peaks than similar storms where the high intensity segment occurs near the beginning of the storm. This outcome is attributable to both the manner in which runoff collects from the tributary drainage of a watershed, and to the infiltration properties of soils. With regard to the soils, near the end of a storm, the surficial soils are at a wetter state than at the beginning, and thus they have lower infiltration capacity. This results in higher runoff rates and larger flood peaks when the high intensity segment occurs near the end of the storm period. In the design of reservoir projects, the occurrence of the flood peak near the end of the flooding period is often a more stringent design consideration because the reservoir volume allocated to flood control is partially filled prior to the arrival of the flood peak. Information on the observed timing characteristics of the high intensity segment of storms is, therefore, an important and necessary element in the assembly of synthetic storms.

In general, observed storms had only one period of high intensity. This was particularly true for the shorter duration events. In those cases where there were two distinct periods of high intensity, they were usually found in intermittent macro patterns for long duration events and represented the passage of separate fronts during a period of several days. When two periods of high intensity occurred, only the highest intensity segment was included in the data for analysis.

Analysis of the frequency characteristics for the time of occurrence of the high intensity segment was accomplished by fitting the data to the Beta distribution [Benjamin and Cornell, 1970]. The method of moments was used to solve for the distribution parameters

for the Beta distribution (equations 2,3) for each of the three IDs in each of the five regions. The lower and upper bounds for the distribution (equation 1) were δ_1=0 and δ_2 equal to the total duration. The results of the analyses are shown in Table 10 and are an expansion of the information contained in Table 4.

The timing data were also examined to determine if the values were related to the magnitude of the kernel ordinates. In simple terms, if a storm exhibited an unusually long (short) timing value, would the magnitude of the kernel ordinate also be more likely to be above (below) average? Alternatively, are the two values unrelated? Correlation analyses of the two variables were performed for each of the three IDs and various region combinations. All correlation coefficients had absolute values less than 0.10 and it was concluded that the correlation coefficients were not significantly different from zero. Therefore, during the assembly of a synthetic storm, the kernel ordinate and the time of occurrence of the high intensity segment can be selected independent of each other.

Table 10. Frequency Characteristics for Time of Occurrence of High Intensity Segment of Extreme Storms

REGIONS	INDEPENDENT DURATION (hours)	TIME OF HIGHEST INTENSITY - HOURS								
		MEAN (hours)	EXCEEDANCE PROBABILITY							
			0.95	0.90	0.80	0.67	0.50	0.33	0.20	0.10	0.05
1 & 2	2	0.70	0.03	0.06	0.12	0.25	0.50	0.80	1.20	1.70	2.15
3 & 4 & 5	2	0.90	0.15	0.23	0.37	0.55	0.80	1.05	1.35	1.75	2.05
1 & 2	6	6.3	1.1	1.7	2.8	4.1	5.9	7.8	9.6	11.6	13.1
3 & 4 & 5	6	9.2	2.2	3.3	5.0	7.0	9.2	11.5	13.4	15.1	16.1
1	24	23.7	1.9	3.8	7.6	13.0	20.8	30.2	39.2	48.5	55.2
2	24	15.6	0.7	1.5	3.5	6.7	12.0	19.0	26.7	35.7	43.0
3	24	25.5	5.0	7.7	12.2	17.3	24.0	31.3	38.3	45.7	51.3
4	24	33.6	10.4	14.3	20.1	26.1	33.3	40.6	47.0	53.4	57.8
5	24	30.6	8.4	11.9	17.2	22.9	29.9	37.1	43.7	50.4	55.3

SEQUENCING OF INCREMENTAL PRECIPITATION SEGMENTS

The sequencing (arrangement) of incremental precipitation amounts surrounding the high intensity segment is another element of an extreme storm which can have an affect on the magnitude of the flood peak discharge. Those sequences which have the high intensity segment near the end of the sequence generally produce larger flood peaks. This applies to both the high intensity sequences immediately surrounding the high intensity segment, and to trisector sequences which describe the storm macro pattern. This phenomenon occurs as a result of the hydraulic response of watersheds and the runoff properties of surficial soils which were discussed in the previous section.

The sequencing characteristics of the incremental precipitation segments within storms can be seen as a companion element to the timing characteristics. Probabilistic information on observed sequences is, therefore, needed to allow realistic development of synthetic storm hyetographs.

Sequencing of High Intensity Segments Within Storms

To investigate the sequencing characteristics of the high intensity segments, each storm was examined to identify the incremental precipitation amounts during the time intervals surrounding the occurrence of the highest intensity. The time increments that were used in this phase of the analysis for each of the three IDs are shown in Table 7. Consideration of the three largest incremental precipitation amounts in a storm resulted in six possible sequences: 123; 132; 213; 312; 231; 321 (see definitions section).

Table 11 contains the results of the analysis on the frequency of occurrence of the six sequences. It should be noted that those sequences, 132 and 231, which separate the two largest increments are fairly rare at all three IDs. In eastern Washington at the 2 hour ID, the sequence 123 occurred most frequently. In all other regions and durations, those sequences, 213 and 312, which

sandwich the highest intensity segment in the middle were the most common and should be preferred in the development of synthetic storms.

No trends were identified which would indicate that the sequencing characteristics are statistically dependent on either the kernel ordinate or on the time of occurrence of the high intensity segment.

Table 11. Sequencing Characteristics of High Intensity Segments

REGIONS	INDEPENDENT DURATION (hours)	NUMBER OF EVENTS	HIGH INTENSITY SEGMENTS					
			FIRST BLOCK SEQUENCES		SECOND BLOCK SEQUENCES		THIRD BLOCK SEQUENCES	
			1 2 3	1 3 2	2 1 3	3 1 2	2 3 1	3 2 1
1 & 2	2	32	11	1	7	6	3	4
			38%		41%		21%	
3 & 4 & 5	2	22	5	0	9	8	0	0
			23%		77%		0%	
1 & 2	6	23	5	2	4	8	1	3
			30%		52%		18%	
3 & 4 & 5	6	56	13	2	12	18	4	7
			27%		54%		19%	
1 & 2	24	28	3	1	9	13	0	2
			14%		79%		7%	
3 & 4 & 5	24	49	3	3	13	19	3	8
			12%		65%		22%	

Sequencing of 6 Hour Segments Within 24 Hour ID Storms

At the 2 hour and 6 hour IDs, information on time of occurrence and sequencing of the high intensity segments, in combination with information on macro storm patterns, is usually adequate to describe a storm hyetograph. Additional information, however, is needed to describe a hyetograph for the longer duration 24 hour ID events. To describe the longer duration storm, the 24 hour ID was broken into four time segments with each segment being 6 hours in duration. As before, the sequence 1234 would represent the first,

second, third and fourth largest incremental precipitation segments, respectively. With four segments, there are 24 separate sequences which can occur. Unfortunately, there were an insufficient number of extreme storms in any region to properly investigate the frequency characteristics. Nonetheless, there was sufficient data to identify some of the more common sequences. Referring to Table 12, it can be seen that the first and second largest precipitation segments occur adjacent to each other in about 80% of the cases. Therefore, regardless of the final sequence selected for use in a synthetic storm, it would be appropriate to keep the two largest 6 hour segments adjacent to each other.

Table 12. Frequency that the First and Second Largest 6 Hour Precipitation Segments Occur Adjacent to Each Other Within 24 Hour ID Extreme Storms

REGION	NUMBER OF EVENTS	SEQUENCE 12.. 21..	SEQUENCE .12. .21.	SEQUENCE ..12 ..21	TOTAL
1	21	24%	14%	33%	71%
2	7	43%	14%	29%	86%
3	16	13%	44%	31%	88%
4	22	18%	36%	32%	86%
5	11	27%	55%	9%	91%

Another sequencing characteristic was investigated by examining the sequence location of the largest 6 hour precipitation segment within the 24 hour ID storms. The frequency of occurrence of the sequence location of the largest segment can be seen in Table 13. There was a general tendency for the largest 6 hour segment to be located in the middle of the 24 hour ID.

Table 13. Sequencing Characteristics of the Largest 6 Hour Precipitation Segment Within 24 Hour ID Extreme Storms

REGION	NUMBER OF EVENTS	SEQUENCE 1...	SEQUENCE .1..	SEQUENCE ..1.	SEQUENCE ...1
1	21	14%	48%	0%	38%
2	7	29%	43%	14%	14%
3	16	0%	50%	31%	19%
4	22	9%	32%	45%	14%
5	11	9%	55%	36%	0%

In each region, several sequences were observed to occur frequently. Those sequences (Table 14) exhibited the tendencies identified in Tables 12 and 13 and are logical choices for use in constructing synthetic storms. The more commonly occurring sequences are ordered from left to right in the table, but the ranking is not necessarily significant. Any of the sequences shown, or minor variations thereof, should be acceptable.

Table 14 Commonly Occurring Sequences for 6 Hour Precipitation Segments Within 24 Hour ID Extreme Storms

REGION	COMMONLY OCCURRING SEQUENCES		
1	4321	3124	2134
2	3124	4321	2134
3	4123	4312	4213
4	4312	4213	4123
5	4123	4312	4213

ANTECEDENT STORMS

The meteorological conditions in the days and weeks prior to the occurrence of an extreme storm predetermine the hydrologic conditions which will prevail in a watershed when the extreme storm occurs. Initial streamflow, antecedent soil moisture conditions and initial reservoir levels are all dependent on prior meteorological conditions. The runoff volume and flood peak discharge produced by an extreme storm are in turn affected by the antecedent hydrologic conditions. Thus, information on antecedent conditions is necessary for proper rainfall-runoff modeling.

An investigation was conducted to examine the precipitation events which occurred antecedent to the extreme storm. Specifically, the 14 day period prior to each extreme storm was examined. The largest precipitation amount for any 24 hour period was recorded along with the number of days elapsed between antecedent and extreme events. Sample statistics were computed for the recorded data and the results are shown in Table 15.

A review of the contents of Table 15 reveals that, typically, extreme storms are <u>not</u> preceded by an unusual storm. In the case of the 2 hour ID storms, which occur predominately in the warm season, the antecedent storms are of a magnitude which occur from 10 to 20 times during any given year. Likewise, for the 6 hour and 24 hour ID storms, which are cool season events, antecedent storms are of a magnitude which occur numerous times during a given year.

In the particular case of the 24 hour ID extreme storms, a plot was made (Figure 13) depicting the relationship between the return period for a given 24 hour ID event and its associated antecedent storm. Partial duration return periods were used in lieu of annual return periods to allow a more direct interpretation of the frequency characteristics of the antecedent storms. Estimates of the return periods of the antecedent storms were based on climatic and precipitation-frequency information contained in publications prepared by Phillips [1964-1970] for Washington State precipitation stations.

Table 15. Characteristics of Storms Antecedent to Extreme Storms

REGION	INDEPENDENT DURATION (hours)	NUMBER OF EVENTS	ANTECEDENT STORM	
			AVERAGE 24 HOUR DEPTH (inches)	AVERAGE # DAYS PRIOR
1	2	32	0.35	8.5
2	2	15	0.45	7.5
3	2	18	0.60	7.5
4	2	17	0.70	6.5
5	2	5	0.65	6.0
1	6	17	0.45	7.5
2	6	6	0.40	7.0
3	6	17	0.80	8.5
4	6	25	1.70	5.5
5	6	11	2.40	4.5
1	24	21	0.60	8.0
2	24	9	0.25	10.0
3	24	16	1.05	8.0
4	24	22	1.60	7.0
5	24	11	1.25	8.5

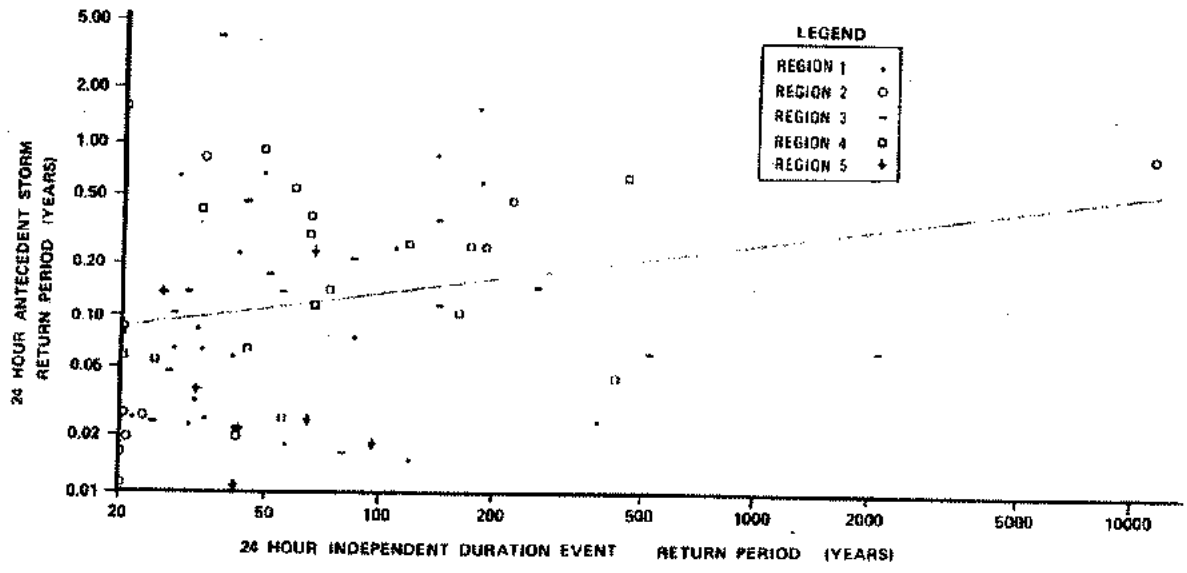


Figure 13. Relationship of Antecedent 24 Hour Duration Storms to 24 Hour ID Extreme Storms

A review of the data in Figure 13 reveals the antecedent storms to be highly variable and nearly independent of the associated extreme storm. The weak trend line depicted on the graph (correlation coefficient 0.24) indicates that for the 24 hour ID storms, there is some small tendency for the rare events to have slightly larger antecedent storms. However, even for extraordinarily rare events, the antecedent storms would not be expected to have a significant magnitude.

The average antecedent storm contained in Figure 13 corresponds to a partial duration return period of 0.11 years (occurs an average of 9 times per year.). This result roughly corresponds to storm magnitudes to be expected during any 14 day period during the cool season. As a practical matter, it would appear reasonable to conclude that the time period preceding a given extreme storm is not significantly different than that same (calendar) time period during any given year.

Based on the foregoing, selection of antecedent conditions, such as individual storm amounts, soil moisture conditions, streamflow, snowpack, initial reservoir levels, etc., can be reasonably made by consideration of the seasonality of the extreme storm and a review of the historical record on the desired items. Selection of a more or less conservative value can then be made on a probabilistic basis when considering each item.

For example, while the antecedent storms for the 24 hour ID storms in western Washington were not large, it was quite common to have extreme storms preceded by a series of small precipitation events. These events undoubtedly produced elevated streamflows and wet soils. These conditions are typical of the winter months and would be expected from a simple review of the historic meteorologic and hydrologic data for the winter months.

SPATIAL CHARACTERISTICS

Investigation of the spatial characteristics of extreme storms was not a major element in this study. This decision was made because the principal applications for the results of this study are on small watersheds. Small as used herein refers to watersheds with a drainage area less than 50 square miles with most applications on watersheds having areas less than 10 square miles. Small also is appropriate as a relative term for the size of the watersheds of interest compared to the extensive areal coverage of extreme storms at the 6 hour and 24 hour ID. Thus, for the longer duration storms, more detailed depth-area and other spatial information was not of great importance. For completeness, conventional depth-area duration curves have been obtained from other sources [NWS Hydrometeorological Report 43, 1966], [NOAA Atlas 2, Miller et al, 1973] and are presented later.

The main objective of this element of the study was to investigate the spatial characteristics of the short duration, warm season, convective events, in eastern Washington. These events are usually localized but may be associated with an organized weather system which can be identified at the synoptic scale. Thunder, lightning and hail often accompanied these storms and the storms have been given the generic label of "thunderstorm" to avoid problems associated with categorizing the causative storm type.

There has been controversy among meteorologists and hydrologists for many years on the typical and potential maximum areal coverage of thunderstorms in eastern Washington. The thunderstorms which are large enough to attract public and news media attention, often have areal coverages of less than 20 square miles. In contrast, the NWS [1966] has estimated an areal coverage of about 500 square miles to be used in association with thunderstorm Probable Maximum Precipitation (PMP) events. Thus, there was a need to investigate the probabilistic characteristics of thunderstorm areal coverage.

THUNDERSTORM CHARACTERISTICS - EASTERN WASHINGTON

The scarcity of recording precipitation gauges in eastern Washington restricted the ability to make detailed analyses of thunderstorm characteristics. It was not possible to examine more complex characteristics, such as the spatial correlation structure of precipitation amounts or the depth-area relations. The study was restricted by data limitations to: investigation of the areal coverage of observed extreme storms; the direction of storm movement; and the general physical shape of the areal distribution. Those elements will be presented in the following sections.

Thunderstorm Areal Coverage

The areal coverage characteristics of eastern Washington thunderstorms were investigated by reviewing the storm catalog and selecting those events for which additional storm information was available. Outside sources which were used to estimate the limits of precipitation included:

- observers notes at precipitation stations
- newspaper accounts
- crop damage reports
- county highway department damage surveys
- U.S. Geological Survey (USGS), continuous recording streamflow records and miscellaneous streamflow measurements
- published accounts of storm events (NWS & USGS)

The areal coverage of a given storm was determined by defining the outer boundary of the storm to be the precipitation amount corresponding to approximately 10% of the maximum observed point rainfall amount. Using the information sources discussed above, considerable judgment was applied in delineating the storm boundary. The delineated area was then measured and the results are listed in Table 16 and displayed in Figure 14. While the

accuracy of any individual areal estimate is questionable, it can still be seen that there is considerable variability in the areal coverage of the storms that have occurred.

Based on these results, it appears that thunderstorm areal coverage on the order of the NWS [1966] estimate of 500 square miles is indeed possible. Also, it appears that little correlation exists between maximum point rainfall and areal coverage. Consideration of meteorological physics would suggest that a larger point rainfall is likely produced by a larger, more organized, more intensive convective cell or cells. This infers that there should be a tendency for storms with greater point rainfall to produce larger areal coverage. However, there is insufficient data to either confirm or refute this trend.

Table 16. Database of Selected Pacific Northwest Thunderstorms

STORM LOCATION	DATE	MAXIMUM MEASURED POINT RAINFALL (inches) *	MAXIMUM REPORTED/ESTIMATED POINT RAINFALL (inches) *	EFFECTIVE DURATION (minutes)	AREAL COVERAGE (sq miles)	DIRECTION OF STORM MOVEMENT (from)
near Sunnyside, WA	6/07/1947	1.62	-	25	35	SW
near Waterville WA	6/10/1948	1.76	4.00±	45	-	SW
near Pomeroy WA	6/17/1950	2.50	-	60	-	SW
near Selah WA	8/10/1952	2.75	4.00±	90	440	W
near Pullman WA	8/10/1952	2.45	-	180	255	W
near Connell WA	5/10/1956	2.00	-	60	330	NE
near Mitchell OR	7/13/1956	3.50	-	30	55	-
near Wenatchee WA	8/25/1956	1.38	-	180	275	SW
near Walla Walla WA	5/08/1957	1.15	-	120	100	-
near Walla Walla WA	5/24/1958	1.62	-	100	200	SW
near Morgan UT	8/16/1958	7.00	7.00	60	200	-
near Pullman WA	6/13/1963	1.47	3.40	60	100	SW
near Pomeroy WA	9/13/1966	1.21	2.25±	45	500	NW
near Walla Walla WA	5/26/1971	1.75	3.36	60	280	SSW
near Clarkston WA	8/03/1976	-	3.00±	45	-	SW
near Dayton WA	7/07/1978	1.20	2.00±	60	125	-
near Cowiche WA	4/21/1988	-	2.25	45	-	SSE

* Duration of rainfall 2 hours or less

Thunderstorms - Direction of Movement

Although there were only 13 events for which the direction of storm movement could be determined, the storm vectors occupied a relatively small sector of the wind rose. Review of Table 16 reveals that nearly all the storms originated from the southwest or west.

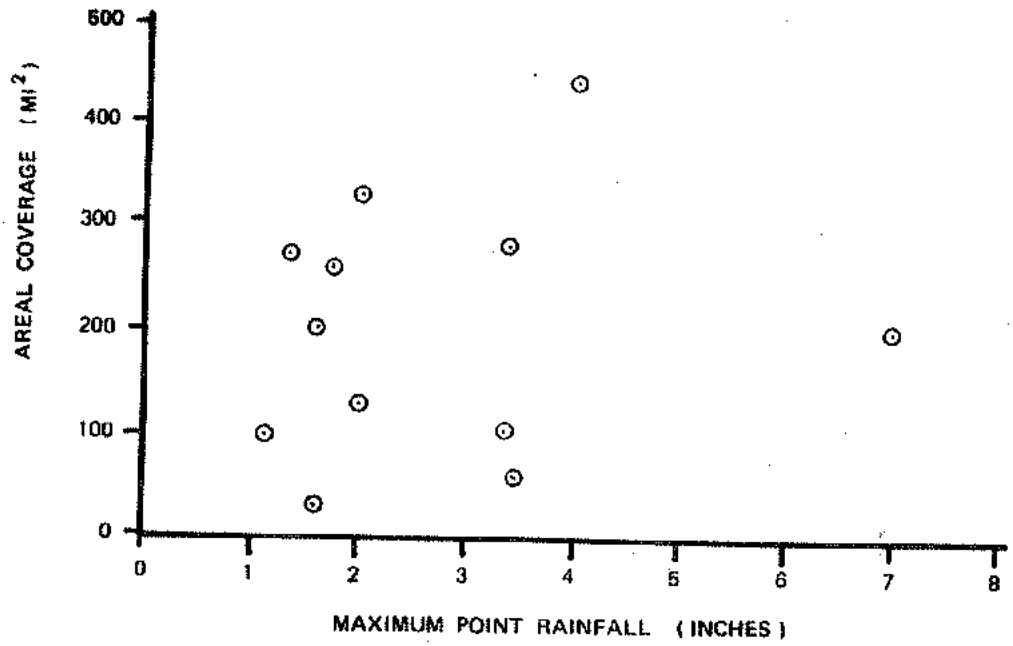


Figure 14. Variation of Areal Coverage with Maximum Point Rainfall for 2 Hour ID Pacific Northwest Thunderstorms

Thunderstorm - Storm Shape

The inability to accurately define the outer boundaries of precipitation (ground print) resulted in "smoothed" storm shapes. Nearly all shapes were ovals with the majority being elongated ovals. Based on newspaper accounts, many of the elongated ovals resulted from storm movement across the area. Measurement of the lengths of the major and minor axes of the ovals produced an average ratio of 2.45:1. The axes ratios ranged from a minimum of 1.15 to 3.33. Based on these results, an elliptical isohyetal pattern with an axes ratio of 2.5:1 would appear to be a reasonable approximation of the storm ground print. Information on storm shape and direction of movement could be important considerations for watersheds which are oriented in such a manner where only partial storm coverage of the basin is likely. This information should be taken into account when applying the depth-area curves discussed in the next section.

DEPTH-AREA RELATIONSHIPS

As discussed previously, the results of this study are intended for use primarily on small watersheds. Therefore, minimal efforts were made to conduct a probabilistic study of the spatial characteristics of extreme storms. In those cases where spatial information is needed for application on large watersheds, conventional depth-area-duration curves can be used to estimate the spatial and temporal distribution of the storm amounts.

The depth-area curves (Figure 15) recommended for use with the 6 hour and 24 hour ID storms were obtained from procedures contained in NWS Hydrometeorological Report 43 [1966] and are similar to curves contained in NOAA Atlas 2 [Miller et al, 1973]. Use of these curves are for watersheds larger than 10 square miles, because at-site precipitation depths are taken to represent an area of 10 square miles for the 6 hour and 24 hour ID cool season extreme storms.

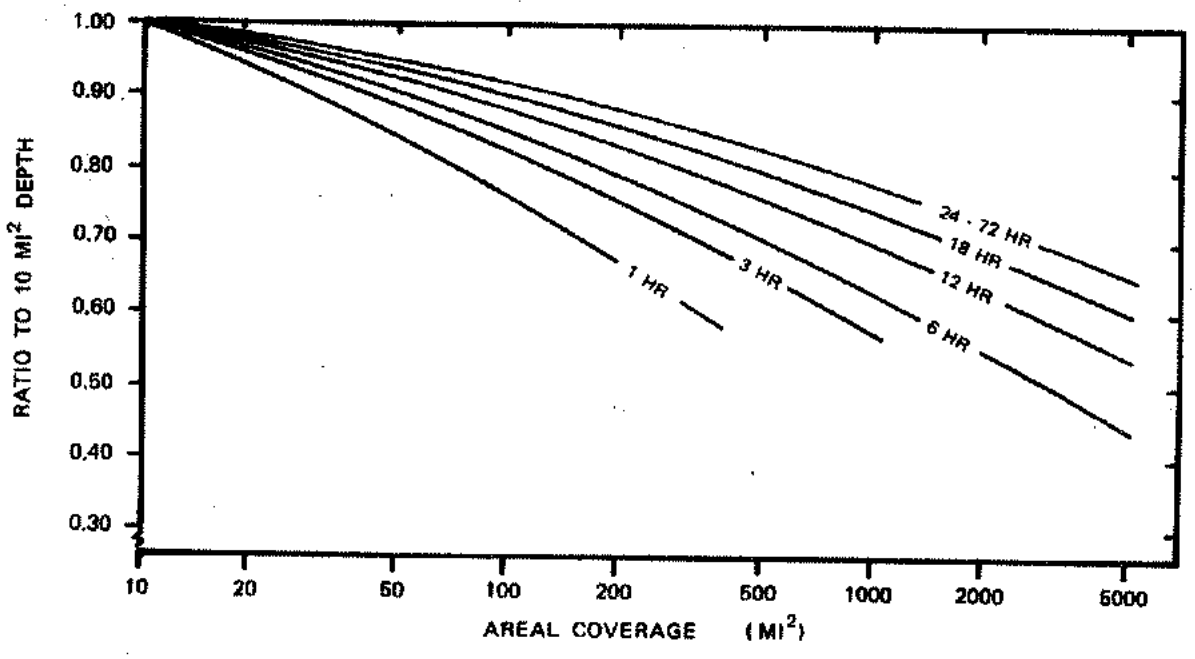


Figure 15. Depth-Area Curves for 6 Hour and 24 Hour ID Storms

The depth-area curves (Figure 16) for use with the 2 hour ID storms in eastern Washington were taken from NWS Hydrometeorological Reports 49 and 55 [1977, 1984]. The original curves were modified for use in Washington and reflect a reduced areal coverage for a nominal 250 square mile coverage versus the 500 square mile coverage of the original. This reduction was based on the finding that the areal coverage of the 2 hour ID storms were typically about 250 square miles. At-site precipitation depths are taken to represent an area of 1 square mile for the 2 hour ID warm season extreme storms.

In western Washington, no specific studies were conducted for the areal coverage of 2 hour ID storms. It is anticipated that the primary application of 2 hour ID storms will be on very small urban watersheds where the depth-area characteristics will not be of great importance. Figure 16 values are recommended for interim usage in western Washington until detailed information becomes available.

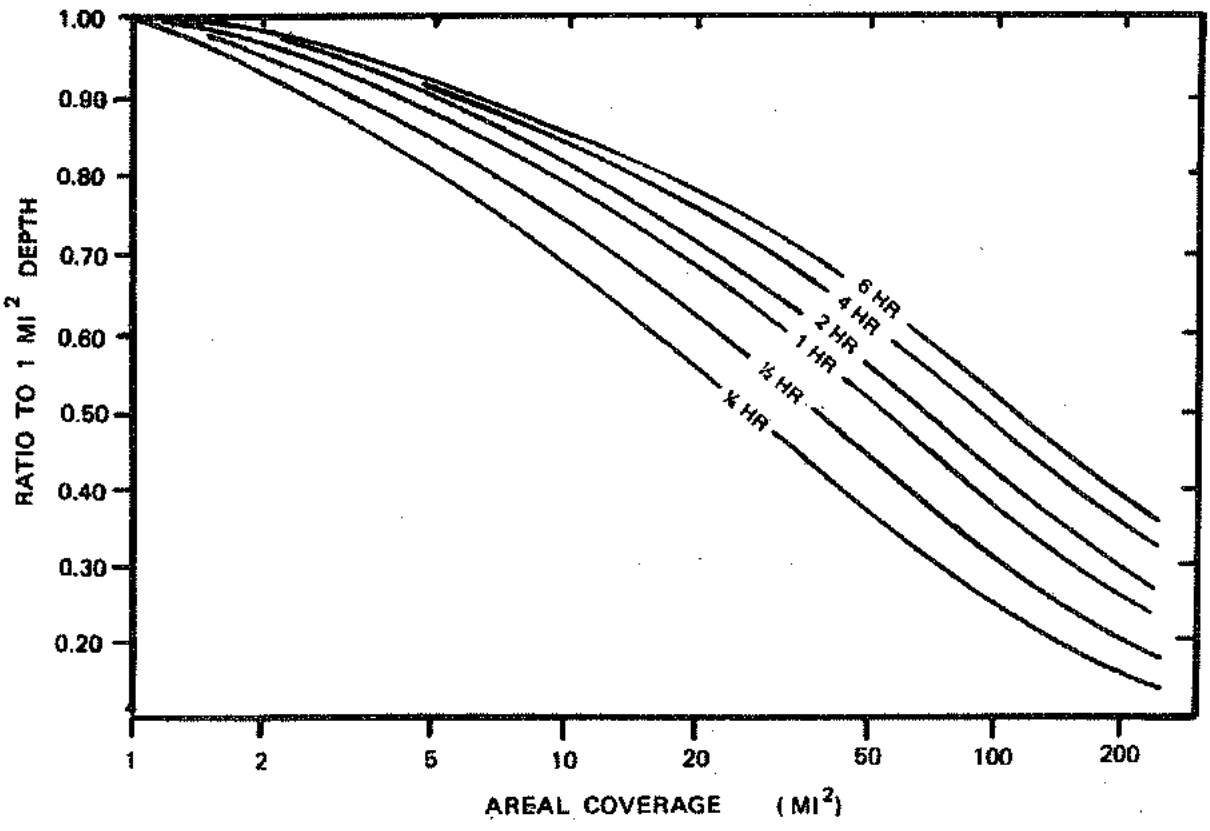


Figure 16. Depth-Area Curves for 2 Hour ID Storms

The following procedures would be employed to apply the depth-area curves to produce a basin-average depth-duration curve for a given ID storm magnitude on a specific watershed:

- Prepare a grid network and overlay the grid on the watershed. Estimate an at-site precipitation depth for the chosen ID and specified exceedance probability for each node point on the grid network of points.

- Compute an average precipitation depth for the watershed from the collection of at-site values for the grid nodes.

- Use the average precipitation depth computed above, in combination with the chosen dimensionless depth-duration curve, to scale the dimensionless ordinates to the desired storm magnitude.

- Compute the basin-average depth-duration curve by using the areal reduction factors from Figure 15 or 16 to adjust the curve computed above for the effects of storm spatial distribution.

In using data from both Figures 15 and 16, it should be recognized that these values represent the average spatial characteristics from a limited pool of data. At the present time, the author is unaware of any published regionalized information or study which addresses the stochastic nature of the spatial characteristics of extreme storms in the Northwest. Until further information is available, these depth-area curves represent the only practical approach to account for the spatial distribution of extreme storm precipitation.

ASSEMBLY OF SYNTHETIC STORMS

The primary objective of this study was to collect sufficient information on the characteristics of extreme storms to allow development of synthetic storm hyetographs for use in rainfall-runoff modeling. In this section, a methodology is presented for the assembly of synthetic storms which incorporates the probabilistic information on storm elements developed in the previous sections.

Assembly of a synthetic storm hyetograph can be viewed as a reversal of the depth-duration analysis process. The incremental precipitation amounts from a depth-duration curve are rearranged to produce a storm mass hyetograph. An important component in the assembly of synthetic storms is that conscious decisions must be made on the level of conservatism to be applied in the selection of the various storm elements. Every storm element discussed previously has been described in probabilistic terms and thus it is possible to reasonably predetermine the likelihood of occurrence of each element being built into the storm. This affords the opportunity to construct storms suited to site specific or commonly encountered types of applications.

In some applications, the selection of individual storm elements representing typical or mean values is appropriate. This is usually the case when attempting to synthetically generate a flood frequency curve of flood peak discharges. Typical storm elements would also be used in the calibration of soil or watershed response parameters in flood modeling when attempting to recreate a flood frequency curve obtained from other sources. In applications involving the design of hydraulic structures, somewhat more conservative values may be desirable.

The term conservative, as used here, refers to the procedure of selecting a more unusual magnitude or sequence of a storm element in order to produce a larger flood. This acts as a hedge against underestimation of the design flood when faced with the ever present uncertainty of obtaining the "correct" flood magnitude for the desired flood frequency. Although this procedure does provide

protection from underdesign, it often results in more expensive construction to accommodate the larger flood. Ultimately, the selection of an acceptable level of conservatism resides with the project manager or the responsible regulatory agency.

In general, the selections of the exceedance probability for the depth-duration curve and the time of occurrence of the high intensity segment have the greatest influence on the resultant flood peak discharge. Variations of sequences for the high intensity segment or for the four 6 hour segments in the 24 hour ID event are of lesser importance. Where appropriate, sensitivity analyses may be used to examine the effects that alternative decisions on the selection of storm elements would have on the resultant flood.

METHODOLOGY FOR ASSEMBLY OF SYNTHETIC STORMS

The assembly of a synthetic storm mass hyetograph begins with the selection of a specific depth-duration curve, the time of occurrence of the high intensity segment and sequences for storm segments. Incremental precipitation amounts from the specified depth-duration curve are then arranged in a manner consistent with the chosen storm characteristics and macro storm pattern. The following list describes the general methodology to be used in storm assembly:

Step 1. Estimate the at-site precipitation depth for the desired Annual Exceedance Probability (AEP) and Independent Duration (ID) of the extreme storm. This can be accomplished using information contained in either NOAA Atlas 2 [Miller et al, 1973] or Schaefer [1989].

Step 1a. If the watershed of interest is larger than 1 square mile at the 2 hour ID, or larger than 10 square miles at the 6 hour or 24 hour IDs, then computation of an average precipitation depth for the watershed is necessary. The average depth can be computed using the grid network

procedures presented in the section on depth-area relationships.

Step 2. Select a dimensionless depth-duration curve from Tables 8a-8l or Tables 9a-9e for the desired level of exceedance probability and appropriate climatic region. Scale the dimensionless depth-duration ordinates to the desired storm magnitude by multiplying the ordinates by the precipitation depth from Step 1 or 1a.

Step 3. Select the time of occurrence of the high intensity segment using information contained in Table 10.

Step 4. Select the sequence for the three high intensity storm segments using information contained in Table 11. The time interval associated with each of the three segments is listed in Table 7.

Step 5. If the extreme storm is a 24 hour ID event, then select the sequence for the four 6 hour storm segments within the ID. Necessary information is contained in Tables 13 and 14.

Step 6. Select a macro storm pattern from Figures 6a-6f which is consistent with the timing and sequencing selections made previously. Choose a six segment macro sequence.
Note: The choice of the number of segments for the macro pattern sequence is arbitrary. The macro patterns in Figure 5 are shown using trisector sequences comprised of three segments. However, this was done to simplify the categorization of observed storms. It is recommended that macro patterns and associated sequences with six segments be used for storm assembly. This is consistent with the time intervals (Table 7) used in the original development of the depth-duration curves and will simplify construction.

Step 7. If Step 1a is utilized above, then the watershed is sufficiently large that the spatial characteristics of the storm must be incorporated. The basin-average depth-duration curve can be computed using the areal reduction factors from Figures 15 or 16 as described in the section on depth-area relationships.

The storm can now be assembled in a manner which incorporates the storm elements chosen in Steps 2 - 6. Worksheets are provided in Appendix 3 which should aid in the bookkeeping aspects of storm assembly. While the methodology for storm assembly appears straightfoward, actual applications will reveal subtleties and possible permutations which may raise questions regarding appropriate procedures. Therefore, a series of examples are provided to demonstrate the assembly of a few synthetic storm mass hyetographs. As mentioned above, there is room for reasonable latitude in determining the manner in which a hyetograph incorporates the various storm characteristics. Minor variations in the completed hyetograph may be expected from separate practitioners even though the same values for the storm elements are employed. In general, these minor variations of the hyetograph would not be anticipated to have significant effects on the resultant flood. Where deemed appropriate, sensitivity analyses may be used to explore the differences in the floods produced by the various hyetographs.

The following examples are presented to clarify the methodology that is used to assemble synthetic storm hyetographs.

Example 1. Development of a typical mass hyetograph for a 2 hour ID event, with an Annual Exceedance Probability (AEP) of 0.01 for a 1 square mile watershed near Olympia, WA in the Puget Sound lowlands.

Given: For a 100 year recurrence interval event (AEP=0.01), the precipitation depth from NOAA Atlas 2 is 1.30 inches. Interpret **typical** event to be median or mean values for all storm elements.

Step 1:

The 2 hour ID precipitation depth is 1.30 inches.

Step 2:

Use the dimensionless depth-duration ordinate values for the 50% exceedance probability (median value) from Table 8b. Multiply the dimensionless ordinates by the 2 hour ID depth to scale the storm to the proper magnitude.

Step 3:

Select the mean value (0.9 hours, 54 minutes) from Table 10 for the time of occurrence of the high intensity segment.

Step 4:

Select the most likely sequence for the three high intensity segments of the storm. Referring to Table 11, this corresponds to either sequence 213 or 312. Choose sequence 213 at 15 minute increments per Tables 7 and 11.

During storm assembly, the incremental precipitation amounts corresponding to this sequence are inserted into the storm mass curve so the largest segment spans the time increment from 45 to 60 minutes of elapsed time (per Step 3).

It should be noted that Table 8b also contains ordinate values for precipitation amounts for three 5 minute segments. These segments are internal to the largest 15 minute high intensity segment and should be inserted within the largest 15 minute increment.

A sequence of 213 may also be used for these segments.

Step 5:

Not applicable.

Step 6:

Select macro pattern Type I based on Figure 6a and selections in Steps 3 and 4. Choose sequence 123456 for the six 1 hour segments.

Step 7:

No corrections for areal coverage are required since the watershed is not larger than 1 square mile.

Examination of the resultant synthetic storm (Table 17, Figure 17) reveals that it contains all of the storm elements described above.

Table 17. Assembly of Synthetic Mass Hyetograph for 2 Hour ID Extreme Storm for 1 Square Mile Watershed near Olympia, WA.

DEPTH-DURATION ORDINATES							
DEPENDENT DURATION (hours)	ORDINATE VALUES				TIME INCREMENT (hours)	INCREMENTAL PRECIPITATION AMOUNT (inches)	SEQUENCE NUMBER
	TABULAR	SCALED	AREAL REDUCTION	FINAL			
0.00	0.000	0.00	----	0.00			
0.08	0.139	0.18	1.00	0.18	0.08	0.18	within
0.17	0.267	0.35	1.00	0.35	0.08	0.17	.25 hour
0.25	0.386	0.50	1.00	0.50	0.08	0.15	hi
0.00	0.000	0.00	----	0.00			
0.25	0.386	0.50	1.00	0.50	0.25	0.50	1 hi
0.50	0.586	0.76	1.00	0.76	0.25	0.26	2 hi
0.75	0.712	0.93	1.00	0.93	0.25	0.17	3 hi
1.00	0.814	1.06	1.00	1.06	0.25	0.13	1 macro
1.25	0.888	1.15	1.00	1.15	0.25	0.09	
1.50	0.931	1.21	1.00	1.21	0.25	0.06	2 macro
2.00	1.000	1.30	1.00	1.30	0.50	0.09	
3.00	1.097	1.43	1.00	1.43	1.00	0.13	3 macro
4.00	1.149	1.49	1.00	1.49	1.00	0.06	4 macro
5.00	1.193	1.55	1.00	1.55	1.00	0.06	5 macro
6.00	1.226	1.59	1.00	1.59	1.00	0.04	6 macro

SYNTHETIC STORM MASS HYETOGRAPH			
TIME (hours)	SEQUENCE NUMBER	INCREMENTAL AMOUNT (inches)	MASS ORDINATE VALUE (inches)
0.00	part of 2 macro	0.06	0.00
0.25			0.06
0.50	part 1 macro	0.13	0.19
0.75	2 hi	0.26	0.45
0.83	within 1 hi	0.17	0.62
0.92	within 1 hi	0.18	0.80
1.00	within 1 hi	0.15	0.95
1.25	3 hi	0.17	1.12
1.50	part of 2 macro	0.09	1.21
2.00		0.09	1.30
3.00	3 macro	0.13	1.43
4.00	4 macro	0.06	1.49
5.00	5 macro	0.06	1.55
6.00	6 macro	0.04	1.59

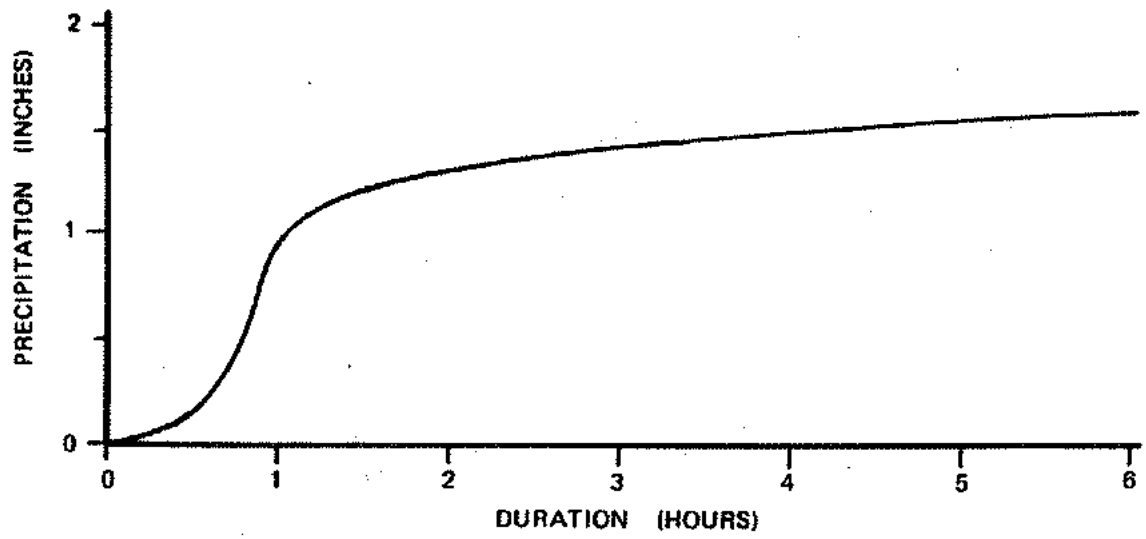


Figure 17. Synthetic Mass Hyetograph for 2 Hour ID Extreme Storm for a 1 Square Mile Watershed near Olympia, WA.

Example 2. Development of a conservative mass hyetograph for a 6 hour ID event, with an AEP of 0.01 for a 5 square mile watershed near Olympia, WA in the Puget Sound lowlands.

Given: For a 100 year recurrence interval event (AEP=0.01), the precipitation depth from NOAA Atlas 2 is 2.40 inches. Interpretation of a **conservative** temporal distribution is taken to mean storm elements having exceedance probabilities of 0.20 - one chance in five of being exceeded:

Step 1:
The precipitation depth is 2.40 inches.
Step 2:
Use the dimensionless depth-duration ordinate values for the 20% exceedance probability (conservative occurrence) from Table 8e. Multiply the dimensionless ordinates by the 6 hour ID depth to scale the storm to the proper magnitude.
Step 3:
Select the 20% exceedance probability value (13.4 hours) from Table 10 for the time of occurrence for the high intensity segment. Remember that the occurrence of the high intensity segment nearer the end of the storm generally produces a larger flood peak discharge. Thus, a longer timing value is conservative relative to a value nearer the start of the storm.
Step 4:
Select a conservative sequence for the three high intensity segments of the storm. The sequence chosen should be one with the larger precipitation segments nearer the end of the sequence.
In consideration of the above, choose sequence 312 at 60 minute increments per Tables 7 and 11. The incremental precipitation amounts corresponding to this sequence are inserted into the storm so the largest amount spans the time increment from 13 to 14 hours of elapsed time (per Step 3). Table 8e also contains high intensity ordinates for two 15 minute segments and one 30 minute segment. These segments should be inserted within the largest 60 minute segment to have the greatest intensity occurring around 13.4 hours.

Step 5:

Not applicable.

Step 6:

Select macro pattern Type IX based on selections in Steps 3,4 and Figure 6c. Use of a six segment sequence for the macro pattern (3 hour time intervals) does allows some latitude in the selection of a sequence which incorporates the previously chosen timing and sequencing elements. Logical choices would include: 654213 and 654312. Choose macro pattern sequence 654213 based on the timing of the high intensity segment at 13.4 hours which is near the boundary between macro segments 4 and 5 (boundary at 12 hours).

Step 7:

No corrections for areal coverage are necessary since the watershed is less than 10 square miles.

The resultant synthetic storm is shown in Figure 18 and the supporting computations for storm assembly are contained in Table 18.

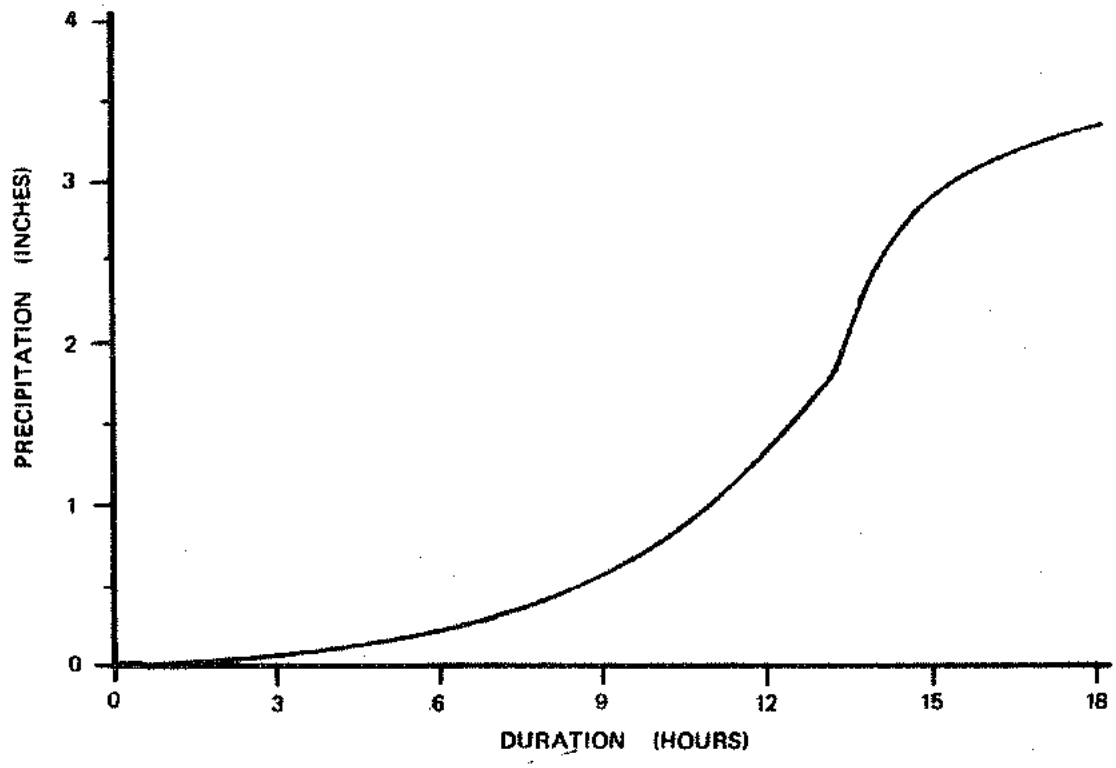


Figure 18. Synthetic Mass Hyetograph for 6 Hour ID Extreme Storm for 5 Square Mile Watershed near Olympia, WA.

Table 18. Assembly of Synthetic Mass Hyetograph for 6 Hour ID Extreme Storm for 5 Square Mile Watershed near Olympia, WA.

DEPTH-DURATION ORDINATES							
DEPENDENT DURATION (hours)	ORDINATE VALUES				TIME INCREMENT (hours)	INCREMENTAL PRECIPITATION AMOUNT (inches)	SEQUENCE NUMBER
	TABULAR	SCALED	AREAL REDUCTION	FINAL			
0.00	0.000	0.00	----	0.00			
					0.25	0.33	within
0.25	0.139	0.33	1.00	0.33			
					0.25	0.15	1 hour
0.50	0.202	0.48	1.00	0.48			
					0.50	0.27	hi
1.00	0.314	0.75	1.00	0.75			
0.00	0.000	0.00	----	0.00			
					1.00	0.75	1 hi
1.00	0.314	0.75	1.00	0.75			
					1.00	0.49	2 hi
2.00	0.515	1.24	1.00	1.24			1 macro
					1.00	0.35	3 hi
3.00	0.664	1.59	1.00	1.59			
					3.00	0.81	2 macro
6.00	1.000	2.40	1.00	2.40			
					3.00	0.41	3 macro
9.00	1.171	2.81	1.00	2.81			
					3.00	0.24	4 macro
12.00	1.272	3.05	1.00	3.05			
					3.00	0.18	5 macro
15.00	1.344	3.23	1.00	3.23			
					3.00	0.09	6 macro
18.00	1.385	3.32	1.00	3.32			

SYNTHETIC STORM MASS HYETOGRAPH			
TIME (hours)	SEQUENCE NUMBER	INCREMENTAL AMOUNT (inches)	MASS ORDINATE VALUE (inches)
0.00			0.00
	6 macro	0.09	
3.00			0.09
	5 macro	0.18	
6.00			0.27
	4 macro	0.24	
9.00			0.51
	2 macro	0.81	
12.00			1.32
	3 hi	0.35	
13.00			1.67
	within 1 hi	0.15	
13.25			1.82
	within 1 hi	0.33	
13.50			2.15
	within 1 hi	0.27	
14.00			2.42
	2 hi	0.49	
15.00			2.91
	3 macro	0.41	
18.00			3.32

Example 3. Development of a very conservative mass hyetograph for a 24 hour ID event, with an AEP=0.01 for a 100 square mile watershed near Olympia, WA. in the Puget Sound lowlands.

Given: For a 100 year recurrence interval event (AEP=0.01), the average precipitation depth for the watershed was computed using the collection of at-site values from NOAA Atlas 2 at nodes on a rectangular grid which encompassed the watershed. The average depth was computed to be 5.40 inches.

Interpretation of a **very conservative** temporal distribution is taken to mean storm elements having exceedance probabilities of 0.05 - one chance in twenty of being exceeded. For purposes of this example, assume flood peak discharge is the primary concern, rather than flood volume. Therefore, use a depth-duration curve developed from a 6 hour kernel.

Step 1a:

The 24 hour average precipitation depth for the watershed was determined to be 5.40 inches.

Step 2:

Use the dimensionless depth-duration ordinate values for the 5% exceedance probability from Table 8j. Multiply the dimensionless ordinates by the 24 hour ID average depth to scale the storm to the proper magnitude.

Step 3:

Select the 5% exceedance probability value (51.3 hours) from Table 10 for the time of occurrence for the high intensity segment.

Step 4:

Select a sequence for the three high intensity segments of the storm. As discussed previously, a more conservative sequence would have the larger precipitation amounts nearer the end of the sequence. In consideration of the above, a very conservative sequence would be represented by sequence 321 at 60 minute increments per Tables 7 and 11.

The incremental precipitation amounts corresponding to this sequence are inserted into the storm so the largest amount spans the time increment from 51 to 52 hours of elapsed time. Table 8j also contains ordinate values for precipitation amounts for two 30 minute high intensity segments. These segments should be inserted within the largest 60 minute segment.

Step 5:

Select a sequence for the four 6 hour segments within the 24 hour ID. As before, a conservative sequence should have the larger precipitation amounts nearer the end of the sequence. Chose sequence 4312 based on information in Tables 13 and 14. The largest 6 hour precipitation amount should include and be centered around the 1 hour high intensity segment at 51.3 hours. This results in the 24 hour ID occurring between 36 and 60 hours of elapsed time.

Step 6:

Select macro pattern Type IX based on selections in Steps 3,4 and 5. Choose macro pattern sequence 654213 for the six segment macro pattern sequence (12 hour time intervals) based on previous selections in Steps 3,4 and 5.

Step 7:

Multiply the scaled ordinate values from Step 2 by the appropriate areal reduction factors in Figure 15 to produce the final ordinates for the basin-average depth-duration curve.

The resultant synthetic storm is shown in Figure 19 and the supporting computations are contained in Table 19. For comparison purposes, a second storm mass hyetograph was computed (computations not shown) using a 48 hour DD kernel (Table 9c) in conjunction with the same characteristics used in Example 3. It can be seen in Figure 19 that the storms have similar mass curves. The primary differences being that the storm generated from the 6 hour DD kernel contains higher intensities and the storm generated from the 48 hour DD kernel has significantly larger total depth. The selection of the appropriate storm for the design of a specific hydraulic structure would depend on whether flood volume or flood peak discharge was the critical consideration.

Table 19. Assembly of Synthetic Mass Hyetograph for 24 Hour ID Extreme Storm for 100 square Mile Watershed near Olympia, WA.

DEPTH-DURATION ORDINATES							
DEPENDENT DURATION (hours)	ORDINATE VALUES				TIME INCREMENT (hours)	INCREMENTAL PRECIPITATION AMOUNT (inches)	SEQUENCE NUMBER
	TABULAR	SCALED	AREAL REDUCTION	FINAL			
0.00	0.000	0.00	----	0.00	0.50	0.31	within 1 hour hi
0.50	0.083	0.45	0.70	0.31			
1.00	0.130	0.70	0.76	0.53	0.50	0.22	
0.00	0.000	0.00	----	0.00	1.00	0.53	1 hi
1.00	0.130	0.70	0.76	0.53	1.00	0.38	2 hi
2.00	0.209	1.13	0.80	0.91	1.00	0.33	3 hi
3.00	0.279	1.51	0.82	1.24	3.00	0.94	1..6 hr
6.00	0.475	2.57	0.85	2.18	3.00	0.74	2..6 hr
9.00	0.629	3.40	0.86	2.92	3.00	0.64	
12.00	0.758	4.09	0.87	3.56	6.00	0.75	3..6 hr 2 macro
18.00	0.886	4.78	0.90	4.31	6.00	0.66	4..6 hr
24.00	1.000	5.40	0.92	4.97	12.00	0.27	3 macro
36.00	1.055	5.70	0.92	5.24	12.00	0.21	4 macro
48.00	1.097	5.92	0.92	5.45	12.00	0.21	5 macro
60.00	1.139	6.15	0.92	5.66	12.00	0.18	6 macro
72.00	1.175	6.35	0.92	5.84			

SYNTHETIC STORM MASS HYETOGRAPH			
TIME (hours)	SEQUENCE NUMBER	INCREMENTAL AMOUNT (inches)	MASS ORDINATE VALUE (inches)
0.0	6 macro	0.18	0.00
12.0	5 macro	0.21	0.18
24.0	4 macro	0.21	0.39
36.0	4....6 hr	0.66	0.60
42.0	3....6 hr	0.75	1.26
48.0	1/3 of .94	0.31	2.01
49.0	3 hi	0.33	2.32
50.0	2 hi	0.38	2.65
51.0	within 1 hi	0.31	3.03
51.5	within 1 hi	0.22	3.35
52.0	2/3 of .94	0.63	3.56
54.0	2....6 hr	0.74	4.19
57.0		0.64	4.93
60.0	3 macro	0.27	5.57
72.0			5.84

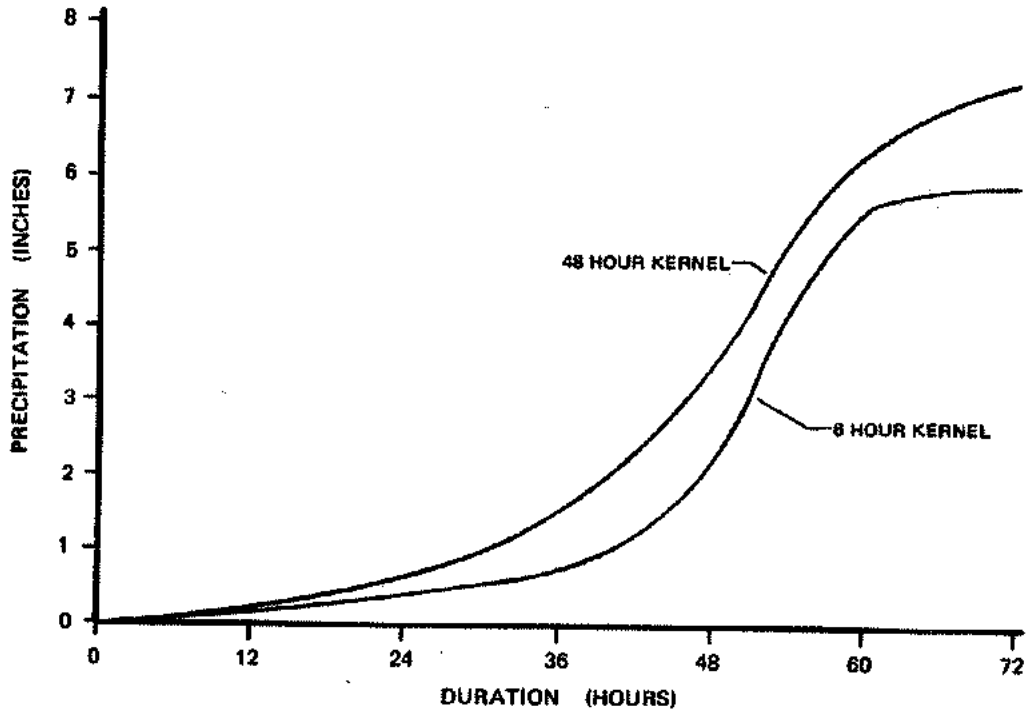


Figure 19. Synthetic Mass Hyetographs for 24 Hour ID Extreme Storms for 100 Square Mile Watershed near Olympia, WA.

One of the findings identified earlier in this study was the general relationship between storm seasonality, precipitation intensity and duration. To reiterate, short duration 2 hour ID extreme storms occur predominately in the warm season and typically contain high intensities but relatively small total depth. By comparison, the long duration 24 hour ID extreme storms are cool season events which contain relatively moderate and uniform intensities and a much larger total depth. The 6 hour ID extreme storms exhibit characteristics intermediate between the two. The general relationship between storm duration and the magnitude of the high intensities contained within the storm can be seen by reviewing the results from the three examples. The highest intensities in the example storms, for the 15 minute DD and no areal reduction, are 2.00 in/hr, 1.32 in/hr and 0.90 in/hr for the

2 hour ID, 6 hour ID and 24 hour ID storms respectively. **This complexity between storm magnitude, duration and the magnitude of the high intensity segments warrants that several synthetic storms be developed at each duration when investigating the flood characteristics of a specific watershed.** This will allow a proper determination of the storm duration and temporal components which have the characteristics to generate the flood which will govern the design of a given hydraulic structure.

SUMMARY AND CONCLUSIONS

Analyses were conducted to describe the probabilistic characteristics of extreme storms in Washington State. An extreme storm was defined as being a precipitation event whose depth for a specified duration, the Independent Duration (ID), represented a return period of 20 years or greater. For purposes of the study, a catalog of extreme storms was developed for three specific IDs, 2 hours, 6 hours and 24 hours, for each of five reasonably homogeneous climatic regions. Storms which exceeded the extreme storm threshold had to meet certain selection criteria to be included in the catalog. For each region, a specific storm (date) could appear at only one of the three IDs. In addition, only the recording station where the storm amount was the rarest was retained in the catalog.

The catalog created by the storm selection process formed the database for the probabilistic analyses. As a result of those analyses, the following observations and conclusions were made:

Seasonality

The season of occurrence of the extreme storms was strongly related to storm duration. The 2 hour ID events, in both eastern and western Washington, were found to occur primarily in the warm season; typically May through September. The influence of solar heating in initiating these convective events is evidenced by the fact that the vast majority of storms occurred between noon and early evening.

The 6 hour and 24 hour ID storms in western Washington were found to occur almost exclusively in the cool season; typically October through February. These storms were characterized by relatively moderate and uniform intensities. The high intensity segments of these storms rarely contained intensities as large as those found in the shorter duration 2 hour ID events.

The 24 hour ID storms in eastern Washington were found to occur primarily in the cool season; typically September through February.

The seasonality of occurrence of the 6 hour ID storms in eastern Washington had a bimodal distribution. Common seasons of occurrence were in spring and in late fall and winter.

Temporal Storm Characteristics

Twelve generalized macro storm patterns (incremental precipitation histograms) were created and used to categorize extreme storms. Six patterns were for storms which contained continuous precipitation and six patterns were for intermittent storms. Continuous patterns were always in the majority, although the percentage of intermittent storms tended to increase with storm duration. Likewise, a greater variety of macro patterns were observed as the ID of the storm increased.

The short duration 2 hour ID storms, in both eastern and western Washington, exhibited predominately Type I macro patterns. This pattern has the high intensity segment near the beginning of the storm.

In eastern Washington, the 6 hour and 24 hour ID storms typically exhibited a Type I macro pattern. In western Washington, the 6 hour and 24 hour ID storms typically occurred with a macro pattern where the high intensity segment was near the middle of the storm.

Probabilistic dimensionless depth-duration curves were developed for each of the three durations and five climatic regions. The depth-duration curves were found to be essentially independent of storm magnitude. Thus, selection of a design storm magnitude and a depth-duration curve are to be considered as independent decisions in the development of synthetic storms for rainfall-runoff modeling.

The cross-correlation structure of the dependent duration (DD) ordinates within the depth-duration curves was investigated for the three IDs in each region. In all cases, a definitive decay structure was observed, wherein, the magnitudes of the cross-correlation coefficients decreased as the time between DD pairs increased in magnitude. The cross-correlation structure resulted in probabilistic dimensionless depth-duration curves having certain characteristic shapes. For all three durations, dimensionless

curves with steeper than average rising limbs had flatter than average upper tails. Conversely, curves having steeper than average upper tails had flatter than average rising limbs. Thus, it was quite rare to see a storm whose dimensionless depth-duration curve ordinates exhibited significantly higher than average values at the high intensity segment of the storm and which exhibited unusually large ordinate values at the total duration.

Probabilistic information was developed on the sequencing (arrangement) characteristics of the incremental precipitation amounts within storms and on the time of occurrence of the high intensity storm segment for each of the three IDs and five regions. The sequencing characteristics were found to occur in a wide variety of possible combinations. Likewise, the timing characteristics of the high intensity segment were highly variable.

Antecedent Storms

Investigations were conducted to examine the largest antecedent precipitation events which occurred in the 14 day period prior to the extreme storms. For all three IDs, it was found that extreme storms are not preceded by an unusual storm.
In particular, antecedent storms are typically of a magnitude which occur numerous times during a given year.

Spatial Characteristics

The areal coverage characteristics of the 2 hour ID "thunderstorms" in eastern Washington were examined. Observed areal coverages were found to be highly variable, ranging from 35 to 500 square miles, and were nearly independent of the storm magnitude. The majority of storms originated out of the southwest or west. Storm movement resulted in areal coverages having an elliptical shape with an average major to minor axis ratio of about 2.5:1.

Assembly of Synthetic Storms

A methodology was presented for assembly of synthetic storms for each of the three IDs and five regions. The assembly methodology contained procedures which allowed decisions to be made regarding the manner in which the observed statistical characteristics could be incorporated in a synthetic storm.

In conclusion, it is intended that the findings from this study will allow engineers, hydrologists, meteorologists and other practitioners of rainfall-runoff modeling to make informed decisions in the selection and development of synthetic storms. Ultimately, it is hoped that this study will result in improved estimates of floods in Washington State.

ACKNOWLEDGMENTS

The author is deeply appreciative of the support provided by the Department of Ecology and in particular by M. Edward Garling while this study was being conducted. Data collection and compilation by Mr. Joe Cason was instrumental to the completion of this study and his efforts are appreciated.

Cover Photo by Dan Kruger:
Autumn Storm over the Cascade Mountains near Mt. Daniel

REFERENCES

Benjamin,J.R. and Cornell,C.A., Probability, Statistics and Decision for Civil Engineers, pp287-292, McGraw-Hill, 1970

Box,G.E. and Jenkins,G.M., Time Series Analysis: Forecasting and Control, pp46-82, Holden-Day, 1976

Chow,V.T., Handbook of Applied Hydrology, pp9.1-9.68, McGraw-Hill, 1964

Istok,J.D. and Boersma,L., A Stochastic Cluster Model for Hourly Precipitation Data, pp257-285, Journal of Hydrology,106, 1989

Fisher,R.A. and Tippett,L.H.C., Limiting Forms of the Frequency Distribution of the Largest or Smallest Member of a Sample, Proceedings Cambridge Phil. Society, 24, 180-190, 1928.

Frederick,R.H., Miller,J.F., Richards,F.P. and Schwerdt, R.W., Interduration Precipitation Relations for Storms - Western United States, Technical Report NWS 27, NOAA, Washington,D.C., 1981

Melone,A.M., Regional Analysis of the Time Distribution of Rainfall, Canadian Society of Civil Engineering, Annual Conference, Saskatoon, SK., May 27-31, 1985.

Miller,J.F., Frederick,R.H. and Tracey,R.S., NOAA ATLAS 2, Precipitation - Frequency Atlas of the Western United States, Volume IX - Washington, U.S. Dept. of Commerce, NOAA, National Weather Service, Washington,D.C., 1973.

NCDC, National Climatic Data Center, Climatological Data-Washington, Monthly Periodical, 1900-present, NOAA, Asheville,NC.

NCDC, National Climatic Data Center, Hourly Precipitation Data Washington, Monthly Periodical, 1951-present, NOAA, Asheville, NC.

NWS, National Weather Service, Hydrometeorological Report 43, Probable Maximum Precipitation for the Pacific Northwest, U.S. Department of Commerce, NOAA, U.S. Weather Bureau, Washington,D.C., 1966

NWS, National Weather Service, Hydrometeorological Report 49, Probable Maximum Precipitation Estimates Colorado River and Great Basin Drainages, U.S. Department of Commerce, NOAA, U.S. Weather Bureau, Washington,D.C., 1966

NWS, National Weather Service, Hydrometeorological Report 55, Probable Maximum Precipitation Estimates-United States Between the Continental Divide and the 103rd Meridian, U.S. Department of Commerce, NOAA, U.S. Weather Bureau, Washington,D.C., 1984.

Phillips,E.J., Washington Climate, Multiple Volumes by County, Washington State University Extension Service, Pullman,WA.

Schaefer,M.G., Regional Analyses of Precipitation Annual Maxima in Washington State, Water Resources Research, Vol.26, No.1, pp119-132, January,1990.

USGS, United States Geological Survey, Water Resources Data-Washington, Annual Periodical, 1961-present, Pacific Northwest District, Tacoma,WA.

USGS, United States Geological Survey, Miscellaneous Streamflow Measurements - in the State of Washington 1890 - January 1961, Water Supply Bulletin No. 23, Pacific Northwest District, Tacoma,WA.

Valencia,D.R. and Schaake,J.C. Jr., Disaggregation Processes in Stochastic Hydrology, Water Resources Research, Vol.9, No.3, pp580-584, June,1973.

Weiss,L.L., Ratio of True to Fixed Interval Maximum Rainfall, Journal of the Hydraulics Division, Proceedings ASCE, Vol. 90, HY-1, pp77-82, January,1964.

Woolhiser,D.A., and Osborn,H.B., A Stochastic Model of Dimensionless Thunderstorm Rainfall, Water Resources Research, Vol. 21, No.4, pp511-522, April,1985.

WMO, World Meteorological Organization, Manual for Depth-Area-Duration Analysis of Storm Precipitation, WMO #237, Geneva,Switzerland, 1969.

APPENDIX 1A

EXTREME STORM CATALOG

REGION 1 - EASTERN WASHINGTON - MOUNTAIN AREAS

2 HOUR INDEPENDENT DURATION STORMS

STATION	DATE	DEPTH (inches)	ESTIMATED ANNUAL EXCEEDANCE PROBABILITY	MACRO STORM PATTERN	EXCEEDED EXTREME STORM THRESHOLD AT INDEPENDENT DURATIONS		
					2 hr	6 hr	24 hr
REPUBLIC RANGER STN	08/23/41	1.43	.01240	I	X	X	
DAYTON 1WSW	07/08/46	0.79	.04629	I	X		
OROVILLE	06/16/47	1.25	.00656	I	X	X	
CENTERVILLE	06/07/47	0.80	.03757	I	X		
METHOW	08/10/48	1.08	.01854	I	X		
METHOW	06/17/50	0.89	.04020	I	X		
COLVILLE	07/19/50	1.00	.01879	I	X		
PULLMAN 2NW	08/10/52	1.77	.00195	VI	X	X	X
WENATCHEE EXP. STN	08/10/52	1.29	.01177	I	X		
COLVILLE	07/06/56	0.82	.04411	I	X		
WENATCHEE EXP. STN	08/25/56	1.38	.00895	I	X	X	
ICE HARBOR DAM	06/05/57	1.67	.00250	I	X		
WALLA WALLA WSO	05/24/58	1.60	.00837	I	X	X	
REPUBLIC RANGER STN	07/05/58	1.10	.03855	I	X		
PLUMMER	07/07/58	0.87	.04089		X		
METHOW	07/08/58	1.33	.00774	I	X	X	
REPUBLIC RANGER STN	08/09/62	1.26	.02166	I	X	X	
BONNERS FERRY 1SW	09/10/62	0.99	.01279		X	X	
PULLMAN 2NW	06/16/63	1.47	.00496	I	X	X	
WENATCHEE EXP.	08/23/65	0.96	.03721	I	X		
PONEROY	09/13/66	1.12	.03500	I	X		
MAZAMA	01/17/71	0.90	.04851	VI	X		
WALLA WALLA WSO	05/26/71	1.75	.00557	I	X	X	X
WENATCHEE EXP.	06/09/72	1.05	.02647	I	X	X	
SPOKANE WSO	06/07/77	0.96	.02712	I	X		
WHITMAN MISSION	08/05/77	0.94	.01971	I	X		
DAYTON 1WSW	07/07/78	1.20	.00669	VI	X	X	
MT ADAMS RNGR STN	01/12/80	1.30	.01848	I	X		
BOUNDARY SWITCHYARD	05/21/81	1.10	.01111	I	X	X	
CHEWELAH	07/20/83	1.00	.02210	I	X		
REPUBLIC RANGER STN	08/10/83	1.50	.01363	I	X	X	X
EASTON	08/26/83	1.80	.00029	I	X		
LAKE WENATCHEE	02/11/85	1.10	.03711	I	X		
MAZAMA	07/16/85	1.10	.01999	I	X		

APPENDIX 1A

EXTREME STORM CATALOG

REGION 1 - EASTERN WASHINGTON - MOUNTAIN AREAS

6 HOUR INDEPENDENT DURATION STORMS

STATION	DATE	DEPTH (inches)	ESTIMATED ANNUAL EXCEEDANCE PROBABILITY	MACRO STORM PATTERN	EXCEEDED EXTREME STORM THRESHOLD AT INDEPENDENT DURATIONS 2 hr	6 hr	24 hr
EASTON	10/31/42	2.13	.02699	V		X	
PLUMMER 3WSW	06/06/47	1.46	.01489	I		X	
MAZAMA	07/16/55	1.83	.01282	I	X	X	
COLVILLE AP	05/13/57	1.45	.00887	VII	X	X	X
BONNERS FERRY 1SW	06/09/58	1.32	.02077	I		X	
COEUR D'ALENE	06/08/64	1.28	.04211			X	
PLUMMER 3WSW	06/17/65	1.42	.01836			X	
LUCERNE 2NNW	12/08/71	1.45	.02683	VI		X	
MAZAMA	01/11/72	2.20	.00396	VI		X	
WENATCHEE EXP STN	10/31/73	1.49	.06729	I		X	
LAKE WENATCHEE	01/17/75	2.10	.01892	VI	X	X	
WENATCHEE EXP STN	08/18/75	1.38	.03884	VI		X	X
GLENWOOD	12/01/77	1.65	.01468	VI		X	
TEKOA	07/04/78	1.30	.05184	I		X	X
PESHASTIN TELMTRY	02/06/79	1.60	.01466	VI		X	X
SATUS PASS 2SW	01/12/80	2.10	.01935	I		X	
WALLA WALLA WSO	10/13/80	1.97	.00801	I	X	X	
LUCERNE 2NNW	01/23/82	1.58	.01402	VI		X	
MAZAMA	12/03/82	2.10	.00538	VI		X	X
REPUBLIC RNGR STN	08/10/83	2.10	.00276	I		X	X

24 HOUR INDEPENDENT DURATION STORMS

SPRAGUE	09/21/45	1.55	.06002	XII			X
BONNERS FERRY 1SW	11/18/46	2.78	.00858	VI			X
UNDERWOOD	12/11/46	4.04	.04535	I		X	X
PULLMAN 2NW	09/15/47	2.10	.05404	I			X
HOOD RIVER EXP	01/06/48	3.33	.03638	VI			X
METHOW	05/28/48	2.02	.02430	VIII			X
OROVILLE	11/16/50	1.96	.02917	I			X
CENTERVILLE	01/09/53	2.36	.03548	VI		X	X
SATUS PASS 2SSW	11/24/60	3.12	.03090	VI			X
LUCERNE 2NW	11/19/62	3.05	.03261	I		X	X
DIXIE 4SE	11/23/64	2.70	.03145	I			X
DAYTON 9SE	12/22/64	3.01	.00922	VII			X
DAYTON 9SE	01/02/66	2.53	.03102	I			X
MAZAMA	02/27/72	3.80	.00578	I	X	X	X
SATUS PASS 2SSW	01/15/74	3.60	.01145	I			X
LUCERNE 2NNW	12/02/75	3.17	.02506	XII			X
SATUS PASS 2SSW	12/13/77	3.30	.02102	XII			X
WALLA WALLA WSO	10/14/80	3.08	.00260	V	X	X	X
MAZAMA	01/12/80	3.20	.01832	I			X
STEHEKIN 4NW	01/23/82	5.00	.00560	I		X	X
BOUNDARY SWITCHYARD	02/15/86	3.10	.00723	I			X

APPENDIX 1B

EXTREME STORM CATALOG

REGION 2 - EASTERN WASHINGTON - CENTRAL BASIN

2 HOUR INDEPENDENT DURATION STORMS

STATION	DATE	DEPTH (inches)	ESTIMATED ANNUAL EXCEEDANCE PROBABILITY	MACRO STORM PATTERN	EXCEEDED EXTREME STORM THRESHOLD AT INDEPENDENT DURATIONS 2 hr	6 hr	24 hr
ELLENSBURG	05/12/43	0.62	.06186	I	X		
WITHROW 4WNW	06/13/44	1.06	.02287	I	X		
YAKIMA	06/19/44	0.90	.02623	I	X		
SUNNYSIDE	06/07/47	1.62	.00161	I	X	X	X
HARRINGTON 4ENE	06/10/48	1.03	.01152	VI	X	X	
WILSON CREEK	06/18/50	1.50	.00261	I	X	X	X
WILSON CREEK	07/24/50	0.80	.03979	I	X		
NACHES 10NW	05/05/57	0.90	.02485	I	X		
CHIEF JOE DAM	06/07/58	0.71	.04654	I	X		
COULEE DAM	04/29/61	0.85	.03374	I	X		
WITHROW 4WNW	08/14/68	0.94	.03615	V	X	X	
WITHROW 4WNW	12/11/69	0.93	.03762	I	X		
YAKIMA	08/18/75	0.98	.01900	V	X	X	
NACHES 10NW	07/07/82	1.20	.00742	I	X		X
NACHES 10NW	08/01/84	0.80	.03979	I	X		

6 HOUR INDEPENDENT DURATION STORMS

WILSON CREEK	06/16/48	1.06	.03072	I		X	
ARLINGTON-OREGON	01/08/53	1.02	.04795			X	
MCNARY DAM	10/01/57	1.86	.00058	VIII	X	X	X
CHIEF JOE DAM	08/23/65	1.02	.04979	I		X	
COULEE DAM 1SW	11/12/73	1.19	.02880	I		X	
PASCO	09/13/80	1.30	.01031	VI	X	X	X
NACHES 10 NW	01/23/82	1.00	.06342	V	X	X	X

24 HOUR INDEPENDENT DURATION STORMS

LIND 3NE	06/25/42	1.53	.02443	I			X
HARRINGTON 4ENE	09/21/45	1.52	.04749	XII			X
COULEE DAM 1SW	05/28/48	1.66	.03021	I			X
HARRINGTON 4ENE	09/25/48	1.51	.02500	I		X	X
NACHES 10 NW	01/14/56	1.43	.06551	I			X
MCNARY DAM	10/02/57	3.15	.00008	I	X	X	X
ARLINGTON OREGON	12/22/64	3.15	.00689			X	X
ELLENSBURG	12/04/74	1.30	.04410	IV			X

APPENDIX 1C

EXTREME STORM CATALOG

REGION 3 - WESTERN WASHINGTON - PUGET SOUND LOWLANDS

2 HOUR INDEPENDENT DURATION STORMS

STATION	DATE	DEPTH (inches)	ESTIMATED ANNUAL EXCEEDANCE PROBABILITY	MACRO STORM PATTERN	EXCEEDED EXTREME STORM THRESHOLD AT INDEPENDENT DURATIONS 2 hr	6 hr	24 hr
EVERETT	09/28/44	1.01	.03311	VII	X	X	
MCMILLIN RESERVOIR	07/08/46	1.10	.02178	VIII	X		
CENTRALIA 1W	10/28/49	1.15	.02101	I	X		
SEATTLE WSO	06/29/52	0.96	.04180	I	X		
MCMILLIN RESERVOIR	09/17/57	1.07	.02585	VI	X		
EVERETT	05/31/58	1.14	.01603	I	X		
AUBURN	06/08/59	0.87	.04232	V	X		
MCMILLIN RESERVOIR	08/26/60	1.70	.00176	VII	X	X	
GOBLE 3SW-OREGON	06/30/63	0.87	.03467		X		
LONGVIEW	08/23/63	1.05	.04125	I	X		
SNOQUALMIE FALLS	09/19/64	1.17	.03576	I	X		
BURLINGTON	08/12/65	1.28	.00877	I	X	X	
PORT TOWNSEND	09/10/67	0.84	.03295	X	X		
EVERETT	09/22/72	0.99	.03713	X	X		
CASTLE ROCK	09/20/73	1.46	.00685	V	X	X	
CENTRALIA 1W	07/08/74	1.20	.01638	V	X		
SEATTLE -EMSU	08/26/77	1.64	.00153	I	X	X	
CARNATION 1W	09/20/77	1.20	.00865	I	X		
LANDSBURG	07/09/80	0.90	.05640	I	X		
SEA-TAC	10/06/81	0.85	.04442	II	X		X
CARNATION	06/18/86	1.00	.03000	I	X		

6 HOUR INDEPENDENT DURATION STORMS

SEA-TAC (WSO)	01/19/43	1.60	.02674	VI		X	
PORT TOWNSEND	06/14/46	1.35	.01637	I		X	X
SEA-TAC (WSO)	02/16/49	1.50	.04348	X		X	
OLYMPIA	12/09/56	2.13	.02460	IX		X	
YELM	11/20/59	1.44	.05487	VIII		X	
EVERETT	10/23/60	1.39	.05067	I		X	
SNOQUALMIE FALLS	10/21/63	2.08	.04165	I		X	
CARNATION 4NW	12/03/68	1.57	.03335	VI		X	
LANDSBURG	06/23/69	1.64	.04089	VI		X	
PORTLAND ORG -WB	09/17/69	1.82	.02002			X	
BLAINE 1ENE	11/03/71	1.60	.03747	V		X	X
YELM	12/21/72	1.43	.05759	I		X	
PORT ANGELES	11/03/78	1.92	.01514	VI		X	
SNOQUALMIE FALLS	01/23/82	2.00	.05516	IX		X	
SEATTLE ENSU	12/03/82	1.56	.03855	V		X	
MCMILLIN RESRVOIR	08/29/83	1.90	.00822	I		X	
BLAINE 1ENE	12/29/83	1.70	.02345	VIII	X	X	X
BLAINE 1ENE	02/15/86	2.00	.00568	V	X	X	

APPENDIX 1C

EXTREME STORM CATALOG

REGION 3 - WESTERN WASHINGTON - PUGET SOUND LOWLANDS

24 HOUR INDEPENDENT DURATION STORMS

STATION	DATE	DEPTH (inches)	ESTIMATED ANNUAL EXCEEDANCE PROBABILITY	MACRO STORM PATTERN	EXCEEDED EXTREME STORM THRESHOLD AT INDEPENDENT DURATIONS 2 hr	6 hr	24 hr
SEA-TAC (WSO)	02/06/45	3.00	.05829	I			X
BURLINGTON	10/24/45	4.91	.00049	I		X	X
BURLINGTON	02/15/49	3.42	.01277	I			X
OLYMPIA WB AIRPORT	02/09/51	4.93	.01859	II			X
BLAINE 1ENE	11/03/55	3.63	.01849	I		X	X
AUBURN	11/20/59	3.63	.02312	II	X		X
PORT ANGELES	01/14/61	3.12	.03318	I			X
LONGVIEW	11/19/62	5.41	.00194	I	X	X	X
CASTLE ROCK	11/23/64	4.62	.03649	II			X
SNOQUALMIE FALLS	01/18/67	4.72	.03595	III			X
SNOQUALMIE FALLS	03/05/72	4.90	.02747	I			X
LONGVIEW	12/02/77	4.70	.00710	I		X	X
LANDSBURG	12/16/79	3.40	.05000	VIII			X
SEA-TAC AIRPORT	10/06/81	3.71	.01218	VI	X		X
SEATTLE EMSU	01/18/86	4.48	.00388	XII			X
LONGVIEW	02/23/86	4.70	.00710	VIII	X	X	X

APPENDIX 1D

EXTREME STORM CATALOG

REGION 4 - WESTERN WASHINGTON - MOUNTAINS

2 HOUR INDEPENDENT DURATION STORMS

STATION	DATE	DEPTH (inches)	ESTIMATED ANNUAL EXCEEDANCE PROBABILITY	MACRO STORM PATTERN	EXCEEDED EXTREME STORM THRESHOLD AT INDEPENDENT DURATIONS 2 hr	6 hr	24 hr
MUD MOUNTAIN DAM	06/10/42	0.99	.05121	I	X		
MUD MOUNTAIN DAM	09/01/43	0.99	.05121	VI	X		
COUGAR 4SW	09/21/44	1.49	.01364	I	X		
SKYKOMISH 1ENE	05/25/45	1.78	.00204	I	X		
MT. BAKER LODGE	06/16/49	1.53	.01349	I	X		
CINEBAR	06/09/53	1.51	.00282	II	X	X	
BONNEVILLE DAM	08/25/56	1.51	.00760		X	X	
RANDLE 1E	08/28/57	1.40	.00422	I	X		
SILVERTON	09/10/67	1.40	.04602	VI	X		
BONNEVILLE DAM	11/20/70	1.40	.01367	I	X		
WHITE RIVER RNGR STA	05/10/75	1.20	.01806	I	X		
CEDAR LAKE	09/20/77	1.40	.05242	I	X		
RANDLE	06/28/78	1.30	.01423	I	X		
MUD MOUNTAIN DAM	07/09/79	1.11	.02402	I	X		
CARSON FISH HATCH	01/12/80	1.40	.01856	I	X		
SILVERTON	09/30/80	1.80	.00542	I	X		
QUILCENE DAM 5SW	11/29/80	1.40	.03717	I	X		

6 HOUR INDEPENDENT DURATION STORMS

STATION	DATE	DEPTH (inches)	ESTIMATED ANNUAL EXCEEDANCE PROBABILITY	MACRO STORM PATTERN	EXCEEDED EXTREME STORM THRESHOLD AT INDEPENDENT DURATIONS 2 hr	6 hr	24 hr
SNOQUALMIE PASS	12/04/41	2.74	.05860	VI	X	X	
SPIRIT LAKE RNGR STA	10/24/43	3.12	.00177	V	X	X	X
MARBLEMOUNT RNGR STA	01/07/45	2.04	.04324	IX		X	
SILVERTON	02/07/45	2.84	.05340	IX		X	
SNOQUALMIE PASS	10/24/45	3.87	.00299	V	X	X	
SAPHO 8E	02/01/47	3.32	.01265	IX	X	X	
BONNEVILLE DAM	10/19/47	3.60	.00079	I	X	X	X
QUILCENE DAM 5SW	12/01/48	2.55	.07421	VI	X	X	
DARRINGTON RNGR STA	09/27/53	2.20	.06177	V		X	
LESTER	12/09/53	2.15	.03030	X		X	
QUILCENE DAM 5SW	02/07/55	2.64	.05816	IX		X	
SILVERTON	12/09/56	3.30	.01631	IX	X	X	
PALMER 3ESE	09/26/59	2.69	.01417	VIII	X	X	
CAMP GRISDALE	11/19/59	4.14	.02681	VI	X	X	
STAMPEDE PASS	11/22/59	2.94	.01517	VI		X	X
STAMPEDE PASS	11/21/61	2.56	.04583	IX		X	
DIABLO DAM	12/08/71	2.50	.02156	VI	X	X	
WHITE RIVER RNGR STA	11/09/73	2.00	.04035	VI	X	X	
MUD MOUNTAIN DAM	08/18/75	2.13	.00677	I	X	X	X
SNOQUALMIE PASS	12/01/75	2.90	.03867	X	X	X	
GREENWATER	12/02/77	2.70	.00221	V	X	X	
PALMER 3ESE	11/03/83	2.40	.03619	I		X	
GREENWATER	01/03/84	2.10	.02290	I	X	X	X
CEDAR LAKE	01/24/84	2.40	.03284	II		X	
CUSHMAN DAM	01/18/86	4.30	.00476	V	X	X	X

APPENDIX 1D

EXTREME STORM CATALOG

REGION 4 - WESTERN WASHINGTON - MOUNTAINS

24 HOUR INDEPENDENT DURATION STORMS

STATION	DATE	DEPTH (inches)	ESTIMATED ANNUAL EXCEEDANCE PROBABILITY	MACRO STORM PATTERN	EXCEEDED EXTREME STORM THRESHOLD AT INDEPENDENT DURATIONS		
					2 hr	6 hr	24 hr
DIABLO DAM	10/24/45	6.42	.01822	VI			X
RAINIER CARBON RIVR	11/17/46	4.30	.04004	V			X
ELECTRON HEADWORKS	12/10/46	4.77	.05000	VII			X
DIABLO DAM	02/16/49	7.57	.00455	XII	X		X
DARRINGTON RNGR STA	11/26/49	4.98	.06920	VIII		X	X
DIABLO DAM	02/09/51	6.47	.01716	V		X	X
QUILCENE DAM 5SW	01/07/59	5.80	.05000	III			X
SKYKOMISH 1ENE	12/14/59	7.70	.01404	VI			X
RAINIER OHANEPECOSH	11/19/62	7.78	.00235	I	X	X	X
PALMER 3ESE	01/28/65	5.14	.04948	VIII			X
GLACIER RNGR STA	03/05/72	4.90	.02150	I			X
STAMPEDE PASS	12/01/75	6.84	.03012	VII			X
CINEBAR	12/02/77	6.80	.00228	I		X	X
GLACIER RNGR STA	12/14/79	5.70	.00522	VI			X
UPPER BAKER DAM	11/21/80	5.80	.05652	XII			X
GREENWATER	01/23/82	5.30	.00583	III	X	X	X
QUILCENE DAM 5SW	10/22/82	7.90	.00627	VII		X	X
SILVERTON	12/03/82	7.70	.01476	VI			X
HOOKSACK HATCHERY	01/10/83	6.30	.01589	XII			X
GREENWATER	01/24/84	4.50	.00284	I	X	X	X
DARRINGTON RNGR STA	01/16/86	6.60	.00850	XI			X
MARBLEMOUNT RNGR STA	02/24/86	6.20	.01586	VII		X	X

APPENDIX 1E

EXTREME STORM CATALOG

REGION 5 - WESTERN WASHINGTON - COASTAL LOWLANDS

2 HOUR INDEPENDENT DURATION STORMS

STATION	DATE	DEPTH (inches)	ESTIMATED ANNUAL EXCEEDANCE PROBABILITY	MACRO STORM PATTERN	EXCEEDED EXTREME STORM THRESHOLD AT INDEPENDENT DURATIONS 2 hr	6 hr	24 hr
TATOOSH ISLAND	11/03/41	1.41	.03972	IX	X		
TATOOSH ISLAND	10/10/42	1.53	.02249	I	X		
WESTPORT	10/30/50	1.47	.01324	I	X	X	
MOCLIPS	01/02/51	1.30	.05650		X		
WESTPORT	10/18/79	1.20	.05473	V	X		
ABERDEEN 20NNE	05/28/82	2.50	.00217	I	X		

6 HOUR INDEPENDENT DURATION STORMS

MOCLIPS	12/11/53	2.47	.04705	VI		X	
ABERDEEN 20NNE	11/02/55	3.47	.05275	V		X	
MONTESANO 3NW	12/22/61	2.46	.05234	VII		X	
FRANCES	11/25/62	2.72	.05101	VI		X	
PT. GRENVILLE	10/29/67	2.98	.03869	VI		X	
QUILLAYUTE	01/25/71	3.21	.02772	V		X	
GRAYS RIVER	11/06/80	3.20	.03226	VI	X	X	
QUINALT RS	02/15/81	4.00	.00863	I	X	X	
FRANCES	12/15/82	2.90	.03137	V	X	X	
WESTPORT 2S	07/01/83	2.20	.05192	VI		X	
GRAYS RIVER	10/26/85	3.10	.04117	VI		X	

24 HOUR INDEPENDENT DURATION STORMS

CLEARWATER	12/03/43	8.41	.02404	VI			X
TATOOSH ISLAND	10/23/44	5.33	.02426	XII		X	X
ABERDEEN 20NNE	11/03/55	8.39	.06235	I		X	X
GRAYS RIVER	01/14/58	6.64	.05847	IV			X
MONTESANO 3NW	11/18/62	5.40	.02750	I			X
QUILLAYUTE	01/18/68	8.32	.01534	I			X
CLEARWATER	01/25/71	7.90	.03790	IX		X	X
CLEARWATER	07/11/72	8.90	.01549	VI			X
MONTESANO 3NW	02/27/80	5.00	.06522	VI			X
CLEARWATER	02/13/82	9.30	.01081	III			X
FRANCES	01/18/86	5.20	.06500	XI			X

APPENDIX 2

CONSTRUCTION OF DEPTH-DURATION CURVES

The depth-duration curve is an analytical tool developed by meteorologists [Chow, 1964] [WMO, 1969] to allow comparisons to be made between storms of the amount of precipitation which occurred during a given time period. Simply stated, the depth-duration curve is a precipitation mass curve created by rearrangement of the incremental precipitation amounts from an observed storm. The new mass curve is constructed in a manner which contains the largest incremental precipitation amounts at the start of the new mass curve. Slight variations exist in the procedures used by various meteorologists, hydrologists and engineers in the construction of depth-duration curves.

Depth-duration curves can be developed for at-site precipitation, representing storm areal coverage for some nominal area such as 1 square mile or 10 square miles, or for a specific area. In the latter case, spatial averaging techniques are first used to define the average temporal distribution of the storm for the given area.

The following list describes procedures for construction of at-site depth-duration curves:

- A time increment for analysis is selected based on the needs of the specific study.

- The precipitation record is examined to determine the largest precipitation amount which occurred in a "window of time" equal to the time increment. This incremental precipitation amount is ranked first and forms the beginning of a new series of reordered amounts from the observed storm.

- The precipitation record is then reexamined to determine the largest precipitation amount which has occurred in a window of time equal to twice the time increment and which includes the initial precipitation amount chosen previously. The precipitation amount which occurred in this second incremental period of time is listed second in the new series being formed. The term "nested" is often applied to the requirement that the duration (time window) being examined must include the entire time period which contained the previously selected amounts.

- The process of expanding the time window by one time increment and selecting the largest nested precipitation amount is continued until the original storm is completely reordered.

- The reordered mass curve is labeled a depth-duration curve.

- A dimensionless depth-duration curve is produced by dividing the ordinates of the curve by the observed precipitation amount corresponding a specic duration of interest.

EXAMPLE: Extreme Storm of October 14, 1945 - Snoqualmie Pass, WA.
6 hour Precipitation Depth= 3.87 inches
Independent Duration= 6 hours, Time Increment= 3 hours
Macro Pattern= Type VI

Solution: Use previously discussed steps to reorder observed storm mass curve into dimensionless depth-duration curve. Incremental precipitation amounts are listed and reordered in Table 20 and displayed in Figure 20.

Table 20. Development of Depth-Duration Curve from Observed 6 Hour ID Extreme Storm of October 14, 1945 at Snoqualmie Pass, WA.

ORIGINAL STORM MASS CURVE			DEPTH-DURATION CURVE			
END OF HOUR	MASS CURVE (inches)	INCREMENTAL VALUE (inches)	DURATION (hours)	INCREMENTAL VALUE (inches)	MASS CURVE (inches)	DIMENSIONLESS ORDINATES
1	0.10	0.10	0	0.00	0.00	0.000
2	0.30	0.20	1	0.88	0.88	0.227
3	0.68	0.38	2	0.67	1.55	0.401
4	1.10	0.42	3	0.75	2.30	0.594
5	1.80	0.70	6	1.57	3.87	1.000
6	2.55	0.75*	9	1.06	4.93	1.274
7	3.22	0.67*	12	0.60	5.53	1.429
8	4.10	0.88*	15	0.25	5.78	1.494
9	4.55	0.45	18	0.20	5.98	1.545
10	4.88	0.33				
11	5.23	0.35	- Continuous Storm			
12	5.51	0.28				
13	5.63	0.12	Trisector 1 = 2.55"			
14	5.73	0.10	Trisector 2 = 2.96"			
15	5.78	0.05	Trisector 3 = 0.47"			
16	5.83	0.05	Macro Pattern = Type VI			
17	5.91	0.08				
18	5.98	0.07	* High Intensity Segment Sequence = 231			

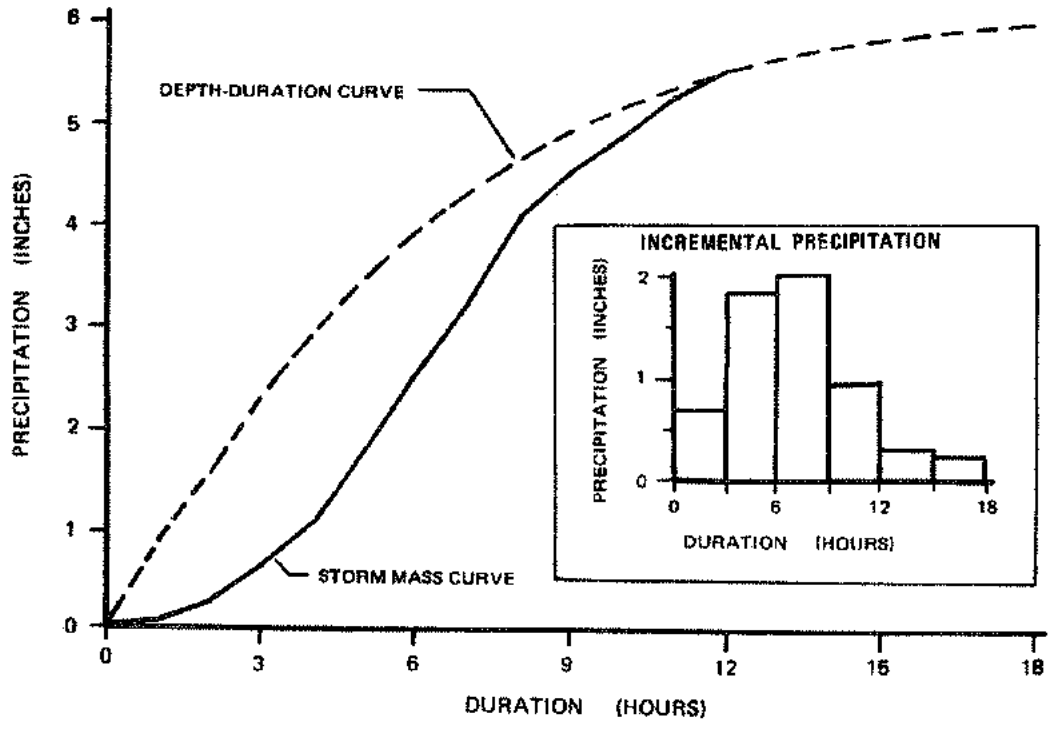


Figure 20. Comparison of Depth-Duration and Observed Mass Curves for Extreme Storm of October 14, 1945 at Snoqualmie Pass, WA.

A P P E N D I X 3

WORKSHEETS FOR ASSEMBLY OF SYNTHETIC STORMS

WORKSHEET FOR ASSEMBLY OF 2 HOUR ID MASS HYETOGRAPHS

PROJECT _____ FILE NO. _____

LOCATION _____ NORTH _____ ° WEST _____ °

WASHINGTON CLIMATIC REGION _____

WATERSHED DRAINAGE AREA (mi^2) _____

2 HOUR ID EXTREME STORM DEPTH _____ Inches KERNEL 0.5 Hours

EXCEEDANCE PROBABILITY OF SELECTED DEPTH-DURATION CURVE _____ %

EXCEEDANCE PROBABILITY OF SELECTED STORM CHARACTERISTICS _____ %

TIME OF OCCURRENCE OF HIGH INTENSITY STORM SEGMENT...AT _____ Hours

HIGH INTENSITY STORM SEQUENCE _ _ _

TIME OF OCCURRENCE OF 2 HOUR ID SEGMENT FROM ____ Hours to ____ Hours

MACRO PATTERN...TYPE _____ MACRO STORM SEQUENCE _ _ _ _ _ _

DEPTH-DURATION ORDINATES

DEPENDENT DURATION (hours)	ORDINATE VALUES				TIME INCREMENT (hours)	INCREMENTAL PRECIPITATION AMOUNT (inches)	SEQUENCE NUMBER
	TABULAR	SCALED	AREAL REDUCTION	FINAL			
0.00	0.000	0.00	----	0.00			
0.08					0.08		within
0.17					0.08		1 hi
0.25					0.08		
0.00	0.000	0.00	----	0.00			
0.25					0.25		1 hi
0.50					0.25		2 hi
0.75					0.25		3 hi
1.00					0.25		1 macro
1.25					0.25		
1.50					0.25		2 macro
2.00	1.000				0.50		
3.00					1.00		3 macro
4.00					1.00		4 macro
5.00					1.00		5 macro
6.00					1.00		6 macro

SYNTHETIC STORM MASS HYETOGRAPH

TIME (hours)	SEQUENCE NUMBER	INCREMENTAL AMOUNT (inches)	MASS ORDINATE VALUE (inches)

WORKSHEET FOR ASSEMBLY OF 6 HOUR ID MASS HYETOGRAPHS

PROJECT _____ FILE NO. _____

LOCATION _____ NORTH _____° WEST _____°

WASHINGTON CLIMATIC REGION _____

WATERSHED DRAINAGE AREA (mi^2) _____

6 HOUR ID EXTREME STORM DEPTH _____ Inches KERNEL 2.0 Hours

EXCEEDANCE PROBABILITY OF SELECTED DEPTH-DURATION CURVE _____ %

EXCEEDANCE PROBABILITY OF SELECTED STORM CHARACTERISTICS _____ %

TIME OF OCCURRENCE OF HIGH INTENSITY STORM SEGMENT...AT _____ Hours

HIGH INTENSITY STORM SEQUENCE _ _ _

TIME OF OCCURRENCE OF 6 HOUR ID SEGMENT FROM ____ Hours to ____ Hours

MACRO PATTERN...TYPE _____ MACRO STORM SEQUENCE _ _ _ _ _ _

DEPTH-DURATION ORDINATES

DEPENDENT DURATION (hours)	ORDINATE VALUES				TIME INCREMENT (hours)	INCREMENTAL PRECIPITATION AMOUNT (inches)	SEQUENCE NUMBER
	TABULAR	SCALED	AREAL REDUCTION	FINAL			
0.00	0.000	0.00	----	0.00			
0.25					0.25		within 1 hi
0.50					0.25		
1.00					0.50		
0.00	0.000	0.00	----	0.00			
1.00					1.00		1 hi
2.00					1.00		2 hi
3.00					1.00		1 macro 3 hi
6.00	1.000				3.00		2 macro
9.00					3.00		3 macro
12.00					3.00		4 macro
15.00					3.00		5 macro
18.00					3.00		6 macro

SYNTHETIC STORM MASS HYETOGRAPH

TIME (hours)	SEQUENCE NUMBER	INCREMENTAL AMOUNT (inches)	MASS ORDINATE VALUE (inches)

WORKSHEET FOR ASSEMBLY OF 24 HOUR ID MASS HYETOGRAPHS

PROJECT_____ FILE NO._____

LOCATION_____ NORTH_____° WEST_____°

WASHINGTON CLIMATIC REGION_____

WATERSHED DRAINAGE AREA (mi^2)_____

24 HOUR ID EXTREME STORM DEPTH_____ Inches KERNEL_____ Hours

EXCEEDANCE PROBABILITY OF SELECTED DEPTH-DURATION CURVE _____ %

EXCEEDANCE PROBABILITY OF SELECTED STORM CHARACTERISTICS _____ %

TIME OF OCCURRENCE OF HIGH INTENSITY STORM SEGMENT...AT _____ Hours

HIGH INTENSITY STORM SEQUENCE _ _ _

TIME OF OCCURRENCE OF 24 HOUR ID SEGMENT FROM ____ Hours to ____ Hours

SEQUENCE OF 6 HOUR SEGMENTS WITHIN 24 HOUR ID _ _ _ _

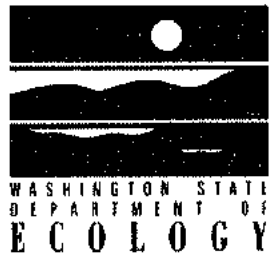
MACRO PATTERN...TYPE _____ MACRO STORM SEQUENCE _ _ _ _ _ _

DEPTH-DURATION ORDINATES

DEPENDENT DURATION (hours)	ORDINATE VALUES				TIME INCREMENT (hours)	INCREMENTAL PRECIPITATION AMOUNT (inches)	SEQUENCE NUMBER
	TABULAR	SCALED	AREAL REDUCTION	FINAL			
0.00	0.000	0.00	----	0.00			
0.50					0.50		within
1.00					0.50		1 hi
0.00	0.000	0.00	----	0.00			
1.00					1.00		1 hi
2.00					1.00		2 hi
3.00					1.00		3 hi
6.00					3.00		1..6 hr
9.00					3.00		2..6 hr
12.00					3.00		
18.00					6.00		3..6 hr
24.00	1.000				6.00		2 macro 4..6 hr
36.00					12.00		3 macro
48.00					12.00		4 macro
60.00					12.00		5 macro
72.00					12.00		6 macro

SYNTHETIC STORM MASS HYETOGRAPH

TIME (hours)	SEQUENCE NUMBER	INCREMENTAL AMOUNT (inches)	MASS ORDINATE VALUE (inches)



Mission

The mission of the Department of Ecology is to protect, preserve and enhance Washington's environment and promote the wise management of our air, land and water for the benefit of current and future generations.

12–Point Strategy

To accomplish this mission, the department will:

- Recognize its most valuable asset is its dedicated and committed employees and it will provide necessary support, training and professional development.
- Promote prevention and conservation as the most effective ways to preserve our natural resources and protect the environment.
- Enforce environmental laws and regulations in a fair and firm manner.
- Provide public education programs to promote wise use of our natural resources and encourage environmental protection.
- Offer information, technical and financial assistance to help the public, governments, businesses and industries comply with environmental laws and regulations.
- Promote the recognition that compliance with environmental laws and regulations is compatible with a sound economy.
- Provide meaningful public involvement in the development of rules, regulations and new initiatives.
- Provide leadership in addressing emerging problems and strive to bring public agencies and diverse interest groups together to address environmental issues.
- Use an integrated approach to resolve environmental issues.
- Place special emphasis on educating and working with youth to create a strong environmental ethic.
- Help state agencies set an example in environmental protection.
- Work with the executive and legislative branches to promote sound environmental policy.

DETERMINING DESIGN/PERFORMANCE GOALS FOR SPILLWAY ADEQUACY: THE WASHINGTON STATE APPROACH

by Douglas L. Johnson, P.E.[a]

A. Introduction

This paper summarizes the conclusions from many years of work by the Washington State Dam Safety Section towards developing a risk-based approach to spillway adequacy. Historically, spillway design for dams with population at risk has been based on deterministic methods (i.e. Probable Maximum Precipitation). This level of protection is widely recognized as appropriate for the design of large dams located above densely populated areas. However, the vast majority of dams regulated by state dam safety programs are small to intermediate in size, where the downstream hazard setting typically includes fewer than 10 homes. These types of projects and downstream hazard settings typically represent situations where the extreme storm used in flood analysis can often be justified as being something less than PMP. However, the key question arises - *What is an acceptable level of safety for these projects?* Our studies in extreme storms and risk-based methods attempt to answer this question.

The key elements to the Washington State approach to spillway design are contained in Technical Note 2: *Selection of Design/Performance Goals for Critical Project Elements*[1], along with its companion paper, Technical Note 3: *Design Storm Construction*[2]. Technical Note 2 is an application of the probability-based extreme storm studies developed by Dr. Mel Schaefer in *Regional Analysis of Precipitation Annual Maxima in Washington State*[3], and applied in Technical Note 3. Technical Note 2 takes a probabilistic approach to design levels for dams vs. a deterministic approach (i.e. PMP). However, the design levels discussed in Technical Note 2 were not intended to replace PMP, but to compliment it. PMP which is a "maximum" event, is still used as an upper limit for large dams with a large population at risk downstream. For smaller dams with less population at risk, however, a probabilistic or "risk-based" approach was developed.

B. Balanced Protection Concept

Historically, the various engineering disciplines involved in dam design/safety evaluation used different methodologies that have resulted in various elements of the project being designed to different standards, resulting in widely dissimilar levels of protection from failure. For example, a spillway may be designed for PMP/PMF, while the outlet conduit is designed using methods common for roadway drainage structures. The *Balanced Protection Concept* sets a common design/performance goal for the design or evaluation of each critical project element to assist in providing reasonably consistent levels of protection. A design/performance goal is simply a goal for the performance of critical project elements (e.g. spillway, embankment stability), which may be used in design or evaluation. It is expressed as an Annual Exceedance Probability (AEP) and is a measure of the chance of adverse behavior, or failure of a critical project element. Technical Note 2 presents a methodology for determining a common design/performance goal for a given level of protection of any critical element of a project, including spillways.

C. Consequence Dependent Design Levels

It is standard practice in civil engineering that the degree of conservativism in design should correspond with the consequences of failure of a given element. If failure of the element poses no public safety concern, the design level is usually based on economic considerations. However, if failure of a given element could pose threat to loss of life, design levels are typically much more conservative to protect from consequences of failure. Also, as the magnitude of loss of life and

---

[a] Dam Inspection Specialist, Dam Safety Section, Washington Department of Ecology

property damage resulting from a failure increases, design levels become more stringent. This concept is called *Consequence Dependent Design Levels.*

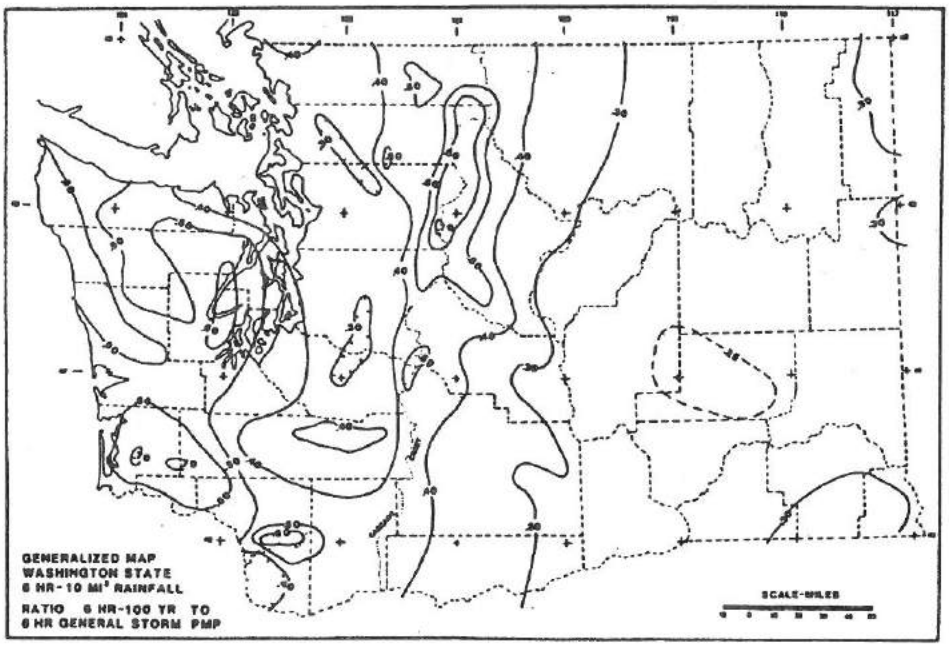
D. Selection of Probabilistic Approach

In the past, the standard design storm in the dam safety community for the design of intermediate and large high hazard projects (3 or more homes) has been the Probable Maximum Precipitation (PMP). PMP is theoretically *the greatest depth of precipitation for a given duration that is physically possible over a given storm area at a particular geographical location at a certain time of year*[4,5]. In the engineering community, it is commonly assumed that PMP provides a consistent level of protection and a "zero risk" design level. However, it is not possible to compute theoretical PMP directly, and numerous procedures and judgements must be used to estimate PMP. Thus, in reality, computed PMP approaches, rather than meets, the theoretical upper limit. This implies that real world precipitation can exceed computed PMP estimates, and use of these values does not carry zero risk.

Further studies by Dr. Schaefer showed that in Washington (as well as across the U.S.), the annual exceedance probability for PMP can vary widely across the state. On the Coast, where the moisture source is near at hand and the rainfall processes are very efficient, PMP (based on HMR-43) has an exceedance probability of about 10^{-5}. In the Puget Sound Area, PMP has an exceedance probability of 10^{-6}, while in Eastern Washington, where the sources of moisture are remote, PMP's exceedance probability approaches 10^{-9} for some locations. Thus using PMP as a design event can provide widely different levels of protection, depending on location within the State.

The situation is further complicated when we look at smaller dams where only a few lives may be at risk. The standards used by many regulatory organizations dictated that ratios of the PMP be used for the design of these facilities, with 50% PMP commonly used as the lower bound when any lives are at risk. However, when we use ratios of the PMP, we know nothing of the level of protection afforded. This is illustrated in Figure 1, which shows that a 100-year event is about 50% to 70% of the 6 hour PMP in coastal areas, while in Eastern Washington, the 100-year precip is only 15% to 20% of PMP.

FIGURE 1 - RATIO OF 6 HR 10 MI² PRECIPITATION TO 6 HR 10 MI² GENERAL STORM PMP (HMR-43) IN WASHINGTON



Recognizing that the PMP (and % PMP) approach is not zero risk, provides different levels of protection, and de facto has an associated exceedance probability and risk, the Dam Safety Section elected to pursue a probabilistic or risk-based approach to spillway design. The PMP was not, however, completely eliminated from consideration. Rather, it was selected as an upper bound for design events, to be used for large dams where the consequences of failure are great. The probabilistic approach was employed for the many small and intermediate sized dams with few to no homes at risk. This approach is termed the Design Step Format and is described in the following section.

E. Design Step Format

The concepts of Balanced Protection and Consequence Dependent Design are implemented through a Design Step Format. The Design Step Format utilizes 8 steps, where the design events become increasingly more stringent as the consequences of a dam failure become more severe. Figure 1 shows the 8-step format employed by the Dam Safety Section.

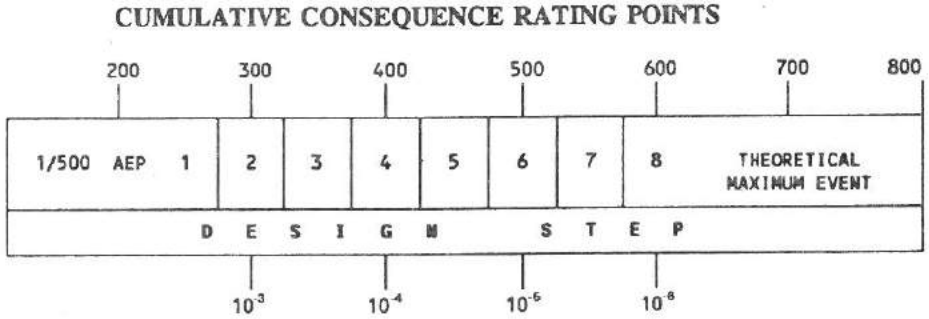


FIGURE 2

Design Step 1 would apply where consequences of a dam failure would be minimal and there would be no chance for loss of life. Step 1 has an annual exceedance probability (AEP) of 1 in 500, one chance in 500 of being exceeded in any given year. This design level is consistent with engineering design practice for dams in similar low hazard settings (National Research Council[6], ICE[7], ICOLD[8], BC Hydro[9]). Design Step 8 applies where a dam failure would be catastrophic with hundreds of lives at risk. In this situation, extreme design events and design loads are used to provide the extremely high levels of reliability needed to properly protect the public. For Design Step 8, the maximum design level is set at an AEP of 10^{-6} (1 chance in 1 million). Step 8 corresponds to theoretical maximum design events (PMP, MCE) and loading conditions. The use of a design/performance goal with an AEP of 10^{-6} is based on existing design standards (EPRI[10]) and review of recommendations for engineered structures with similar extremely serious consequences of failure (CSS[11], Kennedy[12], BC Hydro[9], Nuclear Regulatory Commission[13], Newton[14])

The design step format was completed by providing uniform performance increments between the design steps such that the AEP's for the design/performance goals decrease tenfold for every two design steps. Thus, this format strives to provide a reliability of design with a tenfold increase in protection for every 2 step increase.

F. Benchmarks for Design Step Format

The next step in developing the design step format was the selection of benchmarks for setting design levels which would be consistent with levels of safety provided by other engineering disciplines and governmental regulation.

In many engineering applications, design levels are set by standards or codes which provide guidance or set design minimums. This obscures the actual levels of protection afforded by standards/codes. This result is not entirely unintentional, as governing bodies and standards boards are often hesitant to openly discuss acceptable levels of risk and probabilities of failure, where system failure could pose a threat to loss of life. This situation requires that design levels and probabilities of failure must be back-calculated for standards and codes. This back-calculation has been done for the establishment of design/performance goals in the design and evaluation of Department of Energy Facilities[12]. That information, as well as other sources provided background information for setting the benchmarks shown in Figure 3.

FIGURE 3 - BENCHMARKS FOR CALIBRATING POINT RATING ALGORITHM FOR USE IN DECISION FRAMEWORK

BENCHMARK	CHARACTERISTICS OF IDEALIZED PROJECTS	MINIMUM DESIGN STEP	DESIGN/PERFORMANCE GOAL AEP
1	1 or More Lives at Risk	3	3×10^{-4}
2	Large Dam, over 50 feet High No Downstream Hazard	3	3×10^{-4}
3	Intermediate Dam No Commercial Development 10 Residences at Risk	4	10^{-4}
4	Large Dam Limited Commercial Development 34 Residences at Risk	6	10^{-5}
5	Large Dam Significant Commercial Development 100 Residences at Risk	8	10^{-6}

Note: AEP - Annual Exceedance Probability

Additional guidance in setting design/performance goals was obtained by examining the levels of risk to which the public is exposed in ordinary life. Several of these risks are shown in Figure 4.

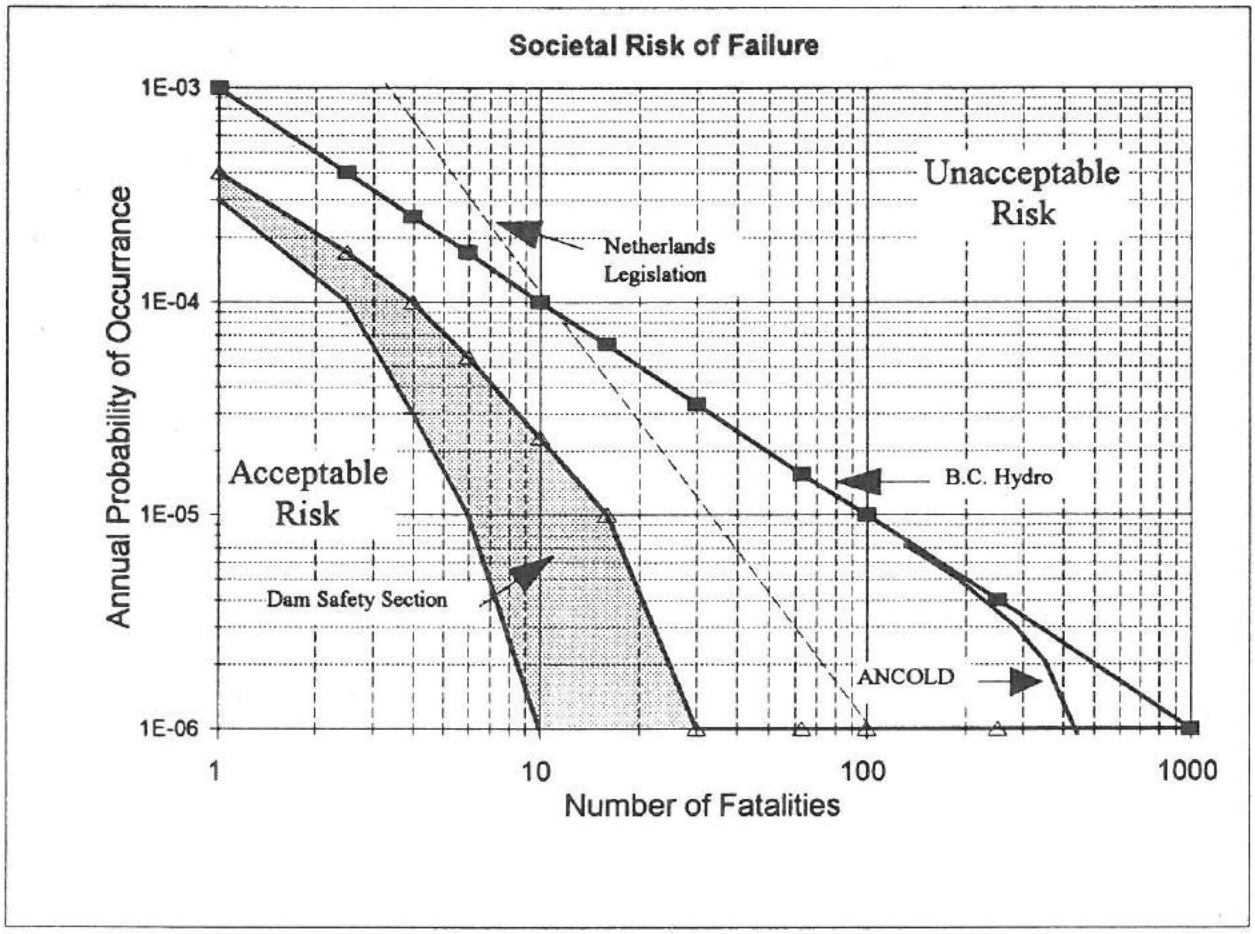
A review of the data in Figure 4 shows a basic trend. In those activities where few lives are at risk and the activity is voluntary in nature, nominal values of protection are accepted by the general public. Conversely, as the number of persons at risk and the level of hazard to the public from a certain activity increases, the level of protection expected by society and the engineering profession increases significantly. This viewpoint is called "risk averse" with regard to loss of life. This is illustrated in Figure 5, which shows the DSS criteria in comparison to other risk-based criteria, such as B.C. Hydro's, which is considered risk neutral.

FIGURE 4 - LISTING OF RISKS FOR VARIOUS ACTIVITIES AND PERFORMANCE LEVELS FOR VARIOUS ENGINEERED SYSTEMS

ACTIVITY/ITEM	TYPICAL NUMBER OF PERSONS AT RISK	RISK LEVEL	PERFORMANCE LEVEL
NATIONAL FLOOD INSURANCE PROGRAM • Risk from Natural Flooding	Varies Widely		1/100 AEP 100 Year Flood
FATAL DISEASE[15] • All Causes	1	1/120 AC	
ASCE STRUCTURAL CODE[16] • Performance of Individual Structural Members for Ordinary Buildings Subject to Natural Hazards due to Wind and Earthquake Loads	Typically 1-20		1/1000 AEP
EXISTING OFFSHORE DRILLING PLATFORMS[17] • Performance Subject to Wind, Wave and Earthquake Loads	Varies 0 - 25		1/1000 AEP
ACCIDENTAL DEATH[18] • All Causes	Few 1-3	1/2000 AC	
ACCIDENTAL DEATH[18] • Motor Vehicles	1-6	1/3000 AC	
ACCIDENTAL DEATH[18] • Non-Motor Vehicles	Few 1-3	1/6000 AC	
UNIFORM BUILDING CODE[12,19] • Performance of Essential Buildings such as Hospitals and Emergency Response Facilities to Maintain Building Functionality and Protect Occupants for Buildings Subjected to Wind and Earthquake Loads	Typically 50-200		1/5,000 AEP
BRITISH SPILLWAY DESIGN[7]	Small Community More than 30		1/10,000 AEP 10,000 Year Flood
DEPT. OF ENERGY BUILDINGS[20,12] • Performance of Building to Contain Radioactive or Toxic Materials and Protect Occupants for Buildings Subjected to Wind, Flood or Earthquake Loads	Varies - Often Large Numbers of People at Risk		1/10,000 AEP
DEPT. OF ENERGY BUILDINGS[20,23] • Very High Confidence of Containment of Radioactive and Toxic Materials and Protection to Occupants for Buildings Subjected to Wind, Flood or Earthquake Loads	Varies - Often Large Numbers of People at Risk Both Onsite and Offsite		1/100,000 AEP
NUCLEAR POWERPLANTS[10] • Damage to Core of Nuclear Powerplant from Earthquakes	Varies Potentially Very Large Numbers of People		1/100,000 AEP
AIR TRANSPORTATION[15,18] • Fatalities - All Aircraft	Varies 1-300	1/150,000 AC**	
AIR TRANSPORTATION[15,18] • Fatalities - Commercial Airlines	Varies 50-350	1/700,000 AC**	
NUCLEAR POWERPLANTS[10] • Performance Goal for Radioactive Releases Greater than 25 REM	Varies Potentially Very Large Numbers of People at Risk		1/1,000,000 AEP

Note: AC - Annual Chance of Occurrence AEP - Annual Exceedance Probability ** - Based on an "Average Traveller"

FIGURE 5 - COMPARISON OF SOCIETAL RISK CRITERIA



G. Additive Point Rating Scheme for Determining Design/Performance Goals

An additive weighting scheme was developed to determine numerical ratings of the consequences of dam failure, which reflects the relative importance of each consequence, and the range of severity of the impacts posed by each consequence. Cumulative consequence rating points with values between 200 and 600 points were used to define the working range for the eight step format. Factors were selected within the 3 general categories shown in Figure 6, which described the nature of the consequences that could be quantified.

FIGURE 6. NUMERICAL RATING FORMAT FOR ADDITIVE WEIGHTING SCHEME FOR ASSESSING CONSEQUENCES OF DAM FAILURE

CONSEQUENCE CATEGORIES	CONSEQUENCE RATING POINTS	INDICATOR PARAMETER	CONSIDERATIONS
CAPITAL VALUE OF PROJECT	0 - 150	DAM HEIGHT	Capital Value of Dam
	0 - 75	PROJECT BENEFITS	Revenue Generation or Value of Reservoir Contents
POTENTIAL FOR LOSS OF LIFE	0 - 75	CATASTROPHIC INDEX	Ratio of Dam Breach Peak Discharge to 100 Year Flood
	0 - 300	POPULATION AT RISK	Population at Risk Potential for Future Development
	0 - 100	ADEQUACY OF WARNING	Likely Adequacy of Warning in Event of Dam Failure
POTENTIAL FOR PROPERTY DAMAGE	0 - 250	ITEMS DAMAGED OR SERVICES DISRUPTED	Residential and Commercial Property Roads, Bridges, Transportation Facilities Lifeline Facilities Community Services Environmental Degradation from Reservoir Contents (Tailings, Wastes, etc.)

Utility Curves and consequence rating tables were developed for each of the indicator parameters in Figure 6 to implement the additive weighting scheme. A worksheet was then developed for compiling the rating points and selecting an appropriate design step. A typical utility curve is shown in Figure 7, and a rating table is shown in Figure 8.

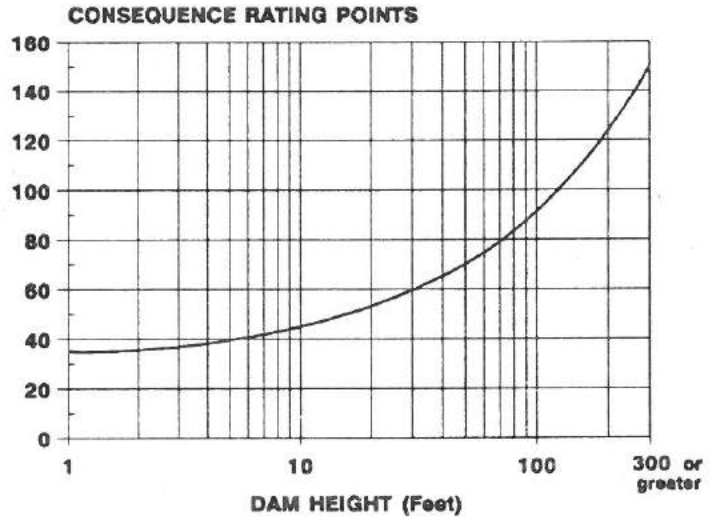


FIGURE 7. CONSEQUENCE RATING POINTS FOR DAM HEIGHT INDEX

FIGURE 8. CONSEQUENCE RATING TABLE FOR LOSS OF PROJECT BENEFITS

CONSEQUENCE SUB CATEGORY	CONSIDERATION	TYPICAL EXAMPLES	RATING POINTS
LIMITED RESOURCE LOSS WOULD AFFECT GENERAL PUBLIC	MANDATORY	PUBLIC WATER SUPPLY RESERVOIR	25 - 75
PRIVATE ENTERPRISE LOSS WOULD NOT AFFECT GENERAL PUBLIC	DISCRETIONARY	IRRIGATION OR INDUSTRIAL WATER SUPPLY	10 - 75
		HYDROPOWER GENERATION	10 - 75
		MINING OR MANUFACTURING	10 - 75
		AESTHETICS, RECREATION OR WILDLIFE HABITAT	10 - 25

H. Selection of the Design Step

Cumulative rating points are used to select an appropriate design step using Figure 2. The design step and corresponding annual exceedance probability are then used to determine a design event/loading for a critical project element. Typical applications of the design step would include:

1. Computation of Inflow Design Floods
2. Assessing the Seismic Stability of Embankments
3. Design of Outlet Conduits
4. Reliability Levels for Critical Electrical and Mechanical Systems

There are several additional issues that need to be considered when applying decision framework to the selection of a design step.

1. **Modes of Failure for Various Critical Project Elements**
   Since procedures are applied for each critical element of project, it is possible to come up with different design steps for each element, due to different reservoir levels, dam break floods, etc. for different failure modes. However, a reasonable approach would be to use the design step for failure mode that would produce the worst consequences, and to use that step for the design of all critical project elements. This follows *the Balanced Protection* concept, and achieves reasonably similar design levels of conservatism and reliability. Under most circumstances, a dam failure by overtopping usually the worst case, and should be examined first in determining the design step.

2. **Projects with Multiple Dams**
   With multiple dam projects, dams are often of different size and have different consequences should they fail. It is reasonable and acceptable that design levels and loadings for each dam can be different. Thus the design loadings and protection afforded at the main dam could be greater than at a saddle dam.

3. **Dams in Series**
   When several dams are located in series on a stream, the failure of upper dam could cause failure of one or more lower dams. Consequently, the design step for any upstream dam which

can cause failure of downstream dam must be equal to or greater than the design step for the downstream dam.

4. **Engineering Judgement**
The Design Step Worksheet is an aid to decision making, and should not replace sound engineering judgement. Prudent reasoning may indicate that a higher or lower Design Step is appropriate.

5. **Design Step Minimum**
For small dams with only a few people at risk downstream, the numerical value of the rating points may not correspond to an adequate design step. Thus, **Design Step 3 is the minimum design step when <u>any</u> lives are at risk.**

I. Relationship of Design Step to Downstream Hazard Classification

Oftentimes during the planning stage of a project there is a need to make a quick assessment of the value of the design step. This can be accomplished by utilizing the Downstream Hazard Classification for the project as a rough indicator for the design step. Experience has shown that the value of the design step typically falls within a small range for each of the Downstream Hazard Classes as shown in Figure 9.

FIGURE 9. RELATIONSHIP OF DESIGN STEP TO DOWNSTREAM HAZARD CLASSIFICATION

DOWNSTREAM HAZARD POTENTIAL	DOWNSTREAM HAZARD CLASSIFICATION	POPULATION AT RISK	ECONOMIC LOSS GENERIC DESCRIPTIONS	ENVIRONMENTAL DAMAGES	TYPICAL DESIGN STEP
LOW	3	0	Minimal. No inhabited structures. Limited agriculture development.	No deleterious materials in reservoir	1 - 2
SIGNIFICANT	2	1 to 6	Appreciable. 1 or 2 inhabited structures. Notable agriculture or work sites. Secondary highway and/or rail lines.	Limited water quality degradation from reservoir contents and only short term consequences	3 - 4
HIGH	1C	7 to 30	Major. 3 to 10 inhabited structures. Low density suburban area with some industry and work sites. Primary highways and rail lines.	Severe water quality degradation potential from reservoir contents and long term effects on aquatic and human life	3 - 6
HIGH	1B	31-300	Extreme. 11 to 100 inhabited structures. Medium density suburban or urban area with associated industry, property and transportation features.		4 - 8
HIGH	1A	More than 300	Extreme. More than 100 inhabited structures. Highly developed, densely populated suburban or urban area with associated industry, property, transportation and community life line features.		8

J. Summary

This paper summarized the approach used by the Washington State Dam Safety Section for the design/evaluation of spillways for dams. The concepts of *Consequence Dependent Design Levels* and *Balanced Protection* are the cornerstones of the decision framework discussed herein. The decision framework utilizes probabilistic methods rather than deterministic methods (such as PMP), for the selection of design/performance goals for spillways and other critical project elements. However, the design approach discussed is not intended to replace PMP but to augment it. PMP is still used as an upper limit for the design of large dams with large populations at risk. The probabilistic design step approach discussed herein attempts to provide a method for determining design/performance goals for smaller projects with less population at risk, where something less than PMP is justified. The design step approach represents an answer for the question - *What is an acceptable level of safety for these smaller projects?*

REFERENCES

1. Schaefer, M.G., *Technical Note 2: Selection of Design/Performance Goals for Critical Project Elements*, Publication No. 92-55F, Water Resources Program, Department of Ecology, Olympia, WA, July 1992.

2. Schaefer, M.G., Dam Safety Guidelines, *Technical Note 3: Design Storm Construction*, Publication No. 92-55G, Water Resources Program, Department of Ecology, Olympia, WA, July 1992.

3. Schaefer, M.G., *Regional Analyses of Precipitation Annual Maxima in Washington State*, Water Resources Research, Vol.26, No.1, pp119-132, January, 1990.

4. Hansen, E.M., Schreiner, LC and Miller, JF, *Application of Probable Maximum Precipitation Estimates - United States East of 105th Meridian*, Hydrometeorological Report 52, US Dept. of Commerce, NOAA, US Weather Bureau, Washington DC, 1982.

5. World Meteorological Organization (WMO), *Manual for Estimation of Probable Maximum Precipitation*, Second Edition, Operational Hydrology Report No. 1, WMO 332, Geneva, Switzerland, 1986.

6. National Research Council, *Safety of Dams, Flood and Earthquake Criteria*, Committee on Safety Criteria for Dams, Water Science Technology Board, Commission on Engineering and Technical Systems, National Science Council, National Academy Press, Washington DC, 1985.

7. Institute of Civil Engineers (ICE), *Reservoir Flood Standards*, Institute of Hydrology, Wallingford, Great Britain, 1975.

8. Brouvard, M., Reporting for International Committee on Large Dams (ICOLD), *16th Congress of ICOLD - IV*, Water Power and Dam Construction, January, 1989.

9. BC Hydro, *Guidelines for Consequence Based Dam Safety Evaluations and Improvements*, BC Hydro, Vancouver, B.C., Draft February, 1993.

10. Electric Power Research Institute (EPRI), *Advanced Light Water Reactor Requirements Document, Appendix A, Probabilistic Risk Assessments Key Assumptions and Groundrules*, EPRI, June, 1989.

11. Council for Sciences and Society (CSS), *The acceptability of Risks*, Barry Rose Publishers Ltd, 1977, Great Britain, p 102.

12. Kennedy, et.al., *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards*, United States Department of Energy, Office of the Assistant Secretary for Environment, Safety, and Health, Report UCRL-15910, June, 1990.

13. Nuclear Regulatory Commission (NRC), *Standard Review Plan, NUREG-0800*, Office of Nuclear Reactor Regulation, Section 2.2.3, Washington DC, 1975, 1981.

14. Newton, D.M., *Realistic Assessment of Maximum Flood Potentials*, ASCE Hydraulics Journal, Vol. 9, June 1983, pp 905-918.

15. Starr, C., *Social Benefit Versus Technological Risk, What is Our Society Willing to Pay for Safety*, Science, Vol 208, April 1980, pp 1232-1238.

16. ASCE, *Minimum Design Loads for Buildings and Other Structures*, American Society of Civil Engineers, ASCE 7-88, July, 1990.

17. Iwan, WD, et.al., *Seismic Safety Requalification of Offshore Platforms*, American Petroleum Institute, March 1992.

18. National Safety Council, *Accident Facts*, 1975, Chicago, Illinois.

19. International Conference of Building Officials, *Uniform Building Code, 1988 Edition*, Whittier, California, 1988.

20. Kennedy, R.P., et.al., *Progress Towards Developing Consistent Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Hazard Phenomena*, Proceedings DOE Natural Hazards Mitigation Conference, Las Vegas, Nevada, 1985.

RISK IS NOT A FOUR LETTER WORD: TEN YEARS OF SUCCESS USING A RISK-BASED DAM SAFETY APPROACH IN WASHINGTON

Doug Johnson
Washington State Dam Safety Supervisor

INTRODUCTION

This paper discusses the application of probability and risk concepts in the state of Washington's dam safety program. Our approach can be characterized as employing risk concepts in a standards-based framework, and using a risk-based prioritization scheme to correct dam safety deficiencies. Under this approach, probability methods, risk concepts, and elements of risk assessment are combined with decision making in setting performance standards that provide acceptable minimum levels of protection. This approach has been quite successful since its implementation in 1990. For similar downstream hazard settings, it has provided consistent levels of protection against flood induced overtopping failures across diverse climatic regions. It has been less successful in addressing the difficult, rapidly evolving seismic concerns confronting the Pacific Northwest. Furthermore, this approach has allowed us to make great progress in repairing the backlog of dams with identified safety deficiencies, as well as design new dams to more consistent standards across the State of Washington.

Why Choose Probabilistic Over Deterministic Approach?

The use of risk-based approaches in the dam safety community is still highly controversial. There is much fear and trepidation among dam safety engineers when "risk" is mentioned in conjunction with dam safety. To many, the word risk implies that we would be designing to accept failure and loss of life, or more insidiously that risk assessment is a way of avoiding making expensive structural repairs to a dam. In addition, many think that using risk entails quantitative risk assessment, a highly complex and time-consuming analysis. Conversely, many dam safety professionals believe that using deterministic standards imply that a dam can pose zero risk to the public (as well as no liability risk to the engineer). Unfortunately, this viewpoint is based on misconceptions in the engineering community about the Probable Maximum Precipitation (PMP) and the Maximum Credible Earthquake (MCE). In reality, these values are estimates of the theoretical maxima that commonly approach, rather than meet, the theoretical upper limits. For example, studies have shown[1] that the annual exceedance probabilities (AEPs) of PMP events vary widely across the nation, from about 10^{-5} to perhaps 10^{-9}. In the Pacific Northwest, PMP events have AEPs that vary from about 10^{-5} on the coast, to 10^{-6} in the Puget Sound region to 10^{-9} in some areas of Eastern Washington[1]. Thus, the use of these values may not only not provide zero risk, they likely do not provide consistent levels of protection across broad geographic areas.

The situation is further complicated when we look at smaller dams where only a few lives would be at risk. This situation represents the majority of dams regulated by Washington and, we believe, most other states (Figure 1). Regulatory organizations have long recognized that PMP and MCE loadings are too stringent for the design/analysis of these smaller projects. Consequently, some percentage of the theoretical maximum PMP is used for hydrologic assessment. An earthquake with a larger probability of exceedance is utilized in the seismic stability assessment. For example, 50% of the PMP is frequently used by many regulatory agencies as the lower bound for smaller dams

where only a few lives are at risk. However, when ratios of the PMP are taken, wildly differing levels of protection may result. For example, based on a regional analysis of some 10,000 station-years of precipitation data covering the Pacific Northwest, 50% of the PMP is only about a 100-year event in the marine climate on the Pacific Coast, while being closer to a 10,000-year event in parts of the arid eastern half of the state. Thus, by using ratios of PMP for design or repair of smaller, lower hazard dams, not only are we accepting that the dam is not zero risk, we often have no idea what the level of risk is!

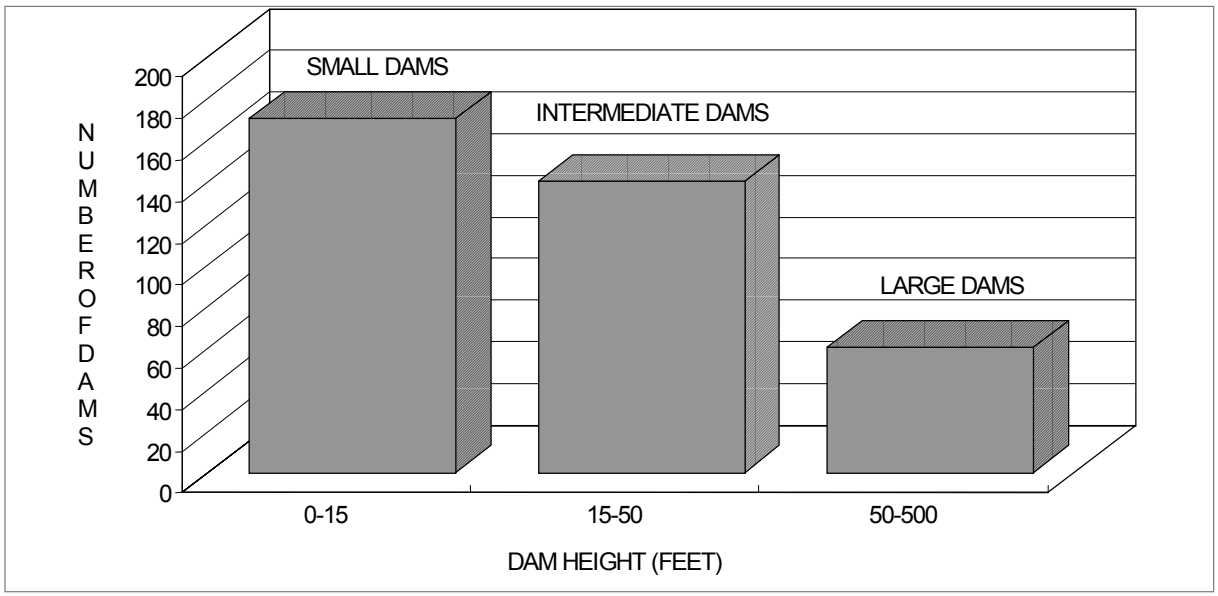


Figure 1 – Dams Sited Above Populated Areas in Washington State

Selection of Risk Based Approach

Recognizing that the PMP/MCE (much less % PMP) approach is not zero risk and provides unbalanced protection across the state, the Dam Safety Office elected to employ a risk-based design approach. This approach was selected based on a number of considerations. The first consideration was the need to provide consistent minimum levels of protection across the state for similar downstream hazard settings. There was also a need to provide methods of analysis that were manageable with limited resources. The state is responsible for over 800 dams, and has limited staffing and resources to apply toward detailed risk assessment. Likewise, most of the regulated community has smaller dams with limited project budgets. Finally, we needed an approach that could be used for the design of new projects as well as for analysis of existing dams. Performing quantitative risk assessments for every project would not be feasible given these considerations. However, employing risk concepts and procedures in a standards-based framework allowed us to address these issues, while realizing the benefits of using a risk-based approach in a relatively simple and inexpensive manner.

We decided to utilize probability and risk concepts in two main areas. The first was to develop risk-based standards for dam design and evaluation of existing dams. These standards were applied through the design step format, which is detailed later in this paper. The second area where these concepts were applied was in the development of a risk-based ranking scheme to prioritize compliance and enforcement efforts on existing dams with identified safety deficiencies.

The combination of both areas was integral to the success of Washington's dam safety program and is detailed in the following sections.

Design Philosophy

The philosophy of the Washington dam safety program utilizes several design principles that provide a framework for evaluating and establishing what design/performance levels are appropriate for the various elements of a dam project. The primary principles related to risk are *Balanced Protection* and *Consequence Dependent Design Levels.*

Balanced Protection - A dam is comprised of numerous critical elements, and like the old chain adage, "is only as strong as the weakest link". The goal of the *Balanced Protection* concept is to establish an appropriate common Annual Exceedance Probability (AEP) as the minimum design level for the evaluation of each critical project element. The term critical project element refers to an aspect of the structure, whose failure could precipitate an uncontrolled release of the reservoir. This office has only achieved partial success in this endeavor. As is noted below, the seismic design aspects lag behind the progress made in the hydrology arena.

Consequence Dependent Design Levels – Standard practice in the civil engineering community is that the degree of conservatism in design should correspond with the consequences of failure of a given element. If failure of a given element could pose a threat of loss of life, design levels are typically much more conservative. That conservatism increases with an increase in the potential magnitude of loss of life and property at risk. This concept is called *Consequence Dependent Design Levels*.

Design Step Format

The philosophies of Balanced Protection and Consequence Dependent Design are implemented through the Design Step Format. This format utilizes eight steps, where the design events become increasingly more stringent as the consequences of failure become more severe. Design Step 1 has an annual exceedance probability of 1 in 500, and would apply where the consequences of dam failure are minimal and there would be no chance for loss of life. Design Step 8 applies to large dams where a dam failure would be catastrophic, with hundreds of lives at risk. In this situation, extreme design loads are used to provide the extremely high levels of reliability needed to properly protect the public. Thus, the AEP of Step 8 is set at 1 in 1,000,000, or the theoretical maximum events (PMP, MCE), whichever is smaller. The design Step 8 AEP of 10^{-6} is based on existing design standards (EPRI[2]) and a review of recommendations for engineered structures with extreme consequences of failure, such as nuclear power plants.

The design step format was completed by providing uniform performance increments between the design steps such that the AEP's decrease tenfold for every two design steps. Figure 2 shows the 8-step format employed by the Washington dam safety program.

Figure 2. Design Step Format

Design Step	Exceedance Probability	Consequence Rating Points
1	1 in 500	< 275
2	1 in 1000	275 - 325
3	1 in 3000 (actually 3160)	326 - 375
4	1 in 10,000	376 - 425
5	1 in 30,000	426 - 475
6	1 in 100,000	476 - 525
7	1 in 300,000	526 - 575
8	1 in 1,000,000 (or theoretical maximum)	> 575

Benchmarks for Selecting Design Steps

A critical question when using risk-based design is "what is 'acceptable' (or tolerable) risk?" This is probably the most controversial aspect of using risk assessment in dam safety. This implies that above some threshold design event/performance level, loss of life would be tolerated. This is actually a common engineering precept used in bridge design, the UBC, and other engineering codes and standards. At the time we were developing our standards, there was very little guidance on tolerable risk criteria in the dam safety field. Thus, rather than try to come up with a definition of tolerable risk on our own, we decided to utilize design levels that would be consistent with the levels of safety provided by other engineering disciplines and governmental regulation. Because the actual levels of protection in many engineering applications are obscured by standards and codes (sometimes intentionally), the actual design levels and probabilities of failure had to be back calculated. This back calculation had been done for the establishment of performance goals in the design and evaluation of Department of Energy facilities[10]. That information, as well as other sources provided background information for setting the benchmarks shown in Figure 3.

Figure 3 – Benchmarks for Calibrating Point rating Algorithm For Use in Decision Framework

BENCHMARK	CHARACTERISTICS OF IDEALIZED PROJECTS	MINIMUM DESIGN STEP	DESIGN/PERFORMANCE GOAL AEP
1	1 or More Lives at Risk	3	3×10^{-4}
2	Large Dam, over 50 feet High No Downstream Hazard	3	3×10^{-4}
3	Intermediate Dam No Commercial Development 10 Residences at Risk	4	10^{-4}
4	Large Dam Limited Commercial Development 34 Residences at Risk	6	10^{-5}
5	Large Dam Significant Commercial Development 100 Residences at Risk	8	10^{-6}

Note: AEP - Annual Exceedance Probability

Additional guidance in setting design levels was obtained by examining the levels of risk to which the public is exposed to in ordinary life. Several of those risks are shown in Figure 4.

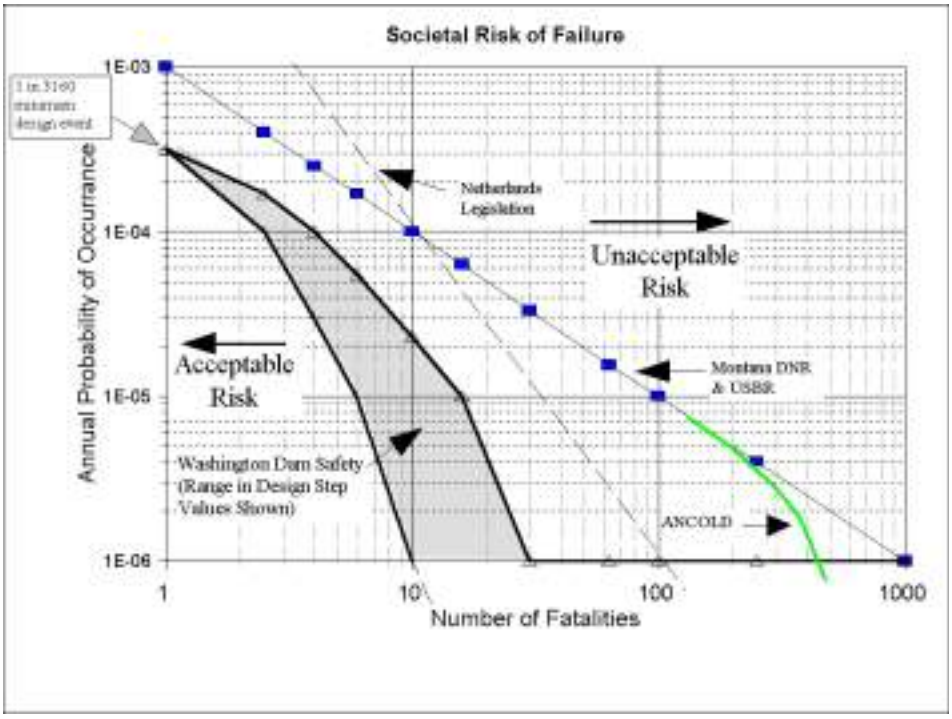
Figure 4 – Listing of Risks and Performance Levels

ACTIVITY/ITEM	TYPICAL NUMBER OF PERSONS AT RISK	RISK LEVEL	PERFORMANCE LEVEL
NATIONAL FLOOD INSURANCE PROGRAM • Risk from Natural Flooding	Varies Widely		1/100 AEP 100 Year Flood
FATAL DISEASE[3] • All Causes	1	1/120 AC	
ASCE STRUCTURAL CODE[4] • Performance of Individual Structural Members for Ordinary Buildings Subject to Natural Hazards due to Wind and Earthquake Loads	Typically 1-20		1/1000 AEP
EXISTING OFFSHORE DRILLING PLATFORMS[5] • Performance Subject to Wind, Wave and Earthquake Loads	Varies 0 – 25		1/1000 AEP
ACCIDENTAL DEATH[6] • All Causes	Few 1-3	1/2000 AC	
ACCIDENTAL DEATH[4] • Motor Vehicles	1-6	1/3000 AC	
ACCIDENTAL DEATH[4] • Non-Motor Vehicles	Few 1-3	1/6000 AC	
UNIFORM BUILDING CODE[7] • Performance of Essential Buildings such as Hospitals and Emergency Response Facilities to Maintain Building Functionality and Protect Occupants for Buildings Subjected to Wind and Earthquake Loads	Typically 50-200		1/5,000 AEP
BRITISH SPILLWAY DESIGN[8]	Small Community More than 30		1/10,000 AEP 10,000 Year Flood
DEPT. OF ENERGY BUILDINGS[9] • Performance of Building to Contain Radioactive or Toxic Materials and Protect Occupants for Buildings Subjected to Wind, Flood or Earthquake Loads	Varies - Often Large Numbers of People at Risk		1/10,000 AEP
DEPT. OF ENERGY BUILDINGS[7] • Very High Confidence of Containment of Radioactive and Toxic Materials and Protection to Occupants for Buildings Subjected to Wind, Flood or Earthquake Loads	Varies - Often Large Numbers of People at Risk Both Onsite and Offsite		1/100,000 AEP
NUCLEAR POWERPLANTS[10] • Damage to Core of Nuclear Powerplant from Earthquakes	Varies Potentially Very Large Numbers of People		1/100,000 AEP
AIR TRANSPORTATION[4] • Fatalities - All Aircraft	Varies 1-300	1/150,000 AC**	
AIR TRANSPORTATION[4] • Fatalities - Commercial Airlines	Varies 50-350	1/700,000 AC**	
NUCLEAR POWERPLANTS[8] • Performance Goal for Radioactive Releases Greater than 25 REM	Varies Potentially Very Large Numbers of People at Risk		1/1,000,000 AEP

Note: AC - Annual Chance of Occurrence AEP - Annual Exceedance Probability ** - Based on an "Average Traveler"

A review of both these tables shows a basic trend. In those activities where few lives are at risk, the public accepts nominal values of protection. Conversely, as the number of persons at risk and the consequences of a failure increase, the level of protection expected by society and the engineering profession increases significantly. This viewpoint is termed "risk-averse" with regard to loss of life. This is illustrated in Figure 6, which shows DSO criteria compared to other risk criteria such as Montana and the USBR[11], which are risk neutral (i.e., a constant value of risk of 1 in 1000 loss of life/year).

Figure 5 – Comparison of Societal Risk Criteria



Additive Point Rating Scheme

The next step in developing the risk-based standards was the development of an additive weighting scheme to determine numerical ratings of the consequences of dam failure. This scheme reflects the relative importance and range of severity of the impacts posed by each consequence. Cumulative rating points with values between 200 and 800 points were used to define the working range for the eight-step format. Factors were selected within the 3 general categories shown in Figure 6, which described the nature of the consequences of dam failure.

Utility curves or consequence rating tables were developed for each of the indicator parameters in Figure 6 to implement the additive weighting scheme. A worksheet (Appendix B, Ref 14) was then developed for compiling the rating points and selecting an appropriate design step. The point rating scheme was calibrated using a wide cross-section of project types and downstream settings to yield results (design steps) consistent with the 5 benchmarks shown in Figure 3.

Figure 6 – Numerical Rating Format for Assessing Consequences of Dam Failure

CONSEQUENCE CATEGORIES	CONSEQUENCE RATING POINTS	INDICATOR PARAMETER	CONSIDERATIONS
CAPITAL VALUE OF PROJECT	0 - 150	DAM HEIGHT	Capital Value of Dam
	0 - 75	PROJECT BENEFITS	Revenue Generation or Value of Reservoir Contents
POTENTIAL FOR LOSS OF LIFE	0 - 75	CATASTROPHIC INDEX	Ratio of Dam Breach Peak Discharge to 100 Year Flood
	0 - 300	POPULATION AT RISK	Population at Risk Potential for Future Development
	0 - 100	ADEQUACY OF WARNING	Likely Adequacy of Warning in Event of Dam Failure
POTENTIAL FOR PROPERTY DAMAGE	0 - 250	ITEMS DAMAGED OR SERVICES DISRUPTED	Residential and Commercial Property Roads, Bridges, Transportation Facilities Lifeline Facilities Community Services Environmental Degradation from Reservoir Contents (Tailings, Wastes.)

Probabilistic Design Data

Before we could implement the risk-based standards described above, magnitude-frequency relationships were needed for extreme events such as floods and earthquakes. Unfortunately, this type of information is not readily available to most states, and much work is still needed around the United States to develop probabilistic precipitation and seismic data for extreme events. In Washington State, we benefited from Dr. Mel Schaefer's detailed studies of extreme storms in the Northwest[12,13], and his development of probabilistic based procedures[14] for generating precipitation magnitude-frequency relationships for any location in the state. Thus, Washington State has the necessary hydrologic data to employ them in a logical and consistent manner in our risk based design/performance practice. This data is used in determining a design storm event with an appropriate AEP to match the design/performance step for the dam in question. This storm is then used to compute the inflow design flood to size the spillway(s) for a new project, or to determine the adequacy of the spillway for an existing dam.

In the seismic arena, we are encountering difficulties on design Step 1 and above in Western Washington and Step 3 and above in Eastern Washington in dealing with the population of existing dams. Our difficulties stem from the severity of the earthquake loadings projected for the Pacific Northwest. Seven interface earthquakes of Moment Magnitude (M_w) 8 or larger are believed to have struck the coast in the last 3500 years[15]. The last event in 1700 was estimated from Japanese tidal records to have been a M_w 9. Thus, all projects in the western half of the state must consider a seismogenic source capable of generating minutes of strong ground motion at a mean recurrence interval of 500 years. With the exception of California, Oregon and Alaska, few other states have to deal with such intense ground motion on so short a mean recurrence interval. In addition, the intensity and duration of shaking yields a high probability of liquefaction. Thus, a significant fraction of the analyses must predict the post-liquefied, deformation response of soils. This is an area of active research in the geotechnical profession. While data is being generated at considerable expense on high profile projects, little guidance is available for extrapolating to the small dams that comprise the majority of the projects under our purview.

Here, any rigorous assessment scheme would face the same difficulties confronting us. In much of the rest of the country the appreciably less intense seismic setting would minimize the difficulties of implementing our design step scheme.

Design Standards for Other Critical Elements

For critical elements at new dam projects where a design loading is not readily applicable (e.g. conduits, seepage), a qualitative approach is used, where redundancy and survivability concepts are employed to achieve adequate reliability against failure. For these critical elements on existing dams, a qualitative approach is used, rather than a quantitative assessment. This is achieved through review of the design and identification of deficiencies for the critical element, coupled with a qualitative assessment of the likelihood of failure based on past experience and engineering judgement. However, we are considering the utilization of some of the more formal risk assessment procedures for these elements currently employed by the Bureau of Reclamation.

Risk Prioritization Scheme

At the close of the 1980's, the Dam Safety Office had over 60 dams listed as having safety deficiencies. Many of these dams were projects inspected under the National Dam Safety Program from 1977-81, and had no action toward making repairs in 10 years. With such a large number of unsafe dams, and limited staffing, it became clear to the DSO that some way of prioritizing these projects was in order. Thus, in conjunction with the development of the risk-based standards described previously, in 1990 the DSO developed a prioritization ranking scheme for dams with safety deficiencies.

The scoring and ranking algorithm developed by the DSO is simple in concept and application, but was been found to be more than adequate for producing an initial ranking of projects. The algorithm is contained within our Microsoft Access database, and a report showing the ranking of projects can be generated by the touch of a key. This ranking is then used as a starting point where other project specific intangibles can be considered by management. The number of projects targeted for enforcement action at any time are chosen to maximize compliance, while not jeopardizing other critical functions of the dam safety program. Typically, this represents an active enforcement workload of about 10 projects.

The underlying logic in the development of this algorithm is fairly simple, and includes the following key ideas:

- For dams with similar deficiencies, those dams with the greatest consequences should be given higher priority.
- For dams with similar consequences, those dams with the more serious deficiencies should be given higher priority.
- For dams with similar deficiencies and similar consequences, those dams with a poorer chance for warning to the public should be given higher priority.
- Dams with only minor deficiencies should be ranked lower than dams with significant deficiencies, regardless of the consequences.
- The risk associated with three minor deficiencies is ranked just below that of one moderate deficiency.
- The risk associated with two moderate deficiencies is ranked just below that of one major deficiency.

- All things being equal, older dams should be given a higher priority.

These concepts were then incorporated into developing the equations for computing the number of priority points. Two different equations were developed for computing the priority points. The first equation is for dams where one or more of the safety deficiencies are rated moderate major or emergency. The second equation is for a project where all deficiencies are rated minor. These equations are shown in Figure 7. Rating points were then developed for the consequences, adequacy of warning, and seriousness of deficiencies, as shown if Figure 8. The points were selected and calibrated to meet the underlying logic goals discussed previously.

Figure 7: Equations for Prioritization Ranking

One or More Safety Deficiencies Rated Moderate, Major or Emergency	**Priority = [*Hazard Class*] + [*Warning*] + [∑(*Seriousness of Deficiencies*)] + [*Agel2*]**
All Safety Deficiencies Rated Minor	**Priority = 0.5 ∗[[*Hazard Class*] + [*Warning*] + [∑(*Seriousness of Deficiencies*)] + [*Agel2*]]**

Figure 8: Rating Points for Prioritization

RATING POINTS FOR CONSEQUENCES – BY HAZARD CLASS	
High Hazard	
Hazard Classification 1A - (100+ homes at risk)	500 points
Hazard Classification 1B – (11-99 homes at risk)	400 points
Hazard Classification 1C – (3-10 homes at risk)	300 points
Significant Hazard	
Hazard Classification 2 – (1 or 2 homes at risk)	200 points
Low Hazard	
Hazard Classification 3 – (0 homes at risk)	100 points
RATING POINTS FOR ADEQUACY OF WARNING	
Inadequate Warning – (< 10 minutes advanced warning)	100 points
Marginal Warning – (between 10 and 30 minutes)	50 points
Adequate Warning – (greater than 30 minutes)	0 points
RATING POINTS FOR SERIOUSNESS OF EACH DEFICIENCY (Primary focus on deficiencies that could lead to a dam failure or uncontrolled release of reservoir)	
Emergency Condition	250 points
Major Deficiency	145 points
Moderate Deficiency	65 points
Uncertain Seriousness	65 points
Minor Deficiency	20 points

The seriousness of safety deficiencies are evaluated based on the matrix in Figure 9. This matrix is intended for guidance only, and ultimately, the final rating of seriousness of deficiencies is based on knowledge of the project and on engineering judgement.

Figure 9 – Matrix for Evaluating Seriousness of Deficiencies

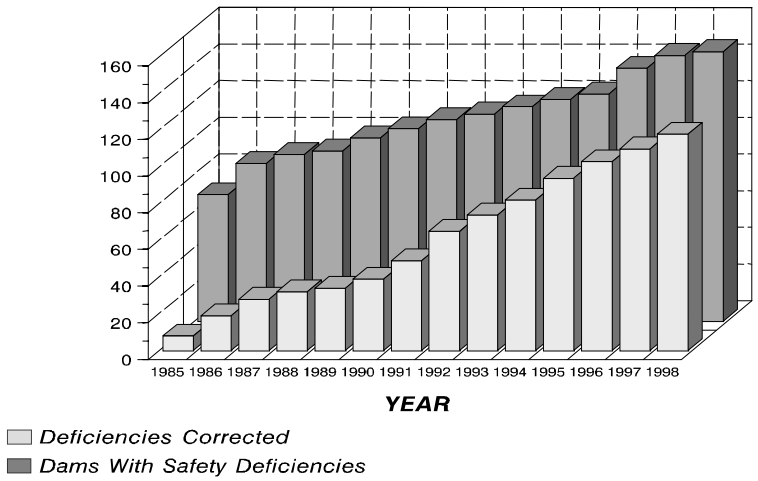
CONDITION	HYDRAULIC ADEQUACY	EMBANKMENT STABILITY	SEEPAGE ON EMBANKMENTS, FOUNDATION, ABUTMENTS	OUTLET CONDUIT(S)
SATISFACTORY	Can accommodate IDF	Meets criteria for static & seismic stability	Minimal seepage consistent with past behavior	KSU Conduit Rating > 8
MINOR DEFICIENCIES	Can only accommodate flood 1 step below Design Step	Meets criteria for static stability, marginal seismic stability under design earthquake	Minor seepage quantity, inconsistent with past behavior No evidence of internal erosion	KSU Conduit Rating 6-8
MODERATE DEFICIENCIES	Can only accommodate flood 2 steps below Design Step	Marginal static stability 1.3 < FS < 1.5 inadequate seismic stability or liquefaction under design earthquake	Moderate seepage quantity Or Anomalous increase in quantity Minor concerns of piping	KSU Conduit Rating 4-6
MAJOR DEFICIENCIES	Can only accommodate flood 3 steps below Design Step	Inadequate static stability 1.0 < FS < 1.3 inadequate seismic stability or liquefaction under design earthquake	Relative Large Seepage Quantity Multiple Points of Seepage And/or Significant concern of piping	KSU Conduit Rating 2-4
EMERGENCY	Cannot Accommodate 25-year Flood	Significant slope failures that intercept dam crest or involve major portion of the embankment	Large or rapidly changing seepage quantity Multiple points of seepage and ongoing piping	KSU Conduit Rating 0-2

CONCLUSIONS

Since its implementation in 1990, the use of the risk-based standards approach has been quite successful in Washington State. It has provided a consistent level of protection against failure between projects located across the state, despite significant differences in seismicity and rainfall. For new dams, we have been able to apply risk concepts in a standards-based approach that is fairly straightforward and easy to use.

For the evaluation of existing dams, we have been able to utilize a combination of probabilistic methods, risk concepts and risk-based standards to determine if the dam has an adequate level of protection against failure. If dams do not meet state standards, we are able to estimate the relative level of risk they currently pose, and prioritize our compliance efforts on those projects with the greatest risk. It has also allowed us to inform dam owners not only that their dams are “unsafe”, but also educate them as to what level of risk their unsafe project poses to the downstream public. In addition, we have utilized a prioritization scheme for compliance efforts on unsafe dams, based on the relative risk of each project. These combined approaches have resulted in great progress in repairing the backlog of dams with identified safety deficiencies in the State of Washington. For example, of the 46 dams inspected under the National Dam Inspection Program still listed as unsafe in 1990, 40 had been repaired by 1999. In addition, 78 of the 101 additional dams identified by the state dam safety program since 1985 have been repaired. Figure 10 shows the cumulative summary of corrective action since 1981.

Figure 10 – Cumulative Number Of Dams Repaired in Washington Since 1981



ASPECTS OF RISK ASSESSMENT THAT MAY BE VALUABLE TO STATE PROGRAMS

Based on our experience, we feel that several aspects of risk assessment and risk management can be of benefit to other dam safety organizations. No matter what standards are used, all dam safety professionals are in the business of managing risk, and the more knowledgeable we are about risk, the better we can make decisions that protect public safety. Using probability and risk concepts allows a dam safety professional to understand the risks and manage them better.

At the 1999 ASDSO/FEMA Specialty Workshop on Risk Assessment for Dams in Logan, Utah, several areas were identified as being potentially of use to state dam safety programs. The areas showing the most promise for the states included qualitative risk assessments such as Failure Mode Evaluation and Analysis (FMEA), prioritization and portfolio approaches, and developing risk-based standards for spillway and/or seismic design, as in Washington and Montana. These areas are highlighted as follows:

- FMEA can be a useful tool, even for those regulators that exclusively use deterministic standards. FMEA allows the regulator a better understanding of the potential site-specific failure modes, the possible failure scenarios and potential consequences, and effective risk reduction measures and dam safety related actions.
- Risk prioritization and portfolio approaches, such as Washington's, can be valuable tool for states to manage their limited resources toward fixing unsafe dams. Using a prioritization scheme, unsafe projects can be ranked for compliance and enforcement activity, based on the risk that they pose to downstream population. The most critical projects can then be targeted for enforcement action.
- Washington's risk-based standards approach may be of interest to some states, especially in spillway design. In fact, Montana's dam safety program has used our example to develop risk based spillway standards of their own. The drawback to implementing these standards on a broader scale is the current lack of probabilistic precipitation data in the U.S. beyond the 500-year event. It can be quite expensive for states to undertake this effort on their own. The Logan workshop identified the need for large-scale regional studies to be performed for probabilities of extreme rainfall events across the U.S. If these studies are completed, then it may be more attractive for some states to implement risk-based spillway standards.

- States using %PMP as a design level for analysis of spillways are already using a non-deterministic standard and by default are accepting risk, but the probability of the %PMP event, and corresponding risk to public safety is unknown. These states may benefit from the aforementioned regional precipitation studies, which would allow them to learn the probability of their %PMP standards. Depending on the results, the states may elect to go to risk-based standards, or may decide to adjust the percentage of PMP to increase or decrease the risk level.

- Quantitative risk assessment is not likely to be a useful tool for most state dam safety programs, due to the lack of probabilistic data, inadequate staffing levels, and amount of effort required to perform an assessment for each dam. Most states regulate a large number of small to medium sized dams, and would not have adequate staffing or resources to complete comprehensive studies on each dam.

References

[1] Schaefer, M.G., *PMP and Other Extreme Storms: Concepts and Probabilities*, Presented at Symposium on Preliminary Assessment of Probabilities and Bounds on Extreme Precipitation Events, National Academy of Sciences, October 1993.

[2] Electric Power Research Institute, *Advanced Light Water Reactor Requirements Document, Appendix A, Probabilistic Risk Assessment Key Assumptions and Groundrules*, EPRI, June 1989.

[3] Starr, C., *Social Benefit Versus Technological Risk, What is Our Society Willing to Pay for Safety*, Science, Vol 208, April 1980, pp 1232-1238.

[4] ASCE, *Minimum Design Loads for Buildings and Other Structures*, American Society of Civil Engineers, ASCE 7-88, July, 1990.

[5] Iwan, WD, et.al., *Seismic Safety Requalification of Offshore Platforms*, American Petroleum Institute, March 1992.

[6] National Safety Council, *Accident Facts*, 1975, Chicago, Illinois.

[7] International Conference of Building Officials, *Uniform Building Code, 1988 Edition*, Whittier, California, 1988.

[8] Institute of Civil Engineers (ICE), *Reservoir Flood Standards*, Institute of Hydrology, Great Britain, 1975.

[9] Kennedy, R.P., et.al., *Progress Towards Developing Consistent Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Hazard Phenomena*, Proceedings DOE Natural Hazards Mitigation Conference, Las Vegas, Nevada, 1985.

[10] Kennedy, R.P., et. al., *Design and Evaluation Guidelines for Department of Energy facilities Subjected to Natural Phenomena Hazards*, US Department of Energy, Report UCRL-15910, June 1990.

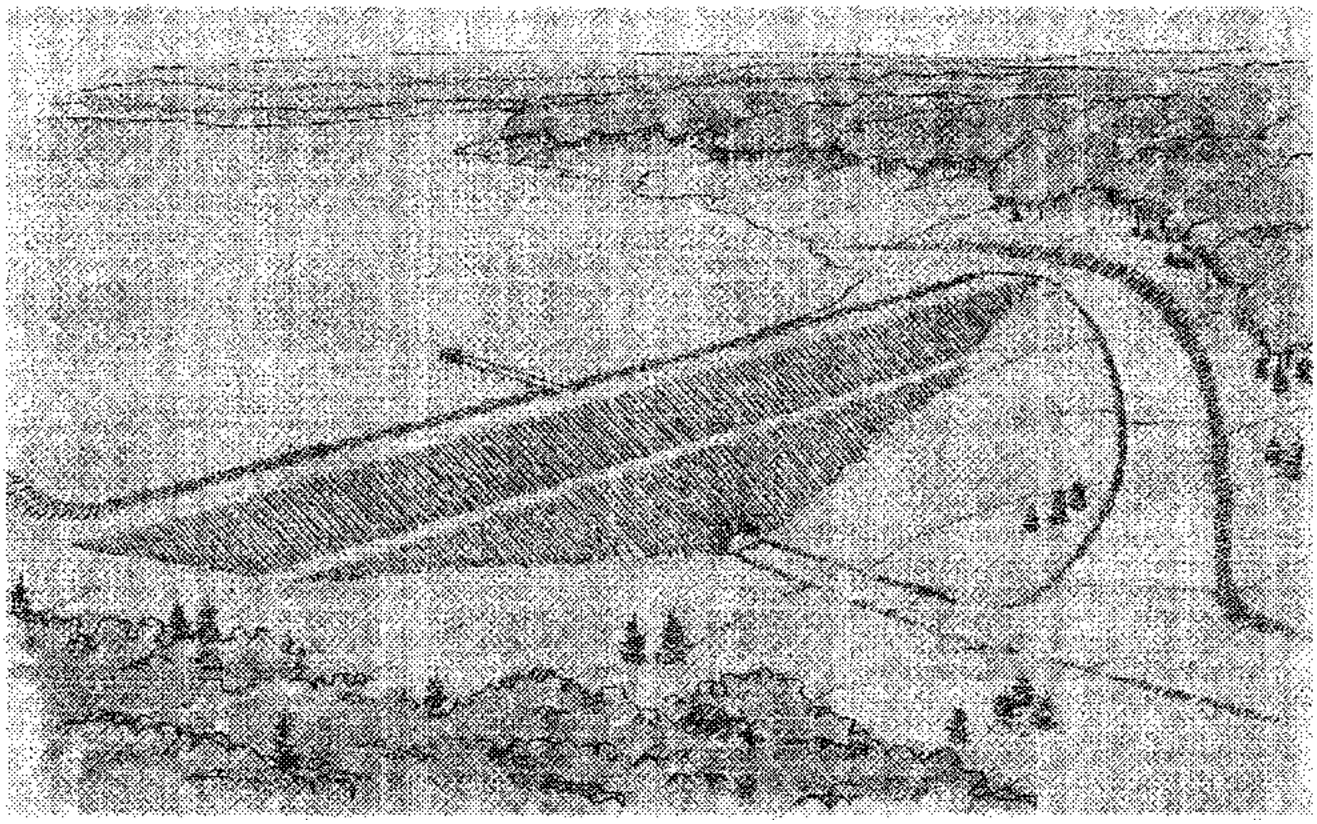
[11] US Bureau of Reclamation, *Guidelines for Achieving Public Protection in Dam Safety Decision Making*, Department of Interior, Denver, CO, Interim Guidelines, April 4, 1997.

[12] Schaefer, M.G., *Regional Analyses of Precipitation annual Maxima in Washington State*, Water resources Research, Vol. 26, No. 1, pp 119-132, January 1990.

[13] Schaefer, M.G., *Characteristics of Extreme Precipitation Events in Washington State*, Department of Ecology, Water Resources Program, Publication No. 89-51, Olympia, WA, October 1989.

[14] Schaefer, M.G., *Dam Safety Guidelines, Technical Note 3: Design Storm Construction*, Publication No. 92-55G, Water Resources Program, Department of Ecology, Olympia, WA, July 1992. Available on the web at http://www.wa.gov/ecology/wr/dams/technote_2.pdf

[15] Atwater, B.F., Hemphill-Haley, E. 1997, Recurrence Intervals for the Great Earthquakes of the Past 3,500 Years at Northeastern Willapa Bay, Washington, U.S. Geological Survey Professional Paper 1576, pg. 99.



Dam Safety Guidelines

Technical Note 3:

Design Storm Construction

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Revised October 2009
Publication #92-55G

Original printed on recycled paper

Publication and Contact Information

This report is available on the Department of Ecology's website at
www.ecy.wa.gov/biblio/9255g.html

For more information contact:

Water Resources Program
P.O. Box 47600
Olympia, WA 98504-7600

Phone: 360-407-6872

Washington State Department of Ecology - www.ecy.wa.gov

o Headquarters, Olympia	360-407-6000
o Northwest Regional Office, Bellevue	425-649-7000
o Southwest Regional Office, Olympia	360-407-6300
o Central Regional Office, Yakima	509-575-2490
o Eastern Regional Office, Spokane	509-329-3400

To ask about the availability of this document in a format for the visually impaired, call the Water Resources Program at 360-407-6872. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call 877-833-6341.



DAM SAFETY GUIDELINES

TECHNICAL NOTE 3

DESIGN STORM CONSTRUCTION

MGS Engineering Consultants, Inc.

for

Water Resources Program
Dam Safety Office
P.O. Box 47600
Olympia, WA 98504-7600
(360) 407-6208

October 2009 (Revised)
92-55G

This page intentionally left blank.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS i

LIST OF FIGURES AND TABLES iii
Figures iii
Tables v

ACKNOWLEDGEMENTS vi

OVERVIEW 1

1. INTRODUCTION 3
1.1 TERMINOLOGY 3
1.2 GENERAL GUIDANCE IN APPLYING CANDIDATE DESIGN STORMS 7
1.2.1 Western Washington 8
1.2.2 Eastern Washington 8
1.2.3 Design Storm Spatial Distribution 8

2. SELECTING THE DESIGN STEP 10
2.1 RELATION OF DESIGN STEP TO PROBABLE MAXIMUM PRECIPITATION 11
2.1.1 Constraints on Applying PMP and Design Step 11

3. COMPUTING PRECIPITATION FOR SCALING CANDIDATE DESIGN STORMS 12
3.1 COMPUTING PRECIPITATION-FREQUENCY RELATIONSHIPS 12
3.1.1 Large Watersheds 14
3.1.2 Design Usage 14

4. DEVELOPING CANDIDATE DESIGN STORMS 15
4.1 DIMENSIONLESS DESIGN HYETOGRAPHS 15
4.1.1 Dimensionless Design Hyetographs Organized by Climatic Region 15
4.1.2 Changes Made in Updating Dimensionless Design Hyetographs 19
4.1.3 Short-Duration Design Storms 19
4.1.4 Intermediate-Duration Design Storms 19
4.1.5 Long-Duration Design Storms 20
4.1.6 Intensity Index Format for Dimensionless Design Hyetographs 20
4.1.7 Dimensionless Depth-Duration Curves for Large Watersheds 20
4.2 ASSEMBLING CANDIDATE DESIGN STORMS FOR SMALL WATERSHEDS 26
4.2.1 Example Assembly of Short-Duration Candidate Design Storm 26
4.2.1 Example Assembly of Long-Duration Candidate Design Storm 28

4.3 ASSEMBLING CANDIDATE DESIGN STORMS FOR LARGE WATERSHEDS 29
4.3.1 Example Assembly of Intermediate-Duration Candidate Design Storm.....30

5. REFERENCES 33

APPENDIX A CATALOG OF HISTORICAL STORMS.....35
OVERVIEW 37

APPENDIX B DIMENSIONLESS DEPTH-DURATION CURVES 53
OVERVIEW 55

LIST OF FIGURES AND TABLES

Page

Figures

Figure 1 – Design Step Format as Applied to Design Storms 10

Figure 2 – Color-Shaded Isopluvial Map of 24-Hour Precipitation Maxima for Washington State, 100-Year Recurrence Interval 13

Figure 3 – Precipitation-Frequency Relationship for 24-hour Precipitation Maxima for a Site near Olympia, Washington 13

Figure 4 – Delineation of Climatic Regions and Transition Zones for Washington State and Surrounding Areas 17

Figure 5 – Short-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Regions 5, 15, 31, 32, 142, 151, and Transition Zone 154 21

Figure 6 – Short-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Regions 13, 14 and Transition Zone 147 21

Figure 7 – Short-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Regions 7 and 77 21

Figure 8 – Intermediate-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Region 5 22

Figure 9 – Intermediate-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Regions 15, 151, 142 and Transition Zone 154 22

Figure 10 – Intermediate-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Regions 31, 32 22

Figure 11 – Intermediate-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Region 14 23

Figure 12 – Intermediate-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Regions 7 and 77 23

Figure 13 – Intermediate-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Region 13 23

Figure 14 – Long-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Region 5 24

Figure 15 – Long-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Regions 15, 142, 151 and Transition Zone 154 24

Figure 16 – Long-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Regions 31, 32 24

Figure 17 – Long-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Region 14 25

Figure 18 – Long-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Regions 7, 77 25

Figure 19 – Long-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Region 13 25

Figure 20 – Flowchart for Construction of a Candidate Design Storm for Small Watersheds 26

Figure 21 – Short-Duration Dimensionless Design Hyetograph for Transition Zone 147 27

Figure 22 – Scaled Short-Duration Candidate Design Storm for Site near Wenatchee, Washington 27

Figure 23 – Long-Duration Dimensionless Design Hyetograph for Climatic Region 32 28

Figure 24 – Scaled Long-Duration Candidate Design Storm for Site near Olympia, Washington 28

Figure 25 – Flowchart for Construction of a Candidate Design Storm for Large Watersheds 29

Figure 26 – Intermediate-Duration Dimensionless Depth-Duration Curve for Climatic Region 31 31

Figure 27 – Scaled Intermediate-Duration Depth-Duration Curves for Climatic Region 31 for Site near Seattle 31

Figure 28 - Intermediate-Duration Dimensionless Design Hyetograph for Climatic Region 31 31

Figure 29 – Intermediate-Duration Candidate Design Storm for a 50-mi^2 Watershed near Seattle, Washington, in Climatic Region 31 32

Tables Page

Table 1 – Areal Adjustment Factors to Account for Storm Spatial Distribution as a Percentage of At-Site Precipitation Amount 10
Table 2 - Catalog of Short-Duration Extreme Storms for Region 5 - Coastal Lowlands 39
Table 3 - Catalog of Short-Duration Extreme Storms for Regions 32 and 31 Interior Lowlands Western Washington 39
Table 4 - Catalog of Short-Duration Extreme Storms for Regions 15, 151 and 142 Mountain Areas in Western Washington 40
Table 5 - Catalog of Short-Duration Extreme Storms for Region 14 East Face of Cascade Mountains 40
Table 6 - Catalog of Short-Duration Extreme Storms for Transition Zone 147 Cascade Foothills in Eastern Washington 41
Table 7 - Catalog of Short-Duration Extreme Storms for Regions 77 and 7 Central Basin and Lowland Areas in Eastern Washington 42
Table 8 - Catalog of Short-Duration Extreme Storms for Region 13 Mountain Areas in Eastern Washington Eastward of Cascade Mountains 43
Table 9 - Catalog of Intermediate-Duration Extreme Storms for Region 5 Coastal Lowlands 43
Table 10 - Catalog of Intermediate-Duration Extreme Storms for Regions 32 and 31 Interior Lowlands Western Washington 44
Table 11 - Catalog of Intermediate-Duration Extreme Storms for Regions 15, 151 and 142 Mountain Areas in Western Washington 45
Table 12 - Catalog of Intermediate-Duration Extreme Storms for Region 14 East Face of Cascade Mountains 46
Table 13 - Catalog of Intermediate-Duration Extreme Storms for Transition Zone 147 Cascade Foothills in Eastern Washington 46
Table 14 - Catalog of Intermediate-Duration Extreme Storms for Regions 77 and 7 Central Basin and Lowland Areas in Eastern Washington 47
Table 15 - Catalog of Intermediate-Duration Extreme Storms for Region 13 Mountain Areas in Eastern Washington Eastward of Cascade Mountains 47
Table 16 - Catalog of Long-Duration Extreme Storms for Region 5 - Coastal Lowlands 48
Table 17 - Catalog of Long-Duration Extreme Storms for Regions 32 and 31 Interior Lowlands Western Washington 49
Table 18 - Catalog of Long-Duration Extreme Storms for Regions 15, 151 and 142 Mountain Areas in Western Washington 50
Table 19 - Catalog of Long-Duration Extreme Storms for Region 14 East Face of Cascade Mountains 51
Table 20 - Catalog of Long-Duration Extreme Storms for Transition Zone 147 Cascade Foothills in Eastern Washington 51
Table 21 - Catalog of Long-Duration Extreme Storms for Regions 77 and 7 Central Basin and Lowland Areas in Eastern Washington 52
Table 22 - Catalog of Long -Duration Extreme Storms for Region 13 Mountain Areas in Eastern Washington Eastward of Cascade Mountains 52
Table 23 – Listing of Ordinates of Dimensionless Depth-Duration Curves for Developing Short-Duration Candidate Design Storms for Large Watersheds 55
Table 24 – Listing of Ordinates of Dimensionless Depth-Duration Curves for Developing Intermediate-Duration Candidate Design Storms for Large Watersheds 56
Table 25 – Listing of Ordinates of Dimensionless Depth-Duration Curves for Developing Long-Duration Candidate Design Storms for Large Watersheds 57

ACKNOWLEDGEMENTS

The revisions and updates to Technical Note 3 were accomplished under the authorship of Melvin Schaefer, Ph.D., P.E., and Bruce Barker, P.E., of MGS Engineering Consultants, Olympia, Washington.

The original Technical Note 3 was compiled in 1993 under the leadership and principal authorship of Dr. Schaefer, supervisor of the Department of Ecology's Dam Safety Section at that time.

OVERVIEW

This Technical Note provides engineering guidance for developing design storms for use in computing Inflow Design Floods (IDFs) using rainfall-runoff computer models. It is a companion document to Technical Note 2, *Selection of Design/Performance Goals for Critical Project Elements*[24], and to Chapter 2.4 of *Part IV* of the *Dam Safety Guidelines* on the computation of Inflow Design Floods.

Originally published in April 1993, the procedures in the original Technical Note 3 were based on the findings of two studies that had been completed in the early 1990s. Site-specific precipitation-frequency estimates were based on the findings of a regional precipitation-frequency analysis that was published in *Regional Analyses of Precipitation Annual Maxima in Washington State*[18]. The temporal patterns of design storms were based on the findings of an analysis of 252 storms, which were published in Ecology Report 89-51, *Characteristics of Extreme Precipitation Events in Washington State*[19].

The original Technical Note 3 was based on storm data collected from 1940-1986. Nearly 20-years have now passed, and in that time, many noteworthy storms have occurred and new technologies have become available. These changes warranted an update of Technical Note 3 to incorporate the additional information and improved techniques.

Of particular note, regional precipitation-frequency analyses were completed in 2006 for Washington State (Schaefer[20, 21]) using more than 700 precipitation gages and high-resolution spatial mapping techniques within a GIS framework. This has resulted in increased reliability for developing site-specific precipitation-frequency estimates.

A study of short-duration precipitation in the Seattle area was completed in 2003 (Schaefer[22]) that provided the first comprehensive examination of the magnitude of 5-minute, 10-minute, and 15-minute precipitation maxima within short, intermediate, and long-duration storms in Western Washington. This has increased the reliability of specifying the high-intensity portions of design storms for Western Washington.

Lastly, analyses have been conducted for the temporal characteristics of 142 noteworthy storms that occurred in the period from 1986 to 2007. Thus, this update of Technical Note 3 is now based on a database of 394 storms for the short, intermediate, and long-duration storms for the various climatic regions across Washington State.

1. INTRODUCTION

Developing candidate design storms is a key step in creating a rainfall-runoff model for computing an Inflow Design Flood (IDF). In particular, the amount and timing of precipitation of a storm are usually dominant factors in determining the size of the resultant flood.

If a project under design/evaluation has a small reservoir relative to the potential runoff of the contributing watershed, then flood peak discharge is normally the controlling consideration. Precipitation intensity is usually the primary consideration in developing the design storm for this case.

In contrast, if the reservoir is very large relative to the potential runoff of the contributing watershed, then runoff volume will be the controlling factor. The total volume of precipitation is then the primary consideration.

For most real world situations, projects are sensitive to various combinations of flood peak discharge and runoff volume. Therefore, both precipitation intensity and volume must be considered in developing design storms.

In the Northwest, considerations of precipitation volume and intensity are further complicated by seasonal effects, which must be accounted for in rainfall-runoff modeling. Short duration thunderstorms, which can contain very high precipitation intensities, typically occur in the warm season. Conversely, the long duration general storm events occur primarily in the winter months. These are characterized by large precipitation volumes but relatively moderate and uniform intensities. To accommodate these meteorological characteristics, it is normally necessary to develop several candidate design storms, representing various storm durations, intensities, and volumes. This allows a determination of the controlling event for design/evaluation of spillway size and hydraulic adequacy.

This technical note is intended to provide engineering guidance in developing candidate design storms that reflect the diversity of storm duration, intensity and volume found in the Northwest.

1.1 TERMINOLOGY

A variety of terms are needed to describe the characteristics of design storms. The following selected terms are defined to clarify their meaning in this technical note and *Part IV of the Dam Safety Guidelines* regarding *Dam Design and Construction.*

At-Site - Refers to site-specific characteristics as distinguished from regional characteristics. When used in the context of regional analyses, it refers to precipitation characteristics at a specific measurement recording station or geographic location of interest.

Annual Exceedance Probability (AEP) - The chance that a specified magnitude of some phenomenon of interest is equaled or exceeded during a given year. Herein, AEP refers to the chance that a specified magnitude of precipitation will be equaled or exceeded during a given year. For example, in Olympia, Washington, a 24-hour precipitation depth of 5.3 inches has an AEP of 0.01. Stated another way, there is one chance in one-hundred that 5.3 inches of precipitation or more will fall in Olympia in some 24-hour period in any given year.

Candidate Design Storm - A hyetograph that is used in rainfall-runoff modeling to examine the flood response of a watershed and the response of a project's reservoir and spillways. The candidate design storm that produces the most stringent loading condition for a project's reservoir and spillway(s) is deemed the Design Storm.

Depth-Duration Curve - A precipitation mass curve constructed in a manner whereby the largest incremental precipitation amounts are located at the start of the mass curve and progressively smaller amounts are accumulated to produce the remainder of the curve (see also reference 24).

Design Step - An integer value from one through eight that is used as an index for increasingly stringent design/performance goals. The design step is used to set design events and loading conditions for critical project elements such as spillways.

Design Storm - The hyetograph, depicting the precipitation volume, intensities, and duration, used in rainfall-runoff modeling to generate the Inflow Design Flood for determining the hydraulic adequacy of a project.

General Storm - A generic term for precipitation produced over large areas by synoptic scale weather features such as cyclones and associated fronts.

Hyetograph - A graphical representation of precipitation as it occurs with time. It may be for a specific location or represent an average over a specified area. It may be

discretized or continuous over time, displaying either precipitation intensities, incremental precipitation or accumulated precipitation.

Interduration - A generic term used for specifying some period of time within a storm. For example, there may be interest in the greatest precipitation amount (precipitation maxima) within any given 1-hour period (the 1-hour interduration) within a long-duration storm.

Intensity Index - A dimensionless measure of the precipitation intensity used in dimensionless design hyetographs to graphically characterize the precipitation intensity. Actual intensities are obtained by multiplying the intensity index values by the applicable value of the 2-hour, 6-hour, or 24-hour *Precipitation Scaling Depth* for the short, intermediate, and long-duration design storms respectively.

Intermediate-Duration Precipitation Event - A precipitation event where the duration of precipitation typically persists from 6 to 18 hours. When used in the context of a design storm, this term refers to 18-hour events which are characterized by moderate to high rainfall intensities, contain a large total precipitation volume.

Large Watershed - For purposes of this technical note, a large watershed is large enough that a storm's spatial distribution may vary significantly over the watershed and must be accounted for explicitly. Generally, these watersheds exceed 10 mi^2 for a long-duration or intermediate-duration storm design event, and larger than 1 mi^2 for a short-duration thunderstorm design event.

Local Storm - A storm comprised of an isolated convective cell or group of cells, commonly referred to as a *Thunderstorm*. These storms can produce very high precipitation intensities over localized areas. Its occurrence is unrelated to any synoptic weather feature such as a cyclone or associated front.

Long-Duration Precipitation Event - A precipitation event that typically persists from 24 to 72 hours. When used in the context of a design storm, this term refers to 72-hour events characterized by relatively moderate and uniform intensities, containing a very large total volume.

Orographic Precipitation - Precipitation that occurs from lifting of atmospheric moisture over mountain barriers.

Precipitation Magnitude-Frequency Curve - A graphical description of the relationship between precipitation magnitude (depth or volume) and annual exceedance probability. Also called a precipitation-frequency curve.

Precipitation Depth - The amount of precipitation, expressed in inches or millimeters, that would collect in a standard measuring device. It is synonymous with point rainfall. When used in connection with a geographic area, such as a watershed, it represents the average precipitation depth over the entire area.

Precipitation Intensity - The rate of precipitation expressed in inches/hour or millimeters/hour.

Precipitation Scaling Depth - The watershed-specific precipitation depth used to scale a dimensionless design hyetograph to the magnitude of interest for the specified Design Step. Precipitation scaling depths for the 2-hour, 6-hour, and 24-hour duration are used for scaling the short-duration, intermediate-duration and long-duration dimensionless design hyetographs, respectively.

Probable Maximum Precipitation (PMP) - Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of the year (National Weather Service[14] definition).

Short-Duration Precipitation Event - A precipitation event lasting from 30 minutes to 6 hours. When used in the context of a design storm, this term commonly refers to thunderstorm events characterized by short bursts of very high rainfall intensities, often with limited total volume occurring over isolated areas.

Small Watershed - For purposes of this technical note, a small watershed is small enough that the spatial variability of precipitation over the watershed is not significant. This corresponds to watersheds smaller than 10 mi^2 when a long-duration or intermediate-duration storm is the design event, and watersheds smaller than 1 mi^2 when a short-duration thunderstorm is the design event.

Storm Characteristics – A generic term that encompasses a variety of statistical measures of features of interest about a storm. This would include such measures as: the elapsed time from onset of precipitation to the occurrence of the maximum intensity; the sequencing of precipitation amounts for 5-minute increments during the 15-minute period of maximum precipitation in the storm; the greatest 1-hour precipitation amount as a proportion of the maximum 24-hour amount; and for

long-duration intermittent storms, the length of the dry period between successive major blocks of precipitation.[1]

Thunderstorm - A generic term for precipitation produced by a convective storm event where thunder is heard. Thunderstorms in the Pacific Northwest are characterized by high precipitation intensities occurring over relatively small areas for short periods of time. They may be accompanied by hail and lightning. (Also see local storm.)

Total Precipitation Depth - The total precipitation amount within a design storm. The total precipitation depth is larger than the precipitation scaling depth for a design storm.

1.2 GENERAL GUIDANCE IN APPLYING CANDIDATE DESIGN STORMS

For most investigations, it is necessary to develop several candidate design storms to analyze the response of the reservoir and spillway(s) to various flood characteristics. The principal storm characteristics that affect the flood peak discharge, runoff volume, and flood hydrograph shape are the intensity, volume, and duration of precipitation. The diversity of these characteristics for storms in Washington can be suitably described using three candidate storms, one for each of three durations. The terms Short-Duration, Intermediate-Duration, and Long-Duration are used to differentiate between the durations of the candidate design storms.

It will be seen later that the precipitation amounts for the 2-hour, 6-hour, and 24-hour durations are used to scale the dimensionless hyetographs for the short, intermediate and long-duration candidate design storms, respectively.

The following general guidance is provided for applying candidate design storms to the design/evaluation of spillway size, hydraulic adequacy, and/or reservoir floodwater storage capacity. This guidance is based on past experience in rainfall-runoff modeling using the design storm procedures described here. However, this does not preclude the user from investigating the flood response from other candidate design storms or historical storms as deemed necessary to determine the controlling event.

[1] See *Characteristics of Extreme Precipitation Events in Washington State*[19] for a detailed discussion of storm characteristics.

1.2.1 Western Washington

Long-duration storms are commonly the controlling design events in Western Washington. This is particularly the case when the reservoir has a relatively large storage volume relative to the runoff potential of the tributary watershed. It is always the design event for off-channel storage reservoirs with minimal tributary watershed area.

Projects with small storage capacity relative to the runoff potential of the tributary watershed are sensitive to flood peak discharge. In these situations, the higher intensities in intermediate-duration storms may become the controlling consideration.

Short-duration thunderstorm events usually do not produce sufficient runoff volume to be the controlling event for project spillways. Stormwater detention facilities in urban areas are the possible exception. In this situation, there may be a high percentage of impervious area, which could make the peak discharge from a short-duration event the controlling consideration.

1.2.2 Eastern Washington

The short duration thunderstorm is commonly the controlling design event in Eastern Washington when the tributary watershed is less than about 20 mi^2. The very high intensities in these storms can produce very large flood peak discharges, which often becomes the dominant consideration in sizing the spillway(s).

The long-duration storm is usually the controlling design event when the tributary watershed is very large or when the reservoir storage capacity is large relative to the runoff potential of the tributary watershed. The long-duration storm is always the design event for off-channel storage reservoirs where there is minimal area tributary to the reservoir. Intermediate-duration storms in Eastern Washington are occasionally found to be the controlling event for design of project hydraulic works.

1.2.3 Design Storm Spatial Distribution

There are two basic approaches used in rainfall-runoff modeling to describe the spatial (areal) distribution of precipitation over the watershed. The most commonly used approach is a "lumped" method where a single temporal distribution of precipitation is used and is expressed in terms of basin-average values. This approach is well-suited to situations where the variability of precipitation depth and temporal distribution does not vary greatly over the watershed. The second approach is a "distributed" method where precipitation depth and the temporal distribution of precipitation vary over the watershed. The variation in precipitation depth and temporal distribution may be allocated on a grid-

cell or polygon basis or may vary by sub-basin depending on the computational structure of the watershed model.

The vast majority of impoundments in Washington reside in small watersheds. As used here, the term *small watershed* refers to the size of the watershed relative to the areal coverage of the storm. In these cases, it is often reasonable to use a lumped method where a single hyetograph describes the temporal distribution of precipitation over the watershed. Since most state regulated dams are on small watersheds, the procedures described here are intended for application of a lumped approach.

The areal reduction factors listed in Table 1[13, 19] may be used for computing basin-average values from point precipitation values. The range of watershed sizes shown in Table 1 may be used as general guidance for the limit of using a lumped method. Specifically, areal adjustments are needed when the watershed under investigation exceeds 10 mi^2 and a long-duration or intermediate-duration storm is the design event. Areal adjustments are also needed when the watershed under investigation is larger than 1 mi^2 and a short-duration thunderstorm is the design event. Additional information on storm attenuation and areal adjustments can be found in *Characteristics of Extreme Precipitation Events in Washington State*[19], HMR-57[14], and NOAA Atlas 2[13].

For large watersheds, there will be cases where it is reasonable to explicitly depict the spatial distribution of precipitation over the watershed. For those cases, GIS-based isopluvial maps have been provided as part of this Technical Note, which are available from Ecology's Dam Safety Office.

Table 1 – Areal Adjustment Factors to Account for Storm Spatial Distribution as a Percentage of At-Site Precipitation Amount

WATERSHED SIZE	STORM INTERDURATION									
	¼-HR	1-HR	2-HR	3-HR	6-HR	12-HR	18-HR	24-HR	48-HR	72-HR
Short-Duration Storm										
1-mi^2	100%	100%	100%	100%	100%	-	-	-	-	-
2-mi^2	93%	97%	98%	98%	99%	-	-	-	-	-
5-mi^2	80%	88%	90%	91%	92%	-	-	-	-	-
10-mi^2	69%	79%	82%	83%	85%	-	-	-	-	-
Intermediate-Duration Storm										
10-mi^2	100%	100%	100%	100%	100%	100%	100%	-	-	-
20-mi^2	85%	94%	95%	95%	96%	97%	97%	-	-	-
50-mi^2	76%	84%	86%	88%	91%	93%	93%	-	-	-
100-mi^2	67%	75%	79%	83%	85%	88%	88%	-	-	-
Long-Duration Storm										
10-mi^2	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
20-mi^2	85%	94%	95%	95%	96%	97%	97%	98%	98%	98%
50-mi^2	76%	84%	86%	88%	91%	93%	93%	95%	95%	95%
100-mi^2	67%	75%	79%	83%	85%	88%	88%	92%	92%	92%

2. SELECTING THE DESIGN STEP

Technical Note 2, *Selection of Design/Performance Goals for Critical Project Elements*[24] discusses the procedures for selecting the Design Step. Technical Note 2 also explains the relationship between the design steps and the design/performance goals. The Design Step format as applied to design storms is reproduced here for convenience (Figure 1).

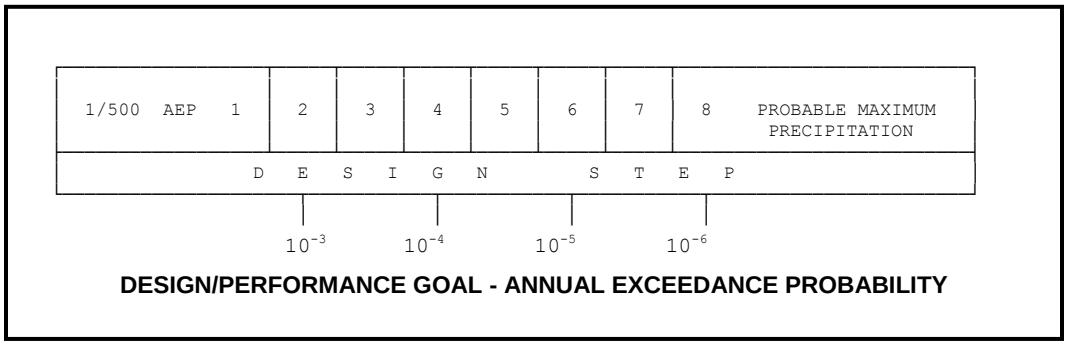


Figure 1 – Design Step Format as Applied to Design Storms

2.1 RELATION OF DESIGN STEP TO PROBABLE MAXIMUM PRECIPITATION

When Design Step 8 is indicated as the appropriate design level, Probable Maximum Precipitation (PMP) is used as the precipitation scaling depth. PMP values are obtained from HMR-57[14] and the design storm may be assembled using HMR-57 procedures or dimensionless design storms may be used from this Technical Note. However, use of PMP values from HMR-57 does not necessarily provide a level of protection equal to a design/performance goal of 10^{-6} AEP.

Since PMP is a deterministic procedure that does not employ probabilistic methods, there is not a fixed relationship between PMP and annual exceedance probability. A comparison of the findings of the recent regional precipitation analysis for Washington (Schaefer et al[20, 21]) with PMP estimates (HMR-57[14]) indicates that the AEP of PMP varies widely across Washington. The AEP of PMP varies with both geographic location and duration, from a minimum of about 10^{-5} AEP to perhaps 10^{-8} AEP.

2.1.1 Constraints on Applying PMP and Design Step

PMP values are estimates. Those estimates, like probabilistic estimates, are subject to uncertainties. Recognizing these uncertainties and the very large variability across Washington in the level of protection afforded by PMP, it was determined that PMP applications must also meet a minimum design/performance goal. This requirement improves consistency of application and avoids the potential for under-design. Therefore, when Design Step 8 is indicated and PMP is selected, the actual precipitation value used in design must be at least as large as that associated with an event with a computed AEP of 10^{-5} (Design Step 6).

Situations may also arise when the precipitation magnitude for the chosen Design Step exceeds the PMP estimate. In these cases, the PMP value is used as the precipitation scaling depth for developing the design storm.

3. COMPUTING PRECIPITATION FOR SCALING CANDIDATE DESIGN STORMS

Studies over past decades have shown that regionalization techniques (Hosking and Wallis[10], National Research Council[25], Potter[16], and Stedinger et al[23]) are vastly superior for estimating magnitude-frequency characteristics than past practices of single station analyses. The procedures used here to provide site-specific precipitation magnitude-frequency estimates are based on regional analysis procedures contained in *Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-Hour and 2-Hour Durations in Western and Eastern Washington* (Schaefer et al[20, 21]). This was a statewide study completed in 2006 for the Washington State Department of Transportation.

3.1 COMPUTING PRECIPITATION-FREQUENCY RELATIONSHIPS

The first step in developing a candidate storm is to determine the precipitation depth, for the selected location and storm duration, to use for scaling the candidate design storm. Gridded GIS datasets for a grid-cell resolution of approximately 0.23 mi^2 were developed as part of the statewide regional precipitation-frequency analysis. A separate gridded dataset was developed for 2-hour, 6-hour, and 24-hour precipitation maxima for the 10-yr, 25-yr, 100-yr, and all 8 Design Steps. These gridded datasets are available as part of this Technical Note. Figure 2 depicts a color-shaded isopluvial[2] map for 24-hour precipitation maxima for the 100-year recurrence interval, created from a gridded dataset.

These datasets can be queried to produce a precipitation-frequency relationship for the site of interest and obtain the precipitation scaling depths for construction of candidate storms. Queries of the gridded datasets can be made using standard GIS software or software that is available through the Dam Safety Office. Figure 3 depicts a precipitation-frequency relationship for 24-hour precipitation maxima for a site near Olympia, Washington. Precipitation-frequency relationships can be developed for 2-hour and 6-hour precipitation maxima in a similar manner for scaling short-duration and intermediate-duration candidate storms, respectively.

[2] A line on a map drawn through geographical points having the same rainfall or precipitation index.

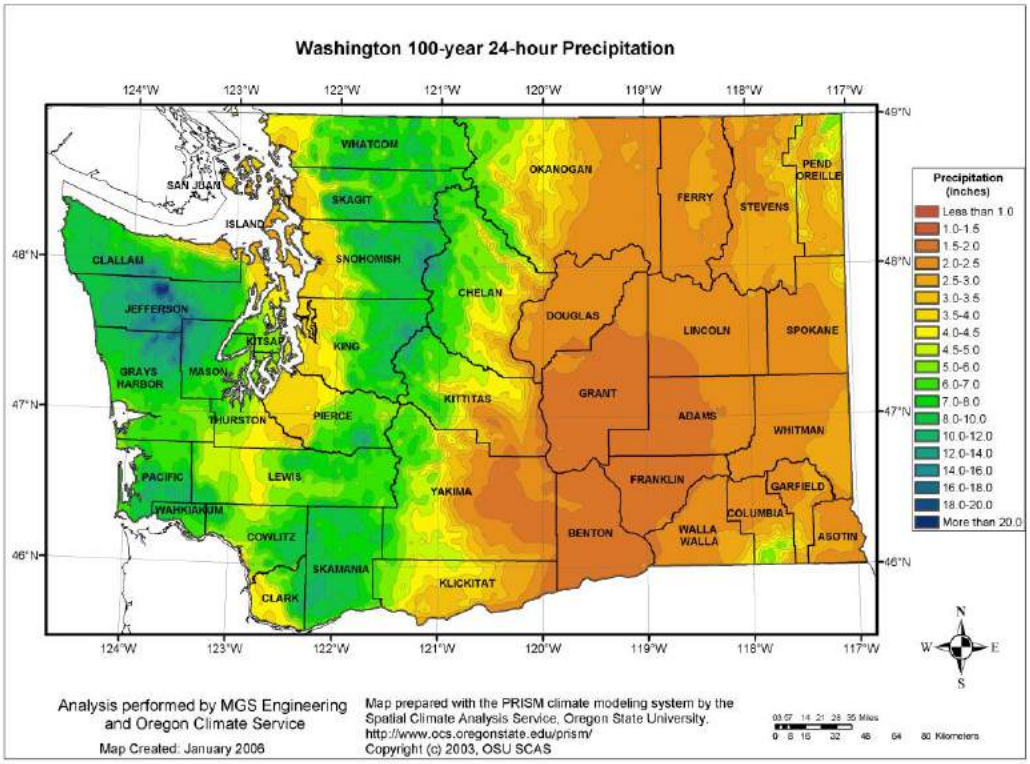


Figure 2 – Color-Shaded Isopluvial Map of 24-Hour Precipitation Maxima for Washington State, 100-Year Recurrence Interval

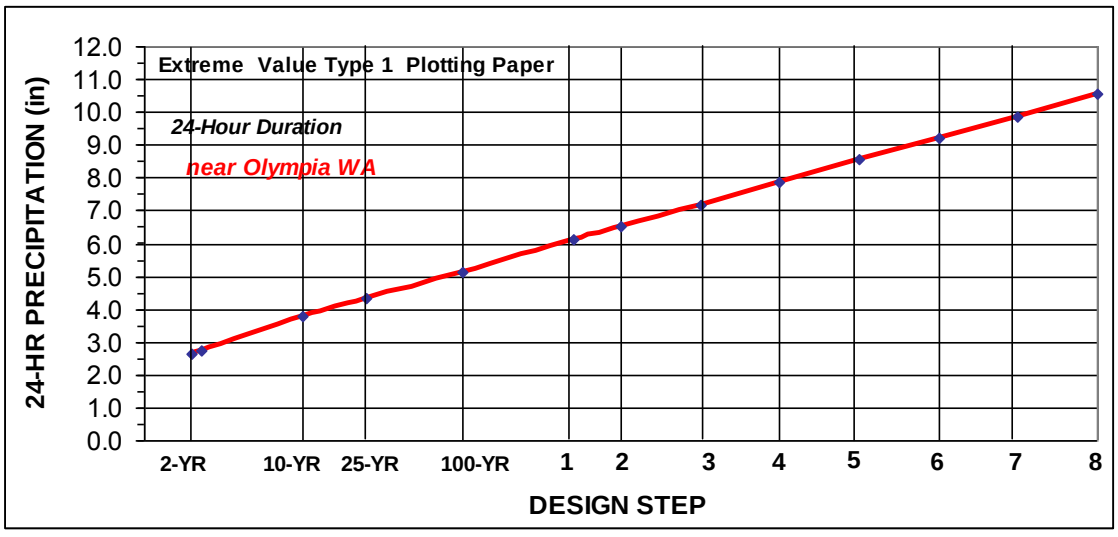


Figure 3 – Precipitation-Frequency Relationship for 24-hour Precipitation Maxima for a Site near Olympia, Washington

3.1.1 Large Watersheds

For large watersheds, a basin-average precipitation value is used for scaling in developing a candidate design storm. A basin-average precipitation value is obtained using GIS software and intersecting the polygon for the watershed boundary with the appropriate gridded precipitation dataset for the selected Design Step. A basin-average value is computed from an areal weighting of the precipitation values for the grid-cells within the watershed. To develop a spatial distribution of precipitation for use with a distributed watershed model, the spatial distribution from the gridded dataset provides a logical starting point.

3.1.2 Design Usage

The gridded precipitation datasets provide expected values (best-estimates) based on the regional solutions for each grid-cell location. In engineering design applications, it is common practice to incorporate some design conservatisms to account for uncertainties and to provide protection from under-design. For probabilistic methods, accounting for uncertainties usually employs some type of confidence interval. Monte Carlo analyses have been conducted to investigate the uncertainties associated with precipitation estimates based on the at-site and regional statistics used to make quantile estimates.

Based on these findings, it was determined that an overage of 15 percent would provide about an 80 percent level of protection from under-design. Thus, all precipitation values obtained from the gridded precipitation datasets which are to be used in a design application are to be increased by 15 percent as shown in Equation (1).

$$P_{sd} = 1.15\, P_{gds} \qquad \text{Equation (1)}$$

where:
- P_{sd} = Precipitation amount to be used for scaling in developing a candidate storm for design application (*precipitation scaling depth*)
- P_{gds} = Precipitation value obtained from gridded dataset for the chosen Design Step

4. DEVELOPING CANDIDATE DESIGN STORMS

A hyetograph describes the time history of precipitation depth or intensity at a given location or over a specific area. The hyetograph is the standard form to input precipitation into rainfall-runoff computer models. The temporal and spatial distribution of precipitation, as described by a hyetograph, are inherently stochastic (random) and vary widely from storm to storm. Therefore, it is important that hyetographs used in design or evaluation of a project be developed using probabilistic procedures. This allows incorporation of storm characteristics that reflect the manner in which extreme storms have historically occurred (Schaefer[19]).

The procedures used here for constructing hyetographs are based on probabilistic analyses of 394 extreme storms in Washington from the period 1940-2006. A thorough discussion of those procedures is contained in *Characteristics of Extreme Precipitation Events in Washington State*[19]. Information and procedures from that document have been used to develop dimensionless hyetographs for small watersheds.

The simplified methods presented in Section 4.2.2 will allow the user to easily assemble candidate design storms using the library of dimensionless design hyetographs available through Ecology's Dam Safety Office.

4.1 DIMENSIONLESS DESIGN HYETOGRAPHS

As discussed previously, it is usually necessary to develop several candidate design storms to analyze the response of the reservoir and spillway(s) to various flood characteristics. The principal storm characteristics which affect the flood peak discharge, runoff volume, and hydrograph shape are the precipitation intensity, volume and duration. The diversity of these storm characteristics can be suitably described using several candidate storms, reflecting a range of storm durations. The following sections present information and procedures for scaling dimensionless design hyetographs to create short, intermediate, and long-duration candidate design storms. Applying the design storms in rainfall-runoff models is discussed in Chapter 2.4 of *Part IV* of the *Dam Safety Guidelines*, titled *Inflow Design Flood*.

4.1.1 Dimensionless Design Hyetographs Organized by Climatic Region

Climatic regions are geographic areas with similar climatic and topographic characteristics that result in storms having similar storm characteristics. One of the major changes that affected this Technical Note was a refinement of the climatic region delineation contained in the 2006 regional precipitation-frequency analysis (Schaefer

et al[20, 21]). This required regrouping of the 252 historical storms that were analyzed in Ecology Report 89-51 (Schaefer[19]). Similarly, the 142 historical storms observed in the period from 1986-2006 were grouped according to the new climatic regions, and analyzed according to procedures described in the report 89-51. Separate analyses were then conducted for each climatic region for each of the three storm durations.

The dimensionless design hyetographs used to develop candidate design storms are organized according to climatic region and duration (short, intermediate, and long). Thus, the user must first identify the climatic region where the project watershed is located in order to select the appropriate dimensionless design hyetograph. Climatic regions (shown in Figure 4) and boundaries are described below.

Climatic Regions for Western Washington

Region 5 **- Coastal Lowlands** – The lowlands along the west coast of Washington, Oregon, and Vancouver Island open to the Pacific Ocean. The eastern boundary is either a generalized contour line of 1,000 feet elevation, or the ridgeline of mean annual precipitation that separates the coastal lowlands from the interior lowlands, such as within the Aberdeen-Montesano gap.

Region 151 **- Coastal Mountains West** – The windward faces of the Olympic Mountains, Willapa Hills, Black Hills, Coastal Mountains in Oregon, and Vancouver Island Mountains in British Columbia above a generalized contour line of 1,000 feet elevation. These areas are bounded to the west by the 1,000 feet contour line, and bounded to the east by the ridgeline of mean annual precipitation near the crestline of the mountain barrier.

Region 142 **- Coastal Mountains East** – The leeward faces of the Olympic Mountains, Willapa Hills, Coastal Mountains in Oregon, and Vancouver Island Mountains in British Columbia above a generalized contour line of 1,000 feet elevation. These areas are bounded to the west by the ridgeline of mean annual precipitation near the crestline of the mountain barrier, and bounded to the east by the 1,000 feet contour line. This also includes isolated mountain features such as the Black Hills.

Region 32 **- Interior Lowlands West** – The interior lowlands below a generalized contour line of 1,000 feet elevation bounded to the east by the trough-line of mean annual precipitation through the Strait of Juan De Fuca, Puget Sound Lowlands and Willamette Valley. This is a zone of low orography where mean annual precipitation generally decreases from west to east.

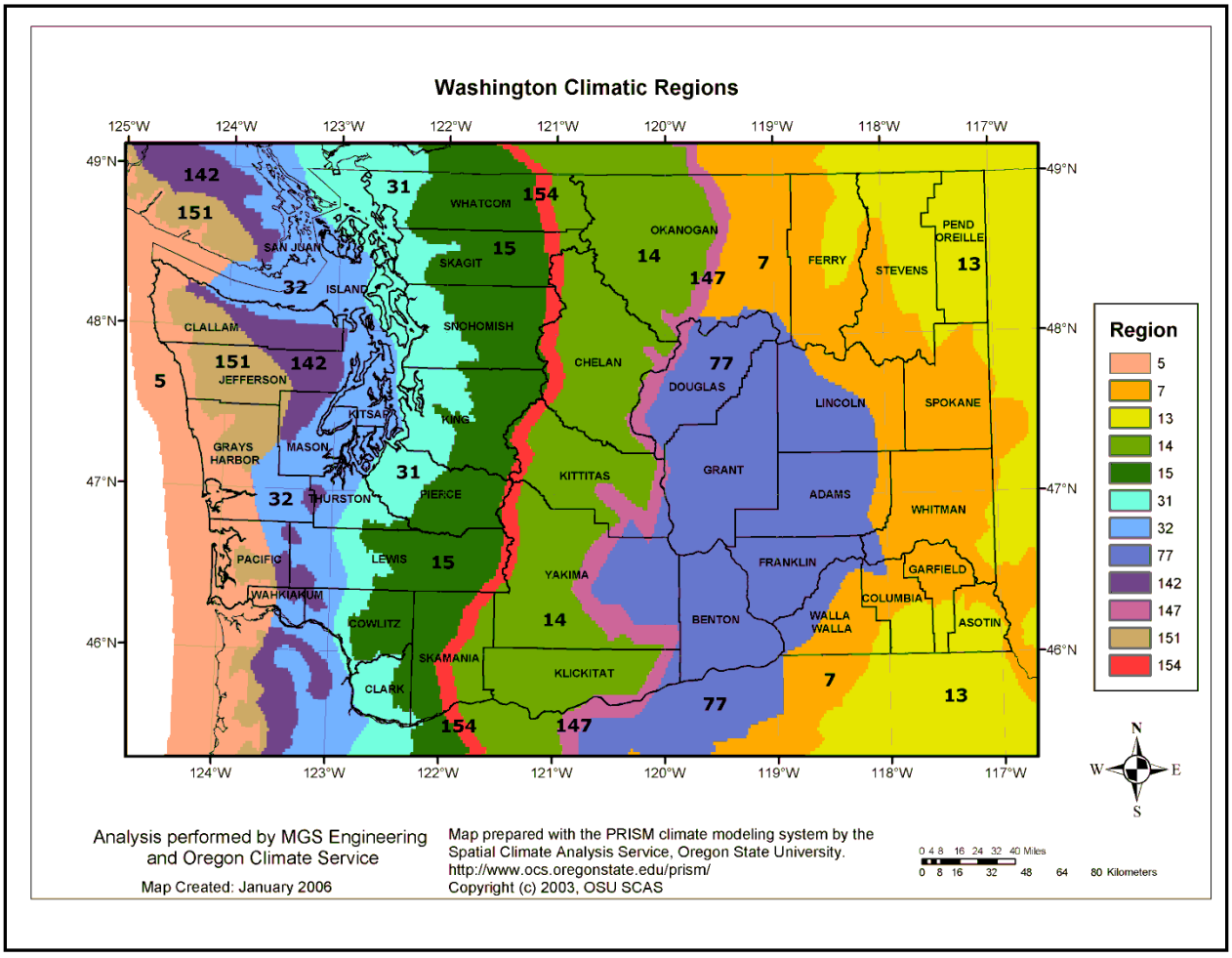


Figure 4 – Delineation of Climatic Regions and Transition Zones for Washington State and Surrounding Areas

Region 31 **- Interior Lowlands East** – The interior lowlands below a generalized contour line of 1,000 feet elevation bounded to the west by the trough-line of mean annual precipitation through the Strait of Juan De Fuca, Puget Sound Lowlands, and Willamette Valley. This is a zone of low orography where mean annual precipitation generally increases from west to east.

Region 15 **- West Slopes of Cascade Mountains** – This region is comprised of the windward face of the Cascade Mountains in Washington, Oregon, and British Columbia above a generalized contour line of 1,000 feet elevation. This region is bounded to the east by the ridgeline of mean annual precipitation near the Cascade crest that forms the boundary with Region 14 located on the east slopes of the Cascade Mountains.

Climatic Regions[3] for Eastern Washington

Zone 154 **- Cascade Crest Transition Zone –** This is a transition zone near the crest of the Cascade Mountains between the west and east slopes of the Cascade Mountains (Regions 15 and 14). The transition zone has a nominal width of about 6 miles.

Region 14 **- East Slopes of Cascade Mountains** – This region is comprised of mountain areas on the east slopes of the Cascade Mountains where precipitation annual maxima are produced predominately by winter storm events. This region is bounded to the west by the ridgeline of mean annual precipitation that generally parallels the crest line of the Cascade Mountains. Region 14 is bounded to the east by the contour of 14 inches mean annual precipitation for locations north of the Methow River Valley and by the contour line of 12 inches mean annual precipitation for areas to the south of the Methow River Valley.

Zone 147 **- Cascade Foothills Transition Zone** – This is a transition zone between the east slopes of the Cascade Mountains (Region 14) and arid and semi-arid areas to the east. The transition zone has a nominal width of about 6 miles.

Region 77 **- Central Basin –** The Central Basin region is comprised of the Columbia Basin and adjacent low elevation (non-orographic) areas in central eastern Washington. It is bounded to the west by Region 14. The region is bounded to the north and east by the generalized (smoothed) contour line of 12 inches mean annual precipitation.

Region 7 **- Okanogan , Spokane, Palouse –** This region is comprised of a mixture of lowland areas of low to moderate relief and extensive valley areas between mountain barriers. This includes areas near Spokane, the Palouse, and areas along the Okanogan River. The region is bounded to the northwest by Region 14. It is bounded to the south and west by Region 77, which generally conforms to the contour line of 12 inches mean annual precipitation at the eastern edge of the Central Basin. It is bounded to the northeast by the Kettle River Range and Selkirk Mountains at approximately the contour line of 22 inches mean annual precipitation. It is bounded to the southeast by the Blue Mountains also at the contour line of 22 inches mean annual precipitation.

Region 13 **- Northeastern Mountains and Blue Mountains –** This region is comprised of mountain areas in the easternmost part of Washington State where there is a significant orographic effect on precipitation depths. It includes portions of the Kettle River Range, Selkirk Mountains, and Cabinet Mountains in the northeast, the Bitterroot Range to the East, and the Blue Mountains in the southeast corner of Eastern Washington. Mean annual precipitation ranges from a minimum of 22 inches

[3] The list of regions in Eastern Washington includes two transition zones.

to over 70 inches in the mountain areas. The western boundary of this region generally conforms to the contour line of 22 inches mean annual precipitation.

4.1.2 Changes Made in Updating Dimensionless Design Hyetographs

As compared to the original release of Technical Note 3, changes to the dimensionless design hyetographs were made in response to four separate sources of new information. First, the new climatic region delineation (Figure 4) resulted in new groupings of historical storms and greater homogeneity of storm characteristics within the new regions. Second, 142 additional storms were analyzed for the short, intermediate and long-durations for the period from 1986-2006. This large number of storm events added greatly to the total database of storms and altered the sample statistics slightly. Third, analyses of short 5-minute, 10-minute and 15-minute precipitation maxima in the Seattle area improved resolution of high-intensity portions of storms for western Washington. Fourth, experience gained since 1990 about the temporal behavior of extreme storms allowed improvements and simplification in the approach to assembly of the dimensionless hyetographs.

The following sections provide brief summaries of the differences in the updated dimensionless design hyetographs relative to those contained in the original Technical Note 3.

4.1.3 Short-Duration Design Storms

Figures 5, 6, and 7 depict short-duration dimensionless design hyetographs for the selected climatic regions. Significant increases were made to the high-intensity portion of the short-duration storm for Western Washington based on data from the Seattle precipitation gaging network and NOAA automated gages (Schaefer[22]). The storm characteristics for Eastern Washington are very similar to those in the original Technical Note 3.

4.1.4 Intermediate-Duration Design Storms

Figures 8 through 13 depict intermediate-duration dimensionless design hyetographs for selected groupings of climatic regions. In general, the high-intensity portions of the new design storms nearly match those for design storms in the original Technical Note 3. Minor changes were made to precipitation maxima for the 15-minute and 30-minute durations for Climatic Regions 14 and 13 for Eastern Washington. Minor increases were also made to the total precipitation for all design hyetographs. The greatest increases in the total precipitation occurred for Climatic Regions 15 and 14 in the Cascade Mountains.

4.1.5 Long-Duration Design Storms

Figures 14 through 19 depict long-duration synthetic design hyetographs for selected climatic regions. In general, the high-intensity portions of the new design hyetographs are similar to the high-intensity sections for design storms in the original Technical Note 3. The largest changes came from regrouping the storms according to the new climatic regions in Eastern Washington. In addition, the time resolution was improved by using a 15-minute time-step to replace the 30-minute time-step used in the original design hyetographs. Lastly, additional data and experience allowed use of one long-duration design storm per climatic region instead of two design storms per region as done in the original Technical Note 3.

4.1.6 Intensity Index Format for Dimensionless Design Hyetographs

The dimensionless design hyetographs displayed in Figures 5 through 20 are constructed using an Intensity Index. This format allows direct conversion to a precipitation intensity hyetograph with units of inches/hour by scaling (multiplying) by the chosen *Precipitation Scaling Depth* for the selected Design Step (2-hour, 6-hour, or 24-hour precipitation for the short, intermediate or long-duration dimensionless design hyetograph, respectively). For example, a precipitation scaling depth of 2.0 inches for the 2-hour duration would yield a maximum intensity of 5.2 inches/hour if applied to Figure 5. Multiply all ordinate values in Figure 5 by 2.0 to yield a precipitation intensity hyetograph.

4.1.7 Dimensionless Depth-Duration Curves for Large Watersheds

Assembly of a candidate design storm for a large watershed represents a watershed-specific application. Generic dimensionless design hyetographs cannot be developed in advance because the scaling of the storm is dependent on areal adjustments for watershed size as well as scaling by precipitation depth. Appendix B contains dimensionless depth-duration curves for all of the dimensionless design hyetographs for use on large watersheds.

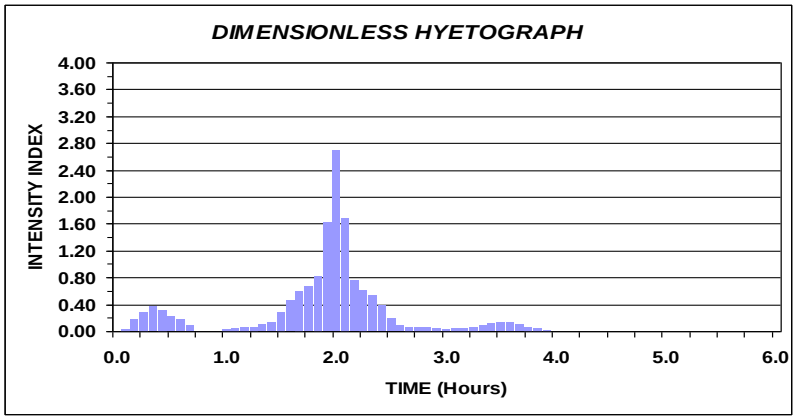


Figure 5 – Short-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Regions 5, 15, 31, 32, 142, 151, and Transition Zone 154

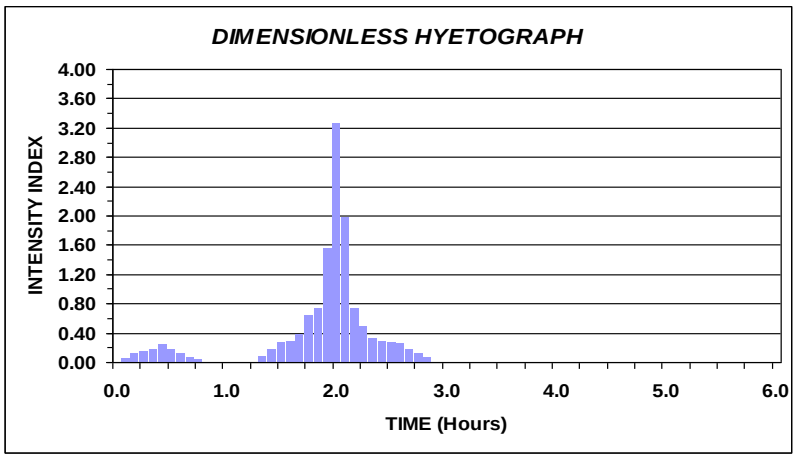


Figure 6 – Short-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Regions 13, 14 and Transition Zone 147

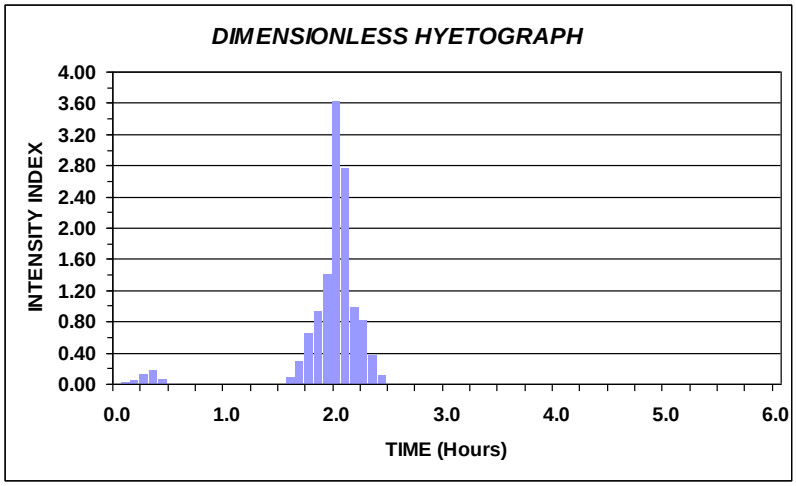


Figure 7 – Short-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Regions 7 and 77

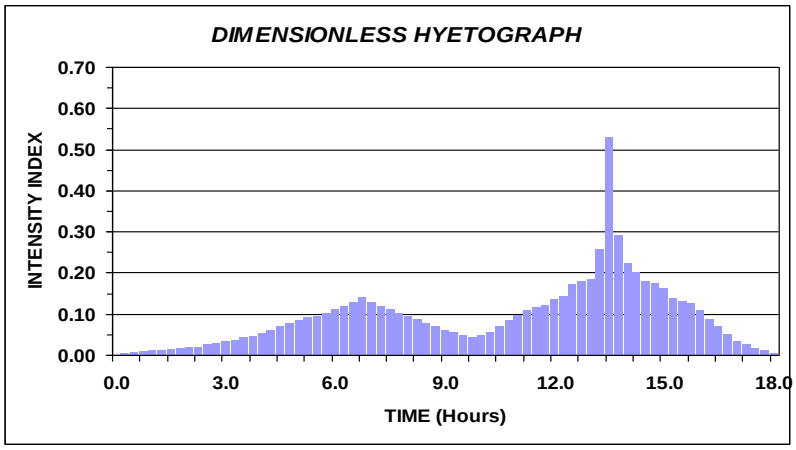


Figure 8 – Intermediate-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Region 5

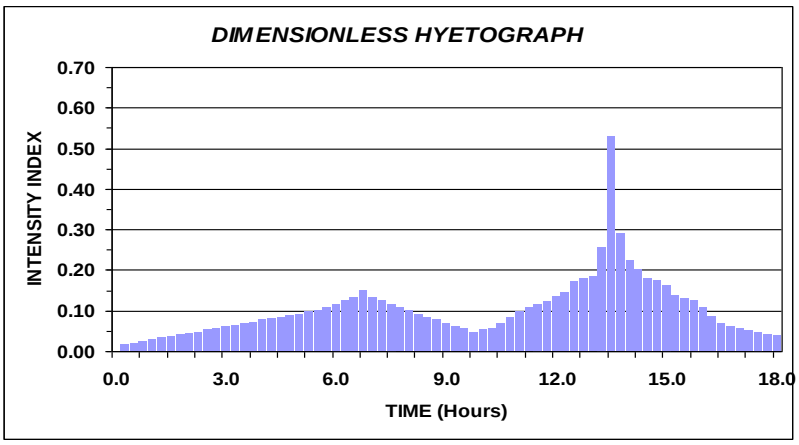


Figure 9 – Intermediate-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Regions 15, 151, 142 and Transition Zone 154

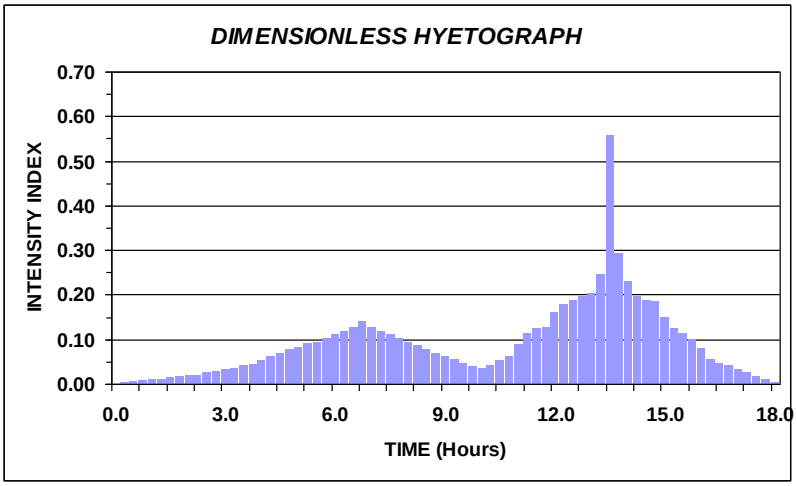


Figure 10 – Intermediate-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Regions 31, 32

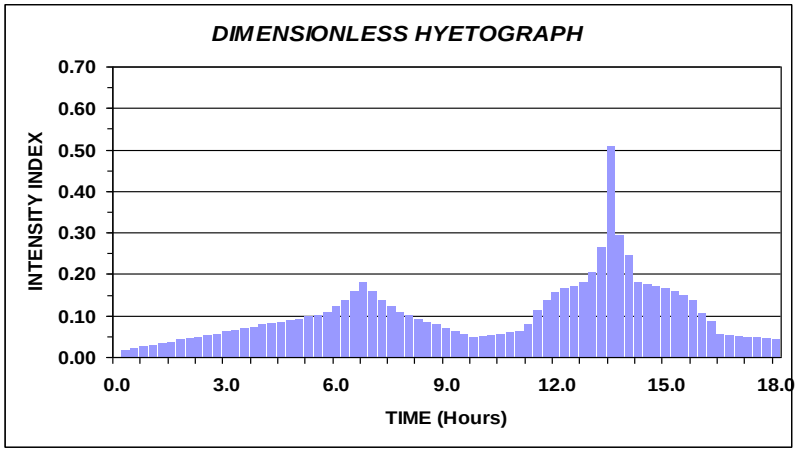


Figure 11 – Intermediate-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Region 14

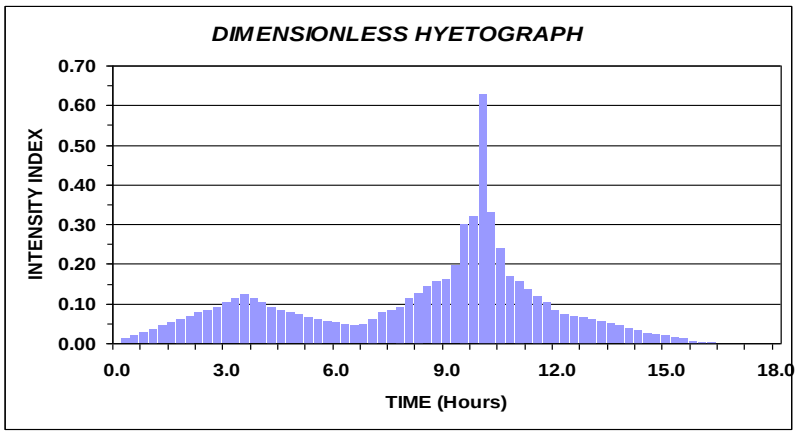


Figure 12 – Intermediate-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Regions 7 and 77

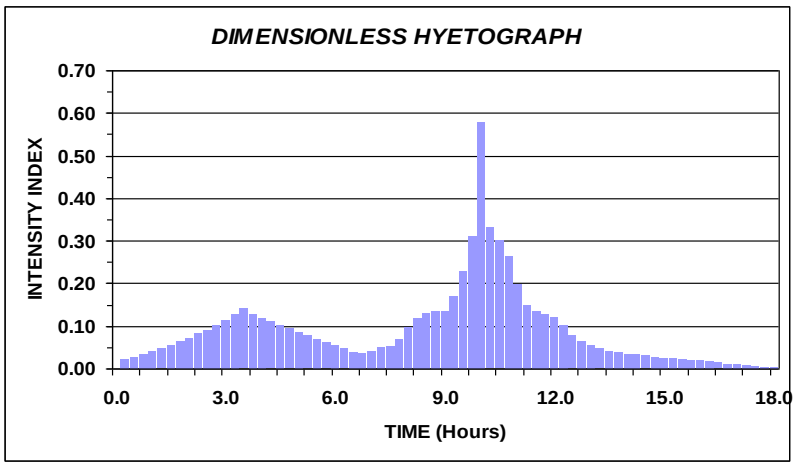


Figure 13 – Intermediate-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Region 13

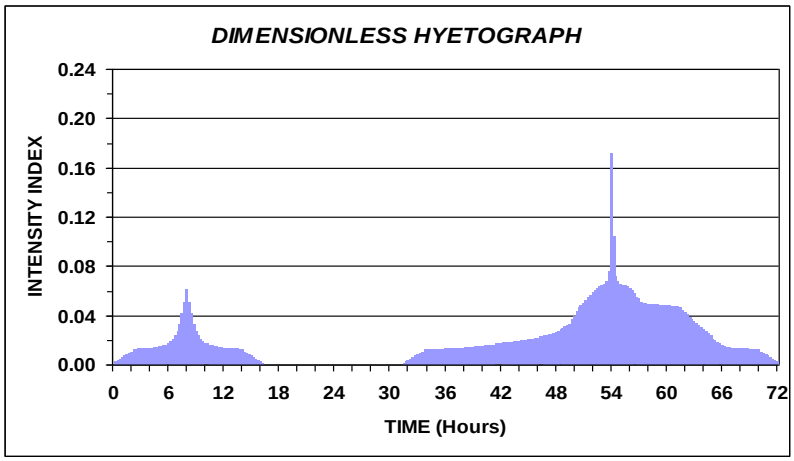


Figure 14 – Long-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Region 5

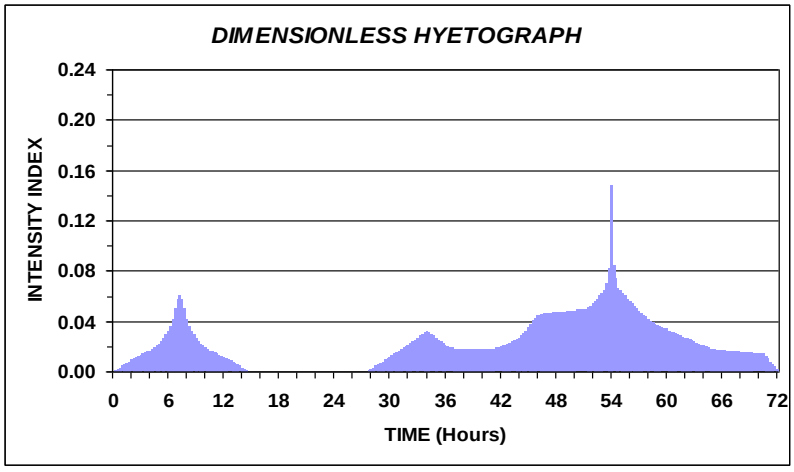


Figure 15 – Long-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Regions 15, 142, 151 and Transition Zone 154

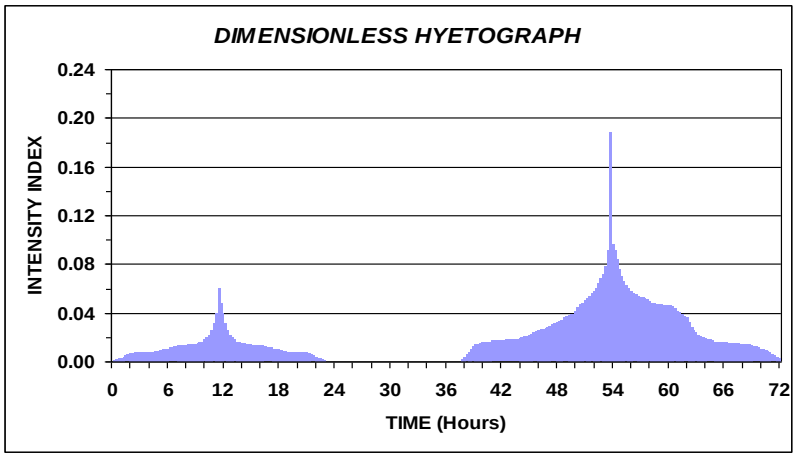


Figure 16 – Long-Duration Dimensionless Design Hyetograph for Western Washington, Climatic Regions 31, 32

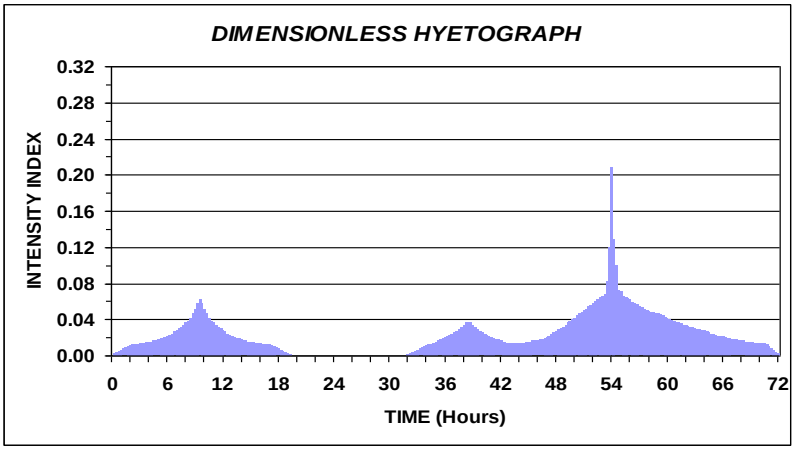


Figure 17 – Long-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Region 14

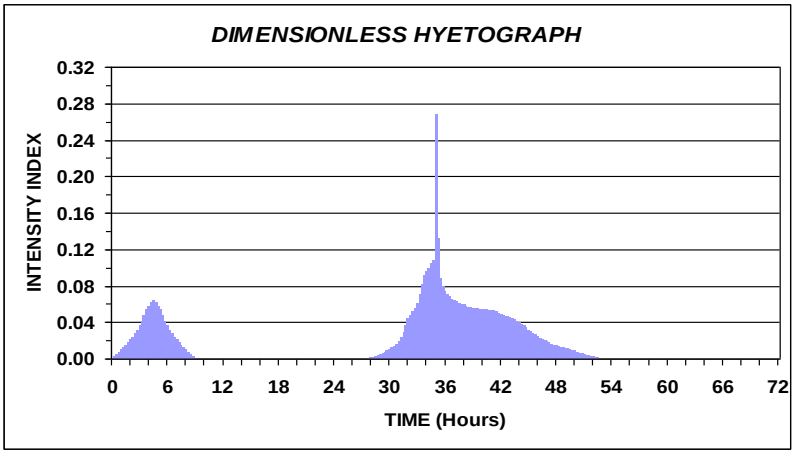


Figure 18 – Long-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Regions 7, 77

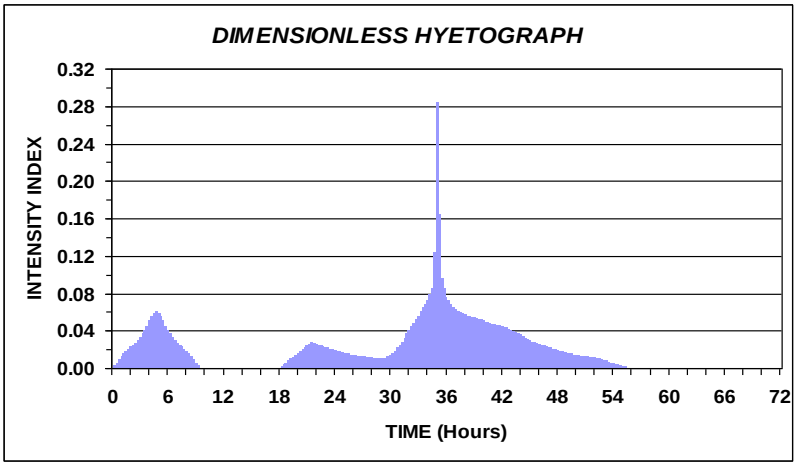


Figure 19 – Long-Duration Dimensionless Design Hyetograph for Eastern Washington, Climatic Region 13

4.2 ASSEMBLING CANDIDATE DESIGN STORMS FOR SMALL WATERSHEDS

In the majority of impoundment projects constructed in Washington, the size of the tributary watershed is very small relative to the areal coverage of the design storm. For these situations, no adjustments to the at-site precipitation estimates are needed to account for the storm's areal distribution over the watershed. For small watersheds, where no adjustments are required to account for the spatial distribution of the storm, dimensionless design hyetographs are available in electronic format on Compact Disc (CD) or on the Department of Ecology website.

The standard steps to construct candidate design storms, when no areal adjustments are required, are shown in the flow chart in Figure 20. The same procedure is used for short, intermediate, and long-duration candidate design storms that are scaled by separate precipitation scaling depths for the 2-hour, 6-hour and 24-hour durations, respectively.

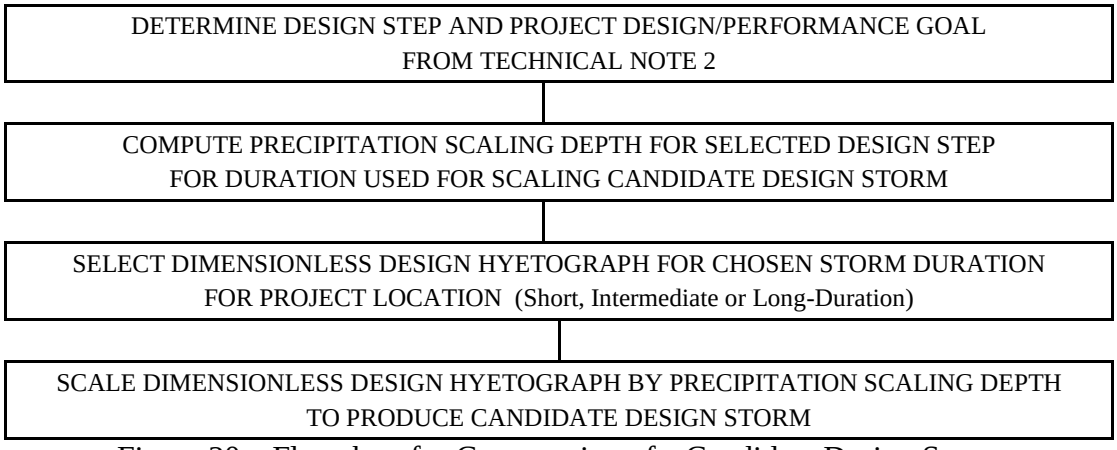


Figure 20 – Flowchart for Construction of a Candidate Design Storm for Small Watersheds

4.2.1 Example Assembly of Short-Duration Candidate Design Storm

Construct a short-duration candidate design storm for a site near Wenatchee, WA.

Given: Climatic Region – Transition Zone 147; 2-hour precipitation scaling depth for Design Step 3 is 3.14-inches, obtained from querying the gridded precipitation dataset for 2-hour precipitation maxima for Design Step 3, and applying the 15 percent design factor per Equation 1 as appropriate.

1. Multiply the ordinates of the short-duration dimensionless design hyetograph for Transition Zone 147 (Figures 6 and 21) by the precipitation scaling depth of

3.14-inches. (The dimensionless design hyetographs are available in electronic format through Ecology's Dam Safety Office.) The resultant candidate design storm is shown in Figure 22.

2. Many watershed models use precipitation depth as input. For these applications, convert precipitation intensities to precipitation depths by multiplying the intensities from Step 1 by 12 for a 5-minute time-step.

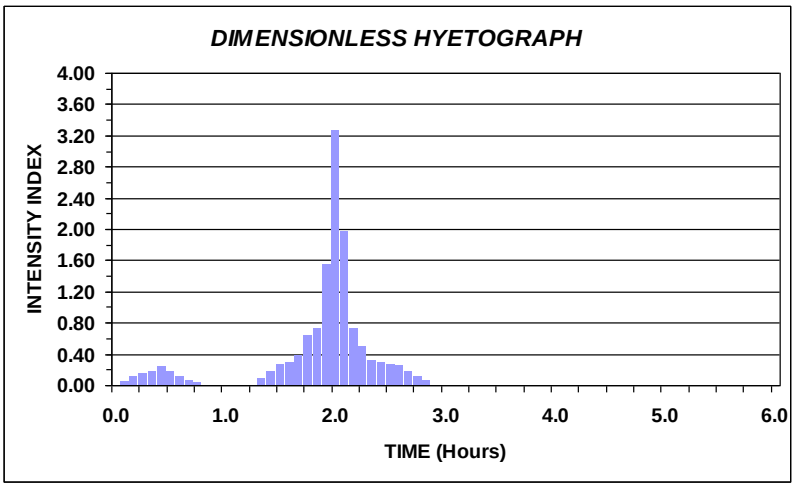


Figure 21 – Short-Duration Dimensionless Design Hyetograph for Transition Zone 147

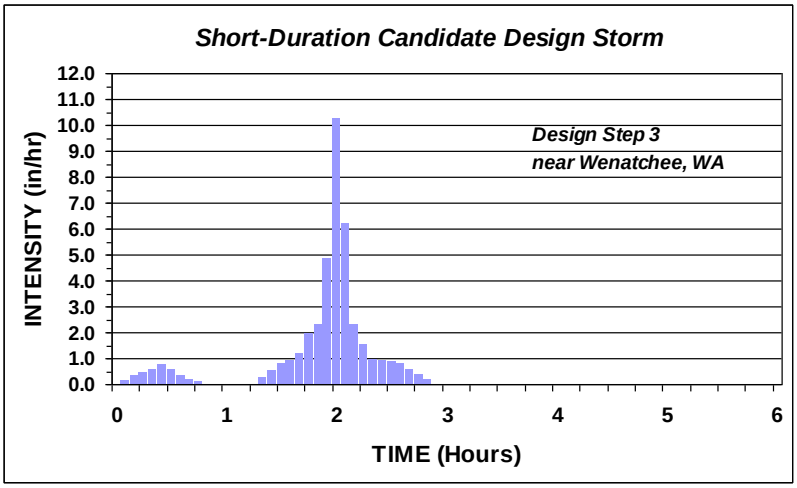


Figure 22 – Scaled Short-Duration Candidate Design Storm for Site near Wenatchee, Washington

4.2.1 Example Assembly of Long-Duration Candidate Design Storm

Construct a long-duration candidate design storm for a site near Olympia, Washington. Given: Climatic Region 32; 24-hr precipitation scaling depth for Design Step 5 is 8.54 inches, obtained from querying gridded precipitation dataset for 24-hour precipitation maxima for Design Step 5, and applying the 15 percent design factor as appropriate.

1. Multiply the ordinates of the long-duration dimensionless design hyetograph for Climatic Region 32 (Figures 16 and 23) by the precipitation scaling depth of 8.54 inches. The resultant candidate design storm is shown in Figure 24.
2. For those watershed models that use precipitation depth as input, convert precipitation intensities to precipitation depths by multiplying the intensities from Step 1 by 4 for a 15-minute time-step.

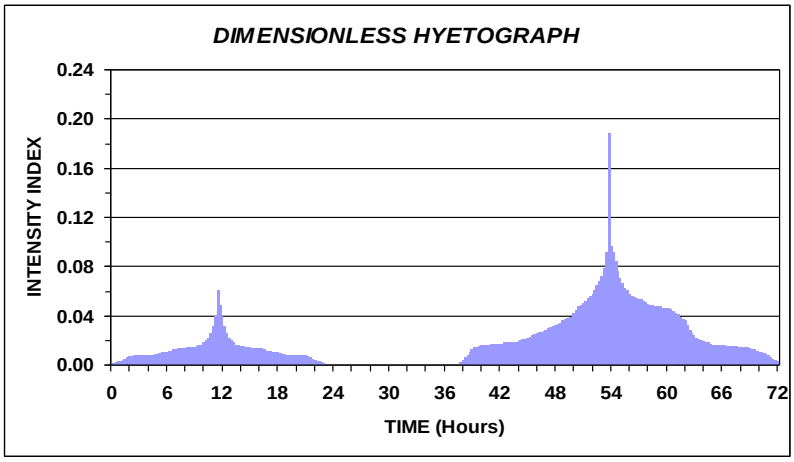


Figure 23 – Long-Duration Dimensionless Design Hyetograph for Climatic Region 32

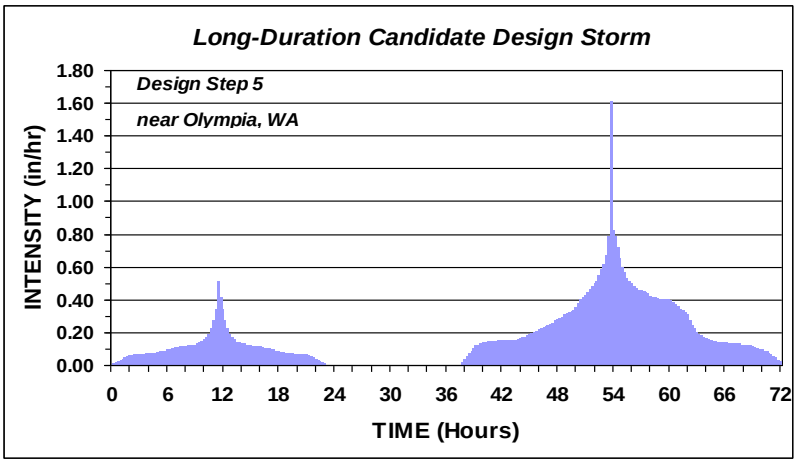


Figure 24 – Scaled Long-Duration Candidate Design Storm for Site near Olympia, Washington

4.3 ASSEMBLING CANDIDATE DESIGN STORMS FOR LARGE WATERSHEDS

As discussed previously, a large watershed is one where the basin-average precipitation varies sufficiently from the maximum point precipitation depth that the spatial distribution of the storm is an important consideration. This corresponds to watersheds that exceed 10 mi^2 for long or intermediate-duration storms as the design event, and watersheds larger than 1 mi^2 for a short-duration thunderstorm as the design event.

Constructing a design storm hyetograph for a large watershed is a watershed-specific application. Thus, generic hyetographs for large watersheds cannot be developed in advance. The areal adjustment values in Table 1 may be used in determining if the dimensionless design hyetographs for small watersheds may be acceptable. Alternatively, if areal adjustments will be important in assembling the candidate design storms for the large watershed, then watershed-specific hyetographs must be developed.

The flow chart in Figure 25 illustrates the standard steps for constructing candidate design storms when areal adjustments are required. Appendix B contains dimensionless depth-duration curves used for assembling the candidate design storms.

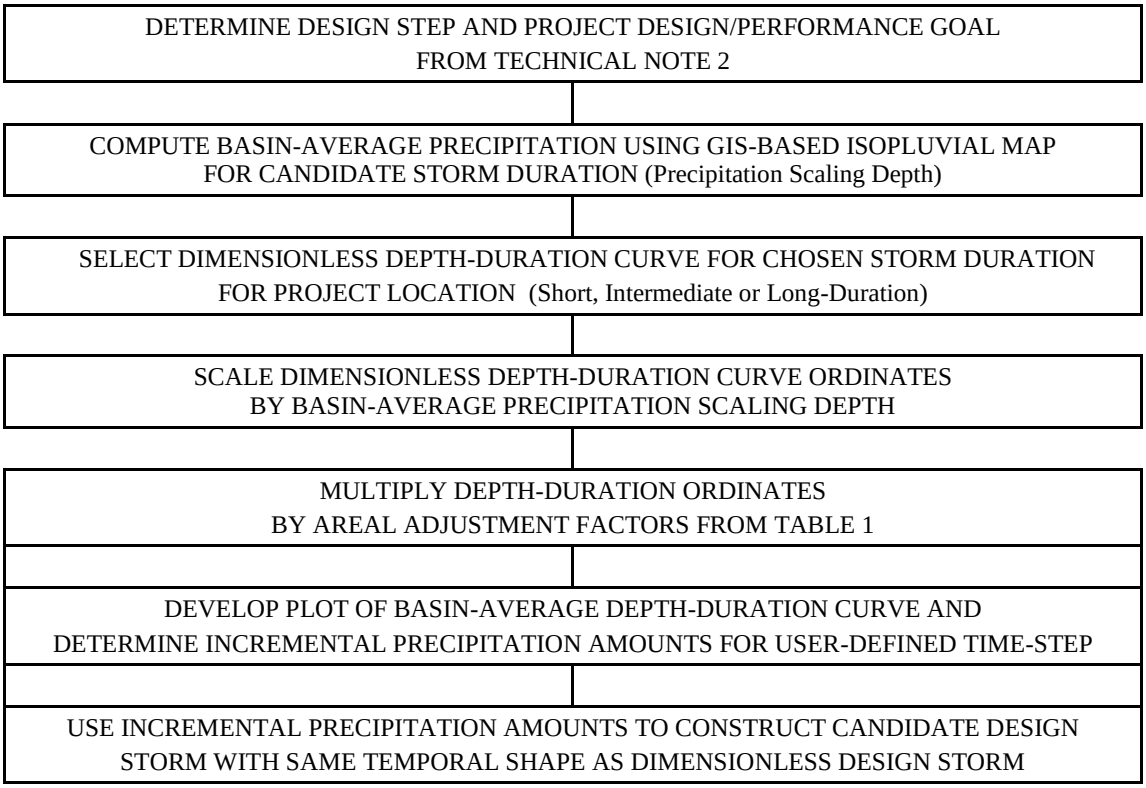


Figure 25 – Flowchart for Construction of a Candidate Design Storm for Large Watersheds

4.3.1 Example Assembly of Intermediate-Duration Candidate Design Storm

Construct an intermediate-duration candidate design storm for a site near Seattle, WA.

Given: Watershed area is 50-mi^2; Climatic Region 31; 6-hour precipitation scaling depth for Design Step 4 is 3.02-inches, obtained from querying the gridded precipitation dataset for 6-hour precipitation maxima for Design Step 4 and computing basin-average precipitation for the watershed, and applying the 15 percent design factor per Equation 1 as appropriate.

1. Multiply the ordinates of the intermediate-duration dimensionless depth-duration curve Figure 26) for Climatic Region 31 (Appendix B) by the precipitation scaling depth of 3.02-inches. This produces a depth-duration curve for watersheds up to 10 mi^2 (Figure 27).
2. Multiply the scaled depth-duration curve ordinate values by the areal reduction factors for the intermediate-duration listed in Table 1 for a 50-mi^2 watershed. Use linear interpolation to obtain areal reduction factors for interdurations residing between listed values. This produces the scaled depth-duration curve for a 50-mi^2 watershed (Figure 27).
3. Obtain incremental precipitation amounts by successively subtracting values from the scaled depth-duration curve (Step 2) on a 15-minute time-step.
4. Multiply the incremental precipitation amounts from Step 3 by a factor of 4 to convert to precipitation intensities (in/hr).
5. Rearrange the incremental intensities in the same pattern as shown for the dimensionless design hyetograph (Figures 10 and 28). This produces the intermediate-duration candidate design storm for the 50-mi^2 watershed (Figure 29).
6. For those watershed models that use precipitation depth as input, convert precipitation intensities to precipitation depths by multiplying the intensities from Step 5 by 4 for a 15-minute time-step.

Note the higher intensity portion of the candidate design storm (Figure 29) is muted relative to the shape of the dimensionless design hyetograph (Figure 28). This is a result of applying the areal reduction factors.

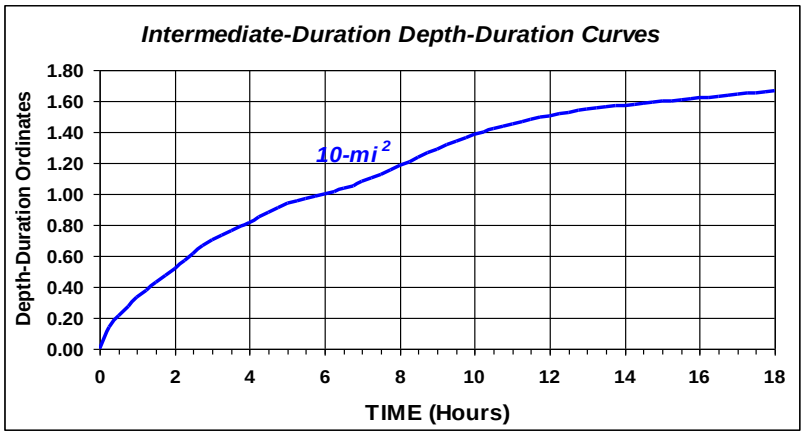


Figure 26 – Intermediate-Duration Dimensionless Depth-Duration Curve for Climatic Region 31

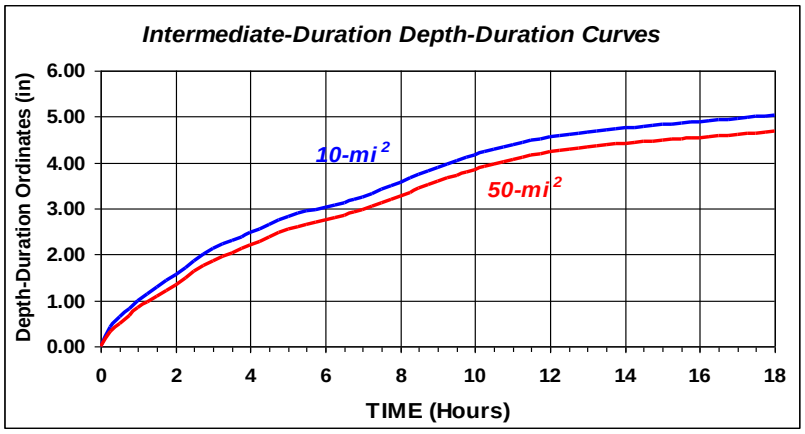


Figure 27 – Scaled Intermediate-Duration Depth-Duration Curves for Climatic Region 31 for Site near Seattle

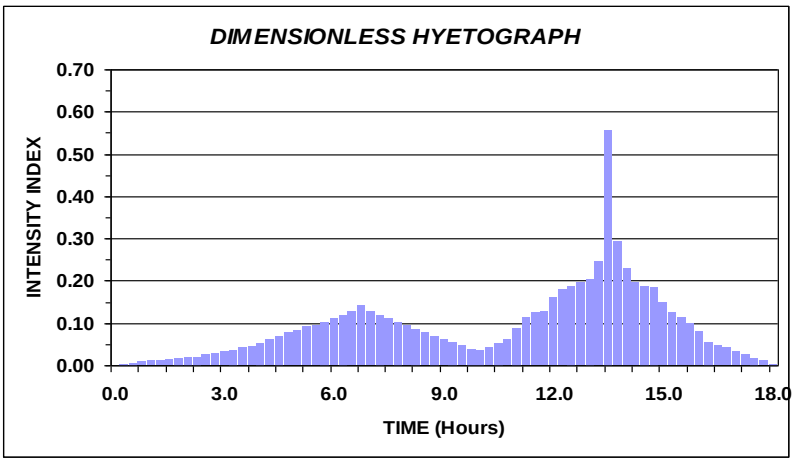


Figure 28 - Intermediate-Duration Dimensionless Design Hyetograph for Climatic Region 31

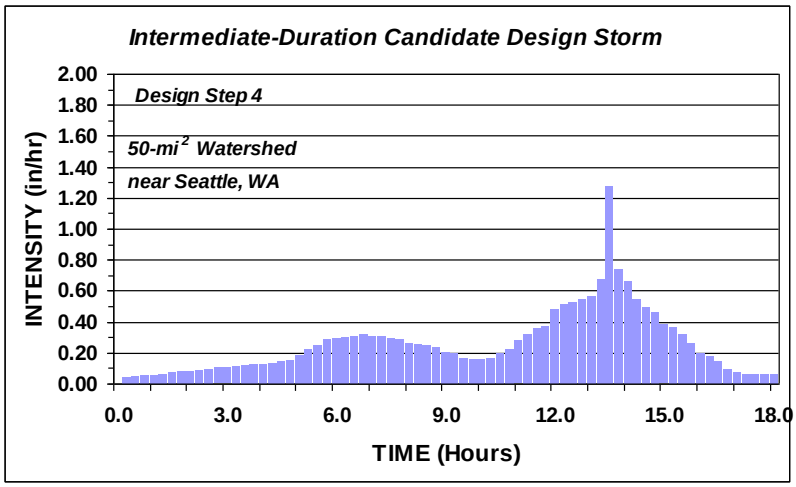


Figure 29 – Intermediate-Duration Candidate Design Storm for a 50-mi^2 Watershed near Seattle, Washington, in Climatic Region 31

5. REFERENCES

1. Bell FC, The Areal Reduction Factors in Rainfall-Frequency Estimation, Natural Environmental Research Council, (NERC), Report 35, Institute of Hydrology, Wallingford UK, 1976.
2. Chow VT, Handbook of Applied Hydrology, pp9.1-9.68, McGraw-Hill, 1964.
3. Cunnane C, Unbiased Plotting Positions - A Review, Journal of Hydrology, 37, 205-222, 1978.
4. Frederick RH, Miller JF, Richards FP and Schwerdt RW, Interduration Precipitation Relations for Storms - Western United States, Technical Report NWS 27, NOAA, Washington, DC, 1981.
5. Helsel DR and Hirsch RM, Statistical Methods in Water Resources, Elsevier Studies in Environmental Science 49, NY, 1992.
6. Hosking JRM, The Theory of Probability Weighted Moments, IBM Research Report RC12210, October 1986.
7. Hosking JRM, L-Moments: Analysis and Estimation of Distributions using Linear Combinations of Order Statistics, Journal Royal Statistical Society, Ser B, 52, pp105-124, 1990.
8. Hosking JRM, The Four Parameter KAPPA Distribution, IBM Research Report RC13412, IBM Research Yorktown Heights NY, 1988.
9. Hosking JRM, and Wallis JR, Some Statistics Useful in Regional Frequency Analysis, Water Resources Research, Vol 29, No. 2, pp271-281, Feb 1993.
10. Hosking JRM, and Wallis JR, Regional Frequency Analysis - An Approach Based on L-Moments, Cambridge Press, 1997.
11. Kuczera G, Combining Site Specific and Regional Information: An Empirical Bayes Approach, Water Resources Research, Vol 18, No. 2, pp306-314, April 1982.
12. Meyers VA, and Zehr RM, A Methodology for Point-to-Area Rainfall Frequency Ratios, NOAA Technical Report NWS 24, NOAA, US Department of Commerce, National Weather Service, Washington DC, 1980.
13. Miller JF, Frederick RH and Tracey RS, NOAA ATLAS 2, Precipitation - Frequency Atlas of the Western United States, Volume IX - Washington, US Dept. of Commerce, NOAA, National Weather Service, Washington, DC, 1973.
14. NWS, National Weather Service, Hydrometeorological Report 57, Probable Maximum Precipitation for the Pacific Northwest, US Department of Commerce, NOAA, National Weather Service, Washington, DC, 1994.

15. NWS, National Weather Service, Hydrometeorological Report 43, Probable Maximum Precipitation for the Pacific Northwest, US Department of Commerce, NOAA, US Weather Bureau, Washington, DC, 1966.

16. Potter KW, Research on Flood Frequency Analysis, 1983-1986, US National Report, International Union of Geodesy and Geophysics, 25(2), pp113-118, 1987.

17. Siriwardena L and Weinmann PE, Derivation of Areal Reduction Factors for Design Rainfalls in Victoria for Rainfall Durations 18-120 Hours, Cooperative Research Centre for Catchment Hydrology, Department of Civil Engineering Monash University, Victoria Australia, Report 96/4, October 1996.

18. Schaefer MG, Regional Analyses of Precipitation Annual Maxima in Washington State, Water Resources Research, Vol 26, No. 1, pp119-132, January 1990.

19. Schaefer MG, Characteristics of Extreme Precipitation Events in Washington State, Washington State Dept. of Ecology, Report 89-51, October 1989.

20. Schaefer MG, Barker BL, Taylor GH and Wallis JR, Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-Hour and 2-Hour Durations in Western Washington, prepared for Washington State Department of Transportation, Report WA-RD 544.1, MGS Engineering Consultants, March 2002.

21. Schaefer MG, Barker BL, Taylor GH and Wallis JR, Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-Hour and 2-Hour Durations in Eastern Washington, prepared for Washington State Department of Transportation, MGS Engineering Consultants, January 2006.

22. Schaefer MG, Analyses of Precipitation-Frequency and Storm Characteristics for the City of Seattle, prepared for Seattle Public Utilities, MGS Engineering Consultants, December 2003.

23. Stedinger JR, Vogel RM, and Foufoula-Georgiou E, Frequency Analysis of Extreme Events, Chapter 18, *Handbook of Hydrology*, McGraw Hill, 1992.

24. Technical Note 2, Selection of Design/Performance Goals for Critical Project Elements, Dam Safety Guidelines, Washington State Dept. of Ecology, Report 92-55F, July 1992.

25. U.S. National Research Council, Estimating Probabilities of Extreme Floods, Methods and Recommended Research, National Academy Press, Washington DC, 1988.

26. Wallis JR, Risk and Uncertainties in the Evaluation of Flood Events for the Design of Hydraulic Structures, in *Pienne e Siccita*, editted by E. Guggino, G. Rossi, and E. Todini, pp3-36, Fondazione Politecnica del Mediterranes, Catania, Italy, 1980.

APPENDIX A
CATALOG OF HISTORICAL STORMS

OVERVIEW

Storm dates and locations listed in this catalog are associated with precipitation amounts that have exceeded a 20-year recurrence interval at a given location at one or more durations. Categorization of a storm as being a short-duration, intermediate duration or long-duration extreme storm is based on comparison of the precipitation maxima for the storm being most rare at the 2-hour, 6-hour or 24-hour duration, respectively. This is the same approach that was used in the original study of extreme storms entitled *Characteristics of Extreme Precipitation Events in Washington State* and completed in October 1989 (Ecology Publication 89-51). Data collection for that study ended in early 1986 and included storms recorded at automated precipitation gages that operated in the period from 1940-1986. Storms identified in the earlier study are listed in black in this catalog.

Records from precipitation gages in Washington State and border areas have been scanned to identify storms that have occurred since 1986 that have exceeded the 20-year recurrence interval criterion as discussed above. As in the original study, storms have been categorized as either short, intermediate or long-duration based on the precipitation maxima at the 2-hour, 6-hour and 24-hour durations respectively. These recent storms are listed in blue in this catalog.

Storms in the original study were grouped into orographic and non-orographic regions in both western and eastern Washington. These regions were defined based on NWS climatic zones in use at that time. Since the original study, regional precipitation-frequency analyses have been conducted for Washington State which included delineation of climatic regions. The complete collection of noteworthy storms from 1940-2007 have been regrouped in this catalog using the new climatic region delineations for Washington State (Figure 4).

Many of the most extreme storms listed in the catalog have been placed in Excel spreadsheets and configured to allow scaling of the storms into larger or smaller storm events. These storms are termed *scalable historical storms* and are particularly useful for examining the flood response of a reservoir and spillway system to the type of storm event that has occurred in the climatic region where a given project is located. Scaling of these storms is done in a manner similar to that for the dimensionless design hyetographs. Use of scalable historical storms provides another avenue to confirm the hydrologic adequacy of a spillway system using a suite of diverse storm characteristics.

Scalable historical storms are available through the Dam Safety Office.

Table 2 - Catalog of Short-Duration Extreme Storms for Region 5 - Coastal Lowlands

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								2-HR	6-HR
45-8332	Tatoosh Island WB	WA	5	48.38	-124.73	100	11/3/1941	1.41	1.89
45-8332	Tatoosh Island WB	WA	5	48.38	-124.73	100	10/10/1942	1.53	2.32
45-9112	Westport 2 S	WA	5	46.87	-124.10	20	10/30/1950	1.47	2.24
45-5488	Moclips	WA	5	47.22	-124.20	120	1/2/1951	1.30	1.97
45-9112	Westport 2 S	WA	5	46.87	-124.10	20	10/18/1979	1.20	1.65
35-0328	Astoria AP Port	OR	5	46.15	-123.87	9	11/25/1998	1.84	2.49

Table 3 - Catalog of Short-Duration Extreme Storms for Regions 32 and 31
Interior Lowlands Western Washington

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								2-HR	6-HR
45-2675	Everett	WA	31	47.98	-122.18	60	9/28/1944	1.01	1.52
45-5224	Mc Millin Reservoir	WA	31	47.13	-122.27	579	7/8/1946	1.10	1.32
45-1277	Centralia 1 W	WA	31	46.70	-122.97	185	10/28/1949	1.15	1.51
45-7470	Seattle EMSU	WA	31	47.68	-122.25	60	6/29/1952	0.96	1.01
45-5224	Mc Millin Reservoir	WA	31	47.13	-122.27	579	9/17/1957	1.07	1.21
45-2675	Everett	WA	31	47.98	-122.18	60	5/31/1958	1.14	1.14
45-0324	Auburn	WA	31	47.32	-122.23	79	6/8/1959	0.87	1.04
45-5224	Mc Millin Reservoir	WA	31	47.13	-122.27	579	8/26/1960	1.70	2.04
35-3340	Goble 3 SW	OR	32	45.98	-122.92	530	6/30/1963	0.87	1.05
45-4769	Longview	WA	31	46.15	-122.92	12	8/23/1963	1.05	1.05
45-7773	Snoqualmie Falls	WA	31	47.53	-121.83	440	9/19/1964	1.17	1.19
45-0986	Burlington	WA	31	48.47	-122.32	30	8/12/1965	1.28	1.50
45-6678	Port Townsend	WA	32	48.10	-122.75	100	9/10/1967	0.84	1.02
35-6751	Portland Intl Airport	OR	32	45.58	-122.60	19	1/11/1970	1.15	1.41
45-2675	Everett	WA	31	47.98	-122.18	60	9/22/1972	0.99	1.13
45-1191	Castle Rock 2 NW	WA	31	46.27	-122.92	39	9/20/1973	1.46	2.35
45-1277	Centralia 1 W	WA	31	46.70	-122.97	185	7/8/1974	1.20	1.50
45-7470	Seattle EMSU	WA	31	47.68	-122.25	60	8/26/1977	1.64	1.66
45-1146	Carnation 4 NW	WA	31	47.68	-121.98	50	9/20/1977	1.20	1.30
45-4486	Landsburg	WA	31	47.38	-121.98	535	7/9/1980	0.90	1.00
45-7473	Sea-Tac Airport	WA	31	47.45	-122.30	400	10/6/1981	0.85	1.21
45-1146	Carnation 4 NW	WA	31	47.68	-121.98	50	6/18/1986	1.00	1.30
45-1146	Carnation 4 NW	WA	31	47.68	-121.98	50	9/19/1988	1.10	1.40
45-0729	Blaine	WA	31	49.00	-122.75	60	8/15/1989	1.40	2.00
	Seattle SPU RG08	WA	31				9/23/1992	1.02	1.02
	King County East Pine PS	WA	31				8/22/2004	1.84	2.50
	Seattle SPU RG16	WA	31				5/31/2005	0.92	0.95
	Seattle SPU RG10	WA	31				6/1/2005	1.15	1.28
	Seattle SPU RG02	WA	31				5/27/2006	1.09	1.12
	Seattle SPU RG20	WA	31				12/14/2006	1.10	1.13

Table 4 - Catalog of Short-Duration Extreme Storms for Regions 15, 151 and 142
Mountain Areas in Western Washington

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								2-HR	6-HR
45-5704	Mud Mountain Dam	WA	15	47.15	-121.93	1308	6/10/1942	0.99	1.08
45-5704	Mud Mountain Dam	WA	15	47.15	-121.93	1308	9/1/1943	0.99	1.11
45-1759	Cougar 4 SW	WA	15	46.02	-122.35	520	9/21/1944	1.49	1.98
45-7709	Skykomish 1 ENE	WA	15	47.70	-121.37	1030	5/25/1945	1.78	1.78
45-6295	Palmer 3 ESE	WA	15	47.30	-121.85	920	5/27/1948	1.20	1.45
45-5663	Mount Baker Lodge	WA	15	48.87	-121.67	4150	6/16/1949	1.53	1.53
45-1457	Cinebar 2 E	WA	15	46.60	-122.48	1040	6/9/1953	1.51	1.90
45-6909	Randle 1 E	WA	15	46.53	-121.93	900	8/28/1957	1.40	1.44
45-7657	Silverton	WA	15	48.07	-121.57	1475	9/10/1967	1.40	2.10
35-0897	Bonneville Dam	OR	15	45.63	-121.95	62	11/20/1970	1.40	1.45
45-6385	White River RS	WA	15	46.92	-121.53	3553	5/10/1975	1.20	1.30
45-1233	Cedar Lake	WA	15	47.42	-121.73	1560	9/20/1977	1.40	2.00
45-6909	Randle 1 E	WA	15	46.53	-121.93	900	6/28/1978	1.30	1.30
45-5704	Mud Mountain Dam	WA	15	47.15	-121.93	1308	7/9/1979	1.11	1.28
45-7657	Silverton	WA	15	48.07	-121.57	1475	9/30/1980	1.80	2.00
45-6851	Quilcene Dam 5 SW	WA	142	47.78	-122.98	1028	11/29/1980	1.40	1.69
45-0013	Aberdeen 20 NNE	WA	151	47.27	-123.70	435	5/28/1982	2.50	2.50
45-5876	Nooksack Salmon Hatchery	WA	15	48.90	-122.15	410	10/20/1992	1.80	2.30
45-1233	Cedar Lake	WA	15	47.42	-121.73	1560	6/22/1993	1.40	1.50

Table 5 - Catalog of Short-Duration Extreme Storms for Region 14
East Face of Cascade Mountains

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								2-HR	6-HR
45-1257	Centerville 2 SW	WA	14	45.73	-120.95	1650	6/7/1947	0.80	0.80
45-5133	Mazama	WA	14	48.60	-120.43	2170	1/17/1971	0.90	0.97
35-4003	Hood River Exp Stn	OR	14	45.68	-121.52	500	5/20/1972	1.00	1.30
45-5659	Mount Adams RS	WA	14	46.00	-121.53	1960	1/12/1980	1.30	1.70
45-1160	Carson Fish Hatchery	WA	14	45.87	-121.97	1134	1/12/1980	1.40	2.00
45-2384	Easton	WA	14	47.23	-121.18	2170	8/26/1983	1.80	1.90
45-4446	Lake Wenatchee	WA	14	47.83	-120.78	2005	2/11/1985	1.10	1.30
45-5133	Mazama	WA	14	48.60	-120.43	2170	7/16/1985	1.10	1.10
45-6472	Peshastin Telemetering	WA	14	47.57	-120.62	1028	8/6/1991	0.90	1.00
45-2157	Diablo Dam	WA	14	48.72	-121.15	891	7/20/1992	1.10	1.40
35-4003	Hood River Exp Stn	OR	14	45.68	-121.52	500	9/18/1998	1.60	2.40
45-2384	Easton	WA	14	47.23	-121.18	2170	9/9/2000	0.90	1.40
35-0571	Bear Springs RS	OR	14	45.12	-121.53	3360	9/14/2001	1.00	1.10
45-3183	Glenwood	WA	14	46.02	-121.28	1896	5/23/2006	0.90	1.00

Table 6 - Catalog of Short-Duration Extreme Storms for Transition Zone 147
Cascade Foothills in Eastern Washington

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								2-HR	6-HR
45-2505	Ellensburg	WA	147	46.97	-120.53	1480	5/12/1943	0.62	0.74
45-9465	Yakima Airport	WA	147	46.57	-120.53	1064	6/19/1944	0.90	0.91
45-6187	Oroville 1 S	WA	147	48.93	-119.43	932	6/16/1947	1.25	1.25
45-5327	Methow 2S	WA	147	48.13	-120.02	1165	8/10/1948	1.08	1.08
45-5327	Methow 2S	WA	147	48.13	-120.02	1165	6/17/1950	0.89	0.89
45-9082	Wenatchee AP	WA	147	47.38	-120.20	1229	8/10/1952	1.29	1.29
45-9082	Wenatchee AP	WA	147	47.38	-120.20	1229	8/25/1956	1.38	1.73
45-5731	Naches 10 NW	WA	147	46.87	-120.77	2280	5/5/1957	0.90	0.90
45-5327	Methow 2S	WA	147	48.13	-120.02	1165	7/8/1958	1.33	1.33
45-9082	Wenatchee AP	WA	147	47.38	-120.20	1229	8/23/1965	0.96	1.19
45-9082	Wenatchee AP	WA	147	47.38	-120.20	1229	6/9/1972	1.05	1.45
35-5734	Moro	OR	147	45.47	-120.72	1870	6/9/1972	0.90	0.90
45-9465	Yakima Airport	WA	147	46.57	-120.53	1064	8/18/1975	0.98	1.39
35-5734	Moro	OR	147	45.47	-120.72	1870	9/27/1981	0.80	0.80
45-5731	Naches 10 NW	WA	147	46.87	-120.77	2280	7/7/1982	1.20	1.20
45-5731	Naches 10 NW	WA	147	46.87	-120.77	2280	8/1/1984	0.80	0.80
35-0265	Arlington	OR	147	45.72	-120.20	277	4/29/1992	0.80	0.80
45-2505	Ellensburg	WA	147	46.97	-120.53	1480	7/3/1998	0.90	0.90

Table 7 - Catalog of Short-Duration Extreme Storms for Regions 77 and 7
Central Basin and Lowland Areas in Eastern Washington

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								2-HR	6-HR
45-6982	Republic RS	WA	7	48.63	-118.73	2630	8/23/1941	1.43	1.54
45-9397	Withrow	WA	77	47.72	-119.82	2533	6/13/1944	1.06	1.11
45-2030	Dayton 1 WSW	WA	7	46.30	-118.00	1557	7/8/1946	0.79	0.83
45-8207	Sunnyside	WA	77	46.32	-120.00	747	6/7/1947	1.62	1.83
45-3515	Harrington 1 NW	WA	77	47.48	-118.25	2190	6/10/1948	1.03	1.13
45-9327	Wilson Creek	WA	77	47.42	-119.12	1280	6/18/1950	1.50	1.55
45-6789	Pullman 2 NW	WA	7	46.75	-117.18	2545	8/10/1952	1.77	2.39
45-9327	Wilson Creek	WA	77	47.42	-119.12	1280	7/24/1955	0.80	0.94
45-8931	Walla Walla WSO	WA	7	46.03	-118.33	949	5/8/1957	1.15	1.15
45-3883	Ice Harbor Dam	WA	77	46.23	-118.87	368	6/5/1957	1.67	1.67
45-8931	Walla Walla WSO	WA	7	46.03	-118.33	949	5/24/1958	1.60	1.62
45-1400	Chief Joseph Dam	WA	77	47.98	-119.65	820	6/7/1958	0.71	0.71
45-6982	Republic RS	WA	7	48.63	-118.73	2630	7/5/1958	1.10	1.20
10-7188	Plummer 3 WSW	ID	7	47.30	-116.95	2920	7/7/1958	0.87	1.03
45-1767	Coulee Dam 1 SW	WA	77	47.95	-119.00	1700	4/29/1961	0.85	0.93
45-6982	Republic RS	WA	7	48.63	-118.73	2630	8/9/1962	1.26	1.26
45-6789	Pullman 2 NW	WA	7	46.75	-117.18	2545	6/16/1963	1.47	1.47
45-6610	Pomeroy	WA	7	46.47	-124.58	1900	9/13/1966	1.12	1.12
45-9397	Withrow	WA	77	47.72	-119.82	2533	8/14/1968	0.94	1.18
45-9397	Withrow	WA	77	47.72	-119.82	2533	12/11/1969	0.93	0.94
45-8931	Walla Walla WSO	WA	7	46.03	-118.33	949	5/26/1971	1.75	1.82
35-8726	Ukiah	OR	7	45.13	-118.93	3400	7/9/1975	2.10	2.10
45-7938	Spokane Intl AP	WA	7	47.62	-117.52	2353	6/7/1977	0.96	1.10
45-9200	Whitman Mission	WA	7	46.03	-118.45	632	8/5/1977	0.94	0.96
45-2030	Dayton 1 WSW	WA	7	46.30	-118.00	1557	7/7/1978	1.20	1.20
45-3515	Harrington 1 NW	WA	77	47.48	-118.25	2190	6/1/1982	1.00	1.00
45-6982	Republic RS	WA	7	48.63	-118.73	2630	7/1/1982	1.10	1.10
45-8207	Sunnyside	WA	77	46.32	-120.00	747	9/15/1986	1.15	1.25
45-1400	Chief Joseph Dam	WA	77	47.98	-119.65	820	7/25/1987	1.00	1.00
45-4679	Lind 3 NE	WA	77	46.98	-118.57	1630	8/20/1990	0.80	0.90
45-9200	Whitman Mission	WA	7	46.03	-118.45	632	7/22/1992	0.80	0.90
45-1400	Chief Joseph Dam	WA	77	47.98	-119.65	820	7/9/1993	1.10	1.10
35-1765	Condon	OR	7	45.22	-120.17	2840	7/13/1993	1.70	2.00
35-3827	Heppner	OR	7	45.35	-119.55	1885	7/19/1993	1.20	1.20
45-4679	Lind 3 NE	WA	77	46.98	-118.57	1630	7/22/1993	1.40	1.40
35-1765	Condon	OR	7	45.22	-120.17	2840	7/27/1998	1.20	1.40
35-9213	Weston	OR	7	45.82	-118.42	1922	10/8/2000	0.70	0.70
45-8348	Tekoa	WA	7	47.22	-117.08	2495	6/27/2001	0.80	0.80
10-7269	Porthill 1 SW	ID	7	48.98	-116.50	1700	7/8/2002	0.80	1.10

Table 8 - Catalog of Short-Duration Extreme Storms for Region 13
Mountain Areas in Eastern Washington Eastward of Cascade Mountains

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								2-HR	6-HR
45-1630	Colville	WA	13	48.53	-117.90	1657	7/19/1950	1.00	1.00
45-1630	Colville	WA	13	48.53	-117.90	1657	7/6/1956	0.82	0.88
45-0849	Boundary Switchyard	WA	13	48.97	-117.35	2500	9/10/1962	0.99	1.17
45-0849	Boundary Switchyard	WA	13	48.97	-117.35	2500	5/21/1981	1.10	1.20
45-1395	Chewelah	WA	13	48.27	-117.72	1670	7/20/1983	1.00	1.00
45-5946	Northport	WA	13	48.90	-117.78	1350	5/27/1987	1.00	1.10
10-1079	Bonners Ferry	ID	13	48.68	-116.32	1770	6/15/1987	0.90	1.00
10-2845	Dworshak Fish Hatchery	ID	13	46.50	-116.32	995	5/27/1989	0.80	0.90
45-1630	Colville	WA	13	48.53	-117.90	1657	8/9/1989	1.30	1.50
35-8985	Walla Walla 13 ESE	OR	13	45.98	-118.05	2400	6/6/1991	1.70	2.30
35-6636	Pilot Rock 11 E	OR	13	45.50	-118.60	1920	8/14/1991	1.40	1.40
10-1956	Coeur D'Alene	ID	13	47.67	-116.80	2133	6/30/1998	0.90	1.00
45-5946	Northport	WA	13	48.90	-117.78	1350	7/11/1998	1.10	1.20
45-1630	Colville	WA	13	48.53	-117.90	1657	8/18/2004	1.90	1.90

Table 9 - Catalog of Intermediate-Duration Extreme Storms for Region 5
Coastal Lowlands

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								6-HR	18-HR
45-1496	Clearwater	WA	5	47.58	-124.30	80	11/23/1948	3.40	4.70
45-5488	Moclips	WA	5	47.22	-124.20	120	12/11/1953	2.47	3.49
45-5549	Montesano 3 NW	WA	5	46.97	-123.62	25	12/21/1961	2.46	3.37
45-6584	Point Grenville	WA	5	47.30	-124.28	100	10/29/1967	2.98	4.38
45-6858	Quillayute AP	WA	5	47.93	-124.55	179	1/25/1971	3.21	6.10
45-3333	Grays River Hatchery	WA	5	46.38	-123.57	100	11/6/1980	3.20	4.50
45-9112	Westport 2 S	WA	5	46.87	-124.10	20	7/1/1983	2.20	2.60
45-3333	Grays River Hatchery	WA	5	46.38	-123.57	100	10/26/1985	3.10	4.90
45-9112	Westport 2 S	WA	5	46.87	-124.10	20	12/4/1990	2.20	2.90
45-6858	Quillayute AP	WA	5	47.93	-124.55	179	8/9/1995	2.87	4.13
35-0328	Astoria AP Port	OR	5	46.15	-123.87	9	11/25/1998	2.49	4.72
45-6858	Quillayute AP	WA	5	47.93	-124.55	179	11/28/2003	3.71	6.08

Table 10 - Catalog of Intermediate-Duration Extreme Storms for Regions 32 and 31
Interior Lowlands Western Washington

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								6-HR	18-HR
45-7473	Sea-Tac (WSO)	WA	31	47.45	-122.30	400	1/19/1943	1.60	2.49
45-6678	Port Townsend	WA	32	48.10	-122.75	100	6/14/1946	1.35	2.21
45-7473	Sea-Tac (WSO)	WA	31	47.45	-122.30	400	2/16/1949	1.50	1.69
45-6114	Olympia AP	WA	32	46.97	-122.90	206	12/9/1956	2.13	3.35
45-9485	Yelm	WA	31	46.95	-122.60	351	11/20/1959	1.44	2.58
45-2675	Everett	WA	31	47.98	-122.18	60	10/23/1960	1.39	1.52
45-7773	Snoqualmie Falls	WA	31	47.53	-121.83	440	10/21/1963	2.08	2.48
45-1146	Carnation 4 NW	WA	31	47.68	-121.98	50	12/3/1968	1.57	1.95
45-4486	Landsburg	WA	31	47.38	-121.98	535	6/23/1969	1.64	2.09
35-6751	Portland Intl Airport	OR	32	45.58	-122.60	19	9/17/1969	1.91	2.38
45-0729	Blaine 1 ENE	WA	31	49.00	-122.75	60	11/3/1971	1.60	3.43
45-9485	Yelm	WA	31	46.95	-122.60	351	12/21/1972	1.43	1.78
45-6624	Port Angeles	WA	32	48.10	-123.42	90	11/3/1978	1.92	2.55
45-7773	Snoqualmie Falls	WA	31	47.53	-121.83	440	1/23/1982	2.00	2.90
45-7470	Seattle EMSU	WA	31	47.68	-122.25	60	12/3/1982	1.56	2.53
45-5224	Mc Millin Reservoir	WA	31	47.13	-122.27	579	8/29/1983	1.90	2.00
45-0729	Blaine 1 ENE	WA	31	49.00	-122.75	60	12/29/1983	1.70	3.10
45-0729	Blaine 1 ENE	WA	31	49.00	-122.75	60	2/15/1986	2.00	2.80
45-5224	Mc Millin Reservoir	WA	31	47.13	-122.27	579	2/19/1991	1.60	2.50
45-0729	Blaine 1 ENE	WA	31	49.00	-122.75	60	11/11/1995	1.60	1.70
35-6751	Portland Intl Airport	OR	32	45.58	-122.60	19	9/15/1996	1.56	2.04
35-2348	Dixie Mountain	OR	32	45.68	-122.92	1430	10/30/1997	2.10	2.80
45-1277	Centralia 1 W	WA	31	46.70	-122.97	185	11/14/2001	2.30	4.40
45-2675	Everett	WA	31	47.98	-122.18	60	11/19/2003	1.40	2.10
	Seattle RG12	WA	31				12/3/2007	2.38	5.26

Table 11 - Catalog of Intermediate-Duration Extreme Storms for Regions 15, 151 and 142 Mountain Areas in Western Washington

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								6-HR	18-HR
45-7781	Snoqualmie Pass	WA	15	47.42	-121.40	3020	12/4/1941	2.74	3.73
45-7919	Spirit Lake RS	WA	15	46.27	-122.15	3240	10/24/1943	3.12	5.46
45-4999	Marblemount RS	WA	15	48.53	-121.45	348	1/7/1945	2.04	4.12
45-7657	Silverton	WA	15	48.07	-121.57	1475	2/7/1945	2.84	4.52
45-7781	Snoqualmie Pass	WA	15	47.42	-121.40	3020	10/24/1945	3.87	6.00
45-7319	Sappho 8 E	WA	151	48.07	-124.12	760	2/1/1947	3.32	4.28
35-0897	Bonneville Dam	OR	15	45.63	-121.95	62	10/19/1947	3.60	4.79
45-6851	Quilcene Dam 5 SW	WA	142	47.78	-122.98	1028	12/1/1948	2.55	3.95
45-1992	Darrington RS	WA	15	48.25	-121.60	550	9/27/1953	2.20	3.32
45-4634	Lester	WA	15	47.20	-121.48	1630	12/9/1953	2.15	3.53
45-6851	Quilcene Dam 5 SW	WA	142	47.78	-122.98	1028	2/7/1955	2.64	3.93
45-0013	Aberdeen 20 NNE	WA	151	47.27	-123.70	435	11/2/1955	3.47	7.14
45-7657	Silverton	WA	15	48.07	-121.57	1475	12/9/1956	3.30	5.31
45-6295	Palmer 3 ESE	WA	15	47.30	-121.85	920	9/26/1959	2.69	3.85
45-1064	Camp Grisdale	WA	151	47.37	-123.60	820	11/19/1959	4.14	7.62
45-8009	Stampede Pass	WA	15	47.28	-121.33	3958	11/22/1959	2.94	6.26
45-8009	Stampede Pass	WA	15	47.28	-121.33	3958	11/21/1961	2.56	4.71
45-2984	Frances	WA	142	46.55	-123.50	231	11/25/1962	2.72	4.40
45-6385	White River RS	WA	15	46.92	-121.53	3553	11/9/1973	2.00	3.70
45-5704	Mud Mountain Dam	WA	15	47.15	-121.93	1308	8/18/1975	2.13	3.41
45-7781	Snoqualmie Pass	WA	15	47.42	-121.40	3020	12/1/1975	2.90	4.90
45-0013	Aberdeen 20 NNE	WA	151	47.27	-123.70	435	12/26/1975	3.30	5.40
45-3357	Greenwater	WA	15	47.13	-121.63	1730	12/2/1977	2.70	4.00
45-6864	Quinault RS	WA	151	47.47	-123.85	220	2/15/1981	4.00	7.10
45-2984	Frances	WA	142	46.55	-123.50	231	12/15/1982	2.90	4.20
45-6295	Palmer 3 ESE	WA	15	47.30	-121.85	920	11/3/1983	2.40	3.60
45-3357	Greenwater	WA	15	47.13	-121.63	1730	1/3/1984	2.10	2.80
45-1233	Cedar Lake	WA	15	47.42	-121.73	1560	1/24/1984	2.40	4.10
45-1934	Cushman Dam	WA	142	47.42	-123.22	760	1/18/1986	4.30	8.00
45-6864	Quinault RS	WA	151	47.47	-123.85	220	11/23/1986	5.00	9.10
35-3770	Headworks Portland Water	OR	15	45.45	-122.15	748	4/25/1989	2.60	3.30
45-7781	Snoqualmie Pass	WA	15	47.42	-121.40	3020	11/9/1989	2.90	6.04
45-6909	Randle 1 E	WA	15	46.53	-121.93	900	2/19/1991	1.80	2.80
45-6851	Quilcene Dam 5 SW	WA	142	47.78	-122.98	1028	12/10/1993	2.70	5.10
45-1759	Cougar 4 SW	WA	15	46.02	-122.35	520	10/31/1994	2.80	5.60
45-0013	Aberdeen 20 NNE	WA	151	47.27	-123.70	435	10/31/1994	3.40	4.20
45-8715	Upper Baker Dam	WA	15	48.65	-121.68	690	2/21/2002	3.30	5.90
45-1233	Cedar Lake	WA	15	47.42	-121.73	1560	9/8/2003	2.60	3.10
45-5876	Nooksack Salmon Hatchery	WA	15	48.90	-122.15	410	11/24/2004	2.60	5.80
35-0897	Bonneville Dam	OR	15	45.63	-121.95	62	12/14/2006	2.30	3.30

Table 12 - Catalog of Intermediate-Duration Extreme Storms for Region 14
East Face of Cascade Mountains

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								6-HR	18-HR
45-2384	Easton	WA	14	47.23	-121.18	2170	10/31/1942	2.13	4.39
45-5133	Mazama	WA	14	48.60	-120.43	2170	7/6/1955	1.83	1.92
45-2157	Diablo Dam	WA	14	48.72	-121.15	891	12/8/1971	2.50	3.70
45-4849	Lucerne 2 NNW	WA	14	48.23	-120.60	1200	12/8/1971	1.45	2.23
45-5133	Mazama	WA	14	48.60	-120.43	2170	1/11/1972	2.20	2.99
45-4446	Lake Wenatchee	WA	14	47.83	-120.78	2005	1/17/1975	2.10	2.50
45-8059	Stehekin 4 NW	WA	14	48.35	-120.72	1270	11/26/1977	2.60	5.74
45-3183	Glenwood	WA	14	46.02	-121.28	1896	12/1/1977	1.65	2.48
45-6472	Peshastin Telemetering	WA	14	47.57	-120.62	1028	2/6/1979	1.60	2.61
45-7342	Satus Pass 2 SSW	WA	14	45.95	-120.67	2610	1/12/1980	2.10	2.90
45-4849	Lucerne 2 NNW	WA	14	48.23	-120.60	1200	1/23/1982	1.58	2.46
45-5659	Mount Adams RS	WA	14	46.00	-121.53	1960	2/20/1982	2.00	3.37
45-5133	Mazama	WA	14	48.60	-120.43	2170	12/3/1982	2.10	3.30
45-3183	Glenwood	WA	14	46.02	-121.28	1896	11/2/1988	1.40	1.98
45-2384	Easton	WA	14	47.23	-121.18	2170	10/31/1994	2.10	3.86
45-8059	Stehekin 4 NW	WA	14	48.35	-120.72	1270	12/29/1996	2.40	2.48
45-7342	Satus Pass 2 SSW	WA	14	45.95	-120.67	2610	10/30/1997	1.70	2.08
45-5133	Mazama	WA	14	48.60	-120.43	2170	10/20/2003	1.50	3.37
35-0571	Bear Springs RS	OR	14	45.12	-121.53	3360	12/21/2005	1.60	2.48

Table 13 - Catalog of Intermediate-Duration Extreme Storms for Transition Zone 147
Cascade Foothills in Eastern Washington

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								6-HR	18-HR
35-0265	Arlington	OR	147	45.72	-120.20	277	1/8/1953	1.02	1.42
45-9082	Wenatchee AP	WA	147	47.38	-120.20	1229	10/31/1973	1.49	1.68
45-9082	Wenatchee AP	WA	147	47.38	-120.20	1229	8/18/1975	1.38	2.04
45-5731	Naches 10 NW	WA	147	46.87	-120.77	2280	1/23/1982	1.00	1.60
45-5731	Naches 10 NW	WA	147	46.87	-120.77	2280	12/9/1987	1.30	2.40
35-0265	Arlington	OR	147	45.72	-120.20	277	12/27/1998	1.00	1.40

Table 14 - Catalog of Intermediate-Duration Extreme Storms for Regions 77 and 7
Central Basin and Lowland Areas in Eastern Washington

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								6-HR	18-HR
10-7188	Plummer 3 WSW	ID	7	47.30	-116.95	2920	6/6/1947	1.46	1.67
45-9327	Wilson Creek	WA	77	47.42	-119.12	1280	6/16/1948	1.06	1.19
45-5231	McNary Dam	WA	77	45.93	-119.28	361	10/1/1957	1.86	3.00
10-7188	Plummer 3 WSW	ID	7	47.30	-116.95	2920	6/17/1965	1.42	2.40
45-1400	Chief Joseph Dam	WA	77	47.98	-119.65	820	8/23/1965	1.02	1.36
45-1767	Coulee Dam	WA	77	47.95	-119.00	1700	11/12/1973	1.19	1.34
45-8348	Tekoa	WA	7	47.22	-117.08	2495	7/4/1978	1.30	2.00
45-6400	Pasco	WA	77	46.22	-119.10	350	9/13/1980	1.30	1.60
45-8931	Walla Walla WSO	WA	7	46.03	-118.33	949	10/13/1980	1.97	2.82
45-8348	Tekoa	WA	7	47.22	-117.08	2495	8/23/1989	1.40	1.60
45-7938	Spokane Intl AP	WA	7	47.62	-117.52	2353	7/25/1990	1.32	1.78
35-9213	Weston	OR	7	45.82	-118.42	1922	8/16/1993	2.20	2.80
45-1690	Connell 1 W	WA	77	46.65	-118.87	1020	5/15/1994	1.00	1.30
45-3515	Harrington 1 NW	WA	77	47.48	-118.25	2190	5/9/2005	1.10	1.50

Table 15 - Catalog of Intermediate-Duration Extreme Storms for Region 13
Mountain Areas in Eastern Washington Eastward of Cascade Mountains

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								6-HR	18-HR
10-7188	Plummer 3 WSW	ID	7	47.30	-116.95	2920	6/6/1947	1.46	1.67
45-9327	Wilson Creek	WA	77	47.42	-119.12	1280	6/16/1948	1.06	1.19
45-5231	McNary Dam	WA	77	45.93	-119.28	361	10/1/1957	1.86	3.00
10-7188	Plummer 3 WSW	ID	7	47.30	-116.95	2920	6/17/1965	1.42	2.40
45-1400	Chief Joseph Dam	WA	77	47.98	-119.65	820	8/23/1965	1.02	1.36
45-1767	Coulee Dam	WA	77	47.95	-119.00	1700	11/12/1973	1.19	1.34
45-8348	Tekoa	WA	7	47.22	-117.08	2495	7/4/1978	1.30	2.00
45-6400	Pasco	WA	77	46.22	-119.10	350	9/13/1980	1.30	1.60
45-8931	Walla Walla WSO	WA	7	46.03	-118.33	949	10/13/1980	1.97	2.82
45-8348	Tekoa	WA	7	47.22	-117.08	2495	8/23/1989	1.40	1.60
45-7938	Spokane Intl AP	WA	7	47.62	-117.52	2353	7/25/1990	1.32	1.78
35-9213	Weston	OR	7	45.82	-118.42	1922	8/16/1993	2.20	2.80
45-1690	Connell 1 W	WA	77	46.65	-118.87	1020	5/15/1994	1.00	1.30

Table 16 - Catalog of Long-Duration Extreme Storms for Region 5 - Coastal Lowlands

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								24-HR	72-HR
45-1496	Clearwater	WA	5	47.58	-124.30	80	12/3/1943	8.41	10.87
45-8332	Tatoosh Island WB	WA	5	48.38	-124.73	100	10/23/1944	5.33	6.53
45-3333	Grays River Hatchery	WA	5	46.38	-123.57	100	1/14/1958	6.64	8.83
45-5549	Montesano 3 NW	WA	5	46.97	-123.62	25	11/18/1962	5.40	7.09
45-6858	Quillayute AP	WA	5	47.93	-124.55	179	1/18/1968	8.32	12.32
45-1496	Clearwater	WA	5	47.58	-124.30	80	1/25/1971	7.90	10.20
45-1496	Clearwater	WA	5	47.58	-124.30	80	7/11/1972	8.90	10.90
45-5549	Montesano 3 NW	WA	5	46.97	-123.62	25	2/27/1980	5.00	7.40
45-1496	Clearwater	WA	5	47.58	-124.30	80	2/13/1982	9.30	14.50
35-0328	Astoria AP Port	OR	5	46.15	-123.87	9	1/9/1990	5.14	6.33
45-9112	Westport 2 S	WA	5	46.87	-124.10	20	11/24/1990	5.40	6.90
45-5549	Montesano 1 S	WA	5	46.97	-123.62	25	12/10/1993	5.40	6.70
45-3333	Grays River Hatchery	WA	5	46.38	-123.57	100	12/27/1994	7.70	10.50

Table 17 - Catalog of Long-Duration Extreme Storms for Regions 32 and 31
Interior Lowlands Western Washington

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								24-HR	72-HR
45-7473	Seattle WB City	WA	31	47.45	-122.30	400	2/6/1945	3.00	3.55
45-0986	Burlington	WA	31	48.47	-122.32	30	10/24/1945	4.91	6.85
45-0986	Burlington	WA	31	48.47	-122.32	30	2/15/1949	3.42	3.79
45-0729	Blaine 1 ENE	WA	31	49.00	-122.75	60	11/3/1955	3.63	4.38
45-0324	Auburn	WA	31	47.32	-122.23	79	11/20/1959	3.63	4.77
45-6624	Port Angeles	WA	32	48.10	-123.42	90	1/14/1961	3.12	3.19
45-4769	Longview	WA	31	46.15	-122.92	12	11/19/1962	5.41	5.91
45-1191	Castle Rock 2 NW	WA	31	46.27	-122.92	39	11/23/1964	4.62	6.68
45-7773	Snoqualmie Falls	WA	31	47.53	-121.83	440	1/18/1967	4.72	5.94
45-7773	Snoqualmie Falls	WA	31	47.53	-121.83	440	3/5/1972	4.90	5.20
45-4769	Longview	WA	31	46.15	-122.92	12	12/2/1977	4.70	5.50
45-7473	Sea-Tac Airport	WA	31	47.45	-122.30	400	10/6/1981	3.71	4.33
45-7470	Seattle EMSU	WA	31	47.68	-122.25	60	1/18/1986	4.48	5.37
45-4769	Longview	WA	31	46.15	-122.92	12	2/23/1986	4.70	5.30
45-5224	Mc Millin Reservoir	WA	31	47.13	-122.27	579	11/24/1986	3.80	4.90
45-7773	Snoqualmie Falls	WA	31	47.53	-121.83	440	1/9/1990	4.90	6.70
45-0986	Burlington	WA	31	48.47	-122.32	30	11/9/1990	3.00	4.10
45-1277	Centralia 1 W	WA	31	46.70	-122.97	185	11/24/1990	5.10	5.80
35-2348	Dixie Mountain	OR	32	45.68	-122.92	1430	4/5/1991	4.00	6.10
35-6751	Portland Intl Airport	OR	32	45.58	-122.60	19	10/27/1994	4.44	5.10
45-1277	Centralia 1 W	WA	31	46.70	-122.97	185	2/8/1996	4.00	6.60
35-6751	Portland Intl Airport	OR	32	45.58	-122.60	19	11/19/1996	3.98	4.56
	Seattle RG03	WA	31				12/29/1996	2.83	4.43
45-5224	Mc Millin Reservoir	WA	31	47.13	-122.27	579	11/25/1998	3.60	4.30
	Seattle RG18	WA	31				10/20/2003	4.01	4.26
35-6751	Portland Intl Airport	OR	32	45.58	-122.60	19	11/6/2006	2.59	5.13
	Seattle RG12	WA	31				12/3/2007	5.61	7.56

Table 18 - Catalog of Long-Duration Extreme Storms for Regions 15, 151 and 142
Mountain Areas in Western Washington

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								24-HR	72-HR
45-6892	Rainier Carbon River	WA	15	47.00	-121.92	1735	11/17/1946	4.30	5.71
45-2493	Electron Headworks	WA	15	46.90	-122.03	1730	12/10/1946	4.77	7.69
45-1992	Darrington RS	WA	15	48.25	-121.60	550	11/26/1949	4.98	8.30
45-0013	Aberdeen 20 NNE	WA	151	47.27	-123.70	435	11/3/1955	8.39	11.76
45-6851	Quilcene Dam 5 SW	WA	142	47.78	-122.98	1028	1/17/1959	5.80	12.66
45-7709	Skykomish 1 ENE	WA	15	47.70	-121.37	1030	12/14/1959	7.70	9.86
45-6896	Rainier Ohanapecosh	WA	15	46.73	-121.57	1950	11/19/1962	7.78	9.70
45-6295	Palmer 3 ESE	WA	15	47.30	-121.85	920	1/28/1965	5.14	9.46
45-3160	Glacier RS	WA	15	48.88	-121.95	935	3/5/1972	4.90	5.10
45-8009	Stampede Pass	WA	15	47.28	-121.33	3958	12/1/1975	6.84	14.96
45-1457	Cinebar 2 E	WA	15	46.60	-122.48	1040	12/2/1977	6.80	8.60
45-3160	Glacier RS	WA	15	48.88	-121.95	935	12/14/1979	5.70	7.34
45-8715	Upper Baker Dam	WA	15	48.65	-121.68	690	11/21/1980	5.80	7.30
45-3357	Greenwater	WA	15	47.13	-121.63	1730	1/23/1982	5.30	6.90
45-6851	Quilcene Dam 5 SW	WA	142	47.78	-122.98	1028	10/22/1982	7.90	9.80
45-7657	Silverton	WA	15	48.07	-121.57	1475	12/3/1982	7.70	8.40
45-5876	Nooksack Salmon Hatchery	WA	15	48.90	-122.15	410	1/10/1983	6.30	9.60
45-3357	Greenwater	WA	15	47.13	-121.63	1730	1/24/1984	4.50	7.00
45-1992	Darrington RS	WA	15	48.25	-121.60	550	1/18/1986	6.60	9.20
45-2984	Frances	WA	142	46.55	-123.50	231	1/18/1986	5.20	7.80
45-4999	Marblemount RS	WA	15	48.53	-121.45	348	2/24/1986	6.20	8.50
45-5704	Mud Mountain Dam	WA	15	47.15	-121.93	1308	11/24/1986	4.20	5.10
45-2984	Frances	WA	142	46.55	-123.50	231	3/3/1987	6.20	9.10
45-1457	Cinebar 2 E	WA	15	46.60	-122.48	1040	1/9/1990	5.00	7.20
45-5876	Nooksack Salmon Hatchery	WA	15	48.90	-122.15	410	2/10/1990	6.70	9.80
45-4999	Marblemount RS	WA	15	48.53	-121.45	348	11/10/1990	6.20	9.50
45-6864	Quinault RS	WA	151	47.47	-123.85	220	11/10/1990	13.50	17.60
45-1233	Cedar Lake	WA	15	47.42	-121.73	1560	11/24/1990	6.40	9.10
35-3705	Haskins Dam	OR	142	45.30	-123.35	756	4/5/1991	5.60	9.00
45-1934	Cushman Dam	WA	142	47.42	-123.22	760	11/20/1994	8.20	14.90
35-1033	Brightwood 1 WNW	OR	15	45.38	-122.03	978	11/27/1994	7.50	8.80
45-7319	Sappho 8 E	WA	151	48.07	-124.12	760	11/8/1995	6.40	9.30
45-4764	Longmire Rainier NPS	WA	15	46.75	-121.82	2762	11/27/1995	6.40	10.60
45-2984	Frances	WA	142	46.55	-123.50	231	4/23/1996	6.20	7.70
35-0897	Bonneville Dam	OR	15	45.63	-121.95	62	11/19/1996	5.90	8.10
45-1934	Cushman Dam	WA	142	47.42	-123.22	760	3/19/1997	9.20	15.00
45-6851	Quilcene Dam 5 SW	WA	142	47.78	-122.98	1028	1/29/1999	7.40	9.80
45-8715	Upper Baker Dam	WA	15	48.65	-121.68	690	10/16/2003	6.80	8.70
45-8009	Stampede Pass	WA	15	47.28	-121.33	3958	11/6/2006	8.79	14.06
45-2984	Frances	WA	142	46.55	-123.50	231	11/6/2006	4.90	9.20
35-4824	Lees Camp	OR	151	45.58	-123.52	655	11/6/2006	13.70	23.40

Table 19 - Catalog of Long-Duration Extreme Storms for Region 14
East Face of Cascade Mountains

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								24-HR	72-HR
45-2157	Diablo Dam	WA	14	48.72	-121.15	891	10/24/1945	6.42	9.23
45-8688	Underwood 4 W	WA	14	45.73	-121.60	1260	12/11/1946	4.04	7.29
35-4003	Hood River Exp Stn	OR	14	45.68	-121.52	500	1/6/1948	3.26	4.48
45-2157	Diablo Dam	WA	14	48.72	-121.15	891	2/16/1949	7.80	9.71
45-2157	Diablo Dam	WA	14	48.72	-121.15	891	2/9/1951	6.47	12.99
45-1257	Centerville 2 SW	WA	14	45.73	-120.95	1650	1/9/1953	2.36	2.76
45-7342	Satus Pass 2 SSW	WA	14	45.95	-120.67	2610	11/24/1960	3.25	4.43
45-4849	Lucerne 2 NNW	WA	14	48.23	-120.60	1200	11/19/1962	3.05	3.43
45-5133	Mazama	WA	14	48.60	-120.43	2170	2/27/1972	3.80	6.00
45-7342	Satus Pass 2 SSW	WA	14	45.95	-120.67	2610	1/15/1974	3.60	5.20
45-4849	Lucerne 2 NNW	WA	14	48.23	-120.60	1200	12/2/1975	3.17	6.64
45-7342	Satus Pass 2 SSW	WA	14	45.95	-120.67	2610	12/13/1977	3.30	5.00
45-5133	Mazama	WA	14	48.60	-120.43	2170	1/12/1980	3.20	3.60
45-8059	Stehekin 4 NW	WA	14	48.35	-120.72	1270	1/23/1982	5.00	6.60
45-7342	Satus Pass 2 SSW	WA	14	45.95	-120.67	2610	12/10/1987	3.90	4.40
45-4446	Lake Wenatchee	WA	14	47.83	-120.78	2005	1/9/1990	5.30	7.60
45-2384	Easton	WA	14	47.23	-121.18	2170	11/24/1990	6.40	10.20
45-3183	Glenwood	WA	14	46.02	-121.28	1896	10/27/1994	3.80	4.20
45-2384	Easton	WA	14	47.23	-121.18	2170	2/8/1996	4.10	8.90
35-4008	Hood River Tucker Bridge	OR	14	45.65	-121.53	383	11/19/1996	4.70	6.60
45-7342	Satus Pass 2 SSW	WA	14	45.95	-120.67	2610	12/28/1998	4.10	4.60
45-5659	Mount Adams RS	WA	14	46.00	-121.53	1960	11/6/2006	3.90	7.50
45-6472	Peshastin Telemetering	WA	14	47.57	-120.62	1028	11/6/2006	3.20	4.90

Table 20 - Catalog of Long-Duration Extreme Storms for Transition Zone 147
Cascade Foothills in Eastern Washington

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								24-HR	72-HR
45-5327	Methow 2 S	WA	147	48.13	-120.02	1165	5/28/1948	2.02	2.32
45-6187	Oroville 1 S	WA	147	48.93	-119.43	932	11/16/1950	1.96	2.02
45-5731	Naches 10 NW	WA	147	46.87	-120.77	2280	1/14/1956	1.43	1.59
35-0265	Arlington	OR	147	45.72	-120.20	277	12/22/1964	2.18	4.51
45-2505	Ellensburg	WA	147	46.97	-120.53	1480	12/10/1987	1.80	1.80
35-0265	Arlington	OR	147	45.72	-120.20	277	4/21/1988	1.70	2.20
45-2505	Ellensburg	WA	147	46.97	-120.53	1480	11/18/1996	1.90	1.90

Table 21 - Catalog of Long-Duration Extreme Storms for Regions 77 and 7
Central Basin and Lowland Areas in Eastern Washington

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								24-HR	72-HR
45-4679	Lind 3 NE	WA	77	46.98	-118.57	1630	6/25/1942	1.53	1.77
45-7956	Sprague	WA	7	47.30	-117.98	1970	9/21/1945	1.55	2.33
45-6789	Pullman 2 NW	WA	7	46.75	-117.18	2545	9/15/1947	2.10	2.59
45-1767	Coulee Dam 1 SW	WA	77	47.95	-119.00	1700	5/28/1948	1.66	1.82
45-5231	McNary Dam	WA	77	45.93	-119.28	361	10/2/1957	3.15	3.20
45-8931	Walla Walla WSO	WA	7	46.03	-118.33	949	10/14/1980	3.08	3.62
45-1400	Chief Joseph Dam	WA	77	47.98	-119.65	820	9/19/1986	1.50	1.70
45-6982	Republic RS	WA	7	48.63	-118.73	2630	7/27/1988	2.00	2.00
45-2030	Dayton 1 WSW	WA	7	46.30	-118.00	1557	11/1/1994	2.20	2.40
45-9200	Whitman Mission	WA	7	46.03	-118.45	632	11/19/1996	2.00	2.40
45-6982	Republic RS	WA	7	48.63	-118.73	2630	5/27/1998	2.50	2.80
45-7938	Spokane Intl AP	WA	7	47.62	-117.52	2353	4/5/2000	1.53	1.73

Table 22 - Catalog of Long -Duration Extreme Storms for Region 13
Mountain Areas in Eastern Washington Eastward of Cascade Mountains

NOAA STATION ID	STATION NAME	STATE	REGION	LAT	LONG	ELEV (ft)	STORM DATE	PRECIPITATION (in)	
								24-HR	72-HR
35-8985	Walla Walla 13 ESE	OR	13	45.98	-118.05	2400	12/28/1945	3.95	4.71
10-1079	Bonners Ferry	ID	13	48.68	-116.32	1770	11/18/1946	2.78	4.11
45-2197	Dixie 4 SE	WA	13	46.08	-118.10	2250	11/23/1964	2.70	3.00
45-2037	Dayton 9 SE	WA	13	46.22	-117.85	2343	12/24/1964	3.01	4.55
45-2037	Dayton 9 SE	WA	13	46.22	-117.85	2343	1/2/1966	2.53	3.69
10-2845	Dworshak Fish Hatchery	ID	13	46.50	-116.32	995	12/1/1977	2.30	2.40
45-0849	Boundary Switchyard	WA	13	48.97	-117.35	2500	2/15/1986	3.10	3.20
35-4622	La Grande	OR	13	45.32	-118.07	2755	2/23/1986	2.00	2.80
45-5946	Northport	WA	13	48.90	-117.78	1350	6/13/1992	2.30	2.50
10-6586	Ola	ID	13	44.17	-116.27	3075	12/27/1996	3.10	5.00
45-1395	Chewelah	WA	13	48.27	-117.72	1670	5/26/1998	2.70	3.40
10-2845	Dworshak Fish Hatchery	ID	13	46.50	-116.32	995	11/25/1999	2.50	3.10
35-8985	Walla Walla 13 ESE	OR	13	45.98	-118.05	2400	10/1/2000	4.30	4.50

APPENDIX B
DIMENSIONLESS DEPTH-DURATION CURVES

OVERVIEW

This appendix contains listing of the ordinates of dimensionless depth-duration curves for use in developing short, intermediate and long-duration candidate design storms for large watersheds. See Section 4.3 for a discussion of the procedures for developing candidate design storms for large watersheds.

Table 23 – Listing of Ordinates of Dimensionless Depth-Duration Curves for Developing Short-Duration Candidate Design Storms for Large Watersheds

TIME (minutes)	CLIMATIC REGIONS		
	Western WA	14 – 147 – 13	77 – 7
0	0.000	0.000	0.000
5	0.224	0.272	0.302
10	0.364	0.436	0.532
15	0.499	0.565	0.649
20	0.567	0.626	0.730
25	0.630	0.687	0.807
30	0.685	0.739	0.875
45	0.831	0.837	0.993
60	0.924	0.902	1.000
75	0.957	0.970	1.000
90	0.972	1.000	1.000
105	0.986	1.000	1.000
120	1.000	1.000	1.000
180	1.139	1.091	1.035
240	1.193	1.111	1.040
300	1.255	1.125	1.055
360	1.256	1.180	1.085

Table 24 – Listing of Ordinates of Dimensionless Depth-Duration Curves
for Developing Intermediate-Duration Candidate Design Storms for Large Watersheds

TIME (hours)	CLIMATIC REGIONS					
	5	151 – 142 15 – 154	31 – 32	14	147 77 – 7	13
0.00	0.000	0.000	0.000	0.000	0.000	0.000
0.25	0.132	0.132	0.139	0.127	0.157	0.145
0.50	0.204	0.204	0.212	0.200	0.240	0.228
0.75	0.268	0.268	0.273	0.266	0.320	0.306
1.00	0.324	0.324	0.330	0.327	0.402	0.381
1.50	0.420	0.420	0.428	0.420	0.502	0.504
2.00	0.508	0.508	0.520	0.498	0.560	0.596
3.00	0.671	0.671	0.704	0.672	0.717	0.730
4.00	0.787	0.787	0.818	0.830	0.852	0.861
5.00	0.917	0.917	0.939	0.940	0.926	0.946
6.00	1.000	1.000	1.000	1.000	1.000	1.000
9.00	1.291	1.314	1.291	1.324	1.287	1.295
12.00	1.507	1.501	1.507	1.571	1.435	1.485
15.00	1.597	1.671	1.597	1.686	1.500	1.540
18.00	1.667	1.854	1.667	1.883	1.520	1.595

Table 25 – Listing of Ordinates of Dimensionless Depth-Duration Curves
for Developing Long-Duration Candidate Design Storms for Large Watersheds

TIME (hours)	CLIMATIC REGIONS					
	5	151 – 142 15 – 154	31 – 32	14	147 77 – 7	13
0.00	0.000	0.000	0.000	0.000	0.000	0.000
0.25	0.043	0.037	0.047	0.052	0.067	0.071
0.50	0.070	0.058	0.071	0.084	0.100	0.112
0.75	0.090	0.078	0.094	0.114	0.127	0.143
1.00	0.107	0.096	0.117	0.139	0.149	0.167
1.50	0.139	0.130	0.158	0.178	0.199	0.208
2.00	0.170	0.163	0.194	0.209	0.248	0.245
3.00	0.235	0.229	0.262	0.274	0.310	0.325
4.00	0.299	0.290	0.320	0.337	0.374	0.405
5.00	0.362	0.336	0.373	0.402	0.440	0.448
6.00	0.414	0.385	0.429	0.455	0.505	0.490
9.00	0.558	0.521	0.578	0.564	0.649	0.650
12.00	0.702	0.667	0.713	0.706	0.777	0.776
18.00	0.870	0.873	0.901	0.888	0.974	0.915
24.00	1.000	1.000	1.000	1.000	1.000	1.000
30.00	1.117	1.155	1.100	1.170	1.076	1.124
36.00	1.203	1.281	1.149	1.280	1.112	1.234
42.00	1.275	1.347	1.197	1.380	1.149	1.278
48.00	1.342	1.403	1.247	1.460	1.149	1.326
54.00	1.379	1.469	1.292	1.520	1.154	1.369
60.00	1.425	1.501	1.349	1.580	1.239	1.378
66.00	1.457	1.556	1.363	1.634	1.256	1.412
72.00	1.480	1.630	1.390	1.678	1.256	1.464

REGIONAL PRECIPITATION-FREQUENCY ANALYSIS AND SPATIAL MAPPING OF PRECIPITATION FOR 24-HOUR AND 2-HOUR DURATIONS IN WESTERN WASHINGTON

WA-RD 544.1

March 2002

Washington State Department of Transportation

Washington State Transportation Commission
Planning and Capital Program Management

REGIONAL PRECIPITATION-FREQUENCY ANALYSIS AND SPATIAL MAPPING OF PRECIPITATION FOR 24-HOUR AND 2-HOUR DURATIONS IN WESTERN WASHINGTON

Prepared for:

Washington State Department of Transportation

By:

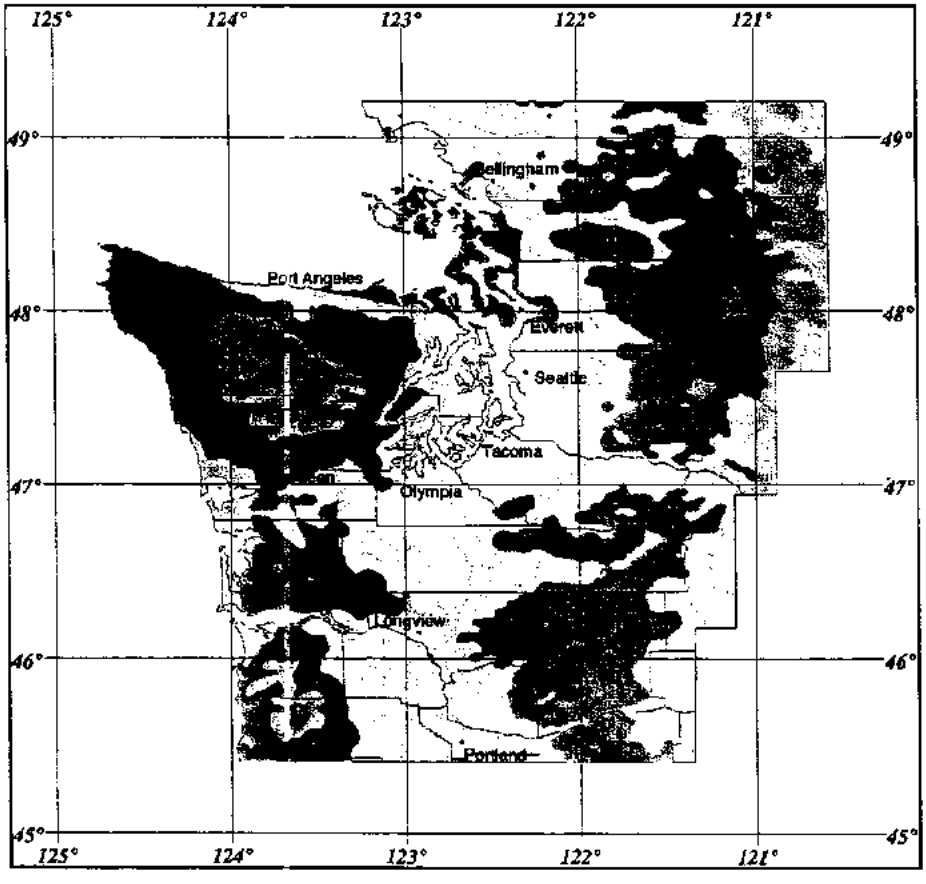
MG Schaefer Ph.D. P.E. MGS Engineering Consultants
BL Barker P.E. MGS Engineering Consultants
GH Taylor CCM Oregon Climate Service
JR Wallis Ph.D. Yale University

March 2002

MGS Engineering Consultants, Inc. Oregon Climate Service

WA STATE DOT LIBRARY
3 3166 0003 6523 9

REGIONAL PRECIPITATION-FREQUENCY ANALYSIS AND SPATIAL MAPPING OF PRECIPITATION FOR 24-HOUR AND 2-HOUR DURATIONS IN WESTERN WASHINGTON



10-Year 24-Hour Precipitation

Washington State Department of Transportation

March 2002

MGS Engineering Consultants, Inc.

Oregon Climate Service

REGIONAL PRECIPITATION-FREQUENCY ANALYSIS AND SPATIAL MAPPING OF PRECIPITATION FOR 24-HOUR AND 2-HOUR DURATIONS IN WESTERN WASHINGTON

EXECUTIVE SUMMARY

Regional frequency analyses were conducted for precipitation annual maxima in western Washington for durations of 24-hours and 2-hours. A total of 430 precipitation gages in Washington, southern British Columbia and northern Oregon were included in the study representing 15,124 and 4,797 station-years of record for the 24-hour and 2-hour durations, respectively. A regional analysis methodology was utilized that pools data from climatologically similar areas to increase the dataset and improve the reliability of precipitation-frequency estimates. The regional analysis methodology included L-moment statistics, and an index-flood type approach for scaling the annual maxima data. L-moment statistics were used to: characterize the variability, skewness and kurtosis of the data; measure heterogeneity in proposed homogeneous sub-regions; and assist in identification of an appropriate regional probability distribution.

It was found that the study area could be described by seven climatic regions. These seven climatic regions were geographic areas that had similar topographic and climatological characteristics and were subjected to similar meteorological conditions during storm events. This included three coastal regions, two interior lowland regions and two Cascade Mountain regions. In particular, the need was recognized to distinguish between windward and leeward areas in both mountain and lowland areas. Separate regional analyses were conducted for each of the seven climatic regions for each of the two durations. Within each climatic region, precipitation gages were assigned to groups where the gage sites had similar magnitudes of mean annual precipitation. A total of 32 sub-regions were formed by this process and were found to be acceptably homogeneous. Predictor equations were then developed to describe the variability of the L-moment ratios, L-Cv and L-Skewness, between the sub-regions and within and/or across climatic region boundaries. The sub-region L-moment ratio plots for L-Skewness and L-Kurtosis revealed the data to be near or slightly more kurtotic than the Generalized Extreme Value distribution. The four-parameter Kappa distribution was chosen to describe the regional magnitude-frequency relationship for both the 24-hour and 2-hour durations.

Spatial mapping techniques were employed for mapping of the precipitation-frequency information. This included spatial mapping of at-site means, L-moment ratio values of L-Cv and L-Skewness, and mapping of precipitation for selected recurrence intervals at both the 24-hour and 2-hour durations. Procedures were employed to minimize differences between mapped values and observed station values in a manner that was consistent with the regional behavior of the data and also recognized uncertainties due to natural sampling variability.

Color-shaded isopluvial maps were developed for the 2-year, 10-year, 25-year, 50-year, and 100-year precipitation at both the 24-hour and 2-hour durations. An isopluvial map was also developed for 6-month, 24-hour precipitation, which is useful for water-quality treatment design applications. Electronic gridded datasets were provided for WSDOT use in creation of GIS applications that utilize precipitation-frequency information.

A catalog of extreme storms was assembled that lists precipitation events in western Washington that exceeded a 20-year return period. The information from the storm catalog was used to conduct seasonality analyses. The seasonality analyses were used to identify the frequency of occurrence of extreme storms by month. In particular, the seasonality analyses identified those months that were the most likely and least likely for an extreme event to occur. This information is useful in rainfall-runoff modeling and can be used by WSDOT staff in conducting hydrologic analyses throughout western Washington.

TABLE OF CONTENTS

SUBJECT	*PAGE*
OVERVIEW	1
STUDY AREA	1
CLIMATIC AND METEOROLOGIC CHARACTERISTICS OF STUDY AREA	3
Annual Precipitation	3
Weather Systems and Sources of Atmospheric Moisture	3
DATA SOURCES	3
Precipitation Gage Types, Methods of Measurement and Reporting	4
Number of Gages and Gage Types	4
DATA SCREENING AND QUALITY CHECKING	7
Stationarity and Serial Independence	7
REGIONAL ANALYSIS METHODOLOGY	7
Description of Climatic/Geographic Regions	8
Regional Growth Curve	10
FORMING HOMOGENEOUS SUB-REGIONS	10
Heterogeneity Measures of Proposed Homogeneous Sub-Regions	11
Acceptance of Proposed Homogeneous Sub-Regions	11
Systematic Variation of L-Cv and L-Skewness with Mean Annual Precipitation	12
ANALYSES OF 24-HOUR DURATION ANNUAL MAXIMA	13
Regional Solutions for L-Moment Ratios, L-Cv and L-Skewness	13
Heterogeneity Measures, 24-Hour Duration	17
Identification of Regional Probability Distribution, 24-Hour Duration	18

TABLE OF CONTENTS

ANALYSES OF 2-HOUR DURATION ANNUAL MAXIMA 19

Regional Solutions for L-Moment Ratios, L-Cv and L-Skewness 20

Heterogeneity Measures, 2-Hour Duration 22

Identification of Regional Probability Distribution, 2-Hour Duration 22

PRECIPITATION MAGNITUDE-FREQUENCY ESTIMATES FOR GAGED SITES 23

SPATIAL MAPPING OF PRECIPITATION-FREQUENCY INFORMATION 26

Mean Annual Precipitation 26

SPATIAL MAPPING OF AT-SITE MEANS 26

Quantitative Assessment of Success Achieved in Spatial Mapping of At-Site Means 29

SPATIAL MAPPING OF REGIONAL L-MOMENT STATISTICAL PARAMETERS 30

PRODUCTION OF ISOPLUVIAL MAPS 30

Precipitation Magnitude-Frequency Estimates for Moderate to Large Size Watersheds 31

Uncertainty Bounds for 100-Year Values 31

ELECTRONIC FILES
LISTING AT-SITE AND REGIONAL PARAMETERS FOR ALL GAGED SITES 33

SEASONALITY OF EXTREME STORMS 33

CATALOG OF EXTREME STORMS 35

REFERENCES 36

APPENDIX A - STATION CATALOGS
AND ELECTRONIC FILES OF PROJECT DELIVERABLES A-1

APPENDIX B - ISOPLUVIAL MAPS FOR SELECTED RECURRENCE INTERVALS B-1

APPENDIX C - SEASONALITY OF 24-HOUR AND 2-HOUR EXTREME STORMS C-1

APPENDIX D - CATALOGS OF EXTREME STORMS
FOR 24-HOUR AND 2-HOUR DURATIONS D-1

APPENDIX E - L-MOMENT STATISTICS E-1

APPENDIX F - SELECTED DEFINITIONS F-1

REGIONAL PRECIPITATION-FREQUENCY ANALYSIS AND SPATIAL MAPPING OF PRECIPITATION FOR 24-HOUR AND 2-HOUR DURATIONS IN WESTERN WASHINGTON

March 2002

OVERVIEW

This report documents the findings of regional precipitation-frequency analyses of 24-hour and 2-hour precipitation annual maxima for western Washington. It also describes the procedures used for spatial mapping of the precipitation-frequency estimates for selected recurrence intervals.

This study is an update of the information contained in the precipitation-frequency atlas published by the National Weather Service in 1973 (NOAA Atlas 2[16]). Data collection for the NWS study ended in 1966, and this study includes the 34-years of record collected since 1966. These additional data provide a precipitation database with more than double the record length than was available in the original NWS study.

Since the original study, major advances have been made in the methods for statistical analysis of precipitation annual maxima, and for spatial mapping of precipitation in complex terrain. Specifically, L-Moment statistical analysis techniques[7,9] conducted within a regional framework have greatly improved the reliability of precipitation magnitude-frequency estimates, particularly for rare storm events. Development of the PRISM model[3] incorporating digital terrain data has also improved the spatial mapping of precipitation and increased the reliability of estimating precipitation in the broad areas between precipitation measurement stations. These methodologies are particularly effective in areas with high topographic and climatic variability such as in western Washington, where mean annual precipitation varies from less than 20-inches to over 200-inches. Both of these methodologies have been utilized in conducting the precipitation-frequency analyses and in developing the isopluvial maps for selected recurrence intervals.

STUDY AREA

While western Washington is the area of interest, the study area was expanded to provide additional data in border areas. Accordingly, the study area included areas in southwestern British Columbia, northwestern Oregon, and areas in the Cascade Mountains in eastern Washington (Figure 1). Specifically, the study area is bounded on the North at latitude 49° 30′ N, bounded to the south by latitude 45° 00′ N, and bounded to the east by the contour line of 20-inches mean annual precipitation, approximately longitude 120°00′ W. Addition of precipitation stations in the boundary areas also provided data from areas climatologically similar to data-sparse areas in Washington such as the windward and leeward faces of the Olympic Mountains, Willapa Hills, and the Cascade Mountains.

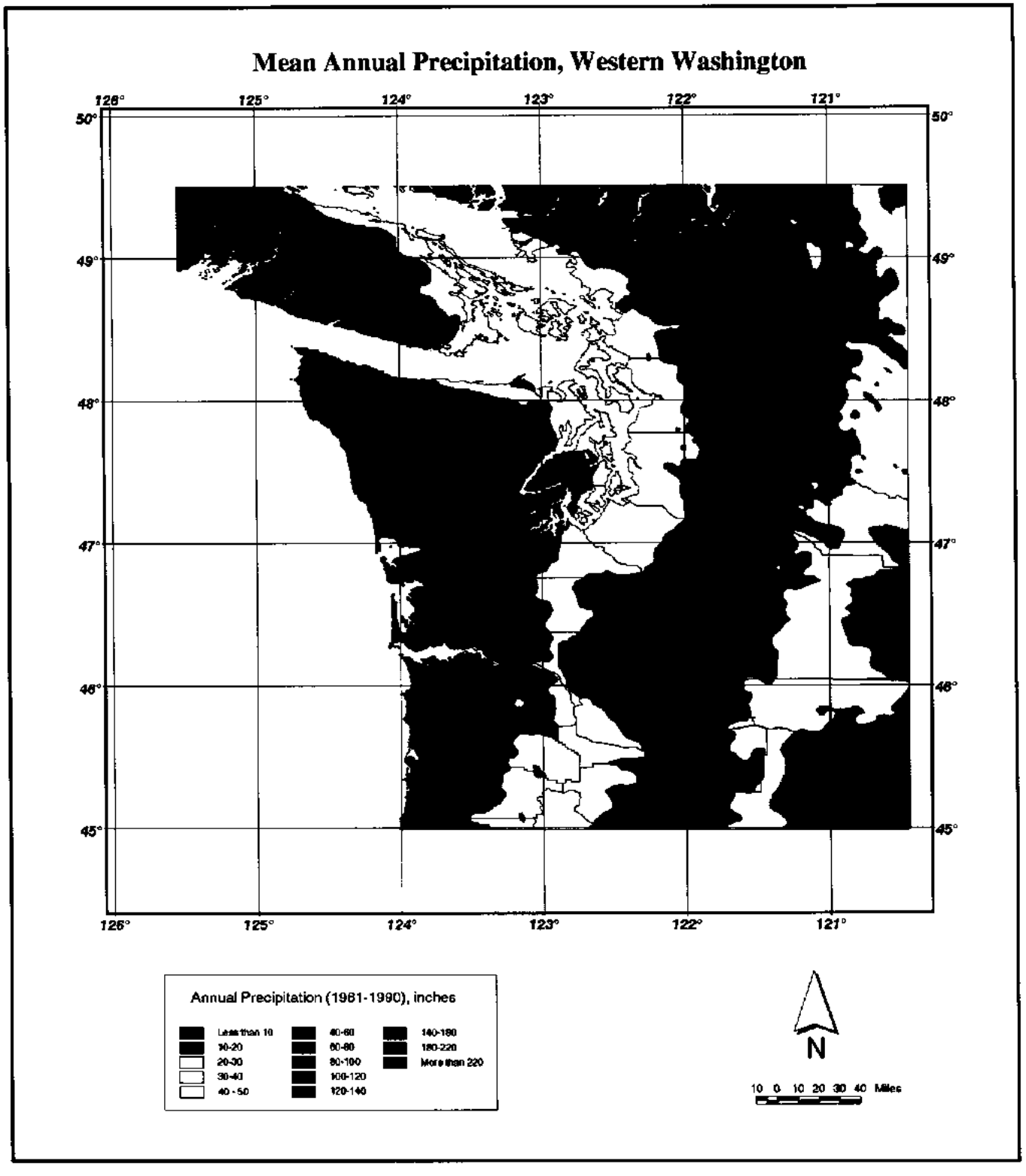


Figure 1 – Mean Annual Precipitation[20,21] for Western Washington Study Area

CLIMATIC AND METEOROLOGIC CHARACTERISTICS OF STUDY AREA

Annual Precipitation

Mean annual precipitation within the study area varies dramatically from the coast to the eastern slopes of the Cascade Mountains (Figure 1). Mean Annual Precipitation[20] (MAP) ranges from a high of over 240-inches in the Olympic Mountains, to a low near 18-inches in the Olympic rain shadow area near Sequim, and to 20-inches in the foothills of the Cascades in eastern Washington.

Weather Systems and Sources of Atmospheric Moisture

In general, two ingredients are needed for precipitation to occur, a source of atmospheric moisture and a meteorological mechanism to release that moisture. There is also a greater potential for extreme precipitation events when the source of moisture originates in areas with warmer temperatures and higher dewpoints. There are three generalized geographic areas that are sources of atmospheric moisture to the study area and have differing characteristic temperatures and dewpoints. These source areas include: the Gulf of Alaska; the Pacific Ocean north of the Canadian border; and the Pacific Ocean from as far south as latitude 20°N near the Hawaiian Islands.

Storm systems[16,18,19] moving in a southeasterly direction out of the Gulf of Alaska primarily affect northern portions of the study area and generally contain cooler temperatures and dewpoints. Storm systems originating over the Pacific Ocean are the most common and those that originate from southerly latitudes near the Hawaiian Islands have been responsible for many of the largest long-duration precipitation events experienced in the winter months. Synoptic-scale cyclonic weather systems and associated fronts generally provide the mechanism for producing precipitation annual maxima at the 24-hour and longer durations. Precipitation is enhanced in mountain areas as atmospheric moisture is lifted over the Olympic, Coastal and Cascade Mountains. This orographic component of precipitation has the greatest effect at 24-hour and longer time scales, and can significantly enhance the total accumulation of precipitation over several days. Precipitation annual maxima at the 24-hour duration occur predominately in the fall and winter seasons in western Washington.

Precipitation annual maxima at the 2-hour duration may occur as a result of several different storm mechanisms. They may occur due to low-to-moderate convective activity associated with a large-scale synoptic weather system in the fall or winter season. In this case, the 2-hour annual maxima are embedded within a much longer duration storm event. They may also occur due to more intense convective activity that may, or may not, be associated with an organized weather system. In this latter case, the 2-hour annual maxima are often associated with "thunderstorms" in the spring and summer, which are short-duration localized storm events with limited areal coverage.

DATA SOURCES

A precipitation annual maximum is the greatest precipitation amount in a 12-month period for a specified duration at a given measurement site. The water-year, October 1st to September 30th is the 12-month period used for determining precipitation annual maxima for the 24-hour and 2-hour durations for these analyses.

Precipitation annual maxima and associated storm dates were obtained from precipitation records from a variety of sources. The majority of the data were obtained from the electronic files of the National Climatic Data Center (NCDC). Data for southwestern British Columbia were obtained from the Canadian Atmospheric Environment Services Agency (AES). Data from Snotel gages in mountains areas were obtained from electronic files from the Natural Resources Conservation Service (NRCS). Several counties in Washington also provided data for urban areas, including: King, Kitsap, Snohomish, Thurston and Clark Counties.

Precipitation Gage Types, Methods of Measurement and Reporting

Precipitation is measured by a variety of devices and reported by a number of different agencies in the United States and Canada. Descriptions of the gage types and reporting methods are summarized below.

Daily Gages – Daily gages in US and Canada are standardized devices comprised of simple vertical cylinders open to the atmosphere. A variety of shields for protection from the wind are used in both countries, with shields being more common now than in the past. Precipitation is measured once each day at a specified time and represents the precipitation for the previous 24-hours.

Automated Gages – Automated gages such as weighing buckets, Fisher-Porter tipping buckets, and other types of tipping buckets can provide information about precipitation intensity on various time scales. The standards in both the US and Canada are for reporting on either hourly or 15-minute intervals. Weighing bucket gages with paper strip charts came on-line around 1940-1945 in the US and many were installed in Canada in the 1950's and 1960's. Tipping bucket gages and automated reporting systems were installed at many sites beginning in the 1970's. These gages are often given the generic term hourly gages to distinguish them from daily gages.

Snotel Gages – Snotel gages are a type of automated gage commonly used in mountain areas. They have external heating systems and are designed for cold weather operation. Precipitation that falls as snow is converted to liquid water for measurement. Snotel gages typically report precipitation on a daily basis on a midnight-to-midnight reporting schedule.

Number of Gages and Gage Types

The number of gages and gage types used in the regional analyses are summarized in Tables 1a,b. Both daily and hourly precipitation gages are co-located at many NCDC sites in the US. This occurred at 61 stations in Washington and Oregon. To avoid duplication, the record from the gage with the longest record was utilized in the analyses for the 24-hour duration. When both the daily and hourly records were of similar length, the record from the hourly gage was selected. The precipitation station networks are shown in Figures 2a,b for the 24-hour and 2-hour durations, respectively.

Table 1a – Number and Type of Gages Utilized for Analyses of 24-Hour Annual Maxima

STATION LOCATION	DAILY GAGE	HOURLY GAGE	SNOTEL GAGE
British Columbia	56	6	0
Washington	146	78	44
Oregon	44	31	11
Municipal Gages	14	0	0
TOTAL	**260**	**115**	**55**

61 NCDC stations have co-located daily and hourly gages

Table 1b – Number and Type of Gages Utilized for Analyses of 2-Hour Annual Maxima

STATION LOCATION	DAILY GAGE	HOURLY GAGE	SNOTEL GAGE
British Columbia	0	24	0
Washington	0	78	0
Oregon	0	31	0
Municipal Gages	0	3	0
TOTAL	**0**	**146**	**0**

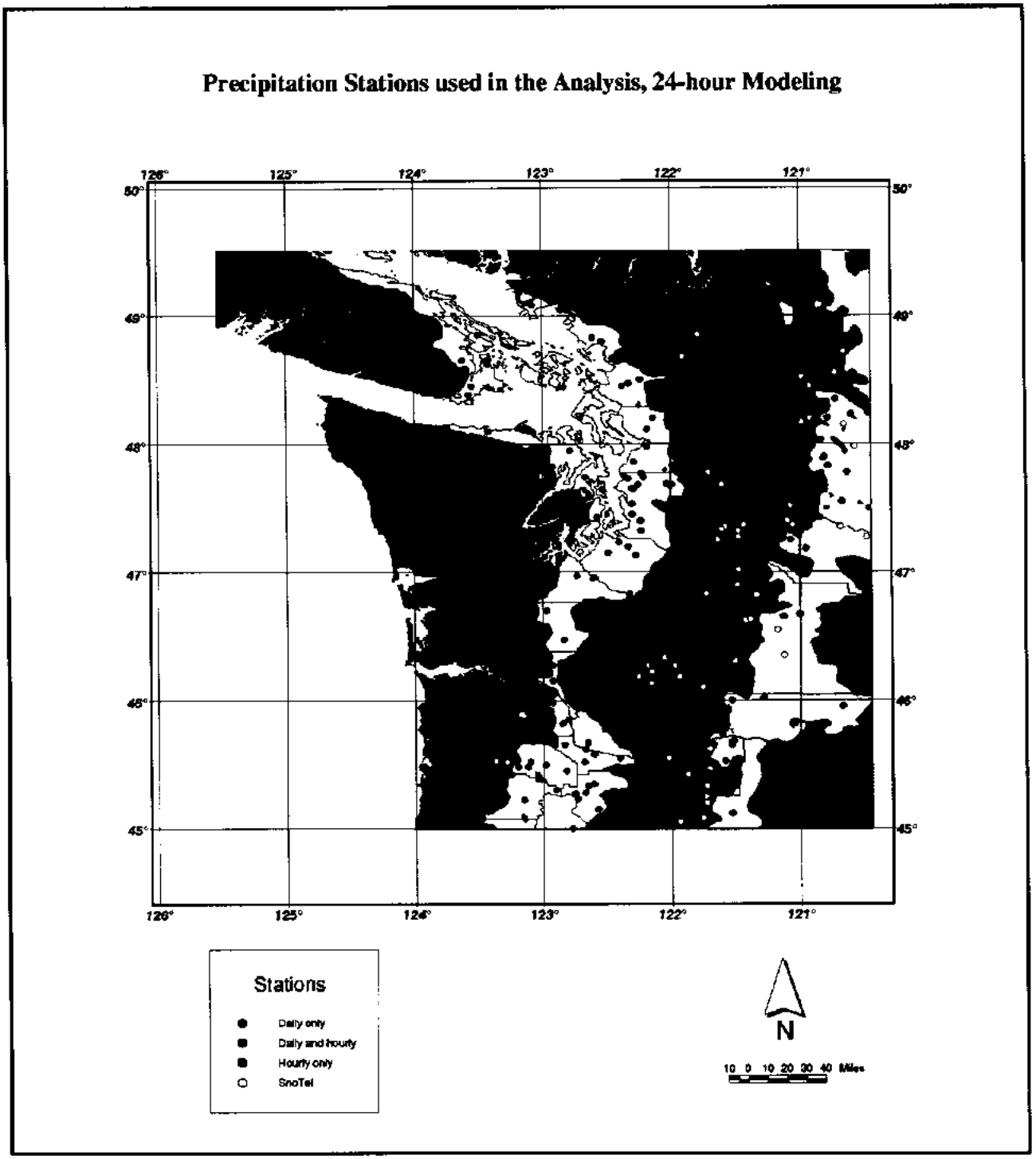


Figure 2a – Precipitation Gaging Network for Analysis of 24-Hour Annual Maxima

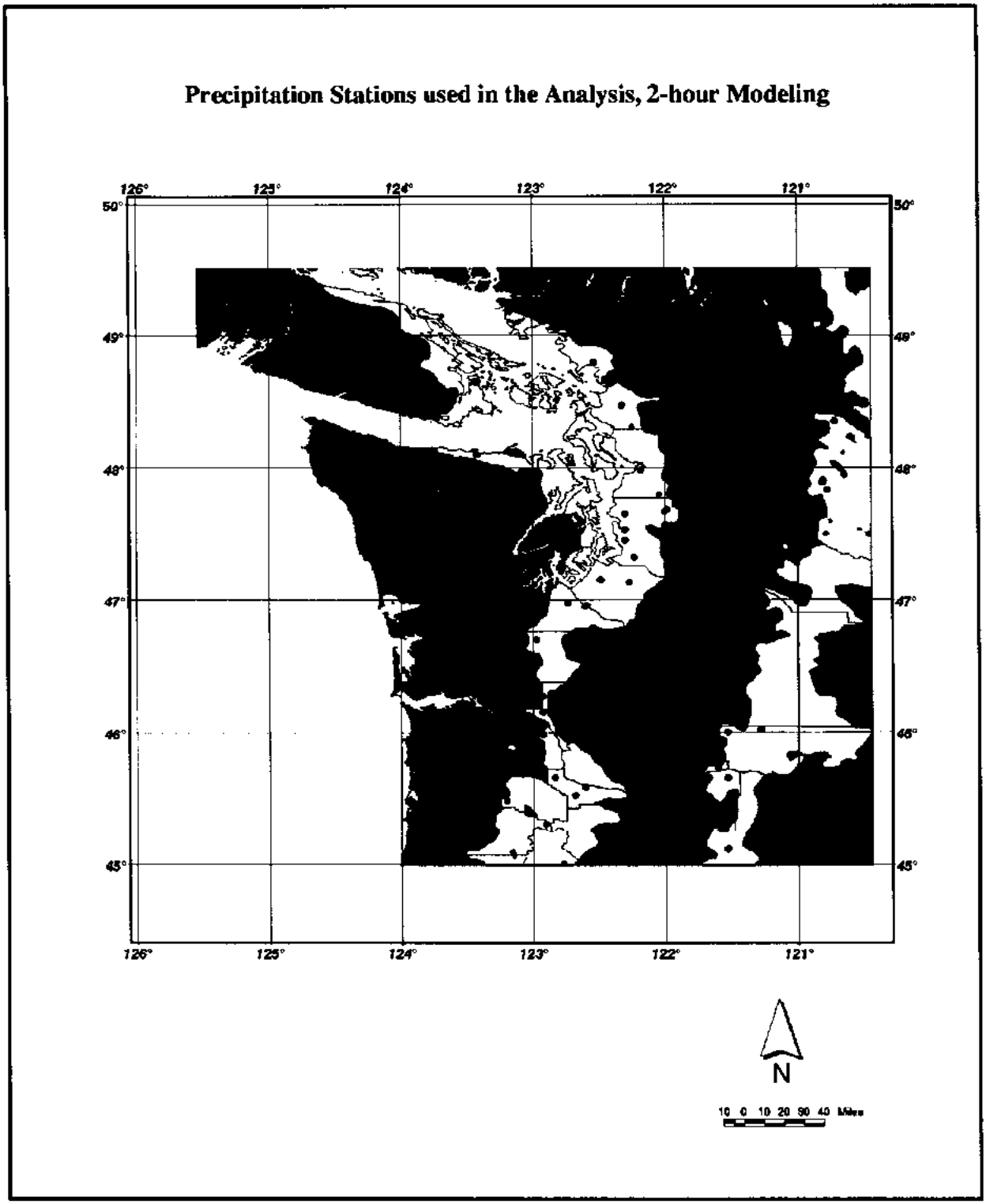


Figure 2b – Precipitation Gaging Network for Analysis of 2-Hour Annual Maxima

DATA SCREENING AND QUALITY CHECKING

Extensive efforts were made in screening and quality checking the annual maxima data. Quality checking was needed to eliminate false annual maxima associated with a variety of data measurement, reporting, and transcription errors, particularly incomplete reporting during some years. The record for all sites and climatic-years was checked for completeness. In addition, all records were scanned for anomalously small or large precipitation amounts and the Hosking and Wallis[9,10] measure of discordancy [9,10] was also used to identify gages whose sample statistics were markedly different from the majority of gages in a given region. Suspicious gages and data were checked to verify the validity of records. Nearby sites were also checked to corroborate the magnitude and date of occurrence of any anomalously small or large precipitation annual maxima. Data that were clearly erroneous were removed from the datasets.

Stationarity and Serial Independence

Two underlying assumptions inherent in frequency analyses are the data are stationary over the period of observation and prediction, and the data at a given site (gage) are serially independent. As part of the data screening process, standard statistical tests for stationarity and serial independence were conducted. Inter-station correlation analyses were also conducted to assess the relative amount of correlation between annual maxima data at nearby gages.

To meet the stationarity criterion, the data must be free from trends during the period of observation. For each duration, this was confirmed by standard linear regression techniques where the station data were first rescaled by division by the at-site mean and then regressed against the year of occurrence minus 1900. This approach allowed comparisons to be made among all gages and to interpret the relative magnitude of any trend over the past century. The average values of the slope parameter were +0.20%, and +0.15% for the 24-hour, and 2-hour durations, respectively. The regression results for the collective group of gages were tested against a null hypothesis of zero slope (stationarity). The null hypothesis could not be rejected at the 5% level and the data at both durations were accepted as stationary.

To confirm independence of the annual maxima data, serial correlation coefficients were computed for the data at each gage for each duration. The regression results for the collective group of gages at each duration were tested against a null hypothesis of zero serial correlation (independence). The null hypothesis could not be rejected at the 5% level. As expected, the annual maxima data were found to be serially independent.

REGIONAL FREQUENCY ANALYSIS METHODOLOGY

The cornerstone of a regional frequency analysis is that data from sites within a homogeneous region can be pooled to improve the reliability of the magnitude-frequency estimates for all sites. A homogeneous region may be a geographic area delineated on a map or it may be a collection of sites having similar characteristics pertinent to the phenomenon being investigated.

Early in the study it was recognized that the climatic and topographic diversity in the study area would likely preclude the use of large geographic areas that would meet statistical criteria for homogeneity. It was decided to employ climatic/geographic regions that had basic similarities in the climatic and topographic setting. It was anticipated that these regions might require further sub-division to meet homogeneity criteria for use in regional frequency analysis.

Description of Climatic/Geographic Regions

Identification of climatologically similar regions meant delineating geographic areas that had similar climatological and topographical characteristics. To assist in this effort, a literature review was conducted to examine region designations utilized in prior studies. This included a review of NOAA Atlas 2[16], studies of extreme precipitation in the Pacific Northwest (NWS[18,19]), and prior regional frequency analyses conducted in coastal mountain areas (Schaefer[23,25,26]).

Based on information in those studies and the spatial characteristics of mean annual precipitation, seven climatic/geographic regions were identified (Figure 3). In particular, the map of mean annual precipitation (Figure 1) developed by Daly using the PRISM[3] model provided the basic mapping information for delineating the boundaries of the climatic regions. This map is based on the 1961-1990 time period, which is the most recent NOAA 30-year decadal-based climate tracking period. The magnitude and gradient of mean annual precipitation were the primary measures used to define the boundaries between the regions. Those regions include:

Coastal Lowlands (Region 5) – The lowlands along the west coast of Washington, Oregon and Vancouver Island that are open to the Pacific Ocean. The eastern boundary is either a generalized contour line of 1,000 feet elevation, or the ridgeline of mean annual precipitation that separates the coastal lowlands from the interior lowlands, such as within the Aberdeen-Montesano gap.

Coastal Mountains West (Region 151) – The windward faces of the Olympic Mountains, Willapa Hills, Black Hills, Coastal Mountains in Oregon, and Vancouver Island Mountains in British Columbia above a generalized contour line of 1,000 feet elevation. These areas are bounded to the west by the 1,000 feet contour line, and bounded to the east by the ridgeline of mean annual precipitation near the crestline of the mountain barrier.

Coastal Mountains East (Region 142) – The leeward faces of the Olympic Mountains, Willapa Hills, Black Hills, Coastal Mountains in Oregon, and Vancouver Island Mountains in British Columbia above a generalized contour line of 1,000 feet elevation. These areas are bounded to the west by the ridgeline of mean annual precipitation near the crestline of the mountain barrier, and bounded to the east by the 1,000 feet contour line.

Interior Lowlands West (Region 32) – The interior lowlands below a generalized contour line of 1,000 feet elevation bounded to the east by the trough-line of mean annual precipitation through the Strait of Juan De Fuca, Puget Sound Lowlands and Willamette Valley. This is a zone of low orography where mean annual precipitation generally decreases from west to east.

Interior Lowlands East (Region 31) – The interior lowlands below a generalized contour line of 1,000 feet elevation bounded to the west by the trough-line of mean annual precipitation through the Strait of Juan De Fuca, Puget Sound Lowlands and Willamette Valley. This is a zone of low orography where mean annual precipitation generally increases from west to east.

Cascade Mountains West (Region 15) – The windward face of the Cascade Mountains in Washington, Oregon, and British Columbia above a generalized contour line of 1,000 feet elevation. This region is bounded to the east by the ridgeline of mean annual precipitation near the Cascade crest.

Cascade Mountains East (Region 14) – The leeward face of the Cascade Mountains in Washington, Oregon, and British Columbia above the 20-inch isopluvial of mean annual precipitation. This region is bounded to the west by the ridgeline of mean annual precipitation near the Cascade crest.

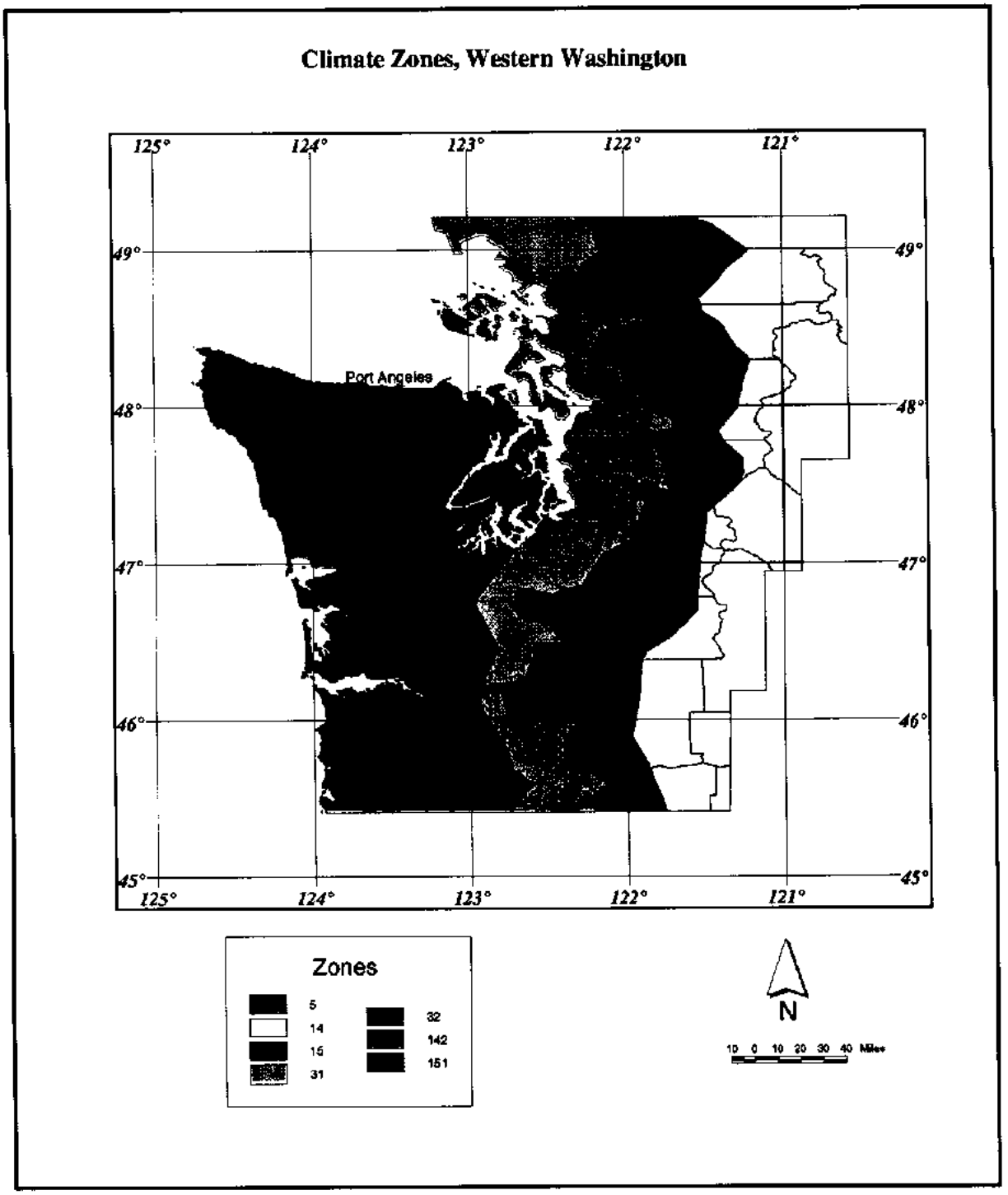


Figure 3 – Delineation of Climatic Regions for Western Washington Study Area

REGIONAL GROWTH CURVE

Implicit in the definition of a homogeneous region is the condition that all sites can be described by one probability distribution having common distribution parameters after the site data are rescaled by their at-site mean. Thus, all sites have a common regional magnitude-frequency curve (regional growth curve, Figure 4) that becomes site-specific after scaling by the at-site mean of the data from the specific site of interest. Thus,

$$Q_i(F) = \hat{\mu}_i \; q(F) \qquad (1)$$

where $Q_i(F)$ is the at-site inverse Cumulative Distribution Function (CDF), $\hat{\mu}_i$ is the estimate of the population at-site mean, and $q(F)$ is the regional growth curve, regional inverse CDF. This is often called an index-flood approach to regional frequency analyses and was first proposed by Dalrymple[2] and expanded by Wallis[30,31].

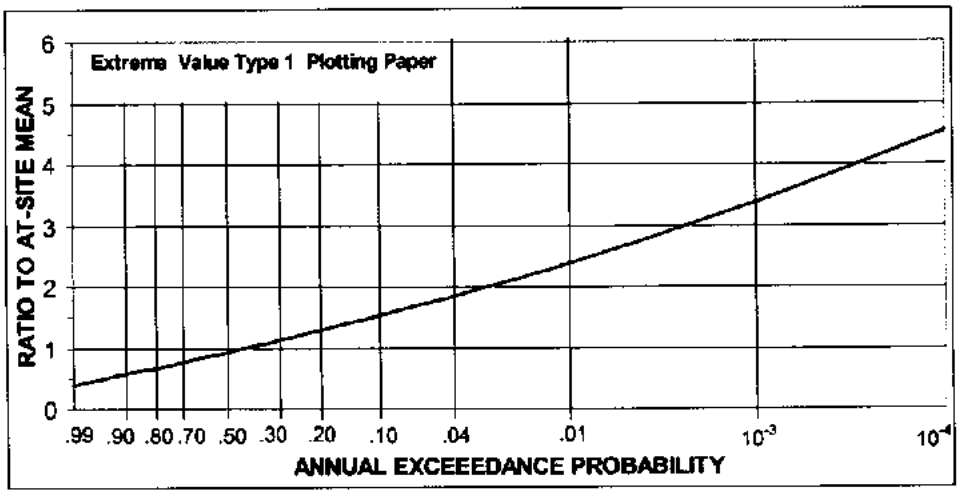


Figure 4 – Example of Regional Growth Curve

FORMING HOMOGENEOUS SUB-REGIONS

It was anticipated that the climatic regions defined here would require sub-division to meet homogeneity criteria. The methodology used herein for forming and testing proposed homogeneous sub-regions follows the procedures recommended by Hosking and Wallis[9,10].

The basic approach is to propose homogeneous sub-regions (grouping of sites/gages) based on the similarity of the physical/meteorological characteristics of the sites. L-moments (Hosking[7,9], Appendix E) are then used to estimate the variability and skewness of the pooled regional data and to test for heterogeneity as a basis for accepting or rejecting the proposed sub-region formulation.

In general, proposed homogeneous sub-regions can be formed by utilizing some measure(s) of physical and/or climatological characteristics for assigning sites/gages to sub-regions. Candidates for physical features[16,18,19] include such measures as: site elevation; elevation averaged over some grid size; localized topographic slope; macro topographic slope averaged over some grid size; distance from the coast or source of moisture; distance to sheltering mountains or ridgelines; and latitude or longitude. Candidate climatological characteristics include such measures as: mean annual precipitation; precipitation during a given season; seasonality of extreme storms; and seasonal temperature/dewpoint indices.

A review of the topographic and climatological characteristics in each region shows that the seven climatic regions already had similarities regarding several of the physical and climatological measures listed above. As such, only one additional measure, mean annual precipitation (MAP) was needed for grouping of sites/gages into homogeneous sub-regions within a given climatic region. Homogeneous sub-regions were therefore formed with gages/sites within a small range of MAP.

Heterogeneity Measures of Proposed Homogeneous Sub-Regions

Heterogeneity measures have been developed by Hosking and Wallis[9,10] as indicators of the amount of heterogeneity in the L-moment ratios for a collection of sites/gages. The statistics H1 and H2 measure the relative variability of observed L-Cv and L-Skewness sample statistics, respectively, for gages/sites in a sub-region. Specifically, these measures compare the observed variability to that expected from a large sample drawn from a homogeneous region from the Kappa distribution[12] having weighted average L-moment ratios that were observed in the sub-region. Initial recommendations from Hosking and Wallis[9,10] were that regions with H1 and H2 values less than 1.00 were acceptably homogeneous. Values of H1 and H2 between 1.00 and 2.00 were possibly heterogeneous. Values greater than 2.00 indicated definite heterogeneity and that redefinition of the region and/or reassignment of sites/gages should be considered.

These heterogeneity criteria measure statistical heterogeneity from known distributions and do not account for variability that arises from other sources. Most cooperative precipitation measurement networks include gages operated by various organizations and individuals that provide a varied level of quality control. Therefore, precipitation measurements often contain additional variability due to: gages being moved during the many years of operation; frequent change of operators and level of diligence in timely measurement; missing data arising from inconsistent reporting; lack of attention to measurement precision; and localized site and wind condition changes over time due to building construction or growth of trees in the vicinity of the gage. Recognizing this additional variability, Wallis[29] has suggested that for precipitation annual maxima, H1 values less than 2.00 may be considered acceptably homogeneous and H1 values greater than 3.00 would be indicative of heterogeneity. Both the H1 and H2 measures will be used later to assess the relative heterogeneity in proposed sub-regions.

Acceptance of Proposed Homogeneous Sub-Regions

When a proposed sub-region is found to satisfy homogeneity criteria, the regional L-moment ratios are then used to conduct goodness-of-fit tests (Hosking and Wallis[9,10]) to assist in selecting a suitable probability distribution, and to estimate the parameters of the regional distribution. Examples of this type of approach are described by Schaefer in his study of Washington State[23], southern British Columbia[25], and the Sierra Mountains in California[26]. The basic approach adapted to this study is summarized below:

Adopted Methodology

1) Form proposed homogeneous sub-regions by assigning gages within a climatic region to groups within a small range of mean annual precipitation;
2) Compute L-moment sample statistics for gages within the proposed homogeneous sub-regions;
3) Use L-moment heterogeneity criteria to test proposed homogeneous sub-regions;
4) Develop a mathematical predictor for describing the behavior of regional L-Cv and L-skewness values with mean annual precipitation across the climatic region;
5) Conduct goodness-of-fit tests to identify a suitable probability distribution for regional growth curve;
6) Solve for the distribution parameters of the selected probability distribution for each sub-region using the regional values of L-Cv and L-skewness (from Step 4).

Systematic Variation of L-Cv and L-Skewness with Mean Annual Precipitation

As described previously, climatic regions were comprised of numerous homogeneous sub-regions. A mathematical relationship was therefore needed to link the sub-regions and provide estimation of L-moment ratios L-Cv and L-Skewness across a climatic region. The relationships were developed in a manner to provide continuity with adjacent climatic regions. This approach had the additional benefit of eliminating or minimizing discontinuities at the boundaries between the climatic regions. Recognizing that the sub-regions were formed as groupings of gages within a small range of mean annual precipitation (MAP), it was found that MAP was a suitable explanatory variable. The predictor equations took the general forms:

$$L\text{-}Moment\ Ratios = \alpha\, e^{-\beta(MAP)} + \delta \qquad (2a)$$

$$L\text{-}Moment\ Ratios = \alpha + \beta(LN[MAP]) \qquad (2b)$$

where: alpha (α), beta (β), and delta (δ) are parameters specific to a given climatic region or group of climatic regions, and delta is a limiting value at large values of mean annual precipitation.

ANALYSES OF 24-HOUR DURATION ANNUAL MAXIMA

Homogeneous sub-regions were formed as collections of gages within small ranges of mean annual precipitation (MAP) within each of the climatic regions. The range of MAP was chosen so that about 8 to 12 gages, 400 to 500 station-years of record, were included in each sub-region with each gage having at least 15 years of record. This resulted in a total of 32 sub-regions for the 24-hour duration (Table 2). Record lengths at precipitation measurement stations varied from a minimum of 15-years to over 100-years, with nearly 50% of the stations having record lengths in excess of 50-years. Figure 5 depicts the number of stations within various ranges of record length.

Table 2 – Number of Sub-Regions, Gages and Station-Years of Record for 24-Hour Duration Annual Maxima

CLIMATIC REGION	NUMBER OF SUB-REGIONS	DAILY GAGES	HOURLY GAGES	SNOTEL GAGES	STATION-YEARS OF RECORD
5	3	18	9	0	1,328
151	2	8	6	0	715
142	3	20	6	1	1,263
32	6	39	17	0	2,838
31	7	45	16	0	3,474
15	6	24	28	19	2,925
14	5	28	13	22	2,581
TOTAL	**32**	**182**	**95**	**42**	**15,124**

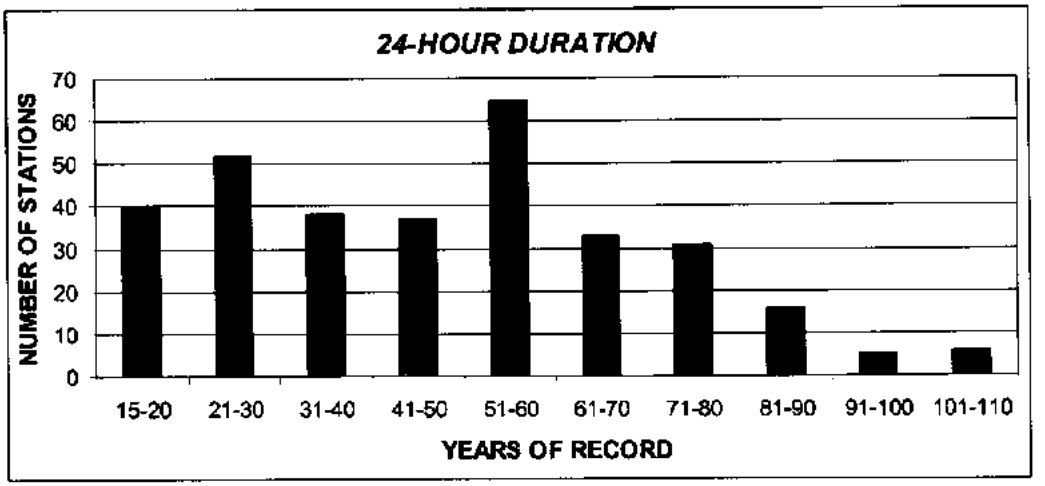


Figure 5 – Histogram of Record Lengths at Stations for 24-Hour Annual Maxima

Regional Solutions for L-Moment Ratios, L-Cv and L-Skewness

Regional predictor equations for L-moment ratios were developed for groupings of sub-regions in the climatic regions using forms of the regression equations shown in Equations 2a and 2b. It was found that a single predictor equation could often be developed applicable to adjacent climatic regions (Tables 3a,b). For those climatic regions where an exponential decay predictor equation was appropriate (Equation 2a), delta values were first estimated based on regional L-moment ratio values computed from those sub-regions with the largest sub-region values of mean annual precipitation.

For the case of climatic regions 15 and 14, where the boundary is near the crest of the Cascade Mountains, sub-region L-moment ratio values were also computed for gages near the Cascade crest. The sub-region and boundary L-moment ratio values were used to assist in estimation of the delta parameter, which provided continuity between mountain regions 15 and 14.

A least squares solution was used to determine the alpha and beta parameters. Standardized root mean square error (RMSE) was also computed for the predictor equation for each region(s) to provide a measure of the goodness-of-fit of the predictor equation. The resultant predictor equations for L-Cv are listed in Tables 3a,b and graphically depicted in Figures 6a,b,c,d.

Few precipitation gages exist at high elevations in the Olympic Mountains. Extrapolation is required in this area to provide L-moment ratio values applicable to locations with mean annual precipitation exceeding about 140-inches. The regression parameters for high mountain areas in region 142, on the leeward face of the Olympic Mountains, were based on the behavior of L-moment ratio values for gages with the greatest mean annual precipitation on the windward face of the Olympics. This approach provided continuity across the crest of the Olympics for very high values of mean annual precipitation as seen in Figures 5a,b and 6a,b.

Table 3a – Predictor Equations for L-Cv for 24-Hour Annual Maxima

$L\text{-}Cv = \alpha + \beta * LN(MAP)$				
REGIONS	**APPLICABILITY**	**ALPHA**	**BETA**	**STANDARDIZED RMSE**
5 - 151	ALL	0.0925	0.0130	5.3%
32 - 142	MAP ≥ 75-inches	0.0925	0.0130	3.2%
31 - 15	MAP ≥ 60-inches	0.1276	0.0054	3.5%

Table 3b – Predictor Equations for L-Cv for 24-Hour Annual Maxima

$L\text{-}Cv = \alpha * EXP[-\beta * MAP] + \delta$					
REGIONS	**APPLICABILITY**	**ALPHA**	**BETA**	**DELTA**	**STANDARDIZED RMSE**
32 - 142	MAP < 75-inches	0.2500	0.0845	0.1480	3.2%
31 - 15	MAP < 60-inches	0.2500	0.0845	0.1480	3.5%
14	ALL	0.1100	0.0330	0.1550	3.3%

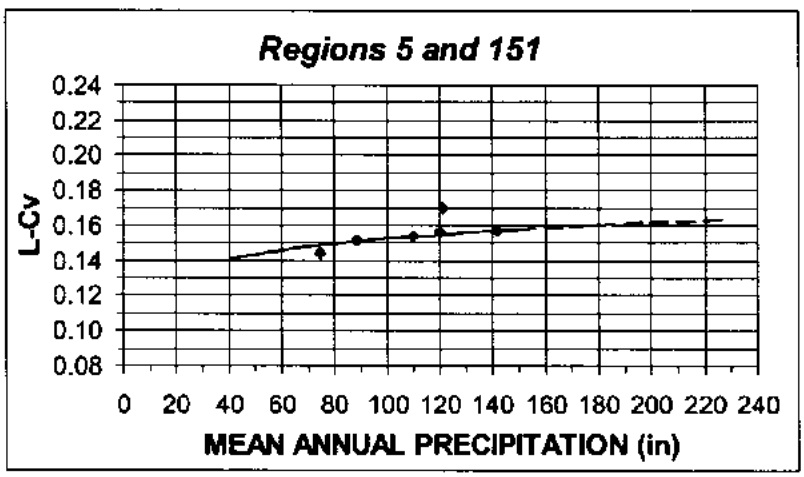


Figure 6a – Predictor Equation Solutions of Observed L-Cv for Climatic Regions 5 and 151 for 24-Hour Duration

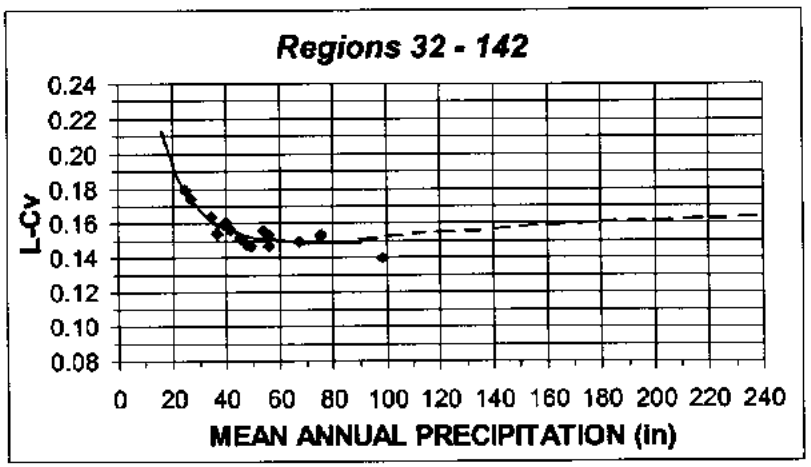


Figure 6b – Predictor Equation Solutions of Observed L-Cv for Climatic Regions 32 and 142 for 24-Hour Duration

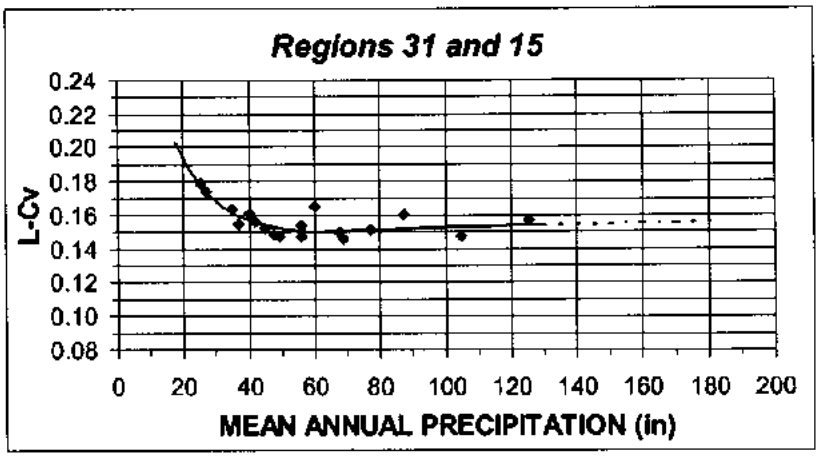


Figure 6c – Predictor Equation Solutions of Observed L-Cv for Climatic Regions 31 and 15 for 24-Hour Duration

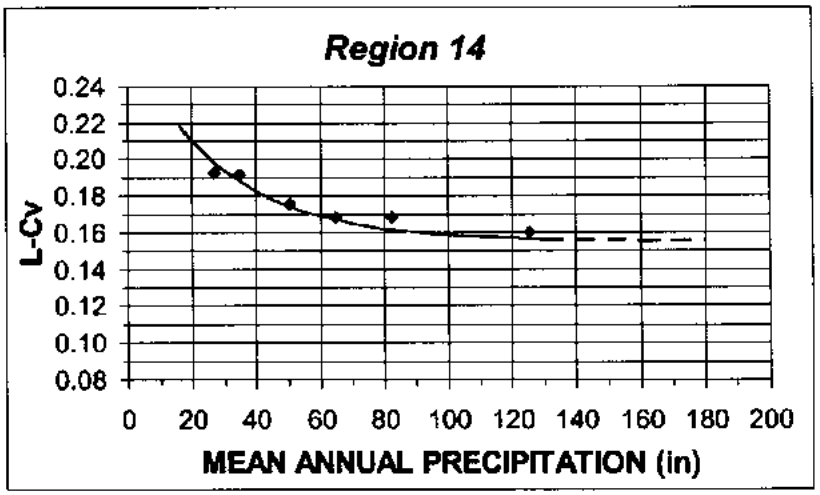


Figure 6d – Predictor Equation Solution of Observed L-Cv for Climatic Region 14 for 24-Hour Duration

Skewness measures are highly variable for the record lengths commonly available for precipitation-frequency analysis. This greater sampling variability is exhibited in larger RMSE values for the predictor equations for L-Skewness (Tables 4a,b). Regional predictor equations for L-Skewness were developed in the same manner as that described above for L-Cv. The predictor equations for L-Skewness are listed in Tables 4a,b and graphically depicted in Figures 7a,b,c,d.

Table 4a – Predictor Equations for L-Skewness for 24-Hour Annual Maxima

$L\text{-}Skewness = \alpha + \beta * LN(MAP)$				
REGIONS	**APPLICABILITY**	**ALPHA**	**BETA**	**STANDARDIZED RMSE**
5 - 151	MAP < 150-inches	0.0930	0.0130	13.7%
5 - 151	MAP ≥ 150-inches	0.1580	0.0000	13.7%
32 - 142	70-inches ≤ MAP < 150-inches	0.0930	0.0130	14.2%
32 - 142	MAP ≥ 150-inches	0.1580	0.0000	14.2%

Table 4b – Predictor Equations for L-Skewness for 24-Hour Annual Maxima

$L\text{-}Skewness = \alpha * EXP[-\beta * MAP] + \delta$					
REGIONS	**APPLICABILITY**	**ALPHA**	**BETA**	**DELTA**	**STANDARDIZED RMSE**
32 - 142	MAP < 70-inches	0.1500	0.0400	0.1400	14.2%
31 - 15	ALL	0.1300	0.0400	0.1580	9.8%
14	ALL	0.1300	0.0400	0.1580	10.5%

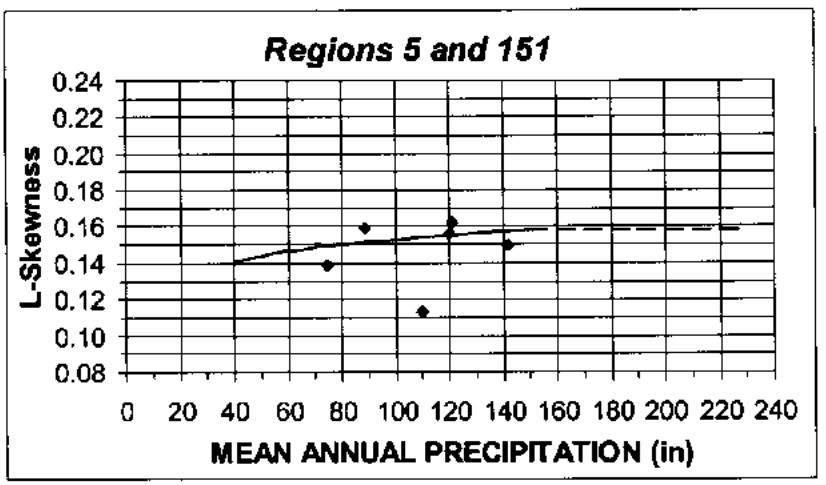


Figure 7a – Predictor Equation Solutions of Observed L-Skewness for Climatic Regions 5 and 151 for 24-Hour Duration

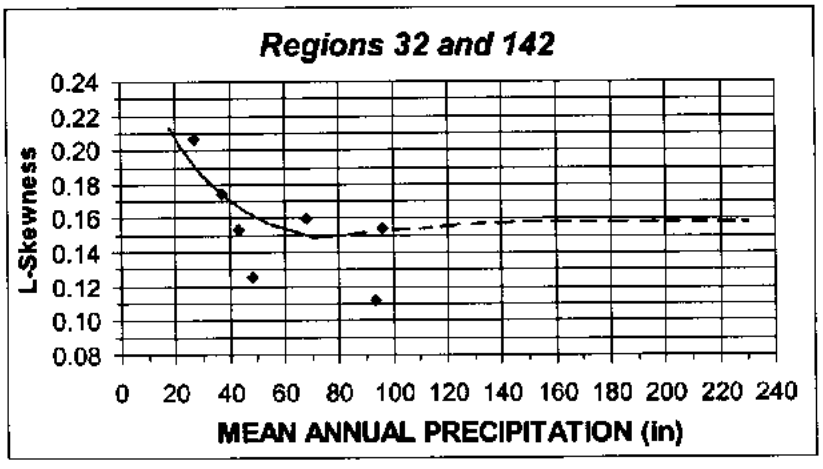


Figure 7b – Predictor Equation Solutions of Observed L-Skewness for Climatic Regions 142 and 32 for 24-Hour Duration

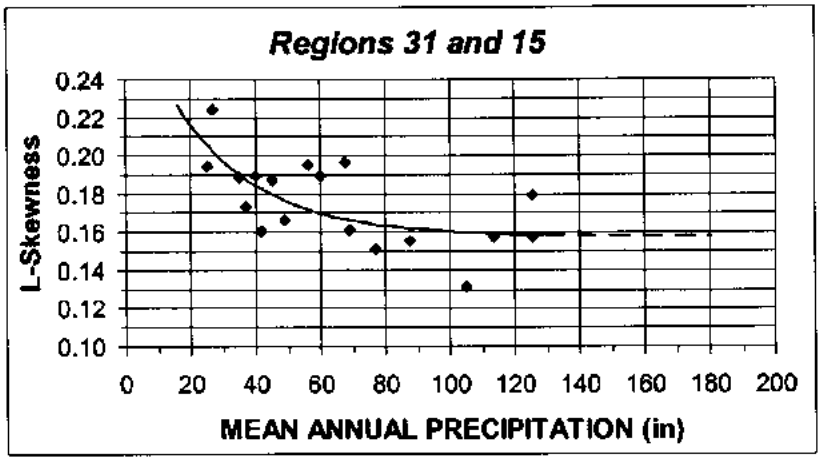


Figure 7c – Predictor Equation Solutions of Observed L-Skewness for Climatic Regions 31 and 15 for 24-Hour Duration

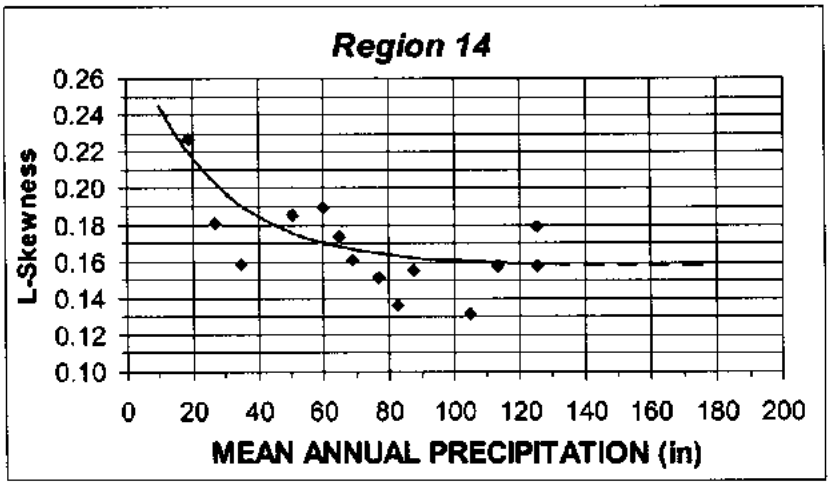


Figure 7d – Predictor Equation Solutions of Observed L-Skewness for Climatic Region 14 for 24-Hour Duration

Heterogeneity Measures, 24-Hour Duration

Heterogeneity measures H1 and H2 (Hosking and Wallis[9,10]) were used to judge the relative heterogeneity in the proposed sub-regions for L-Cv and L-Skewness, respectively. Computation of H1 and H2 values for the various sub-regions indicated the majority of sub-regions were acceptably homogeneous (Table 5). In those cases where computed heterogeneity measures exceeded acceptance criteria, the excursions were generally of a minor amount. Only one sub-region on the windward face of the Olympics had large excursions beyond the acceptance criteria. In summary, mean annual precipitation was an excellent explanatory variable for describing the variability of L-Cv and L-Skewness across the study area.

Table 5 – Results of Heterogeneity and Goodness-of-Fit Tests for 24-Hour Duration

CLIMATIC REGIONS	NUMBER OF SUB-REGIONS	HOMOGENEOUS SUB-REGIONS H1 ≤ 2.00	HOMOGENEOUS SUB-REGIONS H2 ≤ 1.00	SUB-REGIONS ACCEPTING GEV DISTRIBUTION
5 - 151	5	3	4	5
142 - 32	9	6	7	8
31 -15	13	13	11	13
14	5	4	4	3
TOTAL	**32**	**26**	**26**	**29**

Identification of Regional Probability Distribution, 24-Hour Duration

One of the primary tasks in the regional analyses was to identify the best probability distribution for describing the behavior of the annual maxima data. Accordingly, a goodness-of-fit test statistic (Hosking and Wallis[9,10]) was computed for each sub-region for use in identifying the best three-parameter distribution. Using the L-moment based test statistic, the Generalized Extreme Value (GEV) distribution[9,27] was identified most frequently as the best three-parameter probability model (Table 5).

A plot of regional L-Skewness and L-Kurtosis values for the 32 sub-regions at the 24-hour duration in shown in Figure 8. Nearness to the GEV distribution is clearly evident and consistent with the goodness-of-fit test results listed in Table 5.

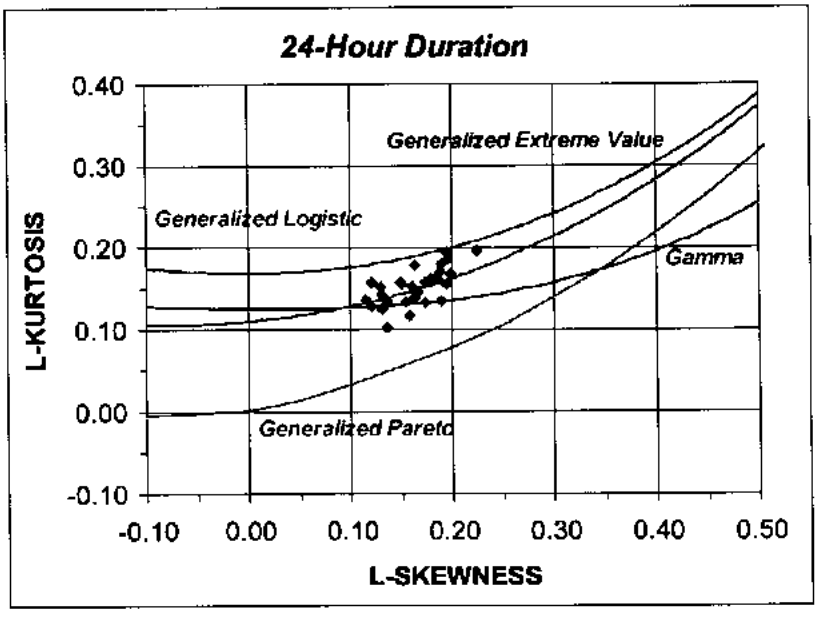


Figure 8 – L-Moment Ratio Plot for Sub-Regions for 24-Hour Duration

The GEV is a very suitable distribution for estimation of precipitation quantiles out to the 500-year recurrence interval. If quantile estimates are desired for events more extreme than the 500-year recurrence interval, it would be worthwhile to refine the selection of the regional probability distribution. Given this consideration, it was decided to utilize the four-parameter Kappa[9,12] distribution, which can mimic the GEV and produce a variety of regional growth curves immediately around the GEV. The inverse form of the Kappa distribution is:

$$q(F) = \xi + \frac{\alpha}{\kappa}\left\{1 - \left(\frac{1 - F^{h}}{h}\right)^{\kappa}\right\} \qquad (3)$$

where: ξ, α, κ, and h are location, scale and shape parameters respectively.

An h value of zero leads to the GEV distribution, an h value of 1 produces the Generalized Pareto (GP) and an h value of -1 produces the Generalized Logistic (GL) distribution. Thus, positive values of h produce regional growth curves that are flatter than the GEV, and negative values of h produce steeper regional growth curves. Minor adjustments of h near a zero value (GEV) allow fine-tuning of the regional growth curves. This minor adjustment of the h value only becomes important for the estimation of very rare quantiles.

To solve for an appropriate h value, a hierarchical approach (Fiorentino[4]) was taken wherein the shape parameter h was computed as the average value from the group of sub-region solutions. An average value of -0.057 was computed with a standard error of estimation of approximately $\pm$ 0.045. Based on this information, a nominal h value of -0.05 was adopted. This produces a regional growth curve slightly steeper than the GEV for very rare events and essentially matches the GEV out to the 100-year recurrence interval.

ANALYSES OF 2-HOUR DURATION ANNUAL MAXIMA

As in the analysis of 24-hour annual maxima, homogeneous sub-regions at the 2-hour duration were formed as collections of gages within small ranges of mean annual precipitation (MAP) within each of the climatic regions. The range of MAP was chosen so that about 6 to 10 gages, 200 to 350 station-years of record, were included in each sub-region with each gage having at least 15-years of record. This resulted in a total of 15 sub-regions for the 2-hour duration (Table 6). Record lengths at precipitation measurement stations varied from a minimum of 15-years to near 60-years, with nearly 50% of the stations having record lengths in excess of 40-years. Figure 9 depicts the number of stations within various ranges of record length.

Table 6 – Number of Sub-Regions, Gages and Station-Years of Record for 2-Hour Duration Annual Maxima

CLIMATIC REGIONS	NUMBER OF SUB-REGIONS	DAILY GAGES	HOURLY GAGES	SNOTEL GAGES	STATION-YEARS OF RECORD
5 - 151	2	0	19	0	721
142 - 32	4	0	27	0	1,101
31 - 15	7	0	63	0	2,424
14	2	0	15	0	551
TOTAL	**15**	**0**	**124**	**0**	**4,797**

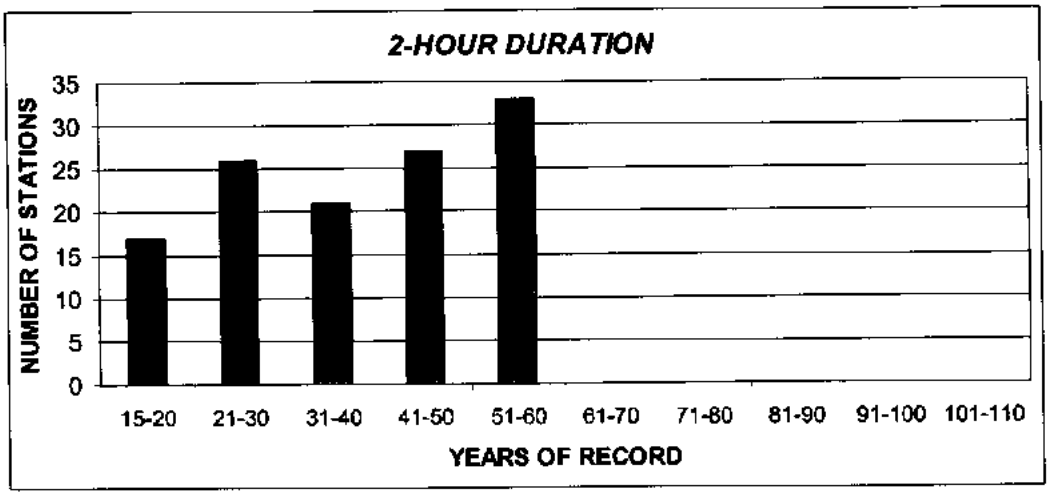


Figure 9 – Histogram of Station Record Lengths for 2-Hour Annual Maxima

Regional Solutions for L-Moment Ratios, L-Cv and L-Skewness

Regional predictor equations for L-moment ratios at the 2-hour duration were developed in the same manner as that for the 24-hour duration. The resultant predictor equations for L-Cv are listed in Table 7 and graphically depicted in Figures 10a,b,c. The predictor equation for L-Skewness is listed in Table 8 and graphically depicted in Figure 11.

Table 7 – Predictor Equations for L-Cv for 2-Hour Annual Maxima

$L\text{-}Cv = \alpha * EXP[-\beta * MAP] + \delta$					
REGIONS	**APPLICABILITY**	**ALPHA**	**BETA**	**DELTA**	**STANDARDIZED RMSE**
5 - 151	ALL	0.0850	0.0200	0.1200	4.6%
142 - 32	ALL	0.0500	0.0250	0.1200	7.9%
31 - 15	ALL	0.0850	0.0200	0.1200	4.6%
14	ALL	0.0850	0.0200	0.1200	1.9%

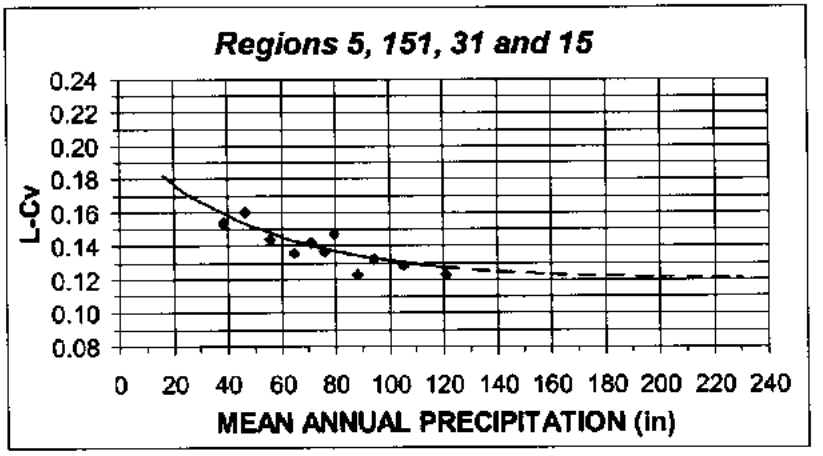


Figure 10a – Predictor Equation Solutions of Observed L-Cv for Climatic Regions 5, 151, 31 and 15 for 2-Hour Duration

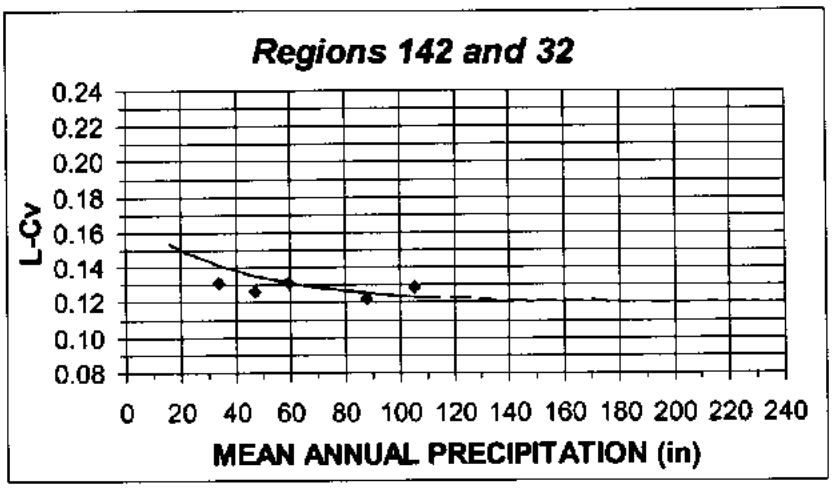


Figure 10b – Predictor Equation Solutions of Observed L-Cv for Climatic Regions 142 and 32 for 2-Hour Duration

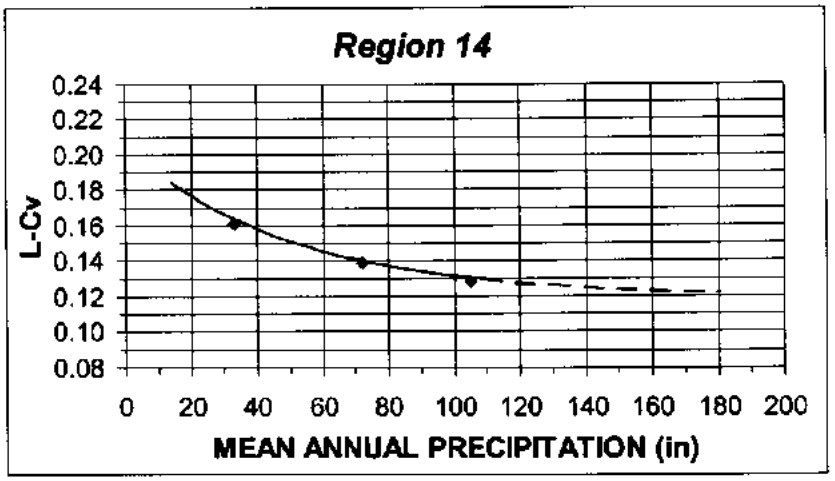


Figure 10c – Predictor Equation Solution of Observed L-Cv for Climatic Region 14 for 2-Hour Duration

Table 8 – Predictor Equations for L-Skewness for 2-Hour Annual Maxima

*L-Skewness = α * EXP [-β * MAP] + δ*					
REGIONS	**APPLICABILITY**	**ALPHA**	**BETA**	**DELTA**	**STANDARDIZED RMSE**
ALL	ALL	0.1800	0.0250	0.1700	15.7%

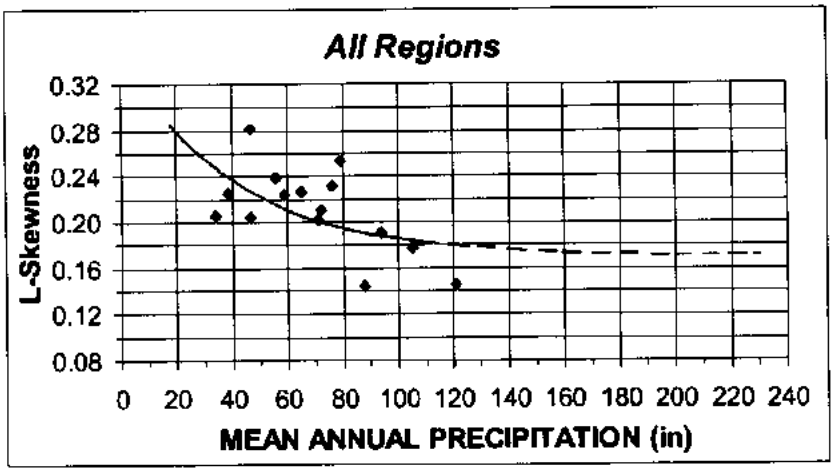


Figure 11 – Predictor Equation Solutions of Observed L-Skewness for All Climatic Regions for 2-Hour Duration

The suitability of the general form of the L-moment predictor equation (Equation 2a) is not as apparent in Figure 11 as was the case for other climatic regions. The naturally high variability of sample L-skewness values makes it more difficult to discern the underlying behavior of the data. However, the general form of the solution curve is consistent with behavior seen at the 24-hour duration and the behavior seen in other regional precipitation studies where the L-skewness values converge to some limiting value for sites with very high mean annual precipitation.

Heterogeneity Measures, 2-Hour Duration

Heterogeneity measures H1 and H2 (Hosking and Wallis[9,10]) were used to judge the relative heterogeneity in the proposed sub-regions for L-Cv and L-Skewness, respectively. Computation of H1 and H2 values for the various sub-regions indicated the majority of sub-regions were acceptably homogeneous (Table 9). In those cases where computed heterogeneity measures exceeded acceptance criteria, the excursions were generally of a minor amount. Only one sub-region on the windward face of the Olympics had large excursions beyond the acceptance criteria. In summary, mean annual precipitation was an excellent explanatory variable for describing the variability of L-Cv and L-Skewness across the study area.

Table 9 – Results of Heterogeneity and Goodness-of-Fit Tests for 2-Hour Duration

CLIMATIC REGIONS	NUMBER OF SUB-REGIONS	HOMOGENEOUS SUB-REGIONS H1 ≤ 2.00	HOMOGENEOUS SUB-REGIONS H2 ≤ 1.00	SUB-REGIONS ACCEPTING GEV DISTRIBUTION
5 - 151	2	1	1	2
142 - 32	4	4	2	4
31 -15	7	5	7	6
14	2	2	2	1
TOTAL	**15**	**12**	**12**	**13**

Identification of Regional Probability Distribution, 2-Hour Duration

The Generalized Extreme Value (GEV) distribution was identified most frequently as the best three-parameter probability model (Table 9) using the L-moment based test statistic for goodness-of-fit. A plot of regional L-Skewness and L-Kurtosis values for the 15 sub-regions at the 2-hour duration in shown in Figure 12. It is seen that the majority of data pairs plot nearest the GEV distribution, with the centroid being slightly above, slightly more kurtotic, than the GEV distribution.

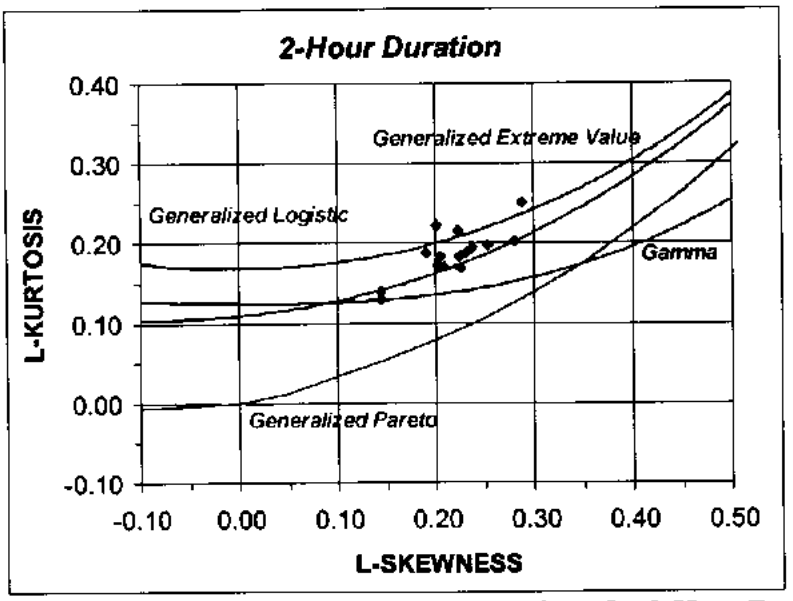


Figure 12 – L-Moment Ratio Plot for Sub-Regions for 2-Hour Duration

As was the case for the 24-hour duration, the GEV is a suitable distribution for estimation of precipitation quantiles out to the 500-year recurrence interval. If quantile estimates are desired for events more extreme than the 500-year recurrence interval, it would be worthwhile to utilize the four-parameter Kappa distribution and to refine the selection of the *h* parameter. To solve for an appropriate *h* value, a hierarchical approach (Fiorentino[4]) was taken wherein the shape parameter *h* was computed as the median value from the group of sub-region solutions. A median value of -0.150 was computed with a standard error of estimation of approximately $\pm$ 0.093. Based on this information, a nominal *h* value of -0.15 was adopted. This produces a regional growth curve slightly steeper than the GEV for very rare events and essentially matches the GEV distribution up to the 100-year recurrence interval.

PRECIPITATION MAGNITUDE-FREQUENCY ESTIMATES FOR GAGED SITES

The first step in developing a site-specific precipitation magnitude-frequency curve is to compute the regional growth curve. The findings described in the previous sections provide the information necessary for developing the regional growth curve for the 24-hour and 2-hour durations. Specifically, the first three parameters of the Kappa distribution (ξ, α, and κ) are solved (Hosking and Wallis[9,12]) using a mean of unity and the applicable regional values of L-Cv and L-Skewness as indicated in Tables 3a,b and 4a,b. The fourth parameter (*h*) of the Kappa distribution is set to the regional average value applicable to the selected duration. Equation 3 is then used to describe the regional growth curve. The site-specific precipitation-frequency curve is obtained by scaling the regional growth curve by the at-site mean.

For gaged sites, the at-site mean ($\hat{\mu}$) can be computed from the gage mean ($\bar{x}$) based on the correction factors (C_{nop}) in Table 10. A correction factor (Weiss[32]) is needed to adjust the gage sample mean to account for precipitation measurement and reporting on a fixed time interval rather than on the desired continuous basis. The at-site mean is computed from the gage mean as:

$$\hat{\mu} = C_{nop}(\bar{x}) \tag{4}$$

Table 10 – Correction Factors (C_{nop}) to Adjust Gage Sample Statistics

GAGE TYPE	DURATION	
	2-Hour	24-Hour
Daily Gage Snotel Gage	n/a	1.13
Automated Gage Hourly Reporting	1.04	1.00
Automated Gage 15-Minute Reporting	1.00	1.00

This procedure can be explained by an example using an existing gaged site. The Seattle-Tacoma Airport gage is located in the Interior Lowlands West, climatic Region 31. The mean annual precipitation for the site is 37.9-inches. For the 24-hour duration, the regional value of L-Cv is 0.159, which is obtained from Equation 2a and parameter values from Table 3b. The regional value of L-Skewness is 0.187, which is obtained from Equation 2a and parameter values from Table 4b. The regional value of the h parameter is -0.05 for the 24-hour duration. Using a mean value of unity, the solution for the four parameters of the Kappa distribution[12,15], yields:

$$\xi = 0.8716,\ \alpha = 0.2166,\ \kappa = -0.0394,\ \text{and}\ h = -0.05.$$

Use of Equation 3 yields the regional growth curve depicted in Figure 13a. Seattle-Tacoma Airport has an hourly gage with a gage mean of 2.10-inches for the 24-hour duration for 60-years of record. Use of Equation 4 with a correction factor of 1.00 yields an at-site mean value of 2.10-inches for the 24-hour duration. The at-site precipitation magnitude-frequency curve is obtained by scaling the regional growth curve by the at-site mean and is depicted in Figure 13b. The observed 24-hour annual maxima for the Seattle-Tacoma Airport site for the period from 1940-2000 are also depicted in Figure 12b for a comparison of the regional solution and the sample data.

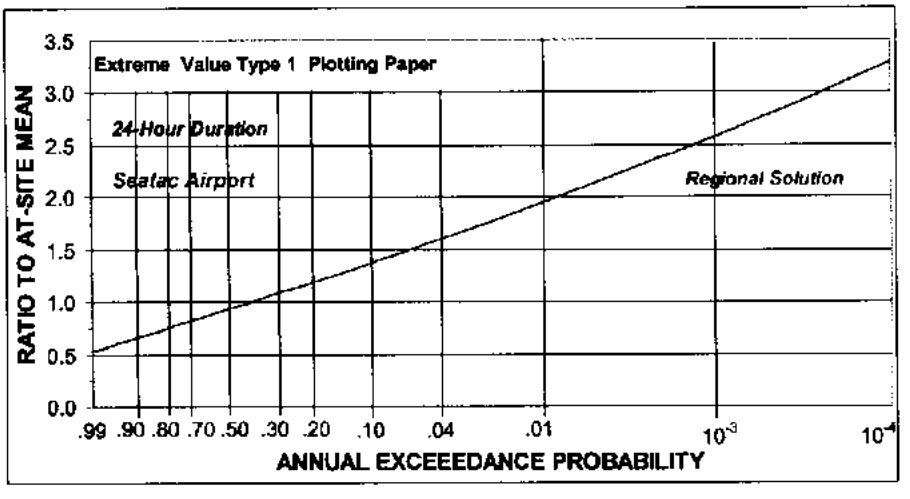


Figure 13a – Regional Growth Curve for Seattle-Tacoma Airport for 24-Hour Duration

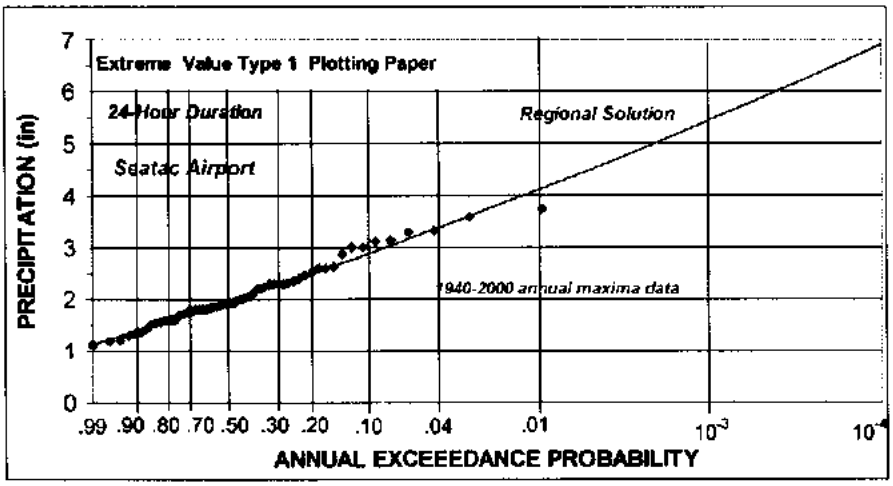


Figure 13b – Precipitation Magnitude-Frequency Curve for Seattle-Tacoma Airport for 24-Hour Duration

SPATIAL MAPPING OF PRECIPITATION-FREQUENCY INFORMATION

Products from the PRISM model[3] operated by Oregon Climate Service were used in conducting spatial mapping of precipitation for selected recurrence intervals. Gridded datasets and isopluvial maps were prepared for the 2-year, 10-year, 25-year, 50-year and 100-year recurrence intervals for the 24-hour and 2-hour durations. A gridded dataset and isopluvial map was also prepared for the 6-month (twice/year) recurrence interval for the 24-hour duration, which is needed for some water quality applications. Precipitation estimates for the 6-month and 2-year recurrence intervals were converted from annual maxima to partial duration series equivalents using the conversion developed by Langbein[15,27]. This was done to improve the frequency estimates for common events and to be consistent with past mapping products produced by the National Weather Service[16].

The spatial mapping of precipitation for selected recurrence intervals is dependent upon the production of two key components in addition to the regional precipitation-frequency information. The first component required is the spatial mapping of at-site means (station mean values, also called mean annual maxima). Grid-cell values of at-site means are used to scale dimensionless magnitude-frequency relationships to obtain precipitation estimates for the recurrence interval of interest. The second component required is the spatial mapping of regional statistical parameters. This provides L-moment ratio statistics applicable to each grid-cell in the study area domain, which are used to determine the probability distribution parameters for describing the magnitude-frequency relationship applicable to each grid-cell. Thus, the spatial mapping of at-site means and the spatial mapping of regional statistical parameters are the primary work products needed for isopluvial mapping.

Mean Annual Precipitation

The gridded dataset of mean annual precipitation provides a basis for spatial mapping of both at-site means and L-moment statistics and is therefore an important element of this project. An analysis of mean annual precipitation for the period from 1961 to 1990 has been completed for the study area by Oregon Climate Service using the PRISM model[3,20]. The resultant map has been utilized in this study and provides digital values of mean annual precipitation on a gridded latitude-longitude system with a nominal resolution of 1.25 minutes per grid-cell for the study area (about 1.4 mi^2). This resolution yields a study area domain that is a matrix of 216 rows by 336 columns, 72,576 grid-cells.

SPATIAL MAPPING OF AT-SITE MEANS

Spatial mapping of at-site means encompasses a number of separate tasks that address the spatial behavior of at-site means and seeks to minimize differences between mapped values and sample values computed at precipitation measurement stations. This typically involves first developing relationships between at-site means computed at precipitation measurement stations and climatic/physiographic factors. These relationships are then used to populate the grid-cells in the study area domain with the values predicted from the regression equation based on the climatic/physiographic factors representative of each grid-cell. Residuals are then computed for each of the station at-site means that quantify the magnitude of difference between mapped values and station values. This allows analyses to be conducted of the residuals to identify if there is a coherent spatial pattern to the magnitude and sign of the residuals. When coherent residual patterns are encountered, they are used to adjust the original estimates. Lastly, standard bias and root mean square error measures are computed to quantify the overall goodness-of-fit of the mapped values relative to the observations at the gages. The completed maps of the at-site means for the 24-hour and 2-hour durations are shown in Figures 14a,b, respectively.

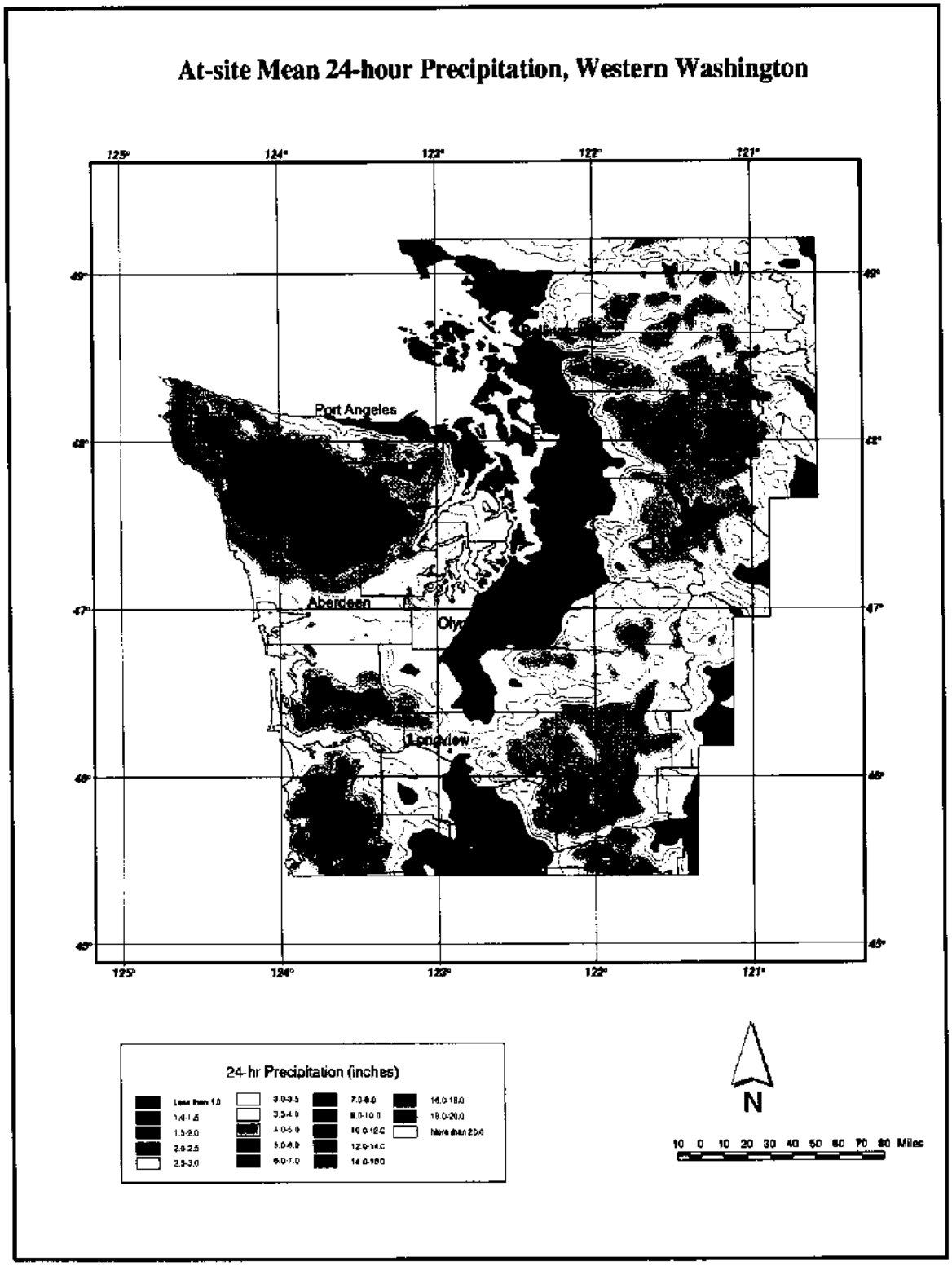


Figure 14a – Map of At-Site Means for 24-Hour Duration for Western Washington

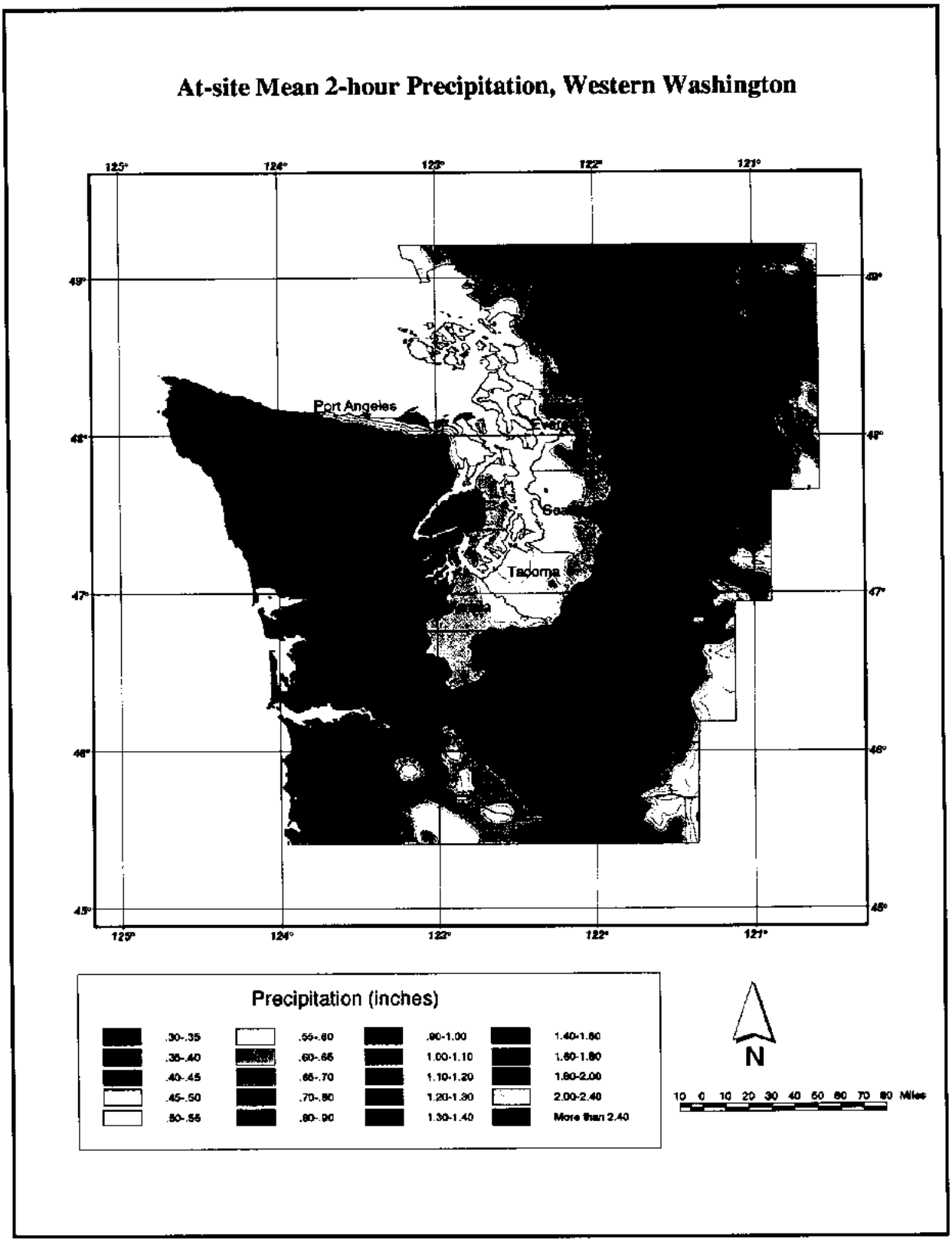


Figure 14b – Map of At-Site Means for 2-Hour Duration for Western Washington

Quantitative Assessment of Success Achieved in Spatial Mapping of At-Site Means
A quantitative measure was needed to assess the relative success of the spatial mapping procedures in capturing the spatial behavior of the at-site means. This is a difficult task in all studies of this type because the true values of the at-site means are unknown. The logical standard for comparison is the station sample value of at-site mean. However, sample values of the station at-site mean will differ from the true population values due to sampling variability, and other natural and man-related variability associated with precipitation measurement and recording.

We chose to approach this problem by framing the question as - how do the observed station values compare with the final mapped values? Given this question, the bias and root mean square error (RMSE) computations can be expressed in standardized units using the mapped values as the predicted value. This equates to computing bias and RMSE for the standardized residuals (SR_2) as:

$$SR_2 = (S - P_2) / P_2 \qquad (5)$$

where: S is the observed station value of the at-site mean (in); and P_2 is the mapped value of the station at-site-mean (in).

The computed standardized residuals are listed in Tables 11a,b. It is seen that the final mapped values of the at-site means are nearly unbiased. If the RMSE values for the stations are representative of the at-site mean maps taken as a whole, then the final maps of at-site means have a standard error of estimate that is near 5%. The RMSE of the final mapped values are generally similar in magnitude to that expected from natural sampling variability and, thus, are as low as can reasonably be expected.

Table 11a –Bias and Root Mean Square Error of Standardized Residuals for Final Mapped Values of At-Site Means for 24-Hour Duration

REGION	FINAL MAPPED VALUES	
	Bias	*RMSE*
COASTAL AREAS		
Region 5	+1.04%	5.26%
Region 151	-0. 68%	2.92%
Region 142	-1.47%	5.07%
INTERIOR LOWLAND AREAS		
Region 32	+0. 56%	6.63%
Region 31	+0.41%	4.42%
CASCADE MOUNTAIN AREAS		
Region 15	+0.02%	4.01%
Region 14	+0.17%	6.27%
ALL REGIONS	+0.18%	5.21%

Table 11b – Bias and Root Mean Square Error of Standardized Residuals for Final Mapped Values of At-Site Means for 2-Hour Duration

REGION	FINAL MAPPED VALUES	
	Bias	*RMSE*
COASTAL AREAS		
Region 5	+0.61%	1.55%
Region 151	-1.58%	5.77%
Region 142	+2.75%	5.57%
INTERIOR LOWLAND AREAS		
Region 32	+0. 35%	3.66%
Region 31	+0.24%	2.95%
CASCADE MOUNTAIN AREAS		
Region 15	+0.55%	4.12%
Region 14	-0.85%	4.70%
ALL REGIONS	+0.21%	3.96%

SPATIAL MAPPING OF REGIONAL L-MOMENT STATISTICAL PARAMETERS

In order to compute precipitation estimates for the selected recurrence intervals, the appropriate value of L-Cv and L-skewness must be obtained for each grid-cell. This was accomplished by populating the grid-cells in the study area domain utilizing the functional relationships for L-Cv and L-skewness (Tables 3a,b and 4a,b) developed in the regional precipitation-frequency analysis.

A smoothing filter was then employed along regional boundaries to provide a smooth transition of L-moment ratio values across boundaries. In general, these were minor adjustments with changes of only a few percent, as particular care had previously been taken in the precipitation-frequency study to minimize differences at regional boundaries.

Separate gridded data files were prepared for L-Cv and L-skewness for each of the two durations, and are included as electronic files with this report (Appendix A).

PRODUCTION OF ISOPLUVIAL MAPS

Production of the isopluvial maps was accomplished by incorporation of the information described in the prior sections. For each grid-cell, the applicable value of the at-site mean and L-moment ratios L-Cv and L-skewness were used to solve the distribution parameters for the four-parameter Kappa distribution[9,12]. The distribution parameters were then used with Equation 3 to compute the expected value of the precipitation for the desired recurrence interval. This procedure was repeated for each grid-cell until the domain for the study area was populated. The resultant precipitation field was then contoured to yield isopluvials for selected values of precipitation.

An example of an isopluvial map produced by this process is depicted in Figure 15, which shows a color-shaded map of 24-hour 100-year precipitation. Isopluvial maps for the other selected recurrence intervals for the 24-hour and 2-hour durations are contained in Appendix B.

Precipitation Magnitude-Frequency Estimates for Moderate to Large Size Watersheds
The precipitation magnitude-frequency information contained in the gridded datasets and depicted on the isopluvial maps corresponds to 10-mi^2 and 1-mi^2 precipitation for the 24-hour and 2-hour durations, respectively. Estimation of precipitation volumes for larger watersheds for a selected recurrence interval requires the application of areal reduction factors[16,18,19]. Areal reduction factors would be obtained from analyses of historical storms. The topic of areal reduction factors, depth-area-duration analyses, and estimation of precipitation for moderate to large size watersheds is beyond the scope of this report. It is mentioned here to alert the reader that precipitation values from the gridded datasets and isopluvial maps need to be scaled by areal reduction factors to obtain estimates of precipitation volumes for moderate to large watersheds.

Uncertainty Bounds for 100-Year Values
The accuracy of estimation of 100-year precipitation annual maxima at a given location is dependent upon the success obtained in estimating the at-site mean, and L-moment ratios L-Cv and L-skewness, and the similarity between the chosen probability model (Kappa distribution) and the actual model mother-nature is using, which is unknown.

In general, uncertainties associated with the estimation of L-moment ratios L-Cv and L-skewness result in standard errors of estimation of about 5% at the 100-year recurrence interval. These relatively low levels of uncertainty are attributable to the very large datasets that were used to estimate the L-moment ratios and identify a suitable probability model. Interaction of these standard errors of estimation with that due to estimation of the at-site mean (Tables 11a,b) yield the standard errors of estimation shown in Table 12. The range in standard errors of estimation for a given duration is primarily due to the region-to-region variation of the standard errors for estimation of the at-site mean for the recurrence intervals cited in Table 12.

The values in Table 12 should be considered approximate as detailed studies for computation of uncertainty bounds have not been conducted. Further, these values represent regional averages. Values applicable to a given location may be somewhat smaller or larger than that indicated in Table 12.

Table 12 – Range of Standard Errors of Estimation for Selected Recurrence Intervals

DURATION	STANDARD ERROR OF ESTIMATION FOR PRECIPITATION	
	10-YEAR	100-YEAR
2-HOUR	4% - 7%	6% - 9%
24-HOUR	5% - 8%	7% - 10%

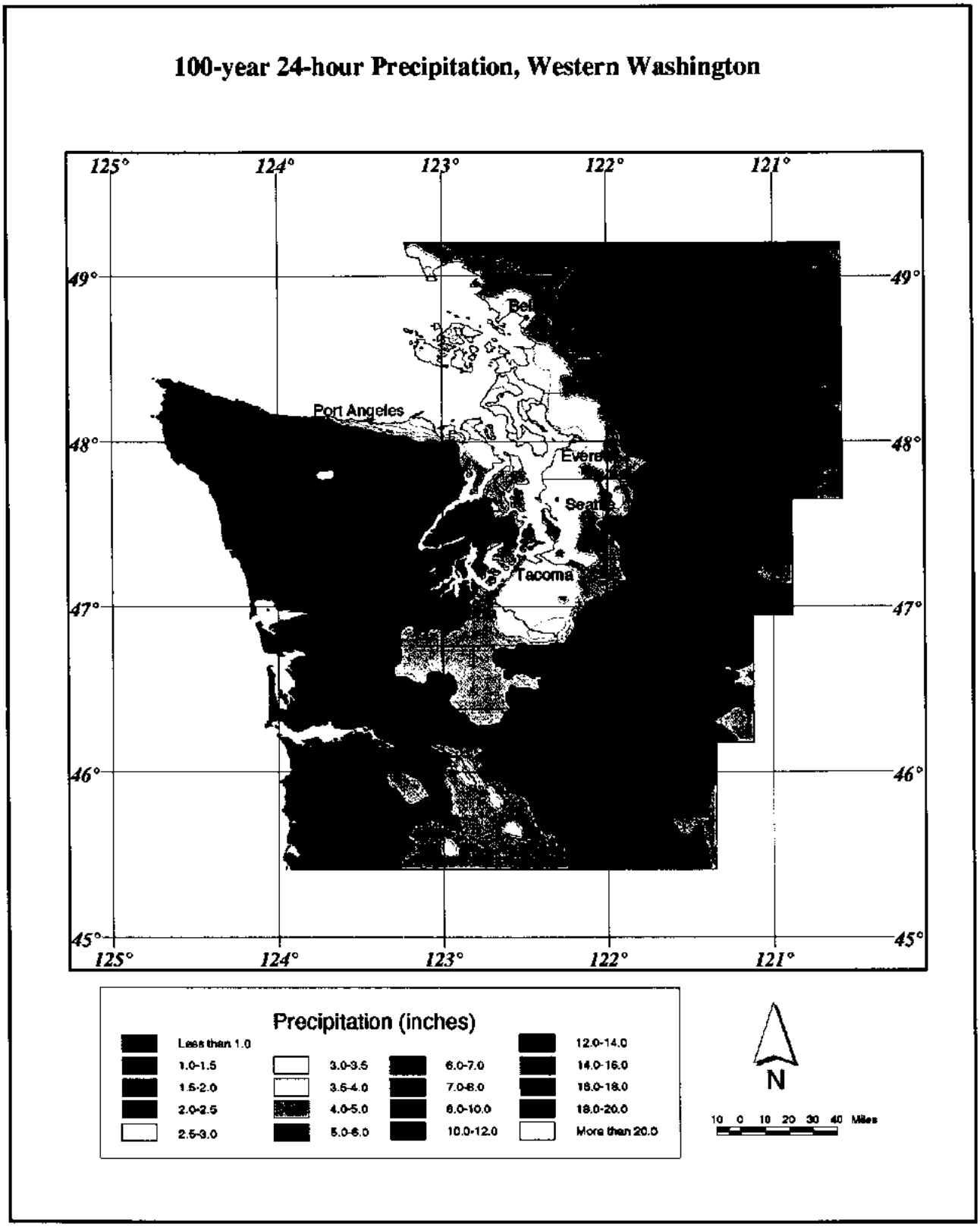


Figure 15 – Isopluvial Map of 24-Hour Precipitation for 100-Year Recurrence Interval for Western Washington

ELECTRONIC FILES
LISTING AT-SITE AND REGIONAL PARAMETERS FOR ALL GAGED SITES

Appendix A includes station catalogs for the stations/gages used in the study. It also references a compact disc (CD) containing ASCII text files and Excel spreadsheets listing the precipitation estimates for selected recurrence intervals. Specifically, the files contain the station identification number, station name, type of gage, climatic region number, latitude, longitude, elevation, mean annual precipitation, sample value of at-site mean, mapped value of at-site mean, regional values of L-Cv, L-skewness, *h* parameter for the Kappa distribution, and estimated 6-month, 2-year, 10-year, 25-year, 50-year, 100-year, and 500-year precipitation.

SEASONALITY OF EXTREME STORMS

The seasonality of extreme storms can be a valuable tool for application of the precipitation-frequency information in rainfall-runoff modeling. Specifically, information on the seasonality of storms is helpful in decision-making for setting watershed conditions antecedent to the storm. The seasonality of extreme storms was investigated by constructing frequency histograms of the storm dates for rare 24-hour and 2-hour precipitation amounts for each of the seven climatic regions. Extreme storms were taken to be precipitation amounts with annual exceedance probabilities less than 0.05 (rarer than a 20-year event). Precipitation amounts/gages with duplicate storm dates (generally dates within 7 calendar days) were removed before constructing the frequency histograms for each climatic region. The results of the seasonality analyses are discussed briefly below and additional frequency histograms are presented in Appendix C.

Well-defined seasonal patterns are apparent for the 24-hour and 2-hour durations. In western Washington, storms which are extreme at the 24-hour duration occur predominantly in the fall and winter months (Figure 16). These storms are the result of synoptic scale cyclonic weather systems and associated fronts. These storms remain organized and penetrate a considerable distance inland from the coast, as the eastern slopes of the Cascade Mountains also exhibit a distinctive fall-winter seasonal pattern.

Storms which are extreme at the 2-hour duration exhibit greater seasonal variability. In lowland areas, storms that are extreme at the 2-hour duration occur both in the warm season and in the fall and winter period (Figure 17a). Some of these events are localized events having limited areal coverage with precipitation occurring over a relatively short period of time. Other events are embedded in longer duration cool season storm events and are associated with large-scale weather systems having more widespread areal coverage. As the precipitation amounts become more rare and increase in magnitude, there is a greater likelihood that they are associated with a localized event and have temporal characteristics of a thunderstorm. These more rare events are more likely to occur in the warm season as a result of convective storm activity. (Figure 17b).

In coastal and mountain areas, the seasonality of extreme 2-hour storms covers the period from late-spring through winter. Moderately large 2-hour precipitation amounts are often embedded within longer duration storms associated with large-scale weather systems. For these sites, there is a greater percentage of storms at the 2-hour duration that occur in the fall and winter period (Figure 18).

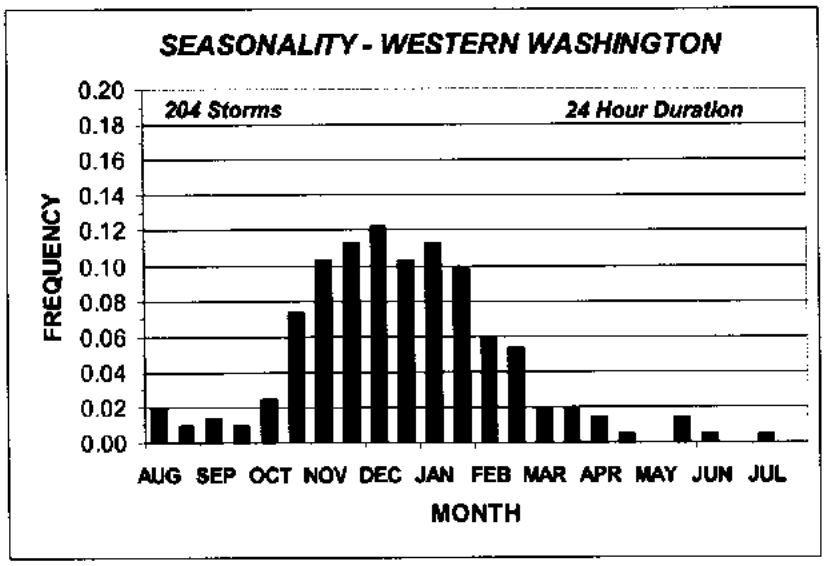


Figure 16 – Seasonality of Extreme Storms for All Climatic Regions for 24-Hour Duration

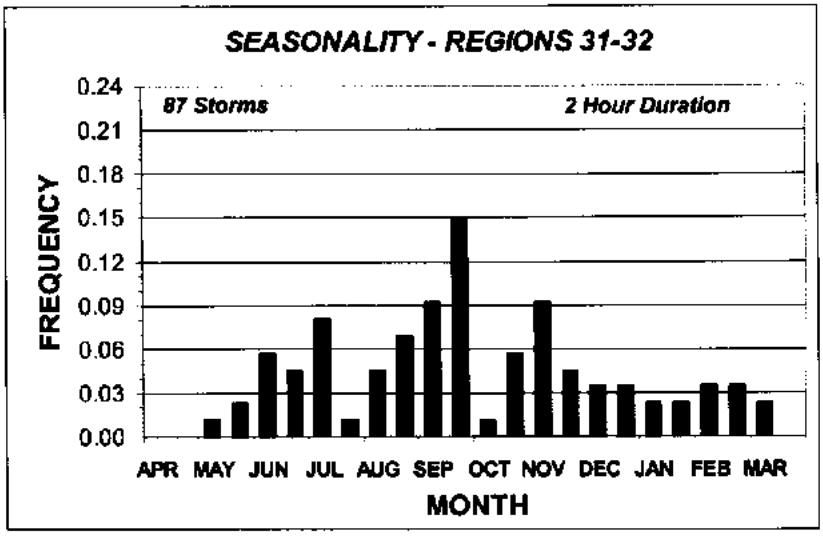


Figure 17a – Seasonality of Extreme Storms in Lowland Climatic Regions 31 and 32 for 2-Hour Duration

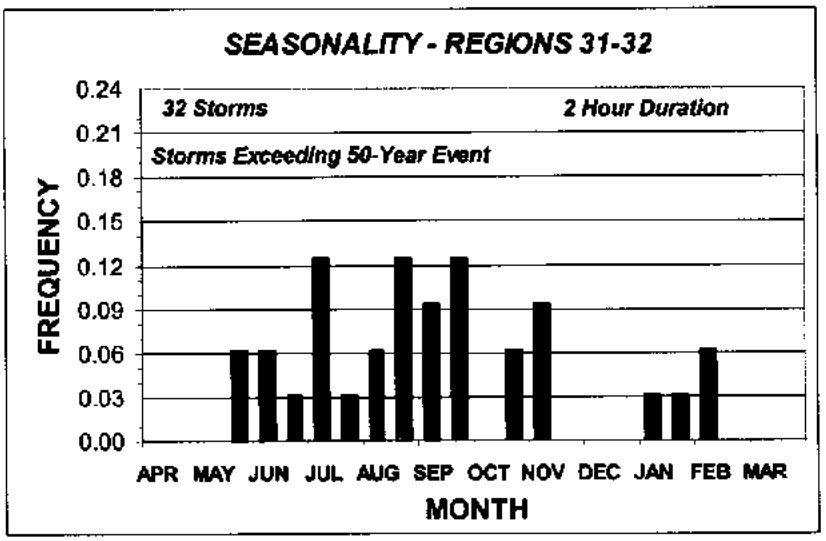


Figure 17b – Seasonality of Extreme Storms that Exceed 50-Year Event in Lowland Climatic Regions 31 and 32 for 2-Hour Duration

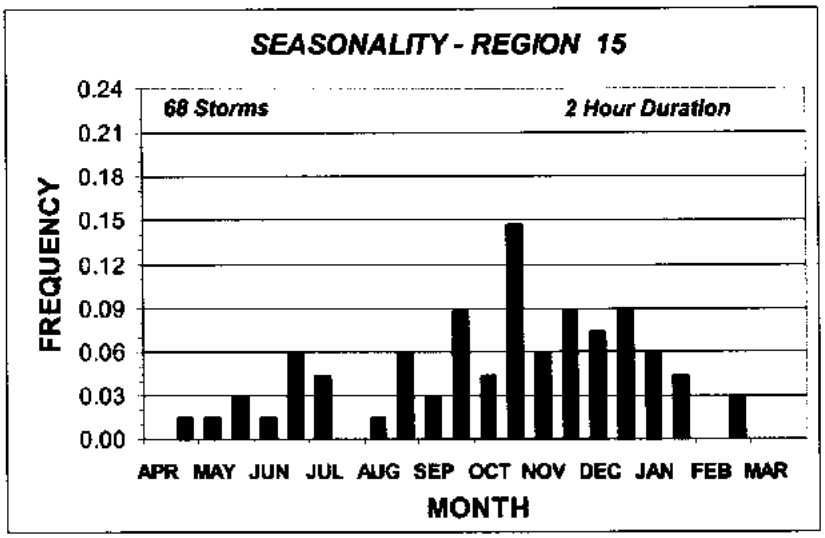


Figure 18 – Seasonality of Extreme Storms for Climatic Region 15 Windward Face of Cascade Mountains for 2-Hour Duration

CATALOG OF EXTREME STORMS

A catalog of extreme storms is contained in Appendix D. The catalog lists those storm events at the 24-hour and 2-hour durations where the annual exceedance probabilities were less than 0.05 (rarer than a 20-year event). These are the same storm events/storm dates as used in the seasonality analysis. The temporal patterns from these storms would be logical candidates for single event rainfall-runoff modeling of extreme storms.

REFERENCES

1. Cunnane C, Unbiased Plotting Positions - A Review, Journal of Hydrology, 37, 205-222, 1978.
2. Dalrymple D, Flood Frequency Analysis, USGS, Water Supply Paper 1543-A, 1960.
3. Daly C, PRISM, Parameter-Elevation Regression on Independent Slopes Model, Oregon State University, Oregon Climate Service, 1994.
4. Fiorentino MS, Gabrielle S, Rossi F and Versace P, Hierarchical Approach for Regional Frequency Analysis, *Regional Frequency Analysis*, Edited by VP Singh, pp35-49, Reidel, Norwell Massachusetts, 1979.
5. Gringorten II, A Plotting Rule for Extreme Probability Paper, Journal of Geophysical Research, 68(3), 813-814, 1963.
6. Helsel DR and Hirsch RM, Statistical Methods in Water Resources, Elsevier Studies in Environmental Science 49, NY, 1992.
7. Hosking JRM, L-Moments: Analysis and Estimation of Distributions using Linear Combinations of Order Statistics, Journal Royal Statistical Society, Ser B, 52, pp105-124, 1990.
8. Hosking JRM, and Wallis JR, A Comparison of Unbiased and Plotting Position Estimators of L-Moments, Water Resources Research, Vol 31, pp2019-2025, 1995.
9. Hosking JRM, and Wallis JR, Regional Frequency Analysis - An Approach Based on L-Moments, Cambridge Press, 1997.
10. Hosking JRM, and Wallis JR, Some Statistics Useful in Regional Frequency Analysis, Water Resources Research, Vol 29, No. 2, pp271-281, Feb 1993.
11. Hosking JRM, and Wallis JR, The Effect of Inter-Site Dependence on Regional Flood Frequency Analysis, Water Resources Research, Vol 24, pp588-600, 1988.
12. Hosking JRM, The Four Parameter KAPPA Distribution, IBM Research Report RC13412, IBM Research Yorktown Heights NY, 1988.
13. Hosking JRM, The Theory of Probability Weighted Moments, IBM Research ReportRC12210, October 1986.
14. Kuczera G, Combining Site-Specific and Regional Information: An Empirical Bayes Approach, Water Resources Research, Volume 18, No. 2, pp306-314, April 1982.
15. Langbein WB, Annual Floods and the Partial Duration Flood Series, Transaction American Geophysical Union, Vol 30, pp879-881, 1949.
16. Miller JF, Frederick RH and Tracey RS, NOAA ATLAS 2, Precipitation - Frequency Atlas of the Western United States, U.S. Dept. of Commerce, NOAA, National Weather Service, Washington DC, 1973.
17. National Research Council, Estimating Probabilities of Extreme Floods, Methods and Recommended Research, National Academy Press, Washington DC, 1988.
18. NWS, National Weather Service, Hydrometeorological Report 43, Probable Maximum Precipitation for the Pacific Northwest, U.S. Department of Commerce, NOAA, U.S. Weather Bureau, Washington DC, 1966

19. NWS, National Weather Service, Hydrometeorological Report 57, Probable Maximum Precipitation for the Pacific Northwest, U.S. Department of Commerce, NOAA, U.S. Weather Bureau, Washington,D.C., October 1994.

20. Oregon Climate Service, Mean Annual Precipitation Maps for Western United States, prepared with PRISM Model for NRCS, Corvallis Oregon, 1997.

21. Oregon Climate Service, Mean Annual Precipitation Map for Southern British Columbia, prepared with PRISM Model for Environment Canada, Corvallis Oregon, 2000.

22. Potter KW, Research on Flood Frequency Analysis, 1983-1986, U.S. National Report, International Union of Geodesy and Geophysics, 25(2), pp113-118, 1987.

23. Schaefer MG, Regional Analyses of Precipitation Annual Maxima in Washington State, Water Resources Research, Vol.26, No.1, pp119-132, January,1990.

24. Schaefer MG, Characteristics of Extreme Precipitation Events in Washington State, Washington State Dept. of Ecology, Report 89-51, October 1989.

25. Schaefer MG, Magnitude-Frequency Characteristics of Precipitation Annual Maxima in Southern British Columbia, MGS Engineering Consultants, Inc., prepared for BChydro Power Supply and Engineering, December 1997.

26. Schaefer MG and Barker BL, Precipitation Magnitude-Frequency Characteristics for the American River Watershed, prepared for US Army Corps of Engineers, Hydrologic Engineering Center, MGS Engineering Consultants, January 2000.

27. Stedinger JR, Vogel RM, and Foufoula-Georgiou E, Frequency Analysis of Extreme Events, Chapter 18, *Handbook of Hydrology*, McGraw Hill, 1992.

28. US Weather Bureau, Mean Annual Precipitation in Washington 1930-1957, Seattle Office National Weather Service. 1965.

29. Wallis JR, Personal Communication, April, 1997.

30. Wallis JR, Risk and Uncertainties in the Evaluation of Flood Events for the Design of Hydraulic Structures, in *Pienne e Siccita*, edited by E. Guggino, G. Rossi, and E. Todini, pp3-36, Fondazione Politecnica del Mediterranes, Catania, Italy, 1980.

31. Wallis JR, Hydrologic Problems Connected with Oil-Shale Development, Environmental Systems and Management, S. Rinaldi, Editor, North Holland, Amsterdam, pp. 85-102, 1982.

32. Weiss LL, Ratio of True to Fixed Interval Maximum Rainfall, Journal Hydraulics, ASCE, 90(HY1), pp77-82, 1964.

Appendix A

STATION CATALOGS

AND

ELECTRONIC FILES OF PROJECT DELIVERABLES

OVERVIEW

This appendix includes station catalogs for the stations/gages used in the study for analysis of precipitation annual maxima at the 24-hour and 2-hour durations. These listings include the station identification number, station name, type of gage, climatic region number, latitude, longitude, elevation, and mean annual precipitation. A compact disc (CD) is also included as part of this appendix that contains electronic files for all of the project deliverables. Two items of particular interest are: a listing of precipitation magnitude-frequency estimates for each of the stations for the 6-month, 2-year, 10-year, 25-year, 50-year, 100-year, and 500-year recurrence intervals; and gridded datasets of precipitation-frequency values for the recurrence intervals listed above, that can be imported into GIS software .

The CD contains files with the following contents:

- catalog of stations
- precipitation annual maxima for all gages
- catalog of extreme storms
- gridded datasets for 24-hour and 2-hour mean annual maxima (at-site means)
- gridded datasets of L-moment ratios L-Cv and L-Skewness for 24-hour and 2-hour durations
- gridded datasets of precipitation estimates for selected recurrence intervals
- precipitation magnitude-frequency estimates for selected recurrence intervals for each station
- final report and supporting graphics

Table A1 – Station Catalog of Gages Used in Analyses of Precipitation Annual Maxima at 24-Hour Duration

STATION ID	STATION NAME	STATE	LAT	LONG	ELEV (ft)	YEAR START	YEAR END	YEARS OPEN	RGN	GAGE TYPE	PRISM MAP[3,20] (in)
1100030	ABBOTSFORD A	BC	49.0333	122.3667	190	1944	1996	53	31	DY	57.8
45-0008	ABERDEEN	WA	46.9500	123.8167	10	1897	2000	104	5	DY	83.5
45-0013	ABERDEEN 20 NNE	WA	47.2667	123.7000	435	1931	2000	70	151	DY	131.0
45-0013	ABERDEEN 20 NNE	WA	47.2667	123.7000	435	1940	2000	61	151	HR	131.0
1100120	AGASSIZ CDA	BC	49.2500	121.7667	49	1889	1995	107	14	DY	67.6
1030180	ALBERNI BEAVER CREEK	BC	49.3667	124.9333	298	1894	1959	66	142	DY	97.2
45-0094	ALDER DAM CAMP	WA	46.8000	122.3167	1300	1948	1954	7	15	DY	50.2
SN-0564	ALDERWOOD WATER DIST	WA	47.8600	122.2839	620	1988	2000	13	31	DY	40.2
1020270	ALERT BAY	BC	50.5833	126.9333	193	1924	1994	71	142	DY	67.5
1100360	ALOUETTE LAKE	BC	49.2833	122.4833	383	1924	1982	59	15	DY	102.5
1100370	ALOUETTE POWER HOUSE	BC	49.3667	122.3167	298	1935	1949	15	15	DY	109.3
21B48S	ALPINE MEADOWS	WA	47.7833	121.7000	3500	1995	1999	5	15	DY	101.5
45-0176	ANACORTES	WA	48.5000	122.6000	20	1897	2000	104	31	DY	27.2
45-0242	ARIEL DAM	WA	45.9667	122.5667	220	1934	1972	39	31	DY	67.3
45-0257	ARLINGTON	WA	48.2000	122.1333	100	1936	2000	65	31	DY	47.0
35-0318	ASTOR EXPERIMENT STN	OR	46.1500	123.8167	49	1948	1973	26	5	DY	83.0
35-0324	ASTORIA	OR	46.1833	123.8333	200	1948	1960	13	5	DY	80.7
35-0328	ASTORIA AP PORT OF	OR	46.1500	123.8667	9	1953	2000	48	5	DY	77.3
35-0328	ASTORIA AP PORT OF	OR	46.1500	123.8667	9	1953	2000	48	5	HR	77.3
45-0324	AUBURN	WA	47.3167	122.2333	79	1954	1977	24	31	HR	38.5
35-0343	AURORA	OR	45.2333	122.7333	72	1951	1969	19	31	DY	40.7
45-0400	BALDY MOUNTAIN	WA	48.1000	122.7000	2190	1983	1989	7	15	HR	90.2
1030605	BAMFIELD EAST	BC	48.8333	125.1167	13	1959	1995	37	5	DY	115.2
45-0456	BARING	WA	47.7667	121.4833	760	1970	2000	31	15	DY	103.2
45-0482	BATTLE GROUND	WA	45.7667	122.5167	284	1930	2000	71	31	DY	50.3
1010720	BEAR CREEK	BC	48.5000	124.0000	1151	1910	1996	87	151	DY	122.5
35-0571	BEAR SPRINGS RS	OR	45.1167	121.5333	3360	1961	2000	40	14	HR	28.6
35-0595	BEAVERTON 2 SSW	OR	45.4500	122.8167	270	1973	2000	28	32	DY	40.2
45-0587	BELLINGHAM 3 SSW	WA	48.7167	122.5167	15	1911	2000	90	31	DY	38.0
45-0574	BELLINGHAM CAA AP	WA	48.8000	122.5333	147	1941	1952	12	31	HR	39.4
45-0574	BELLINGHAM FCWOS AP	WA	48.8000	122.5333	149	1950	2000	51	31	DY	39.4
45-0729	BLAINE	WA	49.0000	122.7500	60	1941	2000	60	31	DY	45.6
45-0729	BLAINE	WA	49.0000	122.7500	60	1941	2000	60	31	HR	45.6
21D33S	BLAZED ALDER	OR	45.4167	121.8667	3650	1981	2000	20	15	DY	114.6
20B02S	BLEWETT PASS	WA	47.3500	120.6833	4270	1982	1999	18	14	DY	33.4
1020885	BLIND CHANNEL	BC	50.4167	125.5000	9	1956	1993	38	142	DY	92.4
KI-04U	BOEING CREEK	WA	47.7508	122.3593	450	1990	2000	11	31	DY	37.8
35-0897	BONNEVILLE DAM	OR	45.6333	121.9500	62	1948	2000	53	15	DY	78.1
35-0897	BONNEVILLE DAM	OR	45.6333	121.9500	62	1940	2000	61	15	HR	78.1
45-0826	BOTHELL 2 N	WA	47.7667	122.2167	112	1948	1959	12	31	DY	39.0
45-0872	BREMERTON	WA	47.5667	122.6667	110	1899	2000	102	32	DY	51.9
35-1028	BRIGHTWOOD	OR	45.3667	122.0167	1070	1959	1982	24	15	DY	89.9
35-1033	BRIGHTWOOD 1 WNW	OR	45.3833	122.0333	978	1971	2000	30	15	HR	79.1
45-0917	BROOKLYN	WA	46.7833	123.5000	190	1928	1974	47	32	DY	81.3
45-0945	BUCKLEY 1 NE	WA	47.1667	122.0000	685	1913	2000	88	31	DY	50.5
45-0969	BUMPING LAKE	WA	46.8667	121.3000	3442	1910	1967	58	14	DY	51.7
21C38S	BUMPING RIDGE	WA	46.8167	121.3333	4600	1979	1999	21	14	DY	50.4
1101140	BUNTZEN LAKE	BC	49.3833	122.8667	32	1924	1983	60	15	DY	131.7
45-0988	BURLINGTON	WA	48.4667	122.3167	30	1941	2000	60	31	HR	36.5
1101200	BURQUITLAM VANCOUVER	BC	49.2500	122.8833	400	1926	1995	70	31	DY	69.0
35-1222	BUXTON	OR	45.6833	123.1833	355	1948	2000	53	32	HR	55.2
35-1227	BUXTON MOUNTAINDALE	OR	45.6833	123.0667	360	1948	1975	28	32	HR	53.5
1021230	CAMERON LAKE	BC	49.2833	124.5833	633	1924	1986	63	32	DY	66.8
45-1064	CAMP GRISDALE	WA	47.3667	123.6000	820	1956	1986	31	151	HR	166.4
35-1329	CANBY 2 NE	OR	45.2833	122.6667	89	1948	1979	32	31	DY	42.8
TH-1168	CAPITOL FOREST	WA	46.9215	123.0900	450	1995	2000	6	142	HR	80.0
1031402	CARMANAH POINT	BC	48.6167	124.7500	124	1968	1995	28	5	DY	120.0
45-1146	CARNATION 4 NW	WA	47.6833	121.9833	50	1941	2000	60	31	HR	49.0
45-1160	CARSON FISH HATCHERY	WA	45.8667	121.9667	1134	1977	2000	24	14	DY	102.0
45-1160	CARSON FISH HATCHERY	WA	45.8667	121.9667	1134	1977	2000	24	14	HR	102.0
35-1407	CASCADE LOCKS	OR	45.6833	121.8833	102	1948	1954	7	15	DY	89.1
45-1191	CASTLE ROCK 2 NW	WA	46.2667	122.9167	39	1954	1978	25	31	HR	47.7
45-1205	CATHLAMET 6 NE	WA	46.2667	123.3000	180	1959	2000	42	142	DY	77.3
45-1207	CATHLAMET 9 NE	WA	46.3167	123.2667	479	1948	1959	12	142	DY	80.9
45-1233	CEDAR LAKE	WA	47.4167	121.7333	1560	1931	2000	70	15	DY	106.9
45-1233	CEDAR LAKE	WA	47.4167	121.7333	1560	1953	2000	48	15	HR	106.9
45-1276	CENTRALIA	WA	46.7167	122.9500	185	1902	2000	99	31	DY	46.2
45-1277	CENTRALIA 1 W	WA	46.7000	122.9667	185	1941	2000	60	31	HR	46.1
1021480	CHATHAM POINT	BC	50.3333	125.4333	75	1958	1995	38	142	DY	86.3
1011500	CHEMAINUS	BC	48.9333	123.7333	246	1919	1995	77	32	DY	44.5
35-1552	CHERRY GROVE 2 S	OR	45.4167	123.2500	781	1948	1983	36	32	DY	54.3
1101530	CHILLIWACK	BC	49.1667	121.9333	19	1879	1995	117	14	DY	70.7

STATION ID	STATION NAME	STATE	LAT	LONG	ELEV (ft)	YEAR START	YEAR END	YEARS OPEN	RGN	GAGE TYPE	PRISM MAP[3,20] (in)
1101N65	CHILLIWACK R HATCHER	BC	49.0833	121.7000	698	1961	1995	35	15	DY	62.6
45-1414	CHIMACUM 4 S	WA	47.9500	122.7833	140	1944	2000	57	32	DY	29.2
45-1426	CHIWAWA RIVER	WA	48.0333	120.8333	2713	1935	1958	24	14	DY	35.9
45-1457	CINEBAR 2 E	WA	46.6000	122.4833	1040	1941	2000	60	15	HR	57.9
21D13S	CLACKAMAS LAKE	OR	45.0833	121.7500	3400	1981	2000	20	14	DY	56.5
45-1465	CLALLAM BAY 1 NNE	WA	48.2667	124.2500	30	1928	1976	49	142	DY	83.4
35-1643	CLATSKANIE	OR	46.1000	123.2000	22	1948	2000	53	32	DY	52.3
35-1643	CLATSKANIE	OR	46.1000	123.2000	22	1954	2000	47	32	HR	52.3
45-1504	CLE ELUM	WA	47.1833	120.9500	1920	1901	2000	100	14	DY	26.8
21D12S	CLEAR LAKE	OR	45.2000	121.7167	3500	1981	2000	20	14	DY	55.1
45-1484	CLEARBROOK	WA	48.9667	122.3333	64	1903	2000	98	31	DY	51.2
45-1496	CLEARWATER	WA	47.5833	124.3000	80	1931	2000	70	5	DY	117.6
45-1496	CLEARWATER	WA	47.5833	124.3000	80	1943	2000	58	5	HR	117.6
35-1682	CLOVERDALE	OR	45.2000	123.8833	12	1948	2000	53	5	DY	98.5
35-1735	COLTON	OR	45.1667	122.4167	680	1948	2000	53	31	HR	58.9
1021830	COMOX A	BC	49.7167	124.9000	79	1944	1996	53	142	DY	48.6
45-1679	CONCRETE PPL FISH ST	WA	48.5500	121.7667	195	1925	2000	76	15	DY	63.7
1101890	COQUITLAM LAKE	BC	49.3667	122.8000	528	1924	1982	59	15	DY	111.5
21B13S	CORRAL PASS	WA	47.0167	121.4667	6000	1982	1999	18	14	DY	70.1
45-1759	COUGAR 4 SW	WA	46.0167	122.3500	520	1941	2000	60	15	HR	67.1
45-1760	COUGAR 6 E	WA	46.0500	122.2000	859	1930	2000	71	15	DY	121.1
21B42S	COUGAR MOUNTAIN	WA	47.2500	121.6333	3200	1982	1999	18	15	DY	89.6
45-1783	COUPEVILLE 1 S	WA	48.2000	122.7000	50	1916	2000	85	31	DY	22.4
1012010	COWICHAN BAY CHERRY	BC	48.7167	123.5500	3	1913	1995	83	32	DY	41.5
1012040	COWICHAN LAKE FOREST	BC	48.8333	124.1333	580	1931	1995	65	142	DY	84.3
1102220	CULTUS LAKE	BC	49.0833	121.9833	150	1931	1994	64	14	DY	65.2
45-1934	CUSHMAN DAM	WA	47.4167	123.2167	760	1931	1973	43	142	DY	97.0
45-1934	CUSHMAN DAM	WA	47.4167	123.2167	760	1941	2000	60	142	HR	97.0
45-1939	CUSHMAN PWR HOUSE 2	WA	47.3667	123.1500	21	1973	2000	28	32	DY	67.3
45-1992	DARRINGTON RANGER ST	WA	48.2500	121.6000	550	1931	2000	70	15	DY	73.6
45-1992	DARRINGTON RANGER ST	WA	48.2500	121.6000	550	1941	2000	60	15	HR	73.6
45-2157	DIABLO DAM	WA	48.7167	121.1500	891	1931	2000	70	14	DY	69.1
45-2157	DIABLO DAM	WA	48.7167	121.1500	891	1944	2000	57	14	HR	69.1
35-2325	DILLEY 1 S	OR	45.4833	123.1167	165	1948	2000	53	32	DY	45.5
35-2348	DIXIE MOUNTAIN	OR	45.6833	122.9167	1430	1976	2000	25	32	HR	56.9
45-2220	DOTY 3 E	WA	46.6333	123.2000	260	1958	2000	43	32	DY	55.2
45-2253	DRYAD	WA	46.6333	123.2500	310	1937	1978	42	32	DY	56.3
45-2309	DUVALL 3NE	WA	47.7666	121.9333	813	1932	1954	23	31	DY	57.9
35-2493	EAGLE CREEK 9 SE	OR	45.2667	122.2000	926	1973	2000	28	15	DY	68.8
KI-14U	EAST FK ISSAQUAH CRK	WA	47.5327	121.9873	520	1988	2000	13	15	DY	79.3
45-2384	EASTON	WA	47.2333	121.1833	2170	1941	2000	60	14	HR	49.5
TH-1938	EATON CREEK	WA	46.9742	122.7300	264	1992	2000	9	31	HR	45.0
21A32S	ELBOW LAKE	WA	48.6833	121.9000	3200	1996	1999	4	15	DY	97.7
45-2493	ELECTRON HEADWORKS	WA	46.9000	122.0333	1730	1948	1980	33	15	DY	69.6
45-2493	ELECTRON HEADWORKS	WA	46.9000	122.0333	1730	1943	1980	38	15	HR	69.6
45-2500	ELK MOUNTAIN	WA	46.1333	122.4667	4480	1983	1990	8	15	HR	118.4
45-2531	ELMA	WA	47.0000	123.4000	70	1928	2000	73	32	DY	67.2
45-2548	ELWHA R S	WA	48.0333	123.5833	360	1943	2000	58	142	DY	56.3
1012700	ESQUIMALT	BC	48.4333	123.4167	45	1872	1950	79	32	DY	35.0
35-2693	ESTACADA 2 SE	OR	45.2667	122.3167	450	1948	2000	53	31	DY	62.6
35-2697	ESTACADA 24 SE	OR	45.0667	121.9667	2200	1948	2000	53	15	HR	72.2
KI-18U	EVANS CREEK	WA	47.6873	122.0305	150	1989	2000	12	31	DY	49.8
45-2675	EVERETT	WA	47.9833	122.1833	60	1930	2000	71	31	DY	37.4
45-2675	EVERETT	WA	47.9833	122.1833	60	1941	2000	60	31	HR	37.4
21B04S	FISH LAKE	WA	47.5167	121.0667	3371	1982	1999	18	14	DY	74.5
35-2997	FOREST GROVE	OR	45.5167	123.1000	180	1928	2000	73	32	DY	43.6
45-2914	FORKS 1 E	WA	47.9500	124.3500	350	1928	2000	73	151	DY	122.0
45-2964	FRANCES	WA	46.5500	123.5000	231	1941	2000	60	142	HR	97.8
45-3160	GLACIER R S	WA	48.8833	121.9500	935	1935	1983	49	15	DY	65.5
45-3160	GLACIER R S	WA	48.8833	121.9500	935	1971	2000	30	15	HR	65.5
45-3177	GLENOMA	WA	46.5167	122.1333	840	1906	2000	95	15	DY	68.0
45-3183	GLENWOOD	WA	46.0167	121.2833	1896	1941	2000	60	14	HR	34.7
35-3318	GLENWOOD 2 WNW	OR	45.6500	123.3000	644	1948	2000	53	142	HR	65.8
35-3340	GOBLE 3 SW	OR	45.9833	122.9167	530	1948	2000	53	32	HR	48.3
1033232	GOLD RIVER TOWNSITE	BC	49.7833	126.0500	383	1966	1995	30	142	DY	121.8
1013240	GOLDSTREAM LAKE	BC	48.4500	123.5500	1505	1894	1953	60	142	DY	43.7
35-3402	GOVERNMENT CAMP	OR	45.3000	121.7333	3960	1951	2000	50	15	DY	72.6
35-3402	GOVERNMENT CAMP	OR	45.3000	121.7333	3960	1955	2000	46	15	HR	72.6
35-3421	GRAND RONDE TREE FAR	OR	45.0500	123.6167	395	1948	2000	53	5	HR	56.1
45-3284	GRAPEVIEW 3 SW	WA	47.3000	122.8667	51	1931	1995	65	32	DY	53.1
45-3320	GRAYLAND	WA	46.8000	124.0833	10	1948	2000	53	5	DY	77.5
45-3333	GRAYS RIVER HATCHERY	WA	46.3833	123.5667	100	1962	2000	39	5	DY	107.4
45-3333	GRAYS RIVER HATCHERY	WA	46.3833	123.5667	100	1954	2000	47	5	HR	107.4
21C10S	GREEN LAKE	WA	46.5500	121.1667	6000	1983	1999	17	14	DY	38.4
21D01S	GREENPOINT	OR	45.6167	121.7000	3200	1980	2000	21	14	DY	57.6
45-3357	GREENWATER	WA	47.1333	121.6333	1730	1939	1981	43	15	DY	61.6
45-3357	GREENWATER	WA	47.1333	121.6333	1730	1940	1999	60	15	HR	61.6

STATION ID	STATION NAME	STATE	LAT	LONG	ELEV (ft)	YEAR START	YEAR END	YEARS OPEN	RGN	GAGE TYPE	PRISM MAP[3,20] (in)
35-3521	GRESHAM	OR	45.4833	122.4167	310	1948	2000	53	31	HR	53.0
45-3386	GROTTO	WA	47.7333	121.4167	850	1948	1970	23	15	DY	110.0
20B11S	GROUSE CAMP	WA	47.2667	120.4833	5380	1983	1999	17	14	DY	30.1
1103332	HANEY UBC RF ADMIN	BC	49.2667	122.5667	469	1962	1996	35	15	HR	88.0
KP-24	HANSVILLE-HOOD CANAL	WA	47.9064	122.5686	230	1982	2000	19	32	DY	30.1
20A05S	HARTS PASS	WA	48.7167	120.6500	6500	1982	1999	18	14	DY	54.2
20A05S	HARTS PASS 2	WA	48.7167	120.6500	6500	1991	1994	4	14	DY	54.2
35-3705	HASKINS DAM	OR	45.3000	123.3500	756	1948	2000	53	142	DY	72.6
35-3705	HASKINS DAM	OR	45.3000	123.3500	756	1948	2000	53	142	HR	72.6
35-3770	HEADWORKS PTLD WTR B	OR	45.4500	122.1500	748	1931	2000	70	15	DY	75.6
35-3770	HEADWORKS PTLD WTR B	OR	45.4500	122.1500	748	1976	2000	25	15	HR	75.6
35-3908	HILLSBORO	OR	45.5000	122.9833	160	1948	2000	53	32	DY	38.8
45-3730	HOLDEN VILLAGE	WA	48.2000	120.7833	3220	1938	2000	63	14	DY	44.5
KP-25	HOLLY BEACH	WA	47.5578	122.9775	15	1991	2000	10	32	DY	56.4
1103510	HOLLYBURN RIDGE	BC	49.3833	123.1833	3051	1954	1995	42	15	DY	112.1
35-4003	HOOD RIVER EXP STN	OR	45.6833	121.5167	500	1928	2000	73	14	DY	29.8
35-4008	HOOD RIVER TUCKER BR	OR	45.6500	121.5333	383	1941	2000	60	14	HR	30.6
1113540	HOPE A	BC	49.3667	121.4833	127	1934	1995	62	14	DY	66.8
1113540	HOPE A	BC	49.3667	121.4833	127	1947	1991	45	14	S6	66.8
1113550	HOPE KAWKAWA LAKE	BC	49.3833	121.4000	498	1910	1977	68	14	DY	62.5
1113581	HOPE SLIDE	BC	49.2833	121.2333	2211	1975	1995	21	14	DY	56.1
45-3807	HOQUIAM FCWOS AP	WA	46.9833	123.9333	12	1943	2000	58	5	DY	73.6
45-3826	HUMPTULIPS SALMON HA	WA	47.2333	123.9833	140	1987	2000	14	151	DY	93.1
45-3909	INDEX	WA	47.8167	121.5500	531	1935	1956	22	15	DY	101.5
1103660	IOCO REFINERY	BC	49.3000	122.8833	173	1916	1995	80	31	DY	73.1
1013720	JAMES ISLAND	BC	48.6000	123.3500	177	1914	1978	65	32	DY	31.9
35-4276	JEWELL WILDLIFE MEAD	OR	45.9333	123.5167	570	1954	2000	47	142	HR	94.5
1013754	JORDAN RIVER DIVERSI	BC	48.5000	124.0000	1289	1973	1996	24	151	HR	122.5
22C09S	JUNE LAKE	WA	46.1333	122.1500	3340	1983	1999	17	15	DY	111.0
45-4085	KALAMA 5 ENE	WA	46.0500	122.7500	902	1946	1967	20	15	DY	59.1
45-4084	KALAMA FALLS HATCHER	WA	46.0167	122.7167	312	1968	2000	33	15	DY	64.0
45-4169	KENT	WA	47.4000	122.2333	30	1912	2000	89	31	DY	38.7
45-4187	KEYPORT TORPEDO STN	WA	47.7000	122.6167	39	1915	1958	44	32	DY	44.2
45-4201	KID VALLEY	WA	46.3667	122.6167	689	1941	1980	40	15	DY	70.2
1034170	KILDONAN	BC	49.0000	125.0000	9	1937	1976	40	151	DY	172.7
45-4360	LA GRANDE	WA	46.8333	122.3167	961	1954	1983	30	15	DY	44.9
1104468	LADNER	BC	49.0833	123.0667	29	1878	1934	57	31	DY	44.1
1104488	LAIDLAW	BC	49.3500	121.5833	88	1977	1995	19	14	DY	80.5
45-4394	LAKE CLE ELUM	WA	47.2500	121.0667	2260	1909	1977	69	14	DY	38.9
1014493	LAKE COWICHAN	BC	48.8167	124.0500	590	1924	1995	72	142	DY	101.8
45-4406	LAKE KACHESS	WA	47.2667	121.2000	2270	1908	1977	70	14	DY	57.2
45-4414	LAKE KEECHELUS	WA	47.3167	121.3333	2480	1908	1977	70	14	DY	74.3
45-4438	LAKE SUTHERLAND	WA	48.0833	123.7000	570	1929	1976	48	142	DY	59.9
45-4446	LAKE WENATCHEE	WA	47.8333	120.7833	2005	1914	2000	87	14	DY	38.1
45-4446	LAKE WENATCHEE	WA	47.8333	120.7833	2005	1971	2000	30	14	HR	38.1
45-4454	LAKE WHATCOM	WA	48.6833	122.3000	322	1944	1954	11	15	DY	57.5
45-4486	LANDSBURG	WA	47.3833	121.9833	535	1931	2000	70	31	DY	56.0
45-4486	LANDSBURG	WA	47.3833	121.9833	535	1954	2000	47	31	HR	56.0
45-4572	LEAVENWORTH 3 S	WA	47.5500	120.6667	1128	1914	2000	87	14	DY	28.1
35-4824	LEES CAMP	OR	45.5833	123.5167	655	1948	2000	53	151	HR	113.6
45-4634	LESTER	WA	47.2000	121.4833	1630	1948	1975	28	15	HR	80.4
21C26S	LONE PINE	WA	46.2667	121.9667	3800	1982	1999	18	15	DY	92.2
45-4748	LONG BEACH EXP STN	WA	46.3667	124.0333	30	1953	2000	48	5	DY	82.6
45-4764	LONGMIRE RAINIER NPS	WA	46.7500	121.8167	2762	1909	2000	92	15	DY	84.7
45-4764	LONGMIRE RAINIER NPS	WA	46.7500	121.8167	2762	1979	2000	22	15	HR	84.7
45-4769	LONGVIEW	WA	46.1500	122.9167	12	1931	2000	70	31	DY	46.1
45-4769	LONGVIEW	WA	46.1500	122.9167	12	1954	2000	47	31	HR	46.1
21C39S	LOST HORSE	WA	46.3500	121.1167	5000	1991	1999	9	14	DY	34.6
45-4849	LUCERNE 1 N	WA	48.2333	120.6000	1200	1942	1989	48	14	HR	22.6
20A23S	LYMAN LAKE	WA	48.2000	120.9167	5900	1980	1999	20	14	DY	84.8
45-4999	MARBLEMOUNT RANGER S	WA	48.5333	121.4500	348	1941	2000	60	15	HR	69.8
45-5026	MARIETTA 3 NNW	WA	48.8333	122.6000	20	1914	1958	45	31	DY	41.2
45-5080	MATLOCK 3 W	WA	47.2333	123.4833	340	1945	1985	41	32	DY	101.3
45-5086	MATLOCK 8 S	WA	47.1500	123.4000	110	1986	2000	15	32	DY	94.3
45-5110	MAYFIELD POWER PLANT	WA	46.5000	122.5833	280	1980	2000	21	31	DY	56.7
45-5128	MAZAMA 6 SE	WA	48.5333	120.3333	1962	1948	1977	30	14	DY	23.3
45-5149	MC CHORD AFB	WA	47.1500	122.4833	290	1941	1979	39	31	HR	39.8
45-5224	MC MILLIN RESERVOIR	WA	47.1333	122.2667	579	1941	2000	60	31	DY	41.5
45-5224	MC MILLIN RESERVOIR	WA	47.1333	122.2667	579	1941	2000	60	31	HR	41.5
35-5384	MC MINNVILLE	OR	45.2167	123.1500	155	1928	2000	73	32	DY	41.6
21B59S	MEADOWS PASS	WA	47.2667	121.4667	3500	1994	1999	6	14	DY	105.0
45-5305	MERWIN DAM	WA	45.9500	122.5500	224	1934	2000	67	31	DY	67.4
45-5305	MERWIN DAM	WA	45.9500	122.5500	224	1983	1988	6	31	HR	67.4
1015105	METCHOSIN	BC	48.3833	123.5667	400	1915	1995	81	32	DY	39.9
45-5425	MINERAL 1 SW	WA	46.7167	122.1833	1470	1935	1980	46	15	DY	84.3
20A40S	MINERS RIDGE	WA	48.1667	120.9833	6200	1989	1999	11	14	DY	95.0
20A39S	MIRROR LAKE	WA	48.1500	120.6500	5600	1983	1988	6	14	DY	46.0

STATION ID	STATION NAME	STATE	LAT	LONG	ELEV (ft)	YEAR START	YEAR END	YEARS OPEN	RGN	GAGE TYPE	PRISM MAP[3,26] (in)
35-5629	MIST 1 SE	OR	45.9833	123.2500	500	1948	1958	11	32	HR	54.8
45-5488	MOCLIPS	WA	47.2167	124.2000	120	1942	1957	16	5	HR	91.9
35-5677	MOLALLA	OR	45.1500	122.5667	400	1948	1977	30	31	DY	48.1
45-5525	MONROE	WA	47.8333	121.9833	120	1929	2000	72	31	DY	49.6
45-5549	MONTESANO 1 S	WA	46.9667	123.6167	25	1948	1953	6	32	DY	77.1
45-5549	MONTESANO 1 S	WA	46.9667	123.6167	25	1954	2000	47	32	HR	77.1
21C17S	MORSE LAKE	WA	46.9000	121.4833	5400	1979	1999	21	14	DY	76.5
45-5659	MOUNT ADAMS RANGER S	WA	46.0000	121.5333	1960	1925	2000	76	14	DY	42.4
45-5659	MOUNT ADAMS RANGER S	WA	46.0000	121.5333	1960	1971	2000	30	14	HR	42.4
45-5663	MOUNT BAKER LODGE	WA	48.8667	121.6667	4150	1948	1983	36	15	HR	81.1
23B06S	MOUNT CRAG	WA	47.7500	123.0000	4050	1990	1999	10	142	DY	71.9
21B21S	MOUNT GARDNER	WA	47.3500	121.5667	3000	1994	1999	6	15	DY	102.0
45-5678	MOUNT VERNON 3 WNW	WA	48.4500	122.3667	14	1956	2000	45	31	DY	33.8
21D08S	MT HOOD TEST SITE	OR	45.3333	121.7167	5400	1981	2000	20	15	DY	116.7
45-5704	MUD MOUNTAIN DAM	WA	47.1500	121.9333	1308	1939	2000	62	15	DY	61.3
45-5704	MUD MOUNTAIN DAM	WA	47.1500	121.9333	1308	1940	2000	61	15	HR	61.3
21D35S	MUD RIDGE	OR	45.2500	121.7333	3800	1979	2000	22	14	DY	62.0
1105658	N VANC GROUSE MTN RE	BC	49.3833	123.0833	3700	1971	1995	25	15	DY	110.6
1105655	N VANCOUVER CAPILANO	BC	49.3500	123.1167	305	1955	1990	36	15	DY	88.3
35-6151	N WILLAMETTE EXP STN	OR	45.2667	122.7500	150	1963	2000	38	31	DY	40.1
1025C70	NANAIMO DEPARTURE BA	BC	49.2167	123.9500	26	1913	1992	80	32	DY	39.5
45-5774	NASELLE 2 ENE	WA	46.3667	123.7500	50	1930	2000	71	5	DY	115.0
45-5801	NEAH BAY 1 E	WA	48.3667	124.6167	10	1930	1987	58	5	DY	120.3
35-5969	NEHALEM	OR	45.7167	123.9000	75	1948	2000	53	5	HR	78.7
35-5971	NEHALEM 9 NE	OR	45.8000	123.7667	140	1969	2000	32	5	DY	109.4
1105550	NEW WESTMINSTER	BC	49.2167	122.9333	390	1874	1980	107	31	DY	63.8
45-5840	NEWHALEM	WA	48.6833	121.2500	525	1926	2000	75	14	DY	89.4
1035610	NITINAT LAKE	BC	48.7500	124.7500	26	1924	1952	29	151	DY	125.7
45-5876	NOOKSACK SALMON HATC	WA	48.9000	122.1500	410	1964	2000	37	15	HR	67.0
22D02S	NORTH FORK	OR	45.5500	122.0167	3120	1980	2000	21	15	DY	132.3
45-5932	NORTH HEAD WB	WA	46.3000	124.0833	210	1940	1953	14	5	HR	81.5
KI-51U	NORWAY	WA	47.7350	122.2083	180	1988	2000	13	31	DY	38.2
45-6011	OAKVILLE	WA	46.8333	123.2333	60	1948	1998	51	32	DY	56.9
KP-34	OLALLA	WA	47.4328	122.5731	345	1983	2000	18	32	DY	47.4
21B55S	OLALLIE MEADOWS	WA	47.3667	121.4333	3700	1982	1999	18	15	DY	110.2
45-6096	OLGA 2 SE	WA	48.6167	122.8000	80	1891	2000	110	31	DY	29.8
45-6114	OLYMPIA AIRPORT	WA	46.9667	122.9000	206	1948	2000	53	32	DY	50.7
45-6114	OLYMPIA AIRPORT	WA	46.9667	122.9000	206	1948	2000	53	32	HR	50.7
45-6109	OLYMPIA PRIEST PT PA	WA	47.0667	122.8833	30	1948	1956	9	32	DY	51.5
35-6334	OREGON CITY	OR	45.3500	122.6000	167	1948	2000	53	31	DY	47.4
35-6366	OTIS 2 NE	OR	45.0167	123.9167	150	1948	2000	53	5	DY	93.5
1035940	PACHENA POINT	BC	48.7167	125.1000	121	1924	1995	72	5	DY	127.1
45-6262	PACKWOOD	WA	46.6167	121.6667	1060	1926	2000	75	15	DY	63.3
45-6295	PALMER 3 ESE	WA	47.3000	121.8500	920	1931	2000	70	15	DY	87.9
45-6295	PALMER 3 ESE	WA	47.3000	121.8500	920	1941	2000	60	15	HR	87.9
21C35S	PARADISE	WA	46.8333	121.7167	5120	1981	1999	19	15	DY	184.7
20A12S	PARK CREEK RIDGE	WA	48.4500	120.9167	4600	1979	1999	21	14	DY	61.8
35-6466	PARKDALE 1 NNE	OR	45.5333	121.5833	1520	1928	2000	73	14	DY	34.6
21D14S	PEAVINE RIDGE	OR	45.0500	121.9333	3500	1982	2000	19	15	DY	67.1
1016120	PENDER ISLAND	BC	48.7667	123.3000	85	1924	1995	72	32	DY	32.3
21C33S	PIGTAIL PEAK	WA	46.6167	121.4167	5900	1982	1999	18	14	DY	77.1
1106180	PITT POLDER	BC	49.3000	122.6333	3	1964	1996	33	31	HR	85.3
45-6534	PLAIN	WA	47.7833	120.6333	1940	1939	2000	62	14	DY	30.0
22C01S	PLAINS OF ABRAHAM	WA	46.2167	122.1500	4400	1984	1987	4	15	DY	120.9
45-6584	POINT GRENVILLE	WA	47.3000	124.2833	100	1947	1980	34	5	DY	89.4
45-6584	POINT GRENVILLE	WA	47.3000	124.2833	100	1957	1977	21	5	HR	89.4
20B24S	POPE RIDGE	WA	47.9833	120.5667	3540	1982	1999	18	14	DY	36.9
1036205	PORT ALBERNI	BC	49.2333	124.8000	193	1917	1981	65	142	DY	81.7
1036240	PORT ALICE	BC	50.3833	127.4500	68	1924	1995	72	151	DY	148.5
45-6624	PORT ANGELES	WA	48.1000	123.4167	90	1948	2000	53	32	DY	33.5
45-6624	PORT ANGELES	WA	48.1000	123.4167	90	1941	2000	60	32	HR	33.5
1016335	PORT RENFREW	BC	48.5833	124.3333	39	1970	1995	26	151	DY	143.9
45-6678	PORT TOWNSEND	WA	48.1000	122.7500	100	1930	2000	71	32	DY	23.2
45-6678	PORT TOWNSEND	WA	48.1000	122.7500	100	1941	1970	30	32	HR	23.2
35-6751	PORTLAND INTL AIRPOR	OR	45.5833	122.6000	19	1942	2000	59	32	DY	38.1
35-6751	PORTLAND INTL AIRPOR	OR	45.5833	122.6000	19	1941	2000	60	32	HR	38.1
35-6749	PORTLAND KGW-TV	OR	45.5167	122.6833	160	1928	2000	73	32	DY	45.2
35-6749	PORTLAND KGW-TV	OR	45.5167	122.6833	160	1948	2000	53	32	HR	45.2
21C14S	POTATO HILL	WA	48.3000	121.5000	4500	1982	1999	18	14	DY	71.9
KP-15	POULSBO	WA	47.7355	122.6583	18	1988	2000	13	32	DY	43.4
45-6803	PUYALLUP 2 W EXP STN	WA	47.2000	122.3333	50	1914	1995	82	31	DY	40.6
1036570	QUATSINO	BC	50.5333	127.6500	26	1895	1995	101	142	DY	99.6
45-6846	QUILCENE 2 SW	WA	47.8167	122.9167	123	1936	2000	65	32	DY	48.6
45-6851	QUILCENE 5 SW DAM	WA	47.7833	122.9833	1028	1941	2000	60	142	HR	68.2
45-6858	QUILLAYUTE WSCMO AP	WA	47.9333	124.5500	179	1966	2000	35	5	DY	104.8
45-6858	QUILLAYUTE WSCMO AP	WA	47.9333	124.5500	179	1966	2000	35	5	HR	104.8
45-6864	QUINAULT RANGER STN	WA	47.4667	123.8500	220	1906	1977	72	151	DY	110.9

STATION ID	STATION NAME	STATE	LAT	LONG	ELEV (ft)	YEAR START	YEAR END	YEARS OPEN	RGN	GAGE TYPE	PRISM MAP[8,20] (in)
45-6864	QUINAULT RANGER STN	WA	47.4667	123.8500	220	1977	2000	24	151	HR	110.9
45-6887	RAINBOW FALLS PK 2 E	WA	46.6333	123.1833	280	1948	1963	16	32	DY	55.2
45-6892	RAINIER CARBON RIVER	WA	47.0000	121.9167	1735	1948	2000	53	15	HR	78.3
45-6898	RAINIER OHANAPECOSH	WA	46.7333	121.5667	1950	1948	2000	53	15	DY	75.5
45-6896	RAINIER OHANAPECOSH	WA	46.7333	121.5667	1950	1941	2000	60	15	HR	75.5
45-6898	RAINIER PARADISE RNG	WA	46.7833	121.7333	5427	1924	2000	77	15	DY	112.5
20A09S	RAINY PASS	WA	48.5500	120.7167	4780	1982	1999	18	14	DY	61.7
45-6909	RANDLE 1 E	WA	46.5333	121.9333	900	1930	2000	71	15	DY	56.9
45-6909	RANDLE 1 E	WA	46.5333	121.9333	900	1954	2000	47	15	HR	56.9
45-6914	RAYMOND 2 S	WA	46.6500	123.7167	30	1980	2000	21	5	DY	92.2
21D04S	RED HILL	OR	45.4667	121.7000	4400	1979	2000	22	14	DY	92.2
35-7127	REX 1 S	OR	45.3000	122.9000	515	1948	2000	53	32	DY	44.8
35-7127	REX 1 S	OR	45.3000	122.9000	515	1948	2000	53	32	HR	44.8
21B17S	REX RIVER	WA	47.3333	121.6000	4000	1996	1999	4	15	DY	100.8
45-7010	RICHARDSON 3 SE	WA	48.4333	122.8333	30	1949	1958	10	32	DY	27.2
45-7038	RIMROCK TIETON DAM	WA	46.6500	121.1333	2733	1917	1977	61	14	DY	24.4
1016780	RIVER JORDAN	BC	48.4167	124.0500	9	1908	1972	65	5	DY	119.7
1106685	ROSEDALE	BC	49.1833	121.8000	36	1967	1988	22	14	DY	65.1
45-7185	ROSS DAM	WA	48.7333	121.0500	1236	1960	2000	41	14	DY	60.4
1016940	SAANICHTON CDA	BC	48.6167	123.4167	200	1914	1995	82	32	DY	34.7
23D01S	SADDLE MOUNTAIN	OR	45.5333	123.3667	3250	1980	2000	21	142	DY	88.4
KP-12	SAKAI INTERMEDIATE SCH	WA	47.6445	122.5288	60	1991	2000	10	32	DY	43.2
19A02S	SALMON MEADOWS	WA	48.6667	119.8333	4500	1982	1999	18	99	DY	24.1
1016990	SALTSPRING ISLAND	BC	48.8500	123.5000	239	1893	1977	85	32	DY	39.0
45-7294	SAM HENRY MOUNTAIN	WA	46.5167	123.0167	1460	1983	1989	7	32	HR	58.8
45-7319	SAPPHO 8 E	WA	48.0667	124.1167	760	1948	1997	50	151	DY	91.2
45-7319	SAPPHO 8 E	WA	48.0667	124.1167	760	1940	1998	59	151	HR	91.2
21B51S	SASSE RIDGE	WA	47.3667	121.0500	4200	1984	1999	16	14	DY	60.6
45-7342	SATUS PASS 2 SSW	WA	45.9500	120.6667	2610	1956	2000	45	99	DY	22.5
35-7572	SAUVIES ISLAND	OR	45.6500	122.8333	40	1948	2000	53	32	HR	45.2
45-7379	SCENIC	WA	47.7000	121.1500	2221	1929	1970	42	14	DY	95.2
35-7586	SCOGGINS DAM 2	OR	45.4833	123.2000	360	1973	1985	13	32	DY	48.2
35-7586	SCOGGINS DAM 2	OR	45.4833	123.2000	360	1973	1985	13	32	HR	48.2
35-7641	SEASIDE	OR	45.9833	123.9167	10	1930	2000	71	5	DY	74.8
45-7459	SEATTLE JACKSON PARK	WA	47.7333	122.3333	370	1941	1986	46	31	DY	36.5
45-7470	SEATTLE SAND PT WSFO	WA	47.6833	122.2500	60	1948	2000	53	31	DY	37.5
45-7473	SEATTLE TACOMA AIRPO	WA	47.4500	122.3000	400	1948	2000	53	31	DY	37.9
45-7473	SEATTLE TACOMA AIRPO	WA	47.4500	122.3000	400	1941	2000	60	31	HR	37.9
45-7478	SEATTLE UNIV OF WASH	WA	47.6500	122.2833	95	1909	1983	75	31	DY	37.2
45-7458	SEATTLE URBAN SITE	WA	47.6500	122.3000	19	1948	1998	51	31	DY	37.0
45-7458	SEATTLE URBAN SITE	WA	47.6500	122.3000	19	1940	1998	59	31	HR	37.0
45-7483	SEATTLE WB AP	WA	47.5333	122.3000	10	1948	1965	18	31	DY	37.1
45-7483	SEATTLE WB AP	WA	47.5333	122.3000	10	1948	1967	20	31	HR	37.1
45-7507	SEDRO WOOLLEY	WA	48.5000	122.2333	60	1898	2000	103	31	DY	44.2
23D02S	SEINE CREEK	OR	45.5167	123.2833	2000	1981	2000	20	142	DY	60.0
45-7544	SEQUIM 2 E	WA	48.0833	123.0500	50	1916	2000	85	32	DY	17.3
1107200	SEYMOUR FALLS	BC	49.4333	122.9667	800	1927	1995	69	15	DY	138.0
1017230	SHAWNIGAN LAKE	BC	48.6500	123.6167	449	1911	1995	85	32	DY	45.9
22C10S	SHEEP CANYON	WA	46.1833	122.2500	4030	1981	1999	19	15	DY	113.2
45-7584	SHELTON	WA	47.2000	123.1000	22	1931	1999	69	32	DY	63.6
45-7604	SHUKSAN	WA	48.9167	121.7000	2031	1955	1974	20	15	HR	86.5
35-7823	SILVERTON	OR	45.0000	122.7667	408	1962	2000	39	31	DY	45.0
35-7823	SILVERTON	OR	45.0000	122.7667	408	1962	2000	39	31	HR	45.0
45-7657	SILVERTON	WA	48.0667	121.5667	1475	1941	1988	48	15	HR	104.4
45-7690	SKAGIT POWER PLANT	WA	48.6833	121.2500	531	1931	1959	29	14	DY	89.4
1117410	SKAGIT RIVER	BC	49.0833	121.1667	1689	1936	1955	20	14	DY	59.5
45-7696	SKAMANIA FISH HATCHE	WA	45.6167	122.2167	440	1965	2000	36	15	DY	81.9
21B60S	SKOOKUM CREEK	WA	47.6833	121.6000	3920	1996	1999	4	15	DY	94.7
45-7709	SKYKOMISH 1 ENE	WA	47.7000	121.3667	1030	1941	2000	60	15	HR	98.3
SN-7124	SMOKEY POINT FIRE STN	WA	48.1136	122.1847	100	1991	2000	10	31	DY	40.9
45-7773	SNOQUALMIE FALLS	WA	47.5333	121.8333	440	1931	2000	70	31	DY	69.0
45-7773	SNOQUALMIE FALLS	WA	47.5333	121.8333	440	1954	2000	47	31	HR	69.0
45-7781	SNOQUALMIE PASS	WA	47.4167	121.4000	3020	1931	1972	42	15	DY	100.0
45-7781	SNOQUALMIE PASS	WA	47.4167	121.4000	3020	1941	2000	60	15	HR	100.0
45-7871	SO OLYMPIC TREE FARM	WA	47.2333	123.5833	580	1945	1956	12	151	DY	115.5
1017560	SOOKE LAKE	BC	48.5167	123.7000	567	1903	1966	64	142	DY	59.5
1017563	SOOKE LAKE NORTH	BC	48.5667	123.6500	757	1966	1995	30	142	DY	57.4
21C20S	SPENCER MEADOW	WA	46.1833	121.9333	3400	1982	1999	18	15	DY	89.6
22C12S	SPIRIT LAKE	WA	46.2667	122.1667	3120	1986	1999	14	15	DY	88.1
45-7919	SPIRIT LAKE R S	WA	46.2667	122.1500	3240	1941	1958	18	15	HR	87.7
45-7987	SPRUCE	WA	47.8000	124.0667	370	1927	1981	55	151	DY	132.6
35-7466	ST HELENS RFD	OR	45.8500	122.8000	100	1976	2000	25	32	DY	43.1
45-8009	STAMPEDE PASS	WA	47.2833	121.3333	3958	1944	2000	57	14	DY	89.0
21B10S	STAMPEDE PASS	WA	47.2833	121.3333	3860	1983	1999	17	14	DY	89.0
45-8009	STAMPEDE PASS	WA	47.2833	121.3333	3958	1943	2000	58	14	HR	89.0
45-8034	STARTUP 1 E	WA	47.8667	121.7167	170	1939	2000	62	31	DY	67.0
1107680	STAVE FALLS	BC	49.2333	122.3667	360	1909	1995	87	15	DY	89.3

STATION ID	STATION NAME	STATE	LAT	LONG	ELEV (ft)	YEAR START	YEAR END	YEARS OPEN	RGN	GAGE TYPE	PRISM MAP[3,20] (in)
45-8059	STEHEKIN 4 NW	WA	48.3500	120.7167	1270	1917	2000	84	14	DY	34.6
45-8059	STEHEKIN 4 NW	WA	48.3500	120.7167	1270	1976	2000	25	14	HR	34.6
45-8089	STEVENS PASS	WA	47.7333	121.0833	4070	1939	1994	56	14	DY	84.8
21B01S	STEVENS PASS	WA	47.7333	121.0833	4070	1981	1999	19	14	DY	84.8
45-8089	STEVENS PASS	WA	47.7333	121.0833	4070	1971	2000	30	14	HR	84.8
1107710	STEVESTON	BC	49.1333	123.1833	3	1896	1995	100	31	DY	45.0
45-8115	STOCKDILL RANCH	WA	48.3667	120.3333	2200	1922	1964	43	14	DY	29.8
22C08S	STRAWBERRY LANDING	WA	46.3333	122.0500	4800	1983	1989	7	15	DY	107.4
21C13S	SURPRISE LAKES	WA	46.1000	121.7500	4250	1981	1999	19	14	DY	90.5
45-8278	TACOMA 1	WA	47.2333	122.4000	25	1935	2000	66	31	DY	38.5
1037890	TAHSIS	BC	49.9167	126.6500	16	1952	1988	37	151	DY	149.3
45-8332	TATOOSH ISLAND WB	WA	48.3833	124.7333	100	1931	1966	36	5	DY	94.4
45-8332	TATOOSH ISLAND WB	WA	48.3833	124.7333	100	1940	1966	27	5	HR	94.4
35-8466	THREE LYNX	OR	45.1167	122.0667	1120	1931	2000	70	15	DY	72.0
35-8466	THREE LYNX	OR	45.1167	122.0667	1120	1971	2000	30	15	HR	72.0
20A07S	THUNDER BASIN	WA	48.5167	120.9833	4200	1988	1999	12	14	DY	99.2
45-8442	TIETON INTAKE	WA	46.6667	121.0000	2280	1920	1972	53	99	DY	20.0
35-8494	TILLAMOOK 1 W	OR	45.4500	123.8667	10	1948	2000	53	5	DY	88.3
35-8504	TILLAMOOK 12 ESE	OR	45.4000	123.5833	420	1949	2000	52	151	HR	112.5
35-8505	TILLAMOOK 13 ENE	OR	45.5500	123.6000	390	1970	1978	9	151	DY	117.6
35-8522	TIMBER	OR	45.7167	123.3000	940	1948	1976	29	142	DY	65.8
21B20S	TINKHAM CREEK	WA	47.3167	121.4667	3070	1994	1999	6	15	DY	114.3
45-8500	TOLEDO	WA	46.4667	122.8333	325	1950	2000	51	32	DY	44.1
45-8508	TOLT SOUTH FORK RESE	WA	47.7000	121.7833	1800	1963	2000	38	15	DY	77.5
20B25S	TROUGH	WA	47.2333	120.3167	5300	1979	1999	21	14	DY	28.1
35-8634	TROUTDALE SUBSTATION	OR	45.5500	122.4000	29	1948	2000	53	31	DY	45.6
45-8688	UNDERWOOD 4 W	WA	45.7333	121.6000	1260	1941	1962	22	14	HR	43.0
45-8715	UPPER BAKER DAM	WA	48.6500	121.6833	690	1960	2000	41	15	DY	77.6
45-8715	UPPER BAKER DAM	WA	48.6500	121.6833	690	1965	2000	36	15	HR	77.6
KI-25U	UPPER ISSAQUAH CREEK	WA	47.4123	121.9263	750	1988	2000	13	31	DY	66.7
20B07S	UPPER WHEELER	WA	47.2833	120.3667	4400	1982	1999	18	99	DY	28.3
45-8773	VANCOUVER 4 NNE	WA	45.6667	122.6500	210	1898	2000	103	31	DY	41.5
1108446	VANCOUVER HARBOUR CS	BC	49.3000	123.1167	3	1925	1995	71	31	DY	64.2
45-8778	VANCOUVER INTERSTATE	WA	45.6167	122.6667	2	1949	1959	11	31	DY	39.5
1108447	VANCOUVER INT'L A	BC	49.1833	123.1667	6	1937	1995	59	31	DY	50.2
1108447	VANCOUVER INT'L A	BC	49.1833	123.1667	6	1947	1995	49	31	S6	50.2
45-8802	VASHON ISLAND	WA	47.4500	122.5000	230	1915	1955	41	32	DY	43.5
45-8838	VERLOT	WA	48.1000	121.7833	975	1971	2000	30	15	HR	110.3
35-8884	VERNONIA 2	OR	45.8500	123.1833	625	1948	2000	53	32	DY	52.7
35-8884	VERNONIA 2	OR	45.8500	123.1833	625	1954	2000	47	32	HR	52.7
1018610	VICTORIA GONZALES HT	BC	48.4167	123.3167	229	1898	1995	98	32	DY	30.0
1018620	VICTORIA INT'L A	BC	48.6500	123.4333	62	1940	1996	57	32	DY	35.0
1018620	VICTORIA INT'L A	BC	48.6500	123.4333	62	1947	1995	49	32	S8	35.0
35-9051	WARREN	OR	45.8167	122.8500	79	1950	1976	27	32	DY	44.2
45-8999	WASHOUGAL 8 NE	WA	45.6000	122.1833	761	1950	1965	16	15	DY	72.0
45-9021	WAUNA 3 W	WA	47.3667	122.7000	17	1939	2000	62	32	DY	50.8
21A31S	WELLS CREEK	WA	48.8500	121.7833	4200	1996	1999	4	15	DY	99.1
35-9206	WEST LINN	OR	45.3333	122.6500	70	1948	1969	22	31	DY	47.6
45-9112	WESTPORT 2 S	WA	46.8667	124.1000	20	1940	2000	61	5	HR	76.2
21C28S	WHITE PASS E.S.	WA	46.6333	121.3833	4500	1981	1999	19	14	DY	77.5
45-9171	WHITE RIVER R S	WA	46.9000	121.5500	3500	1949	1976	28	15	DY	71.7
45-9171	WHITE RIVER R S	WA	46.9000	121.5500	3500	1944	1981	38	15	HR	71.7
1108910	WHITE ROCK CAMPBELL	BC	49.0167	122.7833	49	1929	1995	67	31	DY	48.8
35-9372	WILLAMINA	OR	45.0667	123.4833	230	1948	2000	53	32	DY	48.5
45-9291	WILLAPA HARBOR	WA	46.6833	123.7500	10	1910	1980	71	5	DY	88.1
45-9295	WILLARD FISH LAB	WA	45.7667	121.6333	770	1962	1976	15	14	HR	59.0
45-9342	WIND RIVER	WA	45.8000	121.9333	1150	1911	1977	67	15	DY	101.5
45-9358	WINTERS MOUNTAIN	WA	48.4500	122.3167	3650	1983	1989	7	15	HR	78.1
45-9376	WINTHROP 1 WSW	WA	48.4667	120.1833	1755	1906	2000	95	99	DY	13.7
45-9485	YELM	WA	46.9500	122.6000	351	1941	1979	39	31	HR	42.7

Table A2 – Station Catalog of Gages Used in Analyses of Precipitation Annual Maxima at 2-Hour Duration

STATION ID	STATION NAME	STATE	LAT	LONG	ELEV (ft)	YEAR START	YEAR END	YEARS OPEN	RGN	GAGE TYPE	PRISM MAP[3,20] (in)
1100030	ABBOTSFORD A	BC	49.0333	122.3667	190	1876	1996	21	31	HR	57.8
45-0013	ABERDEEN 20 NNE	WA	47.2667	123.7000	435	1940	2000	61	151	HR	131.0
1100120	AGASSIZ CDA	BC	49.2500	121.7667	49	1960	1990	31	14	HR	67.6
1030426	AMPHITRITE POINT	BC	48.9167	125.5500	88	1980	1996	17	5	HR	130.3
35-0328	ASTORIA AP PORT OF	OR	46.1500	123.8667	9	1953	2000	48	5	HR	77.3
45-0324	AUBURN	WA	47.3167	122.2333	79	1954	1977	24	31	HR	38.5
45-0400	BALDY MOUNTAIN	WA	46.1000	122.7000	2190	1983	1989	7	15	HR	90.2
35-0571	BEAR SPRINGS RS	OR	45.1167	121.5333	3360	1961	2000	40	14	HR	28.5
45-0574	BELLINGHAM CAA AP	WA	48.8000	122.5333	147	1941	1952	12	31	HR	39.4
45-0729	BLAINE	WA	49.0000	122.7500	60	1941	2000	60	31	HR	45.6
35-0897	BONNEVILLE DAM	OR	45.6333	121.9500	62	1940	2000	61	15	HR	78.1
35-1033	BRIGHTWOOD 1 WNW	OR	45.3833	122.0333	978	1971	2000	30	15	HR	79.1
1101140	BUNTZEN LAKE	BC	49.3833	122.8667	32	1969	1983	15	15	HR	131.7
45-0986	BURLINGTON	WA	48.4667	122.3167	30	1941	2000	60	31	HR	36.5
110JA54	BURNABY MTN BCHPA	BC	49.2833	122.9167	1525	1974	1992	19	15	HR	71.0
35-1222	BUXTON	OR	45.6833	123.1833	355	1948	2000	53	32	HR	55.2
35-1227	BUXTON MOUNTAINDALE	OR	45.6833	123.0667	360	1948	1975	28	32	HR	53.5
45-1064	CAMP GRISDALE	WA	47.3667	123.6000	820	1956	1986	31	151	HR	166.4
TH-1168	CAPITOL FOREST	WA	46.9215	123.0900	450	1995	2000	6	142	HR	80.0
45-1146	CARNATION 4 NW	WA	47.6833	121.9833	50	1941	2000	60	31	HR	49.0
1031413	CARNATION CREEK CDF	BC	48.9000	125.0000	200	1975	1986	12	5	HR	130.7
45-1160	CARSON FISH HATCHERY	WA	45.8667	121.9667	1134	1977	2000	24	14	HR	102.0
45-1191	CASTLE ROCK 2 NW	WA	46.2667	122.9167	39	1954	1978	25	31	HR	47.7
45-1233	CEDAR LAKE	WA	47.4167	121.7333	1560	1953	2000	48	15	HR	106.9
45-1277	CENTRALIA 1 W	WA	46.7000	122.9667	185	1941	2000	60	31	HR	46.1
45-1457	CINEBAR 2 E	WA	46.6000	122.4833	1040	1941	2000	60	15	HR	57.9
35-1643	CLATSKANIE	OR	46.1000	123.2000	22	1954	2000	47	32	HR	52.3
45-1496	CLEARWATER	WA	47.5833	124.3000	80	1943	2000	58	5	HR	117.6
35-1735	COLTON	OR	45.1667	122.4167	680	1948	2000	53	31	HR	58.9
1021830	COMOX A	BC	49.7167	124.9000	78	1962	1996	35	142	HR	48.6
1101890	COQUITLAM LAKE	BC	49.3667	122.8000	528	1970	1982	13	15	HR	111.5
45-1759	COUGAR 4 SW	WA	46.0167	122.3500	520	1941	2000	60	15	HR	67.1
1021990	COURTENAY PUNTLEDGE	BC	49.6833	125.0333	78	1964	1995	32	32	HR	53.7
45-1934	CUSHMAN DAM	WA	47.4167	123.2167	760	1941	2000	60	142	HR	97.0
45-1992	DARRINGTON RANGER ST	WA	48.2500	121.6000	550	1941	2000	60	15	HR	73.6
45-2157	DIABLO DAM	WA	48.7167	121.1500	891	1944	2000	57	14	HR	69.1
35-2348	DIXIE MOUNTAIN	OR	45.6833	122.9167	1430	1976	2000	25	32	HR	66.9
KI-14U	EAST FORK ISSAQUAH CK	WA	47.5327	121.9873	520	1988	2000	13	15	DY	79.3
45-2384	EASTON	WA	47.2333	121.1833	2170	1941	2000	60	14	HR	49.5
TH-1938	EATON CREEK	WA	46.9742	122.7300	264	1992	2000	9	31	HR	45.0
45-2493	ELECTRON HEADWORKS	WA	46.9000	122.0333	1730	1943	1980	38	15	HR	69.6
45-2500	ELK MOUNTAIN	WA	46.1333	122.4667	4480	1983	1990	8	15	HR	118.4
35-2697	ESTACADA 24 SE	OR	45.0667	121.9667	2200	1948	2000	53	15	HR	72.2
45-2675	EVERETT	WA	47.9833	122.1833	60	1941	2000	60	31	HR	37.4
45-2984	FRANCES	WA	46.5500	123.5000	231	1941	2000	60	142	HR	97.8
45-3160	GLACIER R S	WA	48.8833	121.9500	935	1971	2000	30	15	HR	65.5
45-3183	GLENWOOD	WA	46.0167	121.2833	1896	1941	2000	60	14	HR	34.7
35-3318	GLENWOOD 2 WNW	OR	45.6500	123.3000	644	1948	2000	53	142	HR	65.8
35-3340	GOBLE 3 SW	OR	45.9833	122.9167	530	1948	2000	53	32	HR	48.3
35-3402	GOVERNMENT CAMP	OR	45.3000	121.7333	3980	1955	2000	46	15	HR	72.6
35-3421	GRAND RONDE TREE FAR	OR	45.0500	123.6167	395	1948	2000	53	5	HR	56.1
45-3333	GRAYS RIVER HATCHERY	WA	46.3833	123.5667	100	1954	2000	47	5	HR	107.4
45-3357	GREENWATER	WA	47.1333	121.6333	1730	1940	1999	60	15	HR	61.6
35-3521	GRESHAM	OR	45.4833	122.4167	310	1948	2000	53	31	HR	53.0
1103328	HANEY MICROWAVE	BC	49.2000	122.5167	1049	1963	1984	22	15	HR	74.9
1103332	HANEY UBC RF ADMIN	BC	49.2667	122.5667	469	1962	1996	35	15	HR	88.0
35-3705	HASKINS DAM	OR	45.3000	123.3500	756	1948	2000	53	142	HR	72.6
35-3770	HEADWORKS PTLD WTR B	OR	45.4500	122.1500	748	1976	2000	25	15	HR	75.6
35-4008	HOOD RIVER TUCKER BR	OR	45.6500	121.5333	383	1941	2000	60	14	HR	30.6
1113540	HOPE A	BC	49.3667	121.4833	127	1963	1995	33	14	HR	66.8
35-4276	JEWELL WILDLIFE MEAD	OR	45.9333	123.5167	570	1954	2000	47	142	HR	94.5
1013754	JORDAN RIVER DIVERSI	BC	48.5000	124.0000	1269	1973	1996	24	151	HR	122.5
45-4446	LAKE WENATCHEE	WA	47.8333	120.7833	2005	1971	2000	30	14	HR	38.1
45-4486	LANDSBURG	WA	47.3833	121.9833	535	1954	2000	47	31	HR	56.0
1104555	LANGLEY LOCHIEL	BC	49.0500	122.5833	331	1971	1986	16	31	HR	59.6
35-4824	LEES CAMP	OR	45.5833	123.5167	655	1948	2000	53	151	HR	113.6
45-4634	LESTER	WA	47.2000	121.4833	1630	1948	1975	28	15	HR	80.4
45-4764	LONGMIRE RAINIER NPS	WA	46.7500	121.8167	2762	1979	2000	22	15	HR	84.7
45-4769	LONGVIEW	WA	46.1500	122.9167	12	1954	2000	47	31	HR	46.1
45-4849	LUCERNE 1 N	WA	48.2333	120.6000	1200	1942	1989	48	14	HR	22.6
45-4999	MARBLEMOUNT RANGER S	WA	48.5333	121.4500	348	1941	2000	60	15	HR	69.8
45-5149	MC CHORD AFB	WA	47.1500	122.4833	290	1941	1979	39	31	HR	39.8

STATION ID	STATION NAME	STATE	LAT	LONG	ELEV (ft)	YEAR START	YEAR END	YEARS OPEN	RGN	GAGE TYPE	PRISM MAP[3,20] (in)
45-5224	MC MILLIN RESERVOIR	WA	47.1333	122.2667	579	1941	2000	60	31	HR	41.5
1045100	MERRY ISLAND	BC	49.4667	123.9167	26	1977	1996	20	31	HR	44.9
45-5305	MERWIN DAM	WA	45.9500	122.5500	224	1983	1988	6	31	HR	67.4
1105192	MISSION WEST ABBEY	BC	49.1500	122.2667	725	1962	1996	35	31	HR	73.1
35-5629	MIST 1 SE	OR	45.9833	123.2500	500	1948	1958	11	32	HR	54.8
45-5488	MOCLIPS	WA	47.2167	124.2000	120	1942	1957	16	5	HR	91.9
45-5549	MONTESANO 1 S	WA	46.9667	123.6167	25	1954	2000	47	32	HR	77.1
45-5659	MOUNT ADAMS RANGER S	WA	46.0000	121.5333	1960	1971	2000	30	14	HR	42.4
45-5663	MOUNT BAKER LODGE	WA	48.8667	121.6667	4150	1948	1983	36	15	HR	81.1
45-5704	MUD MOUNTAIN DAM	WA	47.1500	121.9333	1308	1940	2000	61	15	HR	61.3
1025370	NANAIMO A	BC	49.0500	123.8667	91	1985	1996	12	32	HR	44.4
10253G0	NANAIMO CITY YARD	BC	49.1833	123.9833	374	1979	1996	18	32	HR	42.1
35-5969	NEHALEM	OR	45.7167	123.9000	75	1948	2000	53	5	HR	78.7
45-5876	NOOKSACK SALMON HATC	WA	48.9000	122.1500	410	1964	2000	37	15	HR	67.0
1015628	NORTH COWICHAN	BC	48.8333	123.7167	150	1973	1995	23	32	HR	45.9
45-5932	NORTH HEAD WB	WA	46.3000	124.0833	210	1940	1953	14	5	HR	81.5
45-6114	OLYMPIA AIRPORT	WA	46.9667	122.9000	206	1948	2000	53	32	HR	50.7
45-6295	PALMER 3 ESE	WA	47.3000	121.8500	920	1941	2000	60	15	HR	67.9
110FAG9	PITT MEADOWS STP	BC	49.2167	122.6833	16	1974	1993	20	31	HR	70.2
1106180	PITT POLDER	BC	49.3000	122.6333	3	1964	1996	33	31	HR	85.3
45-6584	POINT GRENVILLE	WA	47.3000	124.2833	100	1957	1977	21	5	HR	89.4
1036206	PORT ALBERNI A	BC	49.2500	124.8833	6	1989	1995	27	142	HR	81.7
45-6624	PORT ANGELES	WA	48.1000	123.4167	90	1941	2000	60	32	HR	33.5
1106256	PORT COQUITLAM CITY	BC	49.2667	122.7833	22	1971	1990	20	31	HR	78.3
1046330	PORT MELLON	BC	49.5167	123.4833	26	1964	1975	12	15	HR	114.3
1108CL2	PORT MOODY GLENAYRE	BC	49.2833	122.8833	426	1970	1996	27	31	HR	71.0
45-6678	PORT TOWNSEND	WA	48.1000	122.7500	100	1941	1970	30	32	HR	23.2
35-6751	PORTLAND INTL AIRPOR	OR	45.5833	122.6000	19	1941	2000	60	32	HR	38.1
35-6749	PORTLAND KGW-TV	OR	45.5167	122.6833	160	1948	2000	53	32	HR	45.2
45-6851	QUILCENE 5 SW DAM	WA	47.7833	122.9833	1028	1941	2000	60	142	HR	68.2
45-6858	QUILLAYUTE WSCMO AP	WA	47.9333	124.5500	179	1966	2000	35	5	HR	104.8
45-6864	QUINAULT RANGER STN	WA	47.4667	123.8500	220	1977	2000	24	151	HR	110.9
45-6892	RAINIER CARBON RIVER	WA	47.0000	121.9167	1735	1948	2000	53	15	HR	78.3
45-6896	RAINIER OHANAPECOSH	WA	46.7333	121.5667	1950	1941	2000	60	15	HR	75.5
45-6909	RANDLE 1 E	WA	46.5333	121.9333	900	1954	2000	47	15	HR	56.9
35-7127	REX 1 S	OR	45.3000	122.9000	515	1948	2000	53	32	HR	44.8
1016942	SAANICH DENSMORE	BC	48.5000	123.4000	193	1963	1974	12	32	HR	34.8
45-7294	SAM HENRY MOUNTAIN	WA	46.5167	123.0167	1460	1983	1989	7	32	HR	58.8
45-7319	SAPPHO 8 E	WA	48.0667	124.1167	760	1940	1998	59	151	HR	91.2
35-7572	SAUVIES ISLAND	OR	45.6500	122.8333	40	1948	2000	53	32	HR	45.2
35-7586	SCOGGINS DAM 2	OR	45.4833	123.2000	360	1973	1985	13	32	HR	48.2
45-7473	SEATTLE TACOMA AIRPO	WA	47.4500	122.3000	400	1941	2000	60	31	HR	37.9
45-7458	SEATTLE URBAN SITE	WA	47.6500	122.3000	19	1940	1998	59	31	HR	37.0
45-7463	SEATTLE WB AP	WA	47.5333	122.3000	10	1948	1967	20	31	HR	37.1
45-7604	SHUKSAN	WA	48.9167	121.7000	2031	1955	1974	20	15	HR	86.5
35-7823	SILVERTON	OR	45.0000	122.7667	408	1962	2000	39	31	HR	45.0
45-7657	SILVERTON	WA	48.0667	121.5667	1475	1941	1988	48	15	HR	104.4
45-7709	SKYKOMISH 1 ENE	WA	47.7000	121.3667	1030	1941	2000	60	15	HR	98.3
45-7773	SNOQUALMIE FALLS	WA	47.5333	121.8333	440	1954	2000	47	31	HR	69.0
45-7781	SNOQUALMIE PASS	WA	47.4167	121.4000	3020	1941	2000	60	15	HR	100.0
45-7919	SPIRIT LAKE R S	WA	46.2667	122.1500	3240	1941	1958	18	15	HR	87.7
45-8009	STAMPEDE PASS	WA	47.2833	121.3333	3958	1943	2000	58	14	HR	89.0
45-8059	STEHEKIN 4 NW	WA	48.3500	120.7167	1270	1976	2000	25	14	HR	34.6
45-8089	STEVENS PASS	WA	47.7333	121.0833	4070	1971	2000	30	14	HR	84.8
1107873	SURREY KWANTLEN PARK	BC	49.2000	122.8667	305	1962	1996	35	31	HR	62.8
45-8332	TATOOSH ISLAND WB	WA	48.3833	124.7333	100	1940	1966	27	5	HR	94.4
35-8466	THREE LYNX	OR	45.1167	122.0667	1120	1971	2000	30	15	HR	72.0
35-8504	TILLAMOOK 12 ESE	OR	45.4000	123.5833	420	1949	2000	52	151	HR	112.5
1036205	TOFINO A	BC	49.0833	125.7667	79	1970	1996	27	5	HR	128.4
45-8688	UNDERWOOD 4 W	WA	45.7333	121.6000	1260	1941	1962	22	14	HR	43.0
45-8715	UPPER BAKER DAM	WA	48.6500	121.6833	690	1965	2000	36	15	HR	77.6
1108446	VANCOUVER HARBOUR CS	BC	49.3000	123.1167	3	1976	1995	20	31	HR	64.2
1108447	VANCOUVER INT'L A	BC	49.1833	123.1667	8	1960	1996	37	31	HR	50.2
1108487	VANCOUVER UBC	BC	49.2500	123.2500	285	1960	1990	31	31	HR	52.1
45-8838	VERLOT	WA	48.1000	121.7833	975	1971	2000	30	15	HR	110.3
35-8884	VERNONIA 2	OR	45.8500	123.1833	625	1954	2000	47	32	HR	52.7
1018610	VICTORIA GONZALES HT	BC	48.4167	123.3167	229	1960	1988	29	32	HR	30.0
1018620	VICTORIA INT'L A	BC	48.6500	123.4333	62	1964	1982	19	32	HR	35.0
45-9112	WESTPORT 2 S	WA	46.8667	124.1000	20	1940	2000	61	5	HR	76.2
45-9171	WHITE RIVER R S	WA	46.9000	121.5500	3500	1944	1981	38	15	HR	71.7
1108914	WHITE ROCK STP	BC	49.0167	122.7667	49	1964	1996	33	31	HR	48.8
45-9295	WILLARD FISH LAB	WA	45.7667	121.6333	770	1962	1976	15	14	HR	59.0
45-9358	WINTERS MOUNTAIN	WA	46.4500	122.3167	3650	1983	1989	7	15	HR	78.1
45-9485	YELM	WA	46.9500	122.6000	351	1941	1979	39	31	HR	42.7

OVERVIEW

This appendix contains isopluvial maps of the 2-year, 10-year, 25-year, 50-year, and 100-year precipitation for the 24-hour and 2-hour durations. An isopluvial map for the 6-month recurrence interval (twice-year) is also depicted for the 24-hour duration. Estimates of precipitation for 6-month and 2-year recurrence intervals were made using standard conversions developed by Langbein[15,27] for conversion from annual maxima to partial duration series equivalents. Gridded datasets used to create these maps are contained on the Compact Disc (CD) described in Appendix A. Electronic files of the graphic images (jpeg files) contained in this appendix are also included on the CD.

6-month 24-hour Precipitation, Western Washington

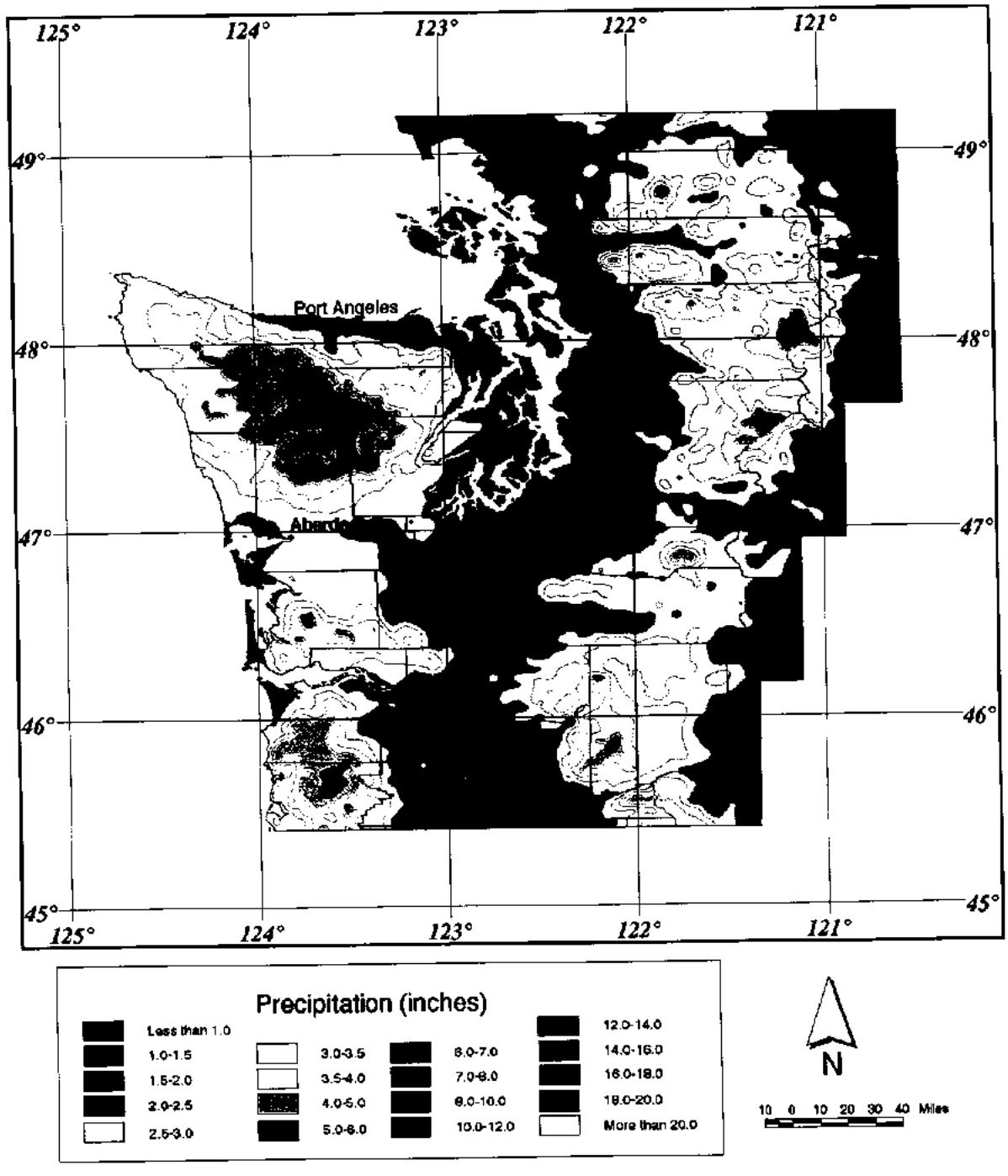


Figure B1 – Isopluvial Map of 24-Hour Precipitation for 6-Month Recurrence Interval for Western Washington

2-year 24-hour Precipitation, Western Washington

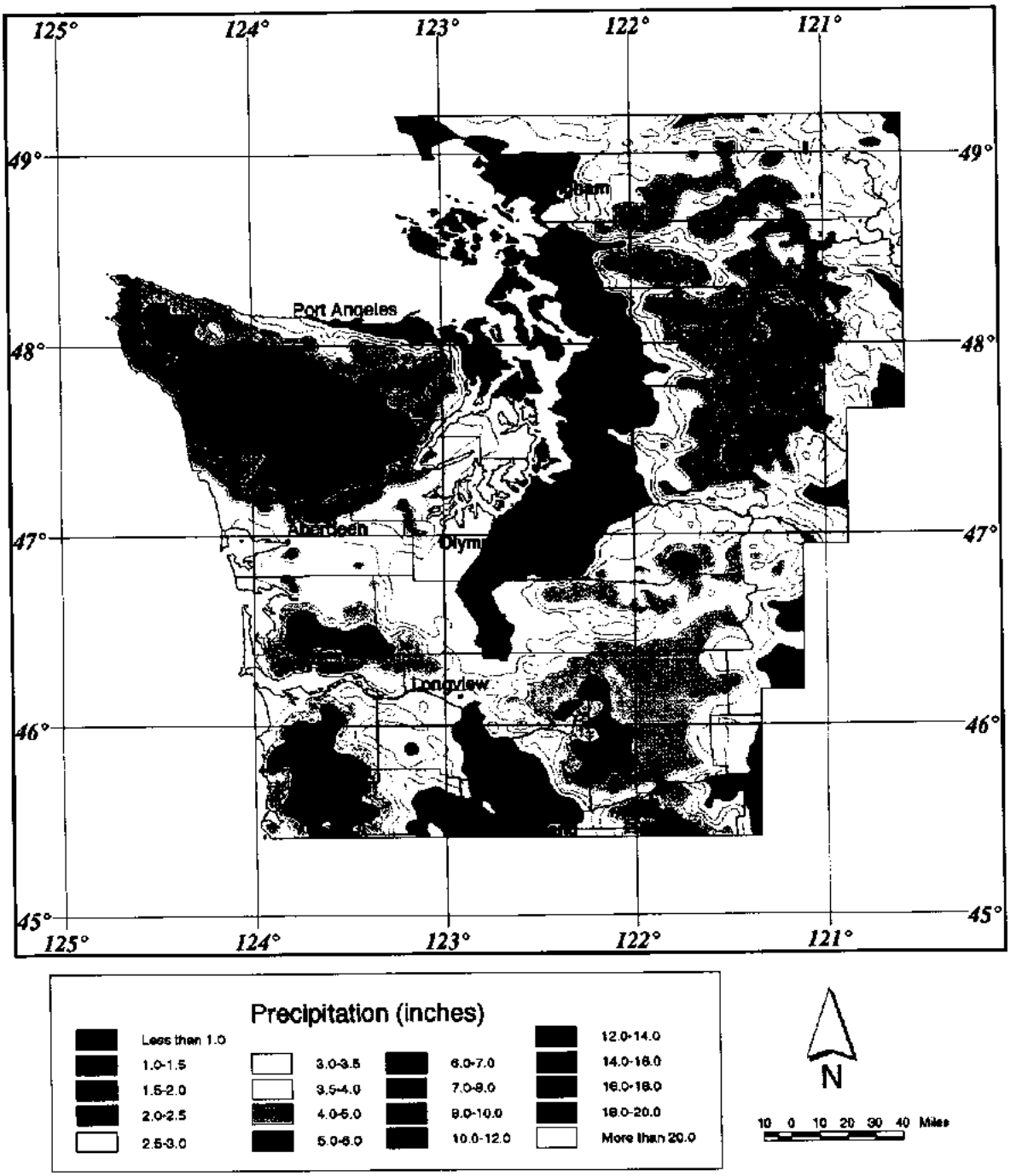


Figure B2 – Isopluvial Map of 24-Hour Precipitation for 2-Year Recurrence Interval for Western Washington

10-year 24-hour Precipitation, Western Washington

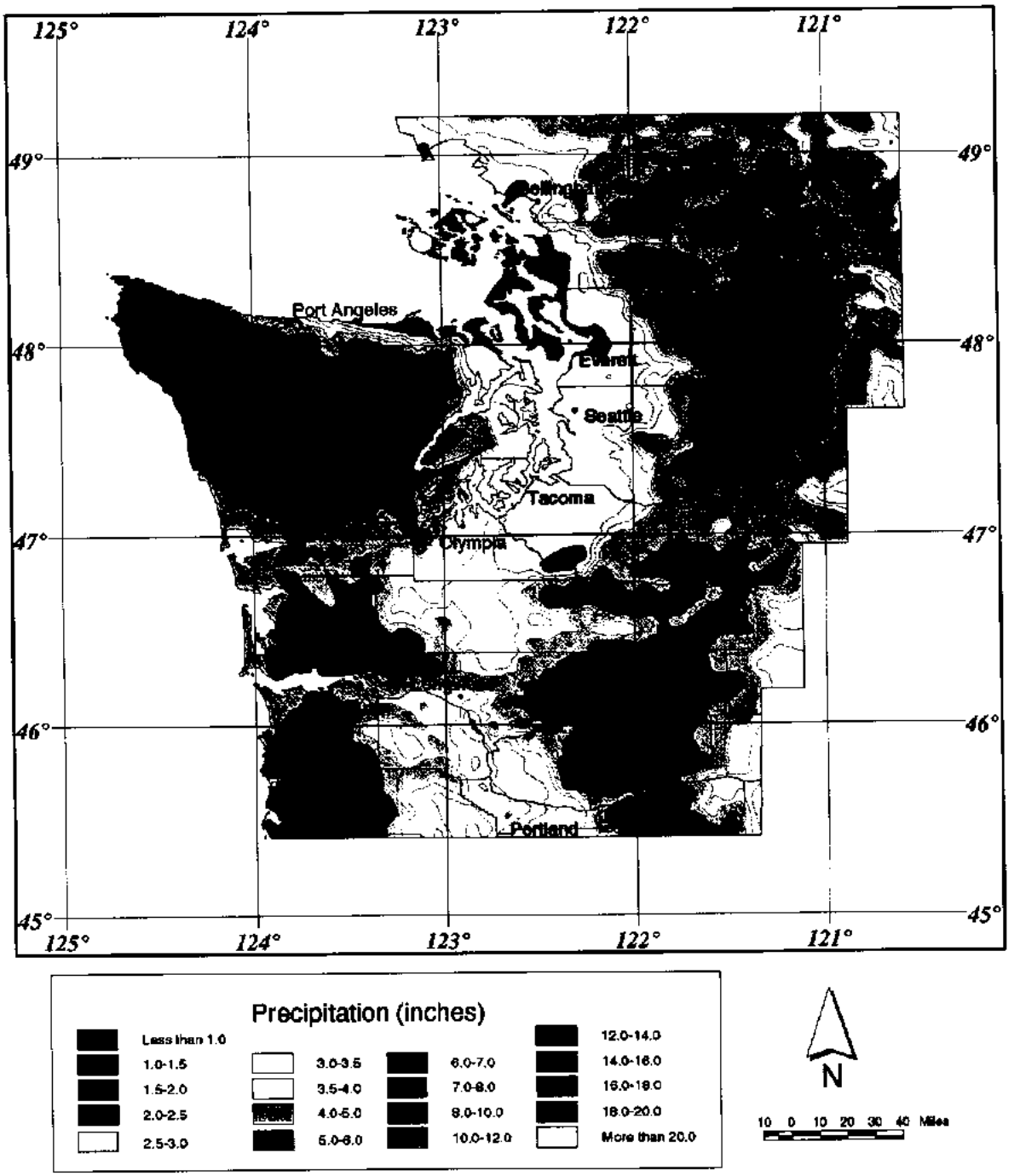


Figure B3 – Isopluvial Map of 24-Hour Precipitation for 10-Year Recurrence Interval for Western Washington

25-year 24-hour Precipitation, Western Washington

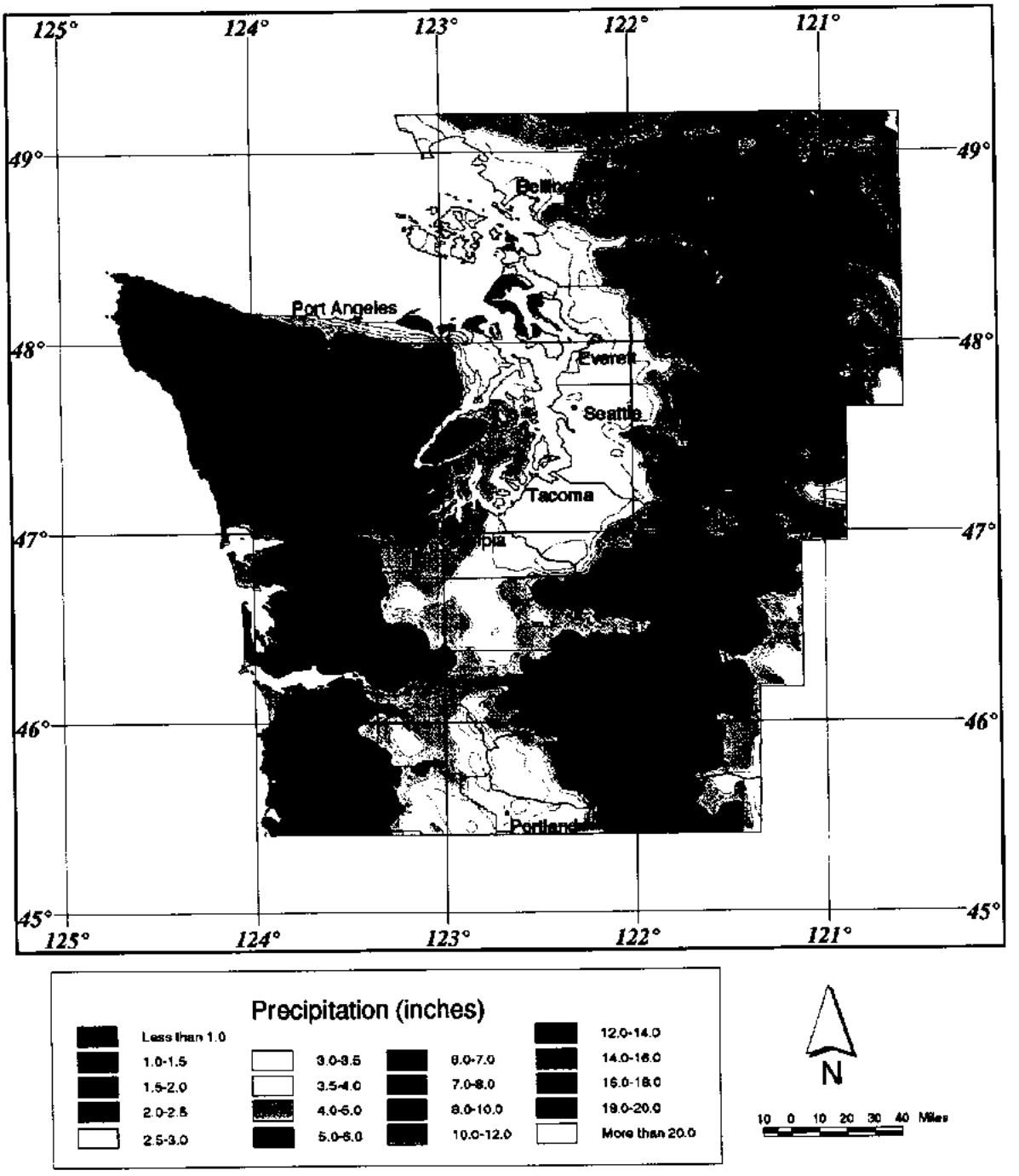


Figure B4 – Isopluvial Map of 24-Hour Precipitation for 25-Year Recurrence Interval for Western Washington

50-year 24-hour Precipitation, Western Washington

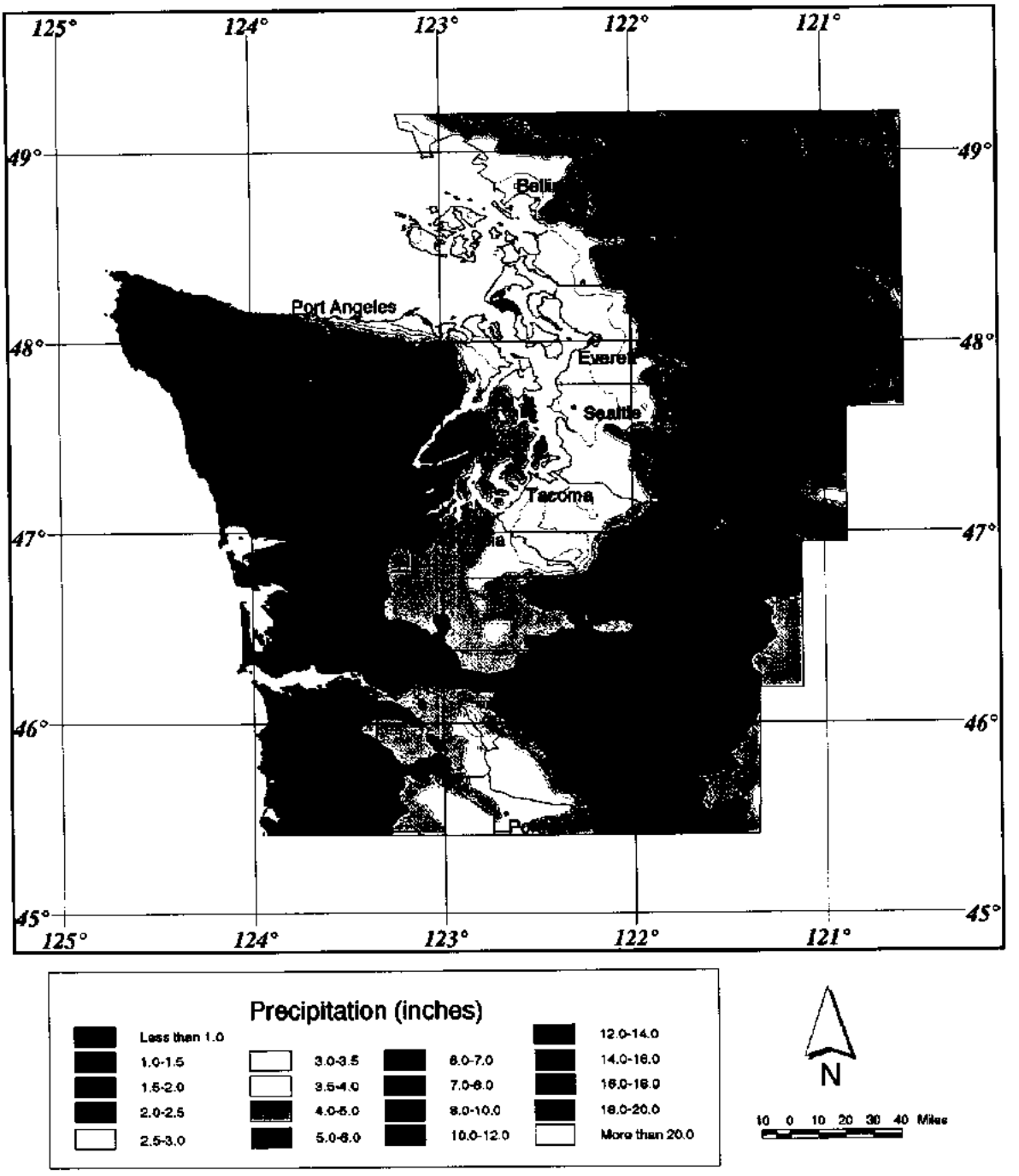


Figure B5 – Isopluvial Map of 24-Hour Precipitation for 50-Year Recurrence Interval for Western Washington

100-year 24-hour Precipitation, Western Washington

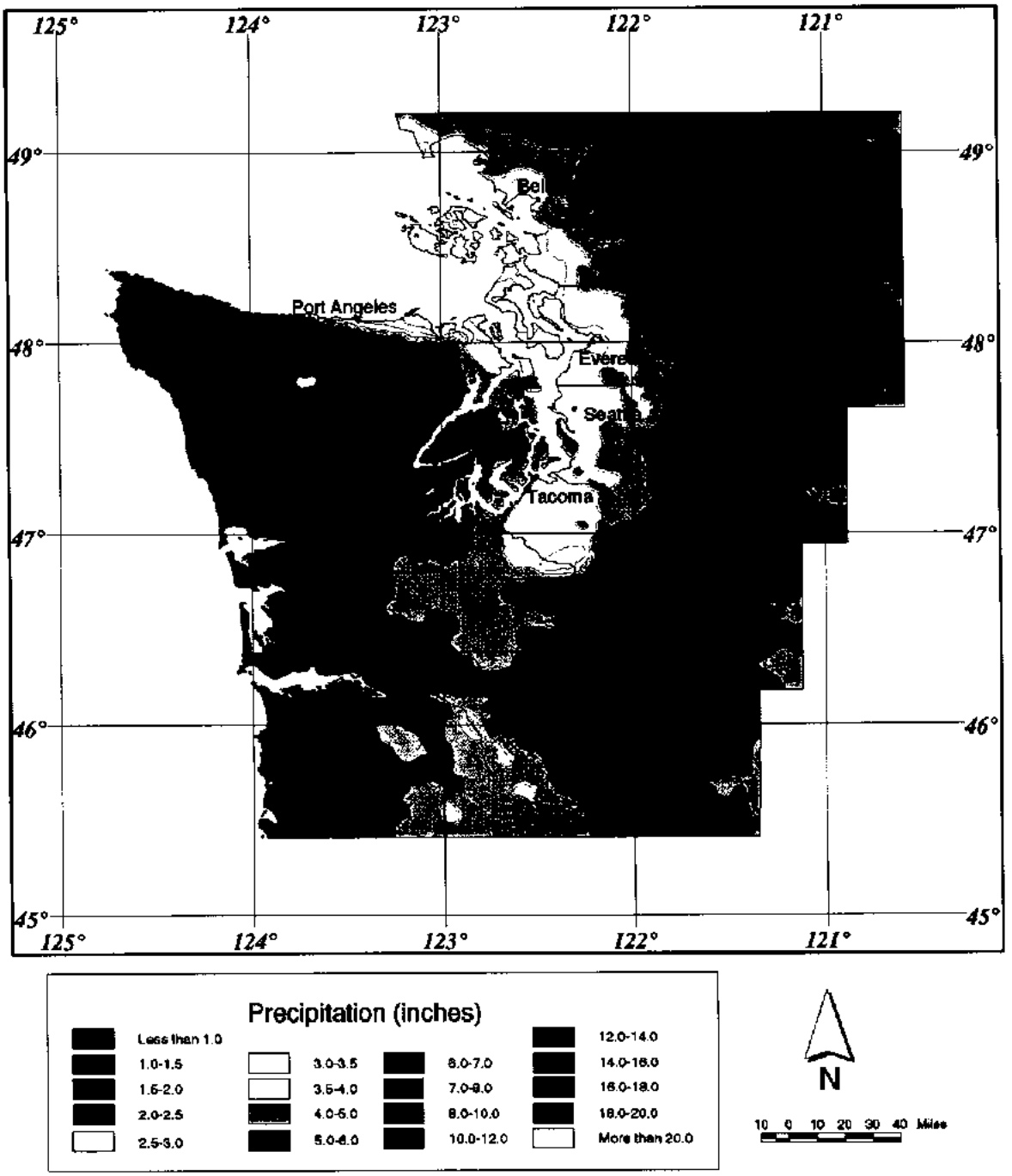


Figure B6 – Isopluvial Map of 24-Hour Precipitation for 100-Year Recurrence Interval for Western Washington

2-year 2-hour Precipitation, Western Washington

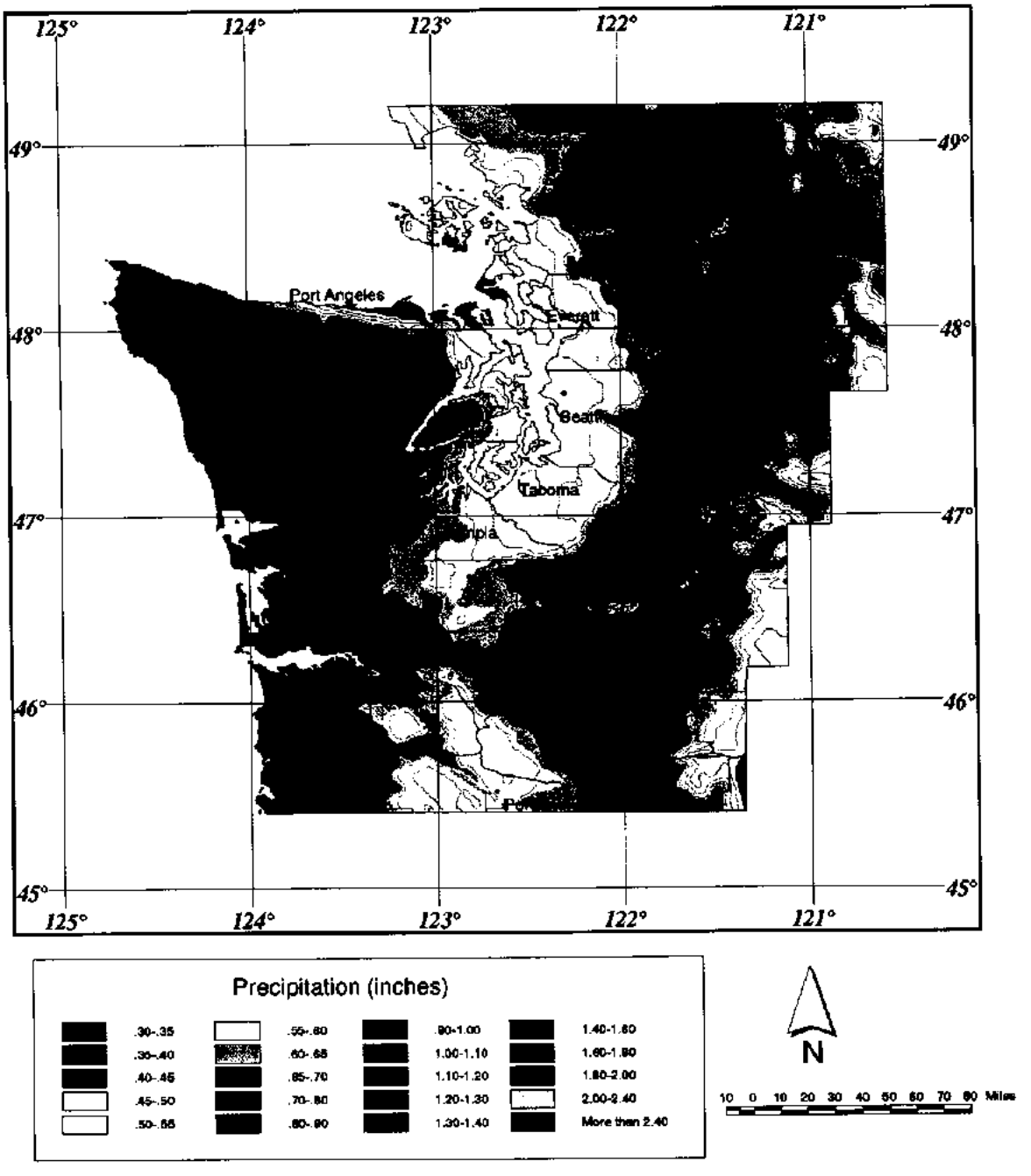


Figure B7 – Isopluvial Map of 2-Hour Precipitation for 2-Year Recurrence Interval for Western Washington

10-year 2-hour Precipitation, Western Washington

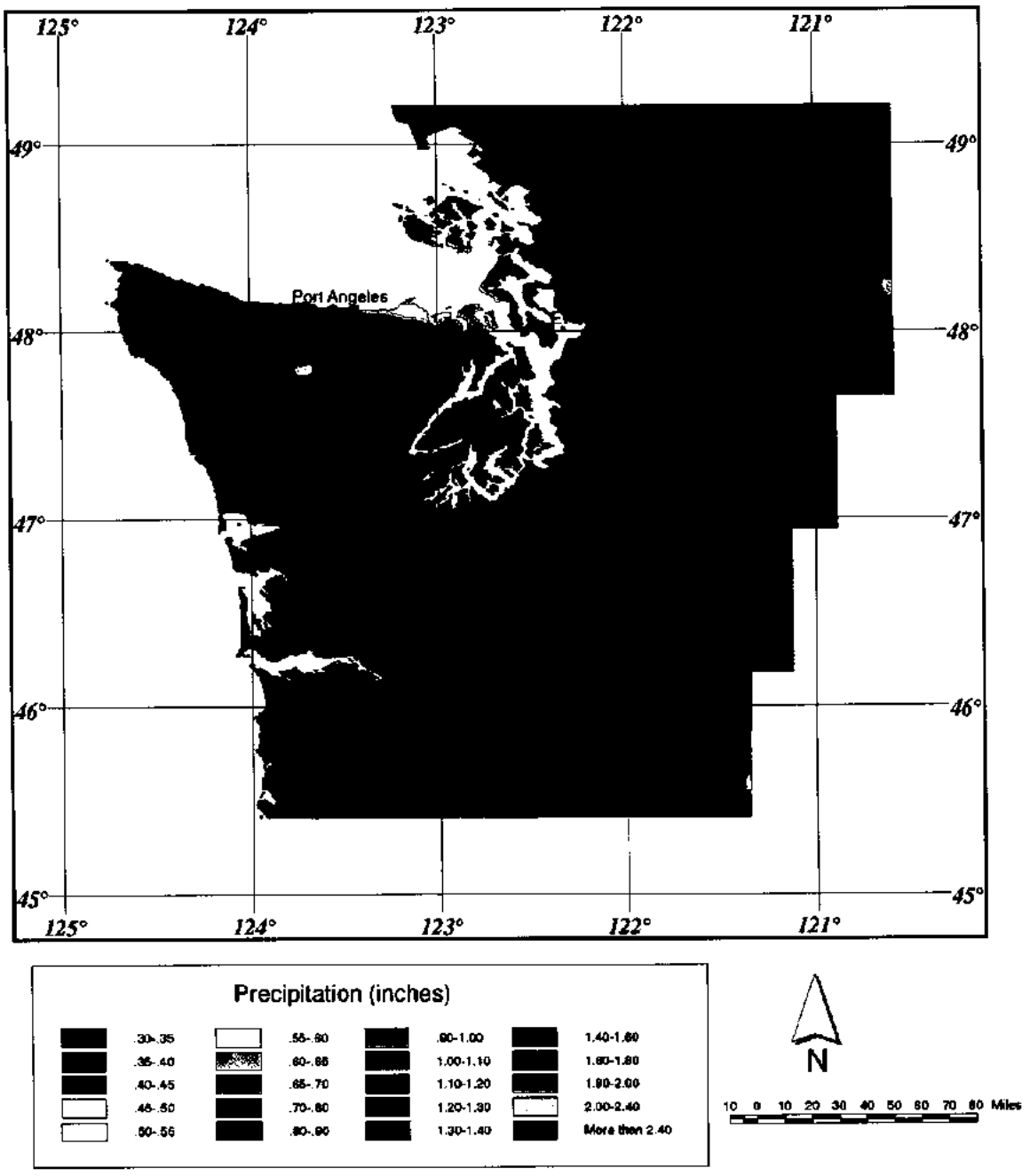


Figure B8 – Isopluvial Map of 2-Hour Precipitation for 10-Year Recurrence Interval for Western Washington

25-year 2-hour Precipitation, Western Washington

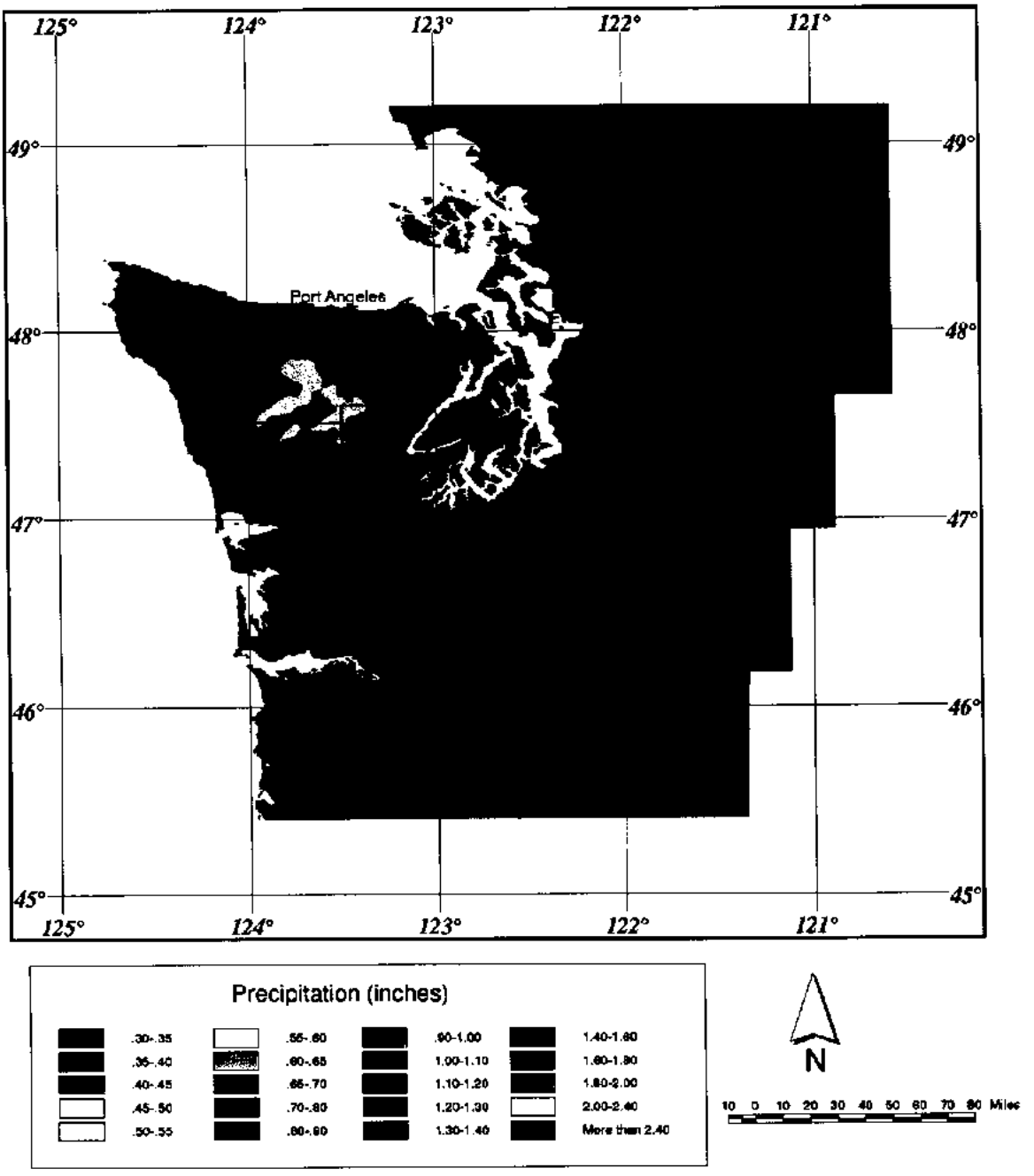


Figure B9 – Isopluvial Map of 2-Hour Precipitation for 25-Year Recurrence Interval for Western Washington

50-year 2-hour Precipitation, Western Washington

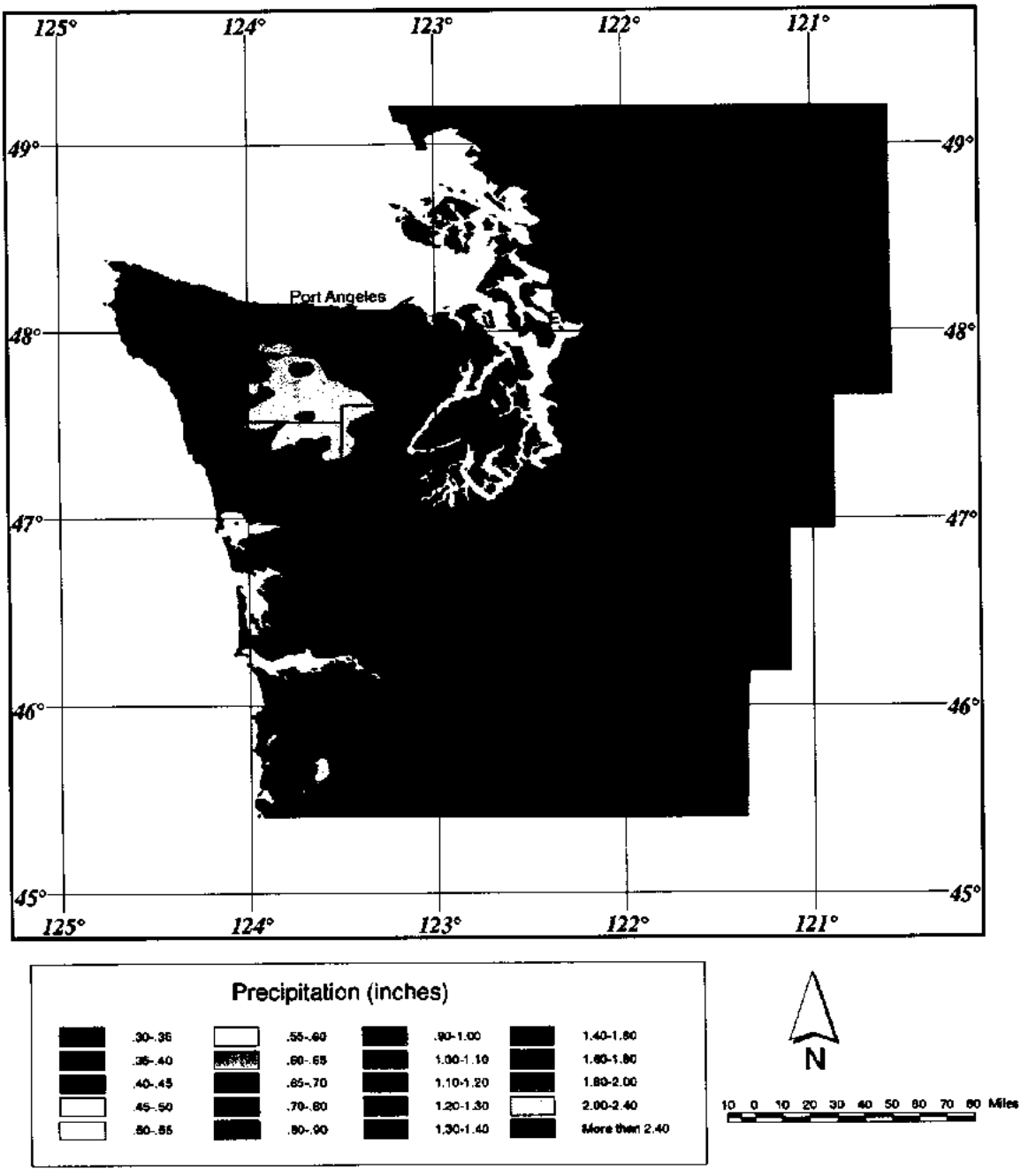


Figure B10 – Isopluvial Map of 2-Hour Precipitation for 50-Year Recurrence Interval for Western Washington

100-year 2-hour Precipitation, Western Washington

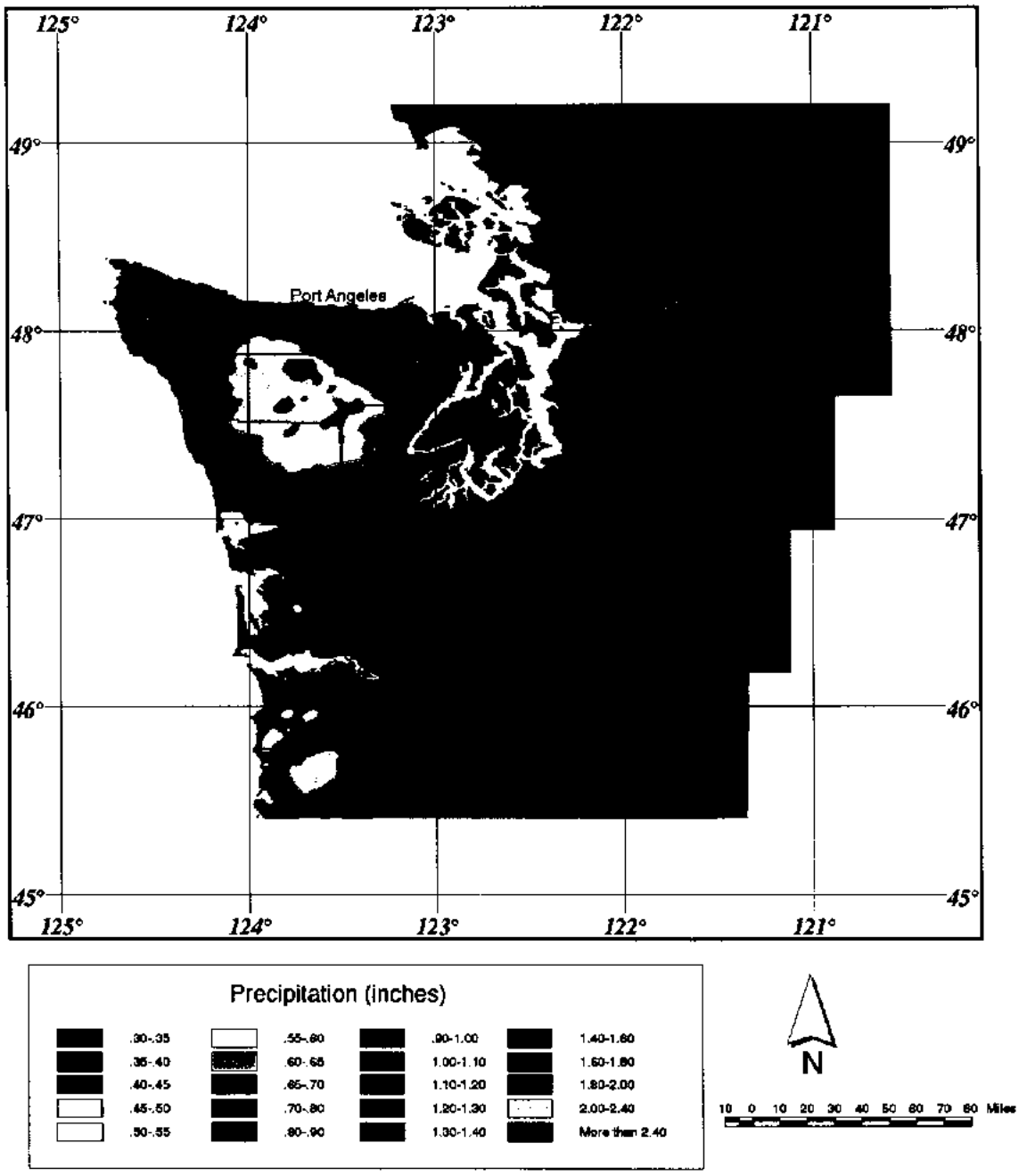


Figure B11 – Isopluvial Map of 2-Hour Precipitation for 100-Year Recurrence Interval for Western Washington

OVERVIEW

The seasonality of extreme storms was investigated by constructing frequency histograms of the storm dates for rare 24-hour and 2-hour precipitation amounts for each of the seven climatic regions. Extreme storms were taken to be precipitation amounts with annual exceedance probabilities less than 0.05 (rarer than a 20-year event). Precipitation amounts/gages with duplicate storm dates (generally dates within 7 calendar days) were removed before constructing the frequency histograms for each climatic region.

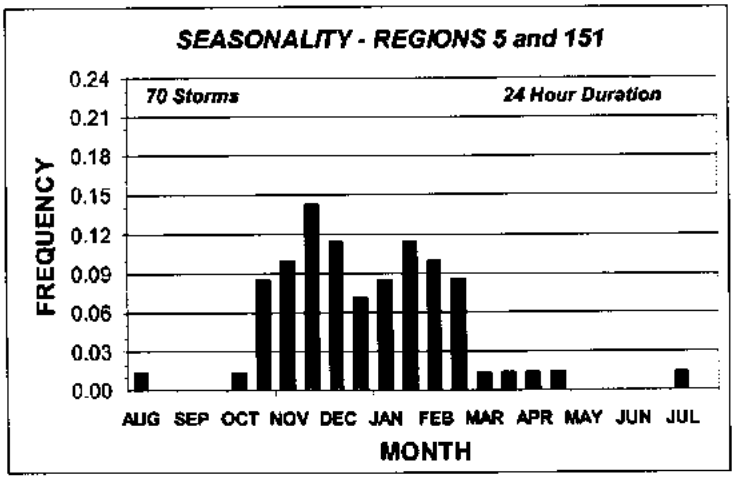


Figure C1 – Seasonality of Extreme Storms at 24-Hour Duration
for Coastal Lowlands and Coastal Mountains West, Climatic Regions 5 and 151

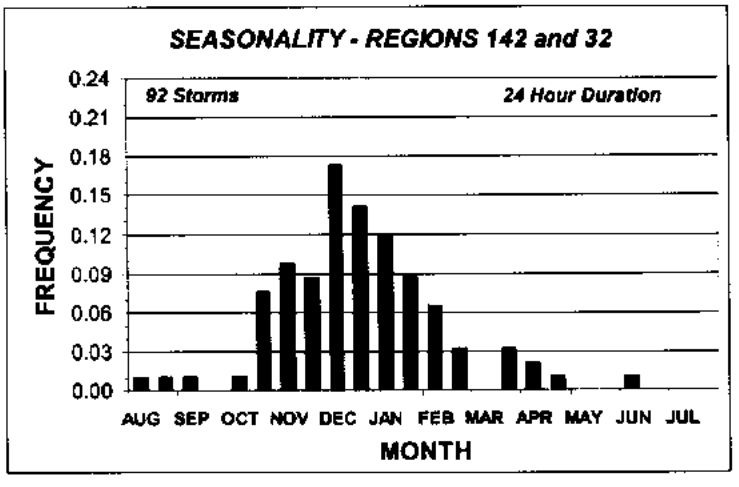


Figure C2 – Seasonality of Extreme Storms at 24-Hour Duration
for Coastal Mountains East and Interior Lowlands West, Climatic Regions 142 and 32

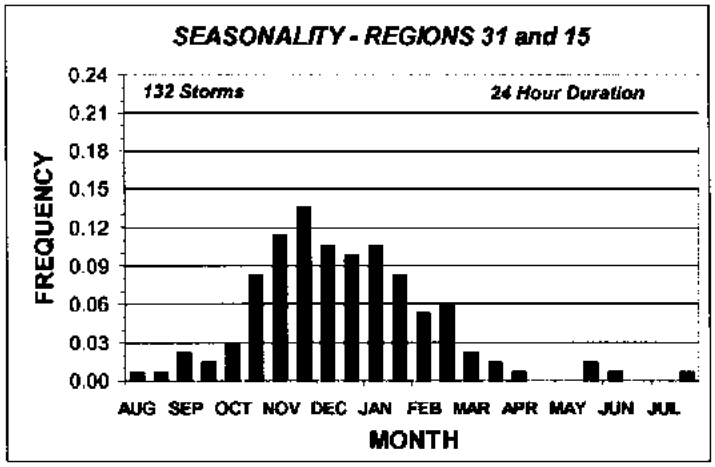


Figure C3 – Seasonality of Extreme Storms at 24-Hour Duration
for Interior Lowlands East and Cascade Mountains West, Climatic Regions 31 and 15

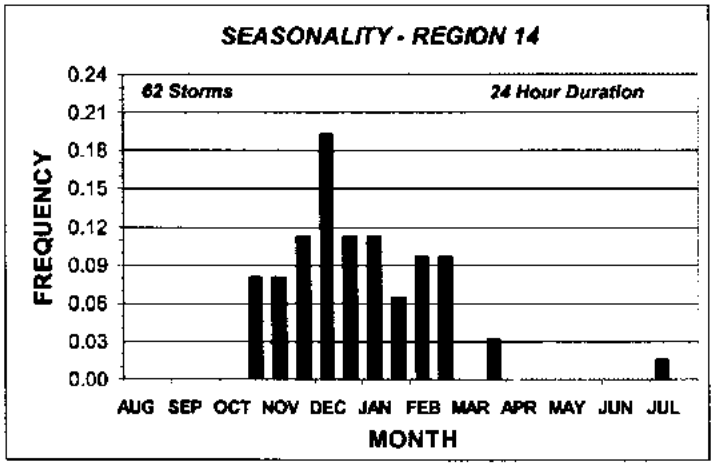


Figure C4 – Seasonality of Extreme Storms at 24-Hour Duration
for Cascade Mountains East, Climatic Region 14

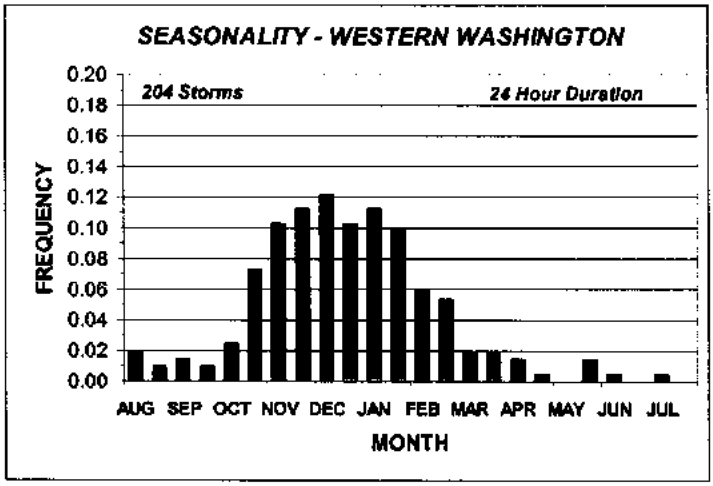


Figure C5 – Seasonality of Extreme Storms at 24-Hour Duration
for All Western Washington Climatic Regions

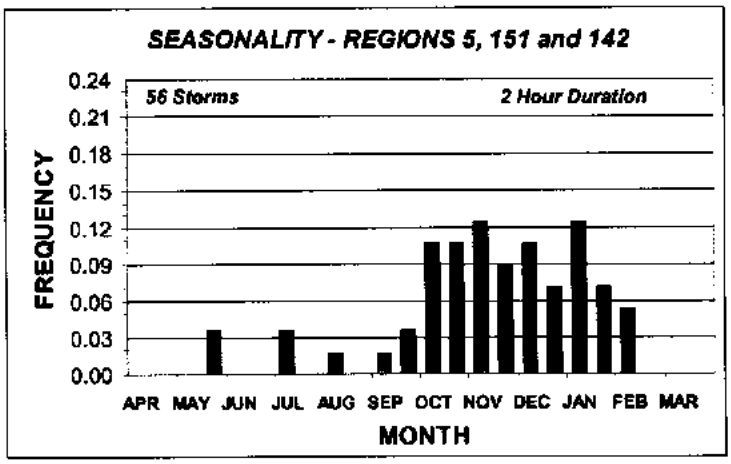


Figure C6 – Seasonality of Extreme Storms at 2-Hour Duration
for Coastal Lowlands and Coastal Mountains, Climatic Regions 5, 151 and 142

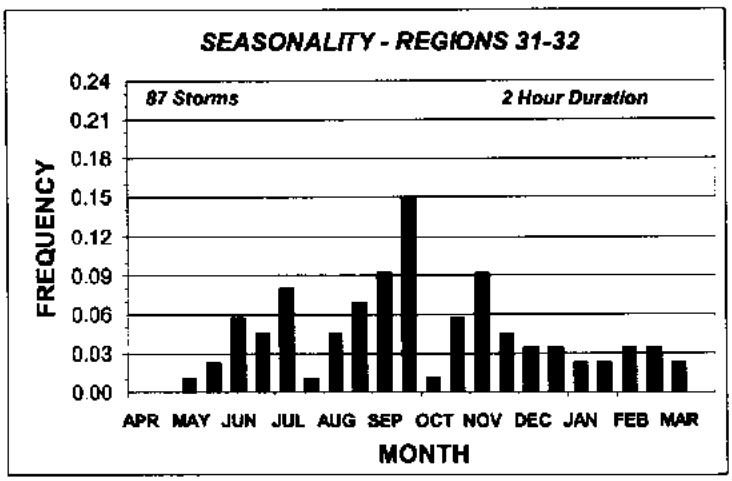


Figure C7 – Seasonality of Extreme Storms at 2-Hour Duration
for Interior Lowlands East and West, Climatic Regions 31 and 32

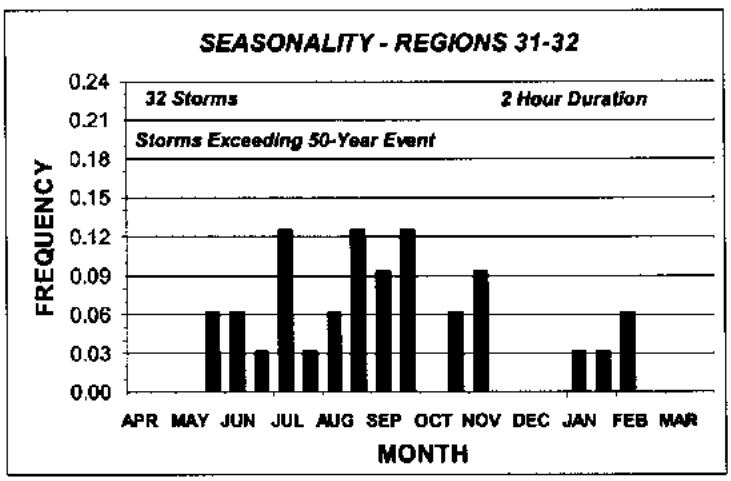


Figure C8 – Seasonality of Extreme Storms that Exceed 50-Year Event at 2-Hour Duration
for Interior Lowlands East and West, Climatic Regions 31 and 32

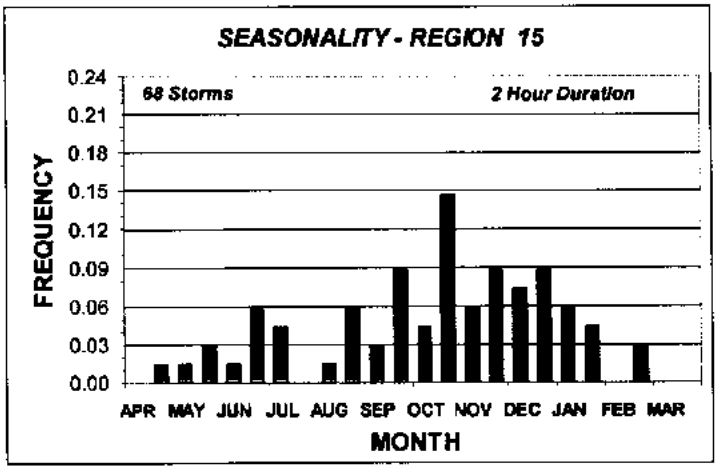


Figure C9 – Seasonality of Extreme Storms at 2-Hour Duration for Cascade Mountains West, Climatic Region 15

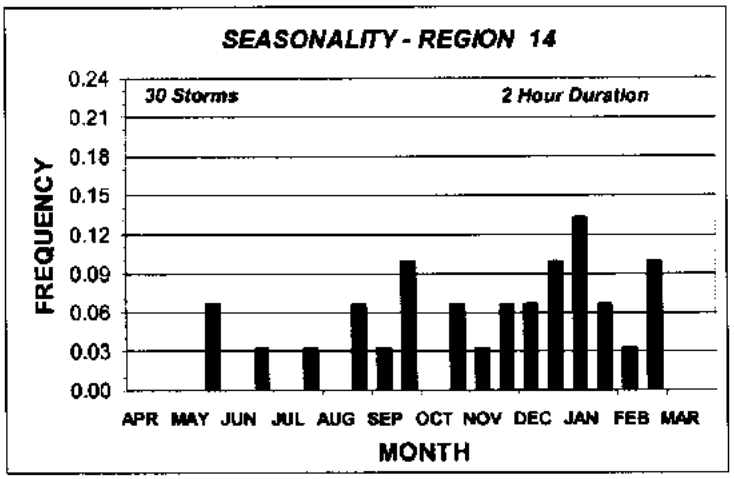


Figure C10 – Seasonality of Extreme Storms at 2-Hour Duration for Cascade Mountains East, Climatic Region 14

Appendix D

CATALOGS OF EXTREME STORMS
FOR 24-HOUR AND 2-HOUR DURATIONS

OVERVIEW

This appendix contains catalogs of the dates and locations of the occurrence of extreme storms. An extreme storm is deemed to occur when a recorded precipitation amount has exceeded a 20-year recurrence interval for that site. When numerous gages record precipitation amounts that exceed the 20-year threshold for a given storm date, the hourly gage with the rarest precipitation measurement is listed in the catalog. Hourly gages are listed because the primary application of the storm catalog is for identification of temporal storm patterns that would be useful in rainfall-runoff modeling of extreme events. Separate tables have been prepared, where the location, date and precipitation amount are listed for the various climatic regions.

Table D1 - Catalog of Extreme Storms for Coastal Lowlands Climatic Region 5 for 24-Hour Duration

EXTREME STORMS AT 24-HOUR DURATION										
STATION ID	STATION NAME	REGION	YEARS RECORD	LAT	LONG	RATIO TO MEAN	PRECIP (in)	MON	DAY	YEAR
45-1496	CLEARWATER	5	52	47.6	124.3	1.66	8.41	12	1	1943
45-8332	TATOOSH ISLAND WB	5	25	48.4	124.7	1.66	5.33	10	23	1944
35-5969	NEHALEM	5	52	45.7	123.9	1.57	5.86	2	10	1949
45-5488	MOCLIPS	5	16	47.2	124.2	1.34	4.22	1	20	1950
45-3333	GRAYS RIVER HATCHERY	5	43	46.4	123.6	1.44	6.64	1	14	1958
45-6584	POINT GRENVILLE	5	19	47.3	124.3	1.44	5.15	11	20	1959
45-5549	MONTESANO 1 S	5	44	47.0	123.6	1.55	5.39	11	19	1962
35-5969	NEHALEM	5	52	45.7	123.9	1.59	5.94	1	28	1965
45-6858	QUILLAYUTE WSCMO AP	5	34	47.9	124.6	1.83	8.32	1	19	1968
45-1496	CLEARWATER	5	52	47.6	124.3	1.76	8.90	7	12	1972
45-6858	QUILLAYUTE WSCMO AP	5	34	47.9	124.6	1.49	6.76	12	26	1972
45-1496	CLEARWATER	5	52	47.6	124.3	1.84	9.30	2	13	1982
45-2984	FRANCES	5	56	46.6	123.5	1.52	6.20	3	3	1987
35-0328	ASTORIA AP PORT OF	5	48	46.2	123.9	1.70	5.14	1	9	1990
45-9112	WESTPORT 2 S	5	60	46.9	124.1	1.48	4.40	2	10	1990
45-9112	WESTPORT 2 S	5	60	46.9	124.1	1.78	5.30	11	24	1990
45-5549	MONTESANO 1 S	5	44	47.0	123.6	1.55	5.40	12	10	1993
45-3333	GRAYS RIVER HATCHERY	5	43	46.4	123.6	1.67	7.70	12	27	1994
45-2984	FRANCES	5	56	46.6	123.5	1.52	6.20	4	23	1996
35-0328	ASTORIA AP PORT OF	5	48	46.2	123.9	1.84	5.57	11	25	1998
45-2984	FRANCES	5	56	46.6	123.5	1.42	5.80	2	25	1999

Table D2 - Catalog of Extreme Storms for Coastal Mountains West Climatic Region 151 for 24-Hour Duration

EXTREME STORMS AT 24-HOUR DURATION										
STATION ID	STATION NAME	REGION	YEARS RECORD	LAT	LONG	RATIO TO MEAN	PRECIP (in)	MON	DAY	YEAR
45-7319	SAPPHO 8 E	151	57	48.1	124.1	1.87	8.15	11	3	1955
45-7319	SAPPHO 8 E	151	57	48.1	124.1	1.55	6.74	12	9	1956
45-1064	CAMP GRISDALE	151	27	47.4	123.6	1.72	10.68	11	19	1962
35-8504	TILLAMOOK 12 ESE	151	48	45.4	123.6	1.46	7.43	12	2	1977
45-7319	SAPPHO 8 E	151	57	48.1	124.1	1.47	6.40	1	24	1982
45-0013	ABERDEEN 20 NNE	151	59	47.3	123.7	1.58	9.00	2	13	1982
45-6864	QUINAULT RANGER STN	151	19	47.5	123.9	1.69	13.50	11	10	1990
45-7319	SAPPHO 8 E	151	57	48.1	124.1	1.47	6.40	11	8	1995

Table D3 - Catalog of Extreme Storms for Coastal Mountains East Climatic Region 142 for 24-Hour Duration

EXTREME STORMS AT 24-HOUR DURATION										
STATION ID	STATION NAME	REGION	YEARS RECORD	LAT	LONG	RATIO TO MEAN	PRECIP (In)	MON	DAY	YEAR
35-4276	JEWELL WILDLIFE MEAD	142	42	45.9	123.5	1.62	5.90	1	11	1972
35-3318	GLENWOOD 2 WNW	142	50	45.7	123.3	1.66	5.35	12	13	1977
35-3318	GLENWOOD 2 WNW	142	50	45.7	123.3	1.67	5.40	10	6	1981
45-6851	QUILCENE 5 SW DAM	142	55	47.8	123.0	1.87	7.90	10	22	1982
45-1934	CUSHMAN DAM	142	59	47.4	123.2	1.81	9.40	1	18	1986
35-3705	HASKINS DAM	142	49	45.3	123.4	1.43	5.60	4	5	1991
45-6851	QUILCENE 5 SW DAM	142	55	47.8	123.0	1.45	6.10	12	10	1993
45-1934	CUSHMAN DAM	142	59	47.4	123.2	1.58	8.20	12	20	1994
45-1934	CUSHMAN DAM	142	59	47.4	123.2	1.77	9.20	3	19	1997
45-6851	QUILCENE 5 SW DAM	142	55	47.8	123.0	1.75	7.40	1	29	1999

Table D4 - Catalog of Extreme Storms for Interior Lowlands West Climatic Region 32 for 24-Hour Duration

EXTREME STORMS AT 24-HOUR DURATION										
STATION ID	STATION NAME	REGION	YEARS RECORD	LAT	LONG	RATIO TO MEAN	PRECIP (In)	MON	DAY	YEAR
45-6678	PORT TOWNSEND	32	29	48.1	122.8	2.10	2.26	6	13	1946
45-6624	PORT ANGELES	32	57	48.1	123.4	1.85	3.26	2	16	1949
45-6114	OLYMPIA AIRPORT	32	46	47.0	122.9	1.76	4.93	2	9	1951
45-6624	PORT ANGELES	32	57	48.1	123.4	1.77	3.12	1	15	1961
35-1227	BUXTON MOUNTAINDALE	32	26	45.7	123.1	1.47	3.26	1	15	1974
35-1222	BUXTON	32	51	45.7	123.2	1.61	4.40	12	13	1977
35-8884	VERNONIA 2	32	45	45.9	123.2	1.72	4.00	10	6	1981
45-6624	PORT ANGELES	32	57	48.1	123.4	2.16	3.80	1	18	1986
35-1643	CLATSKANIE	32	43	46.1	123.2	1.57	4.30	1	9	1990
45-6114	OLYMPIA AIRPORT	32	46	47.0	122.9	2.10	5.90	11	24	1990
35-2348	DIXIE MOUNTAIN	32	22	45.7	122.9	1.39	4.00	4	5	1991
35-6749	PORTLAND KGW-TV	32	50	45.5	122.7	2.23	4.80	10	27	1994
35-6751	PORTLAND INTL AIRPOR	32	59	45.6	122.6	1.38	2.82	11	11	1995
35-1643	CLATSKANIE	32	43	46.1	123.2	1.72	4.70	2	8	1996
35-6749	PORTLAND KGW-TV	32	50	45.5	122.7	1.95	4.20	11	19	1996
35-2348	DIXIE MOUNTAIN	32	22	45.7	122.9	1.39	4.00	12	29	1996
35-1222	BUXTON	32	51	45.7	123.2	1.72	4.70	1	14	1998

Table D5 - Catalog of Extreme Storms for Interior Lowlands East Climatic Region 31 for 24-Hour Duration

EXTREME STORMS AT 24-HOUR DURATION										
STATION ID	STATION NAME	REGION	YEARS RECORD	LAT	LONG	RATIO TO MEAN	PRECIP (in)	MON	DAY	YEAR
45-1277	CENTRALIA 1 W	31	56	46.7	123.0	1.38	2.98	10	31	1942
45-0986	BURLINGTON	31	58	48.5	122.3	2.63	4.91	10	24	1945
45-0986	BURLINGTON	31	58	48.5	122.3	1.83	3.42	2	16	1949
45-9485	YELM	31	38	47.0	122.6	1.45	2.79	11	12	1949
45-5149	MC CHORD AFB	31	35	47.2	122.5	1.77	3.03	2	9	1951
45-0729	BLAINE	31	58	49.0	122.8	1.76	3.63	11	3	1955
45-0324	AUBURN	31	22	47.3	122.2	1.71	3.63	11	21	1959
45-4769	LONGVIEW	31	42	46.2	122.9	2.36	5.41	11	20	1962
45-2675	EVERETT	31	58	48.0	122.2	1.57	2.56	1	4	1967
45-0729	BLAINE	31	58	49.0	122.8	1.67	3.46	11	4	1971
45-7773	SNOQUALMIE FALLS	31	44	47.5	121.8	1.56	4.90	3	5	1972
45-4769	LONGVIEW	31	42	46.2	122.9	2.05	4.70	12	2	1977
45-7473	SEATTLE TACOMA AIRPO	31	60	47.5	122.3	1.78	3.74	10	6	1981
45-0729	BLAINE	31	58	49.0	122.8	1.60	3.30	12	30	1983
45-7458	SEATTLE URBAN SITE	31	49	47.7	122.3	2.18	4.48	1	18	1986
45-4769	LONGVIEW	31	42	46.2	122.9	2.05	4.70	2	23	1986
45-5224	MC MILLIN RESERVOIR	31	57	47.1	122.3	1.94	3.80	11	24	1986
45-7773	SNOQUALMIE FALLS	31	44	47.5	121.8	1.56	4.90	1	9	1990
45-0986	BURLINGTON	31	58	48.5	122.3	1.61	3.00	11	9	1990
45-1277	CENTRALIA 1 W	31	56	46.7	123.0	2.36	5.10	11	24	1990
45-1277	CENTRALIA 1 W	31	56	46.7	123.0	1.85	4.00	2	8	1996
45-2675	EVERETT	31	58	48.0	122.2	1.60	2.60	12	29	1996
45-5224	MC MILLIN RESERVOIR	31	57	47.1	122.3	1.84	3.60	11	25	1998

Table D6 - Catalog of Extreme Storms for Cascade Mountains West Climatic Region 15 for 24-Hour Duration

EXTREME STORMS AT 24-HOUR DURATION										
STATION ID	STATION NAME	REGION	YEARS RECORD	LAT	LONG	RATIO TO MEAN	PRECIP (In)	MON	DAY	YEAR
45-7919	SPIRIT LAKE R S	15	15	46.3	122.2	1.84	5.74	10	23	1943
35-0897	BONNEVILLE DAM	15	59	45.6	122.0	1.83	6.40	10	18	1947
45-9171	WHITE RIVER R S	15	32	46.9	121.6	1.41	4.04	2	17	1949
45-7657	SILVERTON	15	47	48.1	121.6	1.46	6.39	2	9	1951
45-4634	LESTER	15	23	47.2	121.5	1.63	4.69	12	9	1956
45-7781	SNOQUALMIE PASS	15	56	47.4	121.4	1.52	7.00	11	22	1959
45-7709	SKYKOMISH 1 ENE	15	57	47.7	121.4	1.80	7.70	12	15	1959
45-6896	RAINIER OHANAPECOSH	15	51	46.7	121.6	2.00	7.78	11	20	1962
1106180	PITT POLDER	15	30	49.3	122.6	1.46	5.68	1	18	1968
45-6295	PALMER 3 ESE	15	59	47.3	121.9	1.42	5.10	1	9	1971
45-6295	PALMER 3 ESE	15	59	47.3	121.9	1.37	4.90	11	4	1971
45-7604	SHUKSAN	15	14	48.9	121.7	1.32	4.45	12	26	1972
45-9171	WHITE RIVER R S	15	32	46.9	121.6	1.50	4.30	11	9	1973
35-2697	ESTACADA 24 SE	15	49	45.1	122.0	1.59	4.30	1	15	1974
45-1457	CINEBAR 2 E	15	46	46.6	122.5	2.20	6.80	12	2	1977
45-3160	GLACIER R S	15	25	48.9	122.0	1.80	5.90	12	14	1979
45-5663	MOUNT BAKER LODGE	15	23	48.9	121.7	1.32	5.20	2	26	1980
45-8715	UPPER BAKER DAM	15	33	48.7	121.7	1.41	5.60	11	21	1980
45-3357	GREENWATER	15	56	47.1	121.6	1.99	5.30	1	23	1982
45-8838	VERLOT	15	21	48.1	121.8	1.31	6.20	2	14	1982
45-7657	SILVERTON	15	47	48.1	121.6	1.78	7.70	12	3	1982
45-5876	NOOKSACK SALMON HAT	15	32	48.9	122.2	1.75	6.30	1	10	1983
45-3357	GREENWATER	15	56	47.1	121.6	1.69	4.50	1	24	1984
45-1992	DARRINGTON RGR STN	15	56	48.3	121.6	1.89	6.60	1	18	1986
45-4999	MARBLEMOUNT RGR STN	15	56	48.5	121.5	1.82	6.20	2	24	1986
45-5704	MUD MOUNTAIN DAM	15	61	47.2	121.9	1.81	4.20	11	24	1986
45-1457	CINEBAR 2 E	15	46	46.6	122.5	1.62	5.00	1	9	1990
45-5876	NOOKSACK SALMON HAT	15	32	48.9	122.2	1.86	6.70	2	10	1990
45-4999	MARBLEMOUNT RGR STN	15	56	48.5	121.5	1.82	6.20	11	10	1990
45-1233	CEDAR LAKE	15	45	47.4	121.7	1.74	6.40	11	24	1990
45-5704	MUD MOUNTAIN DAM	15	61	47.2	121.9	1.73	4.00	2	20	1991
45-1759	COUGAR 4 SW	15	59	46.0	122.4	1.45	6.40	10	31	1994
45-4764	LONGMIRE RAINIER NPS	15	22	46.8	121.8	1.68	6.40	11	28	1995
45-5704	MUD MOUNTAIN DAM	15	61	47.2	121.9	1.64	3.80	2	8	1996
35-0897	BONNEVILLE DAM	15	59	45.6	122.0	1.69	5.90	11	19	1996
35-0897	BONNEVILLE DAM	15	59	45.6	122.0	1.46	5.10	11	25	1999

Table D7 - Catalog of Extreme Storms for Coastal Lowlands Climatic Region 5 for 2-Hour Duration

EXTREME STORMS AT 2-HOUR DURATION										
STATION ID	STATION NAME	REGION	YEARS RECORD	LAT	LONG	RATIO TO MEAN	PRECIP (In)	MON	DAY	YEAR
45-5932	NORTH HEAD WB	5	13	46.3	124.1	1.42	1.13	11	13	1941
45-8332	TATOOSH ISLAND WB	5	25	48.4	124.7	1.75	1.53	10	10	1942
45-9112	WESTPORT 2 S	5	56	46.9	124.1	1.77	1.47	10	30	1950
45-5488	MOCLIPS	5	15	47.2	124.2	1.46	1.30	1	2	1951
35-5969	NEHALEM	5	52	45.7	123.9	1.40	1.23	1	21	1954
45-5549	MONTESANO 1 S	5	44	47.0	123.6	1.39	1.14	11	2	1955
45-6584	POINT GRENVILLE	5	19	47.3	124.3	1.42	1.33	11	20	1959
45-5549	MONTESANO 1 S	5	44	47.0	123.6	1.36	1.12	12	22	1961
35-0328	ASTORIA AP PORT OF	5	47	46.2	123.9	1.85	1.54	10	8	1962
45-1496	CLEARWATER	5	54	47.6	124.3	1.30	1.34	1	12	1966
45-6858	QUILLAYUTE WSCMO AP	5	34	47.9	124.6	1.34	1.22	10	1	1967
45-3333	GRAYS RIVER HATCHERY	5	42	46.4	123.6	1.27	1.30	12	10	1977
45-3333	GRAYS RIVER HATCHERY	5	42	46.4	123.6	1.47	1.50	11	6	1980
45-2984	FRANCES	5	58	46.6	123.5	1.76	1.50	12	15	1982
45-3333	GRAYS RIVER HATCHERY	5	42	46.4	123.6	1.27	1.30	2	13	1982
45-3333	GRAYS RIVER HATCHERY	5	42	46.4	123.6	1.27	1.30	10	26	1985
45-2984	FRANCES	5	58	46.6	123.5	1.53	1.30	1	14	1988
45-1496	CLEARWATER	5	54	47.6	124.3	1.35	1.40	10	21	1990
45-9112	WESTPORT 2 S	5	56	46.9	124.1	1.57	1.30	12	4	1990
45-6858	QUILLAYUTE WSCMO AP	5	34	47.9	124.6	1.41	1.29	8	6	1995
45-2984	FRANCES	5	58	46.6	123.5	1.65	1.40	9	29	1995
45-1496	CLEARWATER	5	54	47.6	124.3	1.35	1.40	10	25	1995
45-9112	WESTPORT 2 S	5	56	46.9	124.1	1.69	1.40	9	16	1997
35-0328	ASTORIA AP PORT OF	5	47	46.2	123.9	2.21	1.84	11	25	1998

Table D8 - Catalog of Extreme Storms for Coastal Mountains West Climatic Region 151 for 2-Hour Duration

EXTREME STORMS AT 2-HOUR DURATION										
STATION ID	STATION NAME	REGION	YEARS RECORD	LAT	LONG	RATIO TO MEAN	PRECIP (in)	MON	DAY	YEAR
45-7319	SAPPHO 6 E	151	58	48.1	124.1	2.40	1.92	2	2	1947
45-7319	SAPPHO 6 E	151	58	48.1	124.1	1.76	1.41	12	9	1956
45-1064	CAMP GRISDALE	151	28	47.4	123.6	1.75	2.00	11	20	1959
35-8504	TILLAMOOK 12 ESE	151	51	45.4	123.6	2.36	2.25	1	11	1972
45-0013	ABERDEEN 20 NNE	151	57	47.3	123.7	1.40	1.50	12	26	1975
45-7319	SAPPHO 6 E	151	58	48.1	124.1	1.62	1.30	11	8	1976
45-0013	ABERDEEN 20 NNE	151	57	47.3	123.7	2.33	2.50	5	28	1982
45-6864	QUINAULT RANGER STN	151	20	47.5	123.9	1.54	2.00	11	23	1986
45-0013	ABERDEEN 20 NNE	151	57	47.3	123.7	1.59	1.70	10	31	1994

Table D9 - Catalog of Extreme Storms for Coastal Mountains East Climatic Region 142 for 2-Hour Duration

EXTREME STORMS AT 2-HOUR DURATION										
STATION ID	STATION NAME	REGION	YEARS RECORD	LAT	LONG	RATIO TO MEAN	PRECIP (in)	MON	DAY	YEAR
45-6851	QUILCENE 5 SW DAM	142	58	47.8	123.0	1.63	1.35	12	1	1948
45-6851	QUILCENE 5 SW DAM	142	58	47.8	123.0	1.34	1.11	7	5	1957
45-1934	CUSHMAN DAM	142	59	47.4	123.2	1.50	1.50	12	25	1980
45-1934	CUSHMAN DAM	142	59	47.4	123.2	1.40	1.40	12	3	1982
45-1934	CUSHMAN DAM	142	59	47.4	123.2	1.70	1.70	1	18	1986
45-6851	QUILCENE 5 SW DAM	142	58	47.8	123.0	1.44	1.20	11	24	1998

Table D10 - Catalog of Extreme Storms for Interior Lowlands West Climatic Region 32 for 2-Hour Duration

EXTREME STORMS AT 2-HOUR DURATION										
STATION ID	STATION NAME	REGION	YEARS RECORD	LAT	LONG	RATIO TO MEAN	PRECIP (in)	MON	DAY	YEAR
45-6624	PORT ANGELES	32	58	48.1	123.4	1.41	0.72	9	27	1953
45-6114	OLYMPIA AIRPORT	32	47	47.0	122.9	1.53	0.97	12	9	1956
45-6678	PORT TOWNSEND	32	27	48.1	122.8	1.96	0.84	9	10	1967
45-6624	PORT ANGELES	32	58	48.1	123.4	1.57	0.80	11	3	1978
45-6624	PORT ANGELES	32	58	48.1	123.4	1.57	0.80	12	14	1984
45-6114	OLYMPIA AIRPORT	32	47	47.0	122.9	1.42	0.90	1	9	1990

Table D11 - Catalog of Extreme Storms for Interior Lowlands East Climatic Region 31 for 2-Hour Duration

EXTREME STORMS AT 2-HOUR DURATION										
STATION ID	STATION NAME	REGION	YEARS RECORD	LAT	LONG	RATIO TO MEAN	PRECIP (In)	MON	DAY	YEAR
45-2675	EVERETT	31	58	48.0	122.2	1.78	1.01	9	28	1944
45-5224	MC MILLIN RESERVOIR	31	55	47.1	122.3	1.91	1.10	7	8	1946
45-9485	YELM	31	39	47.0	122.6	1.39	0.72	11	22	1946
45-1277	CENTRALIA 1 W	31	58	46.7	123.0	1.93	1.15	10	28	1949
45-7473	SEATTLE TACOMA AIRPO	31	60	47.5	122.3	1.72	0.91	3	3	1950
45-7473	SEATTLE TACOMA AIRPO	31	60	47.5	122.3	1.82	0.96	6	29	1952
45-7773	SNOQUALMIE FALLS	31	45	47.5	121.8	1.35	0.95	6	14	1957
45-5149	MC CHORD AFB	31	37	47.2	122.5	1.49	0.71	7	14	1957
45-5224	MC MILLIN RESERVOIR	31	55	47.1	122.3	1.86	1.07	9	17	1957
45-2675	EVERETT	31	58	48.0	122.2	2.01	1.14	5	31	1958
45-0324	AUBURN	31	36	47.3	122.2	1.59	0.87	6	8	1959
45-5224	MC MILLIN RESERVOIR	31	55	47.1	122.3	2.75	1.58	8	26	1960
45-4769	LONGVIEW	31	43	46.2	122.9	1.74	1.07	11	19	1962
45-7773	SNOQUALMIE FALLS	31	45	47.5	121.8	1.62	1.14	9	19	1964
45-0986	BURLINGTON	31	58	48.5	122.3	2.18	1.28	8	12	1965
45-0324	AUBURN	31	36	47.3	122.2	1.26	0.70	9	17	1969
45-0324	AUBURN	31	36	47.3	122.2	1.28	0.70	2	28	1972
45-2675	EVERETT	31	58	48.0	122.2	1.75	0.99	9	22	1972
45-9485	YELM	31	39	47.0	122.6	1.45	0.75	12	21	1972
45-1191	CASTLE ROCK 2 NW	31	22	46.3	122.9	1.97	1.46	9	20	1973
45-1277	CENTRALIA 1 W	31	58	46.7	123.0	1.84	1.10	7	8	1974
45-0986	BURLINGTON	31	58	48.5	122.3	1.70	1.00	2	12	1975
45-7458	SEATTLE URBAN SITE	31	50	47.7	122.3	2.97	1.61	8	26	1977
45-1146	CARNATION 4 NW	31	59	47.7	122.0	2.01	1.20	9	20	1977
45-1277	CENTRALIA 1 W	31	58	46.7	123.0	1.51	0.90	9	3	1979
45-4486	LANDSBURG	31	45	47.4	122.0	1.48	0.90	7	11	1980
45-1277	CENTRALIA 1 W	31	58	46.7	123.0	1.51	0.90	3	3	1981
45-0729	BLAINE	31	58	49.0	122.8	1.90	1.10	2	15	1986
45-1146	CARNATION 4 NW	31	59	47.7	122.0	1.68	1.00	6	18	1986
45-0986	BURLINGTON	31	58	48.5	122.3	1.70	1.00	5	16	1988
45-1146	CARNATION 4 NW	31	59	47.7	122.0	1.68	1.00	9	19	1988
45-0729	BLAINE	31	58	49.0	122.8	2.24	1.30	8	15	1989
45-0729	BLAINE	31	58	49.0	122.8	2.07	1.20	6	11	1993
45-4486	LANDSBURG	31	45	47.4	122.0	1.48	0.90	9	10	1994
45-4769	LONGVIEW	31	43	46.2	122.9	1.62	1.00	11	11	1995
45-0986	BURLINGTON	31	58	48.5	122.3	1.70	1.00	6	21	1997
45-7458	SEATTLE URBAN SITE	31	50	47.7	122.3	1.53	0.83	11	23	1997
45-7473	SEATTLE TACOMA AIRPO	31	60	47.5	122.3	1.84	0.97	11	4	1998

Table D12 - Catalog of Extreme Storms for Cascade Mountains West Climatic Region 15 for 2-Hour Duration

EXTREME STORMS AT 2-HOUR DURATION										
STATION ID	STATION NAME	REGION	YEARS RECORD	LAT	LONG	RATIO TO MEAN	PRECIP (in)	MON	DAY	YEAR
45-1992	DARRINGTON RGR ST	15	54	48.3	121.6	1.47	1.01	11	3	1941
45-7781	SNOQUALMIE PASS	15	51	47.4	121.4	1.77	1.48	12	4	1941
45-7919	SPIRIT LAKE R S	15	16	46.3	122.2	1.84	1.18	10	24	1943
45-1759	COUGAR 4 SW	15	59	46.0	122.4	1.87	1.49	9	21	1944
45-7709	SKYKOMISH 1 ENE	15	56	47.7	121.4	2.26	1.78	5	25	1945
45-7781	SNOQUALMIE PASS	15	51	47.4	121.4	1.85	1.55	10	24	1945
45-1457	CINEBAR 2 E	15	45	46.6	122.5	1.44	1.00	4	17	1947
35-0897	BONNEVILLE DAM	15	56	45.6	122.0	2.23	1.68	10	19	1947
45-6295	PALMER 3 ESE	15	59	47.3	121.9	1.42	1.20	5	27	1948
45-2493	ELECTRON HEADWORKS	15	38	46.9	122.0	1.32	0.90	12	19	1948
45-5663	MOUNT BAKER LODGE	15	24	48.9	121.7	1.86	1.53	6	16	1949
45-2493	ELECTRON HEADWORKS	15	38	46.9	122.0	1.76	1.20	10	28	1949
45-9171	WHITE RIVER R S	15	34	46.9	121.6	1.77	1.17	2	16	1949
45-1457	CINEBAR 2 E	15	45	46.6	122.5	2.17	1.51	6	9	1953
45-6295	PALMER 3 ESE	15	59	47.3	121.9	1.36	1.15	6	30	1955
45-7604	SHUKSAN	15	14	48.9	121.7	1.28	0.82	11	9	1955
45-1759	COUGAR 4 SW	15	59	46.0	122.4	1.40	1.12	8	2	1956
35-0897	BONNEVILLE DAM	15	56	45.6	122.0	2.00	1.51	8	25	1956
45-4634	LESTER	15	23	47.2	121.5	1.70	1.05	12	9	1956
45-7657	SILVERTON	15	45	48.1	121.6	1.56	1.40	12	9	1956
45-6909	RANDLE 1 E	15	40	46.5	121.9	2.19	1.40	8	28	1957
45-6892	RAINIER CARBON RIVER	15	37	47.0	121.9	1.67	1.05	9	17	1957
45-6295	PALMER 3 ESE	15	59	47.3	121.9	1.62	1.37	9	26	1959
45-6896	RAINIER OHANAPECOSH	15	53	46.7	121.6	1.69	1.23	11	19	1962
45-8715	UPPER BAKER DAM	15	33	48.7	121.7	1.42	1.10	11	15	1970
35-0897	BONNEVILLE DAM	15	56	45.6	122.0	1.86	1.40	11	20	1970
45-4999	MARBLEMOUNT RGR ST	15	56	48.5	121.5	1.28	0.80	12	25	1972
45-9171	WHITE RIVER R S	15	34	46.9	121.6	1.81	1.20	5	10	1975
45-5704	MUD MOUNTAIN DAM	15	56	47.2	121.9	1.60	1.04	8	17	1975
45-1233	CEDAR LAKE	15	45	47.4	121.7	1.53	1.30	9	20	1977
45-3357	GREENWATER	15	54	47.1	121.6	1.71	1.13	12	1	1977
45-6909	RANDLE 1 E	15	40	46.5	121.9	1.88	1.20	6	28	1978
45-5704	MUD MOUNTAIN DAM	15	56	47.2	121.9	1.71	1.11	7	9	1979
45-7657	SILVERTON	15	45	48.1	121.6	2.01	1.80	9	30	1980
45-4764	LONGMIRE RAINIER NPS	15	21	46.8	121.8	1.82	1.30	1	12	1980
45-4999	MARBLEMOUNT RGR ST	15	56	48.5	121.5	1.43	0.90	8	30	1982
45-6892	RAINIER CARBON RIVER	15	37	47.0	121.9	1.28	0.80	9	15	1982
45-1992	DARRINGTON RGR ST	15	54	48.3	121.6	1.60	1.10	12	3	1982
45-3357	GREENWATER	15	54	47.1	121.6	1.52	1.00	1	23	1982
45-3357	GREENWATER	15	54	47.1	121.6	1.52	1.00	1	3	1984
45-1992	DARRINGTON RGR ST	15	54	48.3	121.6	1.45	1.00	9	5	1985
45-5876	NOOKSACK SALMON HAT	15	35	48.9	122.2	1.74	1.40	10	26	1986
45-6896	RAINIER OHANAPECOSH	15	53	46.7	121.6	1.65	1.20	1	18	1986
45-4999	MARBLEMOUNT RGR ST	15	56	48.5	121.5	1.28	0.80	2	23	1986
45-3357	GREENWATER	15	54	47.1	121.6	1.97	1.30	7	18	1987
45-6896	RAINIER OHANAPECOSH	15	53	46.7	121.6	1.51	1.10	12	30	1988
45-4999	MARBLEMOUNT RGR ST	15	56	48.5	121.5	1.28	0.80	11	9	1990
45-6896	RAINIER OHANAPECOSH	15	53	46.7	121.6	1.51	1.10	11	23	1990
45-3160	GLACIER R S	15	20	48.9	122.0	1.78	1.40	12	31	1990
45-1457	CINEBAR 2 E	15	45	46.6	122.5	1.44	1.00	1	9	1990
45-5876	NOOKSACK SALMON HAT	15	35	48.9	122.2	2.23	1.80	10	20	1992
45-1233	CEDAR LAKE	15	45	47.4	121.7	1.65	1.40	6	22	1993
KI-14U	EAST FORK ISSAQUAH C	15	12	47.5	122.0	1.64	1.08	7	4	1994
45-1759	COUGAR 4 SW	15	59	46.0	122.4	1.38	1.10	10	31	1994
45-8715	UPPER BAKER DAM	15	33	48.7	121.7	1.42	1.10	10	9	1995
45-4999	MARBLEMOUNT RGR ST	15	56	48.5	121.5	1.28	0.80	11	28	1995
45-8838	VERLOT	15	23	48.1	121.8	1.59	1.50	12	12	1995
45-1992	DARRINGTON RGR ST	15	54	48.3	121.6	1.45	1.00	12	27	1996
45-6896	RAINIER OHANAPECOSH	15	53	46.7	121.6	1.51	1.10	12	29	1996
45-4999	MARBLEMOUNT RGR ST	15	56	48.5	121.5	1.59	1.00	10	30	1997

Appendix E

L-MOMENT STATISTICS

L-MOMENT STATISTICS

L-moments are a dramatic improvement over conventional statistics for characterizing the variance and skewness of data, for describing the shape of a probability distribution, and for estimating the distribution parameters (Hosking[7,9,13]). They are particularly useful for describing environmental data that are often highly skewed. The at-site L-moment measure of location, and L-moment ratio measures of scale, skewness and kurtosis are:

Location, mean:

$$\text{Mean} = L_1 \quad \text{(E1)}$$

Scale, L-Cv (t_2):

$$t_2 = L_2/L_1 \quad \text{(E2)}$$

L-Skewness (t_3):

$$t_3 = L_3/L_2 \quad \text{(E3)}$$

L-Kurtosis (t_4):

$$t_4 = L_4/L_2 \quad \text{(E4)}$$

where:

$$L_1 = \beta_0 \quad \text{(E5)}$$

$$L_2 = 2\beta_1 - \beta_0 \quad \text{(E6)}$$

$$L_3 = 6\beta_2 - 6\beta_1 + \beta_0 \quad \text{(E7)}$$

$$L_4 = 20\beta_3 - 30\beta_2 + 12\beta_1 - \beta_0 \quad \text{(E8)}$$

and where the at-site data are first ranked in ascending order from 1 to n ($x_{1:n}$) and:

$$\beta_0 = n^{-1} \sum_{j=1}^{n} x_j \quad \text{(E9)}$$

$$\beta_1 = n^{-1} \sum_{j=2}^{n} x_j \, [(j-1)/(n-1)] \quad \text{(E10)}$$

$$\beta_2 = n^{-1} \sum_{j=3}^{n} x_j \, [(j-1)(j-2)]/[(n-1)(n-2)] \quad \text{(E11)}$$

$$\beta_3 = n^{-1} \sum_{j=4}^{n} x_j \, [(j-1)(j-2)(j-3)]/[(n-1)(n-2)(n-3)] \quad \text{(E12)}$$

Regional L-moments ratios are obtained as weighted averages of the at-site L-moments ratios where the at-site values are weighted by record length. Specifically: n_i is the record length at site i of N sites: n_R is the total record length for the N sites in the region; t_2^i, t_3^i, t_4^i are L-moment ratios at site i ; and:

$$n_R = \sum_{i=1}^{N} n_i \tag{E13}$$

Regional Mean (L_1^R) is unity using the index-flood procedure:

$$L_1^R = 1 \tag{E14}$$

Regional L-Cv (t_2^R):

$$t_2^R = n_R^{-1} \sum_{i=1}^{N} n_i \, t_2^i \tag{E15}$$

Regional L-Skewness (t_3^R):

$$t_3^R = n_R^{-1} \sum_{i=1}^{N} n_i \, t_3^i \tag{E16}$$

Regional L-Kurtosis (t_4^R):

$$t_4^R = n_R^{-1} \sum_{i=1}^{N} n_i \, t_4^i \tag{E17}$$

The regional L-moment ratios for L-Skewness (t_3^R) and L-Kurtosis (t_4^R) were corrected for bias based on bias correction equations provided by Hosking and Wallis[8,9]. These equations are valid for the range of regional L-moment ratios observed in the study area, where:

$$\text{bias } t_3^R = 4N(.10 - t_4^R) / n_R \tag{E18}$$

$$\text{bias } t_4^R = 4N(.15 - t_4^R) / n_R \tag{E19}$$

Appendix F

SELECTED DEFINITIONS

At-Site - the term at-site is used in various ways. It may be used to distinguish analyses/data at a specific site from regional analyses/data. It may be used in reference to a given gage/station or a specific geographic location. Observed at-site precipitation is synonymous with observed point rainfall.

At-Site Mean - the mean value of precipitation for a specified duration at a specific location. For a gaged site, it is based on the gaged record for the specified duration. At an ungaged site, it is based on a statistical relationship. Also see mean annual maxima.

Climatic Region - a geographic area that has similar physical and climatological characteristics.

Convective Precipitation - precipitation that results from lifting of atmospheric moisture due to vertical instability in the air column. The thunderstorm is one type of convective precipitation producing mechanism.

Convergence Precipitation - convergence is intended to encompass all precipitation producing mechanisms associated with the circulation of a cyclonic weather system.

Extreme Storm - a precipitation amount for a specified duration that has an annual exceedance probability less than 0.05; rarer than a 20-year event.

Gage Mean - the mean value computed from the annual maxima data at a precipitation gage for some specified duration. At-site mean values are determined from gage mean values using minor correction factors to adjust from fixed measurement intervals to true intervals. See Weiss[32].

Gaged Site - a geographic location where a precipitation gage is used to measure and record precipitation data. See also ungaged site.

Homogeneous sub-region - a collection of sites/gages with similar physical and/or climatic characteristics that can be described by a common regional growth curve.

Mean Annual Maxima (MAM) - the mean value of precipitation annual maxima for a specified duration at a specific location. It is the terminology commonly used in Canada as an alternate to at-site-mean.

Mean Annual Precipitation (MAP) - the average precipitation for a calendar year. (An example of an at-site-mean).

Orographic Precipitation - precipitation that occurs due to the lifting of atmospheric moisture over mountain barriers.

Precipitation Annual Maxima - the greatest precipitation amount in a 12-month period for a specified duration. The annual period may be a calendar year, or any other 12-month period. The water-year, October 1st to September 30th is the 12-month period used in these analyses.

Regional - the term regional is used in a generic manner to distinguish data/analyses for a group of sites/gages as opposed to individual at-site data/analyses. The term regional may be used in reference to homogeneous sub-regions or climatic regions.

Regional Growth Curve - a magnitude-frequency curve with a mean value of unity that is applicable to all sites within a homogeneous region.

Seasonality - frequency characteristics for the time of year (month) during which certain characteristics of precipitation have been observed to occur.

Station - refers to the weather station/collection site for precipitation. A particular station/location may contain any combination of daily, synoptic and automated gages. The term station and site are often used interchangeably.

Ungaged Site - a geographic location where no precipitation measurements are available.

E.48. West Virginia



TITLE 47
LEGISLATIVE RULE
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WATER RESOURCES

SERIES 34
DAM SAFETY RULE

§47-34-1. General.

1.1. Scope and Purpose. -- This legislative rule establishes requirements relating to the design, placement, construction, enlargement, alteration, removal, abandonment, and repair of dams in this State that fall within the definition set forth in 2.12. This legislative rule also establishes requirements to govern the disbursement and use of moneys held in the State Dam Safety Rehabilitation Revolving Fund. The scope does not extend to those dams that are related to coal activities.

1.2. Authority. -- W. Va. Code §22-14-4 and §22-14-19(c).

1.3. Filing Date. -- May 20, 2009.

1.4. Effective Date. -- June 1, 2009.

1.5. Amendment of Existing Rule. -- This legislative rule amends the Dam Safety Rule, 47 C.S.R. 34, filed and made effective May 10, 1995.

§47-34-2. Definitions.

2.1. "Abandonment" means to render a dam non-impounding by filling the reservoir created by that dam with solid materials and by diverting the natural drainway around the site.

2.2. "Act" means the West Virginia Dam Control and Safety Act, W. Va. Code §22-14-1, et seq.

2.3. "Applicant" means a person who applies for a certificate of approval or a loan pursuant to the provisions of this rule.

2.4. "Appurtenances" means any ancillary part of a dam or reservoir system which contributes to the operation or construction of the dam.

2.5. "Assessment Officer" means a person appointed by the Secretary to carry out the review and hearing procedures outlined in this rule.

2.6. “Authority” means the West Virginia Water Development Authority provided in W. Va. Code §22C-1-1 et seq.

2.7. "Average Time Headway" means the number of seconds in one day divided by the average daily traffic.

2.8. "Breach" means partial removal of a dam, creating a channel through the dam at the original stream bottom elevation.

2.9. "Bridge" means a structure, including any abutments or supports appurtenant to that structure, which:

2.9.a. Meets the definition of "dam" set forth in subsection 2.12.;

2.9.b. Is constructed across a natural drainway for the purpose of maintaining a pathway, railway, roadway, support structure, or other passageway for transporting persons, traffic, or other static or moving loads; and

2.9.c. Has an opening under the structure to provide for the passage of normal stream flow.

2.10. "Certificate of Approval" means the written approval issued by the Secretary to a person who has applied to the Secretary for a certificate of approval that authorizes the person to place, construct, enlarge, alter, remove, abandon, or repair a dam and which specifies the conditions or limitations under which the work is to be performed by the applicant.

2.11. "Cost" means the total of all reasonable and necessary costs incurred by a person or the Secretary to finance the engineering, design, alteration, improvement, repair, breaching or removal of a deficient dam for carrying out all works and undertakings necessary or incidental to the accomplishment of any project receiving a loan under this rule, including:

2.11.a. The costs of developmental, planning, and feasibility studies, surveys, plans, and specifications;

2.11.b. The costs of architectural, engineering, financial, legal, or other special services;

2.11.c. The costs of acquisition of land and any buildings and improvements thereon, including the discharge of any obligations of the sellers of such land, buildings, or improvements;

2.11.d. The costs of site preparation and development, including demolition or removal of existing structures, construction and reconstruction, labor, materials, machinery, and equipment;

2.11.e. The reasonable costs of financing incurred by the person applying for a loan from the Fund in the course of the development of the project, carrying charges incurred before placing the project in service, interest on funds borrowed to finance the project to a date subsequent to the estimated date the project is to be placed in service, necessary expenses incurred in connection with placing the project in service, and the funding of accounts and reserves as required by the Secretary;

2.11.f. Other items as are deemed reasonable and necessary by the Secretary.

2.12. "Dam" means an artificial barrier or obstruction --including any works appurtenant to it and any reservoir created by it -- which is or will be placed, constructed, enlarged, altered, or repaired so that it does or will impound or divert water and is or will be twenty-five (25) feet or more in height from the natural bed of a stream or watercourse measured at the downstream toe of the barrier and which does or can impound fifteen (15) acre-feet or more of water or is or will be six (6) feet or more in height from the natural bed of such stream or watercourse measured at the downstream toe of the barrier and which does or can impound fifty (50) acre-feet or more of water. “Dam” does not mean:

2.12.a. Any dam owned by the federal government;

2.12.b. Any dam for which the operation and maintenance thereof is the responsibility of the federal government;

2.12.c. Any farm pond constructed and used primarily for agricultural purposes -- including, but not limited, to livestock watering, irrigation, retention of animal wastes, and fish culture -- that has no potential to cause a loss of human life in the event of embankment failure; or

2.12.d. Roadfill or other transportation structures that do not or will not impound water under normal conditions and that have a designed culvert or similar conveyance or capacity that would be used under a highway at the same location: Provided, That the Secretary may apply the provisions of W. Va. Code §22-14-10 for hazardous, non-impounding structures that become a hazard to human life or property through the frequent or continuous impoundment of water.

2.13. “Deficient dam” means a noncoal-related dam that exhibits one or more design, maintenance, or operational problems that may adversely affect the performance of the dam over a period of time or during a major storm or other inclement weather that may cause loss of life or property; or a noncoal-related dam that otherwise fails to meet the requirements of the Act or this rule.

2.14. "Dam Safety Section" means the Dam Safety Section of the Department of Environmental Protection.

2.15. "Dangerous Condition" means any structural or hydraulic condition of a dam or its appurtenances which may lead to:

2.15.a. Failure of the dam and possible loss of human life or substantial loss of property;

2.15.b. Harm to the public health or welfare; or

2.15.c. Significant harm to the environment.

2.16. "Design Storm" means predicted precipitation of given intensity, frequency, and duration based upon National Weather Service data that is required to be considered in the design of a dam.

2.17. "Disbursement" means the transfer of cash from the Fund to an applicant.

2.18. "Diversion Ditch" means a designed channel constructed for the purpose of collecting and transmitting surface runoff resulting from a given design storm.

2.19. "Embankment" means a constructed deposit of earth or waste materials, usually exhibiting at least one sloping face.

2.20. "Emergency Condition" means an imminently dangerous condition where failure of the dam is possible at any time.

2.21. "Emergency Spillway" means a hydraulic structure designed to discharge water in excess of that which an impoundment is designed to store or which cannot be passed through a principal spillway.

2.22. "Enforcement Action" means a written notification provided to an alleged violator by the Secretary within thirty (30) calendar days of an inspection, or in accordance with the provisions of the Act.

2.23. "Engineer" or "Registered Professional Engineer" means a person who by reason of his or her knowledge of mathematics, the physical sciences, and the principles of engineering, acquired by professional education and practical experience, is qualified to engage in the practice of professional engineering, and holds a current certificate of registration issued by the State granting its licensee the privilege of practicing professional engineering in accordance with the provisions of W. Va. Code §30-13-1 et seq.

2.24. "Freeboard" means the vertical distance between the lowest point of the crest of the embankment of a dam and the reservoir water surface.

2.25. "Fund" means the State Dam Safety Rehabilitation Revolving Fund.

2.26. "Geotechnical Engineering" means the application of soil mechanics, rock mechanics, and geology to the solution of problems involving engineering structures and their interaction with surrounding earth materials.

2.27. "Hazard Classification" means a classification rating assigned to a structure based upon engineering evaluations and judgments for predicting the danger to human life, property, and environment should a failure of the structure occur.

2.28. "High Risk Highway" means a roadway, roadfill, bridge, support structure, or other passageway for transporting persons, traffic, or other static or moving loads where the average time headway between vehicles in traffic is less than the duration of overtopping caused by the dam break flood wave.

2.29. "Hydraulics" means the study of the physical behavior of liquids, especially water, in natural or man-made systems or processes.

2.30. "Hydrologic Analysis" means a determination, using accepted engineering methods, to establish surface water runoff for a given design storm.

2.31. "Hydrology" means the science that deals with the occurrence and behavior of water in the atmosphere, on the ground, and underground.

2.32. "Impoundment" means a basin for the retention of water, sediment, or waste.

2.33. "Incised Reservoir" means an impoundment, or that portion of an impoundment, which has been excavated below the natural stream level into natural ground.

2.34. "Loan" means a loan made by the Authority to an applicant pursuant to section 20.

2.35. "Loan Agreement" means an agreement entered into between the Authority and the applicant pertaining to a loan.

2.36. "Low Risk Highway" means a roadway, roadfill, bridge, support structure, or other passageway for transporting persons, traffic, or other static or moving loads where the average time headway between vehicles in traffic is greater than the duration of overtopping caused by the dam break flood wave.

2.37. "Major Damage" means destruction, ruin, collapse, or displacement of dwellings, commercial or industrial buildings, public highways or bridges, or important public utilities. Dwellings, buildings, public highways or bridges, or important public utilities will sustain major damage when:

2.37.a. The dwelling, commercial or industrial building, public highway or bridge, or important public utility is in the direct path of the dam break flood wave, or;

2.37.b. Important public utilities equipment or public highways or bridges will be harmed sufficiently to cause disruption of service, or to require repair or replacement of the important public utility equipment, or public highway or bridge, or;

2.37.c. The dwelling, commercial or industrial building or important public utility will experience more than 1.5 feet of flood rise due to the dam break flood wave above the lowest ground elevation adjacent to the outside foundation walls; or more than 1.5 feet of flood rise due to the dam break

flood wave above the lowest floor elevation of the dwelling, commercial or industrial building or important public utility. The lower of the elevations shall govern.

2.38. "Minor Damage" means insignificant harm to dwellings, commercial or industrial buildings, public highways or bridges, or public utilities that does not qualify as major damage.

2.39. "Natural Bed" means the lowest elevation of a stream, intermittent stream, or channel created by nature which has not been altered or changed by the actions of man.

2.40. "Natural Drainway" means any natural watercourse which may carry water to the tributaries and rivers of the watershed.

2.41. "Notice of Civil Administrative Penalty" means a written notification provided to a violator by the Secretary, by means of certified mail or personal service, assessing a civil administrative penalty. A notice of civil administrative penalty shall include:

2.41.a. A reference to the section of the statute, rule, notice, order, or certificate of approval term allegedly violated;

2.41.b. A concise statement of the facts alleged to constitute the violation;

2.41.c. A statement of the amount of the initial civil administrative penalty to be imposed; and

2.41.d. A statement of the alleged violator's right to an informal hearing.

2.42. "Notice of Dismissal" means a written notification provided to a violator by the assessment officer or the Secretary dismissing and vacating the civil administrative penalty. A notice of dismissal may be issued at any time during the proceedings.

2.43. “No Hazard” means a situation that is not associated with the structural or hydraulic condition of a dam.

2.44. "P100" means the rainfall amount based upon a one hundred (100) year frequency, six (6) hour duration rainfall event (i.e, a 100-year, 6-hour storm).

2.45. "Person" means any public or private corporation, institution, association, society, firm, organization or company organized or existing under the laws of this or any other state or country; the state of West Virginia; any state governmental agency; any political subdivision of the state or of its counties or municipalities; a sanitary district; a public service district; a drainage district; a conservation district; a watershed improvement district; a partnership; trust, or estate; a person or individual; a group of persons or individuals acting individually or as a group; or any other legal entity. The term "person", when used in this article, includes and refers to any authorized agent, lessee or trustee of any of the foregoing or receiver or trustee appointed by any court for any of the foregoing.

2.46. "Piping" means progressive internal erosion of earth material or adjacent unaltered material caused by water movement through embankment material with sufficient force to move soil particles, leading to the development of a channel or a hole.

2.47. "Principal Spillway" means the hydraulic structure designed to discharge water stored between the normal pool and the emergency spillway invert elevations.

2.48. "Probable Maximum Precipitation" or "PMP" means the depth-duration-area rainfall event for a particular area that represents the maximization of the most critical meteorological conditions that are considered possible to occur.

2.49. “Project” means planning, design, or construction activity necessary to obtain a certificate of approval or to obtain a loan for repair or removal of a dam.

2.50. "Project Area" means all areas physically affected by the construction of a dam including, but not limited to, the dam and its appurtenances, the reservoir area, construction zones, permanent or temporary access roads, borrow areas, materials storage areas, staging areas, and waste disposal areas.

2.51. "Removal" means complete elimination of the dam embankment or structure to restore the approximate original topographic contours of the valley.

2.52. "Roadfill" means a barrier or obstruction which:

2.52.a. Meets the definition of "dam" set forth in subsection 2.12.;

2.52.b. Is constructed across a natural drainway for the purpose of maintaining a roadway or similar crossing across that drainway; and

2.52.c. Has a culvert located in the drainway that is of sufficient size to prevent the normal impoundment of water.

2.53. "Safety Factor" or "Factor of Safety" means the ratio of the sum of the forces or moments resisting mass movement to the sum of the forces or moments tending to produce mass movement.

2.54. "Secretary" means the Secretary of the West Virginia Department of Environmental Protection or his or her authorized representative.

2.55. "Sediment" means solid material, either mineral or organic, resulting from the works of man that has been moved from its site of origin by water.

2.56. "Serious Problem" means a structural or hydraulic condition that if left uncorrected may lead to a dangerous condition.

2.57. "Significant Harm to the Environment" means the degradation of a public or private surface water supply, the alteration of habitat that adversely affects wildlife, or the reduction of the productivity of agricultural land.

2.58. "Site" means the permanent location of a dam, including the dam and its appurtenances, the reservoir area, diversion ditches, and sediment control facilities.

2.59. "Subsidence" means a sinking, collapsing, or cracking of a portion of the earth's surface resulting from the presence of a void or voids beneath the surface.

2.60. "Violator" means the person who is alleged to have violated the Act, or any rule, notice to comply, order, or certificate of approval term imposed pursuant to the Act.

2.61. "Written Decision" means a written decision furnished to the violator concerning the Secretary's final decision regarding the assessment of a civil administrative penalty and the reasons therefor.

§47-34-3. Classification of Dams.

3.1. Types of Dams - For the purpose of this rule, dams are divided into four general types:

3.1.a. Embankment Dams - Embankment dams are usually constructed of materials which exhibit rock-like or soil-like properties.

3.1.b. Gravity Dams - Gravity dams are usually constructed of concrete or masonry materials which form a rigid body.

3.1.c. Waste Disposal Dams - Waste disposal dams are usually constructed of waste materials such as fly ash or coal refuse. The reservoir is utilized to dispose of waste material, thereby creating a continuously decreasing freeboard condition.

3.1.d. Dams of Multiple Type - In cases where a dam exhibits properties of more than one type, such as gabion structures or roller-compacted concrete, the person or his or her agent must apply design techniques which are reasonably applicable to the particular structure involved.

3.2. Dam-Related Measurements.

3.2.a. Measuring Dam Height - The height of a dam is measured from the crest or uppermost point on the dam to the lowest point in the natural bed of the stream or watercourse at the downstream toe of the dam. Gravity overflow dams must be measured to the highest level which is greater than ten percent (10%) of the total crest length of the dam. The height of dams with sloping crests shall be determined by a weighted-average height above the natural bed of the stream or watercourse, excluding spillways.

3.2.b. Measuring Reservoir Volume - For purposes of determining whether a dam meets the criteria set forth in subsection 2.12. as applied to reservoir volume calculations, the volume must be calculated at the crest elevation of the dam that is equivalent to the elevation used in determining the dam height.

3.2.c. Incised Reservoirs - The height of the embankment of an incised reservoir must be measured using the method set forth in paragraph 3.2.a. Reservoir volume must be calculated from the crest of the embankment to the elevation of the lowest point in the natural bed of the stream or watercourse at the downstream toe. That portion of the water stored below stream grade shall not be included in determining whether a dam meets the criteria set forth in subsection 2.12.; however, it must be reported in the application as part of the total reservoir volume.

3.3. Dams in Series - If the Secretary determines that a series or combination of water-impounding structures within the same watercourse, or within the tributaries of the watercourse, which cumulatively meet the definition of "dam" set forth in subsection 2.12. constitute a hazard to human life, and failure of one or more of the impounding structures may induce failure of any or all of the remaining impounding structures, he or she may require the owner or owners of each impounding structure to comply with the requirements of this rule.

3.4. Incidental Dams.

3.4.a. Roadfills.

3.4.a.1. If the Secretary finds that a roadfill has become a hazard to human life or property through the frequent or continuous impoundment of water, he or she may order the owner of that roadfill

to take all steps that are necessary to protect life or property in accordance with the emergency powers provided under W. Va. Code §22-14-10.

3.4.a.2. A certificate of approval will not be required for roadfills.

3.4.b. Bridges.

3.4.b.1. If the Secretary finds that a bridge has become a hazard to human life or property through the frequent or continuous impoundment of water, he or she may order the owner of that bridge to take all steps that are necessary to protect life or property in accordance with the emergency powers provided under W. Va. Code §22-14-10.

3.4.b.2. A certificate of approval will not be required for bridges.

3.4.c. Diversions - A certificate of approval will be required for dikes or other structures used to divert water and otherwise meeting the definition of "dam" set forth in subsection 2.12.

3.4.d. Stream Encroachments - If the Secretary finds that a natural drainway has been restricted by filling or other artificial means so that the restriction can or does impound water, and the fill and resulting reservoir meets the height and storage requirements of a "Dam" as defined in this rule, he or she may order the fill removed or require a certificate of approval or both.

3.5. Classification of Dams - The applicant for a certificate of approval must propose the hazard classification for his or her dam based upon the classification guidelines listed in paragraph 3.5.b. and the hazard evaluation performed pursuant to paragraph 3.5.c. The classification proposed by an applicant is subject to approval by the Secretary.

3.5.a. Changes in Dam Classification - The Secretary will periodically review the hazard classification of each dam subject to this rule and may reclassify a dam if he or she determines that the hazard potential has changed. The owner shall be notified by the Secretary of any hazard classification change.

3.5.b. Hazard Classifications.

3.5.b.1. Class 1 (High Hazard) Dams - Class 1 dams are those dams located where failure may cause loss of human life or major damage to dwellings, commercial or industrial buildings, main railroads, important public utilities, or where a high risk highway may be affected or damaged. This classification must be used if failure may result in the loss of human life.

3.5.b.2. Class 2 (Significant Hazard) Dams - Class 2 dams are those dams located where failure may cause minor damage to dwellings, commercial or industrial buildings, important public utilities, main railroads, or cause major damage to unoccupied buildings, or where a low risk highway may be affected or damaged. The potential for loss of human life resulting from failure of a Class 2 dam must be unlikely.

3.5.b.3. Class 3 (Low Hazard) Dams - Class 3 dams are those dams located in rural or agricultural areas where failure may cause minor damage to nonresidential and normally unoccupied buildings, or rural or agricultural land. Failure of a Class 3 dam would cause only a loss of the dam itself and a loss of property use, such as use of related roads, with little additional damage to adjacent property. The potential for loss of human life resulting from failure of a Class 3 dam must be unlikely.

3.5.b.3.A. An impoundment exceeding forty (40) feet in height or four hundred (400) acre-feet storage volume shall not be classified as a Class 3 dam.

3.5.b.3.B. A waste disposal dam, the failure of which may cause significant harm to the environment, shall not be classified as a Class 3 dam.

3.5.b.4. Class 4 (Negligible Hazard) Dams - Class 4 dams are dams where failure is expected to have no potential for loss of human life, no potential for property damage and no potential for significant harm to the environment. Examples of Class 4 dams include: dams across rivers, failure of which under any conditions will not flood areas above normal stream bank elevations; dams located in the reservoir of another dam which, under any conditions, can contain water released by failure of the Class 4 dam; and dams in series where the toe of the Class 4 dam(s) is in close proximity to the reservoir of a dam which can contain failure of the Class 4 dam(s) under any condition. In considering a request for a Class 4 designation, the Secretary may require written concurrence from the owner(s) of downstream dams that may be affected by failure of the Class 4 dam. Approval for use of this classification is vested in the Secretary, and will be based on engineering evaluation of the dam(s) and downstream areas in question.

3.5.c. Hazard Evaluation.

3.5.c.1. Downstream Hazards - In evaluating the hazard potential of a dam in order to determine its hazard classification, a complete evaluation of the downstream area which will be affected in the event of dam failure must be performed. A sudden flooding of inhabited land accompanied by a water flow with damaging velocity, a wall of water, or the flooding of inhabited structures will all be deemed to have the potential to result in a loss of human life. The planned or potential future development of downstream areas must also be considered when evaluating hazard classification.

3.5.c.2. Dam Break Analysis - An applicant must perform a downstream breach analysis to evaluate and map the downstream inundation area under assumed normal conditions and overtopping failure conditions.

3.5.c.2.A. The Secretary may waive the downstream breach analysis required under subparagraph 3.5.c.2. for a Class 2 or Class 3 or Class 4 dam where downstream conditions prevent any future introduction of new facilities or residences that thereby change the hazard classification of the dam.

3.5.c.3. Upstream Hazards - No dam shall be constructed which, during maximum pool conditions, will flood upstream dwellings, public utilities, primary highways, or main railroads unless otherwise approved by the Secretary based upon site-specific conditions.

3.5.d. Risk Assessment - The applicant may propose a risk assessment according to the following provisions to determine the effect upon dwellings or other buildings downstream (paragraph 3.5.d.1.), to reduce the hazard classification (subdivision 3.5.b.) or to reduce the design storm requirements (paragraph 7.1.a.2.) based upon failure of the dam by overtopping. The applicant must include appropriate calculations to support the request for hazard classification or design storm requirement reduction. The Secretary will not consider risk assessment based upon planned evacuation, probability of inhabitation, or monetary recovery of property damage. If both paragraph 3.5.d.1. (Dwellings or other Buildings Affected Downstream) and paragraph 3.5.d.2. (Highways Affected Downstream) pertain to the downstream area, then the hazard classification representing the greatest risk category and the largest of the design storm requirements resulting from the above calculations shall apply. Approval of hazard classification reduction or reduction of design storm requirements based upon risk assessment is vested in the Secretary, and will be based on engineering evaluation of the dam(s) and downstream areas in question.

3.5.d.1. Dwellings or Other Buildings Affected Downstream - The Secretary may consider reduced design storm requirements (subparagraph 7.1.1.b.) within the approved hazard classification, if the applicant can demonstrate that all affected dwellings, commercial and industrial buildings or important public utilities will be inundated and evacuated prior to the dam failure. The applicant must

also demonstrate that the potential for loss of human life resulting from the dam failure is not significantly increased from that which occurs immediately prior to the dam failure.

3.5.d.2. Highways Affected Downstream - The Secretary may consider reduced hazard classification (paragraph 3.5.b.) and reduced design storm requirements (subparagraph 7.1.a.2.), if the applicant can demonstrate that affected highway(s) will be impassable and traffic will be stopped in the dam failure inundation area due to the highway(s) being flooded by high water prior to the dam failure. The applicant must also demonstrate that the potential for loss of human life resulting from the dam failure is not significantly increased from that which occurs immediately prior to the dam failure.

§47-34-4. Certificates of Approval.

4.1. Certificate Required - A person must obtain a certificate of approval from the Secretary in order to place, construct, enlarge, alter, breach, remove, abandon, or perform major repairs upon any dam in this State that falls within the definition set forth in subsection 2.12.

4.2. Certificate Issuance.

4.2.a. Certificates of approval may constitute full and final approval of a dam or be issued for alterations or repairs, in which case the certificate may or may not constitute final approval of the dam.

4.2.b. The Secretary will issue or refuse to issue a certificate of approval based upon the following:

4.2.b.1. The receipt of a complete application, including all applicable fees, in accordance with the provisions of subsection 5.1;

4.2.b.2. The review of the application form and plan package for sufficiency; and

4.2.b.3. The results of any hearings held in accordance with the provisions of W. Va. Code §22-14-7.

4.2.c. The Secretary will return defective applications to the applicant by certified or registered mail, return receipt requested, in order that the applicant may correct any defect. The applicant must send a corrected application to the Secretary within thirty (30) days of the date of the applicant's receipt of the returned application. The Secretary may extend the thirty-day period upon the receipt of a written request from the applicant.

4.2.d. Upon the receipt of written approval from the Secretary of the sufficiency of the application, the applicant shall immediately publish a Class I legal advertisement in a qualified newspaper, as defined in W. Va. Code §59-3-1, serving the county in which the proposed dam is to be located or in which the existing dam is located. The notice shall include the name and address of the applicant, the location of the dam for which the application was filed, and such other information as may be specified by the Secretary in his or her written approval.

4.3. Hearings Prior to Certificate Issuance - Any person who may be adversely affected by the issuance of a certificate of approval shall have a right to a hearing before the Secretary. A written request for a public hearing, detailing the specific objections to the issuance of the certificate of approval, must be sent to the Secretary within fifteen (15) days of the publication of the Class I legal advertisement required under subdivision 4.2.d. Hearings that concern specific objections to the issuance of a certificate of approval will be conducted in accordance with the provisions of W. Va. Code §22-14-7 at a location and time set by the Secretary.

4.4. Certificate Revocation or Suspension - The Secretary may revoke or suspend a certificate of approval in accordance with the provisions of W. Va. Code §22-14-8 if he or she determines that a dam for which the certificate was issued constitutes a danger to life and property.

4.5. Certificate Terms and Conditions - A certificate of approval may include such terms and conditions as the Secretary may find necessary for the construction or operation of the dam. These terms and conditions may be amended by the Secretary in accordance with the provisions of W. Va. Code §22-14-8.

4.6. Approval to Impound Water - No person may cause a reservoir to initially fill with water, or refill a drained reservoir, without written approval from the Secretary.

4.6.a. Upon the receipt of a written petition from a dam owner, the Secretary may waive or modify the refilling approval requirement of subsection 4.6 in a case where frequent draining and refilling of a reservoir is the intended purpose and normal operation of the owner's dam.

4.7. Other Approvals - The Secretary may refuse to issue a certificate of approval or may delay issuing a certificate of approval if the applicant fails to obtain necessary approvals from State or federal agencies.

4.7.a. Waterways Under State or Federal Jurisdiction - Construction of a dam across a waterway which is under the jurisdiction of the State or federal government may require State or federal agency approval prior to issuance of a certificate of approval by the Secretary.

4.7.b. Wetlands - Construction of a dam which may inundate, drain, or otherwise adversely affect wetlands (i.e., swamps, marshes, bogs, and similar areas) may require State and federal agency approval.

§47-34-5. Application Procedures.

5.1. Application Preparation and Submission.

5.1.a. Applications for a certificate of approval shall be prepared by or under the direct supervision of an engineer.

5.1.b. Applications shall be submitted on the forms provided by the Secretary. Application forms must be completed in their entirety without unauthorized omissions, alterations, or additions. Applications shall be signed by the applicant and an engineer.

5.1.c. A complete application will consist of a completed and signed application form, all applicable fees, and a plan package containing the information required under subsection 6.4.

5.1.d. Plans, reports, specifications, and design drawings shall be signed and sealed by an engineer in accordance with the provisions of subsection 6.2.

5.2. Application Review.

5.2.a. Applications will be reviewed for sufficiency by the Dam Safety Section. The review will consider the completeness and technical accuracy of the information submitted and will evaluate all engineering plans and assumptions to determine the safety of the dam.

5.2.b. Applications which are incomplete or otherwise not in compliance with the requirements of this rule will be returned to the applicant for correction in accordance with the provisions of W. Va. Code §22-14-7.

§47-34-6. Plans and Specifications.

6.1. Plans and Specifications - Plans and specifications relating to the design, placement, construction, enlargement, alteration, removal, abandonment, or repair of a dam must be prepared in accordance with the requirements of sections 7 through 12.

6.2. Engineer's Signature and Seal Required - All plans and specifications shall be signed and sealed by an engineer. The engineer's signature and seal are required on each full-size plan sheet, even if the sheets are bound together, and are further required on the front page of any engineering report book and each unbound sheet of drawings or specifications included in appendices or pockets.

6.3. Engineering Practices - All plans and specifications for the placement, construction, enlargement, alteration, breaching, removal, abandonment, or repair of a dam shall be in the charge of an engineer.

6.3.a. Standard Practices - All engineering designs, procedures, processes, and analyses shall be based upon standard, accepted, and sound engineering practices. Practices which are questionable or difficult to prove analytically may be rejected by the Secretary or returned for additional information.

6.3.b. Experimental Practices - Experimental design will not be approved by the Secretary unless the experiment meets the following conditions:

6.3.b.1. Engineering analysis indicates the design is realistic and success is likely;

6.3.b.2. Failure of the experiment to perform properly will not endanger life and property or cause the failure of the dam; and

6.3.b.3. The engineer and dam owner agree to redesign and modify the experimental design if it does not perform properly.

6.4. Plan Package Organization - Each plan package submitted for approval shall contain the following information, arranged in the following order, unless an alternative submission format is approved by the Secretary:

6.4.a. Project Narrative - A general narrative discussion of the project shall be included in the plan package to detail the following:

6.4.a.1. Existing site conditions;

6.4.a.2. Local geology and geotechnical considerations;

6.4.a.3. Design life of the dam and its appurtenances;

6.4.a.4. Subsidence potential;

6.4.a.5. Design techniques with associated design computations and data;

6.4.a.6. Environmental protection measures for the control of erosion and sedimentation and for the disposal of construction wastes;

6.4.a.7. Method of construction, including clearing and grubbing, topsoil stockpiles, and surface and subsurface drainage structures;

6.4.a.8. Phases or sequence of construction; and

6.4.a.9. Routine inspection and maintenance procedures and schedules.

6.4.b. Construction Sequence and Schedule - A proposed or recommended sequence of construction, with a schedule listing the anticipated number of working days necessary to accomplish each item in the sequence, shall be included in the plan package. The construction sequence and schedule must be specific to the dam and must cover the following general categories:

6.4.b.1. Sediment control measures;

6.4.b.2. Clearing and grubbing;

6.4.b.3. Road or utility relocations;

6.4.b.4. Development of borrow areas;

6.4.b.5. Placement of coffer dams or diversions;

6.4.b.6. Excavation of foundation areas;

6.4.b.7. Excavation of spillways;

6.4.b.8. Placement of embankment or structural materials;

6.4.b.9. Placement of spillways and appurtenances to spillways;

6.4.b.10. Seeding and mulching of the project area;

6.4.b.11. General cleanup of the project area; and

6.4.b.12. Other information as requested by the Secretary.

6.4.c. Project Specifications - Specifications submitted with the plan package must be specific to construction of the dam or must contain a specific section concerning construction of the dam. Inclusion of specifications for the dam throughout other general construction specifications is not acceptable. Specifications shall be included in the plan package to detail the following:

6.4.c.1. Clearing and grubbing;

6.4.c.2. Soil stockpiles;

6.4.c.3. Subdrain construction;

6.4.c.4. Slopes;

6.4.c.5. Grades;

6.4.c.6. Surface drainage structures such as embankment diversion ditches;

6.4.c.7. Spreading and compaction requirements, including lift thicknesses, moisture content, and degree of compaction;

6.4.c.8. Material and gradation requirements for subsurface drainage structures;

6.4.c.9. Pipes;

6.4.c.10. Concrete, including testing and curing;

6.4.c.11. Anti-seep mechanisms;

6.4.c.12. Cutoff trenches including specific treatment of joints, bedding planes, fractures, weak zones, overhangs or faults;

6.4.c.13. Channel and slope protection (e.g., riprap);

6.4.c.14. Project quality control and testing;

6.4.c.15. Blasting;

6.4.c.16. Construction erosion and sediment control;

6.4.c.17. Construction waste disposal;

6.4.c.18. Dust abatement;

6.4.c.19. Revegetation;

6.4.c.20. Installation and reading of monitoring devices;

6.4.c.21. Inspection and maintenance; and

6.4.c.22. Other information as requested by the Secretary.

6.4.d. Maps and Drawings.

6.4.d.1. Maps shall be included in the plan package showing the project area in relation to primary highways, county seats, and major drainages. County highway maps may be used for this purpose.

6.4.d.2. A map showing the limits of the watershed with respect to the project area shall be included in the plan package. The minimum map scale meeting this requirement is a 7-1/2 minute United States Geological Survey topographic map with the project area plotted on it.

6.4.d.3. A plan view map of the project area that shows all disturbed and reservoir areas shall be included in the plan package showing detailed contour intervals (i.e., a five-foot maximum interval).

6.4.d.3.A. The location of the following items, if present, shall be plotted on the plan view map:

6.4.d.3.A.1. Caves;

6.4.d.3.A.2. Cemeteries and graves;

6.4.d.3.A.3. Seeps;

6.4.d.3.A.4. Springs;

6.4.d.3.A.5. Mine drainage;

6.4.d.3.A.6. Underground mine openings;

6.4.d.3.A.7. Underground mine workings;

6.4.d.3.A.8. Borings and test pits;

6.4.d.3.A.9. Cross-sections;

6.4.d.3.A.10. Project stationing;

6.4.d.3.A.11. Reference points;

6.4.d.3.A.12. Instrumentation;

6.4.d.3.A.13. The subdrain system;

6.4.d.3.A.14. Diversion channels;

6.4.d.3.A.15. Surface water drainage channels;

6.4.d.3.A.16. Spillway channels;

6.4.d.3.A.17. Borrow source areas; and

6.4.d.3.A.18. Proposed waste disposal areas.

6.4.d.3.B. Additional detailed plan views of the dam or its spillways and appurtenances may be required by the Secretary.

6.4.d.4. Transverse and longitudinal cross-sections and profiles of the dam shall be included in the plan package showing original ground, subdrain locations, elevations, benches, spillways, and other pertinent features of the project area. A cross-section shall be provided for stability computations showing the dam at critical areas, with subsurface data plotted in accordance with the provisions of part 7.4.b.1.D.4.

6.4.d.5. Cross-sections and profiles of major drainage facilities shall be included in the plan package.

6.4.d.6. Construction drawings shall be included in the plan package showing subdrains, spillways, anti-seep mechanisms, and other pertinent structures.

6.4.e. Inventory of Protected Sites.

6.4.e.1. An inventory of sites protected under State or federal law must be conducted by each applicant seeking a certificate of approval to:

6.4.e.1.A. Construct a new dam; or

6.4.e.1.B. Alter or enlarge an existing dam whereby new areas will be disturbed or flooded.

6.4.e.2. The minimum acceptable protected sites inventory shall include the following components:

6.4.e.2.A. A field survey shall be conducted by the applicant or his or her agents to ascertain the presence of any cave (i.e., a naturally occurring underground subterranean cavity such as a cavern or grotto) within the area to be disturbed or flooded by the project. The location of all caves must then be plotted on the plan view map required under paragraph 6.4.d.3. If no caves are present in the area to be disturbed or flooded, that fact must be noted in a statement attached to the plan view map submitted to the Secretary.

6.4.e.2.B. A field survey shall be conducted by the applicant or his or her agents to ascertain the presence of any cemetery or grave within the area to be disturbed or flooded by the project. The location of all cemeteries and graves must then be plotted on the plan view map required under paragraph 6.4.d.3. If no cemeteries or graves are present in the area to be disturbed or flooded, that fact must be noted in a statement attached to the plan view map submitted to the Secretary.

6.4.e.2.C. A copy of the plan view map required under subparagraph 6.4.d.3. shall be sent by the applicant to the West Virginia Division of Natural Resources, Nongame Wildlife Program, P.O. Box 67, Elkins, West Virginia 26241. A letter of transmittal that briefly explains the nature of the applicant's project must accompany the map so that State officials may have the opportunity to assess whether the applicant's project will adversely impact any animal or plant species that is listed by the federal government as endangered or threatened in Endangered Species Act. [1987 Stat. 884, as amended: 16 U.S.C. 1531 et seq.]. A copy of the applicant's letter of transmittal must be included in the plan package submitted to the Secretary; and

6.4.e.2.D. A copy of the plan view map required under subparagraph 6.4.d.3. shall be sent by the applicant to the West Virginia Division of Culture and History, Historic Preservation Unit, Cultural Center, State Capitol Complex, 1900 Kanawha Boulevard East, Charleston, West Virginia 25305. A letter of transmittal that briefly explains the nature of the applicant's project must accompany the map so that State officials may have the opportunity to assess whether the applicant's project will adversely impact any historic site that is listed by the West Virginia Division of Culture and History on the State Register of Historic Places. A copy of the applicant's letter of transmittal must be included in the plan package submitted to the Secretary.

6.4.e.3. If either artifacts of historical significance or human remains are uncovered by construction or related activities, the Dam Safety Section must be contacted immediately. The Secretary may suspend activities in the vicinity of such artifacts or remains until appropriate investigations have been conducted.

6.4.f. Erosion and Sediment Control - The plan package must include either:

6.4.f.1. A copy of the applicant's letter transmitting a permit application for the WV/NPDES Storm Water Construction General Permit to the Secretary, if the disturbed area within the site will exceed limits necessary for a NPDES permit, or;

6.4.f.2. An erosion and sediment control plan as required in subdivision 7.5.a., if the disturbed area within the site is less than the limits necessary for a NPDES permit.

§47-34-7. Design Requirements.

7.1. Hydrologic Considerations.

7.1.a. General Hydrologic Requirements.

7.1.a.1. Hydrologic Investigation.

7.1.a.1.A. A survey shall be conducted to evaluate soil types, land use, land slope, watershed area, runoff curve number, and any other factors needed to establish watershed characteristics. A summary of all hydrologic and hydraulic data compiled in the initial site investigation and used in the analysis shall be included in table or figure form in the plan package.

7.1.a.1.B. A stream flow analysis shall be conducted to evaluate stream flow quantity and quality as it affects the dam and its appurtenances.

7.1.a.2. Design Storm Requirements - The design storm and any incremental reduction of the design storm proposed by the applicant is subject to approval by the Secretary. All dams shall be designed to meet the following minimum hydrologic criteria based upon hazard classification:

7.1.a.2.A. Class 1 Dams - Class 1 dams shall be designed for the probable maximum precipitation of six (6) hours in duration. The design precipitation for a Class 1 dam may be reduced based on Risk Assessment (subdivision 3.5.d.), but in no case to less than seventy percent (70%) of the probable maximum precipitation.

7.1.a.2.B. Class 2 Dams - Class 2 dams shall be designed for fifty percent (50%) of a probable maximum precipitation of six (6) hours duration. The design precipitation for a Class 2 dam may be reduced based on Risk Assessment (subdivision 3.5.d.), but in no case to less than twenty-five percent (25%) of the probable maximum precipitation.

7.1.a.2.C. Class 3 Dams - Class 3 dams shall be designed for twenty-five percent (25%) of a probable maximum precipitation of six (6) hours in duration. The design precipitation for a Class 3 dam may be reduced based on Risk Assessment (subdivision 3.5.d.), but in no case to less than a P100 rainfall of six (6) hours in duration.

7.1.a.2.D. Class 4 Dams - Class 4 dams shall be designed for a P100 rainfall of six (6) hours in duration.

7.1.a.3. Antecedent Moisture Conditions - Where applicable to the development of a hydrograph, Antecedent Moisture Condition II (AMC II) may be used unless a different condition class is required by the Secretary.

7.1.a.4. Flood Routings - An analysis shall be performed for the reservoir and spillways which includes inflow hydrographs, stage storage curves, stage discharge curves, and routings. The spillways must be able to safely discharge that portion of the design storm that is not stored in the reservoir. If a computer analysis is used, the input data and output results must be clearly labeled and identified. Trial calculations or intermediate results not relevant to the final results may be omitted from the plan package.

7.1.b. Specific Hydrologic Requirements.

7.1.b.1. Embankment Dams.

7.1.b.1.A. Storage and Discharge.

7.1.b.1.A.1. Class 1 dams designed with either an open channel spillway only or with an emergency spillway and a principal spillway together must be capable of discharging that portion of the design storm that cannot be safely stored in the impoundment. Class 1 dams designed with a decant or principal spillway only must be capable of storing the volume of water generated by a PMP rainfall event of six (6) hours in duration. The design of a Class 1 dam must assure that ninety percent (90%) of the stored volume of the design storm will be discharged within ten (10) days after the storm event.

7.1.b.1.A.2. Class 2 dams must be designed with either an open channel spillway only or a combination of principal and emergency spillways. A Class 2 dam shall be capable of passing that portion of the design storm that cannot be safely stored in the impoundment. The design of a Class 2 dam must assure that ninety percent (90%) of the stored volume of the design storm will be discharged within ten (10) days after the storm event.

7.1.b.1.A.3. Class 3 dams must be designed with either an open channel spillway only or a combination of principal and emergency spillways. A Class 3 dam shall be capable of passing that portion of the design storm that cannot be safely stored in the impoundment. The design of a Class 3 dam must assure that ninety percent (90%) of the stored volume of the design storm will be discharged within ten (10) days after the storm event.

7.1.b.1.B. Surface Drainage Control - Surface drainage control devices (e.g., vegetated slopes, benches, groin ditches, and collection channels) shall be provided as necessary to protect the dam and its appurtenances from the effects of erosion. Riprap or other erosion protection measures shall be included where excessive velocity is anticipated or experienced. All surface drainage control devices must be designed to exit safely beyond the downstream toe of an embankment in a natural drainway capable of carrying the design flow without excessive erosion. The 50-year, 6-hour rainfall event shall be used as the design storm for surface drainage systems.

7.1.b.1.C. Spillway Frequency of Operation - Outlet works that incorporate vegetated earth or unlined earth emergency spillways shall be designed so that the average frequency of operation is no greater than the following recurrence schedule, based upon a 6-hour rainfall event:

7.1.b.1.C.1. Class 1 Dams - Once in one hundred (100) years.

7.1.b.1.C.2. Class 2 Dams - Once in fifty (50) years.

7.1.b.1.C.3. Class 3 and Class 4 Dams - Once in twenty-five (25) years.

7.1.b.1.D. Overtopping Embankments - Regardless of their hazard classification, dams designed to overtop in accordance with the provisions of subparagraph 7.4.b.1.E. shall not overtop more frequently than once in one hundred (100) years, based upon a 6-hour rainfall event.

7.1.b.2. Gravity Dams - Gravity dams may be designed in the same manner as the corresponding hazard classes of embankment type dams in subparagraph 7.1.b.1.A. except that designed overtopping of the dam may be substituted for the emergency spillway requirements.

7.1.b.3. Waste Disposal Dams.

7.1.b.3.A. Storage and Discharge - The following storage and discharge systems may be used in design of waste disposal dams:

7.1.b.3.A.1. Open Channel Only or Emergency Spillway with Principal Spillway - A dam designed with either an open channel spillway only or with an emergency spillway and a principal spillway together shall be capable of discharging that portion of the design storm that cannot be safely

stored in the impoundment. This type of design must assure that ninety percent (90%) of the stored volume of the design storm will be discharged within ten (10) days after the storm event. Slurry impoundments shall be provided with a means of removing water to maintain the lowest practical water level.

7.1.b.3.A.2. Principal Spillway or Decant Only - A dam designed with a decant or principal spillway only shall be capable of storing the volume equivalent to a minimum of one (1) design storm. Risk assessment shall not be applied to dams with principal spillway or decant only. This type of design must assure that ninety percent (90%) of the stored volume of the design storm will be discharged within ten (10) days after the storm event. Slurry impoundments shall be provided with a means of removing water to maintain the lowest practical water level.

7.1.b.3.A.3. No Outlet Works - A dam designed without discharge structures shall be capable of storing the volume equal to a minimum of two (2) design storms. Risk assessment shall not be applied to dams with no outlet works. Water shall be removed from the impoundment to its lowest practical level by pumping or other means if storm water reduces the storage capacity to one (1) design storm or less.

7.2. Hydraulic Considerations.

7.2.a. General Hydraulic Requirements.

7.2.a.1. Hydraulic Analysis - Using standard engineering practices, a hydraulic analysis shall be performed for the spillways and surface drainage system. Typical cross-section design techniques may be used where constant slopes are encountered. All hydraulic structures shall be designed to safely control the velocity of water in order to prevent excessive erosion. Accepted engineering practices shall be used to design riprap, non-flexible channel linings, bedding, and energy dissipators.

7.2.b. Specific Hydraulic Requirements.

7.2.b.1. Open Channels - Open channels, including open channel spillways, shall be analyzed for flow depth, velocity, nonuniform flow conditions, super-elevation, and hydraulic jumps.

7.2.b.1.A. Stage Discharge - Where an open channel is used as a spillway, a stage discharge rating shall be developed using standard engineering practices for the type and shape of the spillway. In developing the rating, increase in upstream water depth due to change in velocity head must be considered.

7.2.b.1.B. Water Surface Profiles - Where channel slopes or cross-sections vary and nonuniform flow conditions result, a water surface profile may be necessary in order to analyze the channel flow depths and the location of hydraulic jumps.

7.2.b.1.C. Hydraulic Jumps - Where hydraulic jumps will occur, channel sidewall height shall be sufficient to contain the jump. The channel lining shall be designed to withstand the hydraulic jump without damage.

7.2.b.1.D. Critical Flows - Channels shall be designed so that water will not flow at critical depth for extended distances. In channels of varying slope or cross-section where nonuniform flow occurs, the transition through critical flow shall be as rapid as possible.

7.2.b.1.E. Super-elevation - Channel walls shall be designed to contain super-elevated flows in curves. Where curves occur in spillway channels, the Secretary may approve super-elevation

wall height based upon one-half of the design flow, but not less than the P100 design flow, provided the excess overflow will impinge on natural ground and will not endanger the dam, human life, or property.

7.2.b.2. Closed Conduit Systems - Closed conduit systems including principal spillways, risers, and pipes shall be analyzed to determine the controlling limits of weir, orifice, and pipe flows.

7.2.b.2.A. Risers and Drop Inlets - Risers shall be protected with a designed trash rack and anti-vortex device. The drop inlet shall be sized to provide a rapid transition from partial to full pipe flow conditions.

7.2.b.2.B. Stage Discharge - When a closed conduit system is used as a principal system, a stage discharge rating shall be developed using standard engineering practices for weir, orifice, and pipe flow calculations.

7.2.b.2.C. Slug Flow - Conduit systems shall be designed to avoid formation of alternating partial and full pipe flow conditions through proper selection of pipe slope and headwater or tailwater conditions.

7.3. Geotechnical Considerations.

7.3.a. Geotechnical Investigation - A geotechnical investigation shall be performed. The quantity, location, and depth of borings, test pits, or trenches must be adequate for the evaluation of the bearing capacity and subsurface conditions for the proposed structure and may vary based upon the height, impoundment volume, and hazard classification of the dam. Factors to be considered include depth of soil, characteristics of bedrock, and determination of groundwater location. Results of in-situ testing and soil sampling shall be reported in the plan package. Soil profiles shall be utilized for critical foundation locations of the structure, spillways, and other pertinent locations which affect the safety of the structure. A geological study shall also be conducted to evaluate stratigraphy, landslides, bedrock discontinuities such as soft seams, joints, joint systems, bedding planes, and fault zones which may adversely affect the structure's performance. Past and future mining including thickness of coal seams, depth and type of rock above the coal seam, and previous or expected subsidence problems shall be considered where subsidence may affect the safety of the structure.

7.3.a.1. Project Area Survey - A project area survey shall be conducted to establish baselines and elevations of the dam embankments, reservoir and borrow areas, and appurtenant structures. The survey shall locate all test pits, borings, gas wells, oil wells, water wells, mine openings, landslides, and areas of natural seepage.

7.3.a.2. Borrow Areas - Borrow areas shall be evaluated for appropriate construction materials and required volume. Borrow areas and excavation materials shall be tested to determine the suitability of material for use in embankments or drains.

7.3.b. Laboratory Testing - Laboratory tests shall be conducted on a sufficient number of samples of foundation and embankment materials to provide an accurate representation of soil conditions. Tests shall include, but not be limited to, a complete soil classification including grain size, sieve, hydrometer analysis, Atterberg limits, density, water content, compaction tests, shear strength, consolidation, and permeability where applicable. Compaction and proctor curves shall be developed for all fill materials as appropriate.

7.3.c. Geotechnical Evaluation - A summary of all geotechnical data determined in the initial site geotechnical investigation and used in the analysis shall be included in table or figure form in the plan package.

7.3.c.1. Seepage Analysis - An analysis of seepage and its detrimental effects on structural integrity shall be made. The analysis shall include consideration of potential piping in the embankment, foundations, and abutments. Seepage control measures shall be specified as necessary in order to enhance the stability of the embankment and adjacent area. Drainage systems shall be designed and constructed using a material approved by the Secretary and shall be protected by a properly designed filter zone using standard geotechnical engineering design practices. The design shall specify methods for sealing or controlling seepage encountered in foundation zones during construction.

7.3.c.1.A. Foundation Treatment - If analysis indicates a highly fractured foundation, the engineer shall specify necessary treatment of the foundation zone including, but not limited to, foundation grout curtains, dental concrete treatment of fractures or overhangs, and detailed methods of foundation zone cleaning. Material used in grouts shall be specified in accordance with the provisions of subparagraph 7.4.a.1.B.

7.3.c.2. Foundation Stability - The foundation must be designed to have adequate bearing capacity to support the embankment and any appurtenant works. Potential subsidence and settlement and their consequences shall be considered using standard engineering practices. Special attention shall be given to differential settlement which would lead to cracking of the dam. Spillway pipes on compressible foundations shall be protected from damage due to settlement.

7.3.c.3. Landslides - The potential for landslides, as determined in the initial project area investigation, shall be evaluated by the engineer. If landslides noted in the project area could cause instability of the dam or appurtenant structures, blockage of spillways and other critical drainage structures, or overtopping of the dam by displacement of water in the reservoir area, such conditions shall be corrected to a minimum static safety factor of 1.5.

7.4. Structural Considerations.

7.4.a. General Structural Requirements - All structures shall be designed to perform as intended for the design life of the dam with proper maintenance or replacement.

7.4.a.1. Structural Materials - Materials selected for use in the dam shall be of adequate quality and durability for the intended purpose of the structure. All structures shall be designed to have sufficient strength plus an adequate safety factor against failure during maximum anticipated loading conditions.

7.4.a.1.A. Earth Materials - Earth materials selected for use in dam construction shall be free from roots, brush, organic materials, construction waste, and other debris. Where rock or rock fill is specified, the rock shall be durable and not subject to slaking or breakdown. Size gradations of the earth materials shall be specified to perform as planned. Compaction requirements for earth materials shall be specified in the plan package.

7.4.a.1.B. Concrete Design - Concrete shall be designed in accordance with standard engineering practices. Concrete design specifications shall include materials, proportioning, form-work, reinforcement, joints and embedded items, production, placing, repair of surface defects, finishing, curing and protection, testing, evaluation and acceptance, and allowable tolerances for acceptance.

7.4.a.1.B.1. Concrete Specifications - The engineer shall specify the nature of concrete to be used with sufficient detail for on-site quality control. The concrete may be specified by specific mix, aggregate, water content, additives, compressive strength, slump, and air entrainment or by reference to specific standards of concrete quality. If published standard specifications are referenced, a copy of the standard or pertinent sections of the standard shall be included in the plan package.

7.4.a.1.B.2. Concrete Placement - The engineer shall specify methods and limits of placement of the concrete including foundation preparation, maximum lift height, maximum time allowed between mixing and placement, methods of working into forms and corners, methods of consolidation and use of vibrating devices, and allowable ambient air temperatures and concrete temperatures.

7.4.a.1.B.3. Concrete Curing - The engineer shall specify the method of curing the concrete including moist curing or membrane curing, wetting, types of covering, acceptable curing temperature range of the concrete, any anticipated cold weather curing specifications or methods such as protection from freezing and insulation methods, hot weather placement methods and limitations, and curing time.

7.4.a.1.B.4. Concrete Finishing - The engineer shall specify the type of finishing to be applied to the concrete and the acceptable temperature range.

7.4.b. Specific Structural Requirements.

7.4.b.1. Embankment Dams.

7.4.b.1.A. Selection of Materials - Material selected for construction of embankments shall be select earth material that is free from roots, brush, organic matter, construction waste, and other debris. The material must not be subject to breakdown or chemical reaction. Unless otherwise approved by the Secretary, the selected material must be thoroughly tested for density, shear strength, liquid and plastic limits, and optimum moisture content. The source of the material and available quantities shall be identified and adequate sampling performed in order to attain consistent quality and soil characteristics.

7.4.b.1.B. Seepage and Piping Control - The Secretary may require installation of a properly designed filter drain system to prevent embankment failure due to seepage and/or internal erosion of any dam which can cause loss of human life or major damage to dwellings, or commercial or industrial buildings, important public utilities, or where a high risk highway may be affected.

7.4.b.1.C. Zoned Embankments.

7.4.b.1.C.1. Filter Drains - Filter drains shall be used in embankment zones where necessary to intercept seepage, reduce phreatic level, and reduce potential for internal erosion. Drain outlets shall be visible, not submerged under normal conditions, unobstructed, and protected with an animal guard where conduits are utilized.

7.4.b.1.C.1(a) Gradations - The gradations of the filter material shall be sized to prevent or resist the migration of embankment material into the voids of the filter. The filter shall be permeable relative to the surrounding embankment material.

7.4.b.1.C.1(b) Size - The filter drain shall be capable of passing the maximum anticipated seepage flows without excessive pore pressure. The combination of filter permeability and area shall be considered in sizing the drain.

7.4.b.1.C.1(c) Durability - The material used in the filter shall be hard, durable material that is not subject to slaking, breakdown, or chemical reaction.

7.4.b.1.C.1(d) Conduits - Perforated pipes may be used in the filter drain to increase capacity. Perforations shall be compatible with the filter gradations so that filter material will not enter the pipe. The pipe shall be capable of supporting the fill load and shall be of a material which will last for the design life of the structure. Corrugated metal pipe shall not be used in critical areas of the embankment or in any areas where the pipe is not reasonably accessible for replacement.

7.4.b.1.C.1(e) Filter Cloth - Filter cloth shall not be used in critical areas of the embankment or in any areas where the cloth is not reasonably accessible for replacement.

7.4.b.1.C.2. Diaphragm Cutoff Walls - When concrete cutoff walls are used as an impermeable barrier, the concrete wall shall be placed upon an adequate foundation and be constructed of reinforced concrete. Where pipes pass through the concrete wall, adequate support for the pipe shall be provided to prevent differential settlement and pipe shearing.

7.4.b.1.D. Embankment Stability -The following stability requirements apply to Class 1 through Class 3 dams. The Secretary may approve lower safety factors for Class 4 dams, based on engineering recommendations.

7.4.b.1.D.1. Embankment Safety Factors - Slope stability shall be analyzed to show that the embankment design achieves the following factors of safety under the conditions listed. Unless otherwise indicated, factors of safety requirements apply to both upstream and downstream slopes of the embankment:

7.4.b.1.D.1(a) A safety factor of 1.5 for the embankment loading conditions specified in part 7.4.b.1.D.3.;

7.4.b.1.D.1(b) An end of construction safety factor of 1.3;

7.4.b.1.D.1(c) An upstream slope rapid drawdown safety factor of 1.2; and

7.4.b.1.D.1(d) An earthquake safety factor under steady-state seepage conditions of 1.2 using seismic loading appropriate to the geological site conditions.

7.4.b.1.D.2. Appurtenance Structural Stability - Embankments constructed as part of an appurtenant structure where failure will lead to a dangerous condition in the dam shall achieve a static safety factor of 1.5.

7.4.b.1.D.3. Embankment Loading Conditions - Loading conditions shall assume a long-term steady-state condition with the phreatic surface originating at the elevation of the emergency spillway crest for embankment dams with emergency spillways or at a maximum design pool elevation for embankment dams without spillways.

7.4.b.1.D.4. Stability Analyses - All slope stability analyses shall be performed using standard engineering practices. Exceptions to this requirement will be allowed by the Secretary only where there is sufficient evidence to indicate that slope failures will not occur.

7.4.b.1.D.4(a) Critical cross-sections of the dam using equal X and Y axes scales shall be provided in the plan package. The cross-sections shall show the embankment limits, foundation zones, soil zones, phreatic line, assumed reservoir elevation, stability arcs or failure planes through the dam, and resulting safety factors for each critical arc or failure plane shown.

7.4.b.1.D.4(b) A listing of soil zone unit weights, angles of internal friction, and cohesion values for each soil shown on the cross-section shall be provided in the plan package. If an alternative analysis is utilized, assumed soil values of the analysis shall be shown.

7.4.b.1.E. Overtopping Embankments.

7.4.b.1.E.1. Rock-Covered Embankments - Rock-covered embankments shall be designed so that the rocks selected will be sized to withstand the maximum depth and velocity of the overtopping flow and be individually placed to maximize the interlocking effect. A minimum of two (2) layers of boulders is required. Boulders shall cover the crest, downstream face, and necessary areas of the upstream face of the dam and extend beyond the dam abutments to the extent necessary to contain the overtopping flow depth. Graded smaller rock shall fill the voids where the boulders contact the embankment to prevent erosion due to flow through the voids. The rock cover may be covered with soil and vegetated, provided that the equipment used to place the soil will not break the rock.

7.4.b.1.E.2. Roller-Compacted Concrete Embankments. Roller-compacted concrete lift thickness and width shall be sized to withstand the maximum anticipated loading and uplift forces. Filter drains and weep holes shall be provided to relieve hydrostatic pressure behind roller-compacted concrete facings. The roller-compacted concrete may be covered with soil and vegetated.

7.4.b.2. Gravity Dams. The following stability requirements apply to Class 1 through Class 3 dams. The Secretary may approve lower safety factors for Class 4 dams, based on engineering recommendations.

7.4.b.2.A. Stability Loading Conditions - Loading conditions for the stability analysis shall assume maximum overflow head from the design storm.

7.4.b.2.B. Gravity Dam Stability.

7.4.b.2.B.1. Overturning - The reaction of all forces must act within the middle one-third of the base. This requirement may be modified by the Secretary if detailed computations prove that overturning will not occur.

7.4.b.2.B.2. Sliding - The dam shall have a factor of safety against sliding of at least 3.0 for normal loading conditions and 1.5 for maximum loading conditions. The sliding factor of safety may be reduced to no less than 2.0 for normal loading conditions where intimate knowledge of subsurface conditions has resulted from a state-of-the-art subsurface investigation, testing program and design analysis. The subsurface investigation and testing necessary to reduce the factor of safety should include, but not be limited to: sampling and testing of weak zones such as discontinuities, joints, joint fill material, fracture zones, bedding planes, and faults and; determination of peak, ultimate and residual strengths of foundation materials. Design analyses should include, but not be limited to: three dimensional analyses of foundation strength resulting from the subsurface investigation. The adequacy of subsurface investigations, testing, and design analyses necessary to reduce the factor of safety is subject to approval by the Secretary.

7.4.b.2.B.3. Bearing - The factor of safety against bearing failure shall be at least 1.5 for maximum stress at the downstream toe.

7.4.b.3. Waste Disposal Dams - The potential for liquefaction must be considered and the design shall include safeguards against the development of this condition.

7.4.b.4. Spillways - All spillways shall be designed to discharge an adequate distance beyond the downstream toe of the dam in a natural drainway to prevent erosion of the downstream toe or other detrimental effects to the dam structure.

7.4.b.4.A. Conduit Spillways - Inlets shall be protected by a designed trash rack and riser type spillways shall be designed to prevent detrimental vortexing. Risers shall have adequate weight to be non-buoyant and shall be of sufficient strength to withstand maximum dynamic water and ice forces. Foundations for risers shall be designed to support the riser without serious movement or deformation.

7.4.b.4.A.1. Conduits - Pipe conduits shall be placed on a designed foundation and bedding of sufficient strength to minimize settlement and other detrimental effects to the conduit. Anti-seep or anti-piping mechanisms shall be provided for all conduits passing through the dam, foundation, or abutments to control seepage along the pipe. Design allowances shall be made to compensate for differential settlement, elongation, and movement of the pipe conduit if the cradle is placed on a yielding foundation. Pipe conduits shall be of sufficient strength to support the maximum external loads and the maximum internal hydraulic pressure without leaking, and shall resist uplift pressures. The pipe conduit shall be constructed of material which will not deteriorate during the design life of the structure.

7.4.b.4.A.1(a) Use of Corrugated Metal Pipes - Corrugated metal pipes, whether coated or uncoated, shall not be used in new Class 2 or new Class 1 dams. Corrugated metal pipes in existing dams must be either replaced with new pipe or retrofitted with an appropriate liner if the Secretary determines that the existing pipe constitutes a hazard to the proper operation of the dam because the pipe has developed leaks, has deteriorated, or has otherwise ceased to function properly.

7.4.b.4.A.2. Outlets - Pipe conduits shall be designed to outlet in a natural drainway or a designed channel leading to a natural drainway. An energy dissipator shall be provided to eliminate erosion at the pipe outlet and be designed for maximum pipe flow. If pipe blockage by animals may occur, the pipe outlet shall be protected by an animal guard.

7.4.b.4.A.3. Gated Drain Pipe Required for New Freshwater Dams - All new freshwater dams shall have a gated drainpipe for draining the impoundment. The gate or valve shall be located in the reservoir or in the saturated zone upstream of the cutoff wall or impermeable barrier. If the gate is located within the embankment or structure, a service well shall be provided. The elevation of the gate system shall be such that the reservoir will be drained completely to original stream level. The drain system shall be designed to drain ninety percent (90%) of the volume of stored water at normal pool in ten (10) days including normal base flow and have a minimum capacity of three (3) times the normal base flow for the watershed with a headwater-to-diameter (HW/D) ratio of 1.5, unless otherwise approved by the Secretary. The drain conduit shall meet the requirements for conduits set forth in part 7.4.b.4.A.1. A designed trash rack shall be provided at the inlet of the drain. The controls to operate the drain gate shall be accessible without the use of specialized equipment or of divers. The drawdown rate for reservoir storage volumes in excess of two thousand (2000) acre-feet may be established by the Secretary.

7.4.b.4.A.4. Existing Dams with Gated Drain Pipes - All existing dams currently equipped with a gated drain pipe must meet the design requirements of part 7.4.b.4.A.3. and continue to be operated and maintained with the gated drain pipe. If such a gate or valve was not previously installed, a gate or valve shall be installed in the reservoir or in the saturated zone upstream of the cutoff wall or impermeable barrier. The Secretary may approve reduced drawdown time and flow quantity requirements for existing drains. Drain systems not meeting the design requirements of part 7.4.b.4.A.3. or dams with leaking or inoperative drain systems must be repaired or modified to maintain the greatest practical capacity of the drain system. If installation of the upstream gate or valve is impractical without draining of the reservoir and reservoir drainage will cause major economic loss to the owner, the Secretary may approve delay of the upstream gate or valve installation until the next necessary draining of the reservoir, provided that the existing drain system is functioning properly and is not leaking in a manner that would create a serious problem. If the existing drain system develops a serious problem, the Secretary may order immediate remedial action. The Secretary may grant an exemption to this subpart when investigation of the existing drain system determines to the Secretary's satisfaction that installation of an upstream drain gate or valve is not feasible.

7.4.b.4.A.5. The term "gate" or "valve" as used in this rule is a general term referring to a device used for controlling water flow.

7.4.b.4.B. Open Spillways - Unless specifically excluded, spillways of this type include the various designs of open type spillways including open channel, side channel, chute, labyrinth, and ogee.

7.4.b.4.B.1. Earth Spillways - Spillways that are constructed of or in earth material shall be designed to pass the maximum design flow without excessive erosion. Earth spillways shall not be constructed over dam embankment fill material.

7.4.b.4.B.1(a) Flexible Linings - Vegetation, rock riprap, soil reinforcement, or other flexible linings may be used to increase flow quantities and velocities in earth spillways within design limits.

7.4.b.4.B.2. Concrete Spillways.

7.4.b.4.B.2(a) Concrete - The engineer shall specify the grade and strength of concrete to be used in the spillway construction. The concrete structure shall be of sufficient strength to withstand the maximum design applied load.

7.4.b.4.B.2(b) Foundation - Concrete shall be placed on a prepared foundation and bedding capable of sustaining the applied loads without excessive deformation.

7.4.b.4.B.2(c) Drains - Designed filter drains and water pressure relief devices shall be provided under concrete slabs and walls to collect and safely convey water from seepage or leakage of construction joints and to relieve uplift pressure from seepage conditions.

7.4.b.4.B.2(d) Joints - Construction joints shall be made watertight by use of a sealant material. Sliding joints shall be supported by a slab to maintain alignment.

7.4.b.4.B.2(e) Cutoff Barriers - Cutoff barriers keyed into the foundation shall be provided to prevent or reduce seepage flow under the spillway.

7.4.b.4.B.2(f) Energy Dissipators - An energy dissipator shall be provided to reduce the hydraulic energy at the end of the spillway. The dissipator shall be designed to function properly for flows of at least one-half of the design spillway flow. Flows in excess of the design capacity of the energy dissipator shall not endanger the dam or its appurtenances and may result only in erosion.

7.4.b.4.B.3. Nonstandard Spillway Design - The Secretary may reject any spillway design if such design is of a nonstandard or untested nature and it is not possible to analytically predict the performance of the spillway or the detrimental effects of cross-waves, eddies, vortices, super-elevation, or hydraulic jumps within the spillway system.

7.4.b.5. Water Supply Pipes - Water supply pipes through a dam shall be constructed of a long-life, high-strength material. Welded joints or mechanical joints with sealing rings, or an alternative sealing method approved by the Secretary, shall be utilized. Pipes shall be properly bedded to reduce differential settling or elongation. Anti-seep mechanisms or filter drains shall be provided to prevent piping along the exterior of the pipe. If the pipe is enclosed in or passes through concrete, the relative coefficients of expansion shall be considered. Anti-corrosive measures shall be employed if soil tests indicate corrosion may be a problem. An upstream shutoff valve shall be installed on all new dams or when upgrading existing dams where reservoirs are to be drained as part of the upgrading. The section of the pipe through the dam shall be capable of withstanding a minimum pressure of twice the maximum reservoir head. The pipe shall be pressure-tested for leaks at maximum reservoir head pressure prior to the final covering of the pipe installation.

7.5. Miscellaneous Considerations.

7.5.a. Erosion and Sediment Control - Erosion and sediment control measures sufficient to comply with the provisions of paragraph 8.1.m. shall be included in the project design where the disturbed area within the site is less than NPDES limits. If the disturbed area within the site exceeds NPDES limits, a letter documenting submission of a NPDES permit application must be submitted in accordance with subparagraph 6.4.f.1.

7.5.b. Waste Disposal Areas - The engineer shall delineate locations in the project area which are to be used as waste disposal areas.

7.5.c. Instrumentation - The engineer shall recommend instrumentation as necessary to monitor and measure performance of new dams or modifications to existing dams. The engineer shall specify the types and purpose of the recommended instrumentation.

7.5.c.1. Piezometers or Observation Wells - Piezometers or observation wells may be required by the Secretary on embankment type dams to monitor phreatic level and water pressures in critical areas of the embankment and, if necessary, the foundation or abutments. All piezometer or well heads shall be anchored in concrete and protected from vandalism with a locking metal cylinder surrounding the piezometer or well pipe.

7.5.c.2. Survey Monuments - Survey monuments may be required by the Secretary on embankment and gravity dams to monitor displacement, settlement, rotation, and deformation. Survey monuments on earth dams shall be sufficiently embedded into the structure to prevent localized movement of the monument. Protective casings shall be installed if necessary to prevent damage or forced movement of the survey point.

7.5.d. Staged Construction - Waste disposal dams designed in stages of construction shall be capable of storing or passing the design storm specified in paragraph 7.1.a.2. and subparagraph 7.1.b.1.A. during all stages of construction except during the initial start-up period, unless otherwise approved by the Secretary. During the initial start-up period, the dam shall be capable of storing or passing the P100 rainfall event as soon as possible. Construction shall increase storm capacity, reaching the full design storm capacity within two (2) years.

§47-34-8. Construction or Modification of a Dam.

8.1. Construction Requirements.

8.1.a. Notification of the Commencement of Construction - Prior to the commencement of construction activities in the project area, the person who has been issued a certificate of approval, or his or her representative, shall notify the Secretary of the following:

8.1.a.1. The intent of the contractor to start construction in the project area and the date of such start-up.

8.1.a.2. The name, address, and telephone number of the owner's authorized contact person at the project area who is responsible for communicating with the Dam Safety Section and for receiving inspections reports and legal notifications.

8.1.b. Conformance with Plans - All work undertaken in the construction or modification of a dam shall be in strict conformance with the plans and specifications contained in the plan package submitted under subsection 5.1 and approved by the Secretary. Any changes to the approved plans and specifications shall be submitted to and approved by the Secretary prior to implementation.

8.1.c. On-Site Documents - A copy of the certificate of approval, the approved plans and specifications, all outstanding notices to comply or orders to comply that have been issued by the Secretary, and the monitoring and emergency action plans prepared in accordance with the provisions of subsection 15.6 and subsection 15.7 shall be available at the project area office for reference by construction personnel and the Secretary.

8.1.d. Adverse Weather Conditions - Construction work shall be suspended on all or part of the project when adverse weather conditions (e.g., prolonged precipitation, extreme temperatures) jeopardize the performance of work in conformance with the approved plan package.

8.1.e. Clearing and Grubbing - Clearing and grubbing shall be performed in the foundation, borrow, and soil stockpile areas. Clearing is required in the maximum permanent pool area unless otherwise approved by the Secretary.

8.1.f. Foundation Preparation - Foundation preparation shall include installation of keyways and subdrains, removal of soft areas, and similar project area preparation operations dictated by the approved plans and specifications and by project area conditions. The foundation shall be inspected by the Secretary prior to placement of embankment materials. If foundation problems are discovered during this inspection, additional foundation preparation may be required by the Secretary.

8.1.g. Placement of Materials.

8.1.g.1. All fill shall be placed in accordance with the approved plans and specifications.

8.1.g.2. Compaction testing shall be completed as specified in the approved specifications; the results of such testing shall be reported in accordance with the provisions of subdivision 8.4.a.

8.1.g.3. Filter drains shall be constructed in accordance with the approved plans and specifications. Filter material shall be tested for compliance with design gradations; the results of such testing shall be reported in accordance with the provisions of subdivision 8.4.a. Filter materials shall be placed to prevent segregation and contamination and shall be concurrently covered to prevent contamination or damage.

8.1.h. Grading.

8.1.h.1. All fill shall be graded in accordance with the approved plans and specifications.

8.1.h.2. The working surface and outslopes of the fill shall be concurrently graded through all phases of embankment construction.

8.1.h.3. The top of the fill shall be crowned to provide positive drainage during construction.

8.1.h.4. Final grading shall be conducted in order to facilitate revegetation.

8.1.i. Spillways and Appurtenances.

8.1.i.1. Spillways and appurtenances shall be constructed in accordance with the approved plans and specifications.

8.1.i.2. When downslope placement of fill material is used in the construction of spillways, the fill material shall be compacted in horizontal layers to achieve the design configuration.

8.1.i.3. All riprap material shall be of hard, durable rock which is not acid-forming or toxic. Riprap shall be placed to prevent size segregation.

8.1.i.4. When bedding is used under riprap, the rock material shall be placed in a manner so as not to damage or contaminate the bedding.

8.1.i.5. When protective channel linings are specified, the linings shall be installed as soon as the channel is constructed to grade in accordance with the approved plans and specifications.

8.1.i.6. When concrete is used in construction of spillways and appurtenances, the concrete shall be placed, cured, and finished in accordance with the provisions of part 7.4.a.1.B.2. through part 7.4.a.1.B.4. Standard engineering tests shall be performed in accordance with the provisions of paragraph 8.2.b.1. and reported in accordance with the provisions of subdivision 8.4.a.

8.1.i.7. All pipes, risers, and appurtenances shall be installed in accordance with the approved plans and specifications. Compaction testing shall be completed to ascertain that fill material around pipes, risers, and appurtenances has been placed in accordance with the approved plans and specifications; the results of such testing shall be reported in accordance with the provisions of subdivision 8.4.a. Sufficient fill shall be placed over pipes so as to prevent damage by heavy equipment.

8.1.j. Minimum Stream Flow - An adequate flow of water may be required by the Secretary in the stream below the dam during construction and reservoir filling to maintain water quality in the stream and to support fish and other aquatic life. The Secretary may require stream flow augmentation in accordance with the provisions of subdivision 15.3.b.

8.1.k. Blasting - Blasting may only be utilized in accordance with and as specified in the approved plans and specifications. Blasting based upon unforeseen project area conditions not covered in the approved plan package shall not be performed prior to approval by the engineer with the concurrence of the Secretary.

8.1.l. Storm Water Discharge - The sequence of construction work shall be planned to maximize the safe discharge of storm water while minimizing the amount of water retained in the impoundment. Either the principal spillway structures, including inlets and outlets, shall be operable prior to placement of construction material above the original valley elevation or diversion channels approved by the Secretary shall be in place.

8.1.m. Erosion and Sediment Control.

8.1.m.1. General Requirements - Erosion and sedimentation must be controlled to prevent a degradation of land and streams below the dam or project area, including visible deposits of sediment, and to prevent any violation of State water quality standards. Erosion and sediment control measures shall, at the minimum, conform with current erosion and sediment control reference manuals and apply to the entire project area.

8.1.m.2. Specific Requirements - Cleared areas, borrow areas, disturbed areas along stream channels and waterways, and fills, whether complete or in progress, must be equipped with erosion and sediment control devices (i.e., diversions, waterways, sediment basins, straw bale dikes, or silt fences).

8.1.m.2.A. Location of Sediment Control Devices - Erosion and sediment control devices must be located as close to the disturbed area as practical. Effort must be made to contain the sediment load within the disturbed area in order to prevent the entry of sediments into the natural drainway or stream.

8.1.m.2.B. Removal of Sediment Control Devices - Erosion and sediment control devices must remain in place until permanent vegetation is established or the area is otherwise stabilized. Prior to the removal of the devices, trapped sediment must be removed and placed in a location approved by the Secretary. Straw bale dikes and silt fences must be removed when no longer needed; sediment basins or ponds must be abandoned in a manner approved by the Secretary. Barren and denuded areas remaining after the removal of a control device must be revegetated.

8.1.m.2.B.1. The Secretary may modify or waive the requirements of subparagraph 8.1.m.2.B. for erosion and sediment control devices that are located within the impoundment area of the dam.

8.1.m.2.C. Cleaning Frequency - Sediment control diversions, silt fences, straw bale dikes, and waterways must be inspected once each week, and after each rainfall, and accumulated sediment must be removed in order to maintain design capacity. Sediment ponds, basins, and traps must be restored to design capacity when sediment accumulation approaches sixty percent (60%) of design capacity, or more frequently if so specified by the Secretary in writing.

8.1.m.2.D. Temporary Seeding and Mulching - Temporary seeding and mulching shall be utilized on bare areas where no construction activity is anticipated for a period of three (3) or more weeks. Areas that shall receive seeding and mulching include the reservoir area, borrow areas, soil stock piles, and steep fill slopes where no further work is planned prior to final grading. Where seeding is not feasible due to severe slope or time of year, the Secretary may approve mulching alone at a rate of three (3) tons of straw or hay per acre, or equivalent.

8.1.m.2.E. Water Routing - Water that is pumped or drained from work areas (e.g., excavations, foundations, and below grade fills) must be routed to properly-sized sediment control devices so that any sediment contained in the water is removed prior to discharge of the water from the project area. Pump discharges may not cause erosion or suspension of additional solids. No untreated water may be pumped or drained to the natural stream or stream diversion channel.

8.1.m.2.F. In-Stream Treatment - Barriers, such as silt fences or straw bales, located in the natural drainway or stream will not be considered acceptable as the primary means of sediment control for the project area. Properly designed sediment basins or ponds may be used for sediment control in the natural drainway or stream if the location of the basin or pond does not cause significant additional disturbance in undisturbed downstream areas. Use of a starter dike or the dam under construction may be considered appropriate for sediment control of the reservoir area provided the necessary detention time is achieved.

8.1.m.2.G. Sediment Control During Construction - Erosion and sediment control measures must be in place prior to the beginning of dam construction activities. Clearing and grubbing or sediment control measures not specified for the beginning of construction must be implemented in a timely manner as needed.

8.1.m.2.H. Permanent Erosion Measures - Permanent measures (e.g., vegetation, grading, diversions, waterways, and outlet structures) shall be included on all completed or existing dams, where applicable, to prevent the erosion of embankments, abutments, stream channels, and waterways during the life and operation of the dam.

8.1.n. Disposal of Construction Wastes.

8.1.n.1. General Disposal Requirements - All waste materials that result from construction activities shall be disposed of in a manner approved by the Secretary.

8.1.n.2. Specific Disposal Requirements.

8.1.n.2.A. Surplus Waste Materials - Surplus soil and rock materials shall be deposited in waste disposal areas delineated in the approved plans.

8.1.n.2.B. Organic Waste Materials - Trees, brush, root masses, and construction-related wood materials may be either buried in waste disposal areas delineated in the approved plan package or burned in accordance with local and State burning ordinances

8.1.n.2.C. Concrete Waste Materials - New or old waste concrete materials may be disposed of in areas approved by the Secretary for surplus soil and rock materials. New, unset waste concrete shall not be deposited in a location where it will enter watercourses, either directly or indirectly as a result of runoff. After it has set, the new waste concrete may be moved to waste disposal areas delineated in the approved plans.

8.1.n.2.D. Other Waste Materials - Chemicals, petroleum products, plastics, garbage, sewage, and any associated containers shall be disposed of in a manner approved by the Secretary.

8.1.n.2.E. Off-Site Waste Materials - No waste materials or soil waste may be transported to the project area for disposal.

8.1.o. Dust Abatement - The contractor shall fully suppress dust on haul and access roads and as necessary within the project area. Water, or an alternative dust palliative approved by the Secretary, shall be used for dust suppression; the use of oil or waste oil is prohibited.

8.1.p. Access Roads - A permanent access road shall be provided to each dam site. The road must be adequate for emergency vehicular traffic. Single lane unpaved roads are acceptable provided the roads are properly maintained. The access road must be designed and located as to not be unduly affected by stream or spillway flows during heavy rainfall events. The road may be secured with a locked gate provided that the key is available to dam monitors and State and local emergency personnel for emergency response.

8.2. Quality Control.

8.2.a. Construction Monitoring.

8.2.a.1. All construction activities shall be monitored by an engineer or his or her designated representative. Construction monitoring shall not be the responsibility of the construction contractor unless specifically approved by the Secretary in writing.

8.2.a.2. Responsibility for assessing the quality of the workmanship and ascertaining compliance with the approved plans and specifications shall be vested primarily in the owner's engineer. The Dam Safety Section shall also monitor construction activities and workmanship in order to ascertain compliance with the approved plans and specifications, in accordance with the provisions of W. Va. Code §22-14-9.

8.2.a.3. Critical phases of construction shall be monitored by the engineer or his or her designated representative constantly during active construction; noncritical phases of construction shall be checked at least once per day during active construction.

8.2.a.4. Additional supervision or testing will be required by the Secretary if evidence of inadequate construction supervision exists.

8.2.b. Materials Testing - Construction materials shall be periodically tested on-site to ascertain compliance with design specifications in the approved plan package. Final quality control testing shall not be the responsibility of the construction contractor.

8.2.b.1. Concrete Testing - Routine tests of slump, air entrainment, and temperature shall be performed on each truck delivery. Cylinder samples for compression testing shall be taken each day or every twenty-five (25) cubic yards of delivered concrete, whichever is more frequent, unless otherwise required by the Secretary.

8.2.b.2. Earth Fill Testing - Earth fill materials shall be tested for compaction and moisture content every alternate layer or each one thousand (1,000) cubic yards, whichever is more frequent. Random fill shall be evaluated for compliance with approved gradation specifications. Critical fill areas shall have gradation tests performed to evaluate compliance with the approved specifications.

8.2.b.3. Filter Materials Testing - Gradation tests shall be performed on filter materials. Close visual observation for signs of material segregation shall be performed. Additional tests may be required by the Secretary to determine durability and soundness of the filter material.

8.3. Construction Inspections.

8.3.a. Inspections During Construction.

8.3.a.1. A visual inspection for construction progress, unstable conditions, quality control, and conformance with the approved plans and specifications shall be held at least once each working day (or more frequently as determined by the engineer). The inspection shall be performed by an engineer or a person under the direct supervision of the engineer. The frequency of inspection may be changed by the Secretary depending upon specific project area conditions.

8.3.a.2. Additional inspections shall be held after each heavy rainfall event in order to detect problems and propose remedial measures. These inspections shall be performed by an engineer or a person under the direct supervision of the engineer.

8.3.a.3. Instrumentation shall be monitored every seven (7) days unless otherwise specified by the engineer. Monitoring shall be performed by an engineer or a person under the direct supervision of the engineer. The frequency of monitoring may be changed by the Secretary depending upon specific project area conditions.

8.3.b. Final Construction Inspection - Upon the completion of the construction or modification of a dam, a joint inspection shall be conducted by the Secretary and the engineer. The purpose of the inspection is to verify that all work has been accomplished in accordance with the approved plan package.

8.3.c. Acceptance of Construction - When the dam owner is advised by the Secretary that the construction appears satisfactory, the owner shall submit to the Secretary a certification by an engineer that all construction was in substantial conformance with the approved plans and specifications, including any modifications that have been approved by the Secretary. This certification shall be submitted within ninety (90) days of the Secretary's advisement. As-built drawings, including all variations from the original specifications and changes in location of borrow or waste disposal areas, shall be submitted with the engineer's certification. If substantial modifications of the original specifications have been made during the construction period, the Secretary may require that a corrected application form be submitted. Upon the receipt of the engineer's certification with the as-built drawings (and a corrected application form, if necessary), a letter of acceptance will be issued by the Secretary.

8.3.d. Completed Dams - After acceptance of construction by the Secretary, the dam and its appurtenances shall be inspected annually for a period of three (3) years by an engineer experienced in such inspections. The Secretary reserves the right to attend any inspection and require prior notification of the inspection by the owner of the dam. A report of each inspection shall be prepared and filed with the Secretary in accordance with the provisions of subdivision 15.5.a.

8.4. Construction Reporting Requirements.

8.4.a. Monthly Progress Reports During Construction - A written report containing the results of each inspection of construction progress shall be submitted to the Secretary every month while the dam and its appurtenances are under construction. The report shall include, but not be limited to, specific instrumentation readings, test results, freeboard, crest elevation, and specific construction or quality control problems with documentation of implemented solutions. Upon the completion of the construction or modification of the dam, notice shall be given by the dam owner to the Secretary so that a final construction inspection can be made in accordance with the provisions of subdivision 8.3.b.

8.4.b. Post-Construction Inspection Reports - A report shall be submitted to the Secretary by the dam owner reporting the findings of the final construction inspection required under subdivision 8.3.b. Certification by an engineer shall be submitted to the Secretary with the inspection report to verify that the dam and its appurtenances were constructed in substantial conformance with the approved plans and specifications and that the dam and its appurtenances are functioning as designed.

§47-34-9. Breaching of a Dam.

9.1. Application to Breach a Dam - The owner of a dam must obtain a certificate of approval from the Secretary prior to the breaching of the dam. A complete application in accordance with the provisions of subsection 5.1. must be submitted to and approved by the Secretary prior to the commencement of breaching activities.

9.1.a. Plan Package Requirements - The plan package submitted in order to breach a dam shall be in accordance with the applicable requirements of section 6 and must also include the specific requirements delineated in subsection 9.2 through subsection 9.10. Narratives, plans, or specifications required under section 6 which are clearly not applicable to the proposed breaching activities may be omitted from the submittal; however, the Secretary reserves the right to specify those items which must be included in the breaching plan package.

9.2. Breach Dimensions - The breach opening in the dam shall be designed so that any water resulting from design storm inflows that is temporarily impounded behind the residual structure shall be less than the height and storage requirements of a "dam" set forth in subsection 2.12. The breach shall be to original stream bottom level, except that a small impoundment of less than one (1) acre-foot storage may be retained for sediment control purposes.

9.3. Breach Channel - The embankment shall be breached with a designed channel having the capacity to carry the peak runoff from the design storm corresponding to the dam's hazard classification. The channel created by the breach shall have an erosion-preventive lining adequate to withstand the depth and velocity of the peak flows from a P100 rainfall event. The channel side slopes shall achieve a minimum stability factor of safety of 1.5.

9.4. Safety - Reservoirs shall be completely drained before breaching operations begin. Breaching work shall be scheduled during dry weather using National Weather Service advice and proceed quickly to reduce the potential for impounding water.

9.5. Blasting - If blasting is to be used in the breaching of a dam, a blasting plan shall be submitted to the Secretary for approval. The plan shall include the distance to existing structures and the measures that will be taken to minimize air blast and flying materials. A pre-blast survey of existing nearby structures and water wells which may be affected by blasting may be required by the Secretary.

9.6. Erosion and Sediment Control - Erosion and sediment control measures sufficient to comply with the provisions of paragraph 8.1.m. shall be implemented during the breaching operation. The following measures shall also be implemented:

9.6.a. Reservoir areas, and the sediment deposits therein, shall be protected from erosion after the impounding capability has been eliminated by the breaching of the dam;

9.6.b. Silt deposits and barren areas in the reservoir shall be stabilized and revegetated;

9.6.c. Disturbed areas, including the faces on any remaining embankment, must be protected by vegetation or other means approved by the Secretary;

9.6.d. A channel in the reservoir sediment may be required by the Secretary in order to reestablish a stream channel; and

9.6.e. Permanent sediment basins, subject to ongoing maintenance, may be required by the Secretary if the dam owner cannot demonstrate the effectiveness of other structural and vegetative measures in stabilizing the reservoir area and dam site.

9.7. Placement of Earthen Material - Material removed from the dam shall be placed in waste disposal areas delineated in the approved plan package. The material shall be graded and compacted as necessary and stabilized from erosion by vegetation or other means approved by the Secretary.

9.8. Placement of Non-Earthen Material - Concrete rubble and other rock material shall be placed in waste disposal areas delineated in the approved plan package. The material shall be placed in a manner to reduce hazardous conditions; protruding metal, wire, or bars are prohibited. The requirements of subdivision 8.1.n. shall apply to the disposal of any other waste materials generated by the breaching operation.

9.9. Galleries and Drains - The effect of flows through the breach and backwater pressure on galleries and drains shall be evaluated. The galleries and drains shall be vented or sealed as necessary to prevent failure of the remaining structure.

9.10. Safety of Remaining Structure - The remaining structure shall have sufficient strength to support the maximum hydraulic loading without failure. The engineer shall attempt to reduce or eliminate hazards associated with an "attractive nuisance."

9.11. Construction Practices - The requirements of section 8 shall apply when breaching a dam unless clearly not applicable to the breaching operation; however, the Secretary reserves the right to specify which requirements are applicable.

§47-34-10. Removal of a Dam.

10.1. Application to Remove a Dam - The owner of a dam must obtain a certificate of approval from the Secretary prior to the removal of the dam. A complete application in accordance with the provisions of subsection 5.1. must be submitted to and approved by the Secretary prior to the commencement of removal activities.

10.1.a. Plan Package Requirements - The plan package submitted in order to remove a dam shall be in accordance with the applicable requirements of section 6 and must also include the specific requirements delineated in subsection 10.2 through subsection 10.8. Narratives, plans, or specifications required under section 6 which are clearly not applicable to the proposed removal activities may be omitted from the submittal; however, the Secretary reserves the right to specify those items which must be included in the removal plan package.

10.2. Removal Requirements - Removal of a dam shall consist of the complete removal of the structure to the original ground except in special cases where it may be necessary or advantageous to leave small sections of the structure. Unless otherwise approved by the Secretary, the removal of a dam shall consist of complete removal of the structure to approximate original contour. A total of no more than ten percent (10%) of the length of the structure may remain at the abutment areas.

10.3. Safety - Reservoirs shall be completely drained before removal operations begin. Removal work shall be scheduled during dry weather using National Weather Service advice and proceed quickly to reduce the potential for impounding water.

10.4. Blasting - If blasting is to be used in the removal of a dam, a blasting plan shall be submitted to the Secretary for approval. The plan shall include distance to existing structures and the measures that will be taken to minimize air blast and flying materials. A pre-blast survey of existing nearby structures and water wells which may be affected by blasting may be necessary.

10.5. Erosion and Sediment Control - Erosion and sediment control measures sufficient to comply with the provisions of subdivision 8.1.m. shall be implemented during the removal operation. The following measures shall also be implemented:

10.5.a. Reservoir areas, and the sediment deposits therein, shall be protected from erosion after the impounding capability has been eliminated by the removal of the dam;

10.5.b. Silt deposits and barren areas in the reservoir shall be stabilized and revegetated;

10.5.c. Disturbed areas, including the faces on any remaining embankment, must be protected by vegetation or other means approved by the Secretary;

10.5.d. A channel in the reservoir sediment may be required by the Secretary in order to reestablish a stream channel; and

10.5.e. Permanent sediment basins, subject to ongoing maintenance, may be required by the Secretary if the dam owner cannot demonstrate the effectiveness of other structural and vegetative measures in stabilizing the reservoir area and dam site.

10.6. Placement of Earthen Material - Material removed from the dam shall be placed in waste disposal areas delineated in the approved plan package. The material shall be graded and compacted as necessary and stabilized from erosion by vegetation or other means approved by the Secretary.

10.7. Placement of Non-Earthen Material - Concrete rubble and other rock material shall be placed in waste disposal areas delineated in the approved plan package. The material shall be placed in a manner to reduce hazardous conditions; protruding metal, wire, or bars are prohibited. The requirements of subdivision 8.1.n. shall apply to the disposal of any other waste materials generated by the removal operation.

10.8. Safety of Remaining Structure - If any portion of the structure remains, that portion shall have sufficient strength to support the maximum hydraulic loading without failure. The engineer shall attempt to reduce or eliminate hazards associated with an "attractive nuisance."

10.9. Construction Practices - The requirements of section 8 shall apply when removing a dam unless clearly not applicable to the removal operation; however, the Secretary reserves the right to specify which requirements are applicable.

§47-34-11. Abandonment of a Dam.

11.1. Application to Abandon a Dam - The owner of a dam must obtain a certificate of approval from the Secretary prior to the abandonment of the dam. A complete application in accordance with the provisions of subsection 5.1. must be submitted to and approved by the Secretary prior to the commencement of abandonment activities.

11.2. Reservoir Elimination - The reservoir area shall be completely filled to the crest elevation of the dam with approved material to eliminate the impoundment of water. The maximum impounding capacity upon completion of final grading shall not exceed one (1) acre-foot of impounding capacity. The final top elevation of the reservoir fill shall be higher than, and sloped into, the diversion system required under subsection 11.4.

11.3. Embankment Stability - The remaining embankment shall be shown to achieve a minimum factor of safety in accordance with the provisions of subparagraph 7.4.b.1.D.

11.4. Diversion System - A diversion system designed for a P100 rainfall event shall be provided to capture the stream at the upstream end of the reservoir and convey stream water and embankment runoff water around the site. The diversion system shall outlet safely beyond the downstream toe of the embankment in a natural drainway capable of carrying the design storm without excessive erosion. The Secretary may require the installation of an energy dissipator in accordance with the provisions of subpart 7.4.b.4.B.2.(f).

11.5. Sealing Conduits - All conduits through the embankment, with the exception of underdrain conduits, shall be sealed with concrete at the upstream end prior to elimination of the reservoir. The Secretary may require pressure testing of conduits to determine seal adequacy.

11.6. Erosion and Sediment Control - Erosion and sediment control measures sufficient to comply with the provisions of subdivision 8.1.m. shall be implemented during the abandonment operation.

11.7. Soil and Vegetative Cover - A sufficient layer of topsoil shall be provided to permit long-term growth of vegetation. A seeding and mulching mixture shall be proposed in the abandonment application to accomplish revegetation of the project area.

11.8. Retention of Jurisdiction - The Secretary shall retain jurisdiction over the site for a minimum period of five (5) years after abandonment, during which time the dam and its appurtenances shall be inspected annually by an engineer experienced in such inspections. The inspections shall include measurement readings of instrumentation to determine the level and volume of saturation within the reservoir fill material. The Secretary may also require more frequent reading and reporting of instrument readings to determine seasonal fluctuations of saturation. A report shall be filed with the Secretary detailing the findings of each inspection and describing intended maintenance work. Should a major storm occur, a similar report shall be filed to detail the resultant condition of the structure.

11.9. Final Approval of Abandonment - At the completion of the five-year period, a final joint inspection by the engineer and the Secretary shall be conducted to determine the effectiveness of the

abandonment design and the potential need for continued maintenance. Should the Secretary determine as a result of this inspection that an additional inspection time period or maintenance work is required, a letter detailing these requirements shall be sent to the owner. The Secretary will review instrument records and annual inspection reports to determine if the saturation level of material within the reservoir has decreased in volume to less than the legal definition of a "dam." Should the Secretary determine as a result of the inspection and review of instrumentation records that the volume of saturated material is less than the legal definition of a "dam" and the abandonment design has been effective, a letter of acceptance shall be issued stating that the dam has been properly abandoned.

§47-34-12. Reduction or Enlargement of a Dam.

12.1. Reduction of Dam Height To Less Than Jurisdiction.

12.1.a. A person planning to reduce the height of a dam so that the remaining structure will no longer meet the definition of "dam" set forth in subsection 2.12. must obtain a certificate of approval from the Secretary.

12.1.b. A complete application in accordance with the provisions of subsection 5.1. must be submitted to and approved by the Secretary prior to the commencement of reduction activities. The application must also contain information showing that the remaining impounding structure will not cause loss of life or appreciable property damage downstream should that structure fail.

12.1.b.1. Plan Package Requirements - The plan package submitted in order to reduce the height of a dam shall be in accordance with the applicable requirements of section 6 and must also include the specific requirements delineated in subdivision 12.1.c. and subdivision 12.1.d. Narratives, plans, or specifications required under section 6 which are clearly not applicable to the proposed reduction may be omitted from the submittal; however, the Secretary reserves the right to specify those items which must be included in the reduction plan package.

12.1.c. The remaining structure shall have a properly designed spillway system capable of passing a Class 3 design storm without overtopping.

12.1.d. The remaining structure shall achieve a factor of safety in accordance with the provisions of subparagraph 7.4.b.1.C. or subparagraph 7.4.b.2.B. as appropriate to the type of structure.

12.1.e. The requirements of section 8 apply when reducing the height of a dam unless clearly not applicable to the reduction operation; however, the Secretary reserves the right to specify which requirements are applicable.

12.1.f. The Secretary shall retain jurisdiction over the remaining structure until the reduction operation is completed and a letter of acceptance has been issued by the Secretary.

12.2. Enlargement of a Structure to Jurisdiction.

12.2.a. A person planning to enlarge an existing structure so that the completed structure will meet the definition of "dam" set forth in subsection 2.12. must obtain a certificate of approval from the Secretary.

12.2.b. A complete application in accordance with the provisions of subsection 5.1. must be submitted to and approved by the Secretary prior to the commencement of enlargement activities.

12.2.b.1. Plan Package Requirements - The plan package submitted in order to enlarge a structure to jurisdiction shall be in accordance with the applicable requirements of section 6. Narratives,

plans, or specifications required under section 6 which are clearly not applicable to the proposed enlargement may be omitted from the submittal; however, the Secretary reserves the right to specify those items which must be included in the enlargement plan package.

12.2.c. The Secretary will require adequate drilling and testing of the existing structure and foundation to ascertain in place conditions.

12.2.d. The requirements of section 8 shall apply when enlarging a structure to jurisdiction unless clearly not applicable to the enlargement operation; however, the Secretary reserves the right to specify which requirements are applicable.

§47-34-13. Dams Completed Before July 1, 1973.

13.1. Complete Application Required - An application for a certificate of approval shall be submitted to the Secretary for all dams completed before July 1, 1973 which meet the definition of "dam" set forth in subsection 2.12. If the engineer can demonstrate that the dam meets the design requirements specified in this rule, an application for approval of an existing dam shall be submitted. If the dam requires modification to meet the requirements, an application for modification of an existing dam shall be submitted. If the above options are not exercised by the dam owner, an application to breach, remove, or properly abandon the dam pursuant to this rule shall be submitted.

13.2. Performance Requirements - All dams completed before July 1, 1973 shall meet the applicable design requirements of section 7. Those dams which do not meet the applicable design requirement of section 7 shall be modified, breached, removed, or properly abandoned pursuant to the provisions of this rule. In developing the required plans, specifications, and documentation necessary to bring the structure into conformity with section 7, the design engineer may consider in his or her submitted analyses, peculiarities and local conditions for each impounding structure with recognition of the many factors involved, some of which may not be precisely known. Existing construction documentation and the historical performance of the structure including documented storms and spillway flows may be considered by the engineer as part of the evaluation of the structure. Upon approval by the Secretary of the plans, specifications, and documentation submitted by the engineer, the Secretary may issue a certificate of approval.

13.3. Plan Package Requirements - The plan package submitted for approval or modification of an existing dam shall be in accordance with applicable requirements of section 6, except that testing and analysis results may be substituted for design specifications. If as-built drawings are not available, the engineer may substitute drawings prepared by him or her which represent the existing conditions at the dam as determined through the testing and analysis program.

§47-34-14. Sale or Transfer of a Dam.

14.1. Notification and Documentation - Within thirty (30) days after the sale or transfer of a dam, the Secretary must be notified of that transaction by the person who was issued the certificate of approval for the dam.

14.1.a. The seller of a dam must provide the following documentation to the Secretary:

14.1.a.1. The name and address of new owner;

14.1.a.2. A copy of the signed agreement between the previous and new owner acknowledging certificate of approval responsibility and including any warranties, insurance coverage, or liability agreements between the parties;

14.1.a.3. The effective date of the ownership or responsibility transfer; and

14.1.a.4. Documentation that a copy of the certificate of approval or the most recent Dam Control Act notice to comply or order -- if a valid certificate of approval does not exist -- has been entered in the deed or land records of the county in which the dam is located.

14.1.b. The Secretary may reissue a corrected certificate of approval reflecting the sale or transfer of a dam upon the receipt of appropriate documentation and fees.

§47-34-15. Dam Operations and Safety.

15.1. Safe Operations - The owner of a dam shall ensure that his or her dam is operated in a safe and responsible manner so as not to endanger life or property.

15.2. Operations Plan - Owners of dams which require the operation of gates, penstocks, or other means of regulating the reservoir level or downstream flow shall develop and submit an operations plan to the Secretary for approval.

15.2.a. Plan Contents - The operations plan shall include, but not be limited to, normal and seasonal operational procedures for gates, penstocks, and other reservoir or downstream flow regulating devices. The name, address, and telephone number of each individual authorized to operate the dam shall also be included in the plan.

15.2.b. Plan Implementation - The operations plan shall be implemented immediately upon approval by the Secretary and shall be updated periodically as necessary to reflect any changes in personnel or operation procedures.

15.3. Releasing Water - The owner of a dam may release water or lower the reservoir elevation through the use of gates without prior approval of the Secretary provided that the release of water will not adversely affect the dam structure, property, or water quality or pose a hazard to human life.

15.3.a. Emergency Releases of Water - Under emergency conditions, the owner of a dam may release water at a rate which may violate the criteria established under subsection 15.3. provided that such emergency release will not pose an unjustifiable hazard to human life. Notification must be given of a pending emergency release of water in accordance with the provisions of subdivision 15.8.a. In accordance with the provisions of W. Va. Code §22-14-12, this regulatory provision shall not relieve the owner of the dam of any liabilities resulting from an emergency release of water.

15.3.b. Low Flow Augmentation - The Secretary may require the owner of a dam to maintain a specified stream flow below the dam or to augment the stream flow for appropriate in-stream uses.

15.4. Dam Safety Inspections - Periodic inspections of dams shall be performed to monitor and assess the condition of the dam. These scheduled safety inspections of completed dams shall be in the charge of an engineer.

15.4.a. Inspections by the Dam Owner - The owner of a dam or his or her agent shall perform safety inspections monthly or more frequently. Such inspections must survey the dam and its appurtenances to check for problems or changes since the last inspection. The owner or his or her agent shall inspect the dam more frequently than once per month during adverse weather conditions. The owner shall report any observed problems to the Secretary.

15.4.b. Inspections by the Secretary - The Secretary may inspect any dam at any time in accordance with the provisions of W. Va. Code §22-14-4(i).

15.4.c. Inspections by the Owner's Engineer - An engineering inspection shall be conducted annually for three (3) years after the completion of any dam, in accordance with the provisions of paragraph 8.3.d. Upon the conclusion of this three-year period, the dam shall be inspected by the owner's engineer at the frequency specified in subparagraph 15.4.c.1. through subparagraph 15.4.c.4. as appropriate to the hazard classification of the dam. The Secretary may require additional inspections based upon site conditions. The Secretary reserves the right to attend any inspection and require prior notification of the inspection from the owner of the dam.

15.4.c.1. Class 4 dams shall be inspected at least once every seven (7) years.

15.4.c.2. Class 3 dams shall be inspected at least once every five (5) years.

15.4.c.3. Class 2 dams shall be inspected at least once every three (3) years.

15.4.c.4. Class 1 dams shall be inspected at least once every two (2) years.

15.4.d. Inspection of Dams with Serious Problems - The Secretary may establish the frequency of inspection of dams with serious problems for both inspections by the dam owner under subdivision 15.4.a. and inspections by the owner's engineer under subdivision 15.4.c. The inspection of a dam with serious problems shall monitor slopes, seepage, bulges, scarps, vertical displacement, excessive erosion, piping, sudden changes in monitoring devices, and other visible factors which could indicate potential failure of the embankment, spillways, or other appurtenances. The Secretary reserves the right to attend any inspection and require prior notification of the inspection by the owner of the dam.

15.5. Dam Safety Inspection Reports.

15.5.a. Inspection Reports for Completed Dams - A written report containing the observations of each inspection that is required under subdivision 8.3.d. and subdivision 15.4.c. shall be submitted to the Secretary by the dam owner within thirty (30) days of the inspection. The report shall also describe maintenance work to be performed as a result of the inspection findings. Should a storm equal to or greater than a 50-year, 6-hour rainfall event occur, a similar report shall be filed to detail the resultant condition of the structure. Certification by an engineer shall be submitted to the Secretary with each inspection report to verify that the dam and its appurtenances are functioning as designed.

15.5.b. Inspection Reports for Dams with Serious Problems - A written report containing the observations of each inspection required under subdivision 15.4.d. shall be submitted to the Secretary by the dam owner within thirty (30) days of the inspection.

15.6. Monitoring Plans - Owners of Class 1 dams shall formulate and submit a monitoring plan to the Secretary for approval. Owners of Class 2 and 3 dams may be required by the Secretary to formulate and submit a monitoring plan for approval.

15.6.a. The monitoring plan developed by the dam owner must follow the format of the example plan provided by the Secretary and shall include, but not be limited to, the following:

15.6.a.1. A description of the dam, including appropriate drawings and location maps;

15.6.a.2. A listing of problems and deficiencies and any implemented repairs;

15.6.a.3. The inspection frequency under varying weather conditions;

15.6.a.4. A description of areas or items to be inspected;

15.6.a.5. Corrective actions to be taken;

15.6.a.6. The responsible persons' names, addresses, and telephone numbers;

15.6.a.7. The method of notification of the Secretary and county emergency services authorities; and

15.6.a.8. Other items required by the Secretary based upon site-specific conditions.

15.6.b. Monitoring plans shall be updated annually. More frequent updating of the plans may be required by the Secretary based upon rapidly changing personnel or site conditions. The monitoring plan shall be implemented immediately by the dam owner upon the approval of the plan by the Secretary.

15.7. Emergency Action Plans - Owners of Class 1 dams shall formulate and submit an emergency action plan to the Secretary for approval. Owners of Class 2 and 3 dams may be required by the Secretary to formulate and submit an emergency action plan for approval.

15.7.a. The emergency action plan developed by the dam owner must follow the format of the example plan provided by the Secretary.

15.7.b. The dam owner shall coordinate with county emergency service authorities in the development of the emergency action plan. The dam owner must provide copies of the inundation maps required under paragraph 3.5.c.2. to those authorities.

15.7.c. The dam owner shall provide county emergency services authorities with a copy of the monitoring plan, and all updates of that plan, approved by the Secretary pursuant to subsection 15.6.

15.8. Emergency Procedures.

15.8.a. Emergency Condition - If the owner of a dam determines that an emergency exists, he or she shall immediately notify any person who may be endangered if the dam should fail and then notify the appropriate county emergency services authorities and the Secretary. After providing notification of the emergency condition, the owner shall immediately take any remedial action, such as an emergency release of water, that is necessary to protect life and property. The Secretary may waive the requirement for a certificate of approval, as required under section 4, where it is necessary to accomplish repairs under emergency conditions.

15.8.b. Dangerous Condition - Should a dangerous condition develop, the Secretary shall be informed immediately. The owner of the dam shall immediately take any remedial action necessary to protect life and property. Emergency procedures developed in accordance with the provisions of subsection 15.6. and subsection 15.7. shall be implemented to protect life and property downstream. The site shall be inspected and monitored at least once every eight (8) hours until the emergency situation is alleviated. Continuous monitoring may be required by the Secretary when there is an imminent danger to the health, safety, or welfare of the public.

15.8.c. Evaluation of Dangerous Conditions - If a dangerous condition develops, an engineering evaluation shall be initiated as soon as possible to formulate a plan for permanent correction of the dangerous condition. The evaluation and corrective action plan shall be submitted to and approved by the Secretary prior to implementation.

15.9. Dam Owner Not Relieved of Responsibility - The Secretary's approval of a monitoring plan, or updates to such a plan, pursuant to subsection 15.6. or his or her approval of an emergency action plan

pursuant to subsection 15.7. shall not relieve the dam owner of his or her legal duties, obligations, or liabilities under W. Va. Code §§22-14-10 and 22-14-12.

§47-34-16. Dam Maintenance.

16.1. General Maintenance Requirements.

16.1.a. Required Maintenance - Each dam shall be maintained in accordance with the plans and specifications approved under the applicable certificate of approval. The Secretary may require maintenance to be performed on a dam, whether or not a certificate of approval has been issued for that dam.

16.1.b. Maintenance Plan - Owners of dams shall formulate and submit a written maintenance plan to the Secretary for approval. The maintenance plan shall include, but not be limited to, schedules for maintaining embankments, concrete structures, vegetative or rock covers, gates, gate mechanisms, penstocks, or other reservoir-regulating devices, spillways, and appurtenances. The maintenance plan shall be implemented immediately by the dam owner upon the approval of the plan by the Secretary. The maintenance plan shall be updated periodically as necessary to reflect changing site conditions.

16.2. Specific Maintenance Requirements.

16.2.a. All spillways and appurtenances shall be maintained to operate in accordance with the plans and specifications approved under the applicable certificate of approval.

16.2.b. All failures resulting from landslides or slope failures shall be corrected immediately if the failures significantly affect the safety or design capacity of the dam or its appurtenances. All failures shall be reported to the Secretary.

16.2.c. All pipes shall be repaired or replaced when damaged, or distorted, or if they otherwise fail to function properly in accordance with the plans and specifications approved under the applicable certificate of approval.

16.2.d. Leakage through joints, fissures, and cracks through or under the spillway channel shall be immediately investigated and repaired.

16.2.e. Any new gate which has been installed in a new dam or in the repair or modification of an existing dam, or any gate which has been opened within five (5) years prior to inspection by the Secretary, shall be opened to at least thirty-three percent (33%) of its maximum capacity at least once annually. Gates not meeting the above requirements may remain closed until operated for the purposes of the owner or to alleviate an emergency condition and shall thereafter be opened at least once annually. All gate mechanisms shall be lubricated annually regardless of the operational status of the gate.

16.3. Routine Maintenance.

16.3.a. Routine maintenance of spillways shall be performed. Such maintenance shall include the removal of sediment, brush, trees, obstructions, and rocks in stilling basins and the re-establishment of the structure to its original hydraulic design.

16.3.b. Routine inspections shall be made of all hydraulic structures in order to maintain proper operation. Special inspections shall be conducted whenever a significant flow through the structures has occurred.

16.3.c. If erosion on the embankment face or abutments occurs, the area shall be regraded and be provided with adequate drainage control or revegetation to prevent future occurrences.

16.3.d. All concrete structures and channel linings shall be maintained in accordance with the plans and specifications approved under the applicable certificate of approval. All cracks located in concrete channels shall be sealed immediately with a sealant approved by the Secretary.

16.3.e. Access roads shall be maintained in order to provide access for emergency inspections, vehicles, and equipment.

16.3.f. The embankment or concrete structure of a dam shall be kept clear of trees and shrubs. The downstream toe and abutments of the dam shall be cleared to natural ground for a lateral distance of at least twenty-five (25) feet. All dams with vegetative covers shall be mowed at least once annually. Grazing by farm animals shall be controlled to prevent animal trails or other damage to the vegetative cover.

16.3.g. The embankment shall be kept clear of burrowing animals.

16.3.h. All monitoring devices shall be routinely inspected and repaired or replaced as necessary so that the devices function properly.

§47-34-17. Dam Repairs.

17.1. General Repair Requirements - The Secretary may require repairs to be performed on a dam, whether or not the dam has a certificate of approval. Major repairs shall require a certificate of approval, issuance of which may or may not constitute final approval of the dam, as determined by the Secretary.

17.1.a. Routine Repairs (No Certificate Required) - Repairs conducted in accordance with the provisions of subsection 16.3. shall not normally require an application for a certificate of approval; however, the Secretary may require such an application based upon site-specific conditions.

17.1.b. Major Repairs (Certificate Required) - Any repairs to a dam other than routine repairs listed in subsection 16.3. shall require an application for a certificate of approval in accordance with the provisions of this rule.

17.2. Specific Repair Requirements.

17.2.a. Removal of Trees and Tree Roots - All trees shall be removed from the embankment and abutment areas, unless otherwise approved by the Secretary based upon site-specific conditions. Small trees with a base diameter of four (4) inches or less may be removed without removing the root system unless specific problems with the root system are evident. Larger trees may require special care in removal. The Secretary may require the removal of root systems of large trees if the potential for seepage along the root system exists. If removal of root systems requires extensive excavation of the embankment, the removal shall be considered a major repair requiring a complete application for a certificate of approval.

§47-34-18. Application and Annual Registration Fees.

18.1. Application Fees - Each application submitted to place, construct, enlarge, alter, repair, remove or abandon a dam shall include an application fee. No fee, however, shall be assessed for dams designed and constructed by the soil conservation service for soil conservation districts. The following application fees apply:

18.1.a. The application fee for placement, construction, alteration, enlargement, repair, or approval of a dam is three hundred dollars.

18.1.b. The application fee for breaching, or abandonment of a dam is two hundred dollars.

18.1.c. The application fee for removal of a dam is one hundred dollars.

18.2. Annual Registration Fees - Owners of existing dams holding certificates of approval shall be assessed an annual registration fee. In accordance with provisions of the Dam Control and Safety Act, West Virginia Code §22-14-7, existing certificates of approval will be extended for one year upon receipt of the annual registration fee, an inspection report in accordance with subsection 15.5., a monitoring and emergency action plan in accordance with subsection 15.6. and subsection 15.7., and a maintenance plan in accordance with subdivision 16.1.b.; Provided that where an approved, up-to-date: inspection report; monitoring and emergency action plan; and maintenance plan are on file in the Dam Safety Section, and where no outstanding violation(s) exist, then the certificate of approval will be extended without resubmission of the foregoing documents upon receipt of the annual registration fee. No fee shall be assessed, however, for dams designed and constructed by the soil conservation service for soil conservation districts. The following annual registration fees apply:

18.2.a. Class 4 dams shall be assessed twenty-five dollars.

18.2.b. Class 3 dams shall be assessed fifty dollars.

18.2.c. Class 2 dams shall be assessed seventy-five dollars

18.2.d. Class 1 dams shall be assessed one hundred dollars.

18.3. Any certificate of approval issued pursuant to W. Va. Code §22-14-7 and this rule is void without notification to the person holding the certificate of approval when the annual registration fee is more than one hundred eighty (180) days past due. Resubmission of an application in accordance with section 5 is required where a certificate has become void due to failure to pay the appropriate annual registration fee within one hundred eighty (180) days of the date due.

§47-34-19. Civil Administrative Penalties.

19.1. Enforcement Actions.

19.1.a. General - An authorized representative of the Secretary may commence an enforcement action for any observed violation.

19.1.b. Enforcement Action Procedures - An enforcement action shall be in writing, shall be signed by the Secretary or other authorized representative of the Secretary, and shall set forth with reasonable specificity:

19.1.b.1. The nature of the enforcement action with a reference to the section of the statute, rule, notice, order or certificate of approval term that was allegedly violated;

19.1.b.2. The time and date of the observance of the violation;

19.1.b.3. A reasonable description of the dam where the violation was observed, where within the operation or maintenance of the dam the observation was observed, and the condition or hazard determined by the Secretary;

19.1.b.4. The name, ownership and location of the dam and any identification number associated with it; and

19.1.b.5. In those instances where a notice or order has not been previously issued, the remedial action necessary to alleviate the violation and time limits for accomplishing the remedial action.

19.2. Penalty Assessment Procedures.

19.2.a. Review of Enforcement Action and Penalty Calculation - The Secretary shall review each enforcement action issued for civil administrative penalty assessment to determine:

19.2.a.1. The appropriateness of a civil administrative penalty;

19.2.a.2. The initial amount of penalty, if any, based upon the rates and methods given in subsection 19.5.;

19.2.a.3. The appropriateness of assessing a daily civil administrative penalty for continuing violations;

19.2.a.4. The total initial civil administrative penalty assessed; and

19.2.a.5. The appropriateness of assessing a separate civil administrative penalty against an individual person.

19.2.b. Notice of Civil Administrative Penalty - The Secretary shall provide the violator with a copy of the enforcement action and:

19.2.b.1. A notice of civil administrative penalty which shall include procedures for requesting an informal hearing and a notification of applicable time constraints; or

19.2.b.2. A notice of dismissal.

19.3. Hearings and Appeals.

19.3.a. Right to Informal Hearing - The violator has twenty (20) calendar days from his or her receipt of the notice of civil administrative penalty within which to request, in writing, an informal hearing before the assessment officer. If a hearing is requested, the assessment officer will hold the hearing within 60 days to deduce the actual facts and circumstances regarding the violation and, based thereon, will make a final recommendation of civil administrative penalty assessment to the Secretary. If no hearing is requested, the notice of civil administrative penalty becomes a final order after the expiration of the twenty-day period and the civil administrative penalty becomes due and payable.

19.3.b. Notice and Scheduling of Informal Hearing - If the violator requests an informal hearing within the twenty-day period, the assessment officer shall schedule a hearing in accordance with the following procedures:

19.3.b.1. The time and place the informal hearing is to be held is to be communicated to any authorized representative of the Secretary who filed an enforcement action bringing about the informal hearing, to the violator and to any person who has expressed an interest in writing concerning the enforcement action;

19.3.b.2. The communication shall be provided at least fifteen (15) calendar days prior to the time of the hearing; and

19.3.b.3. The assessment officer may continue the informal hearing only for good cause shown.

19.3.c. Informal Hearing Procedures - An informal hearing, as provided by this rule, is intended to be an informal discussion of the facts which gave rise to the issuance of an enforcement action and shall be conducted in the following manner:

19.3.c.1. The West Virginia Rules of Civil Procedure and West Virginia Rules of Evidence shall not apply;

19.3.c.2. A record of the informal hearing is not required but may be made by any party to the hearing at the party's expense; and

19.3.c.3. At formal review proceedings which may ensue, no evidence as to any statement made by one party at the informal hearing may be introduced as evidence by another party, nor may any statement be used to impeach a witness, unless the statement is or was available as competent evidence independent of its introduction during the informal hearing.

19.3.d. Written Decision - Within thirty (30) calendar days following the informal hearing, the Secretary shall issue and furnish to the violator a written decision affirming, increasing, decreasing, or dismissing the initial civil administrative penalty assessment and giving the reasons for the decision.

19.3.e. Request for Formal Hearing - Within thirty (30) calendar days after notification of the Secretary's informal hearing decision, the violator may request a formal hearing before the Environmental Quality Board. If no formal hearing is requested, the Secretary’s decision becomes a final order after the expiration of the thirty day period and the civil administrative penalty becomes due and payable.

19.4. Separate Civil Administrative Penalties.

19.4.a. The Secretary may assess a separate civil administrative penalty against any corporate director, officer, agent, or employee of a violator, or any other person, who authorizes, orders, or carries out a violation of the statute, rule, notice, order, or certificate of approval term or who fails or refuses to follow an order from the Secretary.

19.4.b. In determining the amount of a civil administrative penalty to be assessed against a person, consideration shall be given to the criteria specified in subsection 19.5.

19.4.c. The Secretary shall serve on each person to be assessed an administrative penalty a notice of separate civil administrative penalty assessment. For purposes of this subsection, service is considered sufficient if it satisfies Rule 4 of the West Virginia Rules of Civil Procedure for service of a summons and complaint. A notice of separate civil administrative penalty assessment shall include:

19.4.c.1. A reference to the section of the statute, rule, notice, order, or certificate of approval term allegedly violated;

19.4.c.2. A concise statement of the facts alleged to constitute the violation;

19.4.c.3. A statement of the amount of the separate civil administrative penalty to be imposed;

19.4.c.4. A copy of the underlying enforcement action; and

19.4.c.5. A statement of a person's right to an informal hearing.

19.4.d. A person shall have twenty (20) calendar days from receipt of the notice of separate civil administrative penalty assessment in which to request, in writing, an informal hearing before the assessment officer. If no hearing is requested, the notice of separate civil administrative penalty becomes a final order after expiration of the thirty-day period and the separate civil administrative penalty becomes due and payable.

19.4.e. The informal hearing, if requested, will be scheduled and conducted pursuant to this section.

19.5. Civil Administrative Penalty Calculation Procedures.

19.5.a. Calculation - The Secretary shall calculate a civil administrative penalty by taking into account the seriousness of the alleged violation, good faith efforts on the part of the violator (as provided for in paragraph 19.5.c. of this section) and any history of violations by the violator.

19.5.b. History of Violations (HOV) - The Secretary shall take into account the violator's history of violations by determining if any enforcement actions concerning Certificate terms, requirements of the Act, rule requirements, notices to comply or any orders have been taken against the violator during twenty-four (24) months prior to the violation. Those enforcement actions which were withdrawn, dismissed, or vacated shall not be included in the determination. Any outstanding violation within the time period shall constitute a history of violations.

19.5.c. Good Faith Effort - Good faith effort shall be determined in accordance with Table B.

19.5.d. Maximum Assessed Penalty - The maximum assessment for a single violation shall not exceed five thousand dollars ($5,000) per day with a maximum cumulative total of twenty thousand dollars ($20,000) for this same violation. Multiple violations shall not exceed a maximum cumulative total of twenty thousand dollars ($20,000) per day. The amounts applicable to a single violation must be adhered to when developing the cumulative total for multiple days.

19.5.e. Penalty - The civil administrative penalty shall be determined through the use of Table A.

19.5.f. Penalty With Good Faith Efforts by Violator - The civil administrative penalty determined by Table A shall be reduced, if applicable, through the use of Table B.

TABLE A

Seriousness of Violation
(dollars/day/violation)

Enforcement Action	**No Hazard**		**Serious Problem**		**Dangerous Condition**	
Failure to Comply With:	No HOV	With HOV	No HOV	With HOV	No HOV	With HOV
Certificate	250	625	750	1250	2500	5000
Act	625	1250	1500	1875	3125	5000
Rule	1250	1875	2125	2500	3750	5000
Notice	1875	2500	3125	3750	4375	5000
Order	2500	3125	3750	4375	4625	5000

TABLE B

Good Faith by Violator

Rating	0	1	2	3	4	5	6	7	8
Percent Reduction	0%	5%	10%	15%	20%	25%	30%	35%	40%

Good Faith Ratings:

0 Violator failed to take appropriate action
1-2 Violator took prompt, but insufficient action to fully comply with the violation within the required time period. Action was completed prior to end of extended time period.
3-4 Violator took prompt action and worked diligently to correct the violation. Conditions beyond the control of the violator prevented full compliance with the enforcement action and required that the compliance time period be extended for just cause.
5-6 Violator initiated compliance action immediately and expended all reasonable efforts to comply. Achieved compliance before the end of the original compliance time period.
7-8 Violator was already taking appropriate action at the time the violation was documented and expended exemplary effort in compliance action before the end of the compliance time period.

Determination of Penalty Assessment:

Enforcement Action Amount (Table A) _____

Less Good Faith Percent (Table B) _____

Total Assessment _____

§47-34-20. State Deficient Dams Rehabilitation Assistance Program.

20.1. The Secretary shall establish a State Deficient Dams Rehabilitation Assistance Program to direct the distribution of loans from the Dam Safety Rehabilitation Revolving Fund created under the Act.

20.2. Use of Moneys in the Fund. -- Moneys in the Fund shall be used to make loans to persons to finance costs for engineering, design, alteration, improvement, repair, breaching or removal of a deficient dam necessary to correct or remove the deficiencies and other activities as authorized by a federal grant or a legislative appropriation. The Fund may also be utilized by the Secretary to repair, remove or take other remedial action with respect to a deficient dam under the authority in section 22 of the Act. The Fund may also be used to defray administrative costs incurred by the Secretary or the Authority.

20.3. Each loan shall be in an amount that covers the reasonable and necessary cost of a project for which funds are sought by the applicant and which are not provided by other available sources. Dam owners may use multiple programs or sources to fund the rehabilitation costs for a deficient dam, up to 100 percent of rehabilitation costs. Dam owners cannot exceed 100 percent funding from multiple programs or sources and must provide the Secretary with any multiple source accounting to verify that the loan amount plus the additional sources of funding do not exceed 100 percent.

20.4. List of Deficient Dams. -- A State List of Deficient Dams shall be developed and updated periodically by the Secretary utilizing a priority ranking system, including, but not limited to, the following factors: size of dam and reservoir; condition of dam and its appurtenances; and hazard potential to life and property.

§47-34-21. Eligibility Criteria.

The Secretary shall consider eligibility for loans to include, but not be limited to, the following criteria:

21.1. Only those dams on the List of Deficient Dams are eligible for a loan from the Dam Safety Rehabilitation Revolving Fund in accordance with the priority specified in the List of Deficient Dams, provided that a person meets the criteria under subsection 21.3.;

21.2. A person has submitted a complete application for a project with eligible costs;

21.3. A person is in a state of readiness to proceed to planning, design or construction and expend loan payments in a timely manner;

21.4. A person has demonstrated his or her ability to pay is less than the estimated cost of repair or removal of the dam;

21.5. A person has demonstrated his or her ability to repay a loan. The Secretary shall evaluate the borrower’s financial stability, financial needs, and ability to repay based upon an appropriate examination of financial information, including, but not limited to, income and credit histories, income tax returns, financial statements and collateral offered to secure the loan;

21.6. Rehabilitation costs for any deficient dam are eligible, except for dams owned by the federal government;

21.7. Costs for State agency-required fish passage are eligible only if they are part of an overall rehabilitation project;

21.8. Costs for lake-enhancement projects such as lake dredging, sediment removal projects, or boat

ramps, which do not enhance the safety of a deficient dam are not eligible to be funded through the Fund;

21.9. A person has provided an acceptable schedule for project initiation and completion; and

21.10. A person has demonstrated he or she has the financial, legal, and managerial capabilities to ensure adequate design, construction, completion of the project, and subsequent operation and maintenance of the dam. As a part of this demonstration, the person shall complete and submit to the Secretary financial capability worksheets supplied by the Secretary.

§47-34-22. Applications for Loans.

22.1. A person who meets the eligibility criteria in section 21 may apply for a loan.

22.2. The applicant shall request a pre-application meeting with the Secretary to discuss the requirements of the program, including eligibility. A pre-application package, in a form prescribed by the Secretary, shall be completed and submitted to the Secretary prior to this meeting.

22.3. The review and approval by the Secretary of the pre-application package, including any project plans, design drawings and specifications, or other documents is for administrative purposes only and does not relieve the applicant or his agents and employees from properly planning, designing, constructing, operating, and maintaining the project as required under applicable federal and state statutes and rules.

22.4. If the project will involve two (2) or more persons, the applicant shall submit an agreement among the parties to the Secretary in a form prescribed by the Secretary.

22.5. After the pre-application meeting, a person desiring a loan from the Fund may make a separate application to the Secretary, on a form prescribed by the Secretary, for each project for which a loan is desired.

§47-34-23. Loan Agreements.

Upon approval of an application for a loan, the Secretary shall specify the provisions that are required to be contained in the loan agreement, including:

23.1. The specific purposes for which the proceeds of the loan shall be expended, the cost of the project, the amount of the loan, and the terms of repayment of the loan and the security therefor, which may include a deed of trust or other appropriate security instrument creating a lien on such project or any other collateral the Secretary may require;

23.2. The procedures as to the disbursement of loan proceeds including an estimated monthly draw schedule, and the duties and obligations imposed upon the applicant in regard to the acquisition or construction of the project;

23.3. The agreement of the applicant to repay the obligations of such applicant under the loan agreement. Revenue may be pledged for the repayment of the loan together with all interest, fees, and charges thereon and all other financial obligations of the applicant under the loan agreement;

23.4. If notes or other interim obligations are being issued by the applicant, the agreement of the applicant to take other repayment actions as are required of the applicant under the loan agreement;

23.5. Payments of the principal and any interest on a loan shall be made by the applicant in accordance with the following:

23.5.a. Computation of Interest on Loans. -- Each loan shall bear interest from the date of the delivery of the notes of the applicant evidencing the loan to the applicant (or such other date as is determined by the Secretary) at a rate or rates per annum, either fixed or variable, as determined by the Secretary.

23.5.b. Fees and Charges. -- In addition to payments of principal and interest on a loan, each applicant shall agree in the loan agreement to pay fees and charges equal to the applicant's share of the administrative expenses of the Secretary and the Authority relating to the loan program or any bond program established by the Secretary and the Authority.

23.6. The agreement of the applicant to accept the Authority's enforcement remedies under the Act in the event of any default under the loan; and

23.7. The agreement of the applicant to comply with all applicable federal and state statutes and rules and regulations and all applicable local ordinances pertinent to the financing, acquisition, design, construction, operation, maintenance and use of the project.

§47-34-24. Loans Conditioned Upon Availability of Moneys in the Fund.

The obligation of the Authority to enter into loan agreements shall be conditioned upon the availability of moneys in the Fund in amounts and on terms and conditions, as at the direction of the Secretary, will enable the Authority to make loans.

§47-34-25. Disbursement of Loan Moneys.

25.1. Following the Secretary's approval of a loan and conditions to be included in the loan agreement, the Authority shall provide the person with the loan agreement setting forth the specific terms of the loan. The loan agreement, following execution by the person, constitutes a binding commitment for moneys from the Fund.

25.2. Moneys shall be disbursed from the Fund only upon a written authorization from the Authority. On a monthly basis, there shall be disbursed to each recipient the amount certified as costs incurred for the project. Said certification shall be made on an approved form. Moneys will be dispensed from the Fund upon presentation of an executed payment request form.

25.3. Each person receiving a loan shall comply with all terms and conditions of the loan agreement or notes or other debt instruments evidencing the loan.

25.4. Prior to commencement of construction, the Secretary and recipient shall hold a pre-construction conference to review the activities that shall take place during construction of the project.

25.5. Interim inspections of the project shall be conducted by the Secretary periodically during construction. A final inspection shall be conducted by the Secretary after construction has been substantially completed and before the final construction loan payment is disbursed.

25.6. The Secretary may use moneys from the Fund in accordance with provisions of section 22 of the Act. Before seeking a requisition from the Fund, the Secretary shall provide the information required in Section 20 of the Act to the Authority. Costs recovered from an owner by civil action shall be promptly deposited in the Fund.

§47-34-26. Owner's Responsibilities.

Once a loan has been granted under this rule, the owner or owners of a dam shall cooperate with the Secretary by:

26.1. Facilitating access to the dam and its appurtenances;

26.2. Making available all records maintained pursuant to the provisions of this rule for inspection by the Secretary upon request and where appropriate by the Authority;

26.3. Furnishing the Secretary with all plans, specifications, operation and maintenance data, instrumentation data, and other information pertinent to the dam and its appurtenances, or the loan;

26.4. Providing the Secretary with an operation and maintenance plan;

26.5. Maintaining the dam and appurtenances in the state of repair and operating condition required by the exercise of prudence; due regard for life or property; the application of sound and accepted engineering principles; and provisions of this rule;

26.6. Developing a monitoring and emergency action plan for the approval of the Secretary and implementing the plan upon approval;

26.7. Providing the Secretary with written, regularly scheduled reports describing progress toward repair or removal of the dam; and

26.8. Demonstrating the ability to appropriately operate and maintain the dam after rehabilitation is complete.

§47-34-27. Procurement Standards.

27.1. Procurement Standards for Publicly-Owned Dams. -- Owners of publicly-owned dams shall comply with all applicable State laws and rules pertaining to competitive bid and prevailing wage requirements.

27.2. Procurement Standards for Privately-Owned Dams. -- Owners of privately-owned dams shall obtain a minimum of three bids prior to design, construction, or major procurement items as determined by the Secretary, provided that the Secretary may grant an exception in situations that may cause loss of life or property.

§47-34-28. Financial Management and Record Keeping.

28.1. Financial Management. -- A loan recipient shall establish and maintain a financial management system to account for all costs incurred related to a project. This system shall assure that generally accepted accounting principles and practices are consistently applied in all financial matters related to the project.

28.1.a. Financial management shall include the following elements:

28.1.a.1. The maintenance of ledgers containing accurate, current, and complete records of all financial actions related to the project;

28.1.a.2. The maintenance of records that identify the source and amount of all moneys used for the project and documentation of how such moneys were used; and

28.1.a.3. The maintenance of records that allow a comparison of actual project costs with

budgeted costs.

28.1.b. The recipient shall maintain an accounting system, which shall:

28.1.b.1. Establish a separate account for the project;

28.1.b.2. Record all transactions in a timely and verifiable manner;

28.1.b.3. Designate one (1) person who is not responsible for project operations to account for all project funds; and

28.1.b.4. Prepare and submit as directed, financial reports of the project.

28.2. Records. -- The recipient shall maintain official records for each loan received that include:

28.2.a. The loan application and loan approval documents;

28.2.b. All contracts and subagreements related to the project;

28.2.c. All documents related to financial management prescribed under subsection 28.1.;

28.2.d. A documentation of compliance with applicable federal and State statutes, rules, and regulations;

28.2.e. A documentation of the amount of moneys received and expended for the project;

28.2.f. A documentation of all property that was purchased for the project; and

28.2.g. Time records related to the project, if applicable.

E.49. Wisconsin



Unofficial Text (See Printed Volume). Current through date and Register shown on Title Page.

Chapter NR 333

DAM DESIGN AND CONSTRUCTION

NR 333.01 Purpose.
NR 333.02 Applicability.
NR 333.03 Definitions.
NR 333.04 Compliance schedules.
NR 333.05 Submission of plans, specifications and analyses.
NR 333.06 Dam hazard ratings.
NR 333.07 Hydraulic design and safety requirements.
NR 333.08 Construction.
NR 333.09 Financial assurance.

Note: Chapter NR 333 as it existed on May 31, 1985 was repealed and a new chapter NR 333 was created effective June 1, 1985.

NR 333.01 Purpose. The purpose of this chapter is to ensure that dams are designed, constructed and reconstructed so as to minimize the danger to life, health and property. This chapter is adopted pursuant to ss. 31.02 (2), 31.19 and 31.33, Stats.

History: Cr. Register, May, 1985, No. 353, eff. 6–1–85.

NR 333.02 Applicability. (1) The provisions of this chapter are applicable to dams not owned by the United States government that:

(a) Have a structural height of more than 6 feet and a maximum storage capacity of 50 acre–feet or more of water.

(b) Have a structural height of 25 feet or more and a maximum storage capacity of more than 15 acre–feet of water.

(c) Have a structural height of 6 feet or less or a maximum storage capacity of less than 50 acre–feet of water if the department determines that the dam is likely to endanger life, health or property if it is not designed, constructed or reconstructed in accordance with this chapter.

(2) All new and existing dams inspected, approved and licensed by a federal agency under 18 CFR Part 12, are exempt from the provisions of this chapter provided that the dam meets requirements which are at least as restrictive as the requirements of this chapter.

Note: Dams exempted from this chapter are still subject to the requirements of ch. 31, Stats., including, but not limited to, the requirements for permits and plan approvals.

History: Cr. Register, May, 1985, No. 353, eff. 6–1–85; CR 00–136: am. Register July 2001, No. 547 eff. 8–1–01.

NR 333.03 Definitions. (1) "Auxiliary spillway" means a secondary spillway designed to pass water only during flows exceeding the capacity of the principal spillway.

(2) "Base flow" means that part of the stream flow that is derived from groundwater and calculated as the 7–day low flow that occurs on an average of once in 2 years or has a 50% chance of occurring in any given year. The notation is $Q_{7,2.}$

(3) "Dam" means any artificial barrier in or across a watercourse which has the primary purpose of impounding or diverting water. A dam includes all appurtenant works, such as a dike, canal or powerhouse.

(4) "Department" means the department of natural resources.

(5) "Development" means any artificial change to improved or unimproved real estate not related to allowable open space use including, but not limited to, the construction of buildings, structures or accessory structures; the construction of additions or substantial improvements to buildings, structures or accessory structures; the placement of buildings or structures; and campgrounds.

(6) "Floodplain with the dam nonexistent" means that area of land downstream from a dam that would be inundated by water during the regional flood if the dam did not exist.

(7) "Floodway" means the channel of a river or stream and those portions of the floodplain adjoining the channel which are required to carry the regional flood discharge.

(8) "Hydraulic shadow" means that area of land downstream from a dam that would be inundated by water upon failure of the dam during the regional flood.

(9) "Land use controls in place" means future development within the hydraulic shadow is required to conform to the criteria specified in a zoning ordinance adopted and approved pursuant to s. 87.30, Stats., and also consistent with land use plans developed under s. 66.1001, Stats., or through restrictive covenants, easements, or other appropriate legal arrangements between the owner of the dam and the owners of all property within the hydraulic shadow.

(10) "Maximum headwater" means the maximum water surface elevation before overtopping would occur.

(11) "Maximum storage capacity" means the volume of water in acre–feet capable of being stored behind a dam at the maximum water surface elevation before overtopping would occur.

(12) "Minimum tailwater" means the water level downstream from a dam at base flow.

(13) "Open space use" means a use which has a relatively low flood damage potential, such as uses associated with agriculture, recreation, parking, storage yards, or certain sand and gravel operations.

(14) "Overtopping" means the flow of water over parts of a dam which are not part of its spillway system.

(15) "Owner" means any individual, partnership, public utility, company, cooperative, trust, corporation, association, state or interstate agency, city, village, town, county or special purpose district such as a drainage district or a public inland lake protection and rehabilitation district which has title to or recorded easement for operation, maintenance and access to a dam or to the specific parcel of land on which a dam exists.

(16) "Principal spillway" means the primary structure for the discharge of normal flow through a dam.

(17) "Q_{10}" means the flood flow having a recurrence interval of 10 years or a 10% chance of occurring or being exceeded in any given year.

(18) "Q_{50}" means the flood flow having a recurrence interval of 50 years or a 2% chance of occurring or being exceeded in any given year.

(19) "Q_{100}" means the flood flow having a recurrence interval of 100 years or a 1% chance of occurring or being exceeded in any given year.

(20) "Q_{500}" means the flood flow having a recurrence interval of 500 years or a 0.2% chance of occurring or being exceeded in any given year.

(21) "Q_{1000}" means the flood flow having a recurrence interval of 1000 years or a 0.1% chance of occurring or being exceeded in any given year.

(22) "Reconstruction" means alteration of an existing dam in a manner which affects its hydraulic capacity or structural integrity.

(23) "Regional flood" means a flood determined to be representative of large floods known to have occurred in Wisconsin and

Unofficial Text (See Printed Volume). Current through date and Register shown on Title Page.

which may be expected to occur on a particular stream once in every 100 years.

Note: The regional flood is based upon a statistical analysis of stream flow records available for the watershed or an analysis of rainfall or runoff characteristics in the watershed or both. The flood frequency of the regional flood is once in every 100 years. In any given year, there is a 1% chance that the regional flood may occur or be exceeded.

(24) "Structural height" means the difference in elevation in feet between the point of lowest elevation of the top of the dam before overtopping and the lowest elevation of the natural stream or lake bed at the downstream toe of the dam.

(25) "Submerged" means that the difference between the water surface elevations upstream and downstream from a dam is one foot or less.

(26) "Total spillway capacity" means the sum of the auxiliary spillway and principal spillway capacities of a dam.

History: Cr. Register, May, 1985, No. 353, eff. 6–1–85; am. (25), Register, April, 1987, No. 376, eff. 5–1–87; CR 00–136: renum. (1) to (4), (9), (13) to (16), (21) to (25), (27) and (28) to be (2) to (4), (1), (8), (14) to (17), (20) to (26), am. (1), (3), (15), (24) and (26), r. (5), (8), (17), (20) and (26), cr. (5), (9) and (13) Register July 2001, No. 547 eff. 8–1–01; **correction in (9) made under s. 13.93 (2m) (b) 7., Stats., Register January 2002 No. 553**.

NR 333.04 Compliance schedules. (1) DAM HAZARD RATING. The department shall assign a dam hazard rating according to the criteria in s. NR 333.06 for all dams subject to the provisions of this chapter. The assignment of a hazard rating shall be based on the findings of a dam failure analysis provided by the owner, pursuant to the standards of s. NR 333.05, according to the following schedule:

(a) For new dams, prior to granting permission or approval to construct.

(b) For existing dams which are to be reconstructed, prior to granting permission or approval to reconstruct.

(c) After a dam failure analysis has been approved by the department or is adopted in a floodplain zoning ordinance pursuant to s. 87.30, Stats., and approved by the department.

(d) Upon issuance of a department directive in a dam safety inspection report pursuant to s. 31.19, Stats.

(2) COMPLIANCE. (a) *New dams.* The design and construction of all new dams shall be in compliance with the requirements of this chapter.

(b) *Existing dams.* The owners of all existing dams shall bring their dams into compliance with the requirements of this chapter within 10 years after being notified of the dam's hazard rating pursuant to sub. (1), unless ordered to do so earlier under s. 31.19 (5), Stats.

(3) ENFORCEMENT. Administrative orders issued by the department under s. 31.19 (5), Stats., may be enforced under ss. 23.50, 23.79 (3), 30.03, 31.23 (2) and 31.25, Stats.

History: Cr. Register, May, 1985, No. 353, eff. 6–1–85; CR 00–136: r. and recr., Register July 2001, No. 547 eff. 8–1–01.

NR 333.05 Submission of plans, specifications and analyses. (1) PLANS AND SPECIFICATIONS. Plans and specifications prepared by a professional engineer registered in the state of Wisconsin shall be submitted to and approved by the department prior to the construction of a new dam or reconstruction of an existing dam.

(2) HYDRAULIC, HYDROLOGIC AND STABILITY ANALYSES. Hydraulic, hydrologic and stability analyses prepared by a professional engineer registered in the state of Wisconsin shall be submitted to and approved by the department prior to the construction of a new dam or the reconstruction of an existing dam. These analyses shall be conducted according to accepted engineering practice and unless the department determines otherwise shall be submitted in the form of a report which includes, at a minimum:

(a) Purpose of the report. Development of an emergency action plan, floodplain zoning or development of the hazard rating for the dam.

(b) Roles and participation of other agencies — DNR, DEG, community officials, other agencies.

(c) Data collection methods and sources of information — Development of cross sectional data, description of past flooding events, reference to previous studies, current floodplain zoning map.

(d) Methodologies and procedures — Operation of dam during high water, breach parameters, description of all spillway components, scenario for failure, failure conditions.

(e) Regional flood flows calculated in conformance with the standards in s. NR 116.07 (3).

(f) Hydraulic modeling — Determination and delineation of the following hydraulic conditions during the regional flood, using the standards in s. NR 116.07(4):

1. Hydraulic shadow — assuming that the dam is in existence and fails. Failure shall be considered to occur at the maximum upstream water elevation or at the point of overtopping, based upon the physical conditions at the dam.

2. Dam in place, no failure — assuming the dam operates in accordance with its department approved operation plan, if one is available, or not operated if there is no plan.

3. Dam nonexistent — assuming the dam has been removed and the natural stream cross–section is restored.

Note: For suggested dam breach parameters, see the National Weather Service "DAMBRK or FLDWAV" Users Manuals.

(g) Comparison table — Summary by cross section of the maximum flood elevation for the 3 hydraulic conditions.

(h) Determination of the dam hazard rating using the criteria in s. NR 333.06.

(i) Design flood flows, based on the hazard rating and the hydraulic design standards in s. NR 333.07.

(j) Calculations for routing of the design flood through the structure. Starting conditions for the routing shall be at the normal pool and normal flow tailwater elevations.

(k) Stability analysis of the dam, which considers sliding, overturning and foundation failure during base flow conditions and at maximum load conditions, including ice loading, during routing of the design flood through the dam.

(L) Appendices:

1. Plan view of the dam.

2. Elevation view of the dam from downstream including breach geometry.

3. Pertinent elevations of the dam.

4. Stage vs. storage curve or area vs. volume curve, or both.

5. Spillway capacity rating curves or calculations, where appropriate.

6. Downstream water surface profiles and floodway data tables, for the dam failure, and the with and without dam conditions, during the regional flood.

7. Maps for the 3 modeled conditions, with cross section locations and structure identification adequate to determine the hazard rating for the dam, for the dam failure condition map, showing the floodway, and to an appropriate scale consistent with the community floodplain zoning map.

8. Cross section plots of actual field cross sections and comparison with dam break input cross sectional data.

9. Hard copy and data disk with computer input and output for all modeled conditions, including hydrology and hydraulic runs.

10. Other supporting calculations as the department deems necessary.

Note: Mapping, profiles and floodway data tables must be suitable for zoning purposes, as required in s. NR 116.07 (4).

(3) ESTIMATED COSTS. The estimated cost of construction of the new dam or reconstruction of the existing dam, and the estimated cost of removing the dam and restoring the channel to its

natural condition, shall be submitted to the department prior to the construction of a new dam or reconstruction of an existing dam.

History: Cr. Register, May, 1985, No. 353, eff. 6–1–85; CR 00–136: am. (1) and (3), r. and recr. (2), Register July 2001, No. 547 eff. 8–1–01.

NR 333.06 Dam hazard ratings. (1) A hazard rating of low, significant or high for all existing and proposed dams shall be determined in accordance with the following criteria:

(a) *Low hazard.* A low hazard rating shall be assigned to those dams that have no development unrelated to allowable open space use in the hydraulic shadow where the failure or mis–operation of the dam would result in no probable loss of human life, low economic losses (losses are principally limited to the owners property), low environmental damage, no significant disruption of lifeline facilities, and have land use controls in place to restrict future development in the hydraulic shadow.

(b) *Significant hazard.* A significant hazard rating shall be assigned to those dams that have no existing development in the hydraulic shadow that would be inundated to a depth greater than 2 feet and have land use controls in place to restrict future development in the hydraulic shadow. Potential for loss of human life during failure must be unlikely. Failure or mis–operation of the dam would result in no probable loss of human life but can cause economic loss, environmental damage, or disruption of lifeline facilities.

(c) *High hazard.* A high hazard rating shall be assigned to those dams that have existing development in the hydraulic shadow that will be inundated to a depth greater than 2 feet or do not have land use controls in place to restrict future development in the hydraulic shadow. This rating must be assigned if loss of human life during failure or mis–operation of the dam is probable.

(2) The owner of a dam may request that the department change the hazard rating of an existing or proposed dam by submitting adequate information which demonstrates that the land use and land use controls downstream from the dam meet the requirements for a different hazard rating. The department shall advise the owner of its action on the requested change within 90 business days after receiving the request.

History: Cr. Register, May, 1995, No. 353, eff. 6–1–85; CR 00–136: r. and recr., Register July 2001, No. 547 eff. 8–1–01.

NR 333.07 Hydraulic design and safety requirements. (1) MINIMUM HYDRAULIC CAPACITY. Except as provided in sub. (2), all proposed and existing dams shall have the minimum hydraulic capacity shown in Table I:

Table I
Required Spillway Design Capacities

Dam Hazard Rating	Minimum Principal Spillway Capacity	Minimum Total Spillway Capacity
Low (L)	Q_{10}	Q_{100}
Significant (S)	Q_{50}	Q_{500}
High (H)	Q_{100}	Q_{1000}

(2) REDUCED REQUIREMENTS. (a) Unless the department determines that public safety requires full compliance with the substantive requirements of this rule, all dams which will be submerged by flows less than the minimum hydraulic capacity specified in Table I shall be designed to pass the flow of the river at submergence.

(b) Any owner may provide documentation to justify a different spillway capacity from that specified in Table I. The department shall review such documentation and may approve the spillway capacity proposed by the owner if it determines that such capacity will not result in an additional hazard to life, health or property when compared to the capacity specified in Table I.

(3) SAFETY MEASURES. The owners of all new and existing dams shall comply with the following safety measures:

(a) The owner shall have an adequate operation, inspection and maintenance plan for the dam.

(b) The dam shall be structurally stable for any flow condition up to and including the design flood flow.

(c) An adequate emergency action plan shall be prepared for the area downstream from the dam in consultation with the local unit of government and concurred in by the division of emergency government. An adequate emergency action plan shall include, but is not limited to, the following information:

1. A notification flow chart identifying involved agencies, other dam owners both upstream and downstream and their phone numbers.

2. Emergency operation procedures.

3. An inundation map of the hydraulic shadow on a scale of l" = 2000' or less that extends downstream to an elevation within one foot of the dam nonexistent profile.

4. Procedures for notification of all property owners affected by a dam failure and a list of their names, addresses and phone numbers.

Note: For additional information on emergency action plans refer to Chapter 6 of the Federal Energy Regulatory Commission's "Engineering Guidelines for the Evaluation of Hydropower Projects".

(d) Documentation showing that the requirements of pars. (a) to (c) have been met shall be submitted to the department for approval. The department shall review and approve or disapprove of the documented safety measures in writing within 90 business days after the department receives the documentation.

History: Cr. Register, May, 1985, No. 353, eff. 6–1–85; CR 00–136: r. (1), renum. (2) to (4) to be (1) to (3) and am. (1), (2), (3) (c) and (d) and Table I, Register July 2001, No. 547 eff. 8–1–01.

NR 333.08 Construction. (1) Construction of a new dam or reconstruction of an existing dam may not begin until the department approves the plans and specifications submitted under s. NR 333.05.

(2) Alterations to any plans or specifications that were approved by the department under s. NR 333.05 which will affect the flood flow capacity or structural integrity of a dam shall be approved by the department before construction or reconstruction of the dam.

(3) All dams shall be constructed or reconstructed under the supervision of a professional engineer registered in the state of Wisconsin. The supervising engineer shall, within 10 days after completing the construction or reconstruction of a dam, submit a statement indicating that the dam was constructed or reconstructed in accordance with the plans and specifications approved by the department under s. NR 333.05.

(4) As–built plans shall be submitted to the department within 30 business days after the completion of construction or reconstruction of a dam.

History: Cr. Register, May, 1985, No. 353, eff. 6–1–85; CR 00–136: am. (3), Register July 2001, No. 547 eff. 8–1–01.

NR 333.09 Financial assurance. (1) GENERAL REQUIREMENT. (a) Except as provided in par. (b), the owner of a dam shall file a bond, escrow account, lien or other financial assurance satisfactory to the department prior to the commencement of construction or reconstruction of the dam. The amount of such financial assurance shall equal the estimated cost of removing the dam and restoring the stream channel to its natural condition or the cost of constructing or reconstructing the dam, whichever is less, based on the cost estimate submitted by the owner under s. NR 333.05 (3).

(b) Where the owner is a state or interstate agency or a city, county, village, special purpose district or other unit of government, financial assurance is not required if the owner demon-

Unofficial Text (See Printed Volume). Current through date and Register shown on Title Page.

strates to the department's satisfaction that it has made or will make sufficient funds available to construct or reconstruct the dam or to ~~r~~emove the dam and restore the stream channel it its natural condition, whichever is less expensive.

(2) NOTIFICATION. As part of its approval of the plans and specifications submitted pursuant to s. NR 333.05, the department shall notify the applicant of the required level of financial assurance.

(3) FORFEITURE REQUIREMENTS. (a) The financial assurance filed with the department shall be conditioned upon faithful performance of all of the requirements of ch. 31, Stats., the provisions of this chapter, and the conditions of any permit or order issued to the applicant for the dam pursuant to ch. 31, Stats.

(4) RELEASE. The department shall release or authorize the release of the applicant's financial assurance within 60 business days after the receipt of a request for release if the department finds that the construction or reconstruction has been completed in accordance with the plans and specifications approved by the department, the provisions of this chapter and the conditions of any permit or order issued to the owner of the dam pursuant to ch. 3l, Stats.

History: Cr. Register, May, 1985, No. 353, eff. 6–1–85; CR 00–136: am. Register July 2001, No. 547 eff. 8–1–01.

Unofficial Text (See Printed Volume). Current through date and Register shown on Title Page.

Chapter NR 335

DAM MAINTENANCE, REPAIR, MODIFICATION, ABANDONMENT AND REMOVAL AID PROGRAM

NR 335.01 Purpose.
NR 335.02 Applicability.
NR 335.03 Definitions.
NR 335.04 Eligibility for a state grant.
NR 335.05 State share.
NR 335.06 Application and award procedures.
NR 335.07 Grant application.
NR 335.08 Eligible and ineligible costs.
NR 335.09 Criteria for priority ranking.
NR 335.10 Construction period.
NR 335.11 Final project approval.
NR 335.12 Grant payments.
NR 335.13 Adoption of land use controls in the hydraulic shadow.
NR 335.14 Grantee accountability.

Note: Chapter NR 335 was repealed and recreated by emergency rule effective 9–1–90. Chapter NR 335 as it existed on April 30, 1991, was repealed and a new chapter NR 335 was created effective May 1, 1991.

NR 335.01 Purpose. The purpose of this chapter is to establish procedures for implementation of the dam maintenance, repair, modification, or abandonment and removal aid program established under s. 31.385, Stats.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

NR 335.02 Applicability. (1) This chapter shall apply to all applications for state aid in the form of matching grants for dam maintenance, repair, modification, or abandonment and removal under s. 31.385, Stats.

(2) The provisions of this chapter are applicable to dams that:

(a) Are owned by a municipality or public inland lake protection and rehabilitation district; and

(b) Are not inspected, approved and licensed by a federal agency under 18 CFR Part 12.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

NR 335.03 Definitions. For the purpose of this chapter:

(1) "Abandonment" means the removal of a dam in compliance with ch. 31, Stats.

(2) "Approval" means the written approval of the department.

(3) "Authorized representative" means the official or employe designated by resolution of the governing body of a municipality or lake district to act on behalf of the owner under this chapter.

(4) "Dam" means any artificial barrier in or across a waterway which has the primary purpose of impounding or diverting water. A dam includes all appurtenant works, such as a dike, canal or powerhouse.

(5) "Department" means the department of natural resources.

(6) "Directives" means the requirements for repair, maintenance, modification or abandonment established by the department in the inspection report sent to the owner.

(7) "Grantee" means the municipality or lake district which receives a grant award from the state under this chapter.

(8) "Hydraulic shadow" means that area of land downstream from a dam that would be inundated by water upon failure of the dam during the regional flood.

(9) "Investigation" means an inspection performed by the department after the owner has received either directives in an inspection report or an order, to determine whether the owner may be eligible for a grant under this chapter for work that remains to be performed on the dam.

(10) "Lake district" means a public inland lake protection and rehabilitation district formed under ch. 33, Stats.

(11) "Land use controls" means a floodplain zoning ordinance adopted and approved pursuant to s. 87.30, Stats., or restrictive covenants, easements or other appropriate legal arrangements between the owner of the dam and the owners of all property within the dam's hydraulic shadow.

(12) "Large dam" means a dam that has either a structural height of more than 6 feet and a maximum storage capacity of more than 50 acre–feet or a structural height of 25 feet or more and a maximum storage capacity of more than 15 acre–feet.

(13) "Maximum headwater" means the maximum water surface elevation in an impoundment before overtopping would occur.

(14) "Maximum storage capacity" means the volume of water in acre–feet capable of being stored behind a dam at maximum headwater.

(15) "Modification" means any physical change to a dam, other than maintenance or repair of the existing components, that results in a change in the dam's hydraulic capacity or structural stability.

(16) "Municipality" means any town, village, city or county in this state.

(17) "Order" means an enforcement order issued by the department under s. 31.19 (5), Stats., to an owner to repair or abandon a dam.

(18) "Overtopping" means the flow of water over parts of a dam which are not part of its spillway system.

(19) "Owner" means any municipality or lake district which has title to a dam or to the specific piece of land on which a dam is physically located.

(20) "Principal spillway" means the primary structure for the discharge of normal flow through a dam.

(21) "Regional flood" means a flood determined to be representative of large floods known to have occurred in Wisconsin and which may be expected to occur on a particular stream once in every 100 years.

Note: The regional flood is based upon a statistical analysis of stream flow records available for the watershed or an analysis of rainfall or runoff characteristics in the watershed or both. The flood frequency of the regional flood is once in every 100 years. In any given year, there is a 1% chance that the regional flood may occur or be exceeded.

(22) "Repair" means work performed on a dam, including maintenance, which is required to provide proper operation or continued structural integrity of the dam and does not change the dam's hydraulic capacity.

(23) "Structural height" means the difference in elevation in feet between the point of lowest elevation of a dam before overtopping and the lowest elevation of the natural stream or lake bed at the downstream toe of the dam.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

NR 335.04 Eligibility for a state grant. (1) Any municipality or lake district that owns a dam in Wisconsin may apply for state aid for repair, modification or abandonment of the dam upon compliance with sub. (2).

(2) To be eligible to receive a grant under this chapter, the owner shall:

Unofficial Text (See Printed Volume). Current through date and Register shown on Title Page.

(a) Request, in writing, financial assistance under this chapter within 6 months after receiving directives or an order for repair, modification or abandonment of the dam resulting from a department investigation or inspection of the dam, or have received a directive from the department or have been under order by the department to repair, modify or abandon the dam, on or before August 9, 1989; and

(b) Comply with all applicable requirements of this chapter.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

NR 335.05 State share. The state share may not exceed 50% of the total eligible project costs nor exceed $200,000 for any one dam.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

NR 335.06 Application and award procedures. Aid available under this program shall be awarded to those projects with the highest points on a priority list, as determined by the criteria in s. NR 335.09, and in accordance with the procedures in this section. Projects on the priority list shall be funded within the limits of available funds. Applications with identical point totals shall be assigned priority based upon the date the complete application was received by the department with highest priority given to the earliest received complete application.

(1) All applications for a grant under this chapter shall be received by the department no later than April 1 of each year.

(2) The department shall establish a priority list by June 1 of each year which ranks all complete applications received by the April 1 deadline. Applicants shall be notified of their placement on the priority list and the probability of approval for funding. The ranking of applicants shall be made available upon written request.

(3) Applicants receiving a commitment for funding shall submit plans and specifications to the department, for approval, prior to October 1 of the same year the application is made.

(4) Applicants receiving a commitment for funding shall submit construction bids for the proposed work to the department within 60 days of department approval of plans and specifications. Following submission to the department, the owner may rebid the project without losing eligibility if the original bid is deemed too high or inappropriate. The applicant shall rebid the project within 60 days of receipt of the original bid. The department shall direct the owner to rebid the project if it deems the bid inappropriate. The applicant shall rebid the project within 60 days of receiving notification from the department that the department deems the bid inappropriate.

(5) The department shall issue, in writing, a notice of grant award within 30 days of receipt of an acceptable construction bid.

(6) All complete applications received after April 1 shall be considered for funding during the next year in which money becomes available. To be considered, any amendment to a late application shall be received by the department no later than the next April 1 application deadline.

(7) If there are insufficient funds to award aid to all eligible applicants on the priority list, the remaining projects shall be considered for funding during the next year in which money becomes available. To be considered, any amendments to unfunded applications shall be received by the department no later than the next April 1 application deadline.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

NR 335.07 Grant application. (1) PROCEDURE. (a) A separate grant application shall be submitted to the department for each individual dam for which financial assistance is requested under this chapter.

(b) The department shall review each application received for completeness and shall advise the applicant of any deficiencies, omissions or errors in the application in writing. Incomplete applications may not be considered if all information is not received by the department by April 1.

(2) CONTENTS OF APPLICATION. An application for a grant under this chapter shall be made on forms furnished by the department. In addition to the application form, the application shall include the following:

(a) Certified copies of the following resolutions of the governing body of the municipality or lake district:

1. A resolution designating an authorized representative, and authorizing the representative to apply for a grant under s. 31.385, Stats., and this chapter, on behalf of the owner.

2. A resolution stating that the owner agrees to pay a share of the eligible costs which is equal to the total project cost minus the state share.

3. Proof of receipt of a letter sent by certified mail, from the owner to the municipality responsible for the implementation of land use controls, informing the municipality that a change in the land use controls may be necessary to secure the hazard rating for the dam.

(b) All data and calculations to show that dams to be repaired or modified will meet all requirements of ch. NR 333 where applicable. All owners shall provide the following with the application:

1. A dam failure analysis including maps suitable for the purpose of implementing land use controls below the dam.

2. A conceptual design and cost estimate for the construction phase of the project defining the eligible project costs.

3. A cost estimate for the engineering work required to complete the project, including preparation of all documents required under this chapter.

(c) All data and calculations to show that dams to be abandoned will meet the requirements of ch. 31, Stats. All owners shall provide the following with the application:

1. An application, under ch. 31, Stats., for a permit or approval to abandon the dam.

2. All information necessary for the municipality responsible for implementation of land use controls to implement controls in the area flooded during the regional flood without the dam in place.

3. A project description and cost estimate for the construction portion of the project defining eligible project costs.

4. A cost estimate for the engineering work required to complete the project, including preparation of all documents required under this chapter.

Note: Application forms are available from the department by writing to the Wisconsin Department of Natural Resources, Bureau of Water Regulation and Zoning, P.O. Box 7921, Madison, WI 53707.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

NR 335.08 Eligible and ineligible costs. (1) ELIGIBLE COSTS. The following project costs, whether incurred under contract or in the form of salaries and benefits, may be reimbursed under this chapter, if the grant is awarded:

(a) Actual and reasonable engineering costs incurred in preparing the studies and application form required under s. NR 335.07 (2) (b) and (c);

(b) Actual and reasonable engineering costs incurred in preparing plans and specifications as required in s. NR 335.06 (3), the operation, inspection and maintenance plan, and the emergency action plan;

(c) Actual and reasonable construction costs incurred in the repair, modification or abandonment of the dam, including labor and materials; and

(d) Actual and reasonable engineering costs involved in the on–site inspection of the repair, modification or abandonment of the dam. On–site inspection by an engineer registered in the state of Wisconsin is required during critical stages of construction.

(2) INELIGIBLE COSTS. Ineligible costs include:

(a) Costs incurred prior to August 9, 1989;

(b) The cost of materials and labor for installation or repair of items directly associated with hydroelectric power facilities at the dam;

(c) Costs incurred prior to the date of the state grant award except engineering costs as provided in sub. (1);

(d) Costs of routine maintenance including, but not limited to, mowing grass, painting signs and debris removal;

(e) Costs of equipment necessary for routine maintenance of the dam;

(f) Costs for which payment has been or will be received under another state or federal cost sharing or grant program or from another municipality or any other outside funding source; and

(g) Costs attributable to the correction of errors or deficiencies in construction funded under this chapter due to failure to comply with department approved construction plans and specifications.

(3) ALLOCATION OF COSTS. Total project costs may be allocated between eligible and ineligible costs using one of the following methods:

(a) *Unit cost method.* When the unit cost method is used, costs for individual work items shall be prorated between eligible and ineligible portions of the project based on an equal cost per unit.

(b) *Project cost method.* When the project cost method is used, eligible project costs shall be based on engineering costs plus the cost of construction reflected in the contractor's billings to the owner. Owners using this method shall submit the contractor's itemized billings showing the breakdown of eligible work items.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

NR 335.09 Criteria for priority ranking. The following criteria shall be used by the department to rank proposed projects for the purpose of determining funding priority:

(1) Dam hazard rating based on current development in the hydraulic shadow:

(a) High hazard rating, 20 points;

(b) Significant hazard rating, 10 points; or

(c) Low hazard rating, 5 points.

(2) Adequate land use controls currently in effect or dam to be abandoned:

(a) Adequate land use controls in the hydraulic shadow, 20 points;

(b) Adequate land use controls in place within the 100 year floodplain, 10 points;

(c) No land use controls or inadequate land use controls in place, 0 points; or

(d) Dam to be abandoned, 20 points.

(3) Financial need (add the points for each column and divide by 2):

Points Applicable to Each Column	*Per Capita Income, Per cent of State Average	*Local Share of Project Cost Plus Current Long Term Non School Indebtedness as a Percent of Statutory Limitation Based on Equalized Valuation
1	135 and over	Less than 10%
2	100 to less than 135	10% to less than 20%
3	89 to less than 100	20% to less than 30%
4	80 to less than 89	30% to less than 40%
5	72 to less than 80	40% to less than 50%
6	65 to less than 72	50% to less than 60%
7	59 to less than 65	60% to less than 70%
8	54 to less than 59	70% to less than 80%
9	50 to less than 54	80% to less than 90%
10	less than 50	90% to less than 100%

* Based on the most recent department of revenue publication,Long Term Indebtedness of Wisconsin Political Subdivisions and Taxes, Aids and Shared Taxes and confirmation of its applicability by department investigation.

When determining financial need points for lake districts, the point totals are to equal the weighted average of the income and indebtedness figures for the individual municipalities making up the district, based on the percent of the district lying within each municipality.

(4) Total eligible project cost:

(a) Total estimated project cost greater than $50,000, 10 points; or

(b) Total estimated project cost of $50,000 or less, 0 points.

(5) Navigability:

(a) Dam on navigable stream, 10 points; or

(b) Dam on nonnavigable stream, 0 points.

(6) Large dam:

(a) Large dam, 10 points; or

(b) Small dam, 0 points.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

NR 335.10 Construction period. (1) All construction performed on an eligible project shall be completed in accordance with s. NR 335.12 within one year from the date of the grant award unless the department extends that period for good cause. If an extension is warranted by the circumstances and is requested in writing by the grantee before the end of the initial one–year construction period, the department may extend the construction period for up to 2 additional years.

(2) If the grantee fails to comply with sub. (1), the grantee may not receive any further state funds and shall reimburse the department for any state funds already received under this chapter. The uncompleted portion of the project shall be considered for funding in the next year in which money becomes available upon submission of a new application in compliance with this chapter.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

NR 335.11 Final project approval. After the project is complete and approved by the owner, the owner shall submit 3 copies of as–constructed plans and specifications, monthly inspection reports prepared by the inspecting engineer on the project, and written certification from the owner's engineer stating that the project was completed in compliance with s. 31.12 (4), Stats. The department shall conduct a final inspection of the project within 60 days after receiving the as–constructed plans and specifications, inspection reports, and certification. A project approval letter shall be sent to the owner within 30 days of final inspection by the department.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

NR 335.12 Grant payments. The grantee shall be paid the state share of those eligible project costs which have prior department approval in the following installments:

(1) If the dam is repaired or modified:

(a) 50% of the state share of total eligible costs, of the engineering contract and the construction bids, shall be paid to the grantee, following 50% completion of the project, within 90 days after the department has received a written request and supporting documentation by the owner's authorized representative. The department shall inspect the project, review the supporting documentation, and determine that the owner has expended at least 50% of the state share of total eligible costs and that the work meets the requirements of this chapter prior to making payment to the owner; and

(b) If the emergency action plan and inspection, operation and maintenance plan are approved by the department prior to the completion of the project, the state share of the remaining eligible costs, based on the final audited project cost, shall be paid to the grantee within 90 days after the department has conducted a final audit and has determined the final audited eligible costs. A final

Unofficial Text (See Printed Volume). Current through date and Register shown on Title Page.

audit shall be conducted within 90 days after the project has been completed and approved by the owner and the department pursuant to s. NR 335.11; or

(c) If the emergency action plan and inspection, operation and maintenance plan are not approved by the department prior to the completion of the project, the state share of the remaining eligible costs less 10%, based on the final audited project cost, shall be paid to the grantee within 90 days after the department has conducted a final audit and has determined the final audited eligible costs. A final audit shall be conducted within 90 days after the project has been completed and approved by the owner and the department pursuant to s. NR 335.11. The remaining state share of eligible costs shall be paid to the grantee within 60 days after the grantee has received approval, by the department, of an emergency action plan and an inspection, operation and maintenance plan.

(2) If the dam is abandoned:

(a) 50% of the state share of total eligible costs, based on the engineering contract and the construction bids, shall be paid to the grantee, following 50% completion of the project, within 90 days after the department has received a written request and supporting documentation by the owner's authorized representative. The department shall inspect the project, review the supporting documentation, and determine that the owner has expended at least 50% of the state share of total eligible costs and that the work meets the requirements of this chapter prior to making payment to the owner; and

(b) The state share of the remaining eligible costs, based on the final audited project cost, shall be paid to the grantee within 90 days after the department has conducted a final audit and has determined the final audited eligible costs. A final audit shall be conducted within 90 days after the project has been completed and approved by the owner and the department pursuant to s. NR 335.11.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

NR 335.13 Adoption of land use controls in the hydraulic shadow. If the grantee or the municipality responsible for the implementation of land use controls in the hydraulic shadow, or both, fail to adopt the land use controls necessary to secure the dam hazard rating in accordance with ch. NR 333, the grantee may not receive any further state funds under this chapter and shall reimburse the department for any state funds already received under this chapter. The necessary land use controls shall be adopted within one year after the department has approved the dam failure analysis submitted with the application. If adequate justification is received and approved by the department an extension of the one year deadline may be given.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

NR 335.14 Grantee accountability. (1) RECORDS MANAGEMENT. Each grantee shall maintain an accounting system that accurately reflects all fiscal transactions, incorporates appropriate controls and safeguards, and provides good audit trails, particularly to source or original documents.

(a) *Accounting procedures.* Financial schedules and statements filed with grant applications and payment requests shall be based on records maintained under generally accepted accounting principles which meet the following minimum requirements:

1. Accounts shall separate grant receipts and eligible project costs from those allocable to other programs and activities.

2. Payments received under another state or federal cost sharing or grant program or from another municipality or any other outside funding source and expenditures shall be listed in sufficient detail to provide a basis for accurate and complete reporting.

3. Supporting records for all expenditures shall be itemized in sufficient detail to reflect the nature and propriety of each. Proof of payment, such as cancelled checks or receipts from vendors, shall be maintained.

4. If the owner uses its own labor force, payroll records shall be maintained that reflect actual program hours worked by each employe as well as allocable gross wages and fringe benefits paid. Time and attendance records describing the work performed, specifying project hours worked by day, and both signed by the employe and bearing evidence of management approval, shall be maintained, along with computations showing hourly pay rates and allocation of fringe benefits.

(b) *Fiscal controls.* 1. Any consultant, construction or service contract totalling $10,000.00 or more annually shall be covered by a formal contract or agreement specifying financial terms, contract duration, and services to be rendered.

2. Allowable rates for use of an owner's own equipment shall be limited to the county–wide rates established annually by the department of transportation (DOT). Eligibility of the use of specialized equipment for which DOT rates are not available shall be based on the allocable portion of depreciation plus normal and reasonable operation expenses attributable to project activities.

(2) RECORDS RETENTION AND AUDITING. The grantee's records, and the records of contractors and engineers which are pertinent to a specific state grant award, shall be subject at all reasonable times to inspection, copying and audit by the department for a period of 7 years from the date of final payment.

History: Cr. Register, April, 1991, No. 424, eff. 5–1–91.

Electronic reproduction of 2007−08 Wis. Stats. database, updated and current through 2009 Act 406 and October 31, 2010.

CHAPTER 31

REGULATION OF DAMS AND BRIDGES AFFECTING NAVIGABLE WATERS

31.01 Definitions.
31.02 Powers and duties of department.
31.03 Permits for the Lower Wisconsin State Riverway.
31.04 Permits for dams.
31.045 Permits for dams that affect drained lands.
31.05 Applications for permits to construct.
31.06 Hearing.
31.07 Applications for permits to operate and maintain existing dams.
31.08 Hearing.
31.09 Proposals to accompany applications.
31.095 Water power permits, condition precedent.
31.10 Permit not to be valued.
31.11 Certificate of terms and forfeiture of permits.
31.12 Map, profile and plans.
31.13 Raising or enlarging existing dams.
31.14 Proof of ability to maintain dams required.
31.18 Obligations of owners of bridges and dams.
31.185 Permits to abandon dams.
31.187 Abandoned dams.
31.19 Inspection of dams; orders.
31.21 Transfer of permit.
31.23 Forfeitures; private bridges and dams.
31.25 Nuisances, abatement.
31.253 Dam removal; opportunity for hearing.
31.26 Civil liabilities.
31.29 May employ hydraulic engineer and assistants.
31.30 Dams on Brule River.
31.305 Dams in the Lower Wisconsin State Riverway.
31.307 Dam on Milwaukee River.
31.309 Portage levee system and canal.
31.31 Dams on nonnavigable streams.
31.32 Dams not to injure other dams or sites.
31.33 Jurisdiction of department.
31.34 Flow of water regulated.
31.35 Dams in areas leased by county; restrictions; control by circuit judge; when.
31.36 Levee commissioners.
31.38 Municipal authority to construct and maintain dams.
31.385 Dam safety; aid program.
31.387 Dam rehabilitation projects.
31.39 Fees for permits, approvals and hearings.
31.99 Parties to a violation.

31.01 Definitions. Terms used in this chapter are defined as follows:

(1) "Corporation" means a private corporation organized under the laws of this state.

(2) "Department" means the department of natural resources.

(3) "Grantee" means the person, firm, corporation or municipality to whom a permit is granted, and all subsequent owners of the grant.

(4) "Municipality" means any town, village, city or county in the state.

(5) "Navigable waters" means all waters declared navigable by ch. 30.

(6) "Permit", unless the context otherwise requires, means legislative permission granted under s. 31.06 to construct, operate and maintain a dam in or across navigable waters, or under s. 31.08 to continue the operation and maintenance of any dam so situated which was constructed before such legislative permits were required.

History: 1983 a. 189.

31.02 Powers and duties of department. (1) The department, in the interest of public rights in navigable waters or to promote safety and protect life, health and property may regulate and control the level and flow of water in all navigable waters and may erect, or may order and require bench marks to be erected, upon which shall be designated the maximum level of water that may be impounded and the lowest level of water that may be maintained by any dam heretofore or hereafter constructed and maintained and which will affect the level and flow of navigable waters; and may by order fix a level for any body of navigable water below which the same shall not be lowered except as provided in this chapter; and shall establish and maintain gauging stations upon the various navigable waters of the state and shall take other steps necessary to determine and record the characteristics of such waters.

(2) The department may investigate and determine all reasonable methods of construction, operation, maintenance, and equipment for any dam so as to conserve and protect all public rights in navigable waters and so as to protect life, health and property; and the construction, operation, maintenance and equipment, or any or all thereof, of dams in navigable waters shall be subject to the supervision of the department and to the orders and regulations of the department made or promulgated under this chapter.

(3) The department or any member or any agent or employee thereof shall at all times be accorded free access to any and all parts of any dam and appurtenances constructed or maintained in navigable waters and may enter upon any property to investigate a waterway or use of water from any lake or stream.

(4) The department may order and require any dam heretofore or hereafter constructed to be equipped and operated, in whole or part, as follows:

(a) With slides and chutes for the passage of logs and timber products.

(b) With a lock, boat hoist, marine railway or other device of a size and construction sufficient to accommodate navigation.

(c) With good and sufficient fishways or fish ladders, or in lieu thereof the owner may be permitted to enter into an agreement with the department to pay for or to supply to the state of Wisconsin annually such quantities of game fish for stocking purposes as may be agreed upon by the owner and the department.

(d) With spillways or flood gates capable of permitting the passage through or over the same of freshets and floods during all seasons of the year.

(e) With booms, piers or other protection works ample to safeguard flood gates from trash or other floating material.

(4g) The department may not impose the requirement under sub. (4) (c) on an owner of a dam unless all of the following apply:

(a) The rules promulgated under sub. (4r) are in effect.

(b) The federal government or the state implements a program to provide cost−sharing grants to owners of dams for equipping dams with fishways or fish ladders and a grant is available to the dam owner under the program.

(4r) The department shall promulgate rules specifying the rights held by the public in navigable waters that are dammed. The rules shall include provisions on the rights held by the public that affect the placement of fishways or fish ladders in navigable waters that are dammed.

(5) The department shall give written notice to the public service commission of any hearing under this chapter involving public utilities.

Text from the 2007−08 Wis. Stats. database updated by the Legislative Reference Bureau. Only printed statutes are certified under s. 35.18 (2), stats. Statutory changes effective prior to 11−2−10 are printed as if currently in effect. Statutory changes effective on or after 11−2−10 are designated by NOTES. Report errors at (608) 266−3561, FAX 264−6948, http://www.legis.state.wi.us/rsb/stats.html

Electronic reproduction of 2007−08 Wis. Stats. database, updated and current through 2009 Act 406 and October 31, 2010.

(6) Except as provided in sub. (7m), the department may operate, repair and maintain the dams and dikes constructed across drainage ditches and streams in drainage districts, in the interest of drainage control, water conservation, irrigation, conservation, pisciculture and to provide areas suitable for the nesting and breeding of aquatic wild bird life and the propagation of fur−bearing animals.

(7) The department shall confer with the drainage commissioners in each drainage district on the formation of policies for the operation and maintenance of the dams; in districts having no commissioners, the department shall confer in like manner with the committee appointed by the county board, if any, to represent either such drainage district, or in the event that the drainage district is dissolved, to represent the interests of the county in all matters whatsoever pertaining to water conservation and control within the area which theretofore constituted such drainage district. This subsection does not apply to the Duck Creek Drainage District.

(7m) The drainage board for the Duck Creek Drainage District shall operate, repair and maintain dams, dikes and other structures in district drains that the board operates in the Duck Creek Drainage District in compliance with ch. 88 and any rules promulgated by the department of agriculture, trade and consumer protection under ch. 88. If a county drainage board fails to perform its duties under this subsection, the department of natural resources may exercise its authority under subs. (6), (8) and (9).

(8) The department shall give careful consideration to the suggestions of the drainage commissioners or committee of the county board, but the final decision in all matters under consideration shall rest with the department.

(9) So far as seems practicable, the department may designate or employ the drainage commissioners of any drainage district, or the committee of the county board above referred to, to operate the dams in such district or area formerly comprising a drainage district or perform services in the repair and maintenance of the dams, dykes and other works.

History: 1999 a. 9; 2001 a. 105; 2007 a. 96.

Cross−reference: See also chs. NR 333 and 353, Wis. adm. code.

Ordering a riparian owner to excavate and maintain a ditch to regulate lake levels was an unconstitutional taking of property. Otte v. DNR, 142 Wis. 2d 222, 418 N.W.2d 16 (Ct. App. 1987).

Artificial lakes and land subdivisions. Kusler, 1971 WLR 369.

31.03 Permits for the Lower Wisconsin State Riverway. For activities in the Lower Wisconsin State Riverway, as defined in s. 30.40 (15), no person obtaining a permit under this chapter may start or engage in the activity for which the permit was issued unless the person obtains any permit that is required for the activity under s. 30.44 or 30.445.

History: 1989 a. 31, 359.

31.04 Permits for dams. Permits to construct, operate and maintain dams may be granted to persons, corporations or municipalities under this chapter.

31.045 Permits for dams that affect drained lands. **(1)** For the construction, raising or enlarging of a dam that will affect the water level in a drainage district organized under ch. 88, no person who obtains a permit under this chapter may construct, raise or enlarge the dam unless the person obtains the approval of the drainage board with jurisdiction of the drainage district.

(2) For the construction, raising or enlarging of a dam that will affect the water level in a drain, for an individual landowner, that is constructed under an order issued under s. 88.94, no person who obtains a permit under this chapter may construct, raise or enlarge the dam unless the person obtains the approval of the landowner.

History: 1993 a. 456.

31.05 Applications for permits to construct. Any person, firm, corporation or municipality desiring a permit to construct, operate and maintain a dam shall file with the department a written application therefor, setting forth:

(1) The name of the navigable waters in or across which a dam is proposed to be constructed and a specific description of the site for the proposed dam.

(2) The purpose or purposes for which the proposed dam is to be constructed, operated and maintained.

(3) In case the application is for a permit to construct, operate and maintain a dam for a private purpose, proof satisfactory to the department that the applicant owns or has an enforceable option to purchase the described dam site and at least 65% of the land to be flowed, or the flowage rights on at least 65% of such land. This subsection shall not apply to a person who has the power of eminent domain.

(4) A general description of the proposed dam, of the material to be used in the construction thereof, and a general description of all booms, piers, and other protection works to be constructed in connection therewith.

(5) The approximate amount of hydraulic power that the proposed dam is capable of developing.

(6) The name of the city, village or town in which the site of the proposed dam will be located and the name of the nearest existing dam above and below the site of the proposed dam.

(7) A map on the scale of not less than one inch per 1,000 feet showing the lands that may be affected by the construction, operation or maintenance of the proposed dam, or by any flowage that may be caused thereby and approximately the outline of such flowage, which map shall indicate the ownership of each tract of land within the flowage.

(8) Such additional information of any nature that may be required by the department.

History: 1975 c. 349; 1993 a. 246.

31.06 Hearing. **(1)** Upon receipt of an application for a permit under s. 31.05 the department may order a hearing or it may mail a notice that it will proceed on the application without public hearing unless a request for a public hearing is filed as provided in this section. The notice shall be mailed to the clerk of each municipality directly affected by the proposed dam. The department may give further or other notice as it considers proper. The department shall mail a copy of the notice to the applicant who shall cause the notice to be published in each county in which affected riparian lands are located as a class 1 notice, under ch. 985. If a hearing is not requested in writing within 30 days after mailing of the notice, the department may waive the hearing.

(2) (a) If a hearing is ordered, the department shall, not less than 10 days before such hearing, mail written notice thereof to each person notified under sub. (1).

(b) The department shall require the applicant to publish a class 1 notice under ch. 985, of the hearing in each county in which affected riparian lands are located, and may require the applicant to mail such other notices as it deems necessary. Proof of publication and proof of mailing under this subsection and sub. (1) shall be filed with the department.

(3) (a) At a hearing under this section, or any adjournment of the hearing, the department shall consider the application and take evidence offered by the applicant and other persons supporting or opposing the proposed dam. The department may require the amendment of the application.

(b) If it appears that the construction, operation or maintenance of the proposed dam is in the public interest, considering ecological, aesthetic, economic and recreational values, the department shall so find and grant a permit to the applicant, provided the department also finds that the applicant has complied with s. 31.14 (2) or (3) and, where applicable, with s. 31.05 (3), based on the department's own estimate of the area of the flowage.

(c) 1. The enjoyment of natural scenic beauty and environmental quality are declared to be public rights to be considered along with other public rights and the economic need of electric power for the full development of agricultural and industrial activity and other useful purposes in the area to be served. In consider-

Text from the 2007−08 Wis. Stats. database updated by the Legislative Reference Bureau. Only printed statutes are certified under s. 35.18 (2), stats. Statutory changes effective prior to 11−2−10 are printed as if currently in effect. Statutory changes effective on or after 11−2−10 are designated by NOTES. Report errors at (608) 266−3561, FAX 264−6948, http://www.legis.state.wi.us/rsb/stats.html

ing public rights to the recreational use and natural scenic beauty of the river, the department shall investigate the potentialities of the lake and lakeshore created by the flowage and shall weigh the recreational use and scenic beauty of the lake and lakeshore against the known recreational use and scenic beauty of the river in its natural state. The department shall further weigh the known recreational use and scenic beauty of the particular section of river involved against the known recreational use and scenic beauty of other sections of the same river and other rivers in the area remaining in their natural state without regard to plans of other dams subsequently filed or to be filed.

2. The department shall deny the permit if it finds any of the following:

a. It appears that the river in its natural state offers greater recreational facilities and scenic value for a larger number of people than can by proper control of the flowage level be obtained from the use of the lake and lakeshore and that the remaining sections of the river and other rivers in the area in their natural state provide an insufficient amount of recreational facilities and scenic beauty, and it further appears that the economic need of electric power is less than the value of the recreational and scenic beauty advantages of the river in its natural state.

b. The permit will cause environmental pollution, as defined in s. 299.01 (4).

(4) Not more than 20 days after receiving notice as provided in sub. (1) each county clerk may and upon request of the chairperson of the county board shall give written notice as provided in s. 59.11 (2) of a special meeting of the county board to be held at a time and place set by the county clerk, not less than 2 weeks nor more than 3 weeks after mailing of such notice, for the purpose of making findings as hereinafter provided. The county clerk shall give notice of the time, place and purpose of such special meeting to the department and to the applicant, who shall cause the same to be published in the county, as a class 2 notice, under ch. 985, and the applicant shall cause a copy thereof to be mailed at least 7 days prior to such special meeting to every person interested in any lands that will be affected by the proposed dam and whose post−office address can by due diligence be ascertained. Proof of such publication and notice shall be filed with the county clerk. At such special meeting the county board shall hear evidence offered by the applicant and other persons and shall find and determine by a majority vote of the county board members−elect whether the lake and lake shore created by the flowage or the river in its natural state offers greater recreational facilities and scenic beauty value for the larger number of people. The county clerk shall forthwith certify such finding and determination to the department. The jurisdiction and findings of each county board shall apply to that part of the proposed dam and flowage which is within the county.

(5) If a hearing on the application for a permit is conducted as a part of a hearing under s. 293.43, the notice and hearing provisions in that section supersede the notice and hearing provisions of this section.

History: 1971 c. 273; 1973 c. 90; 1979 c. 34 s. 2102 (39) (g); 1979 c. 221; 1983 a. 192; 1995 a. 201, 227; 1999 a. 83.

Cross−reference: See also ch. NR 305, Wis. adm. code.

31.07 Applications for permits to operate and maintain existing dams. Any person, firm, corporation or municipality desiring a permit to operate and maintain a dam constructed in or across navigable waters without legislative permission prior to July 10, 1915, shall file with the department a written application therefor setting forth:

(1) The name of the navigable waters in or across which such dam was constructed and a specific description of the dam site.

(2) The year in which the construction of the dam was completed, and a detailed description of the dam and equipment, including the maximum height or head of water that may be maintained thereby and the kind and character of material of which the dam is constructed.

(3) The purpose for which the dam was theretofore operated and is operated at the time application hereunder is made, and the purpose for which it is proposed to operate and maintain the dam.

(4) The approximate amount of hydraulic power developed thereby.

(5) The name of the city, village or town in which the dam site is located and the name of the nearest existing dam above and below the dam site.

(6) Such additional information of any nature whatsoever as may be required by the department.

History: 1993 a. 246.

31.08 Hearing. Upon receipt of an application under s. 31.07 procedure shall be had substantially as required by s. 31.06, and if the department finds that such operation and maintenance does not materially obstruct existing navigation or violate other public rights and will not endanger life, health or property, a permit is hereby granted to the applicant, provided the department also finds that the applicant has complied with s. 31.14 (2) or (3).

Cross−reference: See also ch. NR 305, Wis. adm. code.

31.09 Proposals to accompany applications. Each applicant for a permit to construct, operate and maintain a dam for the purpose of developing power or for the purpose of aiding in the development of power by other dams through the creation of reservoirs or otherwise, and each applicant for a permit to construct, operate and maintain a dam for any other purpose whatsoever, which is capable of developing 50 theoretical horsepower or more available for 50% of the time throughout the year, shall file with an application for a permit, in addition to the requirements of s. 31.05 or s. 31.07, as the case may be, the following proposals:

(1) That the department prior to the time the permit is granted shall value the dam site and all flowage rights and other property necessary for the purposes set forth in the application for the permit, whether the same or any part thereof are owned by the applicant or not.

(2) That the department shall audit all outlays for property and for the construction of the dam, buildings, and other structures and works constructed, maintained, and operated and used and useful under the permit.

(3) That the permit, if granted, shall be granted and accepted subject to the express condition that the state of Wisconsin, if it shall have the constitutional power, or any municipality, on not less than one year's notice, at any time after the expiration of 30 years after the permit becomes effective, may acquire all of the property of the grantee, used and useful under the permit, by paying therefor, the cost of reproduction in their then existing condition of all dams, works, buildings, or other structures or equipment, used and useful under the permit, as determined by the department, and by paying in addition thereto the value of the dam site and all flowage rights and other property as determined by the department prior to the time the permit was granted, as provided in sub. (1), plus the amounts paid out for additional flowage rights, if any, acquired after the valuation made by the department as provided in sub. (1); and that the applicant waives all right to any further compensation.

History: 1991 a. 316.

31.095 Water power permits, condition precedent. **(1)** Except where the stream to be improved forms a boundary line between this and another state, no permit shall be granted or transferred in accordance with this chapter until the applicant has filed with both the department and the public service commission, in addition to all other things required by law to be filed, an agreement setting forth:

Text from the 2007−08 Wis. Stats. database updated by the Legislative Reference Bureau. Only printed statutes are certified under s. 35.18 (2), stats. Statutory changes effective prior to 11−2−10 are printed as if currently in effect. Statutory changes effective on or after 11−2−10 are designated by NOTES. Report errors at (608) 266−3561, FAX 264−6948, http://www.legis.state.wi.us/rsb/stats.html

Electronic reproduction of 2007−08 Wis. Stats. database, updated and current through 2009 Act 406 and October 31, 2010.

(a) That, in the event any electric energy generated under said permit shall be transmitted or conveyed beyond the confines of this state to be there sold, the applicant will furnish to any resident of this state or any corporation domiciled therein electric energy at reasonable rates to be determined by the commission, provided that the commission after public hearing shall find that public convenience and necessity require such service.

(b) That the rate as determined by the commission shall in no event exceed the rate charged by applicant for similar service supplied under like conditions for the energy so transmitted outside the state.

(2) The commission may hold hearings, fix rates and do all things necessary and convenient to carry out the purposes of sub. (1).

31.10 Permit not to be valued. Each and every permit is granted, and shall be conclusively deemed to be accepted, subject to the condition that no element of value whatever shall ever attach to or be allowed for such permit in and of itself in the sale or acquisition of the property used and useful under such permit or otherwise.

31.11 Certificate of terms and forfeiture of permits. The department shall issue to every grantee of a permit a certificate evidencing a grant of the permit allowed by law. Every permit, and every franchise heretofore granted by the legislature, to construct, maintain and operate a dam shall become null and void, unless the dam thereby authorized be completed within 5 years from the time when the permit or the franchise was granted; but the department, for good cause, may extend such time for a period not exceeding 2 years.

31.12 Map, profile and plans. (1) The grantee of a permit under s. 31.06, to construct, maintain and operate a dam, before commencing any work of construction authorized by the permit, shall submit to the department a complete map and profile on the scale of not less than one inch per 1,000 feet showing the land that may be affected by the construction and maintenance of the dam, or by any flowage that may be caused thereby, and the outline of the flowage, and such other hydrographic and topographic data as the department may prescribe, and shall also file complete detailed plans and specifications for the proposed dam, including all booms, piers, or other protection works.

(2) The department shall examine the map, profile, plans and specifications; shall hear the grantee thereon and may reject the same or any part thereof, if unsatisfactory or incomplete, or may suggest and require modifications thereof. If the map, profile and plans and specifications are satisfactory and complete, or, if the same shall be modified as suggested and required, the department shall so find and approve the same, and thereupon the grantee may construct the proposed dam in accordance therewith, but the department may, at any time during the construction of any dam and in the interest of the public safety, or of any public rights in navigable waters, authorize, order or require such changes in the plans and specifications and the construction of the dam as shall be necessary.

(3) If the department, in the case of an application for a permit to construct a dam with a capacity of less than 250 hydraulic horsepower at ordinary stage of water, shall find that the information and data furnished in the original or amended application is sufficient, the applicant shall not be required to furnish the additional or more detailed information or data specified in subs. (1) and (2). The department may, however, at any time during the construction of any such dam authorize, order or require changes in the construction or the method or plan of construction thereof, as provided in sub. (2).

(4) Within 10 days after the completion of any dam the grantee shall file with the department a verified statement that the same was constructed in accordance with the plans and specifications approved by the department; or in case no plans and specifications were required to be filed, then that the dam was constructed in accordance with the description contained in the application.

Cross−reference: See also ch. NR 353 and s. NR 335.11, Wis. adm. code.

31.13 Raising or enlarging existing dams. (1) If the owner of any existing dam wishes to raise or enlarge the same, the owner may apply to the department for permission so to do, but the permission granted under this section shall be in amendment of any existing franchise, license, or permit previously granted authorizing the construction or maintenance of such dam only to the extent of giving the right so to raise or enlarge such dam, and shall in no way enlarge, alter, abridge or nullify property rights, privileges or obligations as to such dam, or the maintenance or operation thereof theretofore acquired or incurred. In addition to the requirements of s. 31.05 (1), (6) and (7), the owner's application shall state:

(a) The year in which the dam was completed.

(b) If constructed by legislative permission, a statement of the act of the legislature authorizing the same.

(c) A detailed description of the dam, including the maximum height or head of water that may be maintained thereby and the kind and character of material of which the same is constructed.

(d) The purpose for which such dam has been and is now used and the purpose for which it is proposed to use the same.

(e) The approximate amount of hydraulic power developed thereby.

(f) Such additional information of any nature whatsoever as the department may require.

(2) Upon receipt of an application under this section procedure shall be had substantially as required by s. 31.06; and if the department finds that the dam, raised or enlarged or rebuilt, or rebuilt, enlarged and raised in accordance with the application, will not materially obstruct existing navigation or violate other public rights, and will not endanger life, health or property, and that the applicant has complied with s. 31.14 (2) or (3), permission is hereby granted to raise or enlarge or rebuild, or rebuild, enlarge and raise the same in accordance with the application.

History: 1991 a. 316.

Cross−reference: See also ch. NR 305, Wis. adm. code.

31.14 Proof of ability to maintain dams required. (1) It is the policy of this section to preserve public rights in navigable waters, including those created by dams, and to provide a means of maintaining dams and the developments which have been made adjacent to the flowage of such dams.

(2) Except as provided in sub. (3), a permit shall not be granted under s. 31.06, 31.08 or 31.13:

(a) Unless the applicant furnishes to the department proof of ability to operate and maintain the dam in good condition, either by the creation of a special assessment district under ss. 31.38 and 66.0703, or by any other means which in the department's judgment will give reasonable assurance that the dam will be maintained for a reasonable period of time not less than 10 years; or

(b) If a majority of the municipalities in which 51% or more of the dam or flowage is or will be located files with the department, prior to the granting of the permit, their objections to the granting of such permit in the form of resolutions duly adopted by the governing bodies of such municipalities.

(3) Subsection (2) does not apply if the applicant complies with each of the following requirements:

(a) Furnishes proof satisfactory to the department that the applicant owns or has an enforceable option to purchase all the land which is or will be flowed by the impoundment, together with the shoreline and an immediately adjacent strip of land at least 60 feet in width, but the department may in a particular case permit a narrower strip where the 60−foot minimum is impractical and may, in furtherance of the policy stated in sub. (1), require ownership of a wider strip.

(b) Files with the department a writing in such form as the department requires in which the applicant agrees that following

Text from the 2007−08 Wis. Stats. database updated by the Legislative Reference Bureau. Only printed statutes are certified under s. 35.18 (2), stats. Statutory changes effective prior to 11−2−10 are printed as if currently in effect. Statutory changes effective on or after 11−2−10 are designated by NOTES. Report errors at (608) 266−3561, FAX 264−6948, http://www.legis.state.wi.us/rsb/stats.html

the initial filling of the proposed pond the applicant will not convey the dam to another without first obtaining department approval. The department may require from an applicant who does not have the power of eminent domain a bond or other reasonable assurances that the applicant will adhere to such agreement.

(c) Furnishes proof satisfactory to the department that the applicant has dedicated or will dedicate a parcel of land for public access to the impounded waters.

(4) No person may assume ownership of a dam after October 21, 1961, or the ownership of that specific piece of land on which a dam is physically located after April 27, 1982, without first complying with sub. (2) or (3). The transfer of the ownership of a dam or the ownership of a specific piece of land on which a dam is physically located made without complying with sub. (2) or (3) is void unless a permit to abandon the dam was granted under s. 31.185 or unless the transfer occurred by operation of law. Every person who accepts ownership by operation of law is subject to this chapter.

(5) For the purpose of implementing the policy stated in sub. (1), the department may by rule require all or specified classes of persons operating a dam for profit to create a fund or reserve to be used for major repairs, reconstruction or removal of the dam when necessary. Such rules shall prescribe the manner in which such fund or reserve is to be created, maintained and expended. This subsection shall not apply to a person who has the power of eminent domain.

History: 1981 c. 246; 1991 a. 316; 1999 a. 150 s. 672.

This section does not apply to cranberry dams. Tenpas v. DNR, 148 Wis. 2d 579, 436 N.W.2d 297 (1989).

31.18 Obligations of owners of bridges and dams. (1) The grantee of any permit, the owner of any dam constructed before permits were required by law, and the owner of any bridge at the city of Portage or at any point above that city, over the Wisconsin River, shall maintain and operate all such dams, slides, chutes, piers, booms, guide booms, weirs, tunnels, races, flumes, sluices, pits, fishways, locks, boat hoists, marine railways and all other equipment required by the department for the protection of public rights in such waters, and for the preservation of life, health and property, in good repair and condition, and shall not willfully, or otherwise, injure, remove or destroy the same, or any part thereof, unless the department shall have approved such removal or destruction in writing. In the event of emergency the department shall have power, pending investigation and hearing, to order the repair of any dam without notice and hearing.

(2) The owner of any such dam shall open such slide or chute for the passage of any craft or material lawfully navigating the stream, whenever requested so to do by the person in charge of such navigation, without charge or toll therefor. But such owner shall be under no obligation to otherwise aid passage through the slide or chute.

(3) Except when emergency shall require the same for the protection of life, health or property, no substantial alteration or addition shall be made to any dam heretofore or hereafter constructed without obtaining an order therefor from the department, which order may be issued only after an investigation and upon a finding that the proposed alterations or additions will not impair the sufficiency of such dam or any existing public rights in such waters.

(4) The department shall in the interest of public rights in navigable waters, or to promote safety and protect life, health and property, require the grantee of any permit, under this chapter, or of any permit or authorization heretofore provided for by legislative enactment, prior to flowing any lands by the construction of a dam thereunder, to remove from such lands all or any portion of the standing and fallen timber and all or any portion of the brush. Provided that in cases where the application for permit proposes construction of a dam for water reservoir or water storage purposes, and not for the purpose of operating a hydroelectric generating plant, the nature, extent and time for such removal shall be determined prior to the granting of a permit, except that subsequent to the granting of a permit the department may make such modification in the removal requirements as may be in the public interest and which will not materially alter the economics of the project; and in making such original determination or any modification thereof the economic need for the project shall be considered.

Cross−reference: See also ch. NR 305, Wis. adm. code.

31.185 Permits to abandon dams. (1) No owner of any dam may abandon or remove or alter the dam without first obtaining a permit from the department. No person may transfer ownership of a dam or the ownership of the specific piece of land on which a dam is physically located without first obtaining a permit from the department.

(2) An application for a permit to abandon, remove or alter a dam or an application for a permit to transfer ownership of a dam or the ownership of a specific piece of land on which a dam is physically located shall be made to the department upon forms prescribed by it and shall contain the owner's name and address, a brief description of the dam and its location and other information as the department requires for the purpose of enabling it to act on the application.

(3) Section 31.06 governs procedure upon all applications hereunder.

(4) Prior to the hearing the department shall have its staff make its own investigation of the dam and, on the basis of such investigation, shall make recommendations as to the type of requirements, if any, which it would impose on the applicant under sub. (5) as a condition to granting the permit. Such recommendations shall be presented at the hearing. If no one registers opposition to the application at the hearing, the department shall grant the permit, subject to such conditions as it deems necessary under sub. (5). If someone registers opposition to the abandonment at the hearing and such opposition is not withdrawn, the department shall defer action on the application for a period of 120 days after the hearing. Within a reasonable time after the expiration of such period, the department shall deny the permit, or grant the permit, subject to such conditions as it imposes under sub. (5), unless, within such 120−day period, one or more municipalities or other persons or associations have agreed to acquire ownership of the dam and have furnished satisfactory proof of intent to comply with s. 31.14 (2) or (3).

(5) As a prerequisite to the granting of a permit under this section, the department may require the applicant to comply with such conditions as it deems reasonably necessary in the particular case to preserve public rights in navigable waters, to promote safety, and to protect life, health and property.

History: 1973 c. 90; 1981 c. 246.

Cross−reference: See also ch. NR 305, Wis. adm. code.

Sub. (5) is not directed to the removal of a dam by the DNR. It creates a different procedure for a private party who seeks to remove a dam. Froebel v. DNR, 217 Wis. 2d 652, 579 N.W.2d 774 (Ct. App. 1998), 97−0844.

31.187 Abandoned dams. (1) The department may remove or cause to be removed, in such manner as it deems fit, old and abandoned dams in streams in this state, upon giving 60 days' notice in writing to the owner thereof, if the owner can be found. If the owner of the dam is unknown or cannot, by due diligence, be found, the department shall publish a class 3 notice, under ch. 985, in the county in which the dam is situated.

(2) Whenever the department determines that the conservation of any species or variety of wild animals will be promoted thereby, the department may maintain and repair any dam located wholly upon lands the title to which is in the state either as proprietor or in trust for the people after giving due consideration to fixing the level and regulating the flow of the public waters.

History: 1983 a. 27 s. 687; Stats. 1983 s. 31.187; 1991 a. 316.

Text from the 2007−08 Wis. Stats. database updated by the Legislative Reference Bureau. Only printed statutes are certified under s. 35.18 (2), stats. Statutory changes effective prior to 11−2−10 are printed as if currently in effect. Statutory changes effective on or after 11−2−10 are designated by NOTES. Report errors at (608) 266−3561, FAX 264−6948, http://www.legis.state.wi.us/rsb/stats.html

Electronic reproduction of 2007−08 Wis. Stats. database, updated and current through 2009 Act 406 and October 31, 2010.

This section, and not s. 31.185 or 283.31, governs removal of a dam by the DNR. There is no statutory authority to grant injunctive relief against the DNR when it causes damages during a dam removal. Froebel v. DNR, 217 Wis. 2d 652, 579 N.W.2d 774 (Ct. App. 1998), 97−0844.

31.19 Inspection of dams; orders. (1g) DEFINITIONS. In this section:

(a) "High hazard dam" means a large dam the failure of which would probably cause loss of human life.

(b) "Low hazard dam" means a large dam the failure of which would probably not cause significant property damage or loss of human life.

(c) "Significant hazard dam" means a large dam the failure of which would probably cause significant property damage but would probably not cause loss of human life.

(1m) DETERMINATION OF DAM SIZE. For the purposes of this section, a dam is considered to be a large dam if either of the following applies:

(a) It has a structural height of 25 feet or more and impounds more than 15 acre−feet of water.

(b) It has a structural height of more than 6 feet and impounds 50 acre−feet or more of water.

(2) LARGE DAM INSPECTION. (a) *Inspection by the department.* At least once every 10 years the department shall conduct a detailed inspection of each high hazard dam and each significant hazard dam.

(ag) *Owner responsibility.* 1. Owners of each high hazard dam, each significant hazard dam, and each low hazard dam shall engage a professional engineer registered under s. 443.04 to inspect the dam as specified in this paragraph.

2. An owner of a high hazard dam shall cause the dam to be inspected at least 4 times between each inspection conducted by the department under par. (a). An owner of a significant hazard dam shall cause the dam to be inspected at least 2 times between each inspection conducted by the department under par. (a). An owner of a low hazard dam shall cause the dam to be inspected at least once every 10 years.

3. The owner of a dam required to be inspected under this paragraph shall submit to the department, no later than 90 days after the date of the inspection, a report of the results of the inspection. The report shall include information on any deficiencies in the dam, recommendations for addressing those deficiencies, and recommendations on improving the safety and structural integrity of the dam.

(ar) *Dam classification.* The department shall classify each dam in this state as a high hazard, significant hazard, or low hazard dam for the purpose of this section.

(b) *Exemption for federally inspected dams.* Notwithstanding the inspection requirements under pars. (a) and (ag), an inspection under par. (a) or (ag) is not required if the dam is inspected periodically by or under the supervision of a federal agency in a manner which is acceptable to the department and if the results of each inspection are made available to the department.

(3) INSPECTION UPON COMPLAINT. If the department receives a complaint in writing from the mayor of a city, supervisor of a town or the president or trustee of a village which alleges that a dam maintained or operated in or across any navigable or nonnavigable waters or a reservoir is in an unsafe condition or if the department receives a complaint in writing from a person which alleges that the person's property or any property under the person's control is endangered by a dam or reservoir, the department shall investigate or cause an investigation to be made of the complaint.

(4) DISCRETIONARY INSPECTION. The department may inspect or cause an inspection to be made of any dam or reservoir.

(5) ORDER; REDUCTION IN WATER LEVEL. If the department finds pursuant to an investigation that a dam or reservoir is not sufficiently strong or is unsafe and that the dam or reservoir is dangerous to life or property, it shall determine what alterations, additions or repairs are necessary and shall order the owner or person having control of the dam or reservoir to cause those alterations, additions or repairs to be made within a time specified in the order. If the department finds pursuant to an investigation that a dam or reservoir is not sufficiently strong or is unsafe and that the dam or reservoir is dangerous to life or property, it may cause to be drawn off, in whole or in part, the water in the reservoir or impounded by the dam if it determines that this action is necessary to prevent impending danger to persons or property.

History: 1975 c. 349, 421; 1983 a. 27; 1989 a. 31; 2009 a. 28.
Cross−reference: See also ch. NR 333, Wis. adm. code.

31.21 Transfer of permit. (1) No transfer or assignment of any permit granted under s. 31.06 or 31.08 shall be of any effect whatsoever unless it is in writing and a certified copy thereof within 10 days after the execution thereof, is filed with the department and unless such transfer or assignment is approved in writing by the department; and no such transfer or assignment shall be approved by the department except after an investigation and a finding that the transfer or assignment is not made or intended to be made for a purpose or to create a condition prohibited by s. 196.665 and that the transferee or assignee has complied with s. 31.14 (2) or (3). No permit shall be transferred or assigned to a foreign corporation, nor shall any permit granted to a municipality be assigned or transferred to any person, otherwise than as security for a loan made in good faith and concurrently with and as consideration for such transfer or assignment, and no foreign corporation shall have power to acquire title to any such permit, nor shall any person have power to acquire title to a permit granted to or acquired by a municipality, otherwise than in the enforcement of such security, and in no case shall any such foreign corporation hold title to or operate under any such permit for a period longer than 3 years.

(2) No municipality shall make or execute any lease or other contract with any person, firm, or corporation for the sale or use of hydraulic or hydroelectric power developed or generated by such municipality under a permit granted under s. 31.06 or 31.08 for a period longer than 10 years, unless the same shall be first approved by the department, after investigation and upon a finding that such lease or contract will not impair or interfere with the purpose or uses for which such dam was acquired or constructed by the municipality.

Cross−reference: See also ch. NR 305, Wis. adm. code.

31.23 Forfeitures; private bridges and dams. (1) Every person who constructs or maintains in navigable waters or aids in the construction or maintenance therein of any bridge or dam not authorized by law, shall forfeit for each such offense, and for each day that the free navigation of such waters are obstructed by such bridge or dam a sum not exceeding $50.

(2) Every person or corporation violating any of the provisions of this chapter, other than those mentioned in sub. (1), or violating any order made by the department pursuant to this chapter, shall forfeit for each such violation not more than $1,000.

(3) (a) There shall be no forfeiture under this section in any case where a bridge is built by a private citizen across any navigable waters having a width of 35 feet or more, providing such bridge does not impair the rights of the public for purposes of navigation or fishing.

(b) No such bridge shall be maintained unless its construction shall first be approved by the department after public hearing and on not less than 10 days' written notice to the applicant and to the county and town clerks of the county and town wherein all or a portion of the proposed bridge is to be located.

(c) Each applicant who shall apply to the department for a permit to construct any such bridge shall state in the application the proposed location of the bridge, the depth of the water to be spanned, the materials to be used in the construction of the bridge, the plans of the proposed bridge, together with such other facts as the department may require.

Text from the 2007−08 Wis. Stats. database updated by the Legislative Reference Bureau. Only printed statutes are certified under s. 35.18 (2), stats. Statutory changes effective prior to 11−2−10 are printed as if currently in effect. Statutory changes effective on or after 11−2−10 are designated by NOTES. Report errors at (608) 266−3561, FAX 264−6948, http://www.legis.state.wi.us/rsb/stats.html

Electronic reproduction of 2007−08 Wis. Stats. database, updated and current through 2009 Act 406 and October 31, 2010.

(d) Every such bridge used by the public shall at all times be maintained in a safe condition by the owners of the land abutting the approaches of the bridge, and the owners shall make such repairs as are reasonably necessary therefor. The town shall not become liable for any damages resulting from the insufficiency or want of repairs of such bridge. If the department upon inspection finds that such bridge is in need of repairs, it shall notify the owners responsible for the repairs thereof, and also send a copy of such notice to the town board, to make all repairs as are reasonably necessary therefor. If such repair work as ordered by the department is not commenced within 60 days after receipt of such notice, the department may close such bridge until it is so repaired. Whenever any owner responsible for such bridge shall fail to repair or maintain the bridge in a good and safe condition, after having been notified so to do by the department for 60 days after such notification, such town board upon its own initiative may make such required repairs on such bridge, and the cost thereof shall be paid by the owners responsible therefor, and the town clerk shall enter such amount of the cost of repairs upon the next tax roll of the town.

History: 1991 a. 316.

Cross−reference: See also chs. NR 301, 305, and 320, Wis. adm. code.

Sub. (1) provides no substantive rule for which a violation would initiate the abatement procedures under s. 31.25. The remedy provided is limited to the forfeiture provided under sub. (1). Capt. Soma Boat Line, Inc. v. Wisconsin Dells, 56 Wis. 2d 838, 203 N.W.2d 369 (1973).

31.25 Nuisances, abatement. Every dam, bridge or other obstruction constructed or maintained in or over any navigable waters of this state in violation of this chapter, and every dam not furnished with a slide, chute or other equipment prescribed by the department, is hereby declared to be a public nuisance, and the construction thereof may be enjoined and the maintenance thereof may be abated by action at the suit of the state or any citizen thereof.

Section 31.23 (1) provides no substantive rule for which a violation would initiate the abatement procedures under this section. Capt. Soma Boat Line, Inc. v. Wisconsin Dells, 56 Wis. 2d 838, 203 N.W.2d 369 (1973).

31.253 Dam removal; opportunity for hearing. **(1)** OPPORTUNITY FOR HEARING PRIOR TO DEPARTMENT ACTION. Except as provided under sub. (4), prior to seeking or causing the removal of a dam under this chapter, the department shall hold a public informational hearing on the proposed removal or publish a class 2 notice under ch. 985 stating that it will seek or cause the removal of the dam without holding a public informational hearing unless a hearing is requested in writing within 30 days after the last publication of the notice. The department may hold further hearings or give further notice as it deems appropriate.

(2) OPPORTUNITY FOR HEARING PRIOR TO COURT ACTION. Except as provided under sub. (4), a court may not order or authorize the removal of a dam in an enforcement action under this chapter unless a public informational hearing or an opportunity for a public informational hearing was provided.

(3) PUBLIC INFORMATIONAL HEARING. If the department conducts a public informational hearing under this section, the department shall explain the basis for its decision to seek or cause the removal of the dam, the procedures which will be followed and opportunities for citizen involvement in those procedures and the department shall provide an opportunity for citizens to present comments, testimony and evidence concerning the removal of the dam. Notwithstanding s. 227.42, this hearing may not be converted or treated as a contested case.

(4) EXCEPTIONS. (a) This section does not apply if the department or a court determines that a dam constitutes an immediate and significant hazard to persons or property.

(b) This section does not apply to an application under s. 31.185 or departmental action under s. 31.185.

History: 1983 a. 507; 1985 a. 182 s. 57.

31.26 Civil liabilities. **(1)** The owner of any dam or of any privately owned bridge across the Wisconsin River or the Black River or any of their tributaries shall be liable for all damages occasioned to property by a failure to provide such dam or bridge with slides, booms and chutes as required by s. 31.18 (1). The person or party suffering any such damage shall have a lien upon the dam and all mills, machinery and appurtenances of such owner erected thereon, or served with water thereby, and on the lands adjoining, not exceeding 40 acres; or, as the case may be, a lien upon such bridge and its approaches.

(2) The claimant of such lien shall file a notice thereof in writing in the office of the clerk of the circuit court of the county in which the dam or bridge is located within 60 days after sustaining such damages and shall commence an action to enforce the lien within 6 months after filing such notice. Such lien shall accrue upon the filing of such notice and failure to file the same or to commence such action within the times specified therefor respectively shall operate as a waiver of the lien. Judgment for the plaintiff for the recovery of damages and declaring such lien may be enforced by an execution sale of the property affected as in ordinary actions at law, and upon such sale all rights to maintain such dam or bridge shall pass to the purchaser.

(3) In case of any personal injury by reason of any such neglect or failure the damages sustained thereby may be recovered and a lien and judgment enforced in like manner; and if death results an action may be maintained by the representatives of the deceased in the manner provided in other cases of death resulting from negligence or wrong.

(4) No common law liability, and no statutory liability provided elsewhere in these statutes, for damage resulting from or growing out of the construction, maintenance or operation of any dam is released, superseded, or in any manner affected by the provisions of this chapter; and this chapter creates no liability on the part of the state for any such damages.

31.29 May employ hydraulic engineer and assistants. The department may employ and fix the salaries of a competent hydraulic engineer and other assistants necessary to carry out the provisions of this chapter.

31.30 Dams on Brule River. It is declared to be the policy of the state to prohibit forever the building or maintaining of any dam or dams across the Brule River or any of its tributaries in Douglas County, except that a dam with an adequate fishway may be constructed across said Brule River at each of the 3 sites hereinafter described, or at such other sites as are selected by the department in place of any or all of the sites hereinafter mentioned, the purpose of which shall be to provide a method whereby fish declared to be undesirable for said stream by the department may be eliminated or prevented from ascending the stream, and to permit said stream to be developed for trout in different stretches thereof: site No. 1 known as Clevedon site in the southeast quarter of the northwest quarter of section 10, township 49 north, range 10 west; site No. 2 known as the Old Mill site in the northwest quarter of the southeast quarter, section 11, township 47 north, range 10 west; and site No. 3, known as the Upper or Rock dam site in the northeast quarter of the southeast quarter of section 22, township 47 north, range 10 west; and all rights, privileges, and franchises granted prior to June 26, 1905, to any person or corporation to improve said Brule River or any of its tributaries in said county for any purpose whatever, are repealed and annulled. No domestic corporation organized subsequent to such date shall exercise any of the powers or privileges authorized or conferred by ss. 180.15 to 180.18, 1925 stats., in, across or along said river or any of its tributaries in Douglas County.

Cross−reference: See s. 30.25 for similar prohibition of dams on the Wolf River.

31.305 Dams in the Lower Wisconsin State Riverway. No dam may be constructed in the lower Wisconsin River as defined in s. 30.40 (14).

History: 1989 a. 31.

Text from the 2007−08 Wis. Stats. database updated by the Legislative Reference Bureau. Only printed statutes are certified under s. 35.18 (2), stats. Statutory changes effective prior to 11−2−10 are printed as if currently in effect. Statutory changes effective on or after 11−2−10 are designated by NOTES. Report errors at (608) 266−3561, FAX 264−6948, http://www.legis.state.wi.us/rsb/stats.html

Electronic reproduction of 2007−08 Wis. Stats. database, updated and current through 2009 Act 406 and October 31, 2010.

31.307 Dam on Milwaukee River. (1) The department shall conduct, or shall cause to be conducted, an environmental and engineering study concerning the removal of the North Avenue dam in the city of Milwaukee from the Milwaukee River.

(3) Upon completion of the study under sub. (1), the city of Milwaukee may apply for a permit to abandon the dam under s. 31.185 or the department may proceed under ss. 31.187 and 31.253 to cause the removal of the dam.

(4) For purposes of s. 30.92 (4) (b) 6., moneys expended from the appropriation under s. 20.370 (5) (cq) for the study under sub. (1) shall be considered as amounts expended for projects considered necessary without regard to location.

History: 1991 a. 39; 1995 a. 27.

31.309 Portage levee system and canal. (1) CITY OF PORTAGE LEVEE. (a) The department shall provide a grant in the 1995−97 fiscal biennium from the appropriation under s. 20.370 (5) (cq) to the city of Portage for the amount necessary for the renovation and repair of the city of Portage levee in the Portage levee system. The grant under this paragraph may not exceed $800,000 in fiscal year 1995−96 and $800,000 in fiscal year 1996−97.

(ag) The department shall provide a grant of $350,000 in fiscal year 2001−2002 and a grant of $350,000 in fiscal year 2002−2003 from the appropriation under s. 20.370 (5) (cq) to the city of Portage for the renovation and repair of the Portage canal.

(am) The city of Portage may use any amounts from the grant awarded under par. (a) for the renovation and repair of the Portage canal.

(b) When the department determines that the renovation and repair described under par. (a) are complete, the city of Portage shall assume the maintenance of the city of Portage levee in the Portage levee system in a manner that will best protect the surrounding area from the overflow of the Wisconsin River.

(2) LEWISTON AND CALEDONIA LEVEES. (a) The department shall maintain the Lewiston and Caledonia levees in the Portage levee system in a manner that will best protect the surrounding area from the overflow of the Wisconsin River.

(b) The department may expend in fiscal year 1995−96, from the appropriation under s. 20.370 (5) (cq), up to $400,000 for a study concerning the future of strengthening and maintaining the Lewiston and Caledonia levees in the Portage levee system. The study shall include a management plan for these 2 levees.

History: 1995 a. 27 ss. 1698, 1699, 1702 to 1706; Stats. 1995 s. 31.309; 1999 a. 9; 2001 a. 16.

31.31 Dams on nonnavigable streams. Any person may erect and maintain upon that person's land, and, with the consent of the owner, upon the land of another, a water mill and a dam to raise water for working it upon and across any stream that is not navigable in fact for any purpose whatsoever upon the terms and conditions and subject to the regulations hereinafter expressed; and every municipality may exercise the same rights upon and across such streams that they may exercise upon or across streams navigable for any purpose whatsoever.

History: 1991 a. 316.

31.32 Dams not to injure other dams or sites. No such dam shall be erected to the injury of any mill lawfully existing, either above or below it on the same stream; nor to the injury of any mill site on the same stream on which a mill or milldam shall have been lawfully erected and used or is in the process of erection, unless the right to maintain a mill on such last−mentioned site shall have been lost or defeated by abandonment or otherwise; nor to the injury of any such mill site which has been occupied as such by the owner thereof, if such owner, within a reasonable time after commencing such occupation, completes and puts in operation a mill for the working of which the water of such stream shall be applied.

31.33 Jurisdiction of department. (1) DAMS HERETOFORE OR HEREAFTER CONSTRUCTED; ACTION FOR DAMAGES. All mills and milldams lawfully erected or constructed, on streams not navigable at the time, under chapter 48, territorial laws of 1840, chapter 62, laws of 1857, ch. 56, R.S. 1858, ch. 146, R.S. 1878, ch. 146, R.S. 1898, ch. 146, 1911 stats., ch. 146, 1913 stats., or ch. 146, 1915 stats., or any special, private or local act, or under any other act whatsoever, that are not now abandoned but are still in existence and use, and all dams heretofore or hereafter erected or constructed on streams not navigable in fact for any purpose, shall be subject to and regulated and controlled, so far as applicable, by ss. 31.02, 31.12, 31.18, 31.19, 31.25, 31.26 and 196.665, except that those sections do not prevent the owner of any land flooded or otherwise injured by any milldam from recovering by action at law, full compensation for all damages resulting to him or her in times past and that will result to him or her in the future in consequence of that flooding and injury but no damages suffered more than 3 years before the commencement of the action shall be recovered. The amount recovered constitutes a first lien upon the milldam and upon the mill, if any, and the lien may be enforced by execution sale of the property affected. In every such action the amount paid or secured to be paid under prior laws as damages shall be considered and proper allowance made therefor. The authority granted under this subsection to bring the action does not preclude the owner from proceeding under ch. 32. The owner may not exercise his or her option to bring the action after condemnation proceedings have been commenced against his or her property under ch. 32.

(2) LICENSE. A license is granted to each owner of any such milldam now in existence and use, and to each owner of any such milldam hereafter constructed, to maintain and use the same to operate mills or machinery, or for any other lawful private or public purpose, but subject, however, to the supervision of the department acting under ss. 31.02, 31.12, 31.18, 31.19, 31.25, 31.26 and 196.665. The right created by the license shall follow the title to the milldam and a conveyance of the latter shall transfer the right to the grantee.

(3) INTERPRETATION. Whenever ss. 31.02, 31.12, 31.18, 31.19, 31.25, 31.26 and 196.665 are applied to mills or milldams specified in sub. (1) every reference in any of them to a "permit" or to a "grantee" of a permit shall be regarded as referring respectively to a license granted by this section and to the owner of such a mill or milldam.

(4) HEIGHT. The height to which water may be raised by any such milldam and the length or period of time for which it may be kept up each year, may be restricted and regulated by the orders of the department.

(5) VIOLATION OF ORDERS, PENALTIES. Every person, firm or corporation violating any of the orders respecting any such mill or milldam made by the department shall forfeit for each such violation a sum not exceeding $500 which may be recovered by civil action as provided by ch. 778.

History: 1979 c. 32 s. 92 (8); 1981 c. 390; 1989 a. 31.

Cross−reference: See also ch. NR 333, Wis. adm. code.

This section applies to nonnavigable artificial waterways insofar as is necessary to protect navigable waters and owners of flooded waters. 63 Atty. Gen. 493.

Wisconsin's Milldam Act: Drawing New Lesson's From Old Law. Martini. 1998 WLR 1305.

31.34 Flow of water regulated. Each person, firm or corporation maintaining a dam on any navigable stream shall pass at all times at least 25% of the natural low flow of water of such stream, except as otherwise provided by law. This section, however, shall not apply to a plant or dam where the water is discharged directly into a lake, mill pond, storage pond or cranberry marsh, nor shall it apply to cases where in the opinion of the department such minimum discharge is not necessary for the protection of fish life. Any person, firm or corporation violating this section shall be fined not less than $50 nor more than $1,000.

31.35 Dams in areas leased by county; restrictions; control by circuit judge; when. (1) Dams controlling the water elevations in areas covered by leases made under s. 59.01 shall be operated in such manner as not to divert waters or with-

Text from the 2007−08 Wis. Stats. database updated by the Legislative Reference Bureau. Only printed statutes are certified under s. 35.18 (2), stats. Statutory changes effective prior to 11−2−10 are printed as if currently in effect. Statutory changes effective on or after 11−2−10 are designated by NOTES. Report errors at (608) 266−3561, FAX 264−6948, http://www.legis.state.wi.us/rsb/stats.html

hold from any cranberry reservoir to the damage of any cranberry marsh now served or dependent upon such water supply or to any crops or works therein.

(2) The circuit court for the county where the leased lands are located shall, upon petition and proof that any cranberry marsh or crops or works thereon are endangered or likely to be damaged by the operation of any dam or water control, make a summary order for the release, impounding or control of the waters affected by the dam or dams, to be and remain in force until dissolved by due notice and hearing.

History: 1977 c. 449.

31.36 Levee commissioners. (1) The right−of−way for such levees, if any additional are found necessary, shall be furnished by the municipalities in which they are located, and no construction work shall be begun until such rights−of−way are provided.

(2) Whenever levee commissioners under either general or special act are charged with the expenditure of money appropriated by the state or by any municipality for the construction, extension, improvement or repair of any levee or breakwater along the shore or bank of a river, stream or lake, s. 31.38 shall apply for the purpose of acquisition and condemnation of lands for such purposes and such commissioners have all the powers conferred by s. 31.38 for these purposes. Condemnations shall comply with s. 66.0703, so far as applicable. Commissioners may procure by condemnation lands for right−of−way, earth material, borrow pits, quarry, timber and brush privileges as they may, in their judgment, deem necessary for such purposes.

(3) Whenever said levee commissioners are not vested with power to buy rights−of−way, earth material, borrow pits, quarry, timber and brush privileges from money appropriated by the state they may receive from any person or municipality donations of land and moneys to pay for lands and privileges condemned hereunder and for the expenses of such condemnation proceedings.

(14) This section does not modify or repeal s. 31.35.

History: 1993 a. 490; 1995 a. 27; 1999 a. 150 s. 672.

31.38 Municipal authority to construct and maintain dams. (1) Every municipality may, subject to this chapter, authorize the acquisition, construction, maintenance or repair of dams across any lake or stream adjoining or within the limits of such municipality, and may locate such dam within or without such limits.

(2) Whenever it is deemed necessary to acquire, construct, maintain or repair any such dam, a plan therefor, with specifications and cost estimates, shall be prepared and presented to the governing body of the municipality for adoption. Cost estimates may include the estimated cost of maintenance for a period of years. When adopted by the governing body, the plan shall, where required, be submitted to the department or proper officer of the United States for approval. No work shall be done in pursuance of such plan until it has been so approved.

(3) For the purpose of this section, a municipality may purchase or condemn lands within and, when necessary, without its limits in order to protect any property situated within such limits.

(4) The municipality shall proceed in accordance with s. 66.0703 to make special assessments to property on account of benefits resulting to the property from the improvement mentioned in sub. (2) or from the acquisition and maintenance of a dam. If the excess of benefits over damages accruing to property within the assessment district is not sufficient to pay the cost of the improvement, the municipality may pay the balance, either out of its general fund or out of any special fund created for that purpose. The municipality may issue its negotiable bonds, as provided in ch. 67, to pay for such improvement. The department upon request of a municipality shall assist in engineering, surveying and determination of charges necessary in establishing special assessment districts under this section, cost of which shall be advanced by the requesting municipality and later charged against the various parcels of the special assessment district in direct proportion to the assessed benefits of each parcel in the district.

(5) Whenever 2 or more municipalities propose to cooperate in acquiring, constructing, maintaining or repairing a dam, their governing bodies shall first meet and adopt a method of proceeding and a plan of apportioning to each its share of the entire cost. Such method of proceeding and plan of apportionment shall be embodied in a resolution adopted by the governing bodies of the cooperating municipalities acting jointly and later such resolution shall be adopted by each of the governing bodies acting separately.

(6) Whenever a county or town acts under this section, the references in s. 66.0703 to a city or village or clerk thereof mean the county or town or clerk thereof, as the case may be.

History: 1999 a. 150 s. 672.

31.385 Dam safety; aid program. (1b) In this section "dam safety project" means the maintenance, repair, modification, abandonment or removal of a dam to increase its safety or any other activity that will increase the safety of a dam.

(1m) The department shall promulgate the rules necessary to administer a financial assistance program for dam safety projects under which financial assistance shall be provided as follows:

(a) To municipalities and public inland lake protection and rehabilitation districts for any type of dam safety projects.

(b) To private owners for the removal of dams.

(c) To any persons for the removal of abandoned dams.

(2) The following standards shall apply to financial assistance under this section for dam safety projects:

(a) 1. Except as provided in subd. 2., financial assistance for a dam safety project is limited to the sum of the following:

a. No more than 50% of the first $400,000 of costs of the project.

b. No more than 25 percent of the costs of the project that exceed $400,000.

2. A project to remove a dam shall not be subject to the cost limits under subd. 1.

3. Financial assistance is limited to no more than $400,000 for each dam safety project.

(ag) Of the amounts appropriated under s. 20.866 (2) (tL) and (tx), at least $250,000 shall be used for projects to remove dams. A project to remove a dam may include restoring the stream or river that was dammed.

(ar) Of the amounts appropriated under s. 20.866 (2) (tL) and (tx), at least $100,000 shall be used for the removal of abandoned dams. The amounts required to be used under this paragraph are in addition to the amounts required to be used for the removal of dams under par. (ag).

(b) The department shall determine which projects shall receive funding priority.

(bm) The department may provide financial assistance for an activity other than the maintenance, repair, modification, abandonment or removal of the dam only if the cost of that activity will be less than the cost of the maintenance, repair, modification or removal of the dam.

(c) No financial assistance may be provided under this section for a dam safety project unless at least one of the following applies:

1. The department conducts an investigation or inspection of the dam under this chapter and the owner of the dam requests financial assistance under this section within 6 months after having received department directives, based on the department's investigation or inspection of the dam, for the repair, modification or abandonment and removal of the dam or for another activity to increase the safety of the dam.

2. The municipality, public inland lake protection and rehabilitation district or other person applying for state financial assis-

Electronic reproduction of 2007−08 Wis. Stats. database, updated and current through 2009 Act 406 and October 31, 2010.

tance under this section has received directives from the department or is under order by the department to maintain, repair, modify, abandon or remove a dam on August 9, 1989.

(d) The financial assistance shall be paid from the appropriations under s. 20.866 (2) (tL) and (tx), except as provided in 1991 Wisconsin Act 39, section 9142 (10d).

(3) The department shall provide municipalities, public inland lake protection and rehabilitation districts and other persons receiving state financial assistance under this section with technical assistance for dam safety projects under this section. The department shall coordinate the financial assistance program under this section with other related state and federal programs.

(4) (a) The department shall maintain an inventory of all dams in the state that require a dam safety project under this section. The inventory shall list the dam safety projects in the chronological order in which they are required to be undertaken. For each dam safety project on the inventory, the department shall include a statement of which parts of the dam safety project are required to protect the rights held by the public in the navigable waters contained by the dam.

(b) The department shall provide notice to the owner of a dam that is included in the inventory. The department shall by rule establish a notice and hearing process for a dam owner to object to the inclusion of the owner's dam on the list. The department shall use this notice and hearing each time a dam is included in the inventory. The process shall include a public hearing in the city, village or town in which the dam is located, a public comment period, and an appeals process.

(5) Notwithstanding the limitations under sub. (2) (a) and the funding allocation requirements under sub. (2) (ag) and (ar), the department shall provide financial assistance to the village of Cazenovia in the amount necessary for a dam safety project to repair a dam that is located in the portion of the village that is in Richland County. The amount of the financial assistance may not exceed $250,000. The village need not contribute to the repair costs, and sub. (2) (c) does not apply to this dam safety project. The repair of this dam need not be included as a dam safety project under the inventory maintained by the department under sub. (4) for the village to receive financial assistance under this section.

(6) (a) Notwithstanding the limitations under sub. (2) (a) and the funding allocation requirements under sub. (2) (ag) and (ar), the department shall provide financial assistance to all of the following:

1. Adams County for a dam safety project for Easton Dam in the amount necessary for the project, but not to exceed $150,000.

2. The city of Stanley for a dam safety project for Stanley Dam in the amount necessary for the project, but not to exceed $150,000.

3. The city of Montello for a dam safety project for Montello Dam, in the amount necessary for the project, but not to exceed $150,000.

4. Eau Claire County for dam safety projects for Lake Altoona Dam, for Lake Eau Claire Dam, and for a dam located in Coon Fork Lake County Park, in the amount necessary for the projects, but not to exceed $27,000.

(b) The counties and cities need not contribute to the costs of the dam safety projects under par. (a) 1. to 4., and sub. (2) (c) does not apply to these projects. The dam safety projects under par. (a) 1. to 4. need not be included as dam safety projects under the inventory maintained by the department under sub. (4) in order to receive financial assistance under this subsection.

History: 1989 a. 31, 336; 1991 a. 39; 1993 a. 16; 1997 a. 27; 1999 a. 9, 185; 2001 a. 16; 2007 a. 97; 2009 a. 28.

Cross−reference: See also chs. NR 335 and 336, Wis. adm. code.

31.387 Dam rehabilitation projects. The department shall establish and administer a grant program under which the department shall provide grants to counties to rehabilitate dams located in those counties. The department may only provide a grant for a project under this section to match federal funds provided for the project under the federal Watershed Protection and Flood Prevention Act of 1953 (Public Law 83−566).

History: 2001 a. 16.

31.39 Fees for permits, approvals and hearings. (1) FEES REQUIRED. The department shall charge a permit or approval fee for carrying out its duties and responsibilities under ss. 31.02 to 31.185 and 31.33 to 31.38. The permit or approval fee shall accompany the permit application or request for approval.

(2) AMOUNT OF FEES. (a) For fees charged for permits and approvals under ss. 31.02 to 31.185 and 31.33 to 31.38, the department shall classify the types of permits and approvals based on the estimated time spent by the department in reviewing, investigating and making determinations whether to grant the permits or approvals. The department shall then set the fees as follows:

1. For a permit or approval with an estimated time of less than 3 hours, the fee shall be $30.

2. For a permit or approval with an estimated time of more than 3 hours but less than 9 hours, the fee shall be $100.

3. For a permit or approval with an estimated time of more than 9 hours, the fee shall be $300.

(b) For conducting a hearing on an application for which notice is provided under s. 31.06 (1), the person requesting the hearing for the permit or approval shall pay a fee of $25.

(2m) ADJUSTMENTS IN FEES. (a) The department shall refund a permit or approval fee if the applicant requests a refund before the department determines that the application for the permit or approval is complete. The department may not refund a permit or approval fee after the department determines that the application is complete.

(b) If the applicant applies for a permit or requests an approval after the project is begun or after it is completed, the department shall charge an amount equal to twice the amount of the fee that it would have charged under this section.

(c) If more than one fee under sub. (2) (a) or s. 30.28 (2) (a) or 281.22 is applicable to a project, the department shall charge only the highest fee of those that are applicable.

(d) The department, by rule, may increase any fee specified in sub. (2).

(2r) FEE FOR EXPEDITED SERVICE. (a) The department, by rule, may charge a supplemental fee for a permit or approval that is in addition to the fee charged under this section if all of the following apply:

1. The applicant requests in writing that the permit or approval be issued within a time period that is shorter than the time limit promulgated under par. (b) for that type of permit or approval.

2. The department verifies that it will be able to comply with the request.

(b) If the department promulgates a rule under par. (a), the rule shall contain a time limit for each type of permit or approval classified under sub. (2) (a) for determining whether the department will grant the permit or approval.

(3) EXEMPTIONS. This section does not apply to any federal agency or state agency.

History: 1977 c. 29; 1979 c. 221; 1981 c. 346; 1989 a. 31, 324; 1995 a. 27, 227; 1997 a. 27.

Cross−reference: See also ch. NR 300, Wis. adm. code.

31.99 Parties to a violation. (1) Whoever is concerned in the commission of a violation of this chapter for which a forfeiture is imposed is a principal and may be charged with and convicted of the violation although he or she did not directly commit it and although the person who directly committed it has not been convicted of the violation.

(2) A person is concerned in the commission of the violation if the person:

(a) Directly commits the violation;

(b) Aids and abets the commission of it; or

Text from the 2007−08 Wis. Stats. database updated by the Legislative Reference Bureau. Only printed statutes are certified under s. 35.18 (2), stats. Statutory changes effective prior to 11−2−10 are printed as if currently in effect. Statutory changes effective on or after 11−2−10 are designated by NOTES. Report errors at (608) 266−3561, FAX 264−6948, http://www.legis.state.wi.us/rsb/stats.html

Electronic reproduction of 2007−08 Wis. Stats. database, updated and current through 2009 Act 406 and October 31, 2010.

(c) Is a party to a conspiracy with another to commit it or advises, hires or counsels or otherwise procures another to commit it.

History: 1975 c. 365.

Text from the 2007−08 Wis. Stats. database updated by the Legislative Reference Bureau. Only printed statutes are certified under s. 35.18 (2), stats. Statutory changes effective prior to 11−2−10 are printed as if currently in effect. Statutory changes effective on or after 11−2−10 are designated by NOTES. Report errors at (608) 266−3561, FAX 264−6948, http://www.legis.state.wi.us/rsb/stats.html

E.50. Wyoming



STATE OF WYOMING

SAFETY OF DAMS

PROGRAM

The purpose of this brochure is to provide you with information concerning the Wyoming Safety of Dams Program and basic knowledge of the terminology used around dams.

Enclosed for your information is a copy of the Safety of Dams Law, (Wyoming Statutes 41-3-307 through 41-3-318), which authorized the Wyoming Safety of Dams Program and Glossary of Terms accompanied with illustrations. A summary of the Safety of Dams Program is presented below, but we urge you to review the enclosed material and become familiar with all aspects of the Law.

The Safety of Dams Program can be broken into two areas of emphasis:

1) The Safety of Dams Law stipulates that duplicate plans and specifications showing the proposed work on any facility, meeting the criteria of the Safety of Dams Law, shall be prepared by or under the direction of a registered professional engineer licensed in Wyoming and experienced in dam design and construction. These plans and specifications must be submitted to the State Engineer for review and approval. No work shall begin until the submitted plans and specifications are approved by the State Engineer. The term "work" includes the following activities, among others: construction of a new facility and any repair, alteration, or rehabilitation which may affect the safety or size of an existing facility.

Once the plans and specifications have been approved by the State Engineer, a qualified engineer shall be in charge of and responsible for the proposed work. The engineer in charge shall inspect the work and submit reports to the Safety of Dams office detailing the information obtained during the inspection and on the progress of the work.

2) Periodic Safety Inspections of existing facilities, meeting certain criteria, are authorized and required by the Safety of Dams Law. If the facility is found to be defective or, in the judgement of the State Engineer, the facility constitutes a menace to the public, the State Engineer may place restrictions on the use of the facility until the owner returns the facility to a safe condition, as approved by the State Engineer.

In case of an emergency, the State Engineer may order breaching of a facility or any repairs deemed necessary to safeguard life and property.

The owner is responsible for safe operation and maintenance of a facility. No aspect of the Safety of Dams Program shall be construed to relieve the owner of a facility of any legal duties, obligations, or liabilities incident to their ownership or operation of it. The owner is solely liable for any damages resulting from the leakage or overflow of water or for floods resulting from failure or rupture of the fill or structure for such works.

If you discover conditions, which you feel are undesirable and could lead to failure of a facility, please promptly contact this office at the address or phone number listed below and/or your local Water Commissioner or Superintendent. We will promptly send someone to access the situation.

In the event of an emergency, where flooding is expected due to either failure of a dam or large releases of water from a reservoir, you must contact one of the following agencies:

1. Your local law enforcement agency;

2. Wyoming Highway Patrol - 1-307-777-4321 (24 Hours)
   or
   1-800-442-9090;

3. Wyoming Emergency Management Agency
   1-307-777-4900 (Days) or the Wyoming Highway Patrol 1-307-777-4321 (evenings, weekends and holidays)

4. State Engineer's Office
   Herschler Building - 4th Floor East
   Cheyenne, Wyoming 82002
   Phone Number - 1-307-777-6153 or 6154 (Days)

STATE OF WYOMING

SAFETY OF DAMS - STATE STATUTES

41-3-307 through 41-3-318, 1992

41-3-307. Definitions.

(a) As used in this act unless the context otherwise requires:

(i) "Alterations" or "repairs" means only such alterations or repairs as may directly affect the safety of the dam or DIVERSION SYSTEM, as determined by the state engineer or his designated representative;

(ii) "Appurtenant works" include, but are not limited to, such structures as spillways, either in the dam or separate therefrom, the reservoir and its rim, low level outlet works, and water conduits such as tunnels, pipelines or penstocks, either through the dam or its abutments;

(iii) "Dam" means any artificial barrier, including appurtenant works, used to impound or divert water and which is or will be greater than twenty (20) feet in height or with an impounding capacity of fifty (50) acre-feet or greater. "DAM" SHALL NOT INCLUDE ARTIFICIAL BARRIERS INCLUDING APPURTENANT WORKS:

(A) SIX (6) FEET IN HEIGHT OR LESS, REGARDLESS OF STORAGE CAPACITY; OR

(B) WHICH IMPOUND LESS THAN FIFTEEN (15) ACRE-FEET, REGARDLESS OF HEIGHT.

(iv) "Days" used in establishing deadlines means calendar days, including Sundays and holidays;

(v) "Diversion system" means any CHANNEL DIVERSION, HEADGATE or DIVERSION STRUCTURE with a carrying capacity in excess of fifty (50) cubic feet of water per second of time;

(vi) "Emergency" means any threat to life or property caused by the condition of any dam, reservoir or diversion system, or by present or imminent floods which threaten the safety or structural integrity of any dam or diversion system;

(vii) "EMERGENCY RESPONSE AGENCY" MEANS ANY AGENCY WHICH THE DAM OWNER MAY BE REQUIRED TO NOTIFY IN CASE OF AN EMERGENCY, SUCH AS SHERIFF'S OFFICE, HIGHWAY PATROL OR LOCAL EMERGENCY COORDINATOR;

(viii) "Enlargement" means any change in or addition to an existing dam or reservoir which raises or may raise the water storage elevation of the water impounded by the dam;

(ix) "Inspection" means visual or mechanical checks, measures, borings and any other methods necessary for determination of the adequacy of construction techniques, conformity of work with approved plans and specifications, and the safety and operating performance of a dam or diversion system and appurtenant works;

(x) "Owner" includes any of the following who own, control, operate, maintain, manage or propose to construct a dam or reservoir:

(A) The state and its departments, institutions, agencies and political subdivisions;

(B) Every municipal or quasi-municipal corporation;

(C) Every public utility;

(D) Every district;

(E) Every person;

(F) THE FEDERAL GOVERNMENT AND ITS DEPARTMENTS, INSTITUTIONS, AGENCIES AND POLITICAL SUBDIVISIONS;

(G) The duly authorized agents, lessees or trustees of any of the foregoing; and

(H) Receivers or trustees appointed by any court for any of the foregoing.

(xi) "Person" means any person, firm, association, organization, partnership, business trust, corporation or company;

(xii) "Reservoir" means any basin which contains or will contain impounded water;

(xiii) "This act" means W.S. 41-3-307 through 41-3-317.

41-3-308. Plans to be prepared by professional engineer; approval of plans and specifications by state engineer; industrial siting permits.

(a) Plans and specifications of any proposed construction, enlargement, MAJOR repair, alteration or removal of a dam or diversion system shall be prepared by or under the direction of a registered professional engineer licensed to practice in the state of Wyoming and experienced in dam design and construction, and shall be submitted to the state engineer for approval. It is unlawful to commence construction, enlargement, repair, alteration or removal until the plans and specifications have been approved by the state engineer. At the request of the state engineer, the professional engineer responsible for the plans and specifications shall carry out any revisions of the plans and specifications or provide such additional information as is necessary to justify or clarify the design.

(b) A copy of all plans and specifications submitted under this section shall be kept on file in the state engineer's office.

(c) In the event that a proposed dam or diversion system is related to a facility which requires an industrial siting permit pursuant to W.S. 35-12-106:

(i) The plans and specifications of the proposed dam or diversion system shall be submitted to the state engineer at the same time that the application for an industrial siting permit is submitted to the industrial siting administration pursuant to W.S. 35-12-108;

(ii) The state engineer shall approve or reject the plans and specifications of the proposed dam or diversion system prior to the public hearing conducted pursuant to W.S. 35-12-109 (b) (i);

(iii) The approval or rejection of the plans and specifications of the proposed dam or diversion system shall be binding on the industrial siting council for the purposes of issuing an industrial siting permit. Source: Laws 1977, ch. 120, 1.

(d) THE STATE ENGINEER SHALL PROVIDE FOR THE REGULATION AND SUPERVISION OF ALL DAMS, DIVERSION SYSTEMS AND RESERVOIRS BY THE STATE TO THE EXTENT REQUIRED TO PROTECT THE PUBLIC SAFETY AND PROPERTY. THE STATE ENGINEER IS AUTHORIZED AND DIRECTED TO PROMULGATE REGULATIONS AND STANDARDS FOR THE DESIGN, CONSTRUCTION, ENLARGEMENT, ALTERATION, ABANDONMENT, MAINTENANCE, MONITORING, OPERATION, REPAIR AND REMOVAL OF DAMS, RESERVOIRS, AND DIVERSION SYSTEMS AS ARE NECESSARY AND PROPER TO CARRY OUT THE PURPOSES OF THIS ACT. THE STATE ENGINEER MAY WAIVE ANY OR ALL OF THE REQUIREMENTS OF THIS ACT IN INSTANCES WHERE THE DAM OR DIVERSION SYSTEM IS LOCATED IN A REMOTE AREA WHERE THERE IS NO THREAT TO THE PUBLIC SAFETY OR PROPERTY.

41-3-309. Inspections performed and reports submitted to state engineer by professional engineer.

(a) A registered professional engineer licensed to practice in the state of Wyoming shall be in charge of and responsible for the construction, enlargement, repair, alteration or removal of any dam or diversion system.

(b) The engineer in charge shall provide for inspections at such intervals as deemed necessary to insure conformity with the approved plans and specifications, either by himself or by a person qualified to perform the inspections and for whose work the engineer stands personally responsible.

(c) All information obtained from, during or as the result of such inspection shall be made part of a report, certified to by the engineer in charge, which shall be submitted to the state engineer at such time or times as may be set by the state engineer.

(d) All reports submitted under this section shall be FILED in the state engineer's office.

41-3-310. Inspections by state engineer or assistant engineer; cost.

(a) If the state engineer believes that inspections carried out under W.S. 41-3-309 are inadequate or that additional inspections are necessary, the state engineer may inspect personally or appoint an assistant engineer to inspect the construction, enlargement, repair, alteration or removal of any dam or diversion system. If after any inspection the state engineer or his representative finds that amendments, modifications or changes are necessary in order to insure the security and integrity of the work and structure, the protection of property or the public safety, the state engineer may order the owner or owners of the dam or diversion system to revise the plans and specifications, or order work stopped. It is unlawful to proceed with or continue THE work until any revisions have been approved by the state engineer.

(b) Any inspections required by this section shall be made at state expense, provided the assistant engineer performing such inspections is an employee of the state of Wyoming.

(c) If the assistant engineer is not a regular employee of the state of Wyoming, inspections shall be made at the expense of the owner. The owner shall be furnished with an estimate of the cost prior to performance of any inspections, but the state engineer is not precluded from collecting any or all additional costs which result from performance of THE inspections. Costs to be paid by the owner shall include, but are not limited to, ALL work or tests as are necessary to fully provide any information and data required by the state engineer or his appointed representative. IF THE OWNER REFUSES OR NEGLECTS TO TURN OVER THE FUNDS WITHIN THIRTY (30) DAYS, AFTER THE PRESENTATION OF THE BILL OF COSTS, THE COSTS SHALL

CONSTITUTE A LIEN UPON THE WORKS OR OTHER PROPERTIES OF THE OWNER OR OWNERS AND MAY BE COLLECTED BY APPROPRIATE ACTION IN ANY COURT OF COMPETENT JURISDICTION. IN ORDER TO HAVE A VALID, ENFORCEABLE LIEN UNDER THIS SECTION, A LIEN STATEMENT SWORN TO BEFORE A NOTARY PUBLIC SHALL BE FILED BY THE CLAIMANT WITH THE COUNTY CLERK OF THE COUNTY IN WHICH THE PROPERTY IS LOCATED. THE COUNTY CLERK SHALL FILE THE STATEMENT AND INDEX BY DATE, NAME OF CLAIMANT AND PROPERTY OWNER, AND BY LEGAL DESCRIPTION. THE LIEN STATEMENT SHALL CONTAIN THE FOLLOWING:

(i) THE NAME AND ADDRESS OF THE GOVERNING BODY SEEKING TO ENFORCE THE LIEN;

(ii) THE NAME AND ADDRESS OF THE PERSON AGAINST WHOSE PROPERTY THE LIEN IS FILED; AND

(iii) THE LEGAL DESCRIPTION OF THE PROPERTY TO WHICH THE LIEN ATTACHES.

(d) All funds paid by the owner to the state engineer shall be deposited in the state engineer's HOLDING account from which account the costs incurred as a result of any inspections or other work deemed necessary under this section SHALL BE PAID. Any funds not so expended shall be returned to the person or persons advancing the funds.

41-3-311. Periodic inspections.

(a) Any dam subject to the terms of this act shall be inspected at least once every TEN (10) years or as often as deemed necessary BASED ON THE HAZARDS OF THE DAM to insure the continued PROTECTION of PUBLIC SAFETY AND PROPERTY.

(b) Inspections referred to in subsection (a) of this section shall be performed by the state engineer or his appointed representative WHO SHALL HAVE RIGHT OF ENTRY UPON PRIVATE OR GOVERNMENT LANDS AND IS AUTHORIZED TO INSPECT THE OWNER'S TECHNICAL DATA AND OTHER DOCUMENTATION AS MAY BE NECESSARY TO PERFORM THESE INSPECTIONS. All information obtained as a result of THE inspections shall be FILED IN the state engineer's office.

(c) Inspections required under this section shall be made at state expense except as provided in W.S. 41-3-312 when a dam, reservoir or diversion system is found to be unsafe by the state engineer. Source: Laws 1977, ch. 120, 1.

(d) IF INSPECTIONS PERFORMED UNDER THIS SECTION DISCLOSE DEFECTS IN THE WORKS WHICH IN THE JUDGMENT OF THE STATE ENGINEER OR HIS AUTHORIZED AGENT CONSTITUTE A THREAT TO LIFE OR PROPERTY, THE STATE ENGINEER MAY, WITHOUT INCURRING ANY LIABILITY, ORDER THE DRAINING OF ANY RESERVOIR INVOLVED, OR THE LIMITATION OR CESSATION OF ITS

USE OR THE USE OF ANY DEFECTIVE WORKS UNTIL SUCH TIME AS THE OWNER OF THE RESERVOIR OR OTHER WORKS RETURNS THE WORKS TO A SAFE CONDITION AS APPROVED BY THE STATE ENGINEER.

41-3-312. Inspections at any time or at request of other party or parties; cost; limitation against unsafe structures.

(a) The state engineer may, or upon written request from any person or persons residing on or owning land near any dam, reservoir or diversion system, shall order an inspection of THOSE works at any time other than the time set for regular inspections as provided for in W.S. 41-3-311(a). Before ordering AN inspection, the state engineer may require any person or persons requesting THE inspection to deposit a sum of money sufficient to pay the expenses of the inspection into the state engineer's HOLDING ACCOUNT. If after THE inspection the dam, reservoir or diversion system is determined to be in a safe and usable condition, the state engineer may cause the whole or part of the expenses of THE inspection to be paid out of the state engineer's HOLDING account. ANY EXCESS FUNDS SHALL BE RETURNED TO THE PERSON OR PERSONS ADVANCING THE FUNDS.

(b) If the dam, reservoir or diversion system is found to be defective, ANY FUNDS DEPOSITED BY THE PERSON OR PERSONS REQUESTING THE INSPECTION SHALL BE RETURNED AND the state engineer may require the person or persons owning the dam, reservoir or diversion system in question to pay the whole or any part of the expenses of inspection. If the state engineer requires A payment, he shall present a bill of costs to the owner or owners, and if the owner or owners refuse or neglect to pay the costs within thirty (30) days after the presentation of THE bill of costs, the costs shall constitute a lien upon the works or other properties of the owner or owners and may be collected by appropriate action in any court of competent jurisdiction. If the inspection discloses defects in the works which in the judgment of the state engineer or his authorized agent constitute a THREAT to life or property, the state engineer may, without incurring any liability, order the draining of any reservoir involved, or the limitation or cessation of its use or the use of any defective works until such time as the owner of the reservoir or other works returns the works to a safe condition as approved by the state engineer. THE LIEN SHALL BE FILED AS PROVIDED BY W.S. 41-3-310(c).

41-3-313. Outlets; maintenance; draining by breaching.

(a) All dams AND reservoirs hereafter constructed, with or without a controlled inlet, shall contain an outlet controlled by a HEADGATE or other control works. The HEADGATE or control works shall be maintained in an operable condition at all times and in A manner that water impounded by or within a dam OR reservoir may be

evacuated or maintained at any water level which may be required by the state engineer.

(b) All dams constructed prior to the effective date of this act which have no outlet or means for lowering the reservoir water level in an expeditious manner, may be drained by breaching at the owner's expense when the public safety so requires.

(c) The state engineer and anyone working under his direction and control shall not be held liable for any damages or loss of water resulting from the draining or imposed restrictions as to the use of a reservoir, DAM or diversion system.

(d) If within thirty (30) days after presentation of an itemized statement the owner fails to reimburse the state engineer for expenses incurred under this section, any unpaid balance of such expense shall automatically constitute a lien upon lands or other properties of the owner. Source: Laws 1977, ch. 120, 1.

41-3-314. Emergency repairs or breaching.

(a) In case of an emergency where the state engineer or his authorized representative declares that repairs or breaching of a dam or diversion system are immediately necessary to safeguard life and property, the necessary repairs or breaching shall be started immediately by the owner or by the state engineer or his representative at the owner's expense, if the owner fails to do so. The state engineer AND EMERGENCY RESPONSE AGENCIES shall be notified at once of any CHANGES IN THE PHYSICAL CONDITIONS OF THE DAM, DIVERSION SYSTEM, OR RESERVOIR WHICH SIGNIFICANTLY INCREASE THE PROBABILITY OF FAILURE OF THE DAM OR DIVERSION WORKS OR THE DANGER TO LIFE OR PROPERTY, proposed emergency repairs or breaching to be instituted by the owner. THESE REPORTING REQUIREMENTS SHALL APPLY ONLY TO CASES IN WHICH AN EMERGENCY HAS BEEN DECLARED PURSUANT TO THIS SUBSECTION.

(b) If emergency repairs have been made and the emergency situation has passed, the owner shall commence all repairs necessary to return the dam or diversion system to a safe and usable condition, as provided in W.S. 41-3-308 through 41-3-310.

(c) All costs incurred by the state engineer during an emergency shall be payable by the owner or owners on receipt of the bill of costs from the state engineer. Costs not paid within thirty (30) days after presentation of the bill shall constitute a lien upon the dam or diversion system or other properties of the owner or owners and may be collected by appropriate action in any court of competent jurisdiction. THE LIEN SHALL BE FILED AS PROVIDED BY W.S. 41-3-310 (c).

41-3-315. Other reservoirs; enforcement reservoirs 20 feet or less in height or impounding less than 50 acre-feet.

FOR ANY RESERVOIR the state engineer may enforce any sections of this act in such manner and by such means as may be necessary to insure the safety of the public and protection of property.

41-3-316. Actions brought against state, state engineer or employees prohibited.

(a) No action shall be brought against the state or the state engineer or any of his agents or employees for the recovery of damages caused by the partial or total failure of any dam, reservoir OR DIVERSION SYSTEM or damages caused by virtue of the operation of any dam, reservoir OR DIVERSION SYSTEM upon the ground that such defendants are liable by virtue of any of the following:

(i) The approval of the dam, reservoir OR DIVERSION SYSTEM or approval of flood handling plans during construction;

(ii) The issuance or enforcement of orders relative to maintenance or operation of any dam or reservoir;

(iii) Control and regulation of any dam, reservoir OR DIVERSION SYSTEM;

(iv) Measures taken to protect against failure during an emergency; or

(v) Failure to take an action required by the provisions of this act. Source: Laws 1977, ch. 120, 1.

41-3-317. Liability of reservoir owners.

Nothing in this act shall be construed to relieve an owner or owners of any reservoir, dam or diversion system of any legal duties, obligations or liabilities incident to their ownership or operation of or any damages resulting from the leakage or overflow of water or for floods resulting from the failure or rupture of the fill or
structure for such works. Source: Laws 1977, ch. 120, 1.

41-3-318. Penalties; cancellation of permit for failure to comply with sections 41-3-308 through 41-3-314.

Failure to comply with the provisions of W.S. 41-3-308 THROUGH 41-3-314 shall subject the permit to cancellation at any time. FAILURE TO COMPLY WITH ANY VALID ORDER ISSUED BY THE STATE ENGINEER PURSUANT TO W.S. 41-3-308 THROUGH 41-3-314, SHALL SUBJECT THE

PERMIT HOLDER TO A PENALTY NOT TO EXCEED FIVE HUNDRED DOLLARS ($500.000) PER DAY FOR EACH DAY THE VIOLATION CONTINUES. The state engineer is authorized to cancel any permit wherein the provisions of the above sections have not been, or are not being, complied with, and the cancellation shall operate as a forfeiture of all rights acquired under and by virtue of any permit theretofore approved by the state engineer. An appeal from any decision of the state engineer may be made to the board of control, and from the decision of the board of control appeal may be taken to the district court. Source: Laws 1903, ch. 69, 6; C.S. 1910, 748; C.S. 1920, 869; R.S. 1931, 122-1507; C.S. 1945, 71-607; W.S. 1957, 41-32; Laws 1977, ch. 120, 2.

CHAPTER 2

GLOSSARY

i. Definitions

This chapter provides basic terminology used in this guidebook. It is not a complete list but is meant to introduce some basic terminology. Other terminology may be obtained from dam safety books.

Abutment - That part of the valley side or concrete walls against which the dam is constructed. See Page 15. Right and left abutments are those on respective sides of an observer when viewed looking downstream.

Alterations - Such changes in the design of the dam as may directly affect the integrity of the dam and thereby affect the safety of persons, property or natural resources.

Appurtenant Works - The structures or machinery auxiliary to dams which are built to operate and maintain dams; such as outlet works, spillway, powerhouse, tunnels, etc.

Berm - A horizontal step or bench in the sloping profile of an embankment dam. See Pages 15 and 17.

Breach - A break, gap or opening (failure) in a dam which releases impoundment water. See Page 17.

Core - A zone of material of low permeability in an embankment dam. See Page 17.

Dam - A barrier built for impounding or diverting the flow of water.

Dike (Levee) - An embankment,, usually applied to embankments or structures built to protect land from flooding. See Page 17.

Drain, Layer or Blanket - A layer of pervious material in a dam to facilitate drainage. Includes toe drain, seephole and chimney drain. See Page 15.

Drawdown - The resultant lowering of water surface level due to release of water from the impoundment.

Embankment - Fill material, usually earth or rock, placed with sloping sides. See also Embankment Dam and Page 17.

Embankment Dam (Fill Dam) - Any dam constructed of excavated natural materials or of industrial waste materials. See Page 17.

Homogeneous Earth Fill Dam - An embankment constructed of similar earth material throughout, except for possible inclusion of drains. Used to differentiate from a zoned earth fill dam.

Zoned Embankment Dam - An embankment dam is composed of zones of selected materials having different degrees of porosity, permeability and density.

Emergency Action Plan - A predetermined plan of action to be taken to reduce the potential for property damage and loss of lives.

Engineer - A licensed or registered engineer in a given state; offers experience and expertise in the design and inspection of dams.

Failure - An incident resulting in the uncontrolled release of water from a dam.

Freeboard - The vertical distance between a stated water level and the top of a dam. See Page 15.

Gate or Valve - In general, a device in which a leaf or member is moved across the waterway to control or stop the flow.

Impoundment - Water or wastewater held back by a dam.

Instrumentation - Permanent devices which are installed in/near a dam to allow monitoring of the dam and impoundment. These devices may include a staff gage (to measure impoundment levels), piezometers, observation wells, settlement or alignment points, rain gage, etc. See Page 16.

Maintenance - The upkeep necessary for efficient operation of dams and their appurtenant works. It involves labor and materials, but is not to be confused with alterations or repairs.

Operator - The owner, or an agent or employee of the owner.

Outlet - An opening through which water can freely discharge for a particular purpose from an impoundment. See Page 15.

Owner - Any person who owns, leases, controls, operates, maintains or manages a dam or impoundment.

Phreatic Surface - The upper surface of saturation in an embankment. See Page 15.

Piping - The progressive development of internal erosion by seepage, appearing downstream as a hole or seam discharging water that contains soil particles.

Plunge Pool - A natural or sometimes artificially created pool that dissipates the energy of free-falling water. The pool is

located a safe distance downstream of the structure from which water is being released. See Stilling Basin and Page 15.

Repair - To essentially restore a dam to its approved design condition.

Riprap - A layer of large stones, broken rock or precast blocks placed in a random fashion on the upstream slope of an embankment dam, on a reservoir shore, or on the sides of a channel as a protection against wave and ice action. See Page 15.

Silt/Sediment - Soil particles and debris in an impoundment.

Slump Area - A portion of earth embankment which moves downslope, sometimes suddenly, often with cracks developing. See Page 17.

Spillway System - A structure over or through which flows are discharged. If the flow is controlled by gates, it is considered a controlled spillway; if the elevation of the spillway crest is the only control, it is considered an uncontrolled spillway. See Pages 15 and 17.

> **Emergency Spillway** - A secondary spillway designed to operate only during exceptionally large floods.
>
> **Principal spillway** - The main spillway for normal and flood flows.

Stilling Basin - A basin constructed to dissipate the energy of fast-flowing water, eg. from a spillway or bottom outlet, and to protect the river bed from erosion. See Plunge Pool. See Page 15.

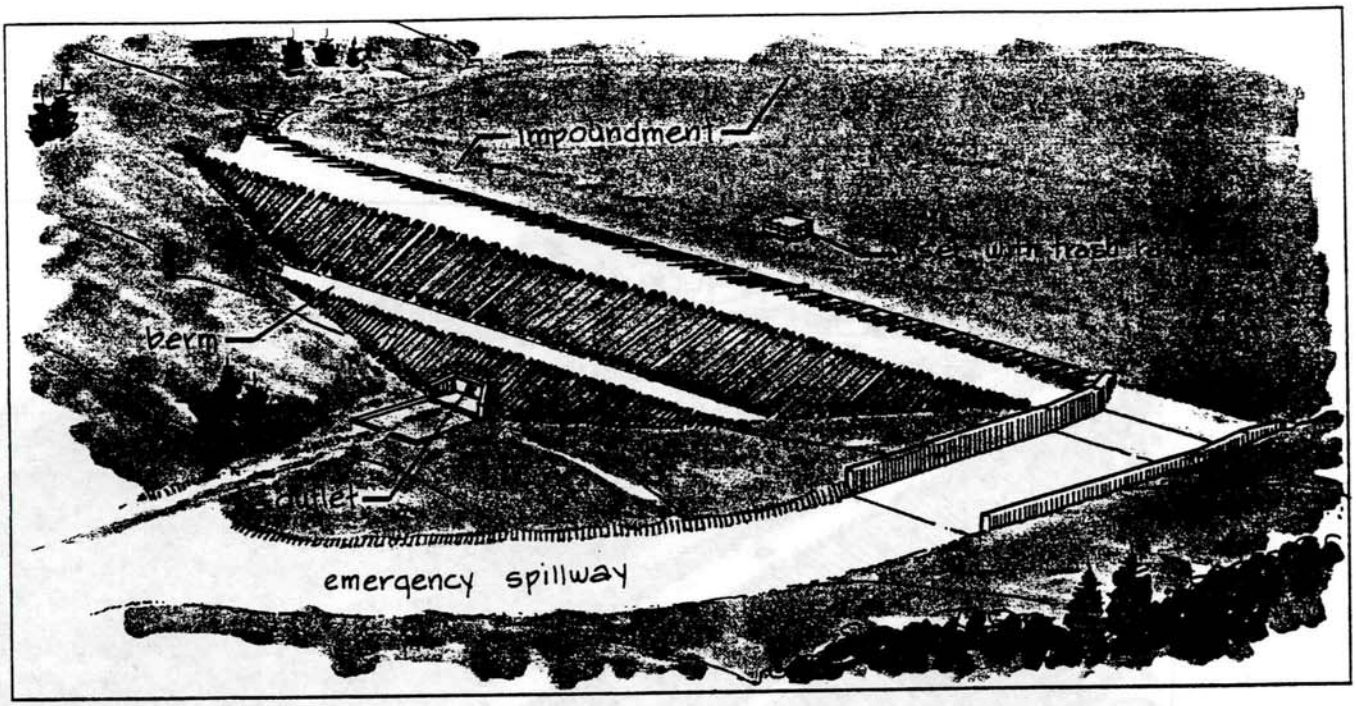
Stoplogs - Logs or timbers, steel or concrete beams placed on top of each other with their ends held in guides on each side of a channel or conduit.

Toe of Embankment - The junction of the face of the dam with the ground surface.

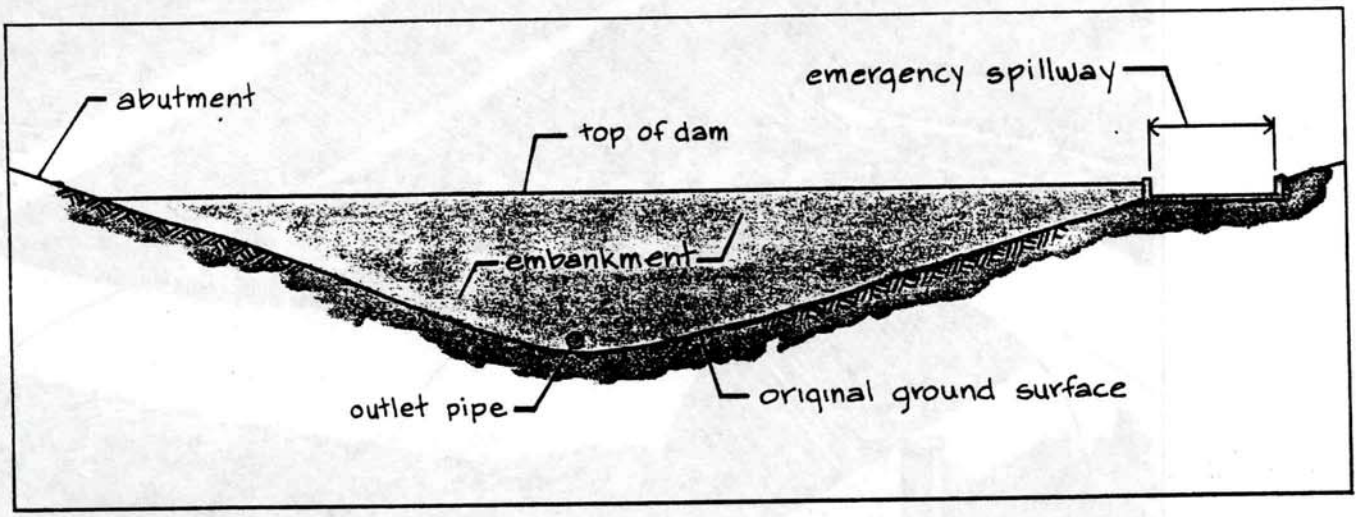
Trash Rack - A structure of metal or concrete bars located in the waterway at an intake to prevent the entry of floating or submerged debris.

Source: Dam Safety Guidebook
Prepared by: STS Consultants, Ltd.
3340 Ranger Road
Lansing, MT 48906

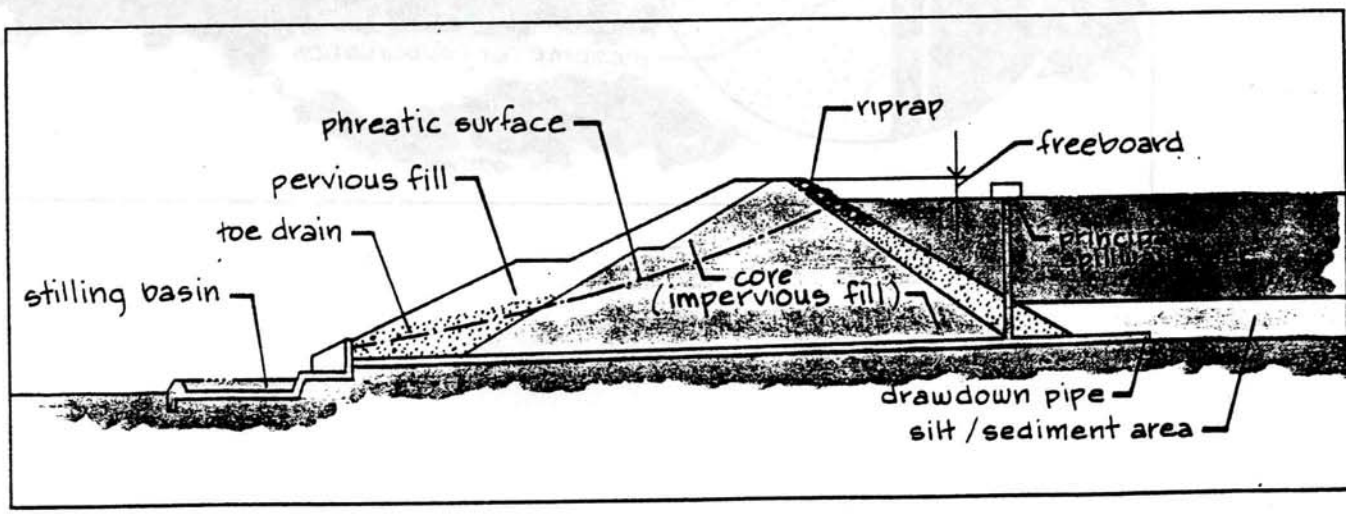
Through a grant from the
Federal Emergency Management Agency



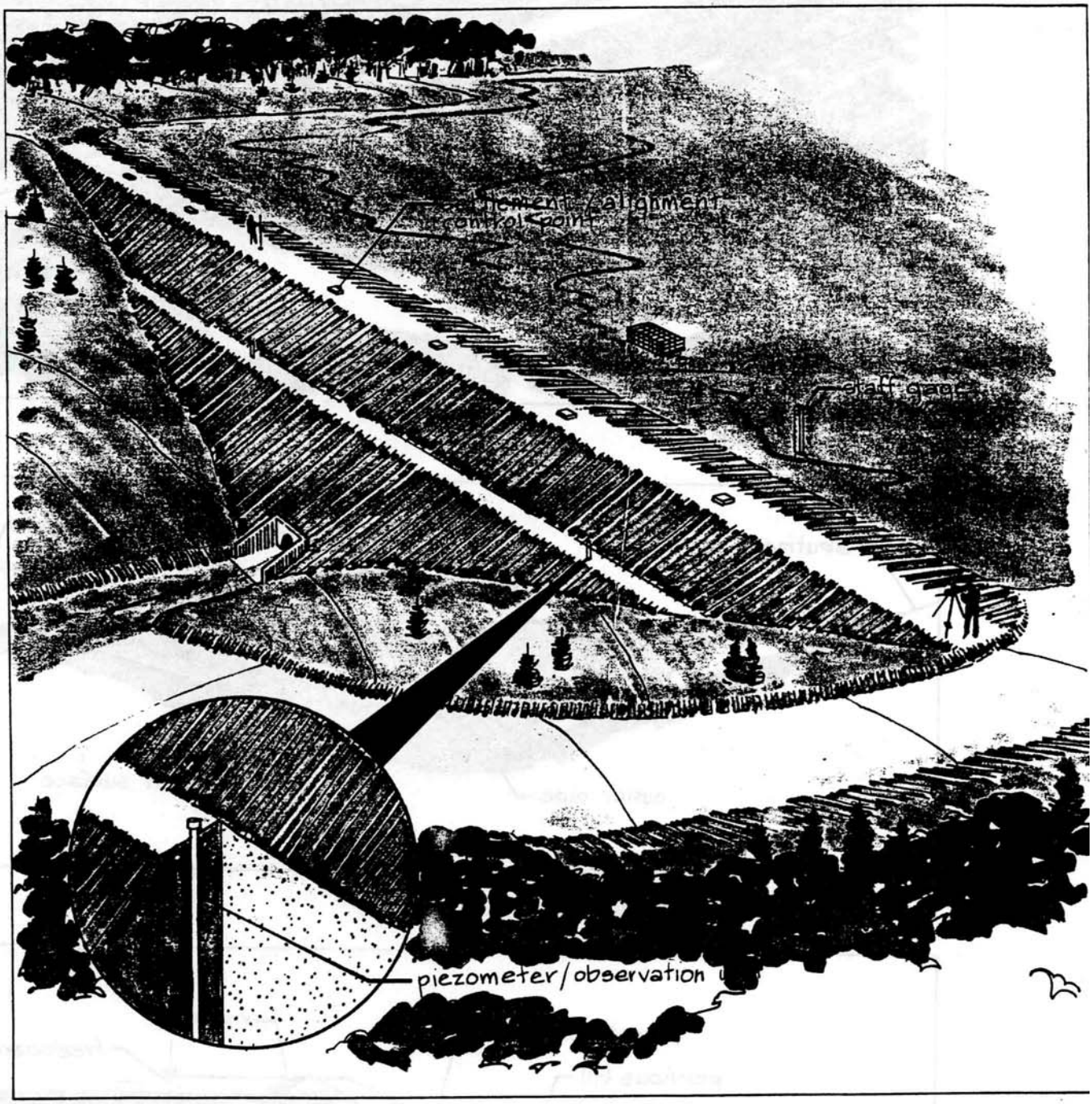
embankment dam



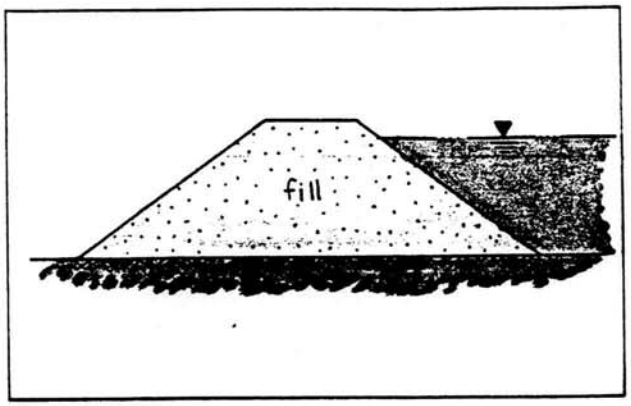
profile along crest dam



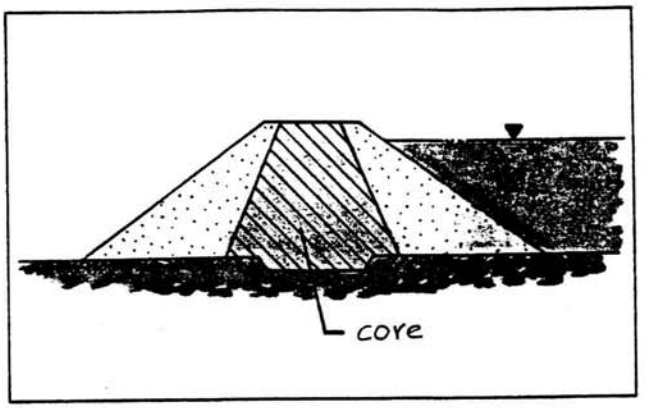
section thru dam



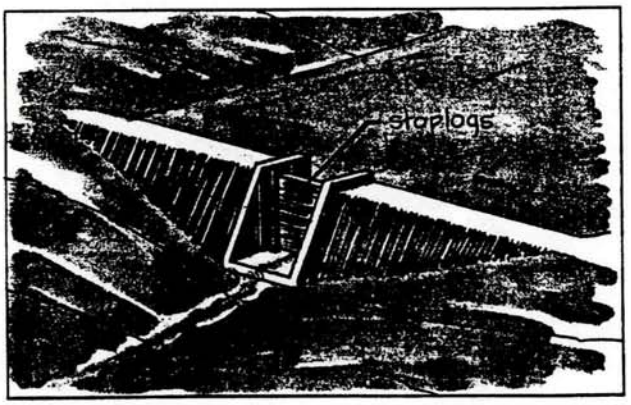
instrumentation



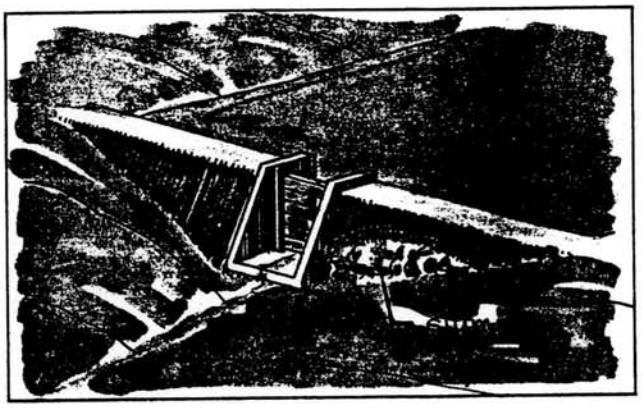
homogeneous earth fill dam



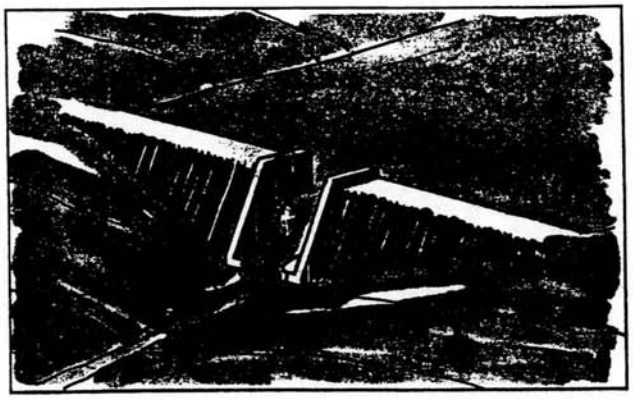
zoned embankment dam



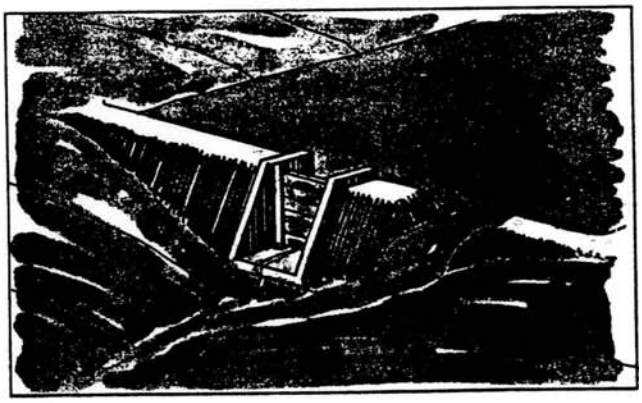
stoplogs



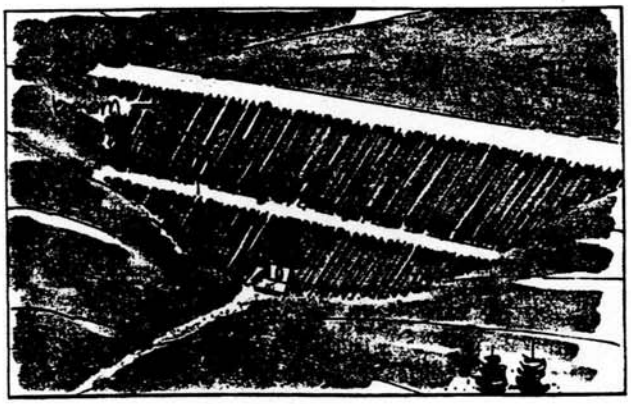
slump area



controlled drawdown



uncontrolled breach



berm



dike (levee)

ARTICLE 3 - RESERVOIRS

41-3-301. Application for reservoir construction permit; contents; procedure.

(a) Any person, corporation, association, or organization, of any nature whatsoever, hereafter intending to store or impound, for beneficial uses, any of the unappropriated waters of the state of Wyoming, shall, before commencing construction of any works for such purpose, or performing any work in connection with said proposed construction, make an application to the state engineer, for a permit to construct a reservoir. The application must set forth the name and post office address of the applicant; the source of the water supply; the nature of the proposed use; the location and description of the proposed work; the time within which it is proposed to begin construction, and the time required for the completion of construction. Maps and plans shall conform with the provisions of W.S. 41-4-510. In case of reservoirs where the storage is for stock purposes only and the capacity does not exceed twenty (20) acre-feet and the height of dam does not exceed twenty (20) feet, the state engineer may issue a permit without the filing of a map; however the state engineer may require certain information be submitted on special forms to be furnished or designated by him. Any violation of subsection (a) of this section shall be punishable pursuant to W.S. 41-3-616 with the exception that the owner of any unpermitted reservoir with a capacity of twenty (20) acre-feet or less and a dam height of twenty (20) feet or less shall have forty-five (45) days after receipt of the written notice of violation pursuant to W.S. 41-3-616(a), to submit an application for a permit. The application shall meet the requirements of the state engineer's office. Each day of the forty-five (45) days shall not be counted as a separate violation if the application for a reservoir permit is received during this forty-five (45) day period.

(b) For reservoir permits issued in conjunction with the national pollutant discharge elimination system (NPDES) for mining operations, the state engineer shall promptly review the application and advise the applicant in writing if it is complete, within thirty (30) days. If the application is complete, or is resubmitted to the satisfaction of the state engineer, it shall be approved or denied within forty-five (45) days of this determination:

(i) For the purpose of this subsection "complete" means that the application contains all the essential and necessary elements and is acceptable for further review for substance and compliance with the provisions of this chapter.

41-3-302. Application for construction permit; conditions; secondary permit; certificate of appropriation.

All applications under this article shall be subject to the provisions of W.S. 41-4-502 through 41-4-510, 41-4-517 and 41-3-615, which set forth the duties and authority of the state engineer and provide for the protection of the rights of applicants; provided that an enumeration of any lands proposed to be irrigated under this article shall not be required in the primary permit, provided, further, that any party or parties desiring to appropriate such stored water to particular lands may file with the state engineer an application for permit to be known herein as the secondary permit, in compliance with the provisions of W.S. 41-4-501 through 41-4-510 and 41-4-517. In the event secondary permit may be desired, said application shall refer to such reservoir for a supply of water and the state engineer shall not approve of said application and issue secondary permit until the applicant thereunder shall show to such state engineer by documentary evidence that he has entered into an agreement with the owners of the reservoir for a permanent and sufficient interest in said reservoir to impound enough water for the purposes set forth in said application. When beneficial use has been completed and perfected under the said secondary permit the division superintendent shall take the proof of the water user under such permit and the final certificate of appropriations shall refer to both the ditch described in the secondary permit and the reservoir described in the primary permit.

41-3-303. Use of stored water.

The use of water stored under the provisions of this chapter may be acquired under such terms as shall be agreed upon by and between the parties in interest. Lands entitled to the use of water in any reservoir may use the water stored therein, and to which they are entitled, at such times and in such amounts as the water users may elect, provided that a beneficial use of water is made at all times.

41-3-304. Use of bed of stream.

Whenever the owner, manager or lessee of a reservoir, constructed under the provisions of this act, shall desire the use of the bed of the stream, or other water course, for the purpose of carrying stored or impounded water from the reservoir to the consumer, or shall desire the use of any ditch to carry, convey or transmit any of the stored or impounded water for the benefit of any person having the right to have the reservoir water carried, conveyed or transmitted through the ditch under the laws of this state, he shall, in writing notify the water commissioner of the district in which the stored or impounded water is to be used, giving the date when it is proposed to discharge water from the reservoir, its volume in acre feet and the names of all persons and ditches entitled to its use, and other

matters as may be necessary to properly distribute the water. It shall then be the duty of the water commissioner to so adjust the headgates of all ditches of ditch companies or appropriators from the stream or water course, and the division boxes of individual consumers of water, not entitled to the use of the stored water, as will enable those having the right to secure the volume of water to which they are entitled. The commissioner shall not in any other manner interfere with the headgates or division boxes, except as otherwise provided by law. The water commissioner shall keep a true and just account of the time spent by him in the discharge of his duties as defined in this section, and it shall be the duty of the water commissioner or division superintendent to present a bill of one-half (1/2) the expense so incurred to the reservoir owner, manager or lessee, and if the owner, manager, or lessee shall neglect for three (3) days, after the presentation of the bills of costs, to pay the costs, the costs shall be made a charge upon the reservoir and shall be collected as delinquent taxes until the complete payment of the bill of costs has been made. Costs recovered under this section shall be paid into the general fund.

41-3-305. Direct flow storage.

The holder or owner of an adjudicated water right to the direct use of the natural unstored flow of any surface stream of the state may store such direct flow so long as no other Wyoming appropriator or user is injured or affected thereby. Prior to the commencement of the storage of water under a direct flow water right, the appropriator shall submit a request for such storage in writing to the state engineer and shall obtain the approval of the state board of control. The state board of control may permit storage at any time so long as there is no interference with existing water rights or uses. The state engineer is authorized and empowered to prescribe such rules and regulations as may be necessary or desirable to enable him to effectively administer the provisions of this section.

41-3-306. Instream stock use.

In the administration of water rights on any stream and in the consideration of any applications for permits, the state engineer may require that water be provided to meet reasonable demands for instream stock use.

41-3-307. Alterations or repairs of dams or diversion systems; definitions.

(a) As used in this act unless the context otherwise requires:

(i) "Alterations" or "repairs" means only such alterations or repairs as may directly affect the safety of the dam or diversion system, as determined by the state engineer or his designated representative;

(ii) "Appurtenant works" include, but are not limited to, such structures as spillways, either in the dam or separate therefrom, the reservoir and its rim, low level outlet works, and water conduits such as tunnels, pipelines or penstocks, either through the dam or its abutments;

(iii) "Dam" means any artificial barrier, including appurtenant works, used to impound or divert water and which is or will be greater than twenty (20) feet in height or with an impounding capacity of fifty (50) acre-feet or greater. "Dam" shall not include artificial barriers including appurtenant works:

(A) Six (6) feet in height or less, regardless of storage capacity; or

(B) Which impound less than fifteen (15) acre-feet, regardless of height.

(iv) "Days" used in establishing deadlines means calendar days, including Sundays and holidays;

(v) "Diversion system" means any channel diversion, headgate or diversion structure with a carrying capacity in excess of fifty (50) cubic feet of water per second of time;

(vi) "Emergency" means any threat to life or property caused by the condition of any dam, reservoir or diversion system, or by present or imminent floods which threaten the safety or structural integrity of any dam or diversion system;

(vii) "Emergency response agency" means any agency which the dam owner may be required to notify in case of an emergency, such as sheriff's office, highway patrol or local emergency coordinator;

(viii) "Enlargement" means any change in or addition to an existing dam or reservoir which raises or may raise the water storage elevation of the water impounded by the dam;

(ix) "Inspection" means visual or mechanical checks, measures, borings and any other methods necessary for determination of the adequacy of construction techniques, conformity of work with approved plans and specifications, and the safety and operating performance of a dam or diversion system and appurtenant works;

(x) "Owner" includes any of the following who own, control, operate, maintain, manage or propose to construct a dam or reservoir:

(A) The state and its departments, institutions, agencies and political subdivisions;

(B) Every municipal or quasi-municipal corporation;

(C) Every public utility;

(D) Every district;

(E) Every person;

(F) The federal government and its departments, institutions, agencies and political subdivisions;

(G) The duly authorized agents, lessees or trustees of any of the foregoing; and

(H) Receivers or trustees appointed by any court for any of the foregoing.

(xi) "Person" means any person, firm, association, organization, partnership, business trust, corporation or company;

(xii) "Reservoir" means any basin which contains or will contain impounded water;

(xiii) "This act" means W.S. 41-3-307 through 41-3-317.

41-3-308. Alterations or repairs of dams or diversion systems; plans and specifications; duties of state engineer.

(a) Plans and specifications of any proposed construction, enlargement, major repair, alteration or removal of a dam or diversion system shall be prepared by or under the direction of a registered professional engineer licensed to practice in the state of Wyoming and experienced in dam design and construction, and shall be submitted to the state engineer for approval. It is unlawful to commence construction, enlargement, major repair, alteration or removal until the plans and specifications have been approved by the state engineer. At the request of the state engineer, the professional engineer responsible for the plans and specifications shall carry out any revisions of the plans and specifications or provide such additional information as is necessary to justify or clarify the design.

(b) A copy of all plans and specifications submitted under this section shall be kept on file in the state engineer's office.

(c) In the event that a proposed dam or diversion system is related to a facility which requires an industrial siting permit pursuant to W.S. 35-12-106:

(i) The plans and specifications of the proposed dam or diversion system shall be submitted to the state engineer at the same time that the application for an industrial siting permit is submitted to the industrial siting administration [industrial siting council] pursuant to W.S. 35-12-108;

(ii) The state engineer shall approve or reject the plans and specifications of the proposed dam or diversion system prior to the public hearing conducted pursuant to W.S. 35-12-110(f)(i);

(iii) The approval or rejection of the plans and specifications of the proposed dam or diversion system shall be binding on the industrial siting council for the purposes of issuing an industrial siting permit.

(d) The state engineer shall provide for the regulation and supervision of all dams, diversion systems and reservoirs by the state to the extent required to protect the public safety and property. The state engineer is authorized and directed to promulgate regulations and standards for the design, construction, enlargement, alteration, abandonment, maintenance, monitoring, operation, repair and removal of dams, reservoirs, and diversion systems as are necessary and proper to carry out the purposes of this act. The state engineer may waive any or all of the requirements of this act in instances where the dam or diversion system is located in a remote area where there is no threat to the public safety or property.

41-3-309. Alterations or repairs of dams or diversion systems; inspections performed and reports submitted to state engineer by professional engineer.

(a) A registered professional engineer licensed to practice in the state of Wyoming shall be in charge of and responsible for the construction, enlargement, major repair, alteration or removal of any dam or diversion system.

(b) The engineer in charge shall provide for inspections at such intervals as deemed necessary to insure conformity with the approved plans and specifications, either by himself or by a person qualified to perform the inspections and for whose work the engineer stands personally responsible.

(c) All information obtained from, during or as the result of such inspection shall be made part of a report, certified to by the engineer in charge, which shall be submitted to the state engineer at such time or times as may be set by the state engineer.

(d) All reports submitted under this section shall be filed in the state engineer's office.

41-3-310. Alterations or repairs of dams or diversion systems; inspections by state engineer or assistant engineer; cost.

(a) If the state engineer believes that inspections carried out under W.S. 41-3-309 are inadequate or that additional inspections are necessary, the state engineer may inspect personally or appoint an assistant engineer to inspect the construction, enlargement, repair, alteration or removal of any dam or diversion system. If after any inspection the state engineer or his representative finds that amendments, modifications or changes are necessary in order to insure the security and integrity of the work and structure, the protection of property or the public safety, the state engineer may order the owner or owners of the dam or diversion system to revise the plans and specifications, or order work stopped. It is unlawful to proceed with or continue the work until any revisions have been approved by the state engineer.

(b) Any inspections required by this section shall be made at state expense, provided the assistant engineer performing such inspections is an employee of the state of Wyoming.

(c) If the assistant engineer is not a regular employee of the state of Wyoming, inspections shall be made at the expense of the owner. The owner shall be furnished with an estimate of the cost prior to performance of any inspections, but the state engineer is not precluded from collecting any or all additional costs which result from performance of the inspections. Costs to be paid by the owner shall include, but are not limited to, all work or tests as are necessary to fully provide any information and data required by the state engineer or his appointed representative. If the owner refuses or neglects to turn over the funds within thirty (30) days, after the presentation of the bill of costs, the costs shall constitute a lien upon the works or other properties of the owner or owners and may be collected by appropriate action in any court of competent jurisdiction. In order to have a valid, enforceable lien under this section, a lien statement sworn to before a notarial officer shall be filed by the claimant with the county clerk of the county in which the property is located. The county clerk shall file the statement and index by date, name of claimant and property owner, and by legal description. The lien statement shall contain the following:

(i) The name and address of the governing body seeking to enforce the lien;

(ii) The name and address of the person against whose property the lien is filed; and

(iii) The legal description of the property to which the lien attaches.

(d) All funds paid by the owner to the state engineer shall be deposited in the state engineer's holding account from which account the costs incurred as a result of any inspections or other work deemed necessary under this section shall be paid. Any funds not so expended shall be returned to the person or persons advancing the funds.

41-3-311. Alterations or repairs of dams or diversion systems; periodic inspections.

(a) Any dam subject to the terms of this act shall be inspected at least once every ten (10) years or as often as deemed necessary based on the hazards of the dam to insure the continued protection of public safety and property.

(b) Inspections referred to in subsection (a) of this section shall be performed by the state engineer or his appointed representative who shall have right of entry upon private or government lands and is authorized to inspect the owner's technical data and other documentation as may be necessary to perform these inspections. All information obtained as a result of the inspections shall be filed in the state engineer's office.

(c) Inspections required under this section shall be made at state expense except as provided in W.S. 41-3-312 when a dam, reservoir or diversion system is found to be unsafe by the state engineer.

(d) If inspections performed under this section disclose defects in the works which in the judgment of the state engineer or his authorized agent constitute a threat to life or property, the state engineer may, without incurring any liability, order the draining of any reservoir involved, or the limitation or cessation of its use or the use of any defective works until such time as the owner of the reservoir or other works returns the works to a safe condition as approved by the state engineer.

41-3-312. Alterations or repairs of dams or diversion systems;

inspections at other than regular times; cost; unsafe structures.

(a) The state engineer may, or upon written request from any person or persons residing on or owning land near any dam, reservoir or diversion system shall, order an inspection of those works at any time other than the time set for regular inspections as provided for in W.S. 41-3-311(a). Before ordering an inspection, the state engineer may require any person or persons requesting the inspection to deposit a sum of money sufficient to pay the expenses of the inspection into the state engineer's holding account. If after the inspection the dam, reservoir or diversion system is determined to be in a safe and usable condition, the state engineer may cause the whole or part of the expenses of the inspection to be paid out of the state engineer's holding account. Any excess funds shall be returned to the person or persons advancing the funds.

(b) If the dam, reservoir or diversion system is found to be defective, any funds deposited by the person or persons requesting the inspection shall be returned and the state engineer may require the person or persons owning the dam, reservoir or diversion system in question to pay the whole or any part of the expenses of inspection. If the state engineer requires a payment, he shall present a bill of costs to the owner or owners, and if the owner or owners refuse or neglect to pay the costs within thirty (30) days after the presentation of the bill of costs, the costs shall constitute a lien upon the works or other properties of the owner or owners and may be collected by appropriate action in any court of competent jurisdiction. If the inspection discloses defects in the works which in the judgment of the state engineer or his authorized agent constitute a threat to life or property, the state engineer may, without incurring any liability, order the draining of any reservoir involved, or the limitation or cessation of its use or the use of any defective works until such time as the owner of the reservoir or other works returns the works to a safe condition as approved by the state engineer. The lien shall be filed as provided by W.S. 41-3-310(c).

41-3-313. Alterations or repairs of dams or diversion systems; outlets; maintenance; draining by breaching.

(a) All dams and reservoirs hereafter constructed, with or without a controlled inlet, shall contain an outlet controlled by a headgate or other control works. The headgate or control works shall be maintained in an operable condition at all times and in a manner that water impounded by or within a dam or reservoir may be evacuated or maintained at any water level which may be required by the state engineer.

(b) All dams constructed prior to the effective date of this act which have no outlet or means for lowering the reservoir water level in an expeditious manner, may be drained by breaching at the owner's expense when the public safety so requires.

(c) The state engineer and anyone working under his direction and control shall not be held liable for any damages or loss of water resulting from the draining or imposed restrictions as to the use of a reservoir, dam or diversion system.

(d) If within thirty (30) days after presentation of an itemized statement the owner fails to reimburse the state engineer for expenses incurred under this section, any unpaid balance of such expense shall automatically constitute a lien upon lands or other properties of the owner.

41-3-314. Alterations or repairs of dams or diversion systems; emergency repairs or breaching.

(a) In case of an emergency where the state engineer or his authorized representative declares that repairs or breaching of a dam or diversion system are immediately necessary to safeguard life and property, the necessary repairs or breaching shall be started immediately by the owner or by the state engineer or his representative at the owner's expense, if the owner fails to do so. The state engineer and emergency response agencies shall be notified at once of any changes in the physical conditions of the dam, diversion system, or reservoir which significantly increase the probability of failure of the dam or diversion works or the danger to life or property, proposed emergency repairs or breaching to be instituted by the owner. These reporting requirements shall apply only to cases in which an emergency has been declared pursuant to this subsection.

(b) If emergency repairs have been made and the emergency situation has passed, the owner shall commence all repairs necessary to return the dam or diversion system to a safe and usable condition, as provided in W.S. 41-3-308 through 41-3-310.

(c) All costs incurred by the state engineer during an emergency shall be payable by the owner or owners on receipt of the bill of costs from the state engineer. Costs not paid within thirty (30) days after presentation of the bill shall constitute a lien upon the dam or diversion system or other properties of the owner or owners and may be collected by appropriate action in any court of competent jurisdiction. The lien shall be filed as provided by W.S. 41-3-310 (c).

41-3-315. Alterations or repairs of dams or diversion systems; enforcement of provisions.

For any reservoir the state engineer may enforce any sections of this act in such manner and by such means as may be necessary to insure the safety of the public and protection of property.

41-3-316. Alterations or repairs of dams or diversion systems; actions brought against state, state engineer or employees prohibited.

(a) No action shall be brought against the state or the state engineer or any of his agents or employees for the recovery of damages caused by the partial or total failure of any dam, reservoir or diversion system or damages caused by virtue of the operation of any dam, reservoir or diversion system upon the ground that such defendants are liable by virtue of any of the following:

(i) The approval of the dam, reservoir or diversion system or approval of flood handling plans during construction;

(ii) The issuance or enforcement of orders relative to maintenance or operation of any dam or reservoir;

(iii) Control and regulation of any dam, reservoir or diversion system;

(iv) Measures taken to protect against failure during an emergency; or

(v) Failure to take an action required by the provisions of this act.

41-3-317. Alterations or repairs of dams or diversion systems; liability of owners.

Nothing in this act shall be construed to relieve an owner or owners of any reservoir, dam or diversion system of any legal duties, obligations or liabilities incident to their ownership or operation of or any damages resulting from the leakage or overflow of water or for floods resulting from the failure or rupture of the fill or structure for such works.

41-3-318. Penalties, cancellation of permit, for failure to comply with W.S. 41-3-308 through 41-3-314.

Failure to comply with the provisions of W.S. 41-3-308 through 41-3-314 shall subject the permit to cancellation at any time pursuant to W.S. 41-3-616(c). Failure to comply with any valid order issued by the state engineer pursuant to W.S. 41-3-308 through 41-3-314, shall subject the permit holder to penalty pursuant to W.S. 41-3-616(b).

41-3-319. Owners of ditches and reservoirs; general rights.

Each owner of a share or shares of the capital stock in an incorporated ditch company existing for the purpose of distributing water through such company's ditch to the owners of such stock, shall have the right to carry, convey and transmit reservoir water, supplementing other water rights he may possess, through the ditch of such ditch company in which he may have such stock, to the full extent of the carrying capacity represented by such stock, but no greater. Each partner in a partnership ditch owned or used for a like purpose, shall have the right to carry, convey and transmit reservoir water, supplementing other water rights he may possess, through such partnership ditch, to the full extent of the carrying capacity represented by his interest, as a partner, in such ditch, but no greater. Every such person carrying, conveying and transmitting water through such ditch, or having the same done for his benefit, shall pay all expenses incurred by reason of all extra labor in cleaning such ditch, change of division boxes, and other additional expenses made necessary by reason of carrying such reservoir water through any such ditch. The right herein granted to any person, shall also extend to the owner, manager or lessee of a reservoir, who desires to use any such ditch to carry, convey or transmit water through such ditch for the benefit of any such person to whom the right herein mentioned has been granted as aforesaid.

41-3-320. Owners of ditches and reservoirs; sale or lease of impounded water.

Except as otherwise provided by deed or other written instruments of the owner or owners of the right to impound water in any reservoir, such reservoir owner or owners shall, after the completion of the works in connection with such reservoir, be held to be the owner of the right to impound the water, and the right to sell or lease a portion or all his right to the impounded waters; provided, that the sale of any portion of the capacity of any reservoir shall carry with it an interest in the reservoir and works appurtenant thereto of such proportion as the portion sold bears to the total capacity of the reservoir; and provided, further, that the water stored in any reservoir cannot be used outside the boundaries of the state of Wyoming without special permit from the state engineer; and provided, further, that the state engineer may deny any use of water from any reservoir that would be detrimental to the public interest.

41-3-321. Owners of ditches and reservoirs; priority of right to store or impound.

The priority of right to store or impound water under this act shall date from the filing of the application in the state engineer's office.

41-3-322. Owner's report of persons entitled to use water; superintendent's report of use of water.

The owner of each reservoir shall annually, in writing, before or during the irrigating season and before the releasing of the water from the reservoir, deliver to the water commissioner having jurisdiction over such reservoir a list or lists of parties entitled to use water from such reservoir during the irrigating season of such year, and also a list as near as may be of the lands proposed to be irrigated, and shall immediately notify such water commissioner of any changes in such list or lists. The superintendent of the water division in which such reservoir is situated shall annually on or before the first day of December in each year make a written report to the state engineer of the state, enumerating in detail the person or persons who during the irrigating season immediately preceding use any part of such reservoir water, and shall also enumerate therein the lands upon or uses for which said water was applied during such irrigating season so that the state engineer may be kept at all times advised as to whether or not such water has been applied to beneficial uses.

41-3-323. Deeds for water rights; attaching of rights to land; sale, lease, transfer or use.

The reservoir water and rights acquired under reservoir permits and adjudications shall not attach to any particular lands except by deed, or other sufficient instrument conveying such water or water rights, executed by the owner or owners of such reservoir, and such water and water rights, except when attached to particular lands as aforesaid, may be sold, leased, transferred and used in such manner and upon such lands as the owner of such rights or partial rights may desire, provided, that such water must be used for beneficial purposes.

41-3-324. Deeds and leases for water rights; execution and recording.

All deeds for reservoir water and water rights and all leases of the same for periods of three (3) years or more shall be executed and acknowledged as deeds are executed, and shall be recorded in the

office of the county clerk of the county in which the reservoir is situated and also filed in the office of the state engineer. All leases of such water and water rights for a period less than three (3) years shall be in writing and filed in the office of the state engineer.

41-3-325. Excess stored water to be furnished applicants; preferences; rates.

The owner or owners of a reservoir impounding a greater quantity of water than the owner or owners thereof necessarily use for irrigation and other beneficial purposes in connection with their own lands shall, when application is made to them for that purpose, furnish such surplus water at reasonable rates to the owners of lands lying under and capable of being irrigated from such reservoir for the purpose of irrigating and rendering the same productive, and maintaining their productiveness, and in case of refusal so to do, the owner or owners of such reservoir may be compelled by proper proceedings to furnish such water on such reasonable terms as to the court may seem meet and proper. The water user who may have used any water from such reservoir for any particular year shall have the preference as to the use of the same water for the next ensuing year. The state engineer, the water commissioner of the particular district and the water superintendent having jurisdiction over the region of any reservoir, shall together constitute a board of special commissioners, and shall have power, when application is made to them by either party interested, to establish reasonable maximum rates to be charged for the use of water from any reservoir, whether furnished by individuals or a corporation. The establishment of such rate shall be made only after notice given and public hearing had, at which hearing the applicants may produce witnesses and evidence, and such witnesses must be sworn and may be cross-examined. No commissioner shall sit upon such board and determine such rate who is employed by one (1) of the applicants or if the relationship of debtor or creditor exists between him and one (1) of the applicants. Nothing contained in this section shall be construed to deny the right to store water for use for more than one (1) year.

41-3-326. Applicability of ownership provisions.

The provisions of this act shall apply to reservoirs heretofore lawfully constructed as well as to all reservoirs hereafter lawfully constructed.

41-3-327. Carey Act lands.

This act shall not apply to Carey Act lands or reservoirs for their

irrigation, nor to any water right or rights to the use of waters of natural streams of this state, initiated from such streams and used through any such reservoir. All acts and parts of acts in conflict herewith, excepting such as relate to Carey Act lands, are hereby repealed.

41-3-328. Witnesses' fees and mileage.

Every witness who shall attend before the court, or the judge thereof in vacation, or before the person appointed to take testimony in causes relating to water rights, under subpoena, by request of any party, shall be entitled to the same fees and mileage as witnesses in civil cases in the district court, and shall be paid by the party requiring the testimony.

41-3-329. Change in point of diversion.

(a) The storage of water by means of a reservoir is a diversion, and the point of diversion is the point defined in the permit where the longitudinal axis of the dam crosses the center of the streambed.

(b) A change in point of diversion of a reservoir may be granted pursuant to W.S. 41-3-114 by the state engineer if the water right is unadjudicated, or by the state board of control if the water right has been adjudicated. No petition shall be granted if the rights of other appropriators shall be injuriously affected thereby or if the change is not within the original project concept. In deciding whether to grant or deny a proposed change in point of diversion of a reservoir within the original project concept, the state engineer or the board of control shall consider:

(i) The distance between the old point of diversion and the new point of diversion;

(ii) The water administration problems which may be created by granting the change in the point of diversion;

(iii) The effect of the petition upon Wyoming's entitlement to water under compacts, court decrees and treaties;

(iv) The rights of other appropriators; and

(v) The safety aspects of the new point of diversion.

Appendix F. Association of State Dam Safety Officials (ASDSO) Summaries

F.1 Size Classification Schemes
F.2 Hazard Classification Schemes



FEMA

F.1. Size Classification Schemes



STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

	Very Large	Large	Intermediate	Small	Minor	Notes
AL						*Not defined; Alabama currently has no dam safety legislation or formal dam safety program. Source: Dam Safety Model Program Jurisdictional definition: Section 6. (a) The following low hazard potential dams are not required to be included in the inventory of dams maintained pursuant to this act: (1) Any dam which is less than six feet in height, regardless of its storage capacity. (2) Any dam which has an impounding storage capacity at maximum water storage elevation of less than 15 acre-feet, regardless of its height.
AK						Source: Dam Safety Model Program To determine if a dam is under state jurisdiction, AS 46.17.900(3) defines a dam as an "artificial barrier and its appurtenant works, which may impound or divert water" and which meets at least one of the following three descriptions "(A) Has or will have an impounding capacity at maximum water storage elevation of 50 ac-ft and is at least 10 ft in height measured from the lowest point at either the upstream or downstream toe of the dam to the crest of the dam." A dam with a jurisdictional height (H) of 10 feet or taller and that stores 50 acre-feet or more of water meets this description, as illustrated in figure 2-1. "(B) is at least 20 feet in height measured from the lowest point at either the upstream or downstream toe of the dam to the crest of the dam." A dam that is 20 ft or more in height meets this dexcription regardless of its storage capacity, as illustrated in figure 2-2. "(C) Poses a threat to lives and property as determined by the department after an inspection." In other words, a barrier with a Class I (high) or Class II (significant) hazard potential classification is considered a dam, even if it does not meet the geometric criteria of A or B, above. See section 2.4 for guidance in determining the hazard potential classification.
AZ	N/A	"Large Dam"- Maximum storage greater than or equal to 50,000 ac-ft; height greater than or equal to 100 ft.	"Intermediate Dam"- Maximum storage between 1,001 and 50,000 ac-ft; height between 41 and 100 ft.	"Small dam"- Maximum storage between 50 and 1,000 ac-ft; height between 25 and 40 ft.	N/A	Source:http://www.azwater.gov/AzDWR/SurfaceWater/DamSafety/HazardandSizeClassifications.htm Owner or engineer determines size by storage capacity or height, whichever results in the larger size.
AR	N/A	"Large Dam"- Maximum storage greater than or equal to 50,000 ac-ft; height greater than or equal to 100 ft.	"Intermediate Dam"- Maximum storage between 1,000 and 50,000 ac-ft; height between 40 and 100 ft.	"Small dam"- Maximum storage between 50 and 1,000 ac-ft; height between 25 and 40 ft.	N/A	Source: http://www.anrc.arkansas.gov/TITLEVII.pdf Section 705.3

STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

CA						Source: Dam Safety Model Program “Dam means any artificial barrier, together with appurtenant works, which does or may impound or divert water, and which either a) os pr will be 25 feet or more in height from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the department, or from the lowest department, if it is not across a stream channel or watercourse, to the maximum possible water storage elevation or b) has or will have an impounding capacity of 50 acre-feet or more.” A chart indicating jurisdictional and non-jurisdictional dam and reservoir sizes can be found at http://www.water.ca.gov/damsafety/images/JurisChart5.jpg
CO	N/A	"Large Dam" is a dam greater than 50 feet in jurisdictional height, and/or greater than 4,000 acre-feet in capacity.	N/A	“Small Dam" is a dam with a jurisdictional height greater than 20 feet but less than or equal to 50 feet and/or a reservoir capacity greater than 100 acre-feet, but less than 4,000 acre-feet.	"Minor Dam" is a jurisdictional size dam that does not exceed 20 feet in jurisdictional height and/or 100 acre-feet in capacity.	Source: http://water.state.co.us/pubs/rule_reg/ds_rules07.pdf Rules and Regulations for Dam Safety and Dam Construction, Rule 4. Jurisdictional height is defined in Rule 4.2.19. The State Engineer shall have final authority over determination of the jurisdictional height of the dam.
CT						Not defined Source: Dam Safety Model Program Jurisdictional definition: Any barrier of any kind whatsoever capable of impounding or controlling the flow of water, including but not limited to storm water retention or detention dams, flood control structures, dikes, & incompletely breached dams.
DE						Not defined Source: Dam Safety Model Program Jurisdictional definition: "Dam" shall mean any artificial barrier, including appurtenant works, with the ability to impound or divert water, wastewater, or liquid-borne materials. No obstruction in a canal used to raise or lower water shall be considered a dam. A fill or structure for highway or railroad use, or for any other purpose that may impound water, may be subject to review by the Department and shall be considered a dam if the criteria in these Regulations are found applicable and if it is classified as a high hazard potential or significant hazard potential dam.
FL						Source: http://www.damsafety.org/map/state.aspx?s=9 A dam is "any artificial or natural barrier, with appurtenant works, raised to obstruct or impound, or which does obstruct or impound, any of the surface waters of the state." There was nothing is the legislation concerning height and volume definitions. Dam height is not defined in the laws. Dams are not classified by any type of criteria in the laws.
GA	“Very large	“Large dam"-	“Medium dam"-	“Small dam"-	N/A	Source: http://rules.sos.state.ga.us/docs/391/3/8/02.pdf

STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

	dam"- storage capacity exceeding 50,000 acre-feet; height exceeding 100 feet.	storage capacity exceeding 1000 acre-feet but not exceeding 50,000 acre-feet; height exceeding 35 feet but not exceeding 100 feet.	storage capacity exceeding 500 acre-feet but not exceeding 1000 acre-feet; height exceeding 25 feet but not exceeding 35 feet.	storage capacity not exceeding 500 acre-feet; height not exceeding 25 feet.		Georgia Code Title 12 Section 12-5-376.1. Applies to Category I dams only. (Category II dams – those for which improper operation or failure would not be expected to result in probable loss of human life - are not classified by size.) Georgia Code Title 12 Section 12-5-376.1.
HI	N/A	"Large Dam"- Storage capacity of 50,000 acre-feet or greater; height of 100 ft or greater.	"Intermediate Dam"- Storage capacity exceeding 1,000 acre-feet but less than 50,000 ac-ft; height of at least 40 ft, and less than 100 ft.	"Small Dam"- Storage capacity of at least 50 acre-feet but not exceeding 1000 acre-feet; height of at least 25 ft, but not exceeding 40 ft.	N/A	Source: http://state.hi.us/dlnr/eng/ds/guides/HI%20Inspection%20Guidelines.pdf Chapter 2, Guidelines for Safety Inspection of Dams
ID	N/A	"Large Dam"- Storage capacity of 4000 ac-ft. or more OR a height of 40 ft. or more.	"Intermediate Dam"- Storage capacity of 100 ac-ft or more, but less than 4000 ac-ft, OR more than 20 ft. in height, but less than 40 ft.	"Small Dam"- Storage capacity less than 100 ac-ft and 20 ft. or less in height.	N/A	Source: http://www.adm.idaho.gov/adminrules/rules/idapa37/0306.pdf 37.03.06- Safety of Dam Rules
IL	N/A	"Large Dam"- Storage capacity more than 50,000 ac-ft; height more than 100 ft.	"Intermediate Dam"- Storage capacity ranging from 1,000 to 50,000 ac-ft; height of 40-100 ft.	"Small Dam"- Storage Capacity less than 1000 ac-ft; height less than 40 ft.	N/A	Source: Dam Safety Model Program
IN						Not listed Source: Dam Safety Model Program Jurisdictional definition: IDNR currently regulates all dams that meet any one of the following criteria: (1) the drainage area above the dam is greater than 1 square mile (2) the dam embankment is greater than 20 feet high (3) the dam impounds more than 100 acre-feet
IA		"Major dam structure" means		"Low head dam" means any dam		Source: Dam Safety Model Program

		a dam meeting any of the following criteria: 1. Any high hazard dam. 2. Any moderate hazard dam with a permanent storage exceeding 100 acre-feet or a total of permanent and temporary storage exceeding 250 acre-feet at the top of the dam elevation. 3. Any dam, including low hazard dams, where the height of the emergency spillway crest measured above the elevation of the channel bottom at the centerline of the dam (in feet) multiplied by the total storage volume (in acre-feet) to the emergency spillway crest elevation exceeds 30,000. For dams without emergency spillways, these measurements shall be taken to		essentially contained within the channel of a river or stream and which is overtopped by normal stream flows.		

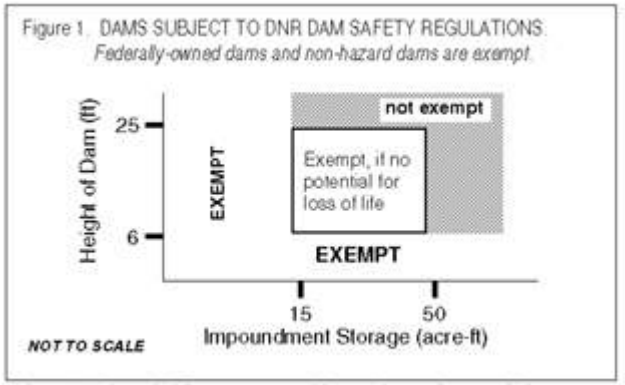
STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		the top of dam elevation.				
KS	N/A	“Class Size 4”- A size factor of more than 30,000.	“Class Size 3”- A size factor of 3,000 to 30,000	“Class Size 2”- A size factor of less than 3,000.	“Class Size 1”- Height of less than 25 feet and an effective storage of less than 50 acre-feet.	Source: Dam Safety Model Program
KY						Not defined Source: Dam Safety Model Program Jurisdictional definition: Kentucky statutes (KRS 150.100) defines a dam as any artificial barrier (including appurtenant works) which does, or can, impound or divert water and is, or will be 1) 25 feet or more high from the natural bed of the stream or watercourse at the downstream tow of the barrier, as determined by the Department for Environmental Protection, or 2) has, or will have an impounding capacity of fifty acre-feet or more at the maximum water storage elevation.
LA						Correlated with hazard classification Source: Dam Safety Model Program Jurisdictional definition: For the purposes of this Chapter, a dam is any artificial barrier, including appurtenant works, which does or will impound or divert water or any other liquid substance and which (1) is or will be twenty-five feet or more in height from the bed of the watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum water storage elevation or (2) has or will have an impounding capacity at maximum water storage elevation of fifty acre-feet or more. This definition does not include any dam or barrier that is not or will not be in excess of six feet in height, regardless of storage capacity or which has or will have a storage capacity of maximum water storage elevation not in excess of fifteen acre-feet, regardless of height.
ME						Not listed Source: Dam Safety Model Program Jurisdictional definition: "Dam" means any artificial barrier, including appurtenant works, the site on which it is located and appurtenant rights of flowage and access, that impounds or diverts water, and that: A. Is 25 feet or more in height from the natural bed of the watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier to the maximum water storage elevation and impounds at least 15 acre-feet of water; or [2001, c. 460, §3 (NEW).] B. Is 6 feet or more in height from the natural bed of the watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier to the maximum water storage elevation and has an impounding capacity at maximum water storage elevation of 50 acre-feet or more. [2001, c. 460, §3 (NEW).]
MD	N/A	“Category I” is a	“Category II” is a	“Category III” is	N/A	Source: Dam Safety Model Program

STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		dam with a normal pool storage of 20,000 ac-ft or more, a normal vol. depth of 50 ft or more, probable loss of life, and potential for serious damage to residential, industrial, or commercial buildings, public roads, or RR.	dam with a normal pool storage greater than 1000 ac-ft and less than 20,000 ac-ft, a normal vol. depth greater than 25 ft and less than 50 ft, small possibility for loss of life, and located in predominately rural or agricultural areas where failure may cause damage to isolated residence or cause interruption of use or service of public utilities or roads. Damage is within financial capability of owner to repair.	a dam with a normal pool storage less than 1000 ac-ft, a normal vol. depth less than 25 ft, and potential loss of life is very unlikely. Damage is of same magnitude as cost of dam and within financial capability of owner to repair.		
MA	N/A	"Large Dam"- 1000 ac-ft of storage or greater; height greater than or equal to 40 ft.	"Intermediate Dam"- Storage of at least 50 ac-ft, but not exceeding 1000 ac-ft; height of at least 15 ft but not greater than 40 ft.	"Small Dam"- Storage of at least 15 ac-ft but not exceeding 50 ac-ft; height of at least 6 ft but not greater than 15 ft.	"Non-jurisdictional Dam"- Storage not in excess of 15 ac-ft regardless of height; height not in excess of 6 ft, regardless of storage capacity.	Source:http://www.mass.gov/dcr/pe/damSafety/downloads/DCR%20Dam%20Safety%20Regulations.pdf For dams not in excess of 25 feet in height or having maximum impounding capacity not in excess of 50 acre-feet, the Commissioner shall make jurisdictional determination by taking into consideration factors or combination of factors such as height, type of structure, volume of the impoundment, extent of downstream development, and other factors deemed appropriate by the Commissioner.
MI						Not defined Source: Dam Safety Model Program Jurisdictional definition: Dams are regulated by Part 315 when they are over 6 feet in height and over 5 acres are impounded during the design flood. Dams are regulated by Part 307 when a circuit court issues an order establishing the level at which the lake is to be maintained.
MN						Source: Dam Safety Model Program

STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

						Jurisdictional definition: State dam safety regulations apply only to structures that pose a potential threat to public safety or property. The potential for damage downstream if a dam fails increases as the height of the dam and the volume of impounded water increases. State dam safety rules do not apply to dams that are so low or retain so little water as to not pose a threat to public safety or property. Dams 6 feet high or less, regardless of the quantity of water they impound, and dams that impound 15 acre-feet of water or less, regardless of their height, are exempt from state dam safety rules. Dams that are less than 25 feet high and impound less than 50 acre-feet are also exempt from state dam safety rules unless there is a potential for loss of life due to failure or misoperation. Figure 1 shows these criteria in a graphical form.  About 900 dams in Minnesota are subject to dam safety regulations.
MS		Large dams are greater than 50 feet in height. and Large lakes are greater than 1,000 acre-feet maximum storage.	Medium dams are greater than 25 feet and less than 50 feet in height. Medium lakes are greater than 150 acre-feet maximum storage and less than 1,000 acre-feet maximum storage.	Small dams are those less than 25 feet in height. Small lakes are less than 150 acre-feet maximum storage.		Source: MS DEQ, Sept. 2010 Size classification found in design guidelines. Requirements depend on hazard classification (Low, Significant or High), the dam height (Small dams are those less than 25 feet in height, Medium dams are greater than 25 feet and less than 50 feet in height and Large dams are greater than 50 feet in height), and the storage volume (Small lakes are less than 150 acre-feet maximum storage, Medium lakes are greater than 150 acre-feet maximum storage and less than 1,000 acre-feet maximum storage and Large lakes are greater than 1,000 acre-feet maximum storage). Size and hazard classifications shown dictate requirements for plans and engineering reports. Jurisdictional definition: Dam—Any artificial barrier, including appurtenant works, constructed to impound or divert water, waste-water, liquid borne materials, or solids that may flow if saturated. All structures necessary to maintain the water level in an impoundment or to divert a stream from its course will be considered one dam.

STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

<table>
<tr><td>MO</td><td></td><td></td><td></td><td></td><td></td><td>
Required Spillway Design Flood Precipitation Values
<table>
<tr><th>Dam Type</th><th>Stage of Construction</th><th>Special Descriptions</th><th colspan="3">Environmental Class</th></tr>
<tr><th></th><th></th><th></th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>Conventional or Industrial</td><td>Completed</td><td>Dams built prior to August 13, 1981</td><td>.75PMP</td><td>.5PMP</td><td>100 Yr.</td></tr>
<tr><td></td><td></td><td>New dams built after August 13, 1981</td><td>.75PMP</td><td>.5PMP</td><td>100 Yr.</td></tr>
<tr><td>Industrial</td><td>Starter Dam</td><td>Any</td><td>.5PMP</td><td>.2PMP</td><td>.1PMP</td></tr>
<tr><td></td><td>After starter dam is finished and before final dam is completed</td><td>Any</td><td>.75PMP</td><td>.5PMP</td><td>.2PMP</td></tr>
</table>
Source: Dam Safety Model Program
Jurisdictional definition: "Dam", any artificial or manmade barrier which does or may impound water, and which impoundment has or may have a surface area of fifteen or more acres of water at the water storage elevation, or which is thirty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or dam, if it is not across a streambed or watercourse, together with appurtenant works. Sections 236.400 to 236.500 shall not apply to any dam which is not or will not be in excess of thirty-five feet in height or to any dam or reservoir licensed and operated under the Federal Power Act.
</td></tr>
<tr><td>MT</td><td></td><td></td><td></td><td></td><td></td><td>
Not defined
Source: Dam Safety Model Program
Jurisdictional definition: "Dam" means any artificial barrier, including appurtenant works, used to impound or divert water with an impounding capacity of 50 acre-feet or greater measured to the crest of the dam embankment.
</td></tr>
<tr><td>NE</td><td></td><td></td><td></td><td></td><td></td><td>
Not listed
Source: http://www.dnr.state.ne.us/floodplain/DamSafety/Title_458_1008.pdf
001.09 Dam means any artificial barrier, including appurtenant works, with the ability to impound water, wastewater, or liquid-borne materials and which (a) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum storage elevation or (b) has an impounding capacity at maximum storage elevation of fifty acre feet or more, except that any barrier described in this subsection which is not in excess of six feet in height or which has an impounding capacity at maximum storage elevation of not greater than fifteen acre-feet shall be exempt, unless such barrier, due to its location or other physical characteristics, is classified as a high hazard potential dam. Dam does
not include: (1) an obstruction in a canal used to raise or lower water; (2) a fill or structure for highway or railroad use, but if such structure serves, either primarily or secondarily, additional purposes commonly associated with dams it shall be subject to review by the department; (3) canals, including the diversion structure, and levees; or (4) water storage or evaporation ponds regulated by the United States Nuclear Regulatory Commission.
</td></tr>
</table>

STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

NV	N/A	"Large Dam" - has an embankment height greater than 50 feet or a reservoir capacity greater than 10,000 acre-feet.	"Medium Dam" is any dam that is neither small nor large.	"Small Dam" has an embankment less than 20 feet in height and reservoir capacity less than 100 acre-feet.	N/A	Source: http://water.nv.gov/Engineering/Dams/dam_size.cfm ; **Please note** that if an embankment height dictates one size dam and the reservoir capacity dictates a different size dam, the larger of the two designations shall apply, e.g. a dam that has an embankment height of 2 feet and a reservoir capacity of 9,000 acre-feet shall be designated a medium size dam.
NH	N/A	"Class C Structure" means a dam that has a high hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in probable loss of human life as a result of: (a) Water levels and velocities causing the structural failure of a foundation of a habitable residential structure or a commercial or industrial structure which is occupied under normal conditions; (b) Water levels rising above the first floor elevation of a habitable residential structure or a commercial or industrial	"Class B structure" means a dam that has a significant hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in any of the following: (a) No probable loss of life; (b) Major economic loss to structures or property; (c) Structural damage to a Class I or II road which could render the road impassable or otherwise interrupt public safety services; (d) Major environmental or public health losses, including: (1) Damage to a public water system, as defined by RSA	"Class A structure" means a dam that has a low hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in any of the following: (a) No probable loss of life; (b) Low economic loss to structures or property; (c) Structural damage to a town or city road or private road accessing property other than the dam owner's which could render the road impassable or otherwise interrupt public safety services; (d) The release of liquid industrial, agricultural, or commercial wastes, septage,	"Class AA structure" means a dam that is not a menace because it is in a location and of a size that failure or misoperation of the dam would not result in probable loss of life or loss to property, provided the dam is: (a) Less than 6 feet in height if it has a storage capacity greater than 50 acre-feet; or (b) Less than 25 feet in height if it has a storage capacity of 15 to 50 acre-feet.	Source: Dam Safety Model Program; http://www.damsafety.org/map/state.aspx?s=29 Hazard classification included with size classifications. Jurisdictional definition: RSA chapter 482 defines the term *dam* as "(a) any artificial barrier, including appurtenant works, which impounds or diverts water, and which has a height of 4 feet or more, or a storage capacity of 2 acre-feet or more, or is located at the outlet of a great pond. A roadway culvert shall not be considered a dam if its invert is at the natural bed of the water course, it has adequate discharge capacity, and it does not impound water under normal circumstances. Artificial barriers which create surface impoundments for liquid industrial or liquid commercial wastes, septage or sewage, regardless of height or storage capacity, shall be considered dams. (b) An artificial barrier at a storm water detention basin, which impounds 0.5 acre-feet or less of water during normal conditions, shall not be considered a dam unless its height is 10 feet or greater or its maximum storage is 6 acre-feet or greater." Part ENV-WR 101 of the Administrative Code (regulations) contains definitions for the terms *great pond*, which is a "water body of more than 10 acres in its natural condition", and *height of dam*, which means the "vertical distance from the lowest point of natural ground on the downstream side of the dam to the highest part of the dam which would impound water". Part ENV-WR 301 further defines "a roadway embankment whose culvert is set at the natural streambed shall be considered a dam if during the 25 year storm; (1) the water surface elevation at the culvert inlet is 6 feet or more above the water surface elevation at the culvert outlet; and (2) it impounds 2 acre-feet or more of water over the crown, or top of the culvert." RSA Chapter 482 lists the classifications of dams as "non-menace", "low hazard potential", "significant hazard potential", or "high hazard potential". The determination of hazard classification of structures is based on the potential threat to life and extent of property damage, and is further explained in part ENV-WR 101 of the regulations.

		structure which is occupied under normal conditions when the rise due to dam failure is greater than one foot; (c) Structural damage to an interstate highway which could render the roadway impassable or otherwise interrupt public safety services; (d) The release of a quantity and concentration of materials which qualify as "hazardous waste" as defined by RSA 471-A:2 VI; or (e) Any other circumstance which would more likely than not cause one or more deaths.	485:1-a, XV, which will take longer than 48 hours to repair; or (2) The release of liquid industrial, agricultural, or commercial wastes, septage, sewage, or contaminated sediments if the storage capacity is 2 acre-feet or more; or (3) Damage to an environmentally-sensitive site that does not meet the definition of reversible environmental losses.	or contaminated sediment if the storage capacity is less than 2 acre-feet and is located more than 250 feet from a water body or water course; or (e) Reversible environmental losses to environmentally-sensitive sites.		
NJ		"Large dams": Dams that raise the waters of any stream more than 70 feet above its usual mean low water height or which impound more than 10,000 acre feet of water.			A "Class IV" dam is any project which impounds less than 15 ac-ft of water to the top of the dam, and has less than 15 feet height-of-dam (as measured to the top of the dam) and which ahs a drainage area above the	Source: http://www.state.nj.us/dep/damsafety/standard.pdf ; http://www.state.nj.us/dep/damsafety/dampres1/index.htm Jurisdictional definition: "Dam" means any artificial dike, levee or other barrier, together with appurtenant works, which is constructed for the purpose of impounding water on a permanent or temporary basis, that raises the water level five feet or more above the usual, mean, low water height when measured from the downstream toe-of-dam to the emergency spillway crest or, in the absence of an emergency spillway, the top-of dam.

STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

					dam of 150 acres or less in extent.	
NM	N/A	A “large dam” is greater than 100 feet in height, or greater than 50,000 acre-feet of storage.	An “intermediate dam” is greater than 40 feet but less than or equal to 100 feet in height, or greater than 1000 acre-feet but less than or equal to 50,000 acre-feet of storage.	A “small dam” is 25 ft or greater but less than or equal to 40 ft in height, or 50 acre-ft or greater but less than or equal to 1000 acre-ft of storage.	N/A	Source: NM Dam Safety Bureau, Sept 2010 and http://www.ose.state.nm.us/PDF/19-25-12-NMAC.pdf A dam shall be less than or equal to the maximum height and storage to qualify for the size classification.
NY	Large Class "C" Dams: For dams that have been assigned a Hazard Classification of Class "C" as of the effective date of this Part; the dam either has a height greater than or equal to 40 feet or impounds 1000 acre-feet or more at normal water surface.	Small Class "C" Dams. For dams that have been assigned a Hazard Classification of Class "C" as of the effective date of this Part; the dam has a height of less than 40 feet and impounds less than 1000 acre-feet at normal water surface.	*”Class "B" Dams: For dams that have been assigned a Hazard Classification of Class "B" as of the effective date of this Part.	**“Class A” dam is a low hazard dam.	A “Class D” dam is a “negligible or no hazard” dam.	Source: http://www.dec.ny.gov/docs/water_pdf/damguideli.pdf ; Dam Safety Model Program Size classification will be determined by either storage or height, whichever gives the larger size category. Classification also refers to the hydrologic design criteria table, in correlation with hazard classifications. *A small class B dam has a spillway design flood of 225% of 100 year; minimum freeboard is 1; service spillway design flood is 25 years. A large class B dam has a spillway design flood of 40% of PMF; minimum freeboard is 2; service spillway design flood is 50 years. **A small class A dam has a spillway design flood of 100 years; minimum freeboard is 1; service spillway design flood is 25 years. A large class A dam has a spillway design flood of 150% of 100 yr; minimum freeboard is 2; service spillway design flood is 10 yr. A “small dam” has a height of less than 40 feet. Storage at normal water surface less than 1000 acre feet. A “large dam” will have a height at dam equal to or greater than 40 feet. Storage at normal water surface equal to or greater than 1000 acre feet.
NC	A “very large dam” will have a total storage equal to or greater than 50,000 ac-ft; a height equal to or greater than 100 ft.	A “large dam” will have a total storage equal to or greater than 7,500 and less than 50,000 ac-ft; height equal to or greater than 50 ft, and	A “medium dam” will have a total storage equal to or greater than 750 and less than 7,500; height equal to or greater than 35 ft and less	A “small dam” will have a total storage less than 750 ac-ft; height less than 35 ft.	N/A	Source: http://www.damsafety.org/media/Documents/STATE_INFO/LAWS_&_REGS/NorthCarolina_L&R.pdf The factor determining the larges size shall govern.

STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

<table>
<tr><td></td><td></td><td>less than 100 ft.</td><td>than 50 ft.</td><td></td><td></td><td></td></tr>
<tr><td>ND</td><td></td><td></td><td></td><td></td><td></td><td>Source: ND State Water Commission, Sept. 2010

North Dakota's Dam Design Classifications are based on both the size of the dam and the hazard classification, as shown in the following table (Source: ND Dam Design Handbook, 1985).

Table 4-1. Dam Design Classifications
<table><tr><th>Dam Height (Feet)</th><th colspan="3">Hazard Categories</th></tr><tr><th></th><th>Low</th><th>Medium</th><th>High</th></tr><tr><td>Less than 10</td><td>I</td><td>II</td><td>IV</td></tr><tr><td>10 to 24</td><td>II</td><td>III</td><td>IV</td></tr><tr><td>25 to 39</td><td>III</td><td>III</td><td>IV</td></tr><tr><td>40 to 55</td><td>III</td><td>IV</td><td>V</td></tr><tr><td>Over 55</td><td>III</td><td>IV</td><td>V</td></tr></table></td></tr>
<tr><td>OH</td><td>N/A</td><td>A “Class I dam” a total storage volume greater than five thousand acre-feet or a height of greater than sixty feet.</td><td>A “Class II dam” will have a total storage volume greater than five hundred acre-feet or a height of greater than forty feet.</td><td>A “Class III dam” will have a total storage volume greater than fifty acre-feet or a height of greater than twenty-five feet.</td><td>A “Class IV dam” will be twenty-five feet or less in height and have a total storage volume of fifty acre-feet or less.</td><td>Source: http://www.dnr.state.oh.us/water/dsafety/whatdam/tabid/3342/Default.aspx
Size classifications are combined with hazard classification definitions.</td></tr>
<tr><td>OK</td><td>N/A</td><td>A “large dam” has maximum storage over 50,000 ac-ft; maximum height over 100 ft.</td><td>An “intermediate dam” has a maximum storage between 10,000 and 50,000 ac-ft; height between 50 and 100 ft.</td><td>A “small dam” has a maximum storage less than 10,000 ac-ft; height less than 50 ft.</td><td>N/A</td><td>Source:http://www.owrb.ok.gov/util/rules/pdf_rul/2010adopted/Adopted2010_Ch25.pdfm</td></tr>
<tr><td>OR</td><td>N/A</td><td>“Large Dam” for dam safety purposes, means a dam with a height of 10 feet or more and impounding</td><td>N/A</td><td>“Small dam” for dam safety purposes, means a dam with a height of less than 10 feet or impounding</td><td>N/A</td><td>Source: http://arcweb.sos.state.or.us/rules/OARS_600/OAR_690/690_020.html</td></tr>
</table>

STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		3,000,000 gallons (9.2 acre-feet) or more of water		less than 3,000,000 gallons (9.2 acre-feet) of water		
PA	N/A	A "Class A" dam will have an impoundment storage equal to or greater than 50,000 ac-ft; height equal to or greater than 100 ft.	A "Class B" dam will have an impoundment storage less than 50,000 ac-ft but greater than 1000 ac-ft; height less than 100 ft but greater than 40 ft.	A "Class C" dam will have an impoundment storage equal to or less than 1000 ac-ft; height equal to or less than 40 ft.	N/A	Source: http://www.pacode.com/secure/data/025/chapter105/s105.91.html *Note: Size classification may be determined by either storage or height of structure, whichever gives the higher category.
PR						
RI						Not defined Source: http://www.dem.ri.gov/pubs/regs/regs//compinsp/dams07.pdf ; Dam Safety Model Program Jurisdictional definition: "**Dam**" means any barrier made by humans, including appurtenant works, that impounds or diverts water.
SC	N/A	A "large dam" will have an impoundment storage greater than or equal to 50,000 ac-ft OR a height greater than or equal to 100 ft.	An "intermediate dam" will have an impoundment storage greater than or equal to 1000 ac-ft, and less than 50,000 ac-ft OR a height greater than or equal to 40 ft, and less than 100 ft.	A "small dam" will have an impoundment storage greater than or equal to 50 ac-ft, and less than 1000 ac-ft OR a height greater than or equal to 25 ft and less than 40 ft.	A "very small dam" will have an impoundment structure less than 50 ac-ft AND a height less than 25 ft.	Source: http://www.scdhec.gov/environment/water/regs/R72-1.doc Size classification may be determined by either storage or height, whichever gives the larger size capacity.
SD	N/A	A "large dam" will have a storage capacity greater than 50,000 ac-ft; height greater than 100 ft.	An "intermediate dam" will have a storage capacity between 1001 and 50,000 ac-ft; height between 41 and 100 ft.	A "small dam" will have a storage capacity between 50 and 1000 ac-ft; height between 25 and 40 ft.	N/A	Source: http://legis.state.sd.us/rules/DisplayRule.aspx?Rule=74:02:08:06 The classification of dams by size is as follows: The size classification is determined by either the maximum storage capacity or the height, whichever gives the larger size category.
TN	N/A	A "large dam" will have a storage of	An "intermediate dam" will have a storage between	A "small dam" will have a storage between	N/A	Source: http://tn.gov/sos/rules/1200/1200-05/1200-05-07.pdf The classification for size is based on the height of the dam and storage capacity in accordance with the table below. The height of the dam is established with respect to

STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		50,000 ac-ft or greater; height of 100 ft or greater.	1,000 and 49,999 ac-ft; height between 50 and 99 ft.	30 and 99 ac-ft; height between 20 and 49 ft.		the maximum water storage elevation measured from the natural bed of the stream or watercourse at the downstream toe of the barrier, or if it is not across a stream or watercourse, the height from the lowest elevation of the outside limit of the barrier, to the maximum water storage elevation. For the purpose of determining project size, the maximum storage elevation will be considered equal to the top of dam elevation as defined in Rule 1200-5-7-.02(26). Size classification will be determined by either storage or height, whichever gives the larger size category. For size classification purposes, fractions of heights and storages shall be rounded down to the nearest whole number, e.g., 49.9 feet would be classified in the 20 to 49 feet category.
TX	N/A	A “large dam” will have an impoundment storage equal to or greater than 50,000 ac-ft; height equal to or greater than 100 ft.	An “intermediate dam” will have an impoundment storage equal to or greater than 1,000 ac-ft and less than 50,000 ac-ft; height equal to or greater than 40 ft and less than 100 ft.	A “small dam” will have an impoundment storage equal to or greater than 50 ac-ft and less than 1,000 ac-ft; height greater than 6 ft and less than 40 ft OR an impoundment storage equal to or greater than 15 ac-ft and less than 1,000 ac-ft; height equal to or greater than 25 ft and less than 40 ft.	N/A	Source: http://www.tceq.state.tx.us/assets/public/legal/rules/rules/pdflib/299b.pdf The executive director shall classify dams for size based on the larger of the height of the dam or the maximum storage capacity.
UT						Not defined Source: Dam Safety Model Program Jurisdictional definition: DAM is any artificial barrier or obstruction, together with appurtenant works, if any, which impounds or diverts water.
VT	N/A	A “large dam” will have a storage of 50,000 ac-ft or greater; height of 100 ft or greater.	A “medium dam” will have a storage equal to or greater than 1,000 ac-ft and less than 50,000 ac-ft; height equal to or greater than 40 ft and less than 100 ft.	A “small dam” will have a storage less than 1,000 ac-ft; height less than 40 ft.	N/A	Source: http://psb.vermont.gov/sites/psb/files/rules/OfficialAdoptedRules/4500_Dam_Safety.pdf (4.500 Safety of Hydroelectric Dams,1990) 4.510 Dams shall be categorized by size. The size category shall be determined by height or storage, whichever gives the larger size category. The height of a dam and its storage shall both be established with respect to its maximum storage potential, measured from the natural bed of the water course to the maximum water storage elevation. For the purpose of determining size category, the maximum water storage elevation shall be considered to be the height above streambed as defined in section 4.521(B).
VA	N/A	A “large	A “medium	A “small	N/A	Source: http://www.dcr.virginia.gov/documents/dsfinregs092608.pdf

STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		impounding structure" will have an impounding capacity greater than or equal to 50,000 ac-ft; height greater than or equal to 100 ft.	impounding structure" will have an impounding capacity greater than or equal to 1,000 ac-ft and less than 50,000 ac-ft; height greater than or equal to 40 ft and less than 100 ft.	impounding structure" will have an impounding capacity greater than or equal to 15 ac-ft, and less than 1,000 ac-ft; height greater than or equal to 6 ft and less than 40 ft.		For the purposes of categorizing and reporting information to national and other dam safety databases, impounding structure size shall be classified as noted.
WA	N/A	A "large dam" is 50 ft or greater in height.	An "intermediate dam" is 15 ft or greater but less than 50 ft.	A "small dam" is less than 15 ft.	N/A	Source: http://www.ecy.wa.gov/pubs/9255b.pdf The size classification and reservoir operation classification of the proposed project should be listed as defined by Tables 2 and 3. These classifications are used throughout *Part IV of the Dam Safety Guidelines* for determining the degree of conservatism of design, and the sophistication of the methodologies to be used in analyses.
WV						Not defined Source: Dam Safety Model Program Jurisdictional definition: *"Dam" means an artificial barrier or obstruction --including any works appurtenant to it and any reservoir created by it -- which is or will be placed, constructed, enlarged, altered, or repaired so that it does or will impound or divert water and is or will be twenty-five (25) feet or more in height from the natural bed of a stream or watercourse measured at the downstream toe of the barrier and which does or can impound fifteen (15) acre-feet or more of water or is or will be six (6) feet or more in height from the natural bed of such stream or watercourse measured at the downstream toe of the barrier and which does or can impound fifty (50) acre-feet or more of water. (List is given of items that are NOT dams as well) The "**coal related** dam safety" rule is as follows: "Dam" means an artificial barrier or obstruction including works appurtenant to it and be placed, constructed, enlarged, altered or repaired so that it does or will impound or divert water and is or will be twenty-five (25) feet or more in height from the natural bed of a stream or watercourse measured at the downstream toe of the barrier and which does or can impound fifteen (15) acre-feet or more of water or is or will be six (6) feet or more in height from the natural bed of such stream or watercourse measured at the downstream toe of the barrier and which does or can impound fifty (50) acre-feet or more of water.
WI		A dam is considered to be a "large dam" if either of the following applies:				Source: http://www.legis.state.wi.us/statutes/Stat0031.pdf ; http://www.damsafety.org/media/Documents/PDF/WI.pdf Jurisdictional definition: Dam is defined in Chapters NR 333 as "any artificial barrier, together with appurtenant works, built across a waterway that has the primary purpose of impounding or diverting water". Jurisdiction for the dam inspection program described in Chapter NR 333 is established by defining large dams as those with 1) a structural

		(a) It has a structural height of 25 feet or more and impounds more than 15 acre−feet of water. (b) It has a structural height of more than 6 feet and impounds 50 acre−feet or more of water.				height of 25 feet or more and that can impound more than 15 acre-feet of water or, 2) structural height of more than 6 feet and that can impound more than 50 acre feet of water. Source: Dam Safety Model Program All large dams in the state, except those owned by the US Government or inspected, approved and licensed by a federal agency, are under Department of Natural Resources jurisdiction and must conform to Chapter NR 333 "Dam Design and Construction Standards".
WY						Source: http://www.damsafety.org/media/Documents/PDF/WY.pdf Jurisdictional definition: Section 41-3-307 of the statutes defines the term dam as any artificial barrier, including appurtenant works, used to impound or divert water and which is or will be greater than twenty (20) feet in height or with an impounding capacity of fifty (50) acre-feet or greater. Dams less than 15 acre-feet in capacity or 6 feet or less in height are excluded. No system of dam classification is provided for in either the laws or the regulations.

F.2. Hazard Classification Schemes



FEMA

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

	Extreme	High	Significant	Low	Very Low	Citation/ Notes
AL	NA	High-Hazard Potential	Moderate-Hazard Potential	Low-Hazard Potential	NA	Source: Alabama Dam Inventory and Classification Act, Section 5 (a). The office may gather necessary updated information regarding the characteristics of a dam and its surroundings in order to verify classification. The office may use information furnished to it by other persons to accomplish the purpose of this act and this section including, but not limited to, the classification of dams as set forth in subsection (a).
AK	NA	Class I (high) hazard potential classification, if the department determines that the failure or improper operation of the barrier will result in probable loss of human life.	Class II (significant) hazard potential classification, if the department determines that the failure or improper operation of the barrier will result in(A) a significant danger to public health; (B) the probable loss of or probable significant damage to homes, occupied structures, commercial property, high-value property, major highways, primary roads, railroads, or public utilities, other than losses described in (3)(B) of this subsection; (C) other probable significant property losses or damage, other than losses described in (3)(B) of this subsection; or (D) probable loss of or significant damage to waters identified under 5 AAC 95.011(a) as important for the spawning, rearing, or migration of anadromous fis	Class III (low) hazard potential classification if the department determines that the failure or improper operation of the barrier will result in (A) limited impacts to rural or undeveloped land, rural or secondary roads, and structures; (B) property losses or damage limited to the owner of the barrier; or (C) insignificant danger to public health.	NA	Source: 11 AAC 93.157. Hazard classification
AZ	NA	High Hazard Potential. Failure or improper operation of a dam would be likely to cause loss of human life because of residential, commercial, or industrial development. Intangible losses may	Significant Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life but may cause significant or high economic loss, intangible damage requiring major mitigation, and disruption or impact on lifeline facilities.	Low Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life, but would produce low economic and intangible losses, and result in no disruption of	Very Low Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life and would produce no lifeline losses and very low economic and intangible losses. Losses	Source: AZ DWR, Sept. 2010 Hazard classification based on evaluation of probable present & future incremental adverse consequences of failure or improper operation of the dam or appurtenances regardless of the condition of the dam or appurtenances. Evaluation includes land use zoning & projected development over 10 years following classification. All of the following are considered: probable loss of human life, economic/ lifeline losses, & intangible losses identified & evaluated by a public resource management or protection agency. -Probable incremental loss of human life determined primarily on the number of permanent structures for human

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		be major and potentially impossible to mitigate, critical lifeline services may be significantly disrupted, and property losses may be extensive. (Loss of human life is probable, with one or more expected. Economic, lifeline & intangible losses can range from low to high; they are not necessary for this classification.)	Property losses would occur in a predominantly rural or agricultural area with a transient population but significant infrastructure.	lifeline services that require more than cosmetic repair. Property losses would be limited to rural or agricultural property, including equipment, and isolated buildings.	would be limited to the 100 year floodplain or property owned or controlled by the dam owner under long-term lease. The Department considers loss of life unlikely because there are no residences or overnight camp sites.	habitation impacted in the event of failure or improper operation of a dam. Loss of human life considered unlikely if: Persons are only temporarily in the potential inundation area; There are no residences or overnight campsites; & the owner has control of access to the potential inundation area & provides an EAP with a process for warning in the event of failure or improper operation. -Probable economic, lifeline & intangible loss determined by property losses, interruptions of services, & intangible losses likely to result from failure or improper operation of a dam. -Hazard class evaluated during each inspection & revised in accordance with current conditions.
AR	NA	Loss of human life expected. Excessive economic loss (extensive public, industrial, commercial, or agricultural development); over $500,000	No loss of life expected. Appreciable economic loss (significant structures, industrial, or commercial development, or cropland); $100,000 to $500,000	No loss of life expected. Minimal economic loss (No significant structures, pastures, woodland, or largely undeveloped land); less than $100,000	NA	Section 705.4. All dams will be classified or reclassified as required to assure appropriate safety considerations. Hazard classification shall be based on the more stringent of either potential loss of human life or economic loss. If doubt exists concerning classification, the more hazardous category must be selected. Loss of human life is based on presence of habitable structures.
CA	Extreme	High	Moderate	Low	NA	Dams are classified as to damage potential (hazard) and condition. This classification is used to determine frequency of inspection and for selection of the return period for hydrology studies. A weighted point system is used to divide the damage potential into four classifications: extreme, high, moderate, and low. Reservoir capacity, dam height, estimated evacuation and potential damage are the factors used to classify the damage potential. A similar point system is used to classify the condition of the dam as: poor, fair, good, and excellent. Age, general condition, geologic, and seismic setting are the factors evaluated to classify the condition of the dam. Hazard classification is reevaluated when development occurs downstream and when the condition of the dam changes, either by identifying deficiencies or when alteration/repair work is completed.
CO	NA	High Hazard - Loss of human life is expected to result from failure of the dam. Designated recreational sites located downstream within the bounds of possible inundation	Significant Hazard - Significant damage is expected to occur, but no loss of human life is expected from failure of the dam. Significant damage is defined as damage to structures where people generally live, work, or	Low Hazard - Loss of human life is not expected, and significant damage to structures and public facilities as defined for a "Significant Hazard" dam is not expected to	No Public Hazard (NPH) - A dam for which no loss of human life is expected, and which damage only to the dam owner's property will result from failure of the dam.	Rule 5.4. Hazard potential is derived from an evaluation of the probable incremental adverse consequences due to failure or improper operation of the dam. Conditions for evaluation are absent flooding, and the reservoir is assumed to be full to the high water line. Classification does not reflect the current condition of the dam with regard to safety, structural integrity, or flood routing capacity. The Hazard Classification evaluation method must be approved by the State Engineer.

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		should also be evaluated for potential loss of human life.	recreate, or public or private facilities. Significant damage is determined to be damage sufficient to render structures or facilities uninhabitable or inoperable.	result from failure of the dam.		
CT	Class C - A high hazard potential dam which, if it were to fail, would result in any of the following: (i) probable loss of life; (ii) major damage to habitable structures, residences, hospitals, convalescent homes, schools, etc.; (iii) damage to main highways (greater than 1500 ADT); or(iv) great economic loss.	Class B - A significant hazard potential dam which, if it wee to fail, would result in any of the following: (i) possible loss of life; (ii) minor damage to habitable structures, residences, hospitals, convalescent homes, schools, etc.; (iii) damage to or interruption of the use of service of utilities; (iv) damage to primary roadways (less than 1500 ADT) and railroads; or (v) significant economic loss.	Class BB - A moderate hazard potential dam which, if it were to fail, would result in any of the following: (i) damage to normally unoccupied storage structures; (ii) damage to low volume roadways (less than 500 ADT); or (iii) moderate economic loss.	Class A - A low hazard potential dam which, if it were to fail, would result in any of the following: (i) damage to agricultural land; (ii) damage to unimproved roadways (less than 100 ADT); (iii) minimal economic loss.	Class AA - A negligible hazard potential dam which, if it were to fail, would result in the following: (i) no measurable damage to roadways; (ii) no measurable damage to land and structures; and (iii) negligible economic loss.	The Commissioner shall assign each dam to one of five classes according to its hazard potential. Such classification shall be determined by the Commissioner during the initial periodic inspection. Source: Guidelines for Inspection and Maintenance of Dams
DE	NA	Class I - "High Hazard Potential Dam" shall mean any dam whose failure or misoperation will cause probable loss of human life.	"Significant Hazard Potential Dam " shall mean any dam whose failure or mis-operation will cause possible loss of life, economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns.	"Low-hazard potential dam" means any dam whose failure or misoperation is unlikely to cause loss of human life but may cause minor economic and/or environmental losses.	NA	
FL	NA	Direct loss of life: Certain (one or more extensive residential, commercial or industrial development) Lifeline losses: Disruption of critical facilities and access Property Losses:	Direct loss of life: Uncertain (rural location with few residences & only transient or industrial development) Lifeline losses: Disruption of essential services & access Property Losses: Major public and private facilities Environmental losses: Major	Direct loss of life: None expected (due to rural location with no permanent structures for human habitation) Lifeline losses: No disruption of services Property Losses: Private agricultural lands,	NA	Source: Design Criteria Memorandum: DCM-1 and “Final Hazard Potential Memorandum” by URS (August 2007)

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		Extensive public and private facilities Environmental losses: Extensive mitigation cost or impossible to mitigate	mitigation required	equipment, & isolated buildings Environmental losses: Minimal incremental damage		
GA	NA	Category I – Improper operation or dam failure would result in probable loss of human life. Situations constituting 'probable loss of life' are those situations involving frequently occupied structures or facilities, including but not limited to, residences, commercial and manufacturing facilities, schools, and churches."	NA	Category II - Improper operation or dam failure would not be expected to result in probable loss of human life."	NA	391-3-8-.03 When an existing Category II dam may be reclassified to a Category I dam because of proposed development, the governing authority issuing the permit for the development shall provide for review by the Safe Dams Programs: (a) location of the Category II dam and the proposed development; (b) a surveyed cross-section of the stream valley at the proposed development location, including proposed finished floor elevations; (c) a dam breach analysis to establish the height of the flood wave in the floodplain. If reclassification is deemed appropriate, the owner of the existing Category II dam may request an inspection from the Director within 10 days of notification of the proposed development. Detailed surveys, hydrologic and hydraulic analyses will not be performed, but the Director may provide an opinion on the hydraulic adequacy of the dam. A written evaluation of the existing Category II dam's compliance with Category I requirements will be provided to the owner of the dam and the local governing authority based on preliminary visual inspection by the Safe Dams Program.
HI	NA	High Hazard: Loss of life: Probable, one or more expected Economic/ Environmental Losses: Yes, but not necessary for this classification	Significant: Loss of life: None expected Economic/ Environmental Losses: Yes	Low: Loss of life: None expected Economic/ Environmental Losses: Low and generally limited to owner property	NA	Rules S.13-190-2
ID	NA	High-Hazard Dams: Catastrophic failure and sudden release of water likely would result in direct loss of human life.	Significant Hazard Dams: Failure would cause significant economic damage to existing infrastructure, or may contribute to the indirect loss of life.	Low Hazard Dams: No permanent habitable structures within inundation zone; failure would cause only minor damage to infrastructure, with low probability for loss of life.	NA	Provided by ID Program, 9/3/2010.
IL	NA	Class I - Failure has a high probability of causing loss of life or substantial economic loss, similar to that of	Class II - Failure has a moderate probability for causing loss of life or substantial economic loss, similar to USACE Significant	Class III - failure has a low probability for causing loss of life or substantial economic loss, similar to USACE	NA	

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		USACE High Hazard Potential or USDA/NRCS Class (c) dams	Hazard Potential or USDA/NRCS Class (b) dams.	Low Hazard Potential or USDA/NRCS Class (a) dams.		
IN	NA	High hazard - If an uncontrolled release of the structure's contents due to a failure of the structure may result in any of the following: (A) The loss of human life. (B) Serious damage to: (i) homes; (ii) industrial and commercial buildings; or (iii) public utilities. (C) Interruption of service for more than one (1) day on any of the following: (i) A county road, state two-lane highway, or U.S. highway serving as the only access to a community. (ii) A multilane divided state or U.S. highway, including an interstate highway. (D) Interruption of service for more than one (1) day on an operating railroad. (E) Interruption of service to an interstate or intrastate utility, power or communication line serving a town, community, or significant military and commercial facility, in which disruption of	Significant hazard - If an uncontrolled release of the structure's contents due to a failure of the structure may result in any of the following: (A) Damage to isolated homes. (B) Interruption of service for not more than one (1) day on any of the following: (i) A county road, state two-lane highway, or U.S. highway serving as the only access to a community. (ii) A multilane divided state or U.S. highway, including an interstate highway. (C) Interruption of service for not more than one (1) day on an operating railroad. (D) Damage to important utilities where service would be interrupted for not more than one (1) day, but either of the following may occur: (i) Buried lines can be exposed by erosion. (ii) Towers, poles, and aboveground lines can be damaged by undermining or debris loading.	Low hazard - If an uncontrolled release of the structure's contents due to a failure of the structure does not result in any of the items given in subdivision (1) or (2) and damage is limited to either farm buildings, agricultural land, or local roads.	NA	The division may modify an assignment of hazard classification, made previously under this article, if changes in the downstream development affect the potential for loss of human life and property. (Natural Resources Commission; 312 IAC 10.5-3-1; filed Jan 26, 2007, 10:45 a.m.: 20070221-IR-312060092FRA) Source: *General Guidelines For New Dams and Improvements To Existing Dams in Indiana* (2010)

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		power and communication would adversely affect the economy, safety, and general well-being of the area for more than one (1) day.				
IA		High Hazard - Located in an area where dam failure may create a serious threat of loss of human life.	Moderate Hazard - Failure may damage isolated homes or cabins, industrial or commercial buildings, moderately traveled roads, interrupt major utility services, but are without substantial risk of loss of human life. Dams are also classified as Moderate Hazard where the dam and its impoundment are themselves of public importance, such as dams associated with public water supply systems, industrial water supply or public recreation or which are an integral feature of a private development complex.	Low Hazard - Damages from a failure would be limited to loss of the dam, livestock, farm outbuildings, agricultural lands and lesser used roads and where loss of human life is considered unlikely.	NA	www.iowadnr.gov/water/floodplain/damsafety.html
KS	NA	Class C dam - A dam located in an area where failure could result in any of the following: Extensive loss of life; Damage to more than one home; Damage to industrial or commercial facilities; Interruption of a public utility serving a large number of customers; Damage to traffic on high-volume roads that meet the requirements for hazard class C dams as specified in subsections (b) and (c) or a high-volume railroad line;	Class B - A dam located in an area where failure could endanger a few lives, damage an isolated home, damage traffic on moderate-volume roads that meet the requirements for hazard class B dams as specified in subsections (b) and (c), damage low-volume railroad tracks, interrupt the use or service of a utility serving a small number of customers, or inundate recreation facilities, including campground areas intermittently used for sleeping and serving a relatively small number of persons.	Class A - A dam located in an area where failure could damage only farm or other uninhabited buildings, agricultural or undeveloped land including hiking trails, or traffic on low-volume roads that meet the requirements for hazard class A dams as specified in subsections (b) and (c). including campground areas intermittently used for sleeping and serving a relatively small number of persons.	NA	K.A.R. 5-40-20. Vehicle-per-day counts used to determine potential hazard created by the roadway: Roads on any part of the embankment or spillway: Class A: 0 through 100 Class B: 101 through 500 Class C: more than 500 Any roadway not on the dam but in the inundation area: Class A: 0 through 500 Class B: 501 through 1,500 Class C: more than 1,500

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		Inundation of a frequently used recreation facility serving a relatively large number of persons; or Two or more individual hazards described in hazard class B.				
KY	NA	Class (C) High Hazard - Structures for which failure would cause loss of life or serious damage to homes, commercial buildings, utilities, highways or railroads.	Class (B) Moderate Hazard - Structures for which failure would cause significant damage to property and project operation, but loss of life is not envisioned.	Class (A) Low Hazard - Structures for which failure would result in loss of the structure itself, but little or no additional damage to other property.	NA	
LA	NA	Potential loss of life: Likely. Potential economic loss: Excessive	Potential loss of life: Possible Potential economic loss: Appreciable	Potential loss of life: Not likely Potential economic loss: Minimal	NA	
ME		Impounding structures in the "high hazard" potential category will be those located where failure may cause serious damage to homes, extensive agricultural, industrial, and commercial facilities, important public utilities, main highways, railroads, or other impounding structures. Urban development: Exists, with more than a small number of habitable structures. Economic loss: Excessive (extensive community, industry, or	"Significant hazard" potential category structures will be those located in predominantly rural or agricultural areas where failure may damage isolated homes, secondary highways, minor railroads, or other impounding structures or cause interruption of use of service of relatively important pubic utilities. Urban development: None. No more than a small number of habitable structures. Economic loss: Appreciable (notable agriculture, industry, or structures)	Structures conforming to criteria for the "low hazard" potential category generally will be found in rural or agricultural areas where failure may damage some farm buildings, limited agricultural land, or country roads. Urban development: None. No permanent structure for human habitation. Economic loss: Minimal (undeveloped to occasional structures or agriculture)	NA	Present and projected development of the flood plain downstream from the impounding structure shall be considered in determining the classification. Evaluation. The commissioner shall evaluate all dams to assign or reassign a hazard potential classification in accordance with the following schedule: A. New or reconstructed dams, within 6 months of construction or reconstruction; [2001, c. 460, §3 (NEW).] B. All other dams, at least once every 6 years; [2001, c. 460, §3 (NEW).] C. Any dam, within 30 days of a request for an evaluation from the dam owner, the municipality in which the dam is located or the emergency management director of the county in which the dam is located; and [2001, c. 460, §3 (NEW).] D. At any time a dam for which, in the judgment of the commissioner, such an evaluation is appropriate.

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		agriculture)				
MD	NA	High hazard (Class 1) where loss of life and extensive property damage are probable should the dam fail,.	Significant hazard (Class 2) where failure would cause extensive damage to public or private property but the loss of life is very unlikely	Low hazard (Class 3) where failure would not cause the loss of life and the damage is within the financial capability of the owner to repair	NA	COMAR 26.17.04-03[B] MD Dam Safety Manual (rev Nov 1993)
MA	NA	High Hazard Potential dam refers to dams located where failure will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).	Significant Hazard Potential dam refers to dams located where failure may cause loss of life and damage home(s), industrial or commercial facilities, secondary highway(s) or railroad(s) or cause interruption of use or service of relatively important facilities.	Low Hazard Potential dam refers to dams located where failure may cause minimal property damage to others. Loss of life is not expected.	NA	
MI	NA	High Hazard Potential: Failure may cause serious damage to inhabited homes, agricultural buildings, campgrounds, recreational facilities, industrial or commercial buildings, public utilities, main highways or class I carrier railroads, or where environmental degradation would be significant, or where danger to individuals exists with the potential for loss of life. (Sec.31503 [11])	Significant Hazard Potential: failure may cause damage limited to isolated inhabited homes, agricultural buildings, structures, secondary highways, short line railroads, or public utilities, where environmental degradation may be significant, or where and danger to individuals exists. (Sec. 31505 [5])	Low Hazard Potential: failure may cause damage limited to agriculture, uninhabited buildings, township or county roads, where environmental degradation would be minimal, and danger to individuals is slight or nonexistent. (Sec. 31504 [2])	NA	
MN	NA	Class I - any loss of life or serious hazard, or damage to health, main highways, high-value industrial or commercial	Class II - possible health hazard or probable loss of high-value property, damage to secondary highways, railroads or other public utilities, or	Class III- property losses restricted mainly to rural buildings and local county and township roads, which	No hazard - no potential for loss of life and no impacts to health, safety, and welfare.	

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		properties, major public utilities, or serious direct or indirect economic loss	limited direct or indirect economic loss to the public other than that described in Class III	are an essential part of the rural transportation system serving the area involved		
MS	NA	High Hazard–A class of dam in which failure may cause loss of life, serious damage to residential, industrial, or commercial buildings; or damage to, or disruption of, important public utilities or transportation facilities such as major highways or railroads. Dams which meet the statutory thresholds for regulation that are proposed for construction in established or proposed residential, commercial, or industrial areas will be assigned this classification, unless the applicant provides convincing evidence to the contrary.	Significant Hazard—A class of dam in which failure poses no threat to life, but may cause significant damage to main roads, minor railroads, or cause interruption of use or service of public utilities.	Low Hazard—A class of dam in which failure would at the most result in damage to agricultural land, farm buildings (excluding residences), or minor roads.	NA	
MO	NA	Class 1 – Downstream of the dam contains at least 10 or more permanent dwellings or any public building.	Class 2 – Downstream of the dam contains 1 to 9 public dwellings or 1 or more campgrounds with permanent water, sewer and electrical services or 1 or more industrial building.	Class 3 – No lives, campgrounds, public dwellings, public buildings or industrial buildings are threatened from a dam failure.	NA	
MT	Dams in Series - (1) The worst case scenario shall govern for determining the hazard classification of	High-hazard - Impoundment capacity is 50 acre-feet or larger and loss of human life is likely to occur within the breach flooded area as a result of failure of	NA	NA	NA	(History: Sec. 85-15-110 , MCA; IMP , Sec. 85-15-209 , MCA; NEW , 1988 MAR p. 2489, Eff. 11/24/88.)

	dams in series where more than one mode of failure is possible among the dams. Classification shall be based on potential for failure under combined and, if applicable, individual dam breach scenarios. (2) If an upstream dam has the capability to create failure in a downstream high-hazard dam because of its failure flood wave, the upstream dam must be classified as a high-hazard dam. (3) If the failure flood wave of the upstream dam will cause failure of the downstream dam, and the combined flows will likely cause a loss of life, the upstream dam must be classified as a high-hazard dam.	the dam. The breach flooded area, for the purpose of this classification only, is the flooded area caused by a breach of the dam with the reservoir full to the crest of the emergency spillway. The evaluation of the effects of flood inundation, for the purpose of classification, will continue downstream until the flood stage is equal to that of the 100-year floodplain. The breach flow hydrograph and downstream routing of the breach flows, for the purpose of classification, will be estimated by the department either by visual determination or dam breach modeling techniques. Loss of life is assumed to occur if the following structures are present or planned for as a matter of public record or notice in the breach flooded area: occupied houses and farm buildings, stores, gas stations, parks, golf courses, stadiums, ball parks, interstate, principal, and other paved highways, and including railroads, highway rest areas, RV areas, developed campgrounds; and excluding unpaved				

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		county roads and all private roads.				
NE	NA	High hazard - Failure or misoperation of the dam resulting in loss of human life is probable.	Significant hazard - Failure or misoperation of the dam would result in no probable loss of human life but could result in major economic loss, environmental damage, or disruption of lifeline facilities.	Low hazard potential - Failure or misoperation of the dam would result in no probable loss of human life and in low economic loss.	NA	Laws 2005, LB 335, § 19, § 32, § 21. Effective Sept 4, 2005. ~ Revised Statutes Supplement 2005, Sections 46-1632, 46-1621
NV	NA	High hazard – when there is reasonable potential for loss of life and/or extreme economic loss.	Significant hazard designation is assigned to a dam if there is a low potential for loss of life but an appreciable economic loss.	Low hazard designation is assigned to a dam if there is a vanishingly small potential for loss of life and the economic loss is minor or confined entirely to the dam owner's own property.	NA	http://water.nv.gov/Engineering/Dams/hazard_designations.cfm NAC 535.140
NH		"**Class C Structure**" means a dam that has a high hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in probable loss of human life as a result of: (a) Water levels and velocities causing the structural failure of a foundation of a habitable residential structure or a commercial or industrial structure which is occupied under normal conditions; (b) Water levels rising above the first floor elevation of a habitable residential structure or a commercial or industrial structure which is occupied	"**Class B structure**" means a dam that has a significant hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in any of the following: (a) No probable loss of life; (b) Major economic loss to structures or property; (c) Structural damage to a Class I or II road which could render the road impassable or otherwise interrupt public safety services; (d) Major environmental or public health losses, including: (1) Damage to a public water system, as defined by RSA 485:1-a, XV, which will take longer than 48 hours to repair; or (2) The release of liquid industrial, agricultural, or	"**Class A structure**" means a dam that has a low hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in any of the following: (a) No probable loss of life; (b) Low economic loss to structures or property; (c) Structural damage to a town or city road or private road accessing property other than the dam owner's which could render the road impassable or otherwise interrupt public safety services; (d) The release of liquid industrial, agricultural, or commercial wastes, septage, or contaminated sediment	"**Class AA structure**" means a dam that is not a menace because it is in a location and of a size that failure or misoperation of the dam would not result in probable loss of life or loss to property, provided the dam is: (a) Less than 6 feet in height if it has a storage capacity greater than 50 acre-feet; or (b) Less than 25 feet in height if it has a storage capacity of 15 to 50 acre-feet.	NHCAR, Env-Wr 100-800

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		under normal conditions when the rise due to dam failure is greater than one foot; (c) Structural damage to an interstate highway which could render the roadway impassable or otherwise interrupt public safety services; (d) The release of a quantity and concentration of materials which qualify as “hazardous waste” as defined by RSA 471-A:2 VI; or (e) Any other circumstance which would more likely than not cause one or more deaths	commercial wastes, septage, sewage, or contaminated sediments if the storage capacity is 2 acre-feet or more; or (3) Damage to an environmentally-sensitive site that does not meet the definition of reversible environmental losses.	if the storage capacity is less than 2 acre-feet and is located more than 250 feet from a water body or water course; or (e) Reversible environmental losses to environmentally-sensitive sites.		
NJ	NA	Class I - High Hazard Potential - Dams, the failure of which may cause probable loss of life or extensive property damage.	Class II - Significant Hazard Potential - Dams, the failure of which may cause significant damage to property and project operation, but loss of human life is not envisioned..	Class III - Low Hazard Potential - Dams, the failure of which would cause loss of the dam itself but little or no additional damage to other property.	Class IV - Small Dams - Any project which impounds less than 15 acre-feet of water, is less than 15 feet in height, and has a drainage area above the dam of less than 150 acres.	N.J.A.C. 7:20-1.8.
NM	NA	High hazard potential: Dams where failure or misoperation will probably cause loss of human life.	Significant hazard potential: Dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in populated areas with significant infrastructure.	Low hazard potential: Dams where failure or misoperation results in no probable loss of life and low economic or environmental losses. Losses are principally limited to the dam owner’s property.	NA	[19.25.12.10 NMAC - N, 3/31/2005] Rating is based on loss of life, damage to property and environmental damage that is likely to occur in the event of dam failure. No allowances for evacuation or other emergency actions by the population should be considered.

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

NY	NA	Class "C" or "High Hazard" dam: A dam failure may result in widespread or serious damage to home(s); damage to main highways, industrial or commercial buildings, railroads, and/or important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; or substantial environmental damage; such that the loss of human life or widespread substantial economic loss is likely.	Class "B" or "Intermediate Hazard" dam: A dam failure may result in damage to isolated homes, main highways, and minor railroads; may result in the interruption of important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; and/or is otherwise likely to pose the threat of personal injury and/or substantial economic loss or substantial environmental damage. Loss of human life is not expected.	Class "A" or "Low Hazard" dam: A dam failure is unlikely to result in damage to anything more than isolated or unoccupied buildings, undeveloped lands, minor roads such as town or county roads; is unlikely to result in the interruption of important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; and/or is otherwise unlikely to pose the threat of personal injury, substantial economic loss or substantial environmental damage.	NA	Source: NY DEC, Sept. 2010 673.5 Hazard Classifications (2009) Revises language related to the hazard classifications that may be assigned to a dam, and the factors that the Department may consider in assigning a hazard classification, for clarity. Requires that the Department must notify a dam owner when it changes the hazard classification, and that the Department will make available a list of dams and the hazard classifications assigned to them. Provides a process for appealing a hazard classification. Also includes Class "D" or "Negligible or No Hazard" dam: A dam that has been breached or removed, or has failed or otherwise no longer materially impounds waters, or a dam that was planned but never constructed. Class "D" dams are considered to be defunct dams posing negligible or no hazard. The department may retain pertinent records regarding such dams.
NC	NA	Class C – High-hazard: Dams located where failure will likely cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, primary highways, or major railroads.	Class B – Intermediate-hazard: Dams located where failure may damage highways or secondary railroads, cause interruption of use or service of public utilities, cause minor damage to isolated homes, or cause minor damage to commercial and industrial buildings. Damage to these structures will be considered minor only when they are located in back water areas not subjected to the direct path of the breach flood wave; and they will experience no more than 1.5 feet of flood rise due to breaching above the lowest ground elevation adjacent to the outside foundation walls or no more than 1.5 feet of flood rise due to breaching above the	Class A – Low-hazard: Dams located where failure may damage uninhabited low value non residential buildings, agricultural land, or low volume roads.	NA	Rule .0105

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

<table>
<tr><td></td><td></td><td></td><td>lowest floor elevation of the structure, the lower of the two elevations governing. All other damage potential will be considered serious.</td><td></td><td></td><td></td></tr>
<tr><td>ND</td><td>NA</td><td>High - Dams located upstream of developed and urban areas where failure may cause serious damage to homes, industrial and commercial buildings & major public utilities. There is potential for loss of more than a few lives if the dam fails.</td><td>Medium – Dams located in predominantly rural or agricultural areas where failure may damage isolated homes, main highways, railroads or cause interruption of minor public utilities. The potential for loss of a few lives may be expected if the dam fails.</td><td>Low – Dams located in rural or agricultural areas where there is little possibility of future development. Failure of low hazard dams may result in damage to agricultural land, township and county roads, and farm buildings other than residences. No loss of life expected.</td><td>NA</td><td>Source: ND State Water Commission, Sept. 2010

North Dakota's Dam Design Classifications are based on both the size of the dam and the hazard classification, as shown in the following table (Source: ND Dam Design Handbook, 1985).

Table 4-1. Dam Design Classifications
<table><tr><th>Dam Height (Feet)</th><th colspan="3">Hazard Categories</th></tr><tr><th></th><th>Low</th><th>Medium</th><th>High</th></tr><tr><td>Less than 10</td><td>I</td><td>II</td><td>IV</td></tr><tr><td>10 to 24</td><td>II</td><td>III</td><td>IV</td></tr><tr><td>25 to 39</td><td>III</td><td>III</td><td>IV</td></tr><tr><td>40 to 55</td><td>III</td><td>IV</td><td>V</td></tr><tr><td>Over 55</td><td>III</td><td>IV</td><td>V</td></tr></table></td></tr>
<tr><td>OH</td><td>NA</td><td>Class I: Sudden failure of the dam would result in probable loss of human life or structural collapse of at least one residence or one commercial or industrial business. Dams having a total storage volume greater than five thousand acre-feet or a height of greater than sixty feet shall be placed in class I.</td><td>Class II: Dams having a total storage volume greater than 500 acre-ft or a height of greater than 40 ft. Loss of human life is not probable. Failure of the dam would result in at least one of the following conditions:
(a) Disruption of a public water supply or wastewater treatment facility, release of health hazardous industrial or commercial waste, or other health hazards.
(b) Flooding of residential, commercial, industrial, or publicly owned structures.
(c) Flooding of high-value</td><td>Class III: Dams having a height of greater than 25 ft, or a total storage volume greater than 50 acre-ft. Loss of human life is not probable. Sudden failure of the dam would result in at least one of the following conditions:
(a) Property losses including but not limited to rural buildings not otherwise described in paragraph A of this rule, and class IV dams and levees not otherwise listed as high-value</td><td>Class IV: Dams 25 ft or less in height and with total storage volume of 50 acre-ft or less. Sudden failure would result in property losses restricted mainly to the dam and rural lands, and loss of human life is not probable. Class IV dams are exempt from the permit requirements of section 1521.06 of the Revised Code pursuant to paragraph (C) of rule 1501:21-19-01 of the Administrative Code.</td><td>Admin. Rules Chapt 13-1501:21-13-01. All pertinent information including any unusual circumstances shall be considered by the chief in establishing an appropriate classification for a dam. Probable future development of the area downstream from the dam that would be affected by its failure shall be considered. Completed downstream hazard mitigation such as acquisition, removal or protection of downstream property may also be considered. However, the above criteria shall in no way preclude the chief’s requirement of greater safety in the interest of life, health, or property.</td></tr>
</table>

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

			property. (d) Damage or disruption to major roads including but not limited to interstate and state highways, and the only access to residential or other critical areas such as hospitals, nursing homes, or correctional facilities as determined by the chief. (e) Damage or disruption to railroads, or public utilities. (f) Damage to downstream class I, II or III dams or levees, or other dams or levees of high value.	property in paragraph A of this rule. At the request of the dam owner, the chief may exempt dams from the criterion of this paragraph if the dam owner owns the potentially affected property. (b)Damage or disruption to local roads including but not limited to roads not otherwise listed as major roads in paragraph A of this rule.		
OK	NA	High hazard: One or more habitable structures with loss of life due to dam failure likely. Excessive economic loss/property damage (extensive community, industrial or agriculture)	Significant hazard: No loss of life Potential for future development exists, habitable structures may exist in inflow design flood floodplain, but dam failure would not endanger lives that would not be endangered if structure did not exist. Appreciable economic loss/ property damage (notable agriculture, industrial or structural)	Low hazard: None (no probable future development; may be zoned to prevent future development).	Minimal economic/property loss (undeveloped to occasional structure or agriculture)	785:25-3-3. Hazard classification subject to regulation and change. (A) For dams inventoried in the National Safety of Dams program authorized under 33 USC 467, hazard classifications set forth in Phase I reports is presumed accurate. If the dam owner disagrees, he has the burden to show that hazard class should be changed. (B) At the discretion of the Board, any proposed or existing dam considered to have classification of a high hazard potential may be subject to regulation regardless of size or impounding capacity. (C) The hazard potential classification may change as the area downstream from a dam develops and the dam may be reclassified from time to time.
OR	N/A	High Hazard: This rating indicates that if the dam fails there is a strong plausibility for loss of life. The plausibility is established because of inhabited infrastructure (such as homes and business) downstream that would be inundated to such a degree see 690-020-0100(2)(d) for specific criteria that it would put the person	Significant Hazard: This rating indicates that if a dam fails, infrastructure (such as roads, power lines or other largely uninhabited buildings) would be damaged or destroyed due to inundation and flooding. The department shall endeavor to inspect this class of dams at least once every three years.	Low Hazard: This rating indicates that if the dam fails there is little plausibility for loss of life, and human infrastructure that could be affected by inundation downstream is minor or non-existent. The department shall endeavor to inspect this class of dams at least once every six years.	NA	http://arcweb.sos.state.or.us/rules/OARS_600/OAR_690/690_020.html

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		who inhabits the structure in jeopardy. Any factor that puts a strong probability of people being downstream in an inundation area of a dam failure shall be considered. The department shall endeavor to inspect this class of dams on an annual basis.				
PA	NA	High Hazard: A dam so located as to endanger populated areas downstream by its failure. Category 1: Substantial loss of life. Excessive economic loss (extensive residential, commercial, agricultural and substantial public inconvenience). Failure would impact two or more habitable structures. Category 2 - High Hazard: Breach inundation area impacts one habitable structure.	Category 2 - Non High Hazard: No habitable structures are impacted (appreciable economic loss only). Category 2: Few fatalities (no rural communities or urban developments and no more than a small number of habitable structures). Appreciable economic loss (Damage to private or public property and short duration public inconvenience).	Category 3: No loss of life expected (no permanent structure for human habitation). Minimal economic loss (undeveloped or occasional structures with no significant effect on public inconvenience).	NA	Source: PA DEP, Sept. 2010
PR	NA	High Hazard - Structures for which failure would cause more than very little loss of life and serious damage to communities, industry and agriculture.	Intermediate Hazard - Structures for which failure would cause very little loss of life and significant damage to property and project operation,	Low Hazard - Structures for which failure would result in loss of the structure itself, but little or no additional damage to other property.	NA	

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

RI	NA	High hazard: Failure or mis-operation results in a probable loss of human life.	Significant hazard: Failure or mis-operation results in no probable loss of human life but can cause major economic loss, disruption of lifeline facilities or impact other concerns detrimental to the public's health, safety or welfare.	Low hazard: Failure or mis-operation results in no probable loss of human life and low economic losses.	NA	In regulations effected December 2007, each dam has a hazard classification of high, significant or low, which is a determination made by the Director relating to the following probable consequences of failure or misoperation of the dam:
SC	NA	Class I - High Hazard: Dams located where failure will likely cause loss of life or serious damage	Class II - Significant Hazard: Dams located where failure will not likely cause loss of life but may damage property.	Class III - Low Hazard: Dams located where failure may cause minimal property damage	NA	
SD	NA	Category 1: Potential loss of life;	Category 2: No loss of life expected: Extensive economic loss potential (community or industry)	Category 3: No loss of life expected: minimal economic loss potential (undeveloped to occasional structures)	NA	http://legis.state.sd.us/rules/DisplayRule.aspx?Rule=74:02:08:05
TN	NA	Category 1: Failure would probably result in any of the following: loss of human life; excessive economic loss due to damage of downstream properties; excessive economic loss, public hazard, or public inconvenience due to loss of impoundment and/or damage to roads or any public or private utilities.	Category 2: Failure may damage downstream private or public property, but such damage would be relatively minor and within the general financial capabilities of the dam owner. Public hazard or inconvenience due to loss of roads or any public or private utilities would be minor and of short duration. Chances of loss of life would be possible but remote.	Category 3: Failure may damage uninhabitable structures or land but such damage would probably be confined to the dam owner's property. No loss of human life would be expected.	NA	Regulations state that dams will be re-evaluated for hazard potential every 5 years (1200-5-7-.05).
TX	NA	A dam in the high-hazard potential category has: (A) loss of life expected (seven or more lives or three or more habitable structures in the breach inundation area downstream of the	A dam in the significant-hazard potential category has: (A) loss of human life possible (one to six lives or one or two habitable structures in the breach inundation area downstream of the dam); or (B) appreciable economic loss, located primarily in rural areas where	A dam in the low-hazard potential category has: (A) no loss of human life expected (no permanent habitable structures in the breach inundation area downstream of the dam); and (B) minimal economic loss (located	NA	Definitions provided by TX Program, 9/3/2010.

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		dam); or (B) excessive economic loss, located primarily in or near urban areas where failure would be expected to cause extensive damage to: (i) public facilities; (ii) agricultural, industrial, or commercial facilities; (iii) public utilities, including the design purpose of the utility; (iv) main highways as defined in §299.2(33); or (v) railroads used as a major transportation system.	failure may cause: (i) damage to isolated homes; (ii) damage to secondary highways as defined in §299.2(58); (iii) damage to minor railroads; or (iv) interruption of service or use of public utilities, including the design purpose of the utility.	primarily in rural areas where failure may damage occasional farm buildings, limited agricultural improvements, and minor highways as defined in §299.2(38) of this title (relating to Definitions)).		
UT	NA	High hazard: Failure has a high probability of causing loss of human life or extensive economic loss, including damage to critical public utilities.	Moderate hazard. Failure has a low probability of causing loss of human life, but would cause appreciable property damage, including damage to public utilities. Subcategories: Over 20 ac-ft: (Approval process requires formal plans) Under 20 ac-ft: (Approval process requires application procedure.)	Low hazard: Failure would cause minimal threat to human life, and economic losses would be minor or limited to damage sustained by the owner of the structure. Subcategories: Over 20 ac-ft and failure would damage property not held by the owner: (Approval process requires formal plans) Over 20 ac-ft with failure consequences limited to property held by the owner. (Approval process requires application procedure.) Under 20 ac ft. (Approval process requires application procedure.)	Low hazard (No formal plans required). Subcategories: NA	The State Engineer has the final authority in assigning hazard ratings.
VT	N	Class 1/High Hazard	Class 2/Significant Hazard	Class 3/Low Hazard	NA	The department classifies dams according to the potential loss resulting from failure, and uses

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

		Dams are those, the failure of which could result in more than a few deaths and excessive economic loss.	Dams, are those, the failure of which could result in a few deaths and appreciable economic loss.	Dams are those, the failure of which is not expected to result in either loss of life or any economic loss.		the Downstream Hazard Classification system recommended by the US Army Corps of Engineers.
VA	NA	High Hazard Potential is defined where an impounding structure failure will cause probable loss of life or serious economic damage. "Probable loss of life" means that impacts will occur that are likely to cause a loss of human life, including but not limited to impacts to residences, businesses, other occupied structures, or major roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, major roadways, railroads, personal property, and agricultural interests. "Major roadways" include, but are not limited to, interstates, primary highways, high-volume urban streets, or other high-volume roadways.	Significant Hazard Potential is defined where an impounding structure failure may cause the loss of life or appreciable economic damage. "May cause loss of life" means that impacts will occur that could cause a loss of human life, including but not limited to impacts to facilities that are frequently utilized by humans other than residences, businesses, or other occupied structures, or to secondary roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, secondary roadways, railroads, personal property, and agricultural interests. "Secondary roadways" include, but are not limited to, secondary highways, low-volume urban streets, service roads, or other low-volume roadways.	Low Hazard Potential is defined where an impounding structure failure would result in no expected loss of life and would cause no more than minimal economic damage. "No expected loss of life" means no loss of human life is anticipated.		4VAC50-20-40. Hazard potential classifications of impounding structures (2008) www.dcr.virginia.gov/documents/dsfinregs092608.pdf The hazard potential classification shall be proposed by the owner and shall be subject to approval by the board. To support the appropriate hazard classification, dam break analysis shall be conducted by the owner's engineer. Present and planned land-use for which a development plan has been officially approved by the locality in the dam break inundation zones downstream from the impounding structure shall be considered in determining the classification. Impounding structures shall be subject to reclassification by the board as necessary.
WA	High-hazard/ Class	High-hazard/ Class 1b:	High-hazard/ Class 1c:	Significant-hazard/	Low-hazard/ Class 3:	Downstream hazard classification reflects current conditions of development in downstream

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

	1a: -PAR*: More than 300 -Economic loss: Extreme. More than 100 inhabited structures. Highly developed, densely populated suburban or urban area with associated industry, property, transportation and community life line features.	-PAR*: 31-300 -Economic loss: Extreme. 11 to 100 inhabited structures. Medium density suburban or urban area with associated industry, property and transportation features. -Environmental damages: Severe water quality degradation potential from reservoir contents and long term effects on aquatic and human life.	-PAR*: 7-30 -Economic loss: Major. 3 to 10 inhabited structures. Low density suburban area with some industry and work sites. Primary highways and rail lines.	Class 2: -PAR*: 1-6 -Economic loss: Appreciable. 1 or 2 inhabited structures. Notable agriculture or work sites. Secondary highway and/or rail lines. -Environmental damages: Limited water quality degradation from reservoir contents and only short term consequences.	-PAR*: 0 -Economic loss: Minimal. No inhabited structures. Limited agricultural development. Environmental damages: No deleterious materials in reservoir contents.	areas. The most serious potential consequences of failure of PAR, economic loss, and environmental damages are used to establish hazard classification. **PAR = Population at Risk*
WV	NA	Class 1 (High Hazard): Dams located where failure may cause loss of human life or major damage to dwellings, commercial or industrial buildings, main railroads, important public utilities, or where a high risk highway may be affected or damaged. This classification must be used if failure may result in the loss of human life.	Class 2 (Significant Hazard): Dams located where failure may cause minor damage to dwellings, commercial or industrial buildings, important public utilities, main railroads, or cause major damage to unoccupied buildings, or where a low risk highway may be affected or damaged. The potential for loss of human life resulting from failure of a Class 2 dam must be unlikely.	Class 3 (Low Hazard): Dams located in rural or agricultural areas where failure may cause minor damage to nonresidential and normally unoccupied buildings, or rural or agricultural land. Failure of a Class 3 dam would cause only a loss of the dam itself and a loss of property use, such as use of related roads, with little additional damage to adjacent property. The potential for loss of human life resulting from failure of a Class 3 dam must be unlikely. An impoundment exceeding 40 ft in height or 400 acre-ft storage volume shall not be classified as a Class 3 dam. A waste disposal dam, the failure of which may cause significant harm to the	Class 4 (Negligible Hazard): Dams where failure is expected to have no potential for loss of human life, no potential for property damage and no potential for significant harm to the environment. Examples: dams across rivers, failure of which under any conditions will not flood areas above normal streambank elevations; dams located in the reservoir of another dam which, under any conditions, can contain water released by failure of the Class 4 dam; and dams in series where the toe of the Class 4 dam(s) is in close proximity to the reservoir of a dam which can contain failure of the Class 4 dam(s) under any condition. In considering a request for a Class 4 designation, the director may require written	

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

				environment, shall not be classified as a Class 3 dam.	concurrence from the owner(s) of downstream dams that may be affected by failure of the Class 4 dam. Approval is vested in the director, and will be based on engineering evaluation of the dam(s) and downstream areas in question.	
WI	N/A	High hazard: A high hazard rating shall be assigned to those dams that have existing development in the hydraulic shadow that will be inundated to a depth greater than 2 feet or do not have land use controls in place to restrict future development in the hydraulic shadow. This rating must be assigned if loss of human life during failure or mis-operation of the dam is probable.	Significant hazard: A significant hazard rating shall be assigned to those dams that have no existing development in the hydraulic shadow that would be inundated to a depth greater than 2 feet and have land use controls in place to restrict future development in the hydraulic shadow. Potential for loss of life during failure must be unlikely. Failure or mis-operation of the dam would result in no probable loss of human life but can cause economic loss, environmental damage, or disruption of lifeline facilities.	Low hazard: A low hazard rating shall be assigned to those dams that have no development unrelated to allowable open space use in the hydraulic shadow where the failure or mis-operation of the dam would result in no probable loss of human life, low economic losses (losses are principally limited to the owners property), low environmental damage, no significant disruption of lifeline facilities, and have land use controls in place to restrict future developments in the hydraulic shadow.	N/A	Source: Page 63 of Dam Design and Construction
WY	NA	High hazard dams would, in case of failure of the dam, likely cause loss of life.	Significant hazard dams would, in case of failure, likely cause significant property damage, but no loss of life.	Failure of a low hazard dam would likely cause only minimal property damage.	NA	http://wyohomelandsecurity.state.wy.us/Library/mitigation_plan/Chap4_Dam_Safety.pdf



FEMA

FEMA P-919
Catalog No. 12161-1